THE DEVELOPMENT OF A GREEN ENERGY SECTOR MODEL FOR THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

Submitted in fulfilment of the requirements for the degree

Doctor of Business Administration

at

Nelson Mandela Metropolitan University, Port Elizabeth

South Africa

by

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April 2016

ABSTRACT

The Southern African Development Community (SADC) region, like most parts of the African continent, faces significant modern energy services access challenges. It is estimated that less than 45% of the SADC region's populace have access to reliable modern energy forms and the situation is worse in rural areas where access is approximately 30%. Poor energy security is exacerbated by electricity power cuts and load shedding in almost all of the member states in the region. With the advent of battery storage, all forms of green energy have the potential to contribute to the shortfall in the supply of peaking power required to meet the daily (morning and evenings) and seasonal (winter) peaks when most power is required on the grid network. The region is endowed with vast green (renewables/low carbon or clean) energy resources.

The purpose of this study is to expand the empirical body of research and knowledge on factors that contribute to widespread access success to green energy in the SADC region. Investments into green energy resources require an understanding of the unique characteristics of the energy sector in the region. In order to achieve this, a conceptual theoretical model was developed and tested empirically. Factors that influence green energy access success were identified through literature reviews and discussions with energy practitioners. All identified factors were then operationalised by carefully defining them in the context of the study. In order to test the proposed theoretical model and the hypothesised relationships, a structured questionnaire was developed and sent to energy practitioners from various sections of the energy sector in the region.

STATISTICA 12 was employed to analyse relationships between variables and responses between identified groups. Pearson Product Moment Correlation (Pearson r) was employed to determine correlations between variables.

Conclusions about hypotheses six (6) to fifteen (15) were made based on correlations between variables. T-tests were employed to make inferences about the views of various categories of respondents with regard to the twelve (12) identified variables. Multivariate analysis of variance (MANOVA) and Analysis of variance (ANOVA) examined associations between the dependent and independent variables with the identified categories of respondents and conclusions about hypotheses one (1) to five (5) and sixteen (16) were also made.

The study finds that policy and the regulatory environment are still the main driving force behind energy access in the region. Power generation is managed by authorities' power utility companies. Unbundling of power utilities supported by new energy business and operating models to accommodate mini and off grid power plants is found to be a key to green energy access in the region. The energy market is transforming in favour of independent power producers (IPPs) and consumers will significantly influence energy access decisions in the future. Green energy power storage to overcome intermittency will feature prominently in the success of green energy access in the region. Widespread access success to green energy will be attained when green energy access is reliable, affordable, efficient, and socially acceptable, meet the demand and reduces environmental pollution.

The study recommends that strategic green energy planning must incorporate green energy infrastructure development, projects finance and human capacity development as priorities amongst SADC region's member countries. Regional energy access enabling institutions must be strengthened; energy policies implemented with vigour and private sector participation enhanced in an integrated energy market.

Key words: Climate change, energy access, energy poverty, energy security, green energy and greenhouse gases

DECLARATION

I, Mbavhalelo Justice Ramagoma, hereby declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in fulfilment of the requirements for the Doctor of Business Administration degree. It has not been submitted before for any degree or examination at this or any other university.

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Mbavhalelo Justice Ramagoma

30 October 2015

ACKNOWLEDGEMENTS

Many individuals contributed profoundly to the successful completion of this research. I am immensely indebted to my supervisor Professor Chris Adendorff for his insights and intelligent guidance in the execution of this research project. I am grateful to Dr Danie Venter (Director, Unit for Statistical Consultation) for the support, remarkable guidance and statistical analysis. A special mention must be made of proof readers for their sterling work, Dr Dennis Ring for English language and grammar editing and Dr Annelie Pretorius for technical editing. In gratitude I wish to thank all those who participated in the research including delegates at the clean energy week-conference in Harare on the 23rd - 27th September 2014. I am grateful to friends, colleagues and acquaintances at Eskom and elsewhere in the region that enriched my thesis in many ways.

A special mention of Dr Steve Lennon, Mr Stephen Koopman and Mr Mmboneni Muofhe for their expert guidance on the energy sector in South Africa, Dr Tobias Bischof-Niemz for his invaluable insights on African energy solutions and world energy perspectives. My sincere appreciation also goes to global energy advocate (Energy for all), Mr Aaron Leopold for enlightening me with global energy access trends. I sincerely appreciate the opportunity the university afforded me to make a contribution to our regional energy access advancement in Southern Africa.

I appreciate the long lasting support and encouragement from my wife Connie in this lengthy journey and hope that this outcome will inspire our son Gundo and daughter Simphiwe and all the children of their generation to believe that the sky is the limit. Finally, a special thanks to my parents, grandparents and my family at large for their immeasurable support all the years.

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AFSEA:	African Sustainable Energy Association
BBBEE:	Broad Based Black Economic Empowerment
CAR:	Central African Republic
CDM:	Clean Development Mechanism
CHP:	Combined Heat and Power
CH4:	Methane Gas
CLP:	China Light and Power Company
CO2:	Carbon Dioxide
COP:	Conference of Parties
CSP:	Concentrating Solar Power
DBSA:	Development Bank of Southern Africa
DRC:	Democratic Republic of Congo
EAPP:	East African Power Pool
ECOWAS:	Economic Community of West African States
EIA:	Energy Information Administration

EU:	European Union
FDI:	Foreign Direct Investment
GCF:	Green Climate Fund
GDP:	Gross Domestic Product
GHG:	Green House Gases
HESS:	Hybrid Energy Storage System
HFCs:	Hydro fluorocarbons
IEA:	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
IPPs:	Independent Power Producers
IRENA:	International Renewable Energy Agency
ISES:	International Solar Energy Society
MOP:	Meeting of Parties
MW:	Megawatt
NEPAD:	New Partnership for Africa’s Development
NERSA:	National Energy Regulator of South Africa

NGOs:	Non-Governmental Organisations
NMMU:	Nelson Mandela Metropolitan University
NPV:	Net present value
NRSE:	New and renewable energy sources
N2O:	Nitrous oxide
OECD:	Organisation for Economic Cooperation and Development
OTEC:	Ocean Thermal Energy Conversion
PFCs:	Per fluorocarbons
PIDA:	Programme for Infrastructure Development in Africa
PPA:	Power Purchase Agreement
PPP:	Public Private Partnership
PNG:	Papua New Guinea
PV:	Photovoltaic
PWC:	Pricewater House Coopers
R&D:	Research and Development
RIDMP:	Regional Infrastructure Development Master Plan

RECS:	Regional Economic Communities
REFIT:	Renewable Energy Feed-in Tariffs
RERA:	Regional Electricity Regulators Association
SAAEA:	Southern African Alternative Energy Association
SACREEE:	SADC Regional Center for Renewable Energy and Energy Efficiency
SADC:	Southern African Development Community
SAPP:	Southern African Power Pool
SEB:	Swaziland Electricity Board
SE4ALL:	Sustainable Energy for All
SESSA:	Sustainable Energy Society of Southern Africa
SF6:	Sulphur hexafluoride
SIDS:	Small Island Developing States
SNEL:	Societe Nationale d'Electricite
SSA:	Sub-Saharan Africa
TFEC:	Total final energy consumption

UNEP:	United Nations Environment Programme
UNFCCC:	United Nations' Framework Convention on Climate Change
US:	United States of America
U$:	United States dollar
WAPP:	West African Power Pool

UNITS OF MEASUREMENT

°C:	Celsius degrees (temperature)
°K:	Kelvin degrees (temperature)
J:	Joule (energy)
W:	Watt (1 joule per second)
GW:	Gigawatts (1 watt x 109); or billion watts (power)
GWh:	Gigawatt-hour
GWh:	Gigawatt hours; or million kWh (energy)
GWhth:	Gigawatt hours thermal; or million kWh thermal (thermal energy)
kW:	Kilowatts; or thousand watts (power: 1 watt x 103)
kWh:	kWh kilowatt-hour (energy)
MBtu:	Million British thermal units (energy)
MPa:	Megapascal; or one million pascals (pressure)
MW:	Megawatt (1 watt x 106); or one million watts (power)
MWh:	Megawatt-hour

MWe:	Megawatt electric; or one million watts electric (power)
MWth:	Megawatt thermal; or one million watts thermal (power)
TW:	Terawatt
TWh:	Terawatt-hour or (power: 1 watt x 1 012)
Mtce:	Million tonnes of coal equivalent (1 Mtce = 0.7 Mtoe) (Coal)
Mcm:	Million cubic metres (gas)
Bcm:	Billion cubic metres (gas)
Tcm:	Trillion cubic metres (gas)
Kg:	Kilogramme (1 000 kg = 1 tonne)
Kt:	Kilotonnes (1 tonne x 103)
Mt:	Million tonnes (1 tonne x 106)
Gt:	Gigatonnes (1 tonne x 109)
$ Million:	1 US dollar x 106
$ Billion:	1 US dollar x 109
$ Trillion:	1 US dollar x 1 012

1 CHAPTER 1: INTRODUCTION, PROBLEM STATEMENT AND DEMARCATION OF THE STUDY

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

About 1.4 billion people worldwide are currently without access to energy and there is a great need for a reliable, affordable, economically viable, socially and environmentally acceptable energy in developing countries (United Nations, 2012). International Energy Agency (IEA) (2014b: 30) indicates that Sub-Saharan Africa (SSA) region has more people living without access to electricity than any other world region, more than 620 million people, and about half of the global total (nearly 80% of those) lacking access to electricity across SSA are in rural areas. Access to energy is a foundation stone of modern life and addressing the challenge of energy poverty is a major international priority and a key tool in eradicating extreme poverty across the globe (World Energy Council, 2013a).

According to Wustenhagen and Menichetti (2012) more than 80% of global energy supply relies on depletable fossil fuels, creating significant energy security challenges and policy makers around the world are recognising the challenge of addressing climate change. Recent estimates indicate that renewable energy accounted for 12.9% of global primary energy supply in 2008, and 16% of the world's final energy consumption in 2010, with a potential to rise to 50% of the global energy demand by 2050 (Wustenhagen and Menichetti, 2012; Fadel, Rachid, El-Samra, Boutros and Hashisho, 2013).

The year 2012 was declared an energy access year, by the United Nations conference (Rio + 20) which recognised the critical role that energy plays in the development process, as access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health and helps to provide for basic human needs (United Nations, 2012).

The United Nations has further called upon world leaders to adopt universal access to modern energy services by 2030 as a critical long-term priority and a catalyst that can be attained by investing in renewable energy particularly in developing countries (United Nations, 2012). According to United Nations Environment Programme (UNEP) (2011: 206) “the global community and national governments are faced with four major challenges with respect to the energy sector:

- Concerns about energy security.
- Combating climate change.
- Reducing pollution and public-health hazards.
- Addressing energy poverty”.

The augmentation of green energy is crucial to expand access to modern energy and to reduce the impact of climate challenge in developing countries. Increasing access to modern energy through burning of fossil fuels is no longer a sustainable option due to noxious gases they release. Gaseous emissions from fossil fuels are resulting in global warming which is affecting the daily lives of people all over the world, with dire consequences particularly in developing countries (Wustenhagen and Menichetti, 2012).

One of the promising options to counter global warming and to meet energy needs is by expanding the use of green energy sources, which involves usage of low carbon emitting energy sources. These include the use of renewable energy which will lead to a reduction of greenhouse gas emissions (GHG) and other types of pollution (United Nations, 2012; Abanda, 2012). Conventional electrical generation using fossil fuels produces large quantities of carbon, sulphur and nitrogen compounds, which have adverse environmental problems such as global warming and ozone layer depletion (Kathirvel and Porkumaran, 2011).

There are high indirect costs associated with the pollution arising from combustion of fossil and traditional fuels, the release of both black carbon particles and other forms of air pollution (sulphur and nitrogen oxides, photochemical smog precursors, and heavy metals, for example), have a detrimental effect on public health (UNEP, 2011). Greening the energy sector can substantially address global warming challenges and energy poverty.

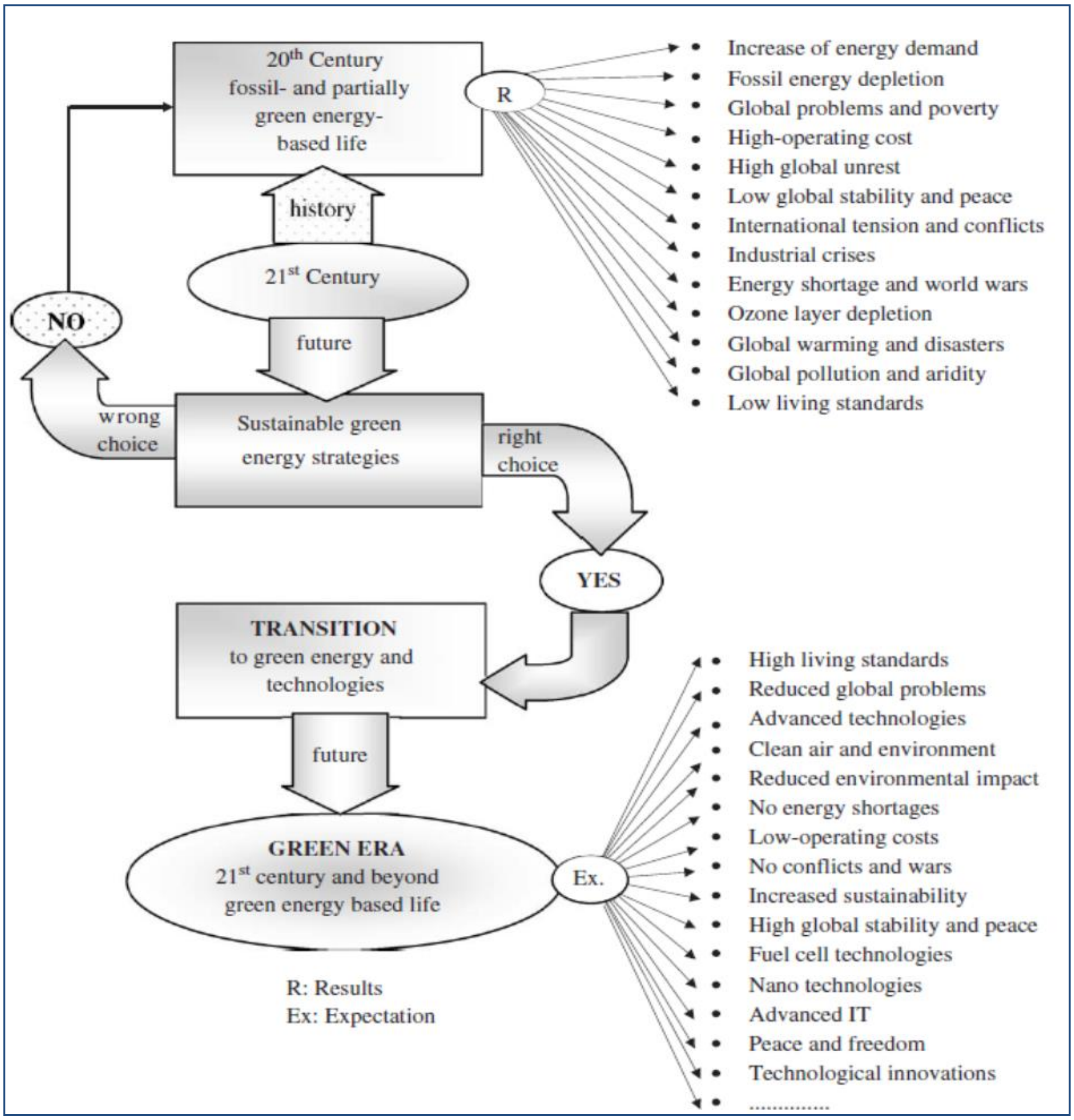
The United Nations conference (Rio + 20) reaffirmed support for the implementation of national and subnational policies and strategies, based on individual national circumstances and development aspirations, using an appropriate energy mix to meet developmental needs, including through increased use of renewable energy sources and other low-emission technologies, the more efficient use of energy, greater reliance on advanced energy technologies, including cleaner fossil fuel technologies, and the sustainable use of traditional energy resources (United Nations, 2012).

Some 70 countries have formally embraced the United Nations' initiative, while numerous corporations and agencies have pledged tens of billions of dollars to achieve its objectives (Sustainable Energy for All (SE4ALL), 2014: 67). The conference committed to promoting sustainable modern energy services for all through national and subnational efforts, inter alia, on electrification and dissemination of sustainable cooking and heating solutions, including through collaborative actions to share best practices and adopt policies, as appropriate (United Nations, 2012).

SE4ALL (2014: 45) indicates that the global final energy consumption can be broadly divided among the following major economic sectors: agriculture, industry, residential, transport and services. Industry is by far the most energy-intensive of these sectors, consuming around 6.8 mega joules per 2005 dollar in 2010, compared with 5.5 for other sectors (residential, transport, and services) and 2.1 for agriculture.

A transition to green energy era can have a profound impact in the quality of life for rural communities. The 20th century was charactarised by fossil fuel and partially green energy based life. Advances and innovation of green energy technology in the 21st century provide an opportunity for a transition to green energy era. Figure 1.1 illustrates a chart of green energy strategies and technologies for sustainable development.

Figure 1.1: Chart of green energy strategies and technologies for sustainable development



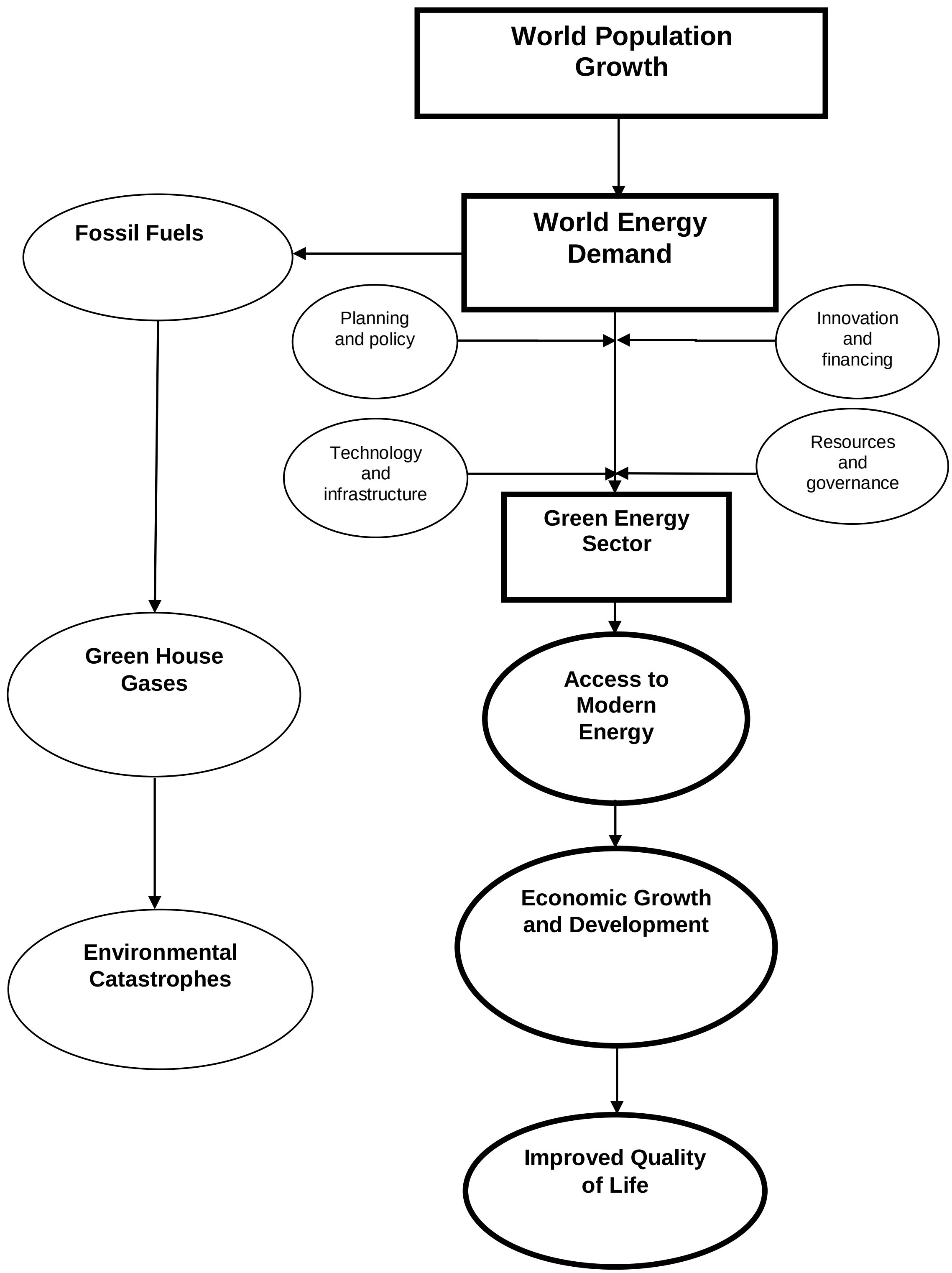
Source: Midilli, Dincer and Ay (2006: 3631)

1.1.1 The theoretical rationale of the study

Increasing urbanisation around the world has often facilitated energy access, SSA is the only region in the world where the number of people without access to electricity is increasing, and population growth is outpacing the many positive efforts to provide access (IEA, 2014b: 30). The theoretical rationale of the study is premised on population growth leading to an increased need for energy supply and meeting energy needs through increased use of green energy as opposed to fossil fuel sources. The rationale postulates that increasing access to modern energy services through green energy will lead to widespread access to modern energy services and an improved quality of life. Energy poverty affects poor communities and poor nations far more severely, and more directly, than in developed nations and the poor globally spend by far the largest percentage of income on energy (Sovacool, 2012; Kammen and Kirubi, 2008).

There are many barriers that must be disentangled in order to take advantage of green energy. The obstacles to widespread energy access and specifically to electricity access, are largely well known according to Bazilian et al. (2012) and Brew-Hammond (2010), these challenges include financing, planning, governance, and human and institutional capabilities, yet not trivial to overcome, particularly in developing countries. The continued extensive use of fossil fuels is likely to lead to environmental damage. Wustenhagen and Menichetti (2012) argue that greenhouse gases that result in global warming have the potential to cause extensive devastation in the form of environmental catastrophes in the future if action is not taken to mitigate it. Figure 1.2 illustrates the theoretical rationale of the study.

Figure 1.2: The theoretical rationale of the study



Source: Researcher's own construction

1.2 STATEMENT OF THE RESEARCH PROBLEM

Demand for electricity is rapidly increasing in developing countries and if the present growth rates continue, social and economic development in many developing countries would suffer due to major constrains in the availability of modern energy (Maslyuk and Dharmaratna, 2013). Energy poverty is an immediate priority for Africa as the population with access to electricity is no more than 30% in SSA (World Energy Council, 2013b). Lack of access to modern energy services can be attributed to many factors which include: poor planning, incoherent policy frameworks, lack of finance and enabling infrastructure, lack of innovative management strategies and weak energy governance structures (Oseni, 2012; Khennas, 2012).

Over 60% of the SADC population depends on biomass energy, comprising of wood fuel, charcoal, animal and crop residue, etc. Thus contributing to deforestation, environmental degradation and negative health impacts (Development Bank of Southern Africa (DBSA), 2014). Continuing poverty and the high cost of accessing modern forms of energy are some of the factors that confine rural and urban populations to the use of biomass (Hammons and Musaba, 2012; DBSA, 2014).

Overall, the level of access to electricity is low in the SADC region of approximately 280 million people. Rural areas energy access averages between 20-30% and 42% for the entire region and the demand for power in SADC is increasing at an average rate of 3-4% per annum (DBSA, 2014; SADC Regional Center for Renewable Energy and Energy Efficiency (SACREEE), 2013). Against the above background the main research problem is formulated as follows: “high dependence on fossil fuels sources of energy for electricity generation is not improving widespread access to modern energy to the vast majority of SADC region’s citizens, despite the endowment of the region with green energy sources”.

The research problem was further categorised into a set of research questions. The primary research question is stated as follows: "How can the SADC region intensify the exploitation of green energy sources and by doing so contribute to widespread access to modern energy to a larger population in the region. The primary research question is further supported by the secondary research questions as presented in Table 1.1.

Table 1.1: Secondary research questions	
Q_1	What are the key drivers to widespread green energy access according to energy practitioners and the industry in the region?
Q_2	What barriers are impeding the augmentation of green energy access in the region?
Q_3	How viable can economic and environmental benefits be derived from a successful access to green energy?
Q_4	How effective are energy governance structures in the region?
Q_5	How aligned are energy policies to the augmentation of green energy in the region?
Q_6	What is the impact of green energy projects financing to the successful green energy access in the region?
Q_7	What is the impact of human capacity development in the augmentation of green energy access in the region?
Q_8	What is the impact of energy infrastructure development in the augmentation of green energy access in the region?
Q_9	How important is the development of green energy local market to a successful access to green energy in the region?
Q_{10}	How can the proposed model be validated by empirical evaluation in the energy sector of the SADC region?
Q_{11}	What interpretations and conclusions can be drawn from the empirical findings?

1.2.1 Research objectives

The primary objective of this research is to debunk how widespread access to green energy can be increased by investing into the green energy sector in the SADC region. The primary objective is supported by the following secondary objectives as shown in Table 1.2.

Table 1.2: Secondary research objectives	
O_1	To test the relationship of identified factors that are key drivers to widespread green energy access success according to literature and energy practitioners in the region.
O_2	To investigate barriers that are impeding the augmentation of green energy access in the region.
O_3	To give an overview of the economic and environmental benefits that can be attained from the perceived widespread access success to green energy.
O_4	To give an overview of energy structures in the SADC region and assess their effectiveness and adequacy in driving widespread access success to green energy.
O_5	To give an overview of existing energy policies in the SADC region and assess their alignment to enhance widespread access success to green energy.
O_6	To conduct an in depth assessment of how green energy projects financing is conducted around the world and how it is impacting widespread access success to green energy in the SADC region.
O_7	To investigate the impact of limited green energy human capacity development to the widespread access success to green energy in the SADC region.
O_8	To investigate the impact of limited energy infrastructure development to the widespread access success to green energy in the SADC region.
O_9	To conduct an in-depth analysis about the development of local market to a successful access to green energy in the region.
O_{10}	To propose a model validated by empirical evaluation of variables for implementation in the region.
O_{11}	To discuss and interpret research results and to make appropriate and meaningful recommendations based on the outcome of statistical analysis.

1.3 HYPOTHESES AND THE THEORETICAL CONCEPTUAL MODEL

The following hypotheses were tested in order to address the research objectives:

H_1: There is a significant difference in support for green energy based on years of experience of respondents (1-6 years and greater (>) 6 years)

H_2: There is a significant difference in support for green energy based on the energy sector association of the respondents (fossil fuel and renewable energy).

H_3: There is a significant difference in support for green energy based on the role of respondents in the energy sector (researchers and industry practitioners).

H_4: There is a significant difference in support for green energy based on a location of respondents that serves as a base country (South Africa and other SADC countries).

H_5: There is a significant difference in support for green energy based on the position held by the respondents (senior manager, middle manager and senior manager).

H_{16}: There is a significant difference in support for the viability of various identified green energy sources amongst different groups in the SADC region: 1-6 years and > 6 years; fossil fuel and renewable energy; researchers and industry practitioners; South Africa and SADC country and junior manager, middle managers and senior managers.

Other hypotheses that were tested are:

H_6: There is a significant positive relationship between strategic green energy planning and the perceived access success to green energy in the SADC region.

H_7: There is a significant positive relationship between green energy economic augmentation and the perceived access success to green energy in the SADC region.

H_8: There is a significant positive relationship between green energy environmental pollution mitigation and the perceived access success to green energy in the SADC region.

H_9: There is a significant positive relationship between green energy governance and the perceived access success to green energy in the SADC region.

H_{10}: There is a significant positive relationship between green energy technology innovation and the perceived access success to green energy in the SADC region.

H_{11}: There is a significant positive relationship between green energy policy alignment and the perceived access success to green energy in the SADC region.

H_{12}: There is a significant positive relationship between green energy projects financing and the perceived access success to green energy in the SADC region.

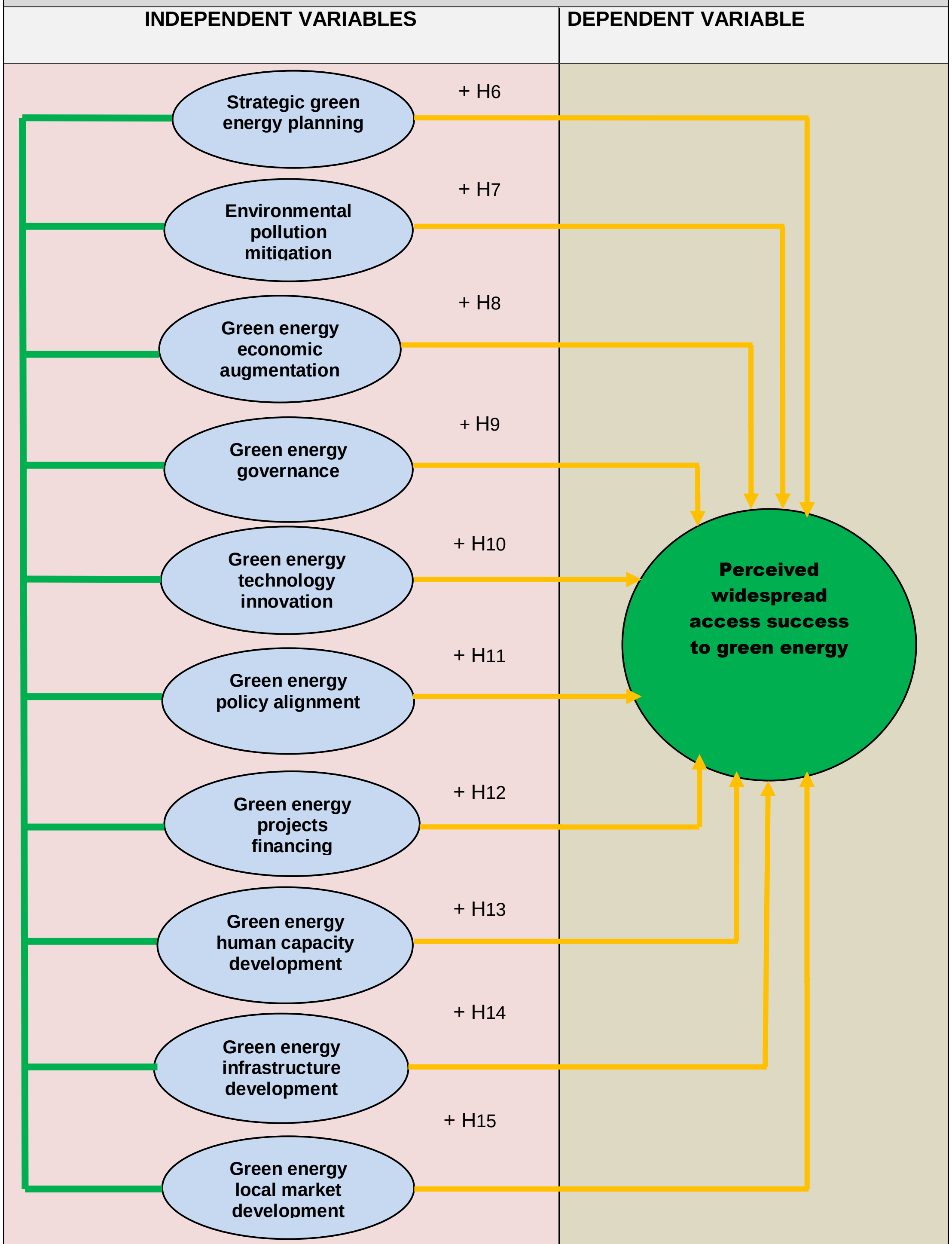
H_{13}: There is a significant positive relationship between green energy human capacity development and the perceived access success to green energy in the SADC region.

H_{14}: There is a significant positive relationship between green energy infrastructure development and the perceived access success to green energy in the SADC region.

H_{15}: There is a positive relationship between green energy local market development and the perceived access success to green energy in the SADC region.

Figure 1.3 illustrates a conceptual theoretical model of green energy access for the SADC region

Figure 1.3: A conceptual theoretical model of green energy access for the SADC region



Source: Researcher's own construction

In order to address the objectives of the study and to test all the hypotheses, the approach employed included secondary and primary research. Chapter 5 discusses the research design and methodology in greater detail.

1.2.2 Secondary research

Secondary research is data that already exist and have not been gathered for the immediate study at hand but were gathered for some other purposes (Diamantopoulos and Schlegelmilch, 2006). In order to identify factors that influence widespread access success to green energy, relevant literature was reviewed and this included books, journals and articles on green energy with the objective to propose a conceptual model.

A comprehensive literature review was also conducted using international and national data searches through the library of the Nelson Mandela Metropolitan University (NMMU) and Rhodes University; this included reviewing of literature from research projects; published on line journal search of Science Direct and Google scholar searches. Review of published reports from SADC region's governments included reports from power utilities, IPPs, energy research institutions and non-governmental institutions that are involved in the energy sector; reports included annually published reports on renewable energy projects, completed and planned energy projects for the future.

1.2.3 Primary research

Diamantopoulos and Schlegelmilch (2006) state that primary research data is collected with a specific purpose in mind, i.e. for the needs of a particular research project. The primary research entailed selecting an appropriate research paradigm, identifying the sample, data collection and analysis of the collected data.

A brief outline of each of the processes to be followed to collect the data is elaborated in the paragraphs that follow, with a detailed discussion presented in Chapter 5.

1.2.3.1 Research paradigm

In order to achieve the research objectives of the study, the positivistic approach was adopted. Leedy and Ormrod (2005) indicate that the positivist paradigm is quantitative in nature and it is also referred to as a traditional and experimental paradigm because it answers questions about relationships amongst measured variables with the purpose of explaining, predicting, and controlling phenomenon. Positivist paradigm approach ends with confirmation or disconfirmation of hypotheses. This approach is suitable for determining the relationship of selected independent variables on the dependent variable (perceived widespread access success to green energy in the SADC region).

1.2.3.2 Sample

After a literature review, 11 (independent and dependent) variables that can potentially influence widespread access success to green energy in the SADC region were identified and included in the proposed theoretical model. A 12th variable (viability of various green energy sources) was added to determine if there were significant differences in support for identified (in the questionnaire) types of green energy in the region amongst different groups of respondents in the SADC region. The composition of the targeted population proposed for this study included a sample of energy practitioners from various sections of the energy sector and they are: respondents from energy ministries in the SADC region, non-governmental institutions, private companies, energy researchers, academics and energy specialists.

Categories of respondents were: respondents with energy sector experience of 1-6 years and greater (>) 6 years; respondents associated with fossil fuel and renewable energy; researchers and industry practitioners; South Africa and other SADC countries based practitioners and junior managers; middle managers and senior managers. Quota sampling technique was employed for the study. Different designs may be more or less appropriate in different situations, falling in two categories that are probability sampling and non-probability sampling (Leedy and Ormrod, 2005). Quota sampling is a non-probability sampling approach. This method of sampling selects respondents in the same proportion that they are found in the general population, but not randomly (Leedy and Ormrod, 2005). The sampling approach is further detailed in Chapter 5.

1.2.3.3 Measuring instrument

Literature reviews and insights obtained from energy practitioners, guided the formulation of the research instrument. All questionnaire items were linked to a 7-point Likert-type scale. To validate the identified variables, a pilot survey was completed to test the questionnaire amongst a sample of conveniently obtained respondents associated with renewable and fossil-fuel energy sectors. Responses were reviewed to check for ambiguously worded questions and to statistically analyse inconsistencies. Minor changes were made to the final questionnaire.

After satisfactory results were obtained from a pilot study, the main study was conducted within the context of a quantitative approach and this involved distributing a questionnaire to targeted respondents in the SADC region. The composition of respondents who participated in the research included the Southern African Power Pool (SAPP) member countries respondents, their contact details were obtained from SAPP official website database.

Other respondents who participated in the research were obtained from official websites and they include: the Southern African Alternative Energy Association (SAAEA); Sustainable Energy Society of Southern Africa (SESSA); African Sustainable Energy Association (AFSEA) and energy enterprises which include contractors, consultants and suppliers that are part of the energy value chain within the SADC region's energy sector.

1.2.3.4 Data analysis

STATISTICA (data analysis software system), version 12 (www.statsoft.com) and the VBA application developed on an Excel platform by a statistician at NMMU university (Dr Danie Venter) were used for the analysis and they provided descriptive statistics for the whole group, giving an overall statistical profile of respondents. The procedure for analysing empirical data involved: Pearson Product Moment Correlation (Pearson r); One-sample T-tests and individual factor T-tests to make inferences about the views of categories of respondents with regard to all identified variables; Cohen's d statistics; Multivariate analysis of variance (MANOVA) and Analysis of variance (ANOVA). These are spelled out in detail in Chapter 5.

1.3 CONTRIBUTION OF THE STUDY

The contribution of this study was to develop a green energy sector model that was tested empirically. The model will serve as a guide on how to improve the energy situation in the SADC region to energy practitioners, governments and non-governmental organisations (NGOs), policy makers, investors, private sector, academics and energy interested and affected stakeholders both inside and outside the SADC region. The study will provide a guideline of how to enhance the growth and integration of green energy in the current energy mix in the region.

The study is intendeded to inform policy makers on how they should gear their policies towards strengthening investments in green energy in order to increase access to modern energy. The study is also meant to inform energy practitioners and the private sector about energy access success factors in the region in order to stimulate green energy enterprises development and growth. It is anticipated that the study will inspire debates on green energy's role in addressing climate change challenge facing the region, African continent and the world at large.

1.4 SCOPE OF THE STUDY

Literature reviews have revealed the drivers and critical success factors that can contribute to the augmentation of a green energy sector in the SADC region. Growth of the green energy sector can lead to improved energy access to modern energy sources to a vast number of communities in the region. Energy is a key input for industrial production at any scale, and it improves the quality of life. Access to modern energy alone does not automatically lead to economic growth, but can energise economic growth and development and these depend on reliable and secured energy supply.

The focus of this research include: reviews of energy planning strategies, assessing energy policies and legislative frameworks; technological choices; governance structures; innovation initiatives; financing of projects and skills required to drive the sector. The study exposed infrastructural necessities required to build a green energy sector successfully. Potential benefits of economic augmentation and environmental pollution mitigation are also investigated. Required investment to meet future energy demands in order to eliminate energy poverty was explored in detail. The development and testing of a conceptual theoretical green energy model is a final outcome of the study.

1.5 DEFINITION OF CONCEPTS AND COUNTRIES GROUPING

1.5.1 Definition of concepts

- Green Energy: Green energy can be defined as the energy source, which has zero or minimum environmental impact, more sustainable and environmentally benign, and produced from solar, hydro, biomass, wind, geothermal, etc. (Midilli, Dincer and Ay, 2006). Green energy means clean energy production and consumption with the merits of environmental protection and being pollution free after being consumed, green energy can be naturally regenerated with almost no pollution (Lu, Huang, Su, Tseng and Chen, 2013). Green energy reduces the negative impact of fossil fuels energy resources and the overall emissions from electricity generation and provides the opportunity to meet the clean energy demand for both industrial and non-industrial applications (Midilli, Dincer and Ay, 2006). According to UNEP (2011) green energy is the supply of energy services from renewable sources, both of which will lead to reduction in greenhouse gases emissions and other types of pollution.

- Energy Security: According to International Renewable Energy Agency (IRENA) (2013a) energy security focuses on reducing dependence on vulnerable energy supplies. UNEP (2011) indicates that increasing energy demand together with rising energy prices raises concerns about energy security and energy security is primarily associated with the reliability and affordability of national energy supply. The International Labour Office (2011) argue that energy security encompasses security of access to energy, security against rising energy prices in times of shortages and ability to source energy from within a country's own national territory.

Energy security is a multidimensional concept and according to Jonsson et al. (2015), it includes aspects such as security of supply, security of demand, affordability issues and revenues from energy, geopolitical considerations associated with security and defence policy, other political risk factors, economic risk factors and energy poverty, as well as technological and environmental risk factors.

- Energy Poverty: Refers to lack of access to reliable and modern energy services (UNEP, 2011). Energy poverty is generally referred to as a lack of access to electricity and dependence on traditional use of biomass for cooking and heating, which is often the case in the majority of households in the developing world (Sovacool et al., 2012). Lack of access to modern sources of energy aggravates poverty, hampers economic growth for rural dwellers and as result they face economic exclusion (Chakravarty and Tavoni, 2013; Pereira, Freitas, and Da Silva, 2011). Energy poverty is characterised by the access of bare minimum energy (derived from all sources) needed to sustain life to a point where energy does not contribute to greater welfare and increasingly higher levels of economic well-being of the community (Barnes, Khandker and Samad, 2011).

- Energy Access: Asian Development Bank (2010:1) defines energy access as any or a combination of the following: "(1) provision of electricity and motive power to households, (2) improvement in the supply and delivery of energy services to households, (3) provision of modern fuels and/or efficient devices for cooking and/or heating to households and (4) provision of finance to households to access energy".

Access to electricity also refers to the availability of electricity in areas not reached by the grid which includes electricity provided by a decentralised or stand-alone power source (petrol or diesel generator), or are renewable energy device (solar PV, wind turbine or biomass gasifier) (Brew-Hammond, 2010). Access to modern energy services can improve the livelihood of a community by expanding income generating activities that can greatly reduce poverty (Sovacool, 2012). Not having access impacts negatively on the welfare of a community and may mean being deprived not only of basic services such as cooking but also other elements which are fundamental for individual and collective development, such as access to education, health, information and participation in politics (González-Eguino, 2015).

- Green House Gases (GHG): These are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the earth's surface; the energy radiated from the sun is absorbed by these gases making the lower part of the atmosphere warmer leading to a phenomenon known as the natural GHG effect (Ramachandra, Aithal and Sreejith, 2015).

Six gases contribute to global warming according to Marchal et al. (2011) and they are responsible for the bulk of global warming and of these, the three most potent are carbon dioxide (CO2), methane gas (CH4), and nitrous oxide (N2O) currently accounting for 98% of the GHG emissions covered by the Kyoto Protocol. The other gases are hydro fluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) which account for less than 2% (Marchal et al., 2011).

Increase in the concentration of these greenhouse gases results in global warming and global warming leads to climate change (Ramachandra, Aithal and Sreejith, 2015). Marchal et al. (2011: 5) indicate that "climate change presents a global systemic risk to society, it threatens the basic elements of life for all people, including: access to water, food production, health, use of land, and physical and natural capital". Inadequate attention to climate change could have significant social consequences for human well-being, hamper economic growth and heighten the risk of abrupt and large-scale changes to our climatic and ecological systems (Ramachandra, Aithal and Sreejith, 2015; Marchal et al., 2011).

1.5.2 Countries grouping

- **OECD:** Organisation for Economic Cooperation and Development (OECD Europe, OECD Americas and OECD pacific).

- **OECD Americas:** Canada, Chile, Mexico and the United States.

- **OECD Pacific:** Austria, Japan, Korea and New Zealand.

- **OECD Europe:** Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, The Slovakia Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

- **Middle East:** Bahrain, the Islamic Republic of Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Qatar, Saudi Arabia, Syria Arab Republic, United Arab Emirates and Yemen.

- **Developing Countries:** Non-OECD, Middle East, Africa and Latin America regional groupings.

- **Central Africa:** Cameroon, Central African Republic (CAR), Chad, Congo, Democratic Republic of Congo (DRC), Equatorial Guinea and Gabon.

- **East Africa:** Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan and Uganda.

- **North Africa:** Algeria, Egypt, Libya, Morocco, Tunisia and Western Sahara (under UN mandate).

- **Southern Africa:** Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, United Republic of Tanzania, Zambia and Zimbabwe.

- **West Africa:** Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, São Tomé and Príncipe, Senegal, Sierra Leone and Togo.

1.6 DELIMITATION OF THE THESIS

The research was conducted within the following demarcation:

- The research was limited to the identified research fields of global and regional energy situation and global warming, access to modern energy, alternative energy sources, transition to low carbon energy sources and barriers to modern energy access in developing countries which are generally similar around the world when studied as areas of interest.

- The geographical scope of the study is the SADC region.
- Electrical energy and related sectors were investigated with a special focus on green energy.
- Limited focus on the role of petrochemicals as sources of fuel for electrical generation.
- Nuclear energy is a non-carbon emitting energy alternative. It has been discussed in the thesis and not indicated as a green energy source.
- The targeted sample population is energy practitioners involved in the energy sector, energy researchers and scholars, regional energy institutions and authorities and leaders of energy enterprises in the region.

1.7 STRUCTURE OF THE THESIS

- Chapter 1: This chapter presents the initial literature review and an orientation to the proposed study. It discusses the background to the study followed by the research objectives, research questions as well as hypotheses that were tested by the study.

- Chapter 2: This chapter includes reviewing of literature dealing with green energy alternative energy sources. It also included critical analysis of literature in relation to case studies of countries that have successfully managed their transition to green energy.

- Chapter 3: This chapter discusses the energy sector in the African continent, SSA region and outlines a detailed analysis of the energy situation in the SADC region in relation to different green energy potential in the region. Barriers impeding growth of a green energy sector in the SADC region is also discussed.

- Chapter 4: This chapter presents the proposed theoretical model of the perceived access success to green energy. It discussed the theoretical model's selected variables. Both the dependent and independent variables were discussed with specific references to literature, together with their hypothesised relationships.

- Chapter 5: This chapter describes the research design and methodology of the study. The sample, measuring instruments and the method followed for data analysis are clearly explained. The research methodology is complemented by statistical techniques adopted to analyse data.

- Chapter 6: In this chapter the results and analysis of the results in the study are presented. This was done through the usage of tables, figures, diagrams and graphs. The chapter also presented the results of the empirical analysis of the various factors impacting on the perceived access success to green energy access in the SADC region.

- Chapter 7: This chapter presents the conclusions of the research which is a summary of the findings of the study and the conclusion derived from results discussions. Recommendations derived from the findings are made for all stakeholders identified in the beginning of the research as potential beneficiaries of the research.

1.8 ASSUMPTIONS

The following assumptions prevailed during the scope of this study:

- All low carbon emitting and non-emitting sources are considered green energy in the study except nuclear energy.
- The current energy governance and institutional framework will remain constant in the SADC region, SSA and the rest of the African continent for the duration of the study.
- Energy access rates and economic conditions will remain constant for the duration of the study.

2 CHAPTER 2: GLOBAL ENERGY SITUATION AND CLIMATE CHANGE

2.1 INTRODUCTION

The need to improve access to modern energy for millions of people around the world and the climate change problem is prompting nations of the world to invest in low carbon energy solutions that are not harmful to the natural environment. This is in contrast to energy obtained from fossil fuels which is currently the most widely used source of energy in the world. Green energy obtained through the use of low carbon energy solutions is acknowledged as a solution to energy poverty and climate change around the world (UNEP, 2011). Green energy can be defined as an energy source, which has zero or minimum environmental impact, environmentally benign and more sustainable, produced from renewable energy sources (Midilli, Dincer and Ay, 2006; UNEP, 2011; Athanas and McCormick, 2013).

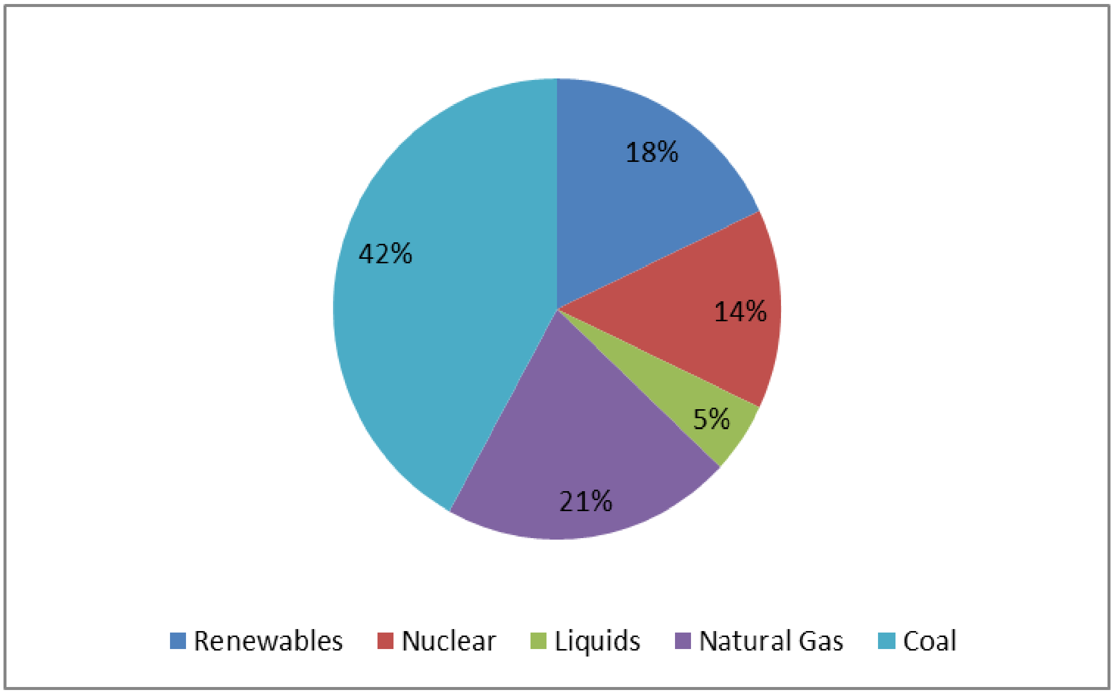
Green energy reduces the negative effects of fossil fuels energy resources and the overall emissions from electricity generation. It also gives an opportunity to meet the clean energy demand for both industrial and non-industrial applications (Midilli, Dincer and Ay, 2006). The debate about nuclear energy being a green energy or not is in dispute. Nuclear energy does not generate greenhouse gases like fossil fuels, but there are concerns which include nuclear radiation and radioactive waste disposal (Kathirvel and Porkumaran, 2011). Green energy sources are generally emission-free and therefore acclaimed as a better option in terms of having less of a negative impact on the environment and human health. Access to modern energy is likely to remain an important ingredient for development in many parts of the world and renewable alternatives are already witnessing a surge in interest and investment (Karakosta, Pappas, Marinakis and Psarras, 2013).

2.2 GLOBAL ENERGY SITUATION

According to SE4ALL (2014: 35) by some measures, progress on access to modern energy services was impressive over the 20 years between 1990 and 2010. The number of people with access to electricity increased by 1.7 billion, while the number of those with access to non-solid fuels for household cooking increased by 1.6 billion. Yet this expansion was offset by global population growth of 1.6 billion over the same period. As a result, the global electrification rate increased only modestly, from 76% to 83%, while the rate of access to non–solid fuels rose from 47% to 59%. In both cases, this represents an increase in access of about one percentage point of global population annually.

In most parts of the world, major electricity generation takes place at a central power station, which utilises coal, oil, water, gas or fossil and nuclear materials as primary fuel sources and large hydro; the rest of the energy sources varies per country (Pioro and Kirillov, 2013a; Kathirvel and Porkumaran, 2011). Currently, the global energy mix is composed of around 80% fossil fuels, including coal, oil, and gas, and 20% carbon-free energies, such as nuclear, hydro, and other renewables (World Energy Council, 2012a). It is estimated that coal accounts for 42% net electrical generation, 21% from natural gas, 18 % is from renewables, 14% from nuclear and 5% contribution from liquid fuel (Karakosta et al., 2013). Figure 2.1 presents global energy production sources.

Figure 2.1: Global energy production sources



Source: Karakosta et al. (2013: 188)

Coal based thermal power plant is the main source of environmental emissions for gases like CO_2, sulphur dioxides and nitrogen oxides which not only degrades the air quality but also is responsible for global warming, acid rain etc. (Porate, Thakre and Bodhe, 2013). Coal fuelled power plants produce up to 1 kg of CO_2 per kW/h of electrical energy which is the major greenhouse gas responsible for global warming (Porate, Thakre and Bodhe, 2013). The finite nature of fossil fuels hinders the development of new methods of generating energy from these conventional fuels and the continued large-scale use of oil and gas in countries not blessed with indigenous reserves is particularly hampered due to the fact that supplies are expensive and rapidly diminishing (Kathirvel and Porkumaran, 2011).

2.2.1 Global universal energy access by 2030 and beyond

According to SE4ALL (2014: 38), “with respect to electricity, the global access deficit amounts to 1.2 billion people and close on percent of those who live without electricity (“the non-electrified population”) live in rural areas, and 87% are geographically concentrated in SSA and South Asia”. The World Energy Council (2012b) observes that future energy mix will depend on indigenous fuel sources, technologies available and the economic drivers and electricity production is responsible for 32% of total global fossil fuel use and 42% of CO2 emissions, overall 40% of global energy production comes from coal and 20% from gas.

By 2035 the World Energy Council (2012b) projects that approximately 60% fossil fuels and 40% carbon–free energies will be used to generate electricity and fossil fuels will continue to play a dominant role for the next two to three decades. Nezhad (2009) identifies global energy driving forces that would shape the energy future as: economic growth rate, energy consumption growth rate, investment requirements, demographic changes, CO2 emissions, technology development and innovation, global energy intensity, oil prices and development of alternative energy sources.

According to SE4ALL (2014: 115) by some measures, to achieve universal access to electricity by 2030, some 50 million more people will have to gain access to electricity each year. About 40% of the additional electricity supply needed for universal access in 2030 would come from grid solutions (of which almost two-thirds would be fossil-fuel based) and the remainder from mini-grid and stand-alone off-grid solutions (of which around 80% would be based on renewables). The United States (US) Energy Information Administration (EIA) international energy outlook (2013) has made energy consumption projections from the year 2010-2040.

Energy consumption projections are divided according to Organisation for Economic Cooperation and Development members (OECD) and non-members (non-OECD). OECD members are divided into three basic country groupings: OECD Americas (United States, Canada, and Mexico/Chile), OECD Europe, and OECD Asia (Japan, South Korea and Australia/New Zealand).

Non-OECD countries are divided into five separate regional subgroups: non-OECD Europe and Eurasia (which includes Russia), non-OECD Asia (which includes China and India), Middle East, Africa and Central and South America (which includes Brazil). The EIA (2013: 5) projects that the world net electricity generation will increase from 20.2 trillion kilowatt-hours in 2010 to 39.0 trillion kilowatt-hours in 2040. In general, the growth of electricity demand in the OECD countries, where electricity markets are well established and consumption patterns are mature, will be slower than in the non-OECD countries, where at present many people do not have access to electricity.

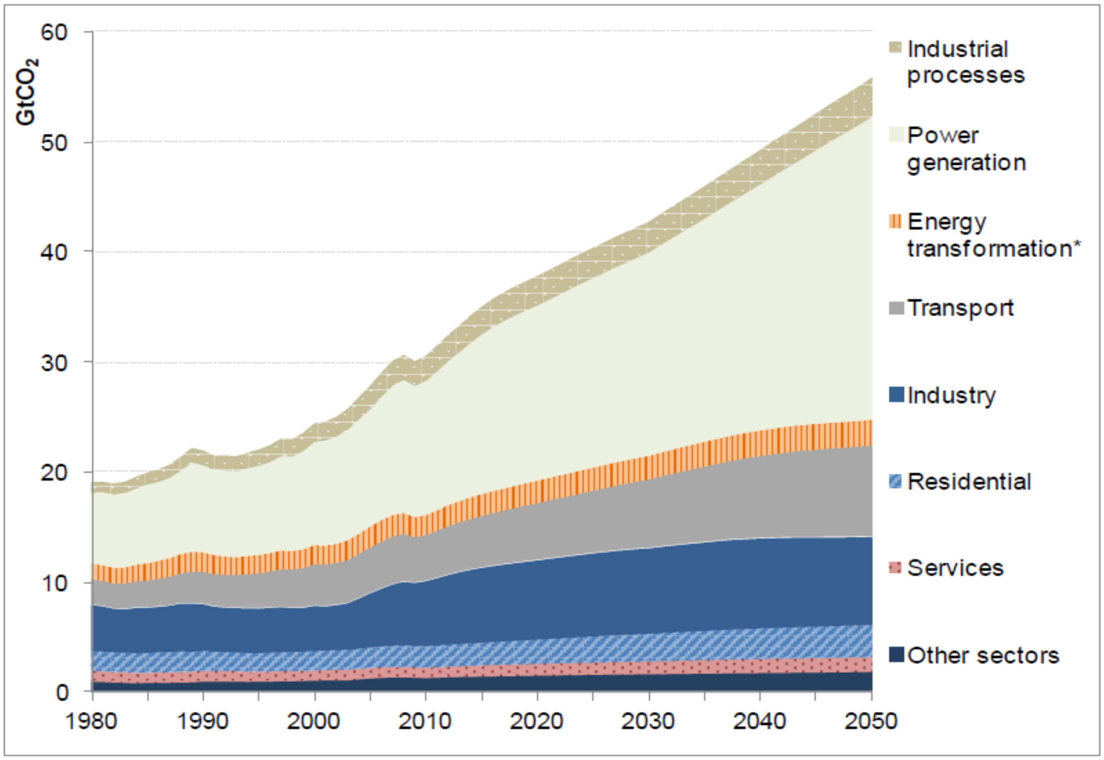
SE4ALL (2014: 115) estimates that universal access to electricity by 2030 will require investment of around $890 billion over the period, of which around $288 billion is projected to be forthcoming under the New Policies Scenario of the IEA meaning that an additional $602 billion would be required to provide universal access to electricity by 2030, an average of $30 billion per year (2011−2030). The annual level of investment would increase over time, reflecting the escalating number of connections being made. More than 60% of the additional investment required would come to SSA; because the region would need the equivalent of an extra $19 billion per year to achieve universal electricity access by 2030.

2.3 GLOBAL WARMING AND CLIMATE CHANGE

The release of both black carbon particles and other forms of air pollution (sulphur and nitrogen oxides, photochemical smog precursors, and heavy metals, for example), have a detrimental effect on public health (UNEP, 2011). Greening the energy sector can substantially address global warming challenges and energy poverty. Generally there is a consensus view that global warming is an unequivocal result of anthropogenic emission of greenhouse gases that remain like a blanket in the atmosphere, thus preventing the reflection of heat back into outer space (Arent, Wise and Gelman, 2011). Consequently, the average earthly temperature has increased by 0.7°C since the pre-industrialisation period and this diminutive rise of temperature has resulted in climate change that has caused devastation to ecosystems and sustainable social and economic development in many parts of the world, particularly developing countries (Arent, Wise and Gelman, 2011; Lau, Lee and Mohamed, 2012).

In many parts of the world, concerns about security of energy supplies and the environmental consequences of greenhouse gas emissions have spurred government policies that support a projected increase in renewable energy sources (EIA, 2013). Global C02 emissions projections between the years 1980–2050 indicate that CO2 will be largely emitted during electrical power generation (Marchal et al., 2011). Figure 2.2 presents global CO2 emissions by source (1980-2050).

Figure 2.2: Global CO2 emissions by source (1980–2050)



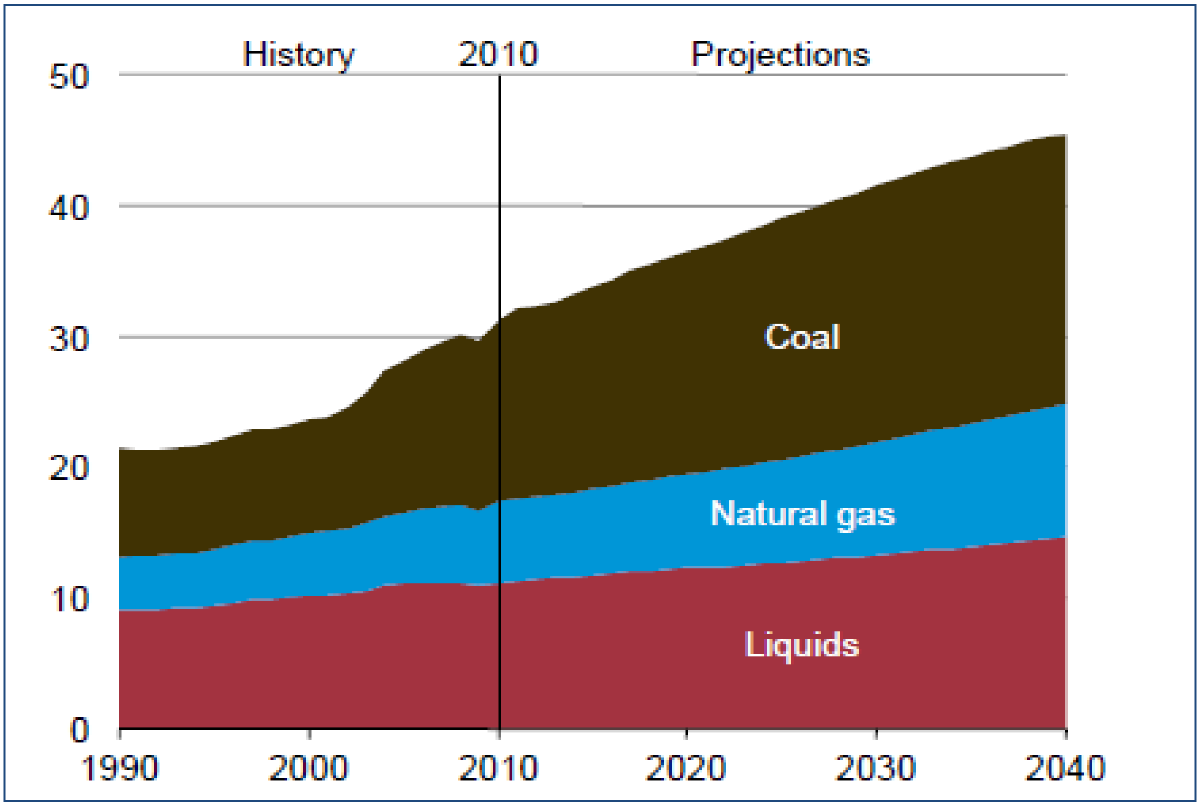
*includes emissions from oil refineries, coal and gas liquefaction.

Source: Marchal et al. (2011: 15)

The EIA (2013) emphasises that coal is the predominant fuel used for electricity generation worldwide and this is likely to be the case for decades to come, it accounts for the most world energy related CO2 emissions. In 2010, coal-fired generation accounted for about 40% of overall worldwide electricity generation. Attempts to tackle global warming requires a shift to low carbon emitting alternative energy sources from traditional fossil fuels, such as lignite, coal and gas, which release large amounts of GHG. Electricity generation from renewable energy sources is a promising option of mitigating climate change (Karakosta et al., 2013).

Indications of trends for 2010 suggest that energy-related CO2 emissions will rebound to reach their highest ever level at 30.6 gigatonnes (GtCO2), a 5% increase from the previous record year of 2008 and in 2009, CO2 emissions originated from fossil fuel combustions were based on coal (43%), followed by oil (37%) and gas (20%). Figure 2.3 presents the world energy related CO2 emissions by fuel type 1990–2040 (billion metric tons).

Figure 2.3: World energy related CO2 emissions by fuel type 1990–2040 (billion metric tons)



Source: EIA (2013: 7)

Global GHG emissions have doubled since the early 1970s driven mainly by economic growth and increasing fossil-energy use in developing countries. Historically, OECD countries emitted the bulk of GHG emissions, but the share of Brazil, Russia, India, Indonesia, China and South Africa in global GHG emissions has increased to 40%, from 30% in the 1970s (Marchal et al., 2011).

2.3.1 The impact of climate change

Marchal et al. (2011) indicate that these GHG gases differ in terms of their warming effect and their longevity in the atmosphere and their contribution to climate change. Apart from the six main GHGs, carbon CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 there are several other atmospheric substances that lead to warming, e.g. chlorofluorocarbons and black carbon or to cooling, e.g. sulphate aerosols (Marchal et al., 2011). Climate change presents a global systemic risk to society. It threatens the basic elements of life for all people according to Marchal et al. (2011: 5) including: access to water, food production, health, use of land, and physical and natural capital.

The unprecedented and exponential rate in GHG, according Lior (2012) is reflected in many environmental catastrophes which include the melting of ice in Greenland and the South Pole, which can result in the increase in sea level and which could possibly submerge coastal areas that are often densely populated (Lior, 2012; Lau, Lee and Mohamed, 2012). To avoid the most serious consequences of global warming above 2°C, industrialised countries are being encouraged by the scientific community to reduce greenhouse gas emissions by 25% to 30% below 1990 levels by 2020 and 80% to 90% below 1990 levels by 2050 (Oldfield, 2011). Studies have been conducted to predict different scenarios resulting from global warming. Marchal et al. (2011: 20) list some of the regional impacts forecasted by the Intergovernmental Panel on Climate Change (IPCC) which include:

- **North America:** Decreasing snowpack in the western mountains; 5%–20% increase in yields of rain-fed agriculture in some regions; increased frequency, intensity and duration of heat waves in cities that already experience them.

- **Latin America**: Gradual replacement of tropical forest by savannah in eastern Amazonia; risk of significant biodiversity loss through species extinction in many tropical areas; significant changes in water availability for human consumption, agriculture and energy generation.

- **Europe:** Increased risk of inland flash floods; more frequent coastal flooding and increased erosion from storms and sea-level rise; glacial retreat in mountainous areas; reduced snow cover and winter tourism; extensive species losses; reductions of crop productivity in southern Europe.

- **Africa:** By 2020, between 75 and 250 million people are projected to be exposed to increased water stress; yields from rain-fed agriculture could be reduced by up to 50% in some regions by 2020; agricultural production, including access to food, may be severely compromised.

- **Asia:** Freshwater availability projected to decrease in Central, South, East and Southeast Asia by the 2050s; coastal areas will be at risk due to increased flooding; the death rate from diseases associated with floods and droughts is expected to rise in some regions. However, overall, all regions are expected to suffer significant net damage from unabated climate change according to most estimates.

2.3.2 Forums to address global warming

Anthropogenic (man-made) GHG emissions and concentrations have increased rapidly over the last fifty years, the fourth assessment report of the IPCC points to human activity as one of the major causes of global warming (Fouquet, 2011; Lior, 2012).

Since the last three decades, lobbying governments around the world about the pending climatic disasters if global warming is not addressed remain active, and developed countries have been lobbying developing countries to be part of the global environmental agenda by scaling up the adoption of strategies that are environmentally benign.

Many forums have been established to mitigate climate change issues. One of the most recognisable global forums aimed at mitigating the impacts of global warming is the United Nations' Framework Convention on Climate Change (UNFCCC), since its formation parties to this forum have always been struggling to find binding agreements that may prevent dangerous impact of climate change (Pegels, 2010; Abanda, 2012). The UNFCCC established the Kyoto Protocol in 1997, deeming it indispensable and necessary to curb the severe damage being caused by global warming (Pegels, 2010; Abanda, 2012).

The Kyoto Protocol defined a global effort in climate change mitigation to reduce GHG emissions from developed countries by 5.2%, with the year 1990 as baseline in the first commitment period of 2008–2012 (Pegels, 2010). According to Lau, Lee and Mohamed (2012: 5281) the Kyoto Protocol proposes three mechanisms to address climate change:

- Clean Development Mechanism (CDM).
- Joint Implementation.
- Emission Trading to assist the developed ratified nations in achieving their assigned Quantified Emission Reduction Limitation or Reduction Commitmen in a more economically feasible way.

The Kyoto Protocol intended to limit emissions of the six gases which are responsible for the bulk of global warming; of these, the three most potent are CO_2, CH_4, and nitrous oxide (N_2O), currently accounting for 98% of the GHG emissions covered by the Kyoto Protocol (Marchal et al., 2011). The other gases, hydro fluorocarbons (HFCs), PFCs and SF6 account for less than 2%, but their total emissions are increasing (Marchal et al., 2011). The deployment of renewable energy has been large during the last decade around the world and the development of national policies incentives, such as the feed-in-tariff, and mechanisms of the Kyoto Protocol, such as the CDM, have aided in this deployment (Pegels, 2010; Karakosta et al., 2013). The ratification of the Kyoto Protocol has made the use of renewable energy more advantageous in the race to cut back on GHG emissions (Karakosta et al., 2013).

Many countries have included investments in renewable energy in their strategy towards reducing dependence on oil and gas imports and the respective price volatilities, as well as mitigating GHG emissions. Renewable energy is seen as a suitable alternative energy source for both developed and less developed countries and relatively low capital demanding and decentralised option, however, a large-scale basis deployment of renewable energy faces important economic and technical feasibility limits, even if effective potential reserves are well documented (Karakosta et al., 2013). The enforcement of the Kyoto Protocol began in 2005 in earnest; Conference of Parties (COP) 11 was also the first Meeting of Parties (MOP 1) of the Kyoto Protocol in order to negotiate issues related to the Kyoto Protocol (Pegels, 2010).

Developing countries particularly countries in the African continent, have too many other pressing issues to deal with such as chronic poverty, corruption/governance, disease, HIV/AIDS, etc. Abanda, Ng'ombe, Keivani, and Tah (2012) indicate that Africa must include embarking on renewable energy investments to address environmental impacts.

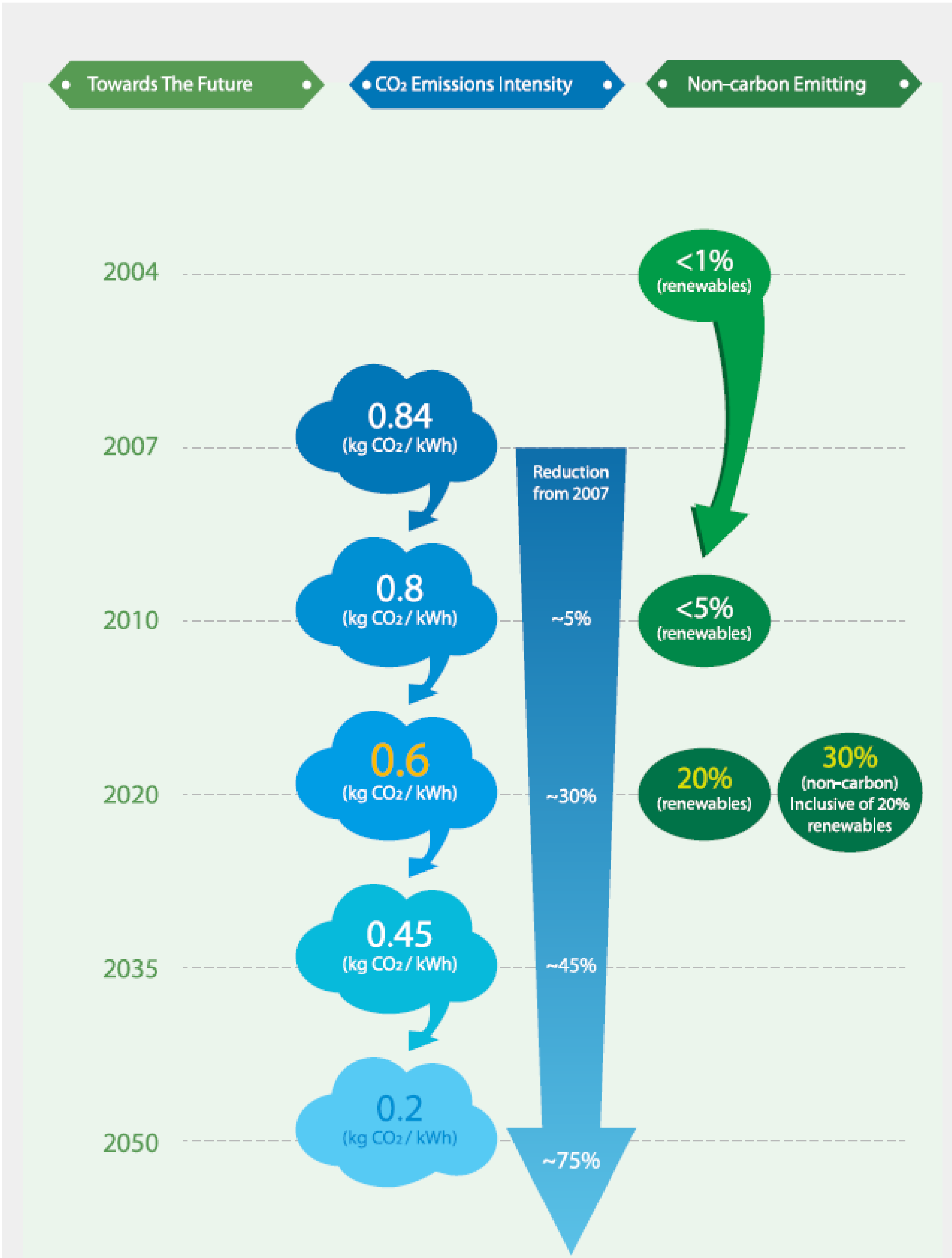
More recently the UNFCCC was held in Copenhagen, Denmark (COP 15), Cancun, Mexico (COP 16) and Durban, South Africa (COP 17), Doha, Qatar

(COP 18), Warsaw, Poland (COP 19) and more recently Lima, Peru (COP 20). The following one will be Cop 21 to held in Paris, France in 2015 (Abanda, 2012; UNFCCC, 2014a). These conferences were held between 7-18 December 2009, 29 November to 10 December 2010, 28 November to 9 December 2011, 26 November to 8 December 2012, 11-23 November 2013 and 1-14 December 2014 respectively. According to Eskom Sustainability Division Report (2014: 1) countries are on high alert as 2014 marks the year in preparation for countries to commit to greenhouse emissions reductions targets in 2015 at the much awaited UNFCCC (COP 21) in Paris. This COP will seek to operationalise the agreements reached at the landmark COP 17 held in Durban in 2011.

The agreement at COP 17 was that at COP 21 developed countries would commit to legally binding targets to reduce their greenhouse gas emissions and developing countries would pledge their commitments to reduce greenhouse gas emissions. This would be the start of a new global legal agreement; basically the next iteration of the Kyoto Protocol. In Asia for example, an ambitious strategy intervention to curb GHG is being implemented by an Asian power utility company called China Light and Power Company (CLP). The CLP group is a Hong Kong electric company that has businesses in a number of Asian markets and Australia. It is one of the two main electric power generation companies in Hong Kong (CLP, 2015).

In 2007, CLP published their Climate Vision 2050, which laid out CO2 emissions intensity reduction targets up to the year 2050. In 2010 the vision was reviewed, new and more ambitious targets for 2050 were set. Figure 2.4 illustrates CLP Group Vision 2050 (CLP, 2015).

Figure 2.4: CLP Group Vision 2050



Source: CLP (2015: 1)

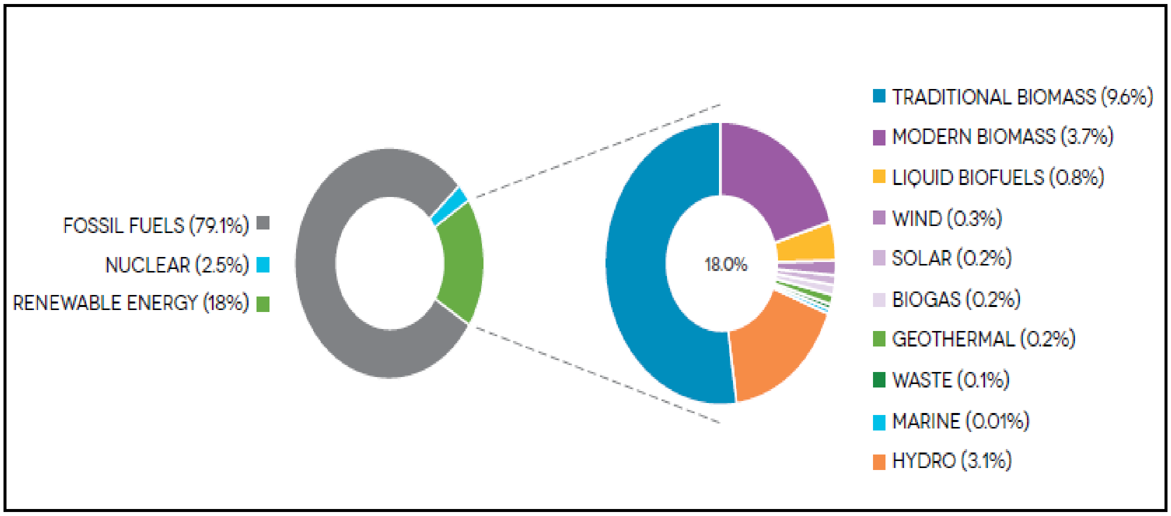
2.4 ALTERNATIVE SOURCES OF ENERGY

The United Nations has called upon world leaders to adopt universal access to modern energy services by 2030 as a critical long-term priority and a catalyst that can be attained by investing in renewables particularly in developing counties (United Nations, 2012). Renewable energy alternatives are an important part of the energy future, and need to be promoted and enabled (Athanas and McCormick, 2013). Renewable energy sources currently account for a small fraction of global energy supply and they have recently experienced significant growth, especially in countries with active renewable energy policies (Wustenhagen and Menichetti, 2012). World Development Indicators is showing that renewable energy consumption increased by more than 55% during the period 1980–2009 (Al-Mulali, Fereidouni, Lee and Sab, 2013). In 2008, new renewables energy investments represented about 229 gigawatts (GW) (excluding large hydro and biomass) of the electricity generating capacity, which is nearly 5% of total global power capacity (about 4 700 GW).

In 2008, global wind capacity was 53% (121 GW) of global renewable capacity (excluding large hydro and biomass); small hydro power was 37% (85 GW), grid-connected solar photovoltaics (PV) was 6% (13 GW), and geothermal was 4% (10 GW); as a percent of installed capacity, renewables increased by about 50% between 2000 and 2008 (Arent, Wise and Gelman, 2011; Pegels, 2010). The EIA (2013: 5) projects that almost 80% of the projected increase in renewable electricity generation will be fuelled by hydro power and wind power. The contribution of wind energy, in particular, has grown rapidly over the past decade, from 18 gigawatts of net installed capacity at the end of 2000 to 183 gigawatts at the end of 2010. Of the 5.4 trillion kilowatt-hours of new renewable generation added over the projection period, 2.8 trillion kilowatt-hours (52%) is attributed to hydro electric power and 1.5 trillion kilowatt-hours (28%) to wind.

Most of the growth in hydro electric generation (82%) occurs in the non-OECD countries, and more than half of the growth in wind generation (52%) occurs in the OECD countries. Renewable energy sources are a better way to generate electricity particularly for remote locations (Kathirvel and Porkumaran, 2011). According to SE4ALL (2014: 52) the share of renewable energy in global total final energy consumption is 18%, fossil fuels consumption is 79.1% and nuclear energy is 2.5%. Figure 2.5 presents share of renewable energy in global Total Final Energy Consumption (TFEC) in 2010.

Figure 2.5: Share of renewable energy in global TFEC in 2010

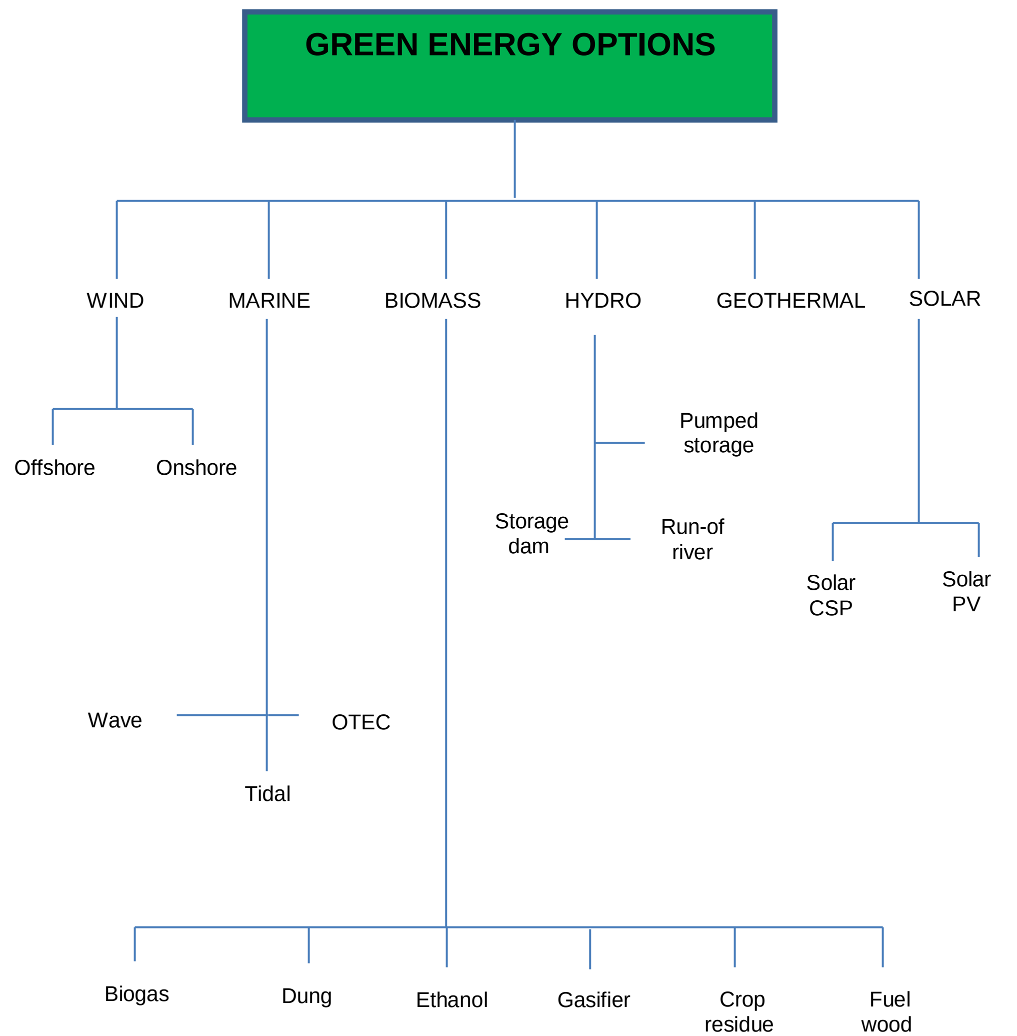


Source: SE4ALL (2014: 52) cited in IEA (2012a)

There are many green energy sources options available for exploitation around the world. Assimilating new technology into the energy mix is not an easy process; the adoption of a new technology starts very slowly because its introduction is usually expensive, unfamiliar and imperfect (Islam, Mekhilef and Saidur, 2013). Compared to fossil fuel alternatives many renewable energy sources are relatively immature technically and are, thus, poised for further cost and performance improvements and technologies such as storage systems and dynamic load after management warrant further research (Arent, Wise and Gelman, 2011).

Intermittence however can be addressed by improving battery storage technology and dispersing green generating facilities over a wide geographic area (EIA, 2013). Figure 2.6 illustrates global green energy options.

Figure 2.6: Global green energy options



Source: Adapted from Kathirvel and Porkumaran (2011: 112)

2.4.1 Solar energy

Solar energy is one of the most widely used sources of renewable energy. There are two main technologies for producing electricity from solar radiation, concentrating solar power (CSP), also known as solar thermal energy, and solar photovoltaic (PV) (Pegels, 2010). One of the main influencing factors for an economically feasible performance of solar energy systems (besides installation costs, operation costs and lifetime of system components) is the availability of solar energy on the ground surface that can be converted into heat or electricity (Angelis-Dimakis., 2011).

According to the World Energy Council (2013a) the sun emits energy at a rate of 3.8x1 023 kW per second, of this total, only a tiny fraction, approximately 1.8x1 014 kW is intercepted by the earth, which is located about 150 million km from the sun, about 60% of this amount reaches the surface of the earth. The rest is reflected back into space and absorbed by the atmosphere, the total annual solar radiation falling on the earth is more than 7 500 times the world's total annual primary energy consumption of 450 EJ (World Energy Council, 2013a).

2.4.1.1 Concentrating Solar Power (CSP)

CSP is a power generation technology that uses mirrors or lenses to concentrate the sun's rays and in most of today's CSP systems, to heat a fluid and produce steam (Pegels, 2010). Ground-based field of mirrors that focus direct solar irradiation on to a receiver mounted high on a central tower where the light is captured and converted into heat. The heat drives a thermo-dynamic cycle, in most cases a water-steam cycle, to generate electric power (IRENA), 2012).

The solar field consists of a large number of computer-controlled mirrors called heliostats that track the sun individually in two axes (Angelis-Dimakis et al., 2011). These mirrors reflect the sunlight onto the central receiver where a fluid is heated up. Solar towers can achieve higher temperatures than parabolic trough and linear Fresnel systems, because more sunlight can be concentrated on a single receiver and the heat losses at that point can be minimised (IRENA, 2012).

Concentrating solar collectors can achieve temperatures in the range of 200 to 1 000°C or even higher, which is ideal for generating electricity via thermodynamic power cycles (World Energy Council, 2013a). Therefore this technology takes advantage of the knowledge base relating to conventional power plants. Another advantage of solar thermal power is that it can easily use fossil fuels such as natural gas as a back-up fuel or store high temperature heat to overcome the disadvantage of the intermittency of sunlight (World Energy Council, 2013a). CSP technology is most suitable in bare areas with a high share of direct irradiation.

The technological advancement of solar thermal systems have led to a broad scope of applications including solar heating and cooling, water treatment through sterilisation and desalination, process heat generation, solar drying and cooking, and thermal power generation (Karakosta et al., 2013). The steam drives a turbine and generates power in the same way as conventional power plants. Other concepts are being explored and not all future CSP plants will necessarily use a steam cycle (IRENA, 2012). Current solar towers use water/steam, air or molten salt to transport the heat to the heat-exchanger/steam turbine system. Depending on the receiver design and the working fluid, the upper working temperatures can range from 250°C to perhaps as high 1 000°C for future plants, although temperatures of around 600°C will be the norm with current molten salt designs (IRENA, 2012).

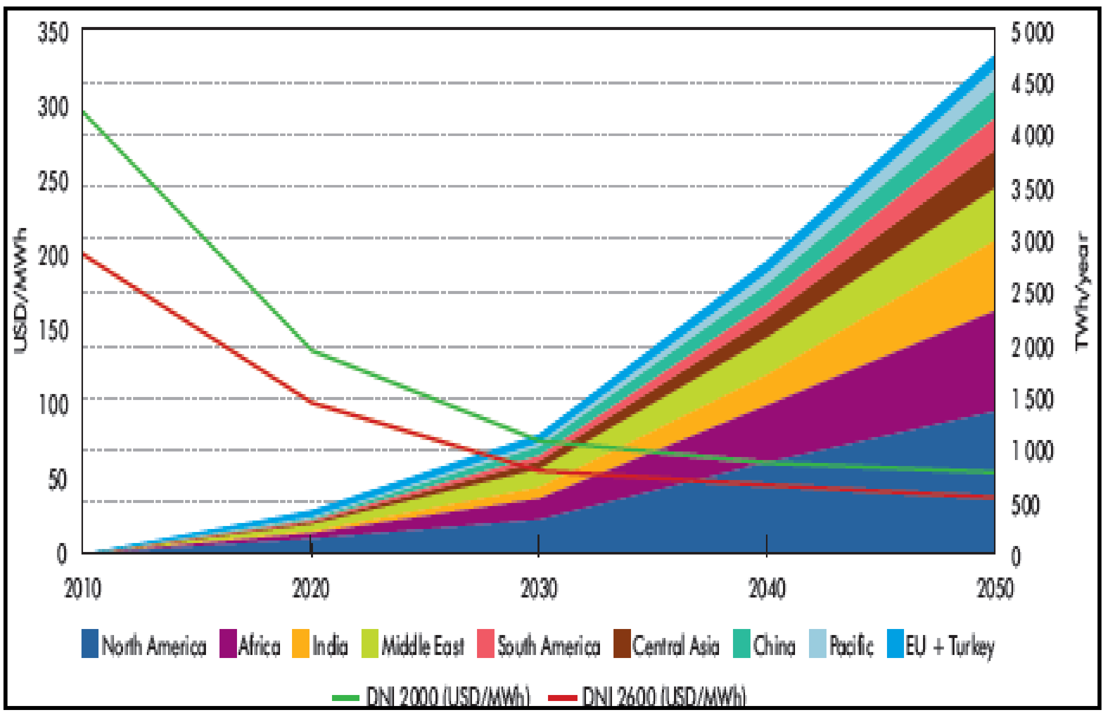
Solar thermal energy systems CSP's can be useful in developing countries to meet energy needs because they are capable of combining heating for water, hospital equipment sterilisation, and cooling applications such as solar power air-conditioning systems will go a long way in reducing the energy consumption, moving away from the weak and unstable grids and discouraging fuel types with high carbon emissions and other greenhouse gases (Nkwetta et al., 2010). Solar thermal energy systems including concentrating solar systems that use reflective materials or concentrators to concentrate the sun's energy and convert it into the heat is becoming increasingly cost effective especially when used for combined heating and cooling systems (Angelis-Dimakis et al., 2011).

Another attribute of CSP plants is that they can be equipped with a heat storage system in order to generate electricity even when the sky is cloudy or after sunset. This significantly increases the CSP capacity factor compared with solar photovoltaics and more importantly, enables the production of dispatchable electricity, which can facilitate both grid integration and economic competitiveness (IRENA, 2012). The CSP technology is expedient in the warmest seasons of the year, particularly in regions like; 255 countries in this region correspond to periods of high insulation, making it possible for solar energy to be most available when comfort cooling is most needed and for other necessities (Nkwetta et al., 2010). CSP plants can be broken down into two groups, based on whether the solar collectors concentrate the sun rays along a focal line or on a single focal point (with much higher concentration factors) (IRENA, 2012):

- Line-focusing systems include parabolic trough and linear Fresnel plants and have single-axis tracking systems.
- Point-focusing systems include solar dish systems and solar power plants and include two-axis tracking systems to concentrate the power of the sun.

According to IRENA (2012) CSP plants are capital intensive, but have virtually zero fuel costs, parabolic trough plant without thermal energy storage has capital costs as low as U$4 600/kW, but low capacity factors of between 0.2 and 0.25. However, cost reduction opportunities are good and as plant designs are perfected and experience gained with operating larger numbers of CSP plants savings opportunities will arise (IRENA, 2012). According to the World Energy Council (2013a), the reported capital costs of solar thermal power plants have been in the range of U$3 000 – 3 500/kW, although less than U$2 500/kW costs are being quoted now; these costs result in a cost of electricity of around U$0.15/kWh. Figure 2.7 presents CSP Roadmap: decreasing cost and increasing cost.

Figure 2.7: CSP Roadmap: Decreasing cost and increasing cost



Source: IEA (2010: 1)

CSP road map key findings as stipulated by the IEA (2010: 1) are:

- By 2050, with appropriate support, CSP could provide 11.3% of global electricity, with 9.6% from solar power and 1.7% from backup fuels (fossil fuels or biomass).

- In the sunniest countries, CSP can be expected to become a competitive source of bulk power in peak and intermediate loads by 2020 and of base-load power by 2025 to 2030.

- The possibility of integrated thermal storage is an important feature of CSP plants, and virtually all of them have fuel-power backup capacity. Thus, CSP offers firm, flexible electrical production capacity to utilities and grid operators while also enabling effective management of a greater share of variable energy from other renewable sources (e.g. photovoltaic and wind power).

- This roadmap envisions North America as the largest producing and consuming region for CSP electricity, followed by Africa, India and the Middle East. Northern Africa has the potential to be a large exporter (mainly to Europe) as its high solar resource largely compensates for the additional cost of long transmission lines.

- CSP can also produce significant amounts of high-temperature heat for industrial processes, and in particular can help meet growing demand for water desalination in arid countries. Given the arid/semi-arid nature of environments that are well-suited for CSP, a key challenge is accessing the cooling water needed for CSP plants. Dry or hybrid dry/wet cooling can be used in areas with limited water resources.

- The main limitation to expansion of CSP plants is not the availability of areas suitable for power production, but the distance between these areas and many large consumption centres. This roadmap examines technologies that address this challenge through efficient, long-distance electricity transportation.

- CSP facilities could begin providing competitive solar-only or solar-enhanced gaseous or liquid fuels by 2030. By 2050, CSP could produce enough solar hydrogen to displace 3% of global natural gas consumption, and nearly 3% of the global consumption of liquid fuels.

2.4.1.2 Solar photovoltaic (PV) power

Solar photovoltaic systems use the photoelectric effect of semi-conductor materials to convert sunlight directly into electricity and the major component of PV systems is the solar module, normally a number of cells connected in series (Arent, Wise and Gelman, 2011). Critical components include indium and tellurium for thin film technologies, and silver for crystalline silicon are very likely to be shows toppers for the deployment PV in the medium term, with the first effects probably to be felt from 2015 if no pro-active mitigation steps are taken (IEA, 2012c).

The biggest advantage of solar PV systems is that they can provide from a few watts to hundreds of megawatts (MW) and development of flexible thin film PV panels makes them ideal for integration in building design (World Energy Council, 2013a). Solar PV power systems can produce negligible emissions during their operation and maintenance, but there are still emissions associated with other lifecycle phases of a solar PV power system (Arent, Wise and Gelman, 2011).

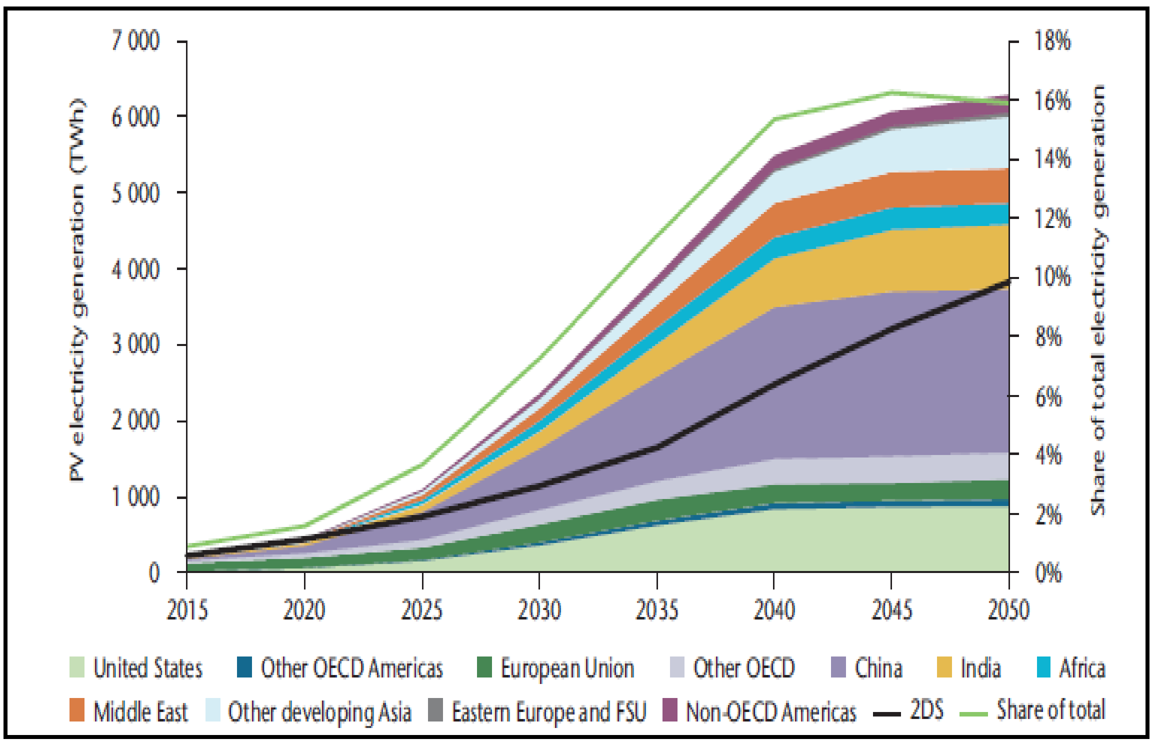
The electricity generation of solar PV depends on the solar insolation level the PV system is exposed to, which is closely linked to the geographical location where the PV system is deployed (Zhai, Cao, Zhao and Yuan, 2011). One of their distinct advantages is that solar photovoltaic devices are that they can be constructed as stand-alone systems to give outputs from microwatts to MW. That is why they have been used as the power sources for calculators, watches, water pumping, remote buildings, communications, satellites and space vehicles, and even multi-MW scale power plants (World Energy Council, 2013a). Four countries have the most solar photovoltaics installed in the world and they include: Germany, Spain, Japan, and the United States.

Germany again has the highest growth in PV capacity, with nearly 4 000 MW in 2007; and Spain is a far second place with about 550 MW in 2007 (Arent, Wise and Gelman, 2011; Pegels, 2010). These solar PV modules have different technical power generation parameters, and accordingly selection of PV modules will have a direct influence on the GHG mitigation potential results, (Zhai et al., 2011).

They have undergone unprecedented market growth during recent years (Arent, Wise and Gelman, 2011). The PV modules have a service life of at least 30 years and can be used in generating power ranging from milli watts to MW, the potential of PV applications in SSA countries is high due to high sunshine compared to other parts of the world, even though it is not economically competitive with conventional energy sources (Nkwetta et al., 2010). The price of PV has dropped continuously since the 1970s and continued price reductions encourage worldwide application of small solar domestic systems; electricity from PV modules can be cost effective and viable in many remote areas where majority of the population in developing countries lives due to the high cost of grid connections based on distances, system losses, and maintenance (Nkwetta et al., 2010).

The need for sustainable energy solutions in SSA makes PV very promising, particularly embedded energy generation within the structure of the building envelope in the form of building integrated, heat generation, or solar shading (Pegels, 2010; Nkwetta et al., 2010). According to IEA (2014a: 21) solar photovoltaic technology road map shows that China is expected to overtake Europe as the largest producer of PV electricity soon after 2020, with its share regularly increasing from 18% of global generation by 2015 to 40% by 2030 then slowly declining to 35% by 2050. From 2030 to 2050, the share of India and other Asian countries is expected to rise from 13% to 25%. By contrast, the United States' share is expected to remain at about 15% from 2020 on, and Europe's share to decrease constantly from 44% in 2015 to 4% in 2045. Figure 2.8 presents regional production of PV electricity envisioned in the roadmap.

Figure 2.8: Regional production of PV electricity envisioned in the roadmap



Source: IEA (2014a: 21)

Road map key findings as stipulated by the solar photovoltaic technology Road map IEA (2014a: 21) are:

- Since 2010, the world has added more solar photovoltaic (PV) capacity than in the previous four decades. New systems were installed in 2013 at a rate of 100 MW of capacity per day. Total global capacity overtook 150 gigawatts (GW) in early 2014.

- The geographical pattern of deployment is rapidly changing. While a few European countries, led by Germany and Italy, initiated large-scale PV development, PV systems are now expanding in other parts of the world, often under sunnier skies. Since 2013, the People's Republic of China has led the global PV market, followed by Japan and the United States.

- PV system prices have been divided by three in six years in most markets, while module prices have been divided by five. The cost of electricity from new built systems varies from U$90 to U$300/MWh depending on the solar resource; the type, size and cost of systems, maturity of markets and costs of capital.

- This roadmap envisions PV's share of global electricity reaching 16% by 2050, a significant increase from the 11% goal in the 2010 roadmap. PV generation would contribute 17% to all clean electricity, and 20% of all renewable electricity. China is expected to continue leading the global market, accounting for about 37% of global capacity by 2050.

- Achieving this roadmap's vision of 4 600 GW of installed PV capacity by 2050 would avoid the emission of up to 4 gigatonnes (Gt) of CO2 annually.

- This roadmap assumes that the costs of electricity from PV in different parts of the world will converge as markets develop, with an average cost reduction of 25% by 2020, 45% by 2030, and 65% by 2050, leading to a range of U$40 to 160/MWh, assuming a cost of capital of 8%.

- To achieve the vision in this roadmap, the total PV capacity installed each year needs to rise rapidly, from 36 GW in 2013 to 124 GW per year on average, with a peak of 200 GW per year between 2025 and 2040.

- Utility-scale systems and rooftop systems will each have roughly half of the global market. Rooftop systems are currently more expensive but the value of electricity delivered on consumption sites or nearby is greater.

- The variability of the solar resource, as of wind energy, is a challenge. All flexibility options – including interconnections, demand-side response, flexible generation, and storage need to be developed to meet this challenge so that the share of global electricity envisioned for PV in this roadmap can be reached by 2050.

- PV has to be deployed as part of a balanced portfolio of all renewables. In temperate countries, wind power tends to be stronger during winter and hence compensate for low solar irradiance. In hot and wet countries, hydro power offers considerable resource in complement to solar PV. In hot and arid countries, solar thermal electricity with built-in thermal storage capabilities can generate electricity after sunset, complementing the variability of PV and thus adding more solar electricity to systems potentially making solar the leading source of electricity by 2040.

- Despite recent falls in the cost of PV electricity, transitional policy support mechanisms will be needed in most markets to enable PV electricity costs to reach competitive levels, as long as electricity prices do not reflect climate change or other environmental factors. The vision in this roadmap is consistent with global CO2 prices of U$46/tCO2 in 2020, U$115/tCO2 in 2030, and U$152/tCO2 in 2040.

- In the last few years, manufacturing of PV systems has been concentrated in Asia, particularly in China and Chinese Taipei, mainly based on economies of scale in large new production facilities.

- Future progress is likely to be driven mainly by technology innovation, which keeps open the possibility of global deployment of manufacturing capabilities if research and development (R&D) efforts and international collaboration are strengthened.

- Appropriate regulatory frameworks – and well-designed electricity markets, in particular – will be critical to achieve the vision in this roadmap. PV costs are incurred almost exclusively up-front, when the power plant is built. Once built, PV generates electricity almost for free. This means that investors need to be able to rely on future revenue streams so that they can recover their initial capital investments.

- Market structures and regulatory frameworks that fail to provide robust long-term price signals – beyond a few months or years – are thus unlikely to deliver investments in volumes consistent with this roadmap in particular and timely decarbonisation of the global energy system in general.

2.4.2 Wind energy

Wind energy today represents the fastest growing technology in the energy production space, globally today and within the low carbon energy generation technologies, wind has emerged as the top technology of choice, and investors are becoming increasingly comfortable backing wind investments (World Energy Council, 2013a). Wind power is the largest addition to the renewable energy capacity and statistical data shows that the wind power installations have increased significantly in recent years; most world wind turbines are sited onshore but offshore wind projects have been completed, or are planned, in China, Denmark, Ireland, Sweden, Germany, the Netherlands, the UK and the USA, by mid-2009, over 1 500 MW was operational (Milborrow, 2011; Karakosta et al., 2013). Offshore wind is attractive in locations where pressure on land is acute and the mean annual wind speeds may be 0.5 –1 m/s higher than onshore, depending on the location (Milborrow, 2011).

World wind energy technology is widely used in developed countries and also has attractions in the developing world as it can be installed quickly in areas where electricity is urgently needed and in many instances it may be a cost-effective solution if fossil fuel sources are not readily available (World Energy Council, 2013a). Among renewable energy sources, wind power is the most rapidly growing technology around the world; in 2008, worldwide capacity reached 121 Gigawatt (GW) with an annual growth rate of some 29% (Boomsma, Meade and Fleten, 2012). Following this growth rate, global wind power attracted investment estimated at $50 billion in 2008; where in addition to public investment incentives, typical sources of investment financing included bank loans, venture capital, and private equity funds (Milborrow, 2011; Boomsma, Meade and Fleten, 2012).

The advantage of wind energy is that the variable costs are generally small, and comprise the costs of operation and maintenance. For wind power projects, these represent the remaining 25% of total costs and include the costs of repairs, spare parts, administration, and insurance (Boomsma, Meade and Fleten, 2012). The offshore installed capacity topped 1.1 GW in 2007, located in just six countries, including Denmark (420 MW), United Kingdom (300 MW), Netherlands (130 MW), Ireland (25 MW) and Sweden (135 MW).

Significant offshore resources to be exploited in the near future have been identified in Finland, Ireland, Italy, the Netherlands, Norway and Spain (Milborrow, 2011; Zhai et al., 2011). Countries intending significant offshore wind deployment should look to the on-going experience of countries in the vanguard, in order to avoid future bottlenecks (IEA, 2012a). Prospects for 2015 look bright, with a total of more than 37 GW planned (Karakosta et al., 2013).

The world had a 29% increase in wind power access in 2008, and reaching a total of 121 GW, while the installed wind power capacity in 2004 was only 48 GW (Zhai et al., 2011). The rapid increase of wind power capacity in 2008 came mainly from the increased number of installations in such countries as the United States (8.4 GW added), China (6.3 GW), India (1.8 GW) and Germany (1.7 GW) (Milborrow, 2011; Zhai et al., 2011). Challenges pertaining to the deployment of wind energy are shortage of skilled personnel in manufacturing, installation, and also operation and maintenance.

This is felt most strongly in 'difficult' locations (e.g. offshore and remote areas) where the sector has grown quickly from a low base (IEA, 2012b). Rapid training and skills transfer within the industry are urgently needed. Skills planning by industry and supportive education policy are longer term requirements (IEA, 2012b).

The second bottleneck is port infrastructure to support offshore wind installation which is lacking in several countries (e.g. UK, Eastern US) this requires a ‘predict and provide’ approach by policymakers and industry working closely, to ensure that this does not become a greater bottleneck (IEA, 2012b). Thirdly, overland transportation of increasingly large turbine components is challenging in countries where installation takes place far from ports or manufacturing sites, such as the US (IEA, 2012b). While European countries have traditionally dominated the wind energy market, increasingly the Asia-Pacific region (especially China) is rapidly emerging as a significant market for new investment in wind energy (Zhang et al., 2013).

China is now the fastest-growing wind power market in the world. China added 3 304 MW of wind capacity during 2007, representing a growth of 145% over 2006 (Zhang et al., 2013). Recently the expansion of onshore wind has been quite dramatic, doubling its capacity year on year and reaching a total of 12.2 GW of installed capacity in 2008, with a large landmass and a long coastline, China has abundant wind energy resources (Zhang et al., 2013). Though the global financial crisis has had some impact on investment in renewable energy, investment in wind energy has nonetheless continued to grow in 2008; wind energy continued to attract the highest level of new investment (US$51.8 billion) of all renewable energy generation technology (Zhang et al., 2013).

According Milborrow (2011) wind energy is developing very rapidly and over 30 GW of capacity was installed worldwide in 2009 installed onshore, offshore wind is slowly taking off and there are plans for around 40 GW in Great Britain alone. Some countries that have invested significantly in wind energy as per MW space installed as of 2009 are: USA (35 159 MW), Germany (26 010 MW), China (10 925 MW) and Spain (19 149 MW). Success in wind energy exploitation is due to the favourable policy on renewable energy in these countries, as it is the case of Spain (Manzano-Agugliaro, Alcayde, Montoya, Zapata-Sierra and Gil, 2013).

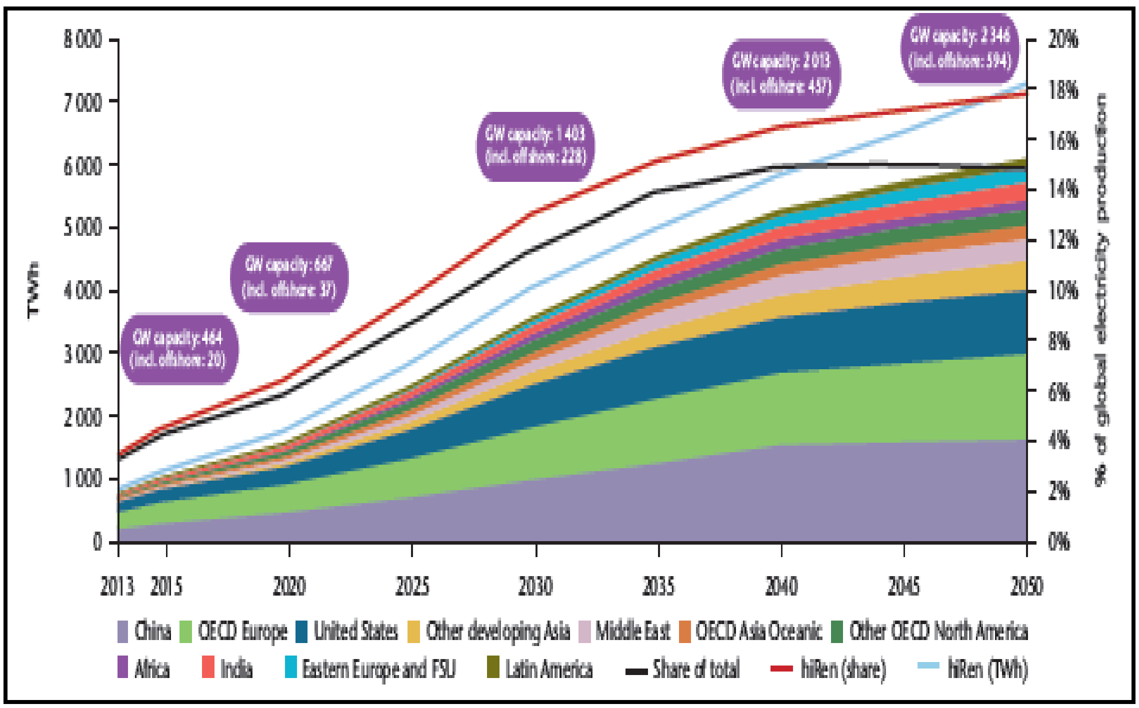
By the end of 2009 in Europe there was more than 1.471 GW of offshore installed capacity, including in Denmark (639 MW), the United Kingdom (882 MW), the Netherlands (246 MW), Ireland (25 MW), Sweden (163 MW), Belgium (30 MW), Finland (24 MW), Norway (2 MW) and Germany (42 MW), with several new large offshore projects planned in these and several other European countries in the near future offshore wind energy installations are also beginning to appear in the Asia-Pacific region albeit not yet on the scale found in Europe (Zhang et al., 2013).

One of the drawbacks of wind energy resource is that wind power output is erratic and dependent on the wind energy density at the geographical location where the wind turbine is installed, and at a specific location, environmental parameters such as wind speed and air density (related to temperature, atmospheric pressure and altitude) jointly determine the wind energy density and wind speeds also vary with the height above the surface of the earth (Zhai et al., 2011). On the commercial market, there is quite a large number of wind turbines developed with different power capacity levels for use under different wind energy density conditions; typical power capacity of a wind turbine for industrial scale application ranges from 1.0 MW to 4.0 MW (Zhai et al., 2011).

Milborrow (2011) states that other environmental issues associated with wind turbines are the effects of noise and disturbance to TV signals and wildlife especially birds; other challenges include the lack of wind turbines suited to very cold conditions which precludes access to the large wind resource at high latitudes (e.g. Scandinavia, Labrador). Turbine designs are being explored to overcome the challenges, though further research, development and testing is needed (IEA, 2012a).

The location of wind farms into the sea can reduce visual impact if the windmills are sited more than 12 miles (19 km) offshore and potentially allow siting near heavily developed coastal cities though; the farms are situated away from large cities due to strong local opposition (Milborrow, 2011; Zhai et al., 2011). Energy storage can be used to reduce or eliminate the reliance on fossil-fuelled generators to back-up renewable electricity generators. Storage accomplishes this task by temporal decoupling of generation from demand, and in most cases by having a very high ramp-rate capability (Pearre and Swan, 2013). Figure 2.9 presents regional electricity production from wind power in TWh and share of global electricity.

Figure 2.9: Regional electricity production from wind power in TWh and share of global electricity



Source: IEA (2013:1)

Road map key capital findings as stipulated by the wind energy technology road map IEA (2013: 21) are:

- Since 2008, wind power deployment has more than doubled, approaching 300 GW cumulative installed capacities led by China (75 GW), the United States (60 GW) and Germany (31 GW). Wind power now provides 2.5% of global electricity demand-and up to 30% in Denmark, 20% in Portugal and 18% in Spain. Policy support has been instrumental in stimulating this tremendous growth.

- Progress in the past five years boosted energy yields (especially in low-wind-resource sites) and reduced operation and maintenance (O&M) costs. Land-based wind power generation costs range from U$ 60/MWh to U$ 130/MWh at most sites. It can already be competitive where wind resources are strong and financing conditions are favourable, but still requires support in most countries. Offshore wind technology costs levelled off after a decade-long increase, but are still higher than land-based.

- This roadmap targets 15% to 18% share of global electricity from wind power by 2050, a notable increase from the 12% aimed for in 2009. The new target of 2 300 gigawatts (GW) to 2 800 GW of installed wind capacity will avoid the emission of up to 4.8 gigatonnes (Gt) of CO2 annually.

- Achieving these targets requires rapid scaling up of the current annual installed wind power capacity (including repowering), from 45 GW in 2012 to 65 GW by 2020, to 90 GW by 2030 and to 104 GW by 2050. The annual investment needed would be U$ 146 billion to U$ 170 billion.

- The geographical pattern of deployment is rapidly changing. While countries belonging to the Organisation for Economic Cooperation and Development (OECD) led early wind development, from 2010 non-OECD countries installed more wind turbines. After 2030, non-OECD countries will have more than 50% of global installed capacity. While there are no fundamental barriers to achieving or exceeding these goals, several obstacles could delay progress including costs, grid integration issues and permitting difficulties.

- This roadmap assumes the cost of energy from wind will decrease by as much as 25% for land-based and 45% for offshore by 2050 on the back of strong R&D to improve design, materials, manufacturing technology and reliability, to optimise performance and to reduce uncertainties for plant output.

- To date, wind power has received only 2% of public energy R&D funding: greater investment is needed to achieve wind's full potential. As long as markets do not reflect climate change and other environmental externalities, accompanying the cost of wind energy to competitive levels will need transitional policy support mechanisms.

- To achieve high penetrations of variable wind power without diminishing system reliability, improvements are needed in grid infrastructure and in the flexibility of power systems as well as in the design of electricity markets.

- To engage public support for wind, improved techniques are required to assess, minimise and mitigate social and environmental impacts and risks. Also, more vigorous communication is needed on the value of wind energy and the role of transmission in meeting climate targets and in protecting water, air and soil quality.

2.4.3 Hydro power

According to the World Energy Council (2013a) hydro power provides a significant amount of energy throughout the world. There has been deployment in more than 100 countries, contributing approximately 15% of the global electricity production. The concept of generating electricity from water has been around for a long time and there are currently many large hydro electric facilities around the world (Islam, Gupta, Masum, Raju and Karim, 2013). Hydro electric power is currently the largest renewable energy resource in the world and it contributes to electricity generation in about 160 countries, but five of them (Brazil, Canada, China, Russia and the USA) account for more than half of the global hydro power production (Manzano-Agugliaro et al., 2013).

Hydro power is usually classified by size (generating capacity) and the type of scheme (run-of-river, reservoir, pumped storage) (Islam et al., 2013). According to the World Energy Council (2013a), the top 5 largest markets for hydro power in terms of capacity are China, Brazil, the United States, Russia, and Canada, with China far exceeding the others at 249 GW, added to these, India, Norway, Japan, France and Turkey complete the top 10 countries in terms of capacity. In addition, in several countries, hydro power accounts for over 50% of all electricity generation including: Iceland, Brazil, Canada, Nepal and Mozambique (World Energy Council, 2013a).

According to the (World Energy Council, 2013a: 3) there are four broad hydro power typologies:

- Run-of-river hydro power provides regular base-load supply, with some flexibility of operation for daily fluctuations in demand through water flow that is regulated by the facility.

- Storage hydro power provides base and peak-load supply, with enough storage capacity to operate independently of the hydrological inflow for periods of weeks/months, and the ability for generation to be shut down and started up at short notice.

- Pumped-storage hydro power provides peak-load supply, utilising water which is cycled between lower and upper reservoirs by pumps which utilise surplus energy from the system at times of low demand, normally on a daily/weekly basis.

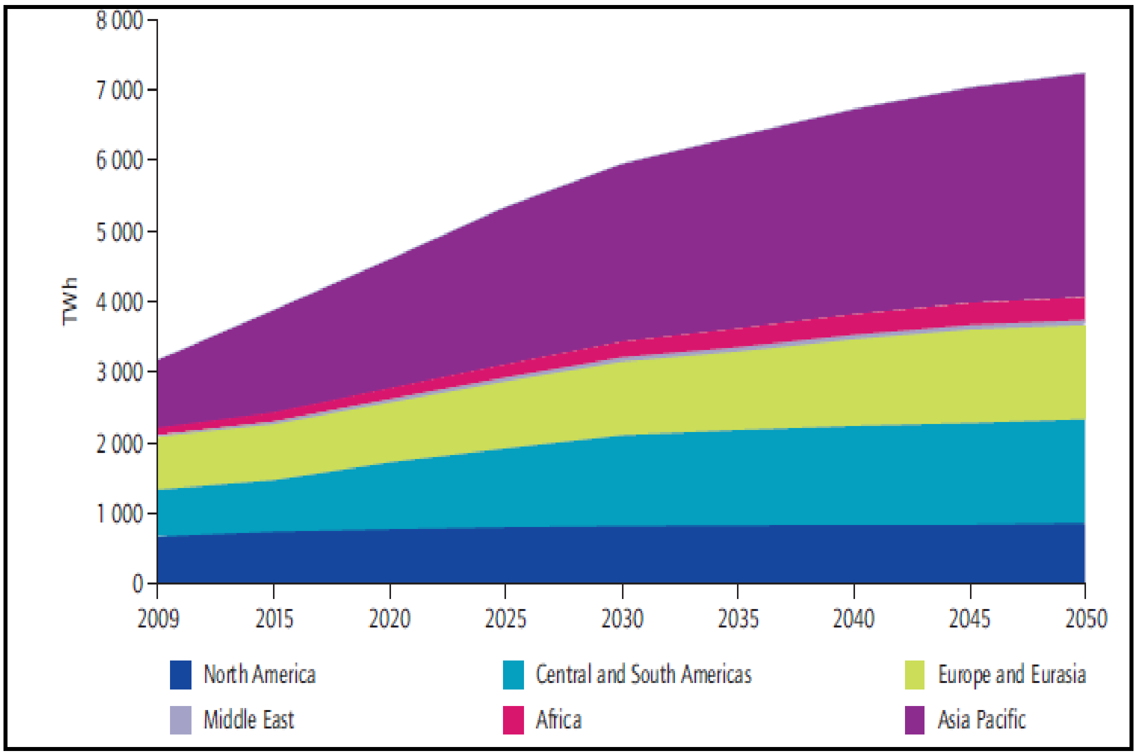
- Offshore hydro power – a suite of technologies using basic hydro power technology in a marine environment. This includes wave and tidal technologies.

Very small power plants below 5 KW are in operation in very few countries and they have huge potential all over the world (Katre and Patil, 2013). The potential of using both high and low volume flowing waters can also be used for producing hydro electric energy, for low volume flowing water; a mini or micro hydro electric power plants can be built on their routes (Sartipipour, 2011). Mini hydro electric power plants usually have an energy generation capacity of less than 25 MW; mini hydro facilities are only built on the route of the river stream often without having any water storage; however, sometimes they involve a water storage section with low capacity (Sartipipour, 2011; Katre and Patil, 2013).

The potential of hydro power is not yet exploited to its fullest capacity and waterfalls at many places can be utilised for generating small amount of electricity (Katre and Patil, 2013). However, large dams and reservoirs are not always appropriate, especially in the more ecologically sensitive areas of the planet (Nangare and Mahajan, 2013).

For making small amounts of electricity without building a dam, the small-scale hydro electric generator is often the best solution, especially where fast-flowing water is available (Nangare and Mahajan, 2013). Mini and micro power plants are more suitable for villages situated alongside the route of water flow (Sartipipour, 2011; Manzano-Agugliaro et al., 2013). Use of such hydro electric power plants in rural areas can be effective for irrigating gardens and farms and helping rural development, job creation and regional welfare. Figure 2.10 presents hydro electricity generation till 2050 in the hydro power roadmap vision (TWh).

Figure 2.10: Hydro electricity generation till 2050 in the hydro power roadmap vision (TWh)



Source: IEA (2012b:19)

Road map key findings as stipulated by the hydro electricity generation road map IEA (2012b: 21) are:

- Hydro electricity presents several advantages over most other sources of electrical power, including a high level of reliability, proven technology, high efficiency, very low operating and maintenance costs, flexibility and large storage capacity.

- Hydro power is the major renewable electricity generation technology worldwide and will remain so for a long time. Since 2005, new capacity additions in hydro power have generated more electricity than all other renewables combined. The potential for additional hydro power remains considerable, especially in Africa, Asia and Latin America.

- This roadmap foresees, by 2050, a doubling of global capacity up to almost 2 000 GW and of global electricity generation over 7 000 TWh. Pumped storage hydro power capacities would be multiplied by a factor of 3 to 5.

- Most of the growth in hydro electricity generation will come from large projects in emerging economies and developing countries. In these countries, large and small hydro power projects can improve access to modern energy services and alleviate poverty, and foster social and economic development, especially for local communities. In industrialised countries, upgrading or redevelopment of existing plants can deliver additional benefits.

- Hydro power reservoirs can also regulate water flows for freshwater supply, flood control, irrigation, navigation services and recreation. Regulation of water flow may be important to climate change adaptation.

- Both reservoir and pumped storage hydro power are flexible sources of electricity that can help system operators handle the variability of other renewable energy such as wind power and photovoltaic electricity.

- In order to achieve its considerable potential for increasing energy security while reducing reliance on electricity from fossil fuels, hydro power must overcome barriers relative to policy, environment, public acceptance, market design and financial challenges.

- Large or small, associated with a reservoir or run-of-river, hydro power projects must be designed and operated to mitigate or compensate impacts on the environment and local populations. The hydro power industry has developed a variety of tools, guidelines and protocols to help developers and operators address the environmental and social issues in a satisfactory manner.

- New turbines and design make modern hydro power plants more sustainable and environmentally friendly; better management helps avoid damage to downstream ecosystems.

- Hydro power projects require very substantial up-front investment, which can range up to tens of billion U$. Although hydro power is the least-cost renewable electricity technology and is usually competitive with all alternatives, financing remains a key issue. This roadmap calls for innovative financing schemes and market design reforms to ensure adequate long-term revenue flows and alleviate risks for investors.

2.4.4 Biomass energy

Biomass represents an abundant carbon-neutral renewable resource for the production of bio-energy and biomaterials, and at present, forestry, agricultural and municipal residues, and wastes are the main feed stocks for the generation of electricity and heat from biomass (Sartipipour, 2011). Biomass resources have largely been used as a traditional fuel resource for cooking and heating and of the total bio-energy produced today. Wood biomass accounts for 87%, agricultural crops for 9% and municipal and industrial waste for 4% (Manzano-Agugliaro et al., 2013; Angelis-Dimakis, et al., 2011). There is significant potential to expand biomass use by tapping the large volumes of unused residues and wastes, the use of conventional crops for energy use can also be expanded, with careful consideration of land availability and food demand, forestry and agricultural residues and other organic wastes (including municipal solid waste) (World Energy Council, 2013a).

Biomass resources are currently being promoted as a strategy to achieve sustainable development because it is mainly available locally, allows the widespread production of energy at reasonable costs and can help to mitigate climate change, develop rural economies and increase energy security (Angelis-Dimakis et al., 2011). There exists various definition of biomass. Angelis-Dimakis et al. (2011) define it as the biodegradable fraction of products, wastes and residues from agriculture, forestry and related industries, as well as the biodegradable fraction of industrial and municipal wastes. Furthermore Angelis-Dimakis et al. (2011: 1191) observe that biomass can be grown on purpose in dedicated energy crops and residual biomasses derive from:

- The agricultural sector, both in the form of crop residues and of animal waste.
- The forestry sector, from forests’ thinning and maintenance.

- The industrial sector of wood manufacture and food industries.
- The waste sector, in the form of residues of parks maintenance and of municipal biodegradable wastes.

Angelis-Dimakis et al. (2011) and Kimemia and Annegarn (2011) indicate that biomass can be supplied by dedicated agricultural crops of arboreous and herbaceous species: short rotation forestry (SRF, e.g. poplars, willows, eucalyptus), annual crops (e.g. corn, soy, sugar cane, sorghum) and perennial grasses (e.g. switch grass, miscanthus) and industrial residues biomass includes wood from sawmills and timber mills and by products' of the food industry. Municipal solid waste, liquid by-products from the pulp and paper production industry and food processing wastes can all be used for energy conversion (Kimemia and Annegarn, 2011). Solid industrial residues consist mainly of clean wood fractions from the secondary wood processing industry. Since the time humans lit the very first fire, biomass resources have continued to provide energy for millions of people and woody biomass is probably the most widely used biofuel today (Kimemia and Annegarn, 2011).

World Energy Council (2013a) observes that globally, the use of biomass in heat and industrial energy applications is expected to double by 2050 under business-as usual scenarios, while electricity production from biomass is projected to increase, from its current share of 1.3% in total power production to 2.4-3.3% by 2030 (corresponding to a 5-6% average annual growth rate). Biomass (Wood) gasification is another viable technology based on latest combustion technologies, Combined Heat and Power (CHP) plants can use biomass for power generation, along with heat (Karakosta et al., 2013). The technology chain, which includes forestry, harvest, transport, plant construction and operation, produces low chemical and the public acceptance for this technology is considered moderate (Jumbe and Mkondiwa, 2013; Karakosta et al., 2013).

Biofuels also known as agro-fuels that are developed from crops residue developed under commercial agriculture farming methods mainly include Biofuel (bio diesel), Ethanol, Biogas have divided development practitioners and policy makers regarding the benefits and detriments of its development in developing countries (Jumbe and Mkondiwa, 2013; Angelis-Dimakis et al., 2011). The dilemmas that policy makers especially in developing countries face when considering the development of the biofuels sector is whether biofuels production and use implies a choice between food and fuel; whether biofuels have positive or negative effects on climate change and the broader environment; or whether biofuels contribute to the socio-economic development, wealth creation and distribution (Jumbe and Mkondiwa, 2013).

The multiplicity of the growing fears, myths and misconceptions about biofuels have also exacerbated these dilemmas with debates spanning across various issues: food prices, land use, environment and greenhouse gas emissions reduction, social and economic impact, energy balance and the need for of biofuels subsidies (Jumbe and Mkondiwa, 2013). Von Maltitz and Stafford (2011: 10) stipulate what African countries should aim to achieve from biofuels and they include:

- Biofuel development must drive rural development biofuel as a driver
- Biofuel development must lead to improvement of local rural livelihoods
- Biofuel development must be sensitive to gender equity issues
- Where large-scale projects are envisaged, these need to benefit rather than displace existing local livelihoods
- Food security needs to be protected
- Biofuel development should lead to greater resilience of rural livelihoods and national economies
- Biofuel development must lead to increased national fuel security
- Biofuel development must lead to increased local access to energy

- Highly desirable foreign investment needs to be appropriate and conditional on achieving policy objectives
- Value-added products rather than raw biofuel feedstock should be exported when servicing export markets
- Biofuel development should maximise the retention of financial benefits within the country
- Biofuel development must represent a net national economic benefit
- Biofuel development must lead to appropriate and sustainable land use
- Biofuel development should link to modernisation of agricultural practices
- Biofuel development should be environmentally appropriate
- Biofuel development should not lead to a net increase in deforestation
- Long-term sustainability

2.4.4.1 Biodiesel

Biofuels are a promising technological option in light duty vehicle transportation due to the possibility of blending with fossil fuels, and fitting with existing fuel distribution infrastructure and light duty vehicles without significant adaptation (Pourhashem, Adler, McAloon and Spatari, 2013). According to the Biomass Energy Data Book (2011) Biodiesel is a clean burning alternative fuel produced from domestic, renewable resources and it is a mixture of fatty acid alkyl esters made from vegetable oils, animal fats or recycled greases. A number of countries have been active in biodiesel production and programmes, with Europe and the United States leading the industry, other countries have drawn up strategies to support biodiesel production (Karakosta et al., 2013; Musango, Brent, Amigun, Pretorius and Müller, 2012). Biodiesel is a cleaner burning replacement fuel; it is contended to potentially contribute to sustainable development in many countries and regions of the world (Musango et al., 2012).

Successful biodiesel development however, entails complex interactions of actors such as the technology developers, government at different levels, communities, as well as the natural environment; different actions or responses in the greater system might hinder or undermine the positive effects of such a development (Musango et al., 2012; Jumbe and Mkondiwa, 2013). Most developing countries struggle to manage successful biodiesel projects and this could be attributed to the policy issues and lack of enabling framework (Musango et al., 2012). Biodiesel is simple to use, biodegradable, non-toxic, and essentially free of sulphur and aromatics, it is usually used as a petroleum diesel additive to reduce levels of particulates, carbon monoxide, hydrocarbons and air toxics from diesel-powered vehicles (Biomass Energy Data Book, 2011).

2.4.4.2 Ethanol

The combined effects of climate change, the continued volatility of fuel prices, the recent food crisis and global economic turbulence have triggered a sense of urgency among policymakers, industries and development practitioners to find sustainable and viable solutions in the area of biofuels and one of the suggested fuels is ethanol and methanol (Amigun, Petrie and Görgens, 2011; Jumbe and Mkondiwa, 2013). There is an opportunity for grain growing farmers to cultivate available or marginal lands for bioethanol crops, including triticale and this sense of urgency is reflected in the recent resurgence of interest in the production of fuel ethanol for use as an alternative motor fuel (Amigun, Petrie and Görgens, 2011). Triticale is a hybrid of wheat and rice with a starch content 64% (Amigun, Petrie and Görgens, 2011; Jumbe and Mkondiwa, 2013). Agricultural residues available in certain regions of the US for example may be used to supply second generation ethanol bio refineries, corn Stover, and wheat and barley straw, the non-grain agricultural residue left above ground after grain harvest are possible feed stocks for ethanol production in certain parts of the US (Pourhashem et al., 2013).

According to Amigun, Petrie and Görgens (2011) there is an opportunity for advanced ethanol plants to be designed that can isolate/fractionate the grain's bran/fibre from the rest of the carbohydrates; the isolated bran can be used for steam generation or even as a feedstock for further ethanol production by cellulosic ethanol production technologies. In 2007, the capacities of methanol in China had reached 60 million tons (Kammen and Kirubi, 2008). In spite of some limitations (blending wall, infrastructure compatibility, etc.) second generation ethanol remains a promising fuel for transportation due to much R&D and the emergence of demonstration-scale facilities that are in operation (Pourhashem et al., 2013).

Among them the total output of methanol was 10.78 million tons; the methanol plants with the prospective capacity of about 12.18 million tons are under construction; the methanol projects that have been approved by Chinese government can bring 13.83 million tons of methanol capacity; and also there are many other projects to be constructed with the capacity of 31.2 million tons (Kammen and Kirubi, 2008). Methanol can be considered to construct the state reserves to substitute for 10-20% of strategic reservation of petroleum and methanol state reserves constructed in the mainland will be safe enough and be used as an adjustment mechanism to regulate the methanol market (Kammen and Kirubi, 2008).

2.4.4.3 Biogas

Biogas is produced from a mixture CH4 and CO2, in a ratio of about 60/40 to 70/30 and after its production biogas can then be burned in stationary engines to produce electrical and/or thermal energy or to fuel vehicles, the largest resource is represented by animal manure, slurries, and organic waste streams (Abanda, 2012; Angelis-Dimakis et al., 2011). Anaerobic co-digestion strategies are needed to enhance biogas production when treating certain residues such as cattle/pig manure (Aragaw, Andargie and Gessesse, 2013).

According to (Dimpl, 2010: 14) most of the commercially run bio-gas power plants in developing countries are of medium size and are installed in industrial contexts, primarily using organic waste material from agro-industrial production processes such as cow, pig and chicken manure, slaughterhouse waste, or residues from sisal and coffee processing. Biogas energy has the potential to provide clean energy in poor regions. There are challenges particularly in developing countries regarding biogas energy production and this includes lack of facilities like laboratories in developing countries resulting in limited access to advanced gas measuring equipment, which may limit research aimed at improving local adapted biogas production (Pham, Triolo, Cu, Pedersen and Sommer, 2013).

Most biogas power plants are connected to agro-industrial facilities and provide electricity only to very few immediate neighbours. However, calculations show that biogas could play a role in supplying isolated grids, where it represents a least cost option (Dimpl, 2010). In recent years biogas has been developing as one of the most attractive renewable energy resources especially in Northern Europe and production of primary energy from biogas has reached 5.9 million tons of oil equivalent (Mtoe), increasing by 20% since 2006. Biogas derives from landfills (49%), waste treatment plants (15%) and agricultural units (36%) (Angelis-Dimakis et al., 2011).

There is little experience to draw on concerning the possibility of using biogas power plants to cover the basic energy needs of the rural population (Dimpl, 2010). Anaerobic digestion is a technology widely used for treatment of organic waste for biogas production; it utilises manure for biogas production and is one of the most promising uses of biomass wastes because it provides a source of energy while simultaneously resolving ecological and agrochemical issues (Aragaw, Andargie and Gessesse, 2013).

Dedicated agricultural crops and crop residues are also promising feedstock such as grasses (e.g. straws from wheat, rice, and sorghum) or silage maize and all agricultural residues and forest wastes can be gasified (Abanda, 2012). Biogas yields vary depending on the kind of raw material used as substrate, given the same conversion technology; this is due to the different chemical and physical composition of the raw material and in particular, to the difference of organic matter (Angelis-Dimakis et al., 2011). The anaerobic fermentation of manure for biogas production does not reduce its value as a fertiliser supplement, as available nitrogen and other substances. Organic kitchen wastes co-digested with cattle manure improved the biogas potential compared to cattle manure alone (Aragaw, Andargie and Gessesse, 2013).

2.4.5 Marine energy

The ocean is an abundant source of energy and unfortunately a significant proportion still remains untapped (Kurniawan, 2013). According to the World Energy Council (2013a) marine energy can be categorised under three separate technologies:

- Tidal Energy
- Ocean Thermal Energy Conversion (OTEC)
- Wave Energy

Technology developers in all of these sectors of marine energy are constrained primarily by a shortage of capital and in particular, by reluctance on the part of investors generally to commit to the significant level of capital necessary to demonstrate commercial feasibility (European Ocean Energy Association, 2013; Angelis-Dimakis et al., 2011; World Energy Council, 2013a).

2.4.5.1 Tidal energy

The European Ocean Energy Association (2013: 3) argues that tidal power (tidal streams and currents) offer a consistent source of kinetic energy caused by regular tidal cycles influenced by the phases of the moon. Energy can be generated both day and night. Tidal barrages exploit the rise and fall of tides in estuaries and bays to produce electricity (World Energy Council, 2013a). An advantage of both tidal range and tidal current energy is that they are relatively predictable with daily, bi-weekly, biannual and even annual cycles over a longer time span of a number of years (IRENA, 2014b: 4). Furthermore, tidal range is hardly influenced by weather conditions. The development of tidal energy has a long history; tidal barrages and lagoons to power small mills have been used in Europe for many centuries (World Energy Council, 2013a). Tidal technologies appear poised to reach commercial breakthrough earlier than wave technologies, and this is highlighted by the number of concepts that have reached sustained full-scale demonstration (SI OCEAN Strategic energy initiative: 2014: 16).

According to IRENA (2014b: 4) worldwide the technically harvestable tidal energy resource from those areas close to the coast, is estimated by several sources at 1 terawatts (TW), total tidal range deployment in 2012 was around 514 MW, and around 6 MW for tidal current (of which 5 MW is deployed in the UK), extensive plans exist for tidal barrage projects in India, Korea, the Philippines and Russia adding up to around 115 gigawatts (GW). Deployment projections for tidal current up to 2020 are in the range of 200 MW. There are three categories of tidal energy technologies (IRENA, 2014b: 3):

- The first category, tidal range technologies use a barrage – a dam or other barrier – to harvest power from the height difference between high and low tide. The power is generated through tidal turbines (most of them come from hydro power design, such as bulb turbines) located in the barrage.

- The second category, tidal current or tidal stream technologies has had more than 40 new devices introduced between the periods 2006-2013. The major differences among the devices are the turbines, which can be based on a vertical or horizontal axis, and in some cases are enclosed (ducted).
- The final category, hybrid applications are forms of tidal range technologies that have great potential if their design and deployment can be combined with the planning and design of new infrastructure for coastal zones.

2.4.5.2 Ocean thermal energy conversion (OTEC)

OTEC is a marine renewable energy technology that harnesses the solar energy absorbed by the oceans to generate electric power (World Energy Council, 2013a). According to European Ocean Energy Association (2013: 3) OTEC devices exploit the temperature difference between deep cold ocean water and warm tropical surface waters. OTEC plants pump large quantities of deep cold seawater and surface seawater to run a power cycle and produce electricity. OTEC uses the temperature differential between cooler deep and warmer shallow or surface ocean waters to run a heat engine (World Energy Council, 2013a). IRENA (2014c: 3) observe that, so far, only OTEC plants up to 1 MW have been built, although it is technically feasible to build 10 MW plants using current design, manufacturing, deployment techniques and materials, the actual operating experience is still lacking. OTEC installations typically use a low boiling point working fluid such as ammonia in a closed cycle arrangement utilising a Rankine cycle (World Energy Council, 2013a).

Practical efficiencies of 2%-3% have been demonstrated and the technology is not new (World Energy Council, 2013a). IRENA (2014c: 4) identifies OTEC as having the highest potential when comparing all ocean energy technologies, and as many as 98 nations and territories have been identified that have viable OTEC resources in their exclusive economic zones. Recent studies suggest that total worldwide power generation capacity could be supplied by OTEC, and that this would have no impact on the ocean's temperature profiles. OTEC is especially suitable and economically viable for remote islands in tropical seas where generation can be combined with other functions e.g., air-conditioning and fresh water production (IRENA, 2014c; World Energy Council, 2013a). IRENA (2014c: 4) and World Energy Council (2013a) identified some of the barriers to OTEC energy exploitation and they include:

- OTEC plants tend to be capital intensive, high up-front capital costs.
- Vulnerable to damage in the marine environment.
- The lack of experience building OTEC plants.
- OTEC plants to scale require large pipes to transport the volumes of water required to produce electricity, which might have an impact on marine life.
- From a technical perspective, the large-scale pipes, bio-fouling of the pipes and the heat exchangers, the corrosive environment, and discharge of seawater are still being researched.

2.4.5.3 Wave energy

The worldwide wave energy potential is estimated of the same order of magnitude as the world electrical energy consumption; however power generation is not currently a widely employed commercial technology in the world (Angelis-Dimakis et al., 2011). The combination of forces due to the gravity, sea surface tension and wind intensity are the main factors of origin of sea waves (Mahbubur, Nirupom, Shahrior and Safi, 2013; Kurniawan, 2013). The ocean can produce two different types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves (Mahbubur et al., 2013). According to IRENA (2014a: 3) wave energy converters capture the energy contained in ocean waves and use it to generate electricity and there are three main categories:

- Oscillating water columns that use trapped air pockets in a water column to drive a turbine.
- Oscillating body converters that are floating or submerged devices using the wave motion (up/down, forwards/ backwards, side to side) to generate electricity.
- Overtopping converters that use reservoirs to create a head and subsequently drive turbines.

The global wave power input is estimated to be in the order of 10^{13} W, comparable to the world's present power consumption (Kurniawan, 2013). Sea waves are a very promising energy carrier among renewable power sources, since they are able to manifest an enormous amount of energy. European Ocean Energy Association (2013: 3) indicate that wave power devices are located at different distances from the shoreline, either on the sea-bed or surface floating and all derive energy from the movement and power of ocean waves.

According to (IRENA, 2014a: 3) more than 100 pilot and demonstration projects exist throughout the world, but only a handful of technologies are close to commercialisation. Ocean wave energy, in particular has a relatively higher energy density than solar or wind energy and it has persistent supply and low environmental impact, making it attractive to utilise (Kurniawan, 2013). Wave energy conversion is a clean electric power production technology and during operation there are no emissions in the form of harmful gases (Haikonen, Sundberg and Leijon, 2013).

The ocean is a true store of renewable energy and it is believed by some that only about 0.2% of the energy in ocean waves could power the entire planet. Ocean waves have two forms of energy, the kinetic energy of the water particles (in general follows circular paths) and the potential energy of elevated water particles (Mahbubur et al., 2013). The scale and character of the wave energy resource in many regions around the world remain poorly understood and ill defined, especially in near shore areas (Angelis-Dimakis et al., 2011). Several efforts have been made to estimate the wave energy potential at regional, national and global scale; several wave energy conversion devices have already demonstrated the potential for commercially viable electricity generation and are expecting pre-commercial deployment in Europe (Angelis-Dimakis et al., 2011; Zhang et al., 2013).

Few studies exist on wave energy conversion topics since it is a relatively new technology. Wave energy conversion has existed for many years but only recently different concepts such as Pelamis, Archimedes Wave Swing, Wave Dragon and the Lysekil Project, have actually been tested in a real offshore environment (Haikonen, Sundberg and Leijon, 2013). Harnessing wave energy in an economically viable manner still remains a dream and there is still a lot of work to be done before the technology reaches the maturity stage (Kurniawan, 2013). Experience and research in wave energy resource indicate that to achieve competitiveness, a good understanding of wave climate at the installation site and weather forecasting techniques are necessary (Angelis-Dimakis et al., 2011).

Efforts to harness energy from the ocean waves into practical use have been made before the 1970's notably by Yoshio Masuda from Japan and Walton Bott from Mauritius; it was not until then that the potential of wave energy was seriously considered (Kurniawan, 2013). However there are unsolved issues considering environmental impacts such as: electromagnetism; the artificial reef effect and underwater noise (Haikonen, Sundberg and Leijon, 2013).

Large wave forces are an inconvenience and expensive to handle and the device must deal with the stochastic nature of waves (Kurniawan, 2013). Waves travel great distances without significant losses and so act as an efficient energy transport mechanism across thousands of kilometres and therefore it is virtually inexhaustible in duration but limited, and also highly variable, in the amount that is available per unit of time (Angelis-Dimakis et al., 2011; Zhang et al., 2013).

The World Energy Council (2013a) has estimated the worldwide wave power resource in deep water between 1 and 10 TW and as most forms of renewables, wave energy is unevenly distributed over the globe, varying by location and time. However, for various reasons, it is estimated that only 10% to 15% can be converted into electrical energy, which is a vast source of energy, able to electrify the whole world (Mahbubur et al., 2013; Angelis-Dimakis et al., 2011). The best wave climates in terms of increased wave activity, with annual average power levels between 20 and 70 kW/m of wave front, are found in the temperate zones (30-608 latitude) (Angelis-Dimakis et al., 2011).

Ocean waves have variable directions, periods and heights on all time scales and a wave energy device must be able to absorb energy optimally from the most frequent occuring waves and to survive the most extreme wave loads (Kurniawan, 2013). Prominent among the leaders in the development and commercialisation of this technology are European countries such as Portugal, Spain, the United Kingdom, Ireland, Spain, and France. Outside of Europe, the Asia-Pacific region is the hub of a number of R&D projects as well as some of the world's first commercial-scale ocean energy projects (Haikonen, Sundberg and Leijon, 2013).

Leaders in ocean energy in the Asia-Pacific region include Korea, Australia, New Zealand, Canada and the United States (Zhang et al., 2013). There are serveral challenges that have been devised to harness wave energy. A wave energy device must firstly work with large forces and low velocities in contrast to current technologies of electrical generation, which is more used to low force and high speed motions (Kurniawan, 2013). While most wave energy projects have been in Europe, there have been a number of significant developments in the Asia-Pacific region, especially in Australia. In Australia, there are at least three companies involved in the research, development, and pre-commercial testing of wave energy devices.

These include the Western Australian company Carnegie Wave Energy Limited whose projects centre on the CETO wave power converter. This is a fully submerged apparatus that produces high pressure seawater from the power of waves which, in turn, is used to power onshore turbines that produce electricity, the technology has the added benefit of being able to act as a reverse osmosis desalination plant producing freshwater (Zhang et al., 2013). Anthropogenic noise is increasing in the oceans worldwide and wave power will contribute to this sound pollution in the oceans (Haikonen, Sundberg and Leijon, 2013). Some of the challenges, gaps and barriers are identified by the Ocean Energy Europe (SI OCEAN Strategic energy initiative, 2014: 20) and they are:

- Enabling technology: Developing cost-effective technology that, once ready, will enhance, or add value to, the deployment capabilities of the wave and tidal sector.

- Risk management: Technology developers are exposed to a series of risks when looking to develop and deploy marine energy projects, utility-scale projects are deemed to be too risky for both investors and developers, thus hindering deployment.

- Technology fragmentation and design consensus: An issue hindering the development of both sectors is presented by the lack of design consensus amongst technologies and subcomponents.

- Grid access, connectivity and infrastructure: Securing access to the grid is necessary to avoid slowing down the development of the ocean energy sector.

- Grid access is one the major infrastructure issues that could potentially slow down marine energy installation; thus providing secure, adequate and timely connection to the grid is of primary importance.

- Establishing equitable environmental mitigation measures: The unknowns related to the environmental impacts of ocean energy parks are causing delays and setbacks to the development of the sector.

2.4.6 Geothermal energy

Geothermal energy is the energy originating from inside the earth, the core of the earth acts as a thermal source and causes formation and emersion of molten materials at temperatures between 650 and 1 200 degrees centigrade in 80 to 100 kilometers depth of the earth (Sartipipour, 2011). World Energy Council (2013a) indicates that geothermal energy comes from the natural heat of the earth primarily due to the decay of the naturally occurring radioactive isotopes of Uranium, thorium and potassium.

Geothermal power is generated by using steam or a hydrocarbon vapour to turn a turbine-generator set to produce electricity, a vapour dominated (dry steam) resource can be used directly, whereas a hot-water resource needs to be flashed by reducing the pressure to produce steam, normally in the 15-20% range (World Energy Council, 2013a).

Worldwide use of geothermal energy has increased steadily over the past few decades and the exploration and development are ongoing at unprecedented levels in Iceland, New Zealand, East Africa, Germany, Chile and Australia (Moore and Simmons, 2013). This thermal energy is the principal factor for such geologic phenomena as volcanoes, earthquake, orogenesis activities and displacement of tectonic plates that has turned the planet earth into a dynamic system of a diversity of changes (Sartipipour, 2011).

The first commercial geothermal power plant was built in Larderello, Italy, in 1913. In this volcanically active area, hot granite lies close to the surface (Moore and Simmons, 2013). Water, boiled by heat from the granite, produces the hot steam that is used to power turbines and Larderello is one of the largest geothermal electricity generators in the world, producing 594 MW of electrical output, sufficient to supply about 594 000 households (Moore and Simmons, 2013).

In a geothermal system, the heat stored in rocks and molten materials in the depth of earth is transferred by fluid conveyor to the surface of the earth (Sartipipour, 2011; Manzano-Agugliaro et al., 2013). Economic viability of geothermal energy production requires a resource with high enough temperature, which will yield individual well flow rates sufficient to justify project development costs (Buscheck et al., 2013). Hot sedimentary basins are a promising target for large-scale, geothermal development within the next decade (Moore and Simmons, 2013).

Measurements from these wells indicate that temperatures above 150°C and high permeability's exist at depths of 3 to 4 km (Moore and Simmons, 2013). Although geothermal energy for electricity generation has been produced commercially since 1913 and the exploitable amount of energy and heat is limited to the characteristics of local resources and reservoirs and certain parts of the world (Manzano-Agugliaro et al., 2013).

Geothermal heat has two primary sources: the decay of the long live radioactive isotopes and the stored energy from planetary accretion and production can be limited by insufficient working fluid and pressure depletion (Buscheck et al., 2013). Geothermal heat has the advantage of being available all day and in all seasons (Manzano-Agugliaro et al., 2013).

Most new geothermal power plants brought on line in recent years in the United States are binary plants (Moore and Simmons, 2013). In year 2000, geothermal resources were identified in over 80 countries and there are quantified records of geothermal utilisation in 58 countries in the world (Manzano-Agugliaro et al., 2013). Geological and hydrogeological studies provide basic information to define any exploration program, and distribution of young volcanic rocks, active volcanoes, craters, calderas, faults and fractures are the main data used in the early stages of geothermal resource assessment, aiming at identifying geothermal phenomena and at estimating the size of the resource (Angelis-Dimakis et al., 2011).

Geochemical surveys are a useful means of determining whether the geothermal source is water or vapour dominated and the chemical characteristics of the deep fluid can be interpreted as geo-thermometers, i.e. a set of experimental relations that allow to define the model of the reservoir and its physical characteristics, such as temperature, electrical conductivity, density, etc., starting from the measured concentration of some minerals (Angelis-Dimakis et al., 2011).

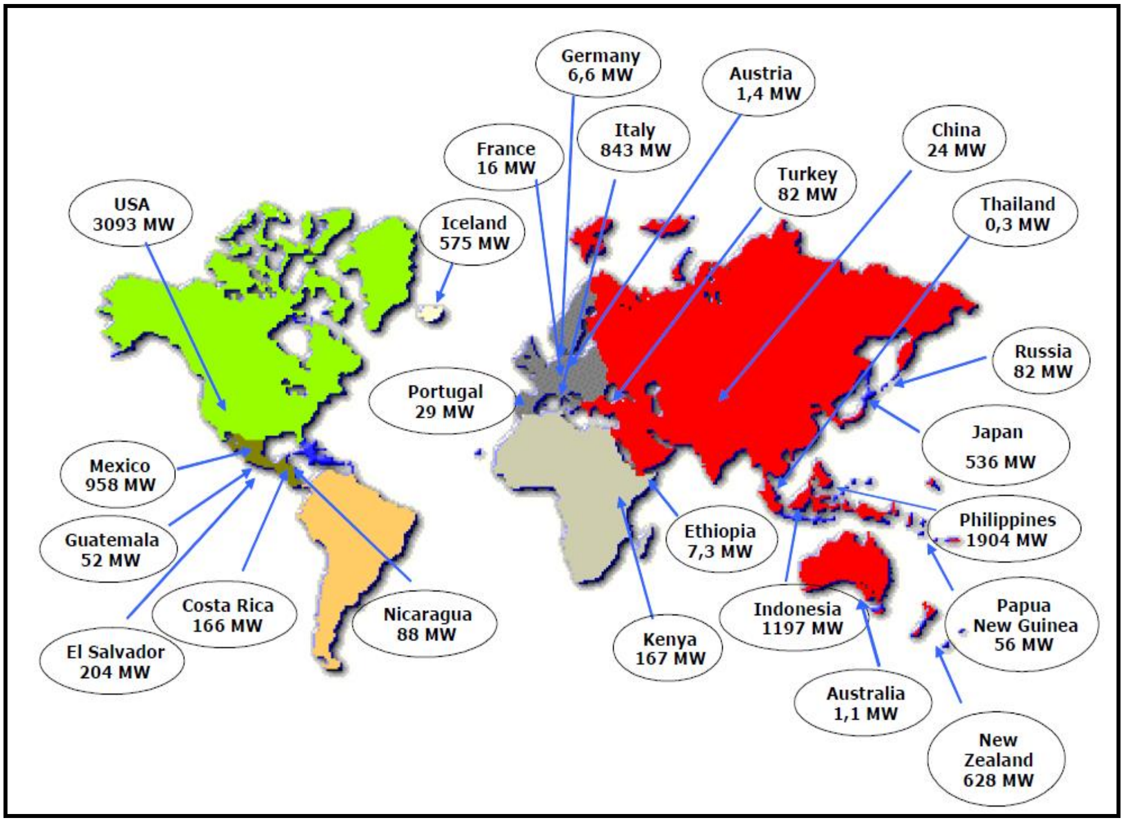
Geothermal energy production can be limited by insufficient working fluid and pressure depletion, whereas Geologic CO2 Storage can be limited by overpressure, which may drive CO2 leakage and cause induced seismicity (Buscheck et al., 2013). Future development will take advantage of the vast untapped thermal resource underlying most continental regions at greater depths of 3 to 10 km (Moore and Simmons, 2013).

Understanding how to develop and manage heat transfer and fluid flow in these deep geologic environments over commercially viable periods (>25 years) remain top priorities for R&D (Moore and Simmons, 2013). The utilisation of geothermal energy has been limited to areas in which geological conditions allow a carrier liquid or steam to transfer the heat from deep zones, but only a small fraction of the geothermal potential has been developed so far, and there is ample space for an increased use of geothermal energy both for electricity generation and direct applications (Angelis-Dimakis et al., 2011).

Geothermal water at temperatures of 30° to 150°C is used for bathing, heating, and greenhouses in 75 countries (Moore and Simmons, 2013). World Energy Council (2013a) indicates that at end 2008, approximately 10 700 MWe of geothermal electricity generating capacity was installed, producing over 63 000 GWh/yr. Bertani (2010: 2) indicates that countries with the largest installed capacity are the USA, China, Sweden, Norway and Germany, accounting for about 63% of the installed capacity and the five countries with the largest annual energy use were: China, USA, Sweden, Turkey and Japan, accounting for 55% of the world use, Sweden, a new member of the 'top-five' obtained its position due to the country's increased use of geothermal heat pumps.

The largest increases in geothermal energy use (TJ/yr) over the past five years are in the United Kingdom, Netherlands, Korea (Republic), Norway and Iceland; and the largest increases in installed capacity (MWt) are in the United Kingdom, Korea (Republic), Ireland, Spain and Netherlands, due mostly to the increased use of geothermal heat pumps (Bertani, 2010: 2). Figure 2.11 presents installed geothermal energy capacities worldwide.

Figure 2.11: Installed geothermal energy capacity worldwide



Source: Bertani (2010: 2).

According to the World Energy Council (2013a: 17) the major barrier to the exploitation of geothermal energy include:

- High financial risk in comparison not only with the use of natural gas but also with most other forms of renewable energy.
- There is a lack of published technical, financial and legislative information for developers, particularly in comparing the experiences gained by others through various individual schemes.
- Environmentally, geothermal schemes are relatively benign, but they generally produce highly corrosive brine which may need special treatment and discharge consents.

- There is also a possibility of noxious gases, e.g. hydrogen sulphide, being emitted and developers must meet local environmental and planning requirements.

2.4.7 Nuclear energy

Nuclear power and hydro electricity are arguably the two of the most powerful sources of energy to bring down the carbon intensity of commercial energy supply today (Karakosta et al., 2013). Nuclear energy plays an important role today in meeting the energy needs of many countries and at the same time in mitigating GHG emissions whereas they save about 10% of CO2 emissions from world energy use (Karakosta et al., 2013). In general, nuclear power is a non-renewable source as the fossil fuels, but nuclear resources can be used significantly longer than some fossil fuels and currently, this source of energy is considered as one of the most viable non GHG emitting source for electrical generation for the next 50–100 years (Pioro and Kirillov, 2013a). According to the World Energy Council (2013a) nuclear material used to generate electricity originates from Uranium, is a naturally occurring element in the earth and traces of Uranium can be found practically everywhere, although mining takes place in locations where Uranium is naturally concentrated.

To produce nuclear fuel from the Uranium ore, Uranium has to be enriched and formed into pellets which are loaded into the reactor fuel rods and Uranium is mined in 20 countries, although about half of world production comes from just ten mines in six countries: Australia, Canada, Kazakhstan, Namibia, Niger and Russia (World Energy Council, 2013a). The energy released from the continuous fission of atoms of the fuel is harnessed as heat in either a gas or water, and is used to produce steam and steam is used to drive the turbines, which in turn drive generators and produce electricity, as in most thermal fossil fuel plants (Poullikkas, 2013).

Nuclear power plants have played a major role in reducing the amount of GHG and it is claimed that without nuclear power, the EU power plant CO2 emissions would have been about one-third higher (Karakosta et al., 2013). In contrast to North America and most countries of Europe, where nuclear power capacity has remained almost steady for the last two decades, the nuclear capacity in Asia has been growing significantly, as a number of countries in East and South Asia, most notably China, India and South Korea, are planning and building new reactors (Karakosta et al., 2013).

According to World Nuclear Association (2014) about 31 countries host over 430 commercial nuclear power reactors with a total installed capacity of over 370 000 MW. This is more than three times the total generating capacity of France or Germany from all sources and about 70 further nuclear power reactors are under construction, equivalent to 20% of existing capacity, while over 160 are firmly planned, equivalent to half of present capacity (World Nuclear Association, 2014).

The “big five” nuclear generating countries World Energy Council (2013a: 6) are:

- United States
- France
- Russia
- South Korea
- Germany

On March 10, 2011, a total of 30 countries had 442 commercial nuclear power reactors with a total installed capacity of 379 001 MWe (World Energy Council, 2012a). In addition, 65 nuclear power reactors were under construction (62 862 MWe, equivalent to 17% of existing capacity), while over 159 were planned (total capacity of 178 123 MWe, equivalent to 47% of present capacity) (World Energy Council, 2012a).

Unlike most other low-carbon energy sources, nuclear energy technology has been in use for more than 50 years and about 29 countries worldwide are operating 440 nuclear reactors for electricity generation and 65 new nuclear plants are under construction in 15 countries (Karakosta et al., 2013). According to the World Energy Council (2012a), operable reactors in early March 2011 in the OECD countries dominated the market.

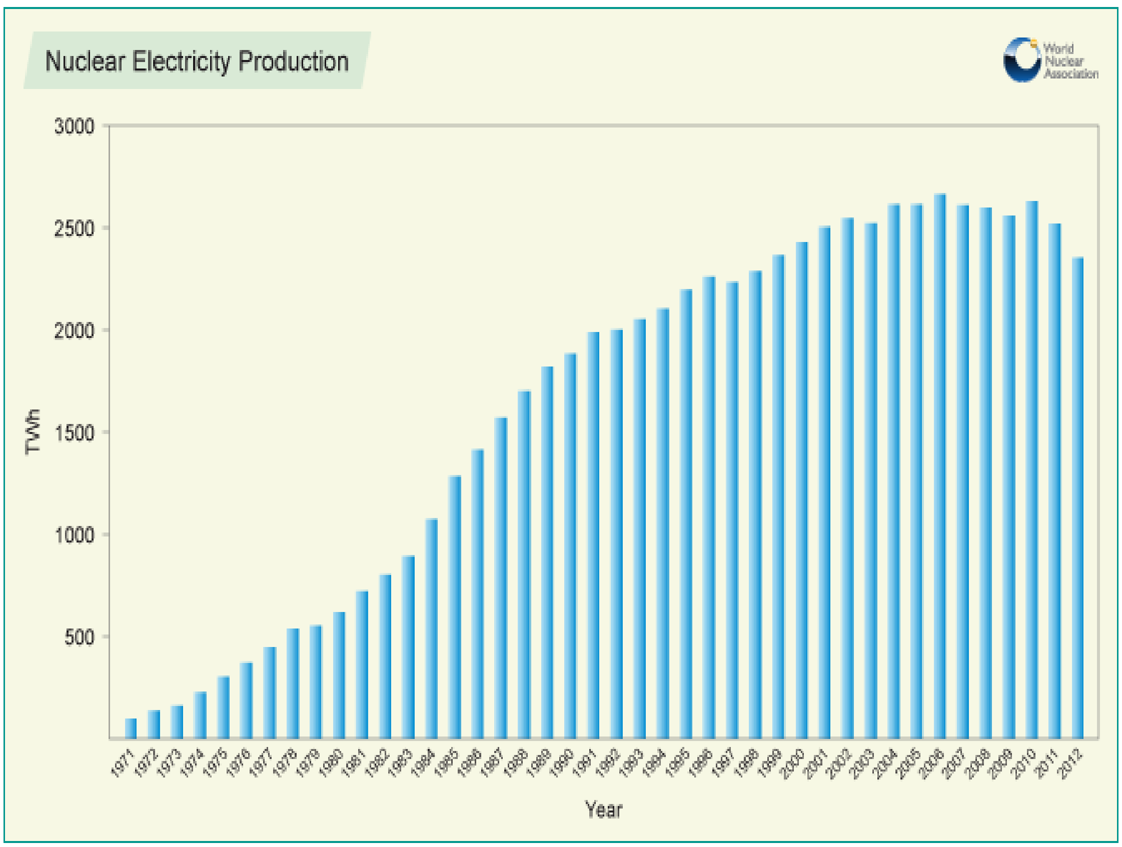
The capacity was the largest in the USA (104 reactors), followed by France (58 reactors), Japan (54 reactors), Russia (32 reactors), South Korea (21 reactors), India (20 reactors), the UK (19 reactors), Canada (18 reactors) and Germany (17 reactors). In contrast, most of the nuclear plants under construction were in non-OECD countries. China alone accounted for 42% of the construction 27 reactors, followed by Russia with 17% (11 reactors), and India with 8% (five reactors) (Karakosta et al., 2013; World Energy Council, 2012a; Bruynooghe, Eriksson and Fulli, 2010).

World Energy Council (2013a) indicates that globally, the nuclear industry is in decline: The 427 reactors operating today are 17 reactors less than at the peak in 2002, annual nuclear electricity generation reached a maximum of 2 660 TWh in 2006, but dropped to 2 346 TWh in 2012 (down by 7% compared to 2011 and down by 12% compared to 2006). According to the World Energy Council (2013a: 6) three-quarters of this decline is attributed to:

- The events in Japan, but 16 other countries, including the top five nuclear generators, decreased their nuclear generation capacities too.
- The temporary unavailability of several reactors at nuclear power plants in Japan, which were shut down in July 2007 after a major earthquake, after in-depth safety inspections and seismic upgrades, two of the seven units were restarted and connected to the grid in 2009.

The World Nuclear Association (2014) indicates that sixteen countries depend on nuclear power for at least a quarter of their electricity. France gets around three quarters of its power from nuclear energy, while Belgium, Czech Republic, Hungary, Slovakia, Sweden, Switzerland, Slovenia and Ukraine get one third or more. South Korea, Bulgaria and Finland normally get more than 30% of their power from nuclear energy, while in the USA, UK, Spain and Russia almost one fifth is from nuclear. Japan is used to relying on nuclear power for more than one quarter of its electricity and is expected to return to that level (World Nuclear Association, 2014). Among countries which do not host nuclear power plants, Italy and Denmark get almost 10% of their power from nuclear (World Nuclear Association, 2014). Figure 2.12 illustrates nuclear electricity production by 2012.

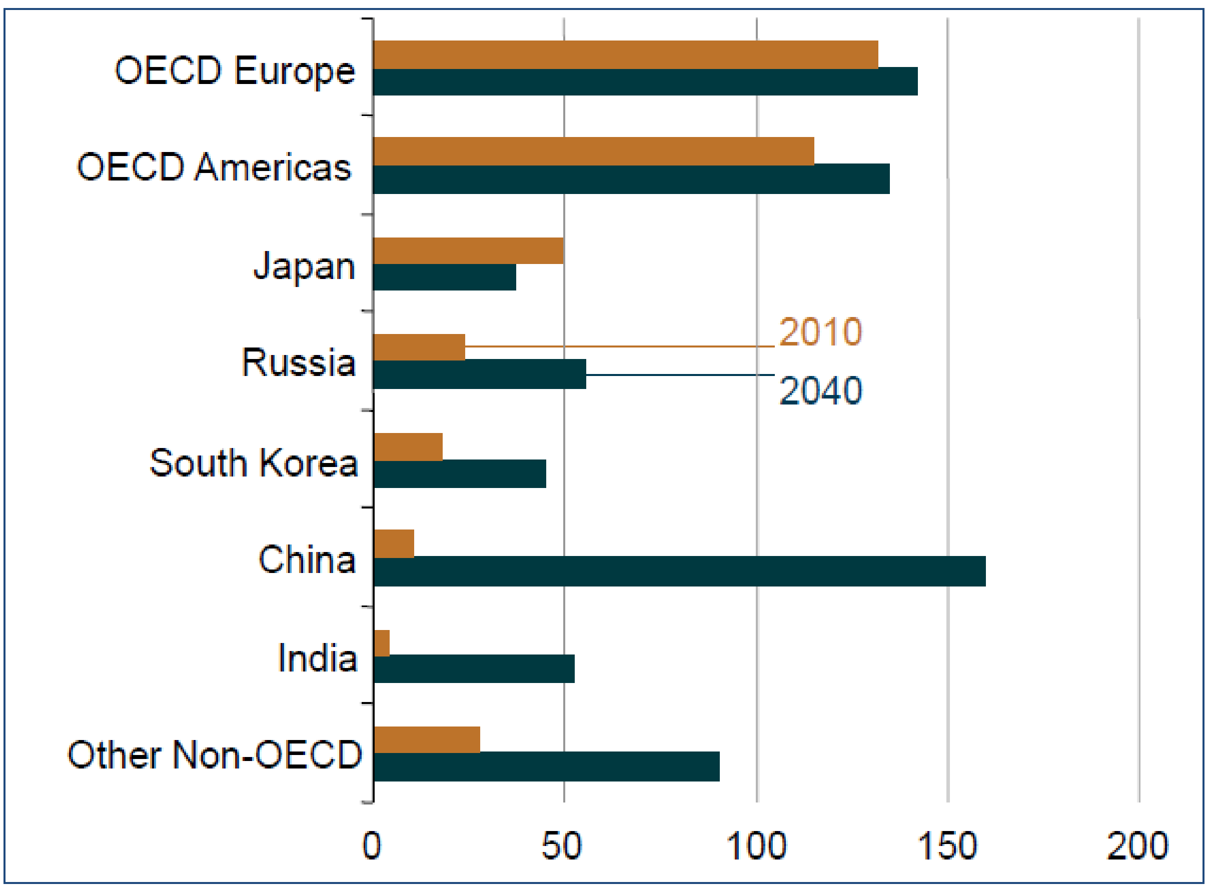
Figure 2.12: Nuclear electricity production by 2012



Source: World Nuclear Association (2014: 1)

The EIA (2013: 5) projects that "electricity generation from nuclear power worldwide increases from 2,620 billion kilowatt-hours in 2010 and will be 5,492 billion kilowatt-hours in 2040. Factors underlying nuclear power projections include the consequences of the March 2011 disaster at Fukushima Daiichi, Japan; planned retirements of nuclear capacity in OECD Europe under current policies; and continued strong growth of nuclear power in non-OECD Asia". World Energy Council (2013a) indicates non-OECD economies (mainly China and India) are expected to dominate future prospects. Figure 2.13 illustrates world operating nuclear power generation capacity by country grouping, 2010 and 2040 (gigawatt).

Figure 2.13: World operating nuclear power generation capacity by country grouping, 2010 and 2040 (gigawatt)



Source: EIA (2013: 6)

2.4.7.1 The Fukushima accident

Before the Fukushima incident, Japan was the world’s third-largest producer of electricity from nuclear power (Karakosta et al., 2013). The World Energy Council (2012a) indicates that nuclear energy accounted for about 30% of the country’s total electricity production (54 reactors providing 47 GW).The Japanese government had ambitious plans to expand the nuclear component of the country’s energy mix to reach 41% of the country’s total power supply by 2017, and 53% by 2030 (up from about 29% in 2010) (Karakosta et al., 2013). Plans were in place to construct nine new reactors by 2020 and another five by 2030 (Karakosta et al., 2013).

The Fukushima accident rendered these ambitious long-term plans into doubt, partly because of severe public resistance. Immediately after the accident, the Prime Minister was forced to request that some nuclear reactors in the rest of the country be shut down (World Energy Council, 2012a). On Friday March 11, 2011, an earthquake measuring 9.0 on the Richter scale hit northeast Japan, with an epicentre near the island of Honshu (World Energy Council, 2012a). It triggered a tsunami 43-49 feet high which struck the Fukushima Daiichi nuclear power plant. The plant comprises six reactor units, producing a total of 4 696 MW (World Energy Council, 2012a; Lior, 2012).

In response to the tsunami, Units 1, 2, and 3 (which were operating at that time) underwent an automatic emergency shutdown while Units 4, 5, and 6 were already offline for the usual periodic inspections. After the reactors in Units 1, 2 and 3 were safely shut down the emergency core-cooling system was activated and the tsunami meant that the emergency cooling system was flooded, which caused the loss of all functions, making it impossible to control the reactors (World Energy Council, 2012a; Lior, 2012).

The incident at the Fukushima Daiichi nuclear power plant, a result of a devastating earthquake and subsequent tsunami on 11 March 2011 has re-invigorated the debate on how to meet the world's growing demands for energy and the contribution of nuclear power to the global energy mix (World Energy Council, 2012a; Lior, 2012). The nuclear disaster in Japan and nuclear power and also the remaining unresolved concerns with radioactive waste (especially the long life, dangerous up to a million years) disposition, with mounting proliferation risks, and to some extent with safety is contributing to a very slow growth of nuclear power (Lior, 2012). Since no major nuclear accidents occurred for about 25 years since the massive 1986 disaster in Chernobyl, and since the 104 US reactors operated at a remarkable capacity factor of 91.2%.

Japan's Fukushima accident has some immediate consequences ranged so far from a re-examination of all US and EU nuclear reactors, shelving by Japan of a 2010 goal to build 14 nuclear reactors over the next 20 years, and to complete moratoria on nuclear power in Germany and Switzerland (Lior, 2012). In contrast, several countries (mostly developing countries) have re-affirmed their intentions to develop nuclear power as an important part of their energy mix, or substantially increase nuclear capacity (World Energy Council, 2012a).

They are motivated by the need to meet rising power demands efficiently, and/or the desire to reduce dependence on fossil fuels (and quell associated concerns about security of supply and emissions). Of the 31 countries with nuclear energy programmes, those that experienced the most profound public reactions and public policy changes included: Japan, Germany, Italy, and Switzerland (World Energy Council, 2012a). Germany and Switzerland announced plans to phase out or shut down their operating reactors by 2022 and 2034, respectively".

The federal government in Germany has returned to its prior deal with the electricity sector, which implies it will phase out nuclear power over the course of the next 10 years. Switzerland will follow suit with a similar plan (Lior, 2012). In June 2011, in a second referendum on the subject since 1987, the Italian population expressed overwhelmingly their opinion that their country should not engage in the construction of nuclear reactors domestically, more countries in especially the developed world may pursue these examples (Van der Zwaan, 2013)**.**

The demand for clean, non-fossil based electricity is growing, suggestions have been made about the need to develop new nuclear reactors with higher thermal efficiencies in order to increase electricity generation and decrease detrimental effects on the environment (Pioro and Kirillov, 2013b). Currently, a group of countries, including Canada, EU, Japan, Russia, USA and others have initiated an international collaboration to develop the next generation nuclear reactors (Generation IV reactors) (Pioro and Kirillov, 2013b). The ultimate goal of developing such reactors is an increase in thermal efficiencies of NPPs from 30-36% to 45-50% and even higher (Pioro and Kirillov, 2013b).

Designing all nuclear power plants to withstand catastrophic freak accidents like Fukushima's (or worse) would probably make the power produced uncompetitive, and yet designing them based on some below certainty risk probability forecast maintains the risk of another major disaster (Lior, 2012). Designs combining all these desirable features would go beyond the currently planned Generation IV reactors and may take more than 50 years to materialise (World Energy Council, 2012a; Lior, 2012). According to Lior (2012) the consistent iniquitous trait of all major nuclear accidents, three Mile Island in the US, Chernobyl in the USSR, and Monju and Fukushima in Japan, have not been managed properly and the public have not been well informed about these incidents (Lior, 2012; Van der Zwaan, 2013; Poullikkas, 2013).

Many energy analysts argue that despite its multiple drawbacks, among which especially the production of long-lived radioactive waste, the risks of reactor accidents with pervasive environmental and health consequences, and the diversion of nuclear materials and technologies for military or terrorist purposes, nuclear energy can in principle play a role in mitigating global climate change (Van der Zwaan, 2013).

2.5 GREEN ENERGY STORAGE

High construction costs can make the total cost of building and operating renewable generators higher than those for conventional plants and the intermittence of wind and solar energy, in particular, can further hinder the economic competitiveness of those resources, as they are not necessarily available when they would be of greatest value to the system (EIA, 2013: 5). Intermittence however can be addressed by, improving battery storage technology and dispersing wind and solar generating facilities over wide geographic areas could help to mitigate some of the problems associated with intermittency over the projection period (EIA, 2013).

Solomon, Kammen and Callaway (2014) infer that generating very significant electric energy from intermittent renewable resources would require significant use of energy storage technologies and currently little is known about the nature of storage need in an interconnected grid and factors that can limit or enhance its potential. To regularise an intermittent renewable energy output, Ma, Yang and Lu (2015) advocate the solution as the adoption of an appropriate energy storage component with high specific power and at the same high specific energy over periods minutes or hours is required. Weitemeyer, Kleinhans, Vogt and Agert (2015) observe that integrating a high share of electricity from non dispatchable renewable energy sources in a power supply system is a challenging task.

One option considered in many studies dealing with prospective power systems according to Weitemeyer et al. (2015) is the installation of storage devices to balance the fluctuations in power production and it is not yet clear how soon storage devices will be integrated and the process depends on different storage parameters. Solomon, Kammen and Callaway (2014) argue that the existing grid in developing countries is not yet optimised to accommodate very large variable renewable energy systems and a very high penetration will most likely require the capability to enhance the use of energy from the variable technologies. There are three important aspects to address before the integration is ensured according to Solomon, Kammen and Callaway (2014: 75) namely:

- The first is regarding the possibility to achieve an optimal temporal match between the variable generators output to the demand profile.

- The second one relates to a set of technological requirements that enable these optimal matching capabilities while providing sufficient capacity to meet the demand at any time of the year.

- The third is the possible operational requirements to optimise the use of these resources in order to achieve carbon reduction.

The need for access to green energy is more manifested in rural areas. Energy generated by renewable sources for remote rural areas has many advantages over conventional supplies, but a negative aspect is that the supply that it is stochastic in nature and consequently difficult to control (Ma, Yang and Lu, 2015). Cho and Kleit (2015) indicate that battery storage technologies have developed to the point that some are mature enough to serve as a generation resource and an example is battery ESS (Energy Storage System) that can potentially solve this problem by storing electricity energy when demand is low and offering stored energy when demand is high.

As a result, battery ESS may be considered a generation resource for a variety of reasons, such as for use in energy arbitrage, self-generation resource for Demand Response, and ancillary service (Cho and Kleit, 2015). Because of its technical maturity and wide availability, Ma, Yang and Lu (2015) infer that the possibility and benefit to combine super capacitors and traditional batteries for achieving a complementary performance between two devices batteries by creating Hybrid Energy Storage System (HESS). For example: the HESS can perform as the primary energy source for longer periods and the super capacitor as the auxiliary power source for peak power smoothing and the combination makes energy storage possessing both high power and energy density, and extending battery life as well.

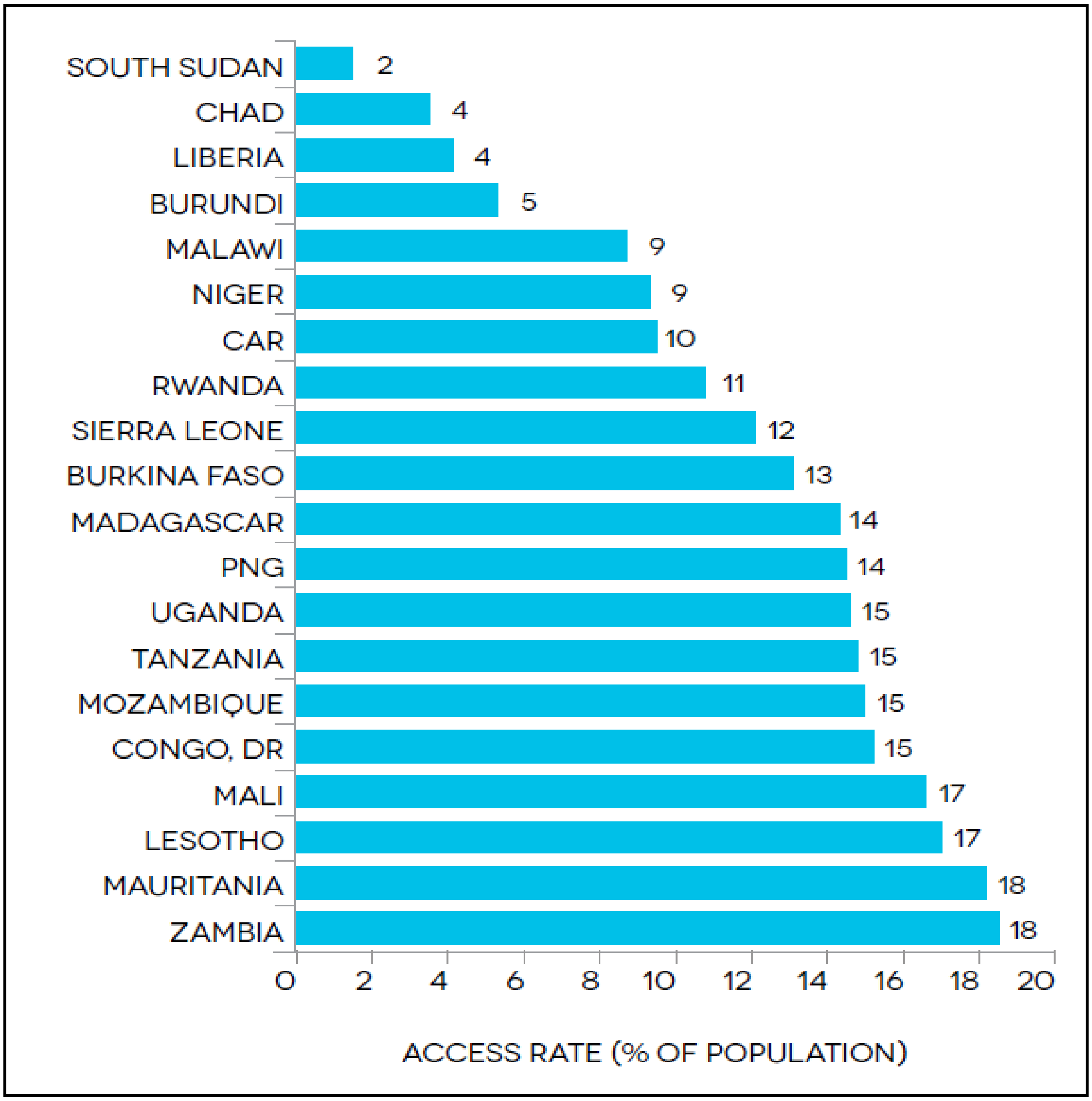
2.6 TRANSITION TO LOW CARBON ENERGY SOLUTIONS

2.6.1 Energy poverty and access

Energy poverty is the point at which people use the bare minimum energy due to lack of access (derived from all sources) needed to sustain life (Barnes, Khandker and Samad, 2011). Energy contributes to greater welfare and increasingly higher levels of economic well-being as electricity and other modern energy sources particularly renewable energy become more available. Below this point people are not using enough energy to sustain normal lives. Access to modern energy can help to alleviate energy poverty and the use of electricity, in particular, can significantly improve household income for poor and non-poor households alike (Barnes, Khandker and Samad, 2011). About 1.2-1.5 billion people worldwide are currently without access to energy and there is a great need for a reliable, affordable, economically viable, socially and environmentally acceptable energy in developing countries (Oldfield, 2011; United Nations, 2012).

SE4ALL (2014: 92) indicates that SSA and Oceania are the only regions where the majority of the population remains un-electrified. SSA accounts for 48% of the un-electrified rural population in the world. Figure 2.14 illustrates Top 20 countries with lowest access rates.

Figure 2.14: Top 20 countries with lowest access rates



Note: CAR=Central African Republic; PNG=Papua New Guinea;
DR =Democratic Republic.

Source: SE4ALL (2014: 99) cited in World Bank's Global Electrification Database (2012).

Pereira, Freitas and Da Silva (2011) liken energy poverty to the premise that poverty in a society is unacceptable in the context of the multiple nature which extends to other spheres beyond income, that can be more accurately perceived as a multidimensional phenomenon, usually including a combination of some or all of the following elements: physical weakness (sub-nutrition, lack of strength, precarious health, incapacity, high rate of active adults who are dependent on others, etc.); isolation (isolated geographical location; social isolation due to lack of education, lack of access to reliable information or knowledge, etc.); lack of income; lack of energy (electricity, etc.); vulnerability (increased exposure to natural disasters, social unrest, war, etc.) and impotence (lack of choices or lack of resources enabling adaptation).

As such, serious efforts to tackle poverty need to take into account the specific elements that need to be addressed in the particular social/economic/geographical context (Pereira, Freitas and Da Silva, 2011). Lack of access to energy is more pronounced in developing countries; one of the paths toward economic sustainability is the availability of access to regular electric energy, where access is a key element for the economic development of the rural environment and for the reduction of poverty (Sovacool, 2012). Lack of access to modern sources of energy aggravates poverty, particularly in the countryside, where opportunities are scarce, so that rural dwellers are largely impotent in the face of their social exclusion (Pereira, Freitas and Da Silva, 2011).

National targets to increase access are expected to succeed in delivering improvements over the projection period, but only on a limited scale it is estimated that annual spending on energy access needs to increase to more than five times current levels in order to achieve universal access to electricity and clean cooking facilities by 2030 and the investment amount must range from US$9.1 billion to US$48 billion annually (Birol, 2012).

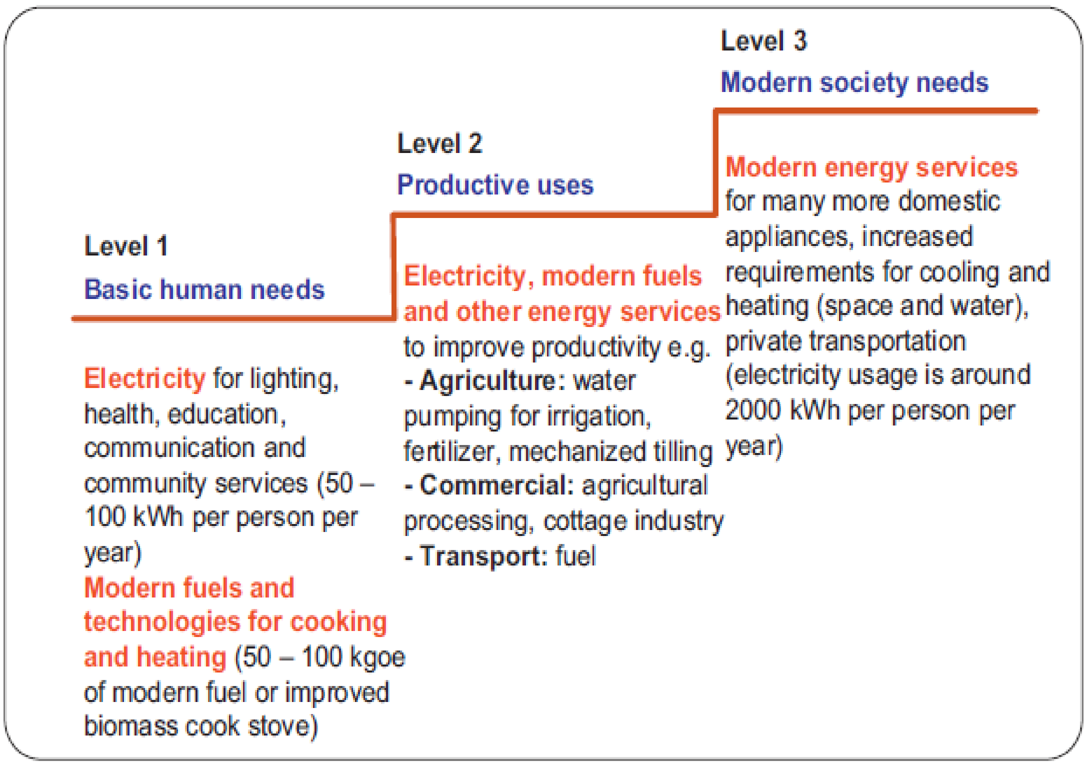
According to the IEA (2011) energy for all case scenarios, U$640 billion is required to achieve universal access to electricity for a period of 20 years since 2010. The highest share of additional investment (U$ 20 billion annually) in the energy for all case scenarios is related to mini-grid and off-grid solutions (Javadi, Rismanchi, Sarraf, Afshar, Saidur, Ping, and Rahim, 2013). Achieving universal access by 2030 would increase global electricity generation by 2.5%, but in the case of mini grid and off grid generation which primarily supply rural areas, more than 90% of this additional electricity is likely to come from renewables (Birol, 2012).

In order to reach the goal of universal energy access by 2030, national governments and donors will need to adopt clear and consistent statements about accessibility targets and strategies, coupled with performance monitoring framework to support policymakers with timely information on progress. One important way to do this is by adopting specific, staged national energy access targets and allocating funds for their achievement (Hailu, 2012; Birol, 2012). For many commercial enterprises in developing countries, unreliable and costly supplies of electricity and modern fuels impede production, growth and development and for the vast majority of Africans.

Lack of access to modern energy services constitutes a major obstacle for achieving an improved quality of life, and in the wider sense an impediment to the continent's development objectives (Sokona, Mulugetta and Gujba, 2012). The global effort to address the energy access problem, particularly in developing countries, aspires to completely bring the challenge within the fold by 2030 (Hailu, 2012). In some of the rapidly growing economies like India projections show an electrification rate of 98% in urban areas and 84% in rural areas by 2030 (Birol, 2012).

Thus, access to modern energy services (including equipment and machineries) at all stages of production in this sector will be critical to income generation and poverty alleviation from level one where it only meet basic needs, level two where it is available for production uses and level 3 where access to modern energy will improve the quality of life in general (Birol, 2012; Sokona, Mulugetta and Gujba, 2012). Figure 2.15 presents an increase of energy uses due to improved access to modern energy.

Figure 2.15: Increase of energy uses due to improved access to modern energy



Source: Sokona, Mulugetta and Gujba (2012: 5) cited in Advisory Group on Energy and Climate Change (2010)

2.6.2 Energy infrastructure

Huge investments are necessary to expand energy access, develop new energy technologies, replenish aging infrastructure and build new energy infrastructure assets and associated supply chains (Khennas, 2012; World Energy Council, 2012b). Expansion of modern energy services will include construction of infrastructure to the approximately 1.3 billion people without electricity and 2.7 billion without clean cooking facilities is estimated to require U$48 billion per year until 2030, representing only a 3% increase on total investment (World Energy Council, 2012b).

In developing countries, high-capacity power lines that enable long-distance electricity transmission which supply rural areas with electricity, while featuring efficient and flexible operation and control, require high automation and self-adaptation mechanisms will be necessity (World Energy Council, 2012b). Moreover, with the large-scale exploitation and utilisation of renewable energies, connecting renewable energy power to the grid becomes an urgent task. Power utilities and investors prioritise investments in urban infrastructure and often subsidise grid electricity to existing customers instead of expanding access or incorporating off grid technologies (Sovacool, 2013).

2.6.3 Energy demands and security of supply

The UNEP (2011) observes that energy security concerns are particularly relevant for low-income countries, but also for emerging and developed economies, where a relatively high dependence on a limited range of suppliers can mean higher risks to the security of national energy supply due to geo-political and other developments; risks can also impinge on energy security at local levels (UNEP, 2011).

Energy security gives assurance of the individual consumer's energy needs, securing economic interests of the society and the state from both internal and external threats (Augutis, Martišauskas and Krikštolaitis, 2015). The definition and dimensions of energy security is dynamic, and evolve as circumstances change overtime, and it is shaped by technologies advances and awareness of climate change (Ang, Choong and Ng, 2015). The projected economic and population growth from roughly 7 billion to 9.3 billion people by 2050 as well as the aspirations of a rapidly growing global middle class, will drive energy demand (World Energy Council, 2012b). World population is predicted to rise 35% by 2050 (Lior, 2012). Climate change and security of supply, energy poverty is an issues that will dominate public concern over coming decades (Oldfield, 2011).

This estimate is based on the current trend of slowly declining population increase rate, but some populous countries are at this time encouraging their population growth or implicitly allowing it, so the population increase may in fact be much larger and energy consumption is expected to increase substantially (Lior, 2012; Suganthi and Samuel, 2012). The USA as one of the leading energy per capita-users and CO2 emitters, for the UK arbitrarily chosen as a developed country that has a very high standard of living using a much smaller amount of energy per capita than the US (Lior, 2012). Energy demand management is critical to meet the needs of the community.

Energy demand management involves effective utilisation of the energy resources, reliability in supply, efficient management of energy resources, energy conservation, combined heat and power systems, renewable energy systems, integrated energy systems, independent power delivery systems, etc. (Lior, 2012; Suganthi and Samuel, 2012). Meeting energy demands of rapidly growing populations through renewable energy has always been raised as a concern.

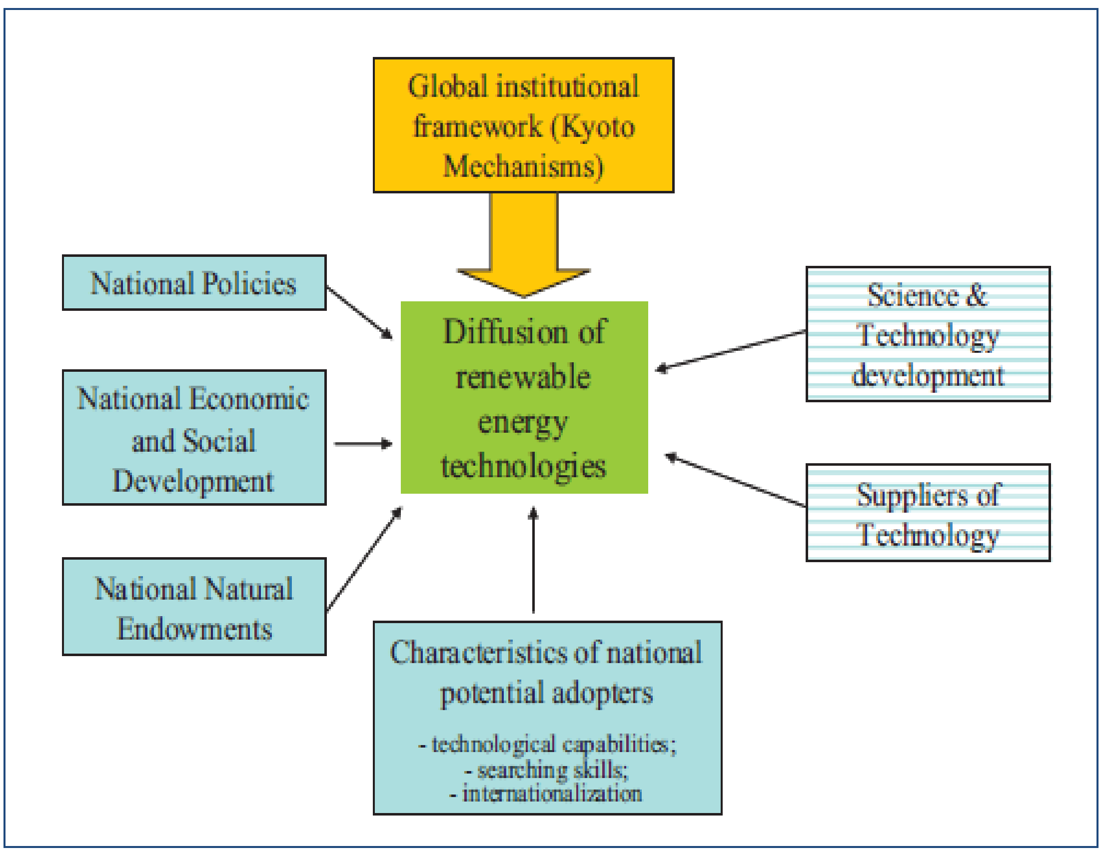
In the case of India Sukhatme (2011) argues that even with a frugal per capita electricity need of 2 000 kWh/annum and a stabilised population of 1 700 million by 2070, India would need to generate 3 400 TWh/yr, systematic analysis of the information available on all the renewable energy sources indicates that the total potential is only around 1 229 TWh/yr. In the future as fossil fuels are exhausted, renewable sources alone will not suffice for meeting India's energy needs. India's economy which is growing at the rate of 8% or 9% every year for the past few years, and a high growth rate is projected for the years ahead (Sukhatme, 2011). According to the World Energy Outlook prepared by the International Energy Agency, the global demand for energy will be more than 50% higher in 2030 than today; China and India alone will together account for 45% of the increase in demand in this scenario (Zhang et al., 2013).

2.6.4 Technological innovation

As the cost-competitiveness of renewable technologies remains driven by technological, market and institutional factors, countries having more researches and practical experiences have more opportunities to achieve diffusion of renewable energy (Thiam, Benders and Moll, 2012). Energy technologies can be optimised to meet the needs of developing and developed nations, as part of achieving a global objective of stabilising and reducing emissions of greenhouse gases and adapting to inevitable climate impacts (Oldfield, 2011). It is therefore imperative that investment in green energy and related technologies are scaled up to ensure the global energy access and stability by reducing the harmful effects of the fossil-based energy consumption (Midilli, Dincer and Ay, 2006). Up front communication with the community about the costs associated with the use of electricity also contributes to the success of implementation (Barry, Steyn and Brent, 2011).

The involvement of the community has also been shown to be especially important for the success of renewable energy technology implementation (Barry, Steyn and Brent, 2011). China optimised the diversifications of energy utilisation technology, choosing those products and technologies that are, mature, and feasible (Kammen and Kirubi, 2008). Freitas, Dantas and Lizuka (2012) indicate factors that influence the diffusion of renewable technologies to include: national policies, endowments with natural resources, science and technology development, suppliers' technology and characteristics of national adopters; these have an influence on the decision to adopt a certain energy technology. Figure 2.16 illustrates factors affecting the diffusion of renewable technologies.

Figure 2.16: Factors affecting the diffusion of renewable technologies



Source: Freitas, Dantas and Lizuka (2012: 119)

2.6.5 Financing mechanisms for green energy

Renewable energy investments must be conducted with caution because they are characterised, by irreversibility of the investment, an uncertainty environment and flexibility in the decision process. Renewable green investment has risen substantially during the past decade, with most of the increase occurring after 2004, between 2000 and 2010, renewable green investment increased more than 20-fold from $7 billion to $154 billion (Eyraud, Clements and Wane, 2013). With costs that cannot be recovered once the project is carried out and high uncertainty about its future profits, there can be a significant value to postponing the investment, also referred to as a value of waiting (Boomsma, Meade and Fleten, 2012). The main drivers of the increase include global economic growth, increasing prices of fossil fuels, technology advances, policy support, and increasing demand of populations for a cleaner environment (Eyraud, Clements and Wane, 2013).

The profitability of most renewable electricity investments strongly depends on public incentives, the value of a renewable energy project further depends on the flexibility of the investment (Boomsma, Meade and Fleten, 2012; Pegels, 2010). With costs that cannot be recovered once the project is carried out and high uncertainty about its future profits, there can be a significant value to postponing the investment, also referred to as a value of waiting (Boomsma, Meade and Fleten, 2012). Investments in renewable energy are most extensively employed through support schemes, namely, feed-in tariffs and renewable energy certificate trading (Boomsma, Meade and Fleten, 2012; Pegels, 2010). These two regimes may differ in terms of the level of subsidy payments but also in the degree of risk exposure to an investor (Boomsma, Meade and Fleten, 2012).

Renewable energy support schemes worldwide were first applied successfully in Germany; the scheme has spread to more than 40 countries. The idea behind a feed-in tariff is to guarantee producers fixed tariffs for power from renewable energy sources over a certain period of time, in most schemes 10-20 years. The profitability of most renewable electricity investments heavily relies on public incentives and in particular the support scheme employed (Boomsma, Meade and Fleten, 2012).

2.6.5.1 Feed-in tariff

Feed-in tariffs are based on the theory that the initial capital costs of developing renewable energy deter investors because they are prohibitively high, but investors will not be deterred by those initial costs if they are guaranteed a certain level of return over time (Streich, 2009). Accurate calculation of the tariff to be applied is vital, if the feed-in tariff is set too low, it will not provide sufficient incentives to the investors, thereby defeating the purpose (Boomsma, Meade and Fleten, 2012). If the feed-in tariff is too high, it will create high rent and not be cost-effective (Boomsma, Meade and Fleten, 2012). Governments have developed two main methods for calculating the ideal tariff, one approach bases the tariff amount on the value of renewable energy generation to the utility and/or society, and the other focuses on the levelised cost of renewable energy generation (Streich, 2009).

The first approach determines the level of payment based on the value of the renewable energy, either to the utility or to society (Boomsma, Meade and Fleten, 2012; Pegels, 2010). This value can be determined by assessing the utility's avoided costs or by internalising the external costs of other sources of electricity generation (Boomsma, Meade and Fleten, 2012). By definition, external costs are not borne by the energy producer; instead society bears these unaccounted-for costs in the form of increased health care expenses, depleted agricultural resources, and a reduced quality of life (Streich, 2009).

Through the implementation of feed-in tariffs, electricity market price risk is either completely removed or the investor is exposed to electricity market price risk only (with what is known as a price premium) (Boomsma, Meade and Fleten, 2012; Streich, 2009). A feed-in tariff involves a payment to the renewable electricity producer proportional to the volume fed into the (Boomsma, Meade and Fleten, 2012).

This can be implemented as a fixed tariff for electricity or as an electricity price premium. Under a fixed feed-in tariff, the renewable producer power producer receives a fixed payment that is independent of the electricity spot price, whereas under a price premium, he/she receives a payment on top of this price (Boomsma, Meade and Fleten, 2012). Renewable energy project often involve higher upfront costs than their conventional energy counterparts (Boomsma, Meade and Fleten, 2012). Renewable energy support schemes worldwide were first applied successfully in Germany and the scheme has spread to more than 40 countries. The idea behind a feed-in tariff is to guarantee producers fixed tariffs for power from renewable energy sources over a certain period of time, in most schemes 10-20 years. This creates a basis for long-term investment planning, since revenues are known and guaranteed in advance (Pegels, 2010).

The World Future Council (2007) observes that, one of the most frequent arguments against feed-in tariffs is that they are expensive, to a large extent, these arguments are the same that have been levelled at renewable energy technologies since the advent of the industry, and are not so much an argument against feed-in tariffs as they are against renewables in general. Essentially, the core of this argument is that the incremental costs of renewable energy above conventional fuels makes renewable energy investments a mistake for society.

According to World Future Council (2007:1) a well-designed feed-in tariff generally includes the following features:

- Long-term contracts with pre-determined prices.
- Rates (or tariffs) based on the cost of generation plus a reasonable profit, not based on avoided cost-in other words, the targeted resources receive a payment rate that reflects what they need to be profitable, rather than a rate tied to fossil fuel generation or average wholesale prices.
- Tariff rates that are adjusted periodically, for example every two to four years or automatically according to a pre-set schedule, in order to respond to changing market conditions and place downward pressure on prices.
- Technology-specific rates (e.g. wind receives a different tariff than solar).
- Policy costs that are incorporated into electricity rates, rather than recovered from taxpayers.
- A streamlined application process that is open to all potential participants.

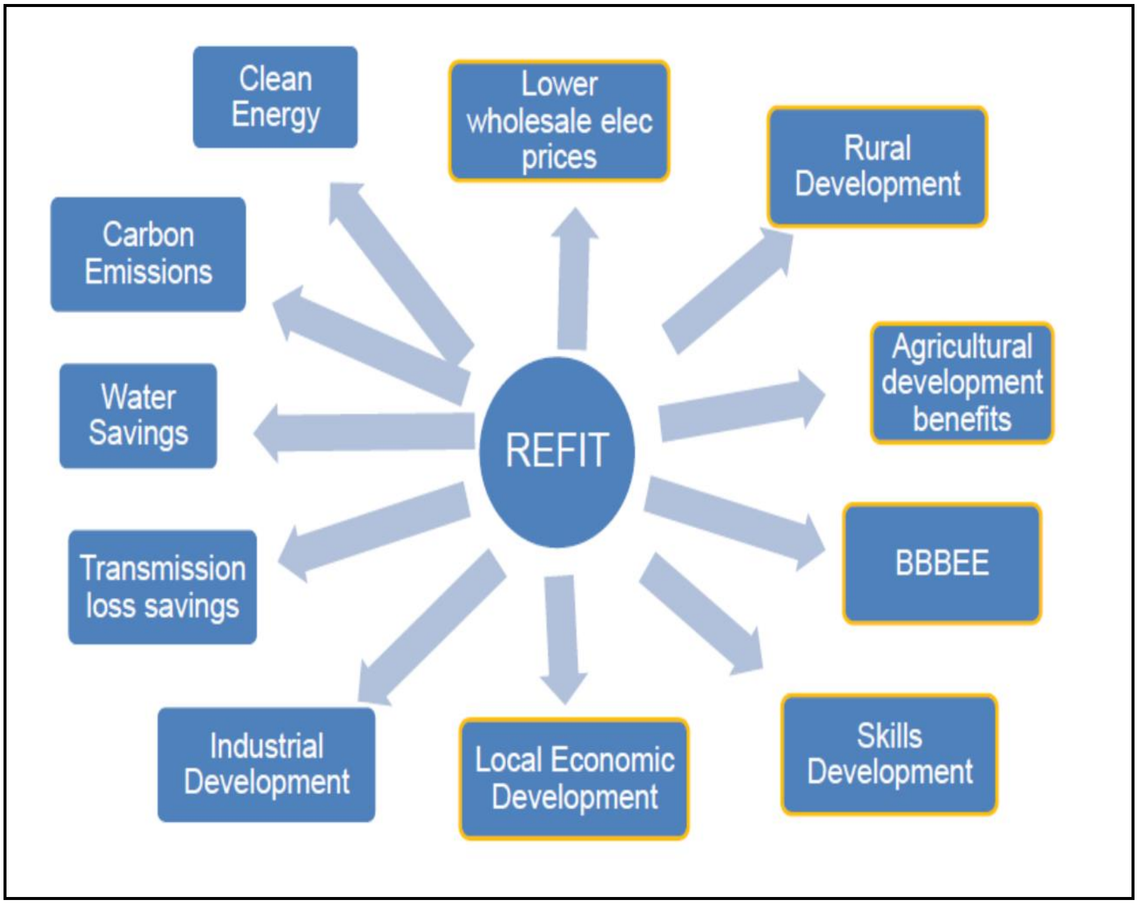
Chown (2011) comments on proposed National Energy Regulator of South Africa (NERSA) tariff revisions for the year 2011 suggest the following considerations:

- Renewable energy developers must not earn outsized returns at the expense of consumers and Renewable Energy Feed - in Tariffs (REFIT) need to be reviewed periodically in order to ensure that consumers are getting fair value.
- Tariffs must reflect the true cost of production and risk and be attractive enough to overcome significant risk capital that will continue to be spent. Methodology for tariff-setting must be transparent and

understood by all and initial tariffs must be attractive enough to attract private and foreign investment.

Figure 2.17 illustrate Value of Renewable Energy Feed - in Tariffs (REFIT).

Figure 2.17: Value of Renewable Energy Feed - in Tariffs REFIT)



Source: Chown (2011: 4)

Germany is another success story in terms of the development of rapid renewable energy industry largely due to the country's feed-in tariff program, which has had incredible ecological and economical effect (Streich, 2009).
Germany's use of renewable energy resulted in the creation of more than 300 000 jobs by 2009, and in that year alone, the renewable energy industry accounted for the avoidance of almost 118 million tons of CO_2, by 2009; renewable energy source represented 16.1% of Germany's total gross

electricity consumption and 8.9% of the country’s primary energy consumption (Streich, 2009). Instead of relying on huge government subsidies, Germany has produced these results largely by raising the electricity costs of each household approximately €3.4 per billing cycle. That ability to jumpstart investment in renewable energy while avoiding excessive government subsidies has made Germany’s policies especially attractive to other governments trying to meet target levels of reliance on renewable energy. According to Apak, Atay and Tuncer (2011) the German government expects the use of renewable energy to increase the creation of jobs to 400 000 by 2020.

China has been enjoying the world’s fastest economic growth and this has triggered fast growing energy consumption especially fossil energy; one report from Chinese Academy of Science predicts that the total energy demand amount will reach 2.89-3.88 billion tonnes standard coal equivalents in 2020 (Zhang et al., 2013). China has set an ambitious 5 year development goal for renewable energy: by 2010, 10% of total energy consumption was to come from renewables, rising to 15% by 2020; one of the reasons why both the onshore and offshore wind energy sectors in China are rapidly growing is the successive national and regional laws and policies that promote the sector’s development (Leary and Esteban, 2011).

2.6.5.2 Certificate trading

In contrast, the implementation of renewable energy certificate trading allows for a significant risk from market prices of both electricity and the certificates themselves (Boomsma, Meade and Fleten, 2012).

The levy is borne by taxpayers or consumers, in spite of the risk that the tariff will be reduced if consumers object to paying the levy (Boomsma, Meade and Fleten, 2012). Renewable energy certificates are issued to the renewable power producer in proportion to the volume generated and traded when portfolio standards or quotas obligate suppliers or consumers to produce or use a certain share from renewable energy sources and demonstrate compliance with a required number of certificates (Boomsma, Meade and Fleten, 2012). Cap and trade encourages firms to reduce emissions at a cost lower than the allowance price; doing so means firms will reduce their compliance costs because fewer allowances need to be purchased, or they will have surplus allowances that can be sold to others (Kammen and Kirubi, 2008).

After a price is set, the financial cost of implementation is divided up and passed on to energy consumers; individually, each consumer faces only negligible rate hikes (Streich, 2009). Around the world, developing countries are seeking to rapidly scale-up renewable energy investment. In spite of the flexibility of the investment, most likely, the costs of a renewable energy project cannot be recovered once the project is carried out (Boomsma, Meade and Fleten, 2012). Renewable energy projects often involve higher upfront costs than their conventional energy counterparts (Boomsma, Meade and Fleten, 2012).

The cost of capital shows the return expected by investors on the capital they supply to finance a renewable energy project, and should be competitive with the returns on alternative investments with the same risk profile (Fagiani, Barquı´n and Hakvoort, 2013). For these reasons, policy makers should pay particular attention to how support policies affect the risk of renewable energy projects (Wustenhagen and Menichetti, 2012; Fagiani, Barquı´n and Hakvoort, 2013). However, not all the types of risk are equally affected by policy decisions.

They exceed the normal electricity price paid by consumers and ideally enable the investor to cover his costs and earn a reasonable return on his investment.

The additional costs due to the higher tariffs are passed on to all power consumers in the form of a premium per kilowatt hour. In some schemes, tariffs are adjusted over time to prevent consumers from paying unnecessarily high prices and to allow for technology learning curves. However, these adjustments must be predictable if investment certainty is to be maintained (Pegels, 2010). Despite having already implemented a renewable energy support scheme, governments occasionally alter the choice of support scheme (an example is the replacement of competitive tendering in the United Kingdom with the tradable certificate trading) (Boomsma, Meade and Fleten, 2012; Onyeji, Bazilian and Nussbaumer, 2012).

This experience shows that, unfortunately, energy savings need many actions. The best energy saving results is the result of many measures in parallel: legislation, financing and information are the three pillars required (Koskimäki, 2012). Measures concerning energy consuming products are a good starting point.

2.7 THE ROLE OF ENERGY IN SOCIETY

Job creation is an especially pressing issue as the world recovers from one of the most severe recession in decades with double digit unemployment rates in many countries particularly in developing countries (Wei, Patadia and Kammen, 2010). Many regions of the world are starting to align their economic development to energy consumption, energy based economic development is a process by which economic developers; energy policymakers and planners; government officials; industry, utility, and business leaders; and other stakeholders in a given region strive to increase energy efficiency (Carley et al., 2011; Zhang et al., 2013).

2.7.1 Economic growth and development

Development implies the general concept of improvements in material well-being, such as better health services and education (Welle-Strand, Ball, Hval and Vlaicu, 2012). In poor regions severe electricity shortages often go together with poor general infrastructure provision, little business mobility, and limited access to markets needed for investment and production to be profitable and self-sustainable (Odhiambo, 2010; Welle-Strand et al., 2012). Electricity's contribution to poverty alleviation and economic development may be substantial, which suggests that targeting aid disbursements on electricity infrastructure can be an effective means of encouraging economic growth (Xie, 2009).

Debate is still raging about the role energy plays in economic growth. According to Odhiambo (2010: 2463) the main stream views are:

- Economic growth causes energy consumption and that as the economy grows the demand for energy from different sections of the economy increases.
- The other view is that, it is the consumption of energy that causes economic growth.
- The third view argues that both electricity consumption and economic growth cause each other, i.e. that there is a bi-directional causality between electricity consumption and economic growth.

While these three views support the causal relationship between energy consumption and economic growth, the fourth view contends that there is no causal relationship between energy consumption and economic growth. In other words, both energy consumption and economic growth are neutral with respect to each other (Odhiambo, 2010).

Many international aid strategies as well as domestic policies in countries around the world have been focusing on aid efforts on a number of factors believed to be critical for positive and sustainable development outcomes and one factor which has been continually emphasised is economic growth (Odhiambo, 2010; Welle-Strand et al., 2012). Carley et al. (2011) define economic development as a process of creating wealth for regions, nations or subnational regions such as states and countries and improving the economic opportunities for the people that live and work within them. Desired results from this process include improved standards of living and reduced levels of poverty (Welle-Strand et al., 2012).

Diversifying energy a resource is widely recognised as a strategy to contribute for job creation, job retention, and regional wealth creation (Carley et al., 2011). There is a drive around the world to fast track low carbon economy is a new kind of pattern of the economic development with the features of low energy consumption, high efficiency, and less pollution (Xie, 2009). As energy prices rise and regions must spend a greater share of their fiscal resources on imported energy resources, the perceived need to replace imported energy with home-grown energy continues to rise (Carley et al., 2011).

Low carbon economy is widely regarded as the most important progress ever made for human civilisation next to the agricultural revolution and industrial revolution (Xie, 2009). The nature of low carbon economy refers to the low carbon energy in the economic activities and develops the clean and efficient technologies for the fossil energy (Wei, Patadia and Kammen, 2010). Economic development also works to improve factors that contribute to a healthy economy, such as business climate, workforce, healthcare provision, education, and quality of life (Carley et al., 2011). According to Wei, Patadia and Kammen (2010) there are three key arguments for building a domestic clean energy industry: improved energy security, environmental protection and benefits, and as a potential engine for economic growth.

Businesses have a choice either to increase output and energy consumption together using existing systems of production or to restructure their systems of production to increase energy efficiency and benefit from an increased supply of useful work per unit of energy consumed (and paid for) (Warr and Ayres, 2010). Such decisions must be made in light of estimates of the future cost of energy supplies against capital costs/process modifications required to increase energy efficiency (Warr and Ayres, 2010).

2.7.2 Rural economies and green energy

Javadi et al. (2013) define rural area as a region which is not urbanised and one of the main characteristics of rural area is its low population density and high portions of the lands in rural areas are normally devoted to agriculture. Expanding renewable energy access for rural and increasingly poor communities is a daunting task in many parts of the world (Sovacool, 2013; Hailu, 2012). Therefore, there is no unique definition of the rural area that can be applied to all regions in the world and it can be variable from each country to another.

However, the most critical aspect in the rural area rather than low population density is less access to energy sources, lack of education, health, and welfares (Javadi et al., 2013; Sovacool, 2013; Hailu, 2012). Increasing access to affordable and reliable energy services is an approach to reduce the energy poverty in these regions (Javadi et al., 2013). Many renewable energy strategies such as solar thermal energy systems and electrical generation systems such as photovoltaic, wind and small-scale hydro can make a contribution to on farm as well as off-farm applications (Javadi et al., 2013; Sovacool, 2013; Hailu, 2012).

In addition there are possibilities to generate on-farm energy requirements from on-farm sources such as agricultural wastes and other biomass derived energy sources that can effectively replace fossil fuels (Nnadi et al., 2011). Those without electricity or dependent on traditional fuels tend to have low income levels, purchasing power, and consumption levels far below what private companies and electric utilities typically deem profitable, reluctance further attenuated by the inaccessibility of the these communities to national electricity grids (Sovacool, 2013). However, a new type of Public Private Partnership (PPP) has emerged in recent years involving governments as well as private companies, microfinance institutions, multilateral development banks, and non-profit organisations (including NGOs) in expanding access to energy services (Sovacool, 2013; Nnadi et al., 2011).

Many international donors continue to focus only on pushing particular technologies instead of holistically utilising energy services to improve standards of living and productivity for rural communities (Sovacool, 2013). Consumers in Africa for example, do not easily accept renewable energy technologies because they lack knowledge about the advantages and opportunities for using these types of technologies (Barry, Steyn and Brent, 2011).

In order to derive technical benefits from the application of energy innovation technologies in poorer areas, Alazraque-Cherni (2008) advises that innovation must be positioned in conjunction with other aspects of sustainability such that societal and environmental improvements may happen at the same time. In developing countries on the other hand, because of the lack of skilled resources, the emphasis is on technology selection and transfer to achieve rapid economic and social development (Barry, Steyn and Brent, 2011). The risk challenges facing the renewable energy sector can be addressed through adequate technical assistance programmes that can help project developers and others understand the benefits of financial risk management.

In addition, the development of technology specific insurance cover public and private financial institutions would encourage an increased number of renewable energy projects (Apak, Atay and Tuncer, 2011). Poverty and dependence on traditional sources of fuels go hand in hand and as household incomes rise, people normally switch to modern fuels, if these are available (Nnadi et al., 2011; Apak, Atay and Tuncer, 2011). Energy inputs are critical to agricultural production and long-term sustainability of global agricultural production will require renewable alternative energy resources (Nnadi et al., 2011). There are many systems that can provide on-farm energy resources from renewable sources.

Solar energy, wind and small scale hydro systems can provide on-farm as well as off-farm energy resources and these renewable resources have a huge potential for the agriculture industry (Nnadi et al., 2011). The principal energy services utilised by households residing in rural agriculture based settings in developing countries can be categorised into (a) lighting, power for mobile phone recharging, other media and information technologies such as radio and television, (b) cooking and heating and (c) agro-processing and/or pumping (Adkins, Oppelstrup and Mod, 2012). The concepts of sustainable food, fibre and feed production lies on a delicate balance of maximising productivity and maintaining economic stability, while minimising the utilisation of finite natural resources and detrimental environmental impacts. It also emphasises replenishing the soil for future use (Nnadi et al., 2011).

Lack of access to modern sources of energy is more conspicuous in rural areas in African States, rural access rates below 10%; however, a significant energy resource potential is a feature of the continent at large (Hailu, 2012).
Hence, there is a need for promoting use of renewable energy systems for sustainable food production, for instance, solar photovoltaic water pumps and electricity, greenhouse technologies, solar dryers for post-harvest processing, and solar hot water heaters and so on (Hailu, 2012).

The energy requirements for production agriculture, less than 3% of global energy use, represent a small portion of the demand for fossil fuels, but are a critically important input to the food, feed and fibre production system. Interest in reducing the dependence on fossil fuel for agricultural production increased dramatically just after the oil embargo of 1973 (Nnadi et al., 2011). Other realities in Africa, such as poverty alleviation, can derail the implementation of renewable energies as conventional energy implementation is cheaper in the short-term (Barry, Steyn and Brent, 2011).

2.7.3 Employment potential in the green energy sector

Green energy can create many domestic jobs, directly and indirectly, and additionally, many of these jobs are guaranteed to stay domestic as they involve construction and installation, by investing in energy efficiency measures, money otherwise spent on energy costs can be redirected to stimulate the economy through job creation (Wei, Patadia and Kammen, 2010).

Access to modern energy services can expand income generating activities that can greatly reduce poverty particularly in rural areas (Sovacool, 2012). Poverty and energy deprivation go hand-in-hand, with energy expenses accounting for a significant proportion of household incomes in many developing countries. In the agricultural sector modern energy is needed to operate agricultural machineries and irrigation systems, and processing, preservation, storage and transport of agricultural products, etc., which contribute to rural agricultural development and triggers employment opportunities (Sokona, Mulugetta and Gujba, 2012). The rising installation of renewable energy systems in some European countries such as Germany, Denmark and Spain, more recently also in other parts of the world such as China, have intensified the discussion of costs and benefits of renewable energy systems (Lehr, Lutz and Edler, 2012).

Renewable energy provides an opportunity for job creation, through replacing out-dated infrastructure and developing better energy conservation and production practices, a foundation is built for future domestic stability and growth (Wei, Patadia and Kammen, 2010). The German wind industry, for instance, makes up to 70% of its 2009 turnover from exports. Hydro energy and solar modules also exhibit high export shares in their respective turnover (Lehr, Lutz and Edler, 2012).

Green energy jobs present many challenges; critics of green job studies cite allegedly incomplete accounting for the costs of green job programmes, namely the jobs that are lost or shifted by such programmes (Wei, Patadia and Kammen, 2010). Renewable energy industry is a high-opportunity branch that faces growing product demand and is attractive to investors. Successful stories like the wind energy industry in Germany indicate that entrepreneurs can play an important role in stimulating renewable energy industry, in creating new branch for industry growth, and even in reshaping regional industrial structure, contributing to regional sustainable development (Liuxu, 2008).

It also offers the potential to enhance the reliability of energy source and system resilience, provided through a combination of centralised and distributed (decentralised) technologies and systems (Sokona, Mulugetta and Gujba, 2012). The international community has clear economic, political, and environmental and energy security interests in helping poor countries along the path to energy development but as long as poverty persists, the poorest regions will remain vulnerable to social and political instability and to humanitarian disasters (Birol, 2012).

2.7.4 Green energy and gender

Energy poverty generally affects both the gender roles within society particularly educational opportunities and healthcare.

Females are generally exposed to physical injury collecting fuel and bear the brunt having to bear the costs of fuel and stoves; and time impacts related to fuel and water collection, cooking, and the care of sick children (Sovacool, 2012). In developing countries many children, typically girls, are withdrawn from school to complete their chores, including cooking and fuel wood collection and lighting (Alazraque-Cherni, 2008; Sovacool, 2012). Renewable energy technologies can extend the time children have to study at night, and can also lead to better equipped schools with computers and the internet (Sovacool, 2012). In developing countries poor families spend one-fifth or more of their income on wood and charcoal, devote one-quarter of household labour collecting fuel wood (Sovacool, 2012).

2.7.5 Benefits of green energy projects to local communities

According to Donnelly (2012: 14) renewable energy projects socio-economic benefits for local communities include:

- Local job creation through construction and operations phase of the project.
- Local content through assembly and construction activities.
- Rural development and community involvement through direct investment.
- Plans to expand education and development skills given active project involvement.
- Extensive black economic empowerment enterprises being established.
- Socio-economic development in the region.
- In addition the project can actively invest in socio-economic development initiatives, focusing on, although not limited to: Education; Health and HIV/AIDS; Skills development and Environmental conservation.

2.8 BARRIERS TO THE TRANSITION TO GREEN ENERGY SECTOR

According to the SE4ALL (2014: 121) several barriers must be overcome if universal access to energy is to be achieved, the barriers are not insurmountable, but they will require the collective strengths of national governments, the private sector, and civil society. Some of the common barriers are listed below.

2.8.1 Conflict with local communities

Large scale development of renewable energy structures often occurs in relatively undeveloped and rural landscapes and research shows increased conflicts as structures become more numerous and McPartland (2012) cautions that some of these structures, wind turbines and solar collectors are particularly visible from long distances and require being in high or open areas. Communities located or invested in areas where development exists have largely responded negatively to these highly visible structures and the potential for future conflicts, as well as partnerships, between renewable energy developers and these communities will increase proportionately with expanded development (McPartland, 2012).

2.8.2 Capital market restrictions

Less experience on the lender side with renewable energy technologies result in higher risk premiums and uncertainty on future revenues may also be an impediment to attract project finance (Lehmann et al., 2012). This not only affects the total system costs which have to be paid for by consumers but also the market share of renewable energy technologies, since the latter generally have a different risk profile compared to conventional generation (Fagiani, Barquı´n and Hakvoort, 2013).

2.8.3 Uneven political playing field

Apart from market failures, as observed by Lehmann et al. (2012), the implementation of renewable energy technologies is also hampered by the existing political framework, which often puts fossil fuels at an undue advantage over renewable energy. According to Pasqualetti (2011), the first thought might be that barriers erected to renewable are politically motivated, and no doubt that factor is important in the introduction of anything as fundamental as a change in the source of electricity.

2.8.4 Planning consent and policy commitment

Traditionally, spatial development plans preferred centralised (fossil-fuel) over spatially dispersed renewable energy generation projects (Lehmann et al., 2012). Complicated and lengthy planning procedures, often involving many different authorities, imply larger (ex-ante) per-unit costs for small-scale renewable energy projects than for large-scale fossil-fuel investments (Collier and Venables, 2012; Lehmann et al., 2012). Uncertainty about future modifications of support schemes and other legislation around renewable energy facilities, such as technical standards, can also deter renewable energy investors and particularly suppliers of equipment (Fadel et al., 2013).

2.8.5 Lack of network infrastructure

One major driver of energy demand is population growth; its rapid increase coupled with industrialisation in the 20th century has brought about a huge energy demand; energy infrastructure serves as an essential input into private sector production (Oseni, 2012). Lack of access to energy infrastructure seriously hinders economic growth, undermines employment and consequently results in a vicious circle of poverty (Oseni, 2012; Nkwetta et al., 2010).

Grid extension has not caught up with the boost of renewable energy capacities; existing grids are increasingly reaching their capacities in transmitting renewable energy (Nkwetta et al., 2010; Lehmann et al., 2012). A lack of network capacity can become a barrier to new projects. Furthermore even if capacity is available, significant cost of network connection, in particular for offshore wind, can be a significant barrier to renewable energy deployment if it has to be financed by project developers (Lehmann et al., 2012).

Transmission networks are natural monopolies, due to economics of scale and scope and because of the physical properties of electricity that require network management to be integrated for stability reasons. To prevent the abuse of market power, monopolist network operators are usually regulated. Since transmission capacity, connection policies, system management, and grid codes are crucial for the deployment of renewable energy and renewable energy integration (Lehmann et al., 2012).

2.8.6 Intermittency, controllability and securing peak capacity

Non-interrupted supply, power quality and stable frequency are public goods in the electricity system (Lehmann et al., 2012). One of the drawbacks of renewable energy supply is that it is intermittent and dependent on external factors such as wind speeds and solar radiation (EIA, 2013). The volatility of renewable energy supply in combination with reduced controllability of renewable energy, particularly if generated by wind turbines or photovoltaic, is nonetheless highlighted as a major drawback (Fagiani, Barquı´n and Hakvoort, 2013). Transmission networks are usually managed by Transmission System Operators that are responsible for a certain geographical region (control area), typically of the size of countries or smaller (Lehmann et al., 2012).

2.8.7 Lack of information sharing and awareness

Many countries are faced with a series of barriers that preclude renewable energy from market penetration including a lack of information sharing and awareness, a lack of regulatory frameworks, a restricted access to renewable energy technologies (Fadel et al., 2013). High up-front investment cost or a lack of access to capitals, a lack of standards and certification, a lack of skilled professionals and training facilities as well as trade barriers national levels limited work has assessed the role of international, regional, and at times national organisations in tackling renewable energy knowledge barriers (Fadel et al., 2013).

Dominant firms tend to invest mainly in incremental improvements of technologies that are currently in use rather than in fundamental technological change (Kammen and Kirubi, 2008; Gujba, Thorne, Mulugetta, Rai and Sokona, 2012). They may also use their market power to impede the entry of new competitors, operating, for example, renewable energy installations (Lehmann et al., 2012). Thus, there are fewer operating firms investing in innovation, which reduces the probability of a technological break-through (Lehmann et al., 2012).

2.9 SUSTAINABLE ENERGY SOLUTION

The motivation for a transition to green energy is not a legal mandate for both developing and developed countries; it is largely recognised as a moral gesture in response to global climate challenges. Sustainable energy solution entails complex interwoven links between public and private actors, governments and regulators, economic and social factors, national resources, environmental concerns and individual behaviours (World Energy Council, 2012a).

In order to expedite a transition to sustainable energy solution, the year 2012 was declared year of energy access and 2030 has been set as the year for achieving universal access to modern energy service, in public policy debates at the national level, and no longer the sole concern of donor agencies and multilateral institutions (Sokona, Mulugetta and Gujba, 2012). The United Nations conference (Rio + 20) reaffirmed support for the implementation of national and sub-national policies and strategies, based on individual national circumstances and development aspirations, using an appropriate energy mix to meet developmental needs, including through increased use of renewable energy sources and other low-emission technologies, the more efficient use of energy, greater reliance on advanced energy technologies, including cleaner fossil fuel technologies, and the sustainable use of traditional energy resources (United Nations, 2012).

The conference committed to promoting sustainable modern energy services for all through national and subnational efforts, inter alia, on electrification and dissemination of sustainable cooking and heating solutions, including through collaborative actions to share best practices and adopt policies, as appropriate (United Nations, 2012). A sustainable energy solution which enhances environmental protection and economic growth is critical, particularly in developing countries. The World Energy Council (2012a) definition of energy sustainability is based on three core dimensions - energy security, social equity, and environmental impact mitigation. A study on sustainable energy solution commissioned by the World Energy Council (2012a) solicited opinions of Chief Executive Officers and senior executives from leading energy companies and they have three main recommendations for how policymakers must expedite the development of sustainable energy systems:

- Design coherent and predictable energy policies.
- Support market conditions that attract long-term investments.
- Encourage initiatives that foster R&D in all areas of energy technology.

SE4ALL (2014) argues that energy access solutions are context-specific and need to be supported by efforts to build the capacity of local institutions; most address generic problems found in all or most countries seeking to deliver access to modern energy; they involve financial, planning, and regulatory measures needed to strengthen the operating environment of private developers and service providers. As highlighted by SE4ALL (2014:121) a set of common elements will have to be put in place to overcome those barriers and they include:

- High-level commitments on the part of each country's political leadership to achieving universal energy access.
- A realistic energy-access strategy and clear implementation plans linked to overall national development and budget processes.
- Strong communication campaigns to inform stakeholders of planned changes and related benefits.
- Sufficient funding to support the delivery of energy services from appropriate sources and at affordable rates.
- An increase in financing from all sources and in various forms is required, from large projects down to the micro level.
- A robust financial sector, willing to lend to the energy sector and to provide end-user financing.
- A legal and regulatory framework that encourages investment.
- The active promotion of project and business opportunities and a consistent flow of deals or transactions to attract a critical mass of private sector players (such as banks).
- Processes to match actors around specific projects and proposals, particularly in public-private partnerships.
- Energy access for community institutions (for example, rural multifunctional platforms, typically driven by diesel that powers pumps, grain mills, generators etc.).

- The means to support successful small-scale projects and solutions to reach a larger scale.
- Robust and effective public utilities.
- Strong internal capacity, potentially supported by external technical assistance.
- A deliberate effort to improve the availability of accurate and timely information.
- Reconciliation of regional and national interests in energy projects.

2.9.1 Design coherent and predictable energy policies

The Environmental outlook baseline to 2050 scenario envisages that without more ambitious policies than those in force today, GHG emissions will increase by another 50% by 2050, primarily driven by a projected 70% growth in CO2 emissions from energy generation and use. This is primarily due to a projected 80% increase in global energy demand (Marchal et al., 2011).

It is not yet clear whether and how sustainable energy discussions can be integrated into sectorial policy decisions that enable the practical implementation of widening modern energy access (Marchal et al., 2011; Sokona, Mulugetta and Gujba, 2012). Part of the explanation is that energy cuts across many sectors and therefore requires a cross-sectorial conversation, which does not sit well with the traditional approach in development planning (Sokona, Mulugetta and Gujba, 2012). The World Energy Council (2012a) indicates that global energy sustainability requires addressing three challenges in the energy sector:

- Energy security - whether it is security of supply or demand - to fuel economic growth.
- Energy access and the reduction of energy poverty.
- Environmental impact mitigation.

2.9.2 Support market conditions that attract long-term investments

It is imperative that clear and unambiguous policies are adopted to ensure sustainable energy systems support market conditions that attract long-term investments. Contradictory and ad hoc policies developed in isolated 'silos' hinder energy investments (World Energy Council, 2012a). In the context of tight government budgets, finding least-cost solutions and engaging the private sector will be critical to stimulating investment; costly overlaps between policies must also be avoided at all costs (Marchal et al., 2011).

With consistent and committed regulatory approaches, policymakers must encourage the development of attractive markets to stimulate long-term private investments in energy infrastructure and technologies, simultaneously. Policies must support the development of new investment mechanisms that can reduce risks and stimulate greater private sector investment in the energy sectors (World Energy Council, 2012a). Mechanisms that stimulate investment include green banks, a green bond market, and public-private partnerships; these efforts must be underpinned by a stable and predictable carbon price necessary to drive the transition to low-carbon energy system sectors (World Energy Council, 2012a). Feed-in tariffs have been found to be an effective means of promoting renewable investment in Germany (Reuter, Szolgayová, Fuss and Obersteiner, 2012).

2.9.3 Energy technology research and development

To drive innovation further in all areas of energy technology, policymakers should implement goal-driven policies rather than prescriptive policies (World Energy Council, 2012a). Low carbon energy technology selected must be based on research in order to impact on both the priorities of the local population, as well as on the social and environmental targets of the government (Barry, Steyn and Brent, 2011).

New renewable energy and fossil fuel technologies development can bring the world much closer to attaining sustainable energy systems and potentially spur economic growth, and for this to happen, policymakers need to leave it to the market to decide which types of technology should survive so that they can remain competitive in the long- term (World Energy Council, 2012a).

2.9.4 Policy and regulatory frameworks

Developing a policy framework that advances a transition to renewable economy has proven to be a challenge in both developing countries. One of the countries in the forefront of innovative renewable energy legal frameworks is Germany. The German Renewable Energy Sources Act is regarded as a global model for the use of renewables (Pfeiffer, 2010). A total of 47 countries have now adopted similar legislation and the latest revision of the Act in Germany entered into force on 1 January 2009 (Pfeiffer, 2010).

New Zealand is also one of the successes stories of renewable energy implementation. Leary and Esteban (2011) indicate that roughly 70% of New Zealand's electricity comes from renewable energy, including hydro electricity, geothermal power, and wind energy. New Zealand's National Energy Strategy released in 2007 was aimed at increasing the proportion of electricity generated from renewable sources to 90% by 2025 (Leary and Esteban, 2011). The 'green economy' has emerged as a strong policy direction in Obama's administration with $100 billion in dedicated funds over the next decade to provide infrastructure investment for a range of initiatives including alternative energy technologies that will lessen the reliant on foreign oil supplies and this is seen as an ambitious effort by his administration to capitalise on renewable energy (Peters and Britez, 2010).

India is following an active policy for developing the use of renewable energy sources for providing energy in the form of heat and electricity and Sukhatme (2011) observes that surveys conducted a few years ago indicated that there was a potential for installing a total capacity of 45 000 Mega Watts (MW) of wind energy on land in India to address their countries' energy needs; this estimate was based on wind machines with hub heights up to 50 metres and currently, wind machines with hub heights up to 80 metres are available, and it is estimated that the wind resource on land is probably around 65 000 MW.

Another Asian country that has set up long-term investments in renewable energy is South Korea in September 2008. The government released its long-term energy plan for the period up to 2030 (Leary and Esteban, 2011). In Turkey, their energy requirements are different; meeting Turkey's energy needs is a challenge as indicated by Yüksel (2009). Turkey with its young population and growing energy demand per person, its fast growing urbanisation, has been one of the fastest growing power markets in the world for the last two decades. Turkey is heavily dependent on expensive imported energy resources that place a big burden on the economy, and air pollution is becoming a great environmental concern in the country.

2.9.4.1 Policy and regulatory frameworks in developing countries

In Africa, the energy sector had been beset by several decades of crises, which compromised access to electricity to for the majority of people (Sebitosi and Okou, 2010). African energy policies are politicised and can be conceptualised as two games, one played between the government and citizens, and the other between government and investors (Collier and Venables, 2012). The game between government and citizens concerns the pricing of energy and African governments are distinctive in that urban electorates hold them responsible for this price and access to energy is more prevalent in urban areas (Oseni, 2012; Collier and Venables, 2012).

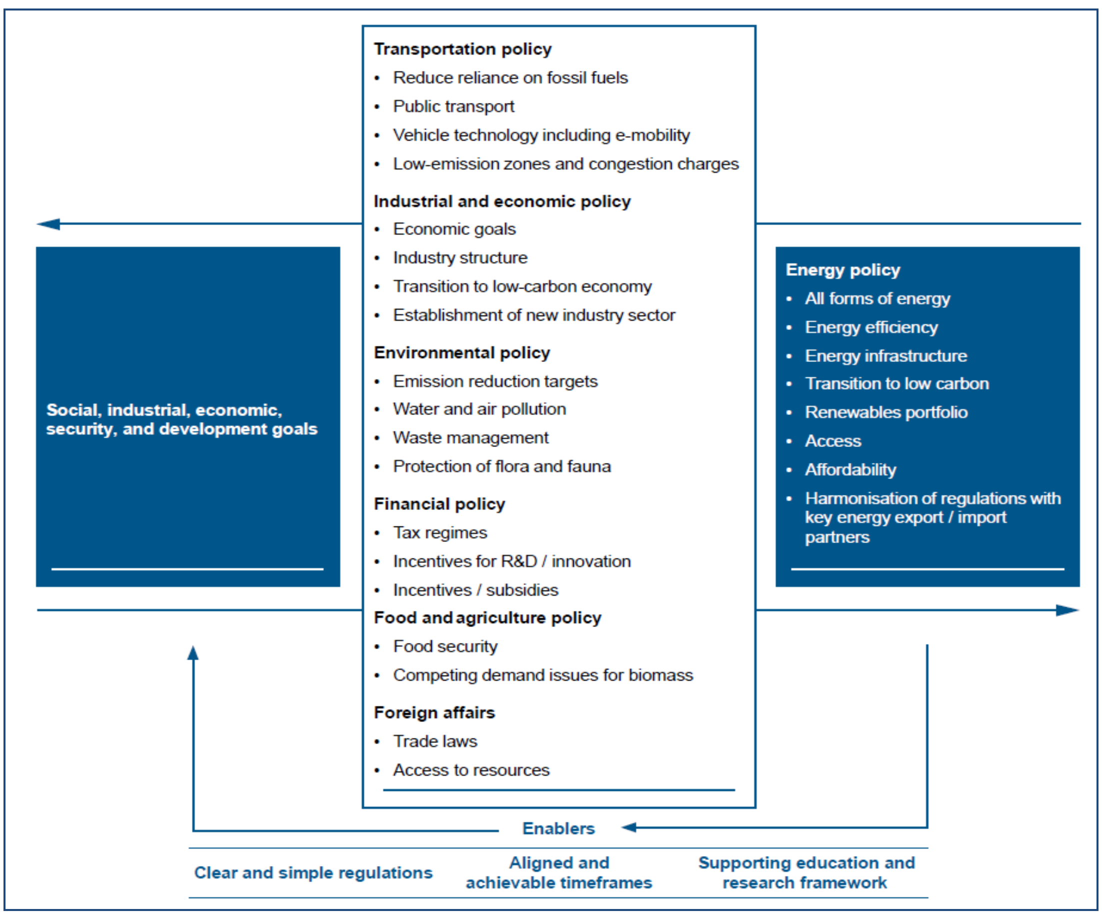
Energy generation is largely monopolised in Africa and governments are responsible for energy generation and distribution, compounded by policies of generalised price controls (Welsch et al., 2013; Collier and Venables, 2012). Most African states still influence electricity price control; it is not left to market forces (Collier and Venables, 2012). The SSA region has good prospects to improve access to modern energy sources if countries can harmonise and coordinate energy policies within the context of regional economic integration (Collier and Venables, 2012; Oseni, 2012). Regional economic communities (RECS) can promote unity, enhance sustainable development, increase competitiveness, and integrate African countries into the global economy (Owen, Van der Plas and Sepp, 2013).

Energy policies in the region should focus on minimising the dependence on volatile energy markets to guarantee sustainable development and therefore, greater regional energy self-sufficiency should be one of the objectives of SSA countries (Welsch et al., 2013; Oseni, 2012). SSA region has significant solar, wind, hydro electric, and geothermal potentials, which, together with proven oil and gas reserves, can be tapped to reliably supply energy to the region and improve the energy supply, in general (Owen, Van der Plas and Sepp, 2013).

The lack of adequate financial, physical, and human capital is an obstacle, if countries pursue energy-related policies individually (Welsch et al., 2013). To improve access to modern energy services and for sustainability energy system, government at all levels must be strongly committed to the development of renewable energy utilisation and the progress has to be continuously reviewed to know how well it performs (Oseni, 2012). Deichmann, Meisner, Murray and Wheeler (2011) emphasise that energy planners in SSA region in particular should pay careful attention to opportunities for the expansion of renewable power.

It is critical that an enabling environment is create; this can help to promote supportive policy, regulatory, institutional, legal and commercial frameworks and SSA could especially profit from on-going efforts in industrialised countries to adjust related network standards (Welsch et al., 2013). Owen, Van der Plas and Sepp (2013) observe that current energy policies in Africa are unrealistic and incomplete, failing to recognise the realities of actual energy costs, future consumption trends, the significant potential offered by renewable energy. A coherent energy policy must be imbended in a framework that addresses other policies such as transport, industrial and economic, environmental, financial, agricultural and foreign policy. The energy policy must stimulate social, industrial, economic, security and development goals. Figure 2.18 illustrates elements of a coherent energy policy.

Figure 2.18: Elements of a coherent energy policy



Source: World Energy Council (2012a: 39)

2.9.5 Investment risks and returns of green energy

As a starting point, risk and return are essential drivers of investment decisions (Kammen and Kirubi, 2008; Gujba et al., 2012). Risk is reflected in the cost capital firms need to pay for financing their projects (Fagiani, Barquı´n and Hakvoort, 2013). Therefore, policy makers aiming at an increased share of renewable energy should do what they can to reduce risk and provide adequate returns (Wustenhagen and Menichetti, 2012). Fagiani, Barquı´n and Hakvoort (2013: 650) identify major areas of risk to manage pertaining to renewable energy investment:

- Price risk: Reflects the uncertainty of fuel, CO2 and electricity prices affecting both the cost and the revenues that will be obtained by generators.
- Technical risk: Indicates the uncertainty of investment, operating, maintenance and decommissioning costs.
- Financial risk: Includes credit, interest rate and contractual risk that will be borne by the investor.

Addressing risks associated with renewable energy investments Gujba et al. (2012) suggest a combination of public sector funds, in particular, investments for pre-design phase and capital investments for projects that could be addressed via national budgets; concessional loans from national and international financial institutions; capital grants from bilateral and multilateral organisations and mobilisation of both international and local private investment. The financial incentive of an investment drives the private sector toward a more substantial and meaningful innovation than might occur under a more prescriptive command and control regulatory scheme (Kammen and Kirubi, 2008; Gujba et al., 2012).

Renewable energy investors must take into account the risk associated with uncertain future cash flows, done by adopting an appropriate discount rate reflecting the riskiness of the renewable energy project. For example, as the uncertainty of future cash flows increases, the discount rate used to calculate the Net Present Value (NPV) should also increase (Fagiani, Barquı´n and Hakvoort, 2013). A positive NPV means that the present value of future cash flows is higher than the initial cost of the project and therefore should be accepted, on the contrary, a negative NPV means that the project should be rejected (Fagiani, Barquı´n and Hakvoort, 2013). Policy makers should become more familiar with the tools that investors use to set the cost of capital for renewable energy investments (Wustenhagen and Menichetti, 2012).

Renewable energy investments remain small and the share of Africa in global Foreign Direct Investment (FDI) remains small. The main reasons are identified to include: war, conflict and political stability as the main obstacles (Komendantova, Patt, Barras and Battaglini, 2012). The funds that are available are through various international, regional and national organisations such as the Global Environment Facility, the World Bank, the African Development Bank, and DBSA, the International Finance Corporation, and other bilateral Development Banks (Gujba et al., 2012).

2.9.6 Energy infrastructure

Weak and unstable grids characterise the African continent, particularly the SSA region (Nkwetta et al., 2010). Lehmann et al. (2012) argue that, with more than a century of experience and build up infrastructure; fossil fuels display numerous advantages for business on business relevant time scales compared to renewable energy technologies, particularly the grid. To fast track the transition to low carbon technologies (Streich, 2009) suggests that utility companies must develop the grid in rural areas.

Therefore, depending on the service quality of the existing grid network, the distances and topography involved, extending the national grid to rural areas is not always the only most effective or cost efficient way to alleviate poverty in developing countries (Nkwetta et al., 2010). For many countries with remote rural populations, off-grid electrification solutions powered by a low carbon energy source represent the optimal means of extending electricity provision in terms of the required investment, efficiency and quality of service (Streich, 2009; Nkwetta et al., 2010).

If a community is close enough to an existing grid network that provides reliable power to both its urban and rural customers, grid extension may be preferable; alternatively, if grid extension is not feasible, the decision must fall on a low carbon off-grid option (Streich, 2009; Nkwetta et al., 2010). There is a wide array of different renewable energy off-grid technologies and each carries their own set of advantages and disadvantages (Nkwetta et al., 2010). Information and communication technologies can support electricity systems with high shares of renewables and an active demand side (Yadoo and Cruickshank, 2012). As an intervention Yadoo and Cruickshank (2012: 596) suggest the introduction of smart grids in certain instances as a solution because they offer a number of advantages which include:

- They enable advanced functionalities such as real-time pricing and remote meter reading.
- They may also enable more functions such as remote control or visualisation of consumption profiles.
- Communication infrastructure provides for bi-directional information exchange and enables new services such as dynamic pricing or demand side management that support a flexible electricity system.

2.10 CHAPTER SUMMARY

This chapter exposed the essential role that green energy can play in improving access to modern energy and powering economic development. In general the diffusion of green energy would depend largely on the reduction in their costs, and this can be facilitated by developing domestic capacities in the manufacturing of these technologies. Renewable energy has challenges, most of the technologies produce power intermittently and research is still being conducted to address the short coming through storage of the generated power for later use. Green energy has the potential of creating jobs in manufacturing, power plant operations and agriculture and this is good news for developing countries with high unemployment rate; however there is a need to train people so that they are fit for these jobs (Shukla, Dhar and Fujino, 2010). For the development of low carbon technologies, countries will have to align policies to be suitable to the conditions of a country based on green energy endowment, energy consumptions patterns and environmental protection.

3 CHAPTER 3: ENERGY ACCESS IN AFRICA, SUB-SAHARAN AFRICA (SSA) AND THE SADC REGION

3.1 INTRODUCTION

Energy is a vital ingredient for economic development and a powerful engine of social change. No country can manage to develop and sustain development beyond a subsistence economy without having access to modern energy services for the larger portion of its population (Khennas, 2012). Poor access to modern energy is limiting opportunities for economic growth in developing countries. Electricity demand has grown in Africa, and energy security is constricted as a result of the lack of the required investment (World Energy Council, 2013b). Studies indicate a strong correlation between energy consumption and economic growth and development. Access to modern energy services directly contributes to poverty reduction by creation of wealth through increased economic activities (Oseni, 2012). This chapter reveals the energy situation in Africa and narrows it down to SSA and the SADC region. The chapter will also focus on specific modern energy access challenges faced by SADC countries.

3.2 ENERGY ACCESS SITUATION IN AFRICA

There are conspicuous modern energy access disparities in the African continent. Excluding South Africa and Egypt It is estimated that about 20% overall, and in some countries as little as 5%, of the population in Africa has direct access to grid electricity (Adkins, Oppelstrup and Mod, 2012). North Africa and South Africa have the highest access to modern energy in the continent and are thus characterised by the highest Gross Domestic Product (GDP) (Khennas, 2012). North Africa is characterised by a high dependence on oil and gas either for exports (Algeria, Libya, and Egypt) or for imports (Morocco) (Adkins, Oppelstrup and Mod, 2012; Khennas, 2012).

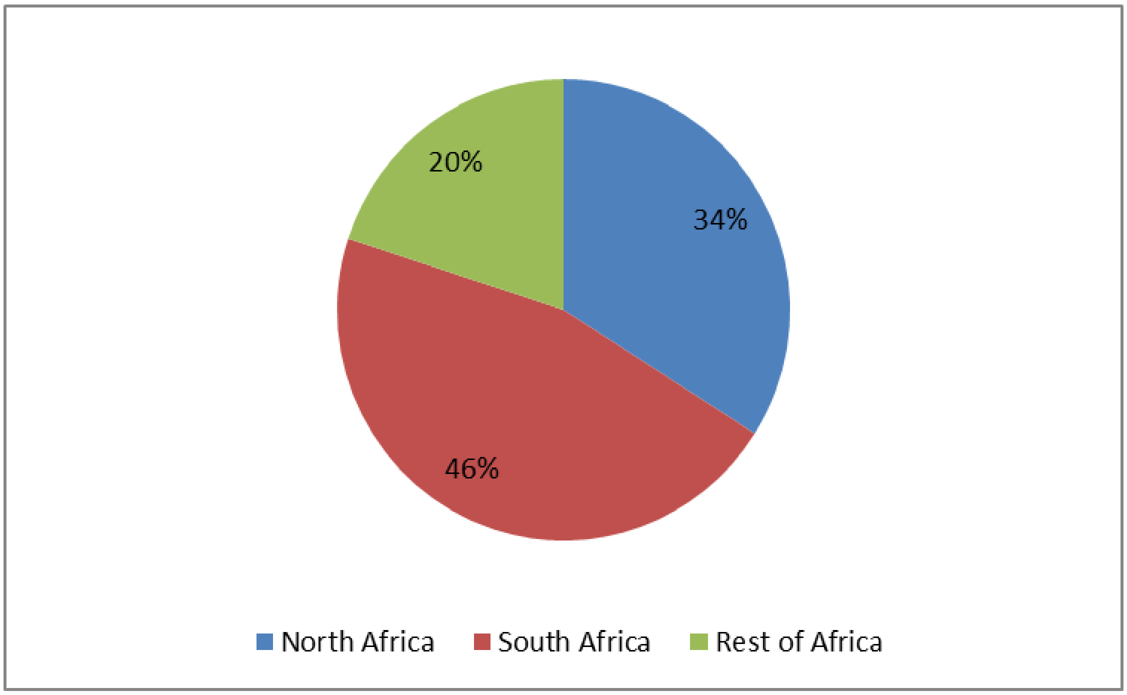
North Africa has the lowest number of people relying on traditional biomass, less than 10 million out of a total population of over 200 million; this is in sharp contrast to SSA where the corresponding number will rise from around 600 million people currently to over 700 million in 2030 (Sovacool, 2013). The recognition of green energy access imperatives is not a new concept in Africa. In 1981, Africa hosted the first International Conference on New and Renewable Sources of Energy in Nairobi; the conference acknowledged the realities facing Africa with regard to access to modern energy and the unprecedented high petroleum energy prices (Kammen and Kirubi, 2008).

Africa, as elsewhere in the world, embraced the strong optimism and vision for transition to renewable energy sources. Although important initiatives have since been taken, notably in biomass and solar energy, the promise of renewable energy in Africa remains largely unmet (Kammen and Kirubi, 2008). The renewable energy conference played a key role in launching programmes for research, design, and dissemination of improved household woodstoves in the region (Kammen and Kirubi, 2008). Africa is endowed with abundant renewable and non-renewable energy resources, nevertheless, about two-thirds of its population still lacks access to modern energy services, such as electricity and non-solid cooking fuels (IRENA, 2015).

Fortunately, rapid advances in the reliability, efficiency and cost-competitiveness of renewable energy technologies provide the continent with the opportunity to increase energy access and security; this can be done without the environmental and economic costs associated with an energy development path based on fossil fuels (IRENA, 2015; KPMG, 2014). The renewable energy and/or low-carbon energy plans vary from country to country. However, these plans generally include exploiting natural resources such as solar, wind, hydro, geothermal, natural gas and nuclear (KPMG, 2014). Currently, the continent's only nuclear power plant is in South Africa.

However, there are other jurisdictions that are considering nuclear power in their long-term plans, such as Nigeria, Ghana, Senegal, Kenya, Uganda and Namibia. Oil-rich countries such as Nigeria, Ghana, Angola, Tanzania, Sudan and South Sudan also plan to increase the use of natural gas for both their current and future power plants (KPMG, 2014). In terms of percentages, South Africa has the highest of electricity supply at 46% in the continent followed by the northern African countries combined with a supply amount of 34% and the rest of African countries that share 20% of supply (Nkwetta et al., 2010). Figure 3.1 illustrates the proportion of electricity supply in Africa.

Figure 3.1: The proportion of electricity supply in Africa



Source: Nkwetta et al. (2010: 1)

According to OPEC Fund for International Development (OFID) (2008), Africa's landmass of 30.3 million km² is endowed with rich natural resources including fossil fuel and renewable energy and unfortunately most of the resources are not exploited to the benefit of the continent.

It has been estimated that Africa's energy resource endowments with respect to the world totals are in the following order of magnitude (OFID, 2008):

- Oil 9.5%
- Coal 5.6%
- Natural gas 8.0%

Africa is one of the continents with the fastest growing population in the world and the demand for energy is in constant increase (Onyeji, Bazilian and Nussbaumer, 2012). Africa's long-term economic growth and competitiveness fundamentally depends on reliable access to energy services (Onyeji, Bazilian and Nussbaumer, 2012; Athanas and McCormick, 2013). The challenges of securing investment required to meet both the need to increase access to clean energy and the rapidly growing demand in a sustainable way are enormous (Nganga, Wohlert and Woods, 2013). It is estimated that at least US$40 billion is needed annually in the power sector to meet future demand (Nganga, Wohlert and Woods, 2013). The reasons contributing to Africa lagging behind in electrical energy production are multifaceted and the most prominent of these factors according to OFID (2008) are:

- Poor economic status of African states especially south of the Sahara desert.
- Poor governance or unstable governments.
- Wars, regional and domestic social and ethnic conflicts.

The reality of energy poverty has been extensively researched and it is widely acknowledged by governments in the continent. Policy makers all over the continent, from national governments, regional organisations and the African Union accept the urgency of the problem and have made commitments to address the energy poverty problem (Nganga, Wohlert and Woods, 2013).

Amongst others, strategies for electrification and increasing access to modern energy are being steered by the newly established African body. The New Partnership for Africa's Development (NEPAD), together with other regional organisations like the SADC, the Forum of Energy Ministers in Africa, Economic Community of West African States (ECOWAS), East African Community (EAC), and the Commission de la Communauté Economique et Monétaire de l'Afrique Centrale (Musango and Brent, 2011; Bazilian et al., 2012). Regional and inter-regional power sector integration will provide opportunities for exploiting the economies of scale of large hydro power, geothermal, wind, solar and biomass projects (IRENA, 2015).

Brew-Hammond (2010: 2294) observes that, in response to energy poverty in Africa, NEPAD has set energy targets and the following energy sector development objectives were put forward:

- To increase from 10% to 35% or more, access to reliable and affordable commercial energy supply by Africa's population in 20 years.
- To improve the reliability as well as lower the cost of energy supply to productive activities in order to enable economic growth of 6% per annum.
- To reverse environmental degradation that is associated with the use of traditional fuels in rural areas.
- To exploit and develop the hydro power potential of river basins of Africa.
- To integrate transmission grids and gas pipelines so as to facilitate cross-border energy flows.
- To reform and harmonise petroleum regulations and legislation in the continent.

Progress to improve access is hindered by financial constraints, Brew-Hammond (2010) notes that the World Bank takes a position that in Africa even 50% by 2015 is not achievable and that the more realistic set of targets to aim for in the case of electricity access are 35% by 2015 and 48% by 2030; the big challenge is expected to be the $6–15 billion per annum required to meet any target between 35% and 50% by 2015. The African continent has had discoveries of oil and gas in a number of countries including, Chad, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Mali, Mauritania, Mozambique, Sao Tome Principe, Senegal, Sierra Leone, Tanzania, Togo and Uganda and substantial coal deposits in South Africa and Mozambique (Collier and Venables, 2012). These discoveries are yet to energise economic growth meaningfully in the continent and large quantities of these reserves are exported (OFID, 2008; Collier and Venables, 2012).

Capital injection into the power sector infrastructure has been minimal for several decades particularly in SSA region (Sebitosi and Okou, 2010). Sustainable access to quality energy infrastructure is an essential ingredient for sustained economic growth and development (Khennas, 2012). Energy infrastructure serves as an essential input into private sector production, thus augments output and productivity resulting in economic growth (Oseni, 2012).

A deliberate, systematic and concerted effort to integrate, upgrade and modernise such infrastructure as roads, railways, aviation, telecommunications and fuel lines would offer the required catalyst (Sebitosi and Okou, 2010). In most African countries, infrastructure investment is mainly limited to urban centres, such a concentration of investment infrastructure, is basically due to the political power mainly retained by urban elites and as a result, the lack of representation of other stakeholders (rural communities, cities and towns far away from the capital) (Khennas, 2012). The majority of the existing power stations in Africa were commissioned way before the 90s (KPMG, 2014).
Sebitosi and Okou (2010) advocate for the location of industries to be closer to to customers, particularly heavy industry should be positioned as close to generation as possible considering the level of capital investment. Sebitosi and

Okou (2010) and Khennas (2012) argue that the long lead times that went into the construction of transmission infrastructure such as from the Zambezi and Congo basins through thousands of kilometres to South Africa is quite evident that such money would have been better invested in building new manufacturing industry.

IRENA (2013b) argues that the coordinated planning and construction of reinforced transmission infrastructure could play a significant role in reducing the costs of power and raising the share of renewables generation in Africa. Substantial expansion in quantity, quality and access to energy infrastructure services are essential to rapid and sustained economic growth, employment generation, poverty reduction and overall wellbeing of a country where greater portion of its population resides in the rural areas (Khennas, 2012).

Lack of access to energy infrastructure seriously hinders economic growth, undermines employment and consequently results in a vicious circle of poverty (Oseni, 2012). Sanoh et al. (2014: 607) analyses of various generation and transmission cost possibilities in Africa make the following inferences:

- The emerging picture of a short-term energy system in Africa relies on the development of hydro power. In particular, the vast hydro potential of central Africa can be shipped to any place on the continent at a maximum cost of U$0.20. For example, for the two largest energy consumers, the Inga Hydro cost is approximately U$0.13 in Egypt and U$0.09 in South Africa.

- The geothermal potential in East Africa is inexpensive and can serve as a base load but is limited in its quantity and ability to meet the needs of countries outside of this region.

For example, geothermal energy from Kenya has a cost of approximately U$0.19 in North Africa and is competitive with domestic sources.

- Hydro resources from central Africa are competitive in West Africa, but when the availability of inexpensive natural gas from Nigeria is considered, the connection of these two regions is less optimal in the long-term.

- Although high wind potential is available on the coasts of Somalia, Morocco, and Tanzania, the relatively low capacity factors for these sites triple the transmission costs. However, wind energy represents a competitive long-term energy source for East Africa.

- Although good solar energy is available throughout most of Africa, transmission from the desert and the Sahel areas to other parts of the continent becomes feasible only in the long-term when solar investment costs decrease more than 50% to compensate for the high transmission costs.

In terms of strategic interconnection, it is more sensible in the short-term to invest in transmission lines that ship hydro power from Central Africa to Southern Africa and from Eastern to North Africa. Compared to other regions, Southern Africa has the highest capacity of 51.61GW, added to planned new generation it totals to 23.347GW. Table 3.1 presents new generation by region, planning period and source.

Table 3.1: New generation by region, planning period and source

	West Africa	Central Africa	East Africa	North Africa	Southern Africa	Total
Capacity (GW)	10.82	3.95	5.06	45.57	51.61	117.01
Consumption (billion kWh)	34.42	12.96	18.63	187.36	260.47	
Thermal (%)	75.48	66.68	59.61	91.67	47.12	
Hydro (%)	23.28	32.47	46.95	8.33	37.08	
Gen.cons (US$ cents/ kWh)	0.31	0.22	0.20	0.37	0.13	0.246
New generation 2015 (GW)	1.199	4.805	5.085	2.803	4.376	18.267
Hydro	1.199	4.805	3.593	0	2.329	11.925
Geothermal	0	0	0.378	0.816	0.219	1.414
Wind	0	0	1.114	1.689	0	2.803
Solar	0	0	0	0.297	1.828	2.125
New generation 2020 (GW)	1.705	6.205	5.982	3.761	7.068	24.721
Hydro	1.267	6.205	3.889	0	2.556	13.926
Geothermal	0	0	0.504	1.089	0.292	1.885
Wind	0.000	0	1.589	1.807	0	3.396
Solar	0.438	0	0	0.865	4.210	5.513
New generation 2025 (GW)	2.814	6.655	7.233	5.567	11.902	34.171
Hydro	1.334	6.655	4.185	0	2.740	14.914
Geothermal	0	0	0.504	1.089	0.292	1.885
Wind	0.000	0	2.544	1.925	0	4.469
Solar	1.479	0	0	2.553	8.870	12.903
Total	**5.717**	**17.665**	**18.300**	**12.130**	**23.347**	**77.159**

Source: Sanoh et al. (2014: 605)

Michaelowa, Hoch, Schurig and Butzengeiger (2013: 7) state that the key elements that inform the international financing of renewable energy include:

- Need for technical assistance to assess the renewable energy potential, and its cost structure, as well as developing the administrative structure of the REFIT.

- Support for political processes that overcome the resistance of incumbent electricity utilities and grid operators.

- The cost differential between conventional electricity generation facilities and the different types of renewable electricity technologies, as well as adjustment procedures to trigger changes in the REFIT due to changes in the cost differential.

- The duration for which the REFIT is granted.

- A mechanism to allocate limited GCF resources, e.g. country ceilings or caps (capacity/kWh generated), above which the REFIT is no longer granted.

The total discounted system cost to meet total demand in 2025 is reduced from U$131.93 to U$94.47 billion or a 28% reduction relative to the clean energy scenario (Sanoh et al., 2014: 605). This reduction primarily results from the replacement of the expensive solar option in the desert regions with cheap domestic fossil fuel electricity generation in Northern and Southern Africa (Sanoh et al., 2014: 605). Table 3.2 presents generation (GW), technology share (%) and total cost for clean energy and in combination with fossil fuels in Africa.

Table 3.2: Generation (GW), technology share (%) and total cost for clean energy and in combination with fossil fuels in Africa

	Clean energy only		Clean energy + fossil fuels	
	Net generation (GW)	Share of total (%)	Net generation (GW)	Share of total (%)
New generation by 2025	77.159	100	77.159	100
Hydro	40.765	52.8	27.899	36.2
Wind	10.667	13.8	11.785	15.3
Geothermal	5.184	6.7	1.909	2.5
Solar	20.541	26.6	3.596	4.7
Coal			20.393	26.4
Natural gas			11.023	14.3
Oil			0.553	0.7
Total Cost in billions (US$)	131.93	100	94.47	100
Generation	82.97	62.9	53.70	56.85
Transmission	48.96	37.1	40.77	43.15

Source: Sanoh et al. (2014: 607)

Regardless of the differences in forecasts, there is a consistent and clear message: Africa has to raise electricity consumption at very high and unprecedented growth rates to achieve increased economic growth and social development consistent with the expectations of the growing population (IRENA, 2015; KPMG, 2014). It is estimated that this translates into electricity energy consumption growth of 5.7% per year; the present installed capacity and annual energy consumption in Africa is estimated at 125 GW and 600 terawatt-hours (TWh) respectively.

It is projected to increase by nearly 700 GW to support energy consumption in excess of 3 100 TWh by 2040 (IRENA, 2015: 13). Table 3.3 presents a Programme for Infrastructure Development in Africa (PIDA) regional electricity forecasts for 2010-2040.

Table 3.3: PIDA regional electricity forecasts for 2010-2040

Region	Average annual growth in GWh consumption (%)	Access (share of population) (%)		Additional capacity required
		2010	2040	MW
West African Power Pool	8.9	45	67	90 000
Central African Power Pool	7.3	21	63	26 000
Eastern Africa Power Pool	6.5	37	68	140 000
Maghreb Committee on Electricity	6.0	>95	>99	298 000
Southern African Power Pool	4.4	25	64	129 000
Total	**5.7**			**683 000**

*gigawatt hours (GWh)

Source: IRENA (2015: 13) as cited in Sofreco et al. (2011)

3.3 ENERGY ACCESS SITUATION IN SSA REGION

The SSA region is geographically, the area of the continent of Africa that lies south of the Sahara desert and politically it consists of all African countries that are fully or partially located south of the Sahara desert (excluding North Sudan). It contrasts with North Africa, which is considered a part of the Arab world. Lack of access to energy in Africa particularly in the SSA region is widely reported in literature. Hailu (2012) states that only 30.5% have access to electricity in the SSA region. If new investments to address energy poverty are not initiated, most investments will continue to be devoted to new on-grid electricity connection in urban areas due to population growth.

By the year 2030 the number of people without access to energy will be about 1.2 billion around the world with more than 60% coming from the SSA region (IEA, 2011). The vast majority of people thus continue to rely on traditional biomass and kerosene (Nganga, Wohlert and Woods, 2013). Renewable energy mini-grids provide the policy maker and rural development practitioner with a means of combating poverty, mitigating against increased GHG emissions and improving adaptive capacity to climatic change disadvantages (Nkwetta et al., 2010). The currently installed generation capacity of SSA Africa is approximately 70 000 MW but, due to technical restrictions, not all is available. About 44 000 MW of these are installed in South Africa alone. Regional integration and interconnection is gaining ground with the development maturity of the power pools in SSA region (World Energy Council, 2013b).

There are four power pools in the SSA region established to facilitate Africa's cooperation and to manage Africa's endemic energy problems. They are established through the signing of respective Inter-government Memorandum of Understanding amongst SSA region countries. They include: Southern African Power Pool (SAPP), launched in 1995, the West African Power Pool (WAPP), launched in 2000), the Central African Power Pool or Pool Energe´ tique d' Afrique Centrale, launched in 2003), and the East African Power Pool (EAPP), launched in 2005 by East African countries member of COMESA and Nile Basin Initiative including Egypt and Tanzania) (Musango and Brent, 2011). More than in any other region in the world, access to affordable and appropriate energy services in Africa must grow significantly in order to improve the standard of living of the continent's growing population (Sokona, Mulugetta and Gujba, 2012).

The envisaged benefits from power pools according to Musango and Brent (2011) include:

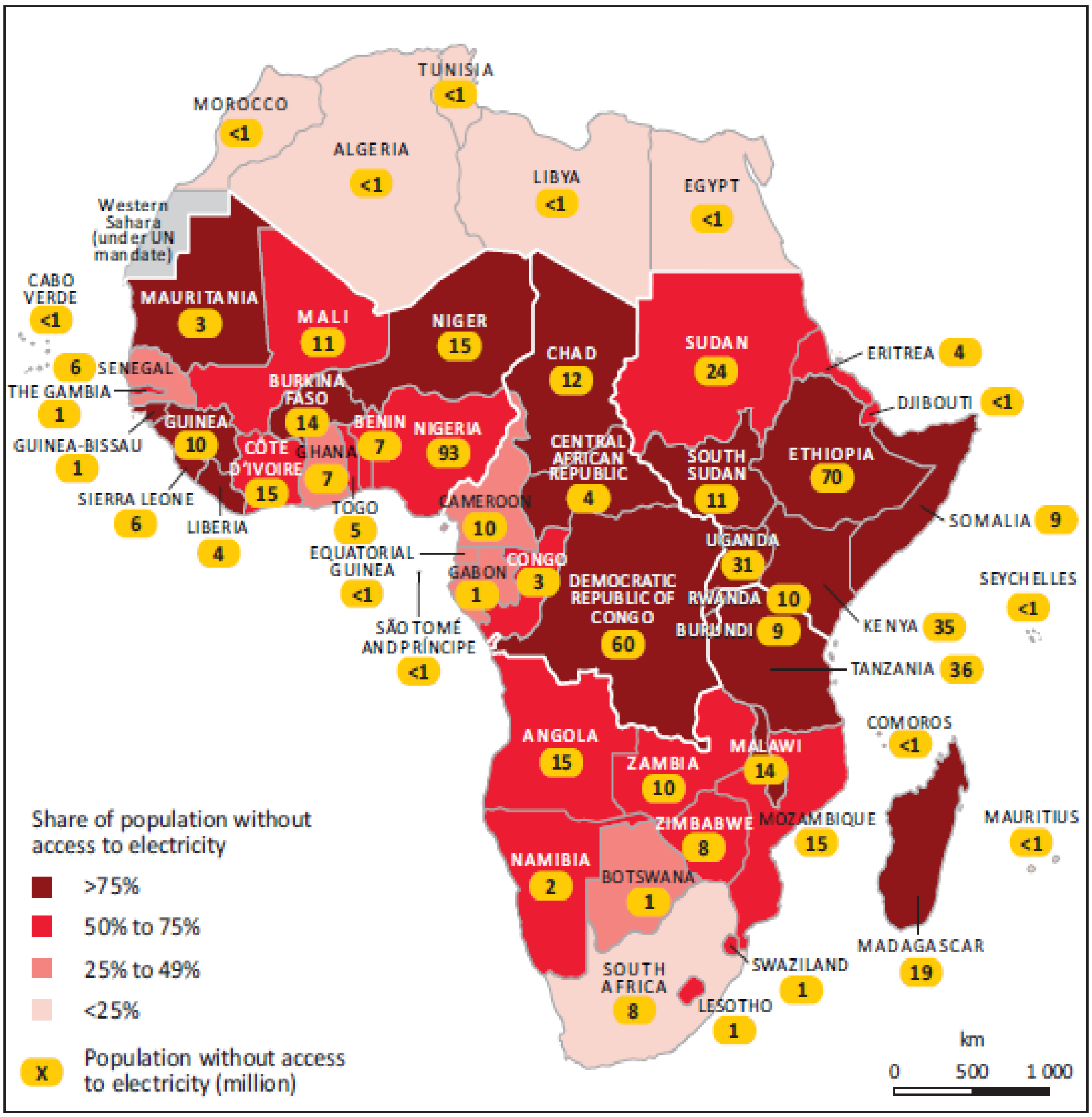
- Reduction in capital and operating costs through improved coordination among power utilities.
- Optimisation of generation resources with large units.
- Improved power system reliability with reserve sharing.
- Enhanced security of supply through mutual assistance.
- Improved investment climate through pooling risks, coordination of generation and transmission expansion, increase in inter-country electricity exchanges, and development of regional markets for electricity.

There has been under-investment over the past two decades. The current generation assets are aging further, which leads to decreasing efficiency, increasing maintenance cost and unexpected outages. The frequent power outages have resulted in the growing use of emergency power, using liquid fuels, which are expensive. Using a single source of power has proven to be unsustainable and given the increasingly stringent climate change regulations, this approach will likely result in additional costs, especially for coal and liquid fuel generated power (KPMG, 2014).

In some parts of the SSA region, political strife hamper the rehabilitation of the existing installations and construction of new power generation facilities and transmission lines (Sebitosi and Okou, 2010). According to IEA (2014b: 30) in 37 SSA countries the number of people without electricity has increased since 2000 while the regional total rose by around 100 million people. On a more positive note, about 145 million people gained access to electricity since 2000, led by Nigeria, Ethiopia, South Africa, Ghana, Cameroon and Mozambique. Overall, the electricity access rate for SSA has improved from 23% in 2000 to 32% in 2012.

In North Africa, more than 99% of the total population has access to electricity. Nearly 80% of those lacking access to electricity across SSA are in rural areas, an important distinction when considering appropriate energy access strategies and technical solutions. Figure 3.2 illustrates the number and share of people without access to electricity by country by 2012 IEA (2014b: 30).

Figure 3.2: Number and share of people without access to electricity by country in 2012



IEA (2014b: 31)

Sustainable energy access enables the provision of vital services needed for development in the form of lighting, heating, cooking, food processing, clean water, sanitation, education and healthcare, etc. and the SSA region is in dire need of these services (Nganga, Wohlert and Woods, 2013). Like in many developing countries, access to modern energy services by 2030 in Africa, particularly SSA region, will require more effective mobilisation and use of both domestic and external funding, and the development and implementation of innovative policy frameworks of energy (Sovacool, 2013; Bazilian et al., 2012).

SSA is characterised by an impressive demographic growth including in rural areas, the population of SSA Africa is projected to grow from some 770 million in 2005 to between 1.5 and 2 billion in 2050 (Khennas, 2012). Access to modern forms of energy in Africa would enable living conditions to be transformed and boost industrial, agricultural, urban and rural development (Sokona, Mulugetta and Gujba, 2012).

Energy access is not a panacea for poverty reduction and economic development. In order respond comprehensively to energy poverty and underdevelopment OFID (2008) calls for an effective energy access programme that is implemented within a broader perspective in an integrated and bundled approach that includes, complementary infrastructure such as roads, communication facilities, and water supply; availability of income generation activities especially through small-scale enterprises; access to market and credit; and promotion of private sector/community initiatives for energy supply. Table 3.4 presents energy access rates in selected countries in SSA.

Table 3.4: Energy access rates in selected countries in SSA

Country	Electrification rate (%)	Population without electricity (Millions)	Country	Electrification rate (%)	Population without electricity (Millions)
Malawi	9.0	12.7	Eritrea	32.0	3.4
Uganda	9.0	28.1	Namibia	34.0	1.4
DR Congo	11.1	58.7	Sudan	35.9	27.1
Mozambique	11.7	20.2	Gabon	36.7	0.9
Tanzania	13.9	37.7	Congo	37.1	2.3
Burkina Faso	14.6	12.6	Zimbabwe	41.5	7.3
Lesotho	16.0	1.7	Senegal	42.0	7.3
Kenya	16.1	33.4	Botswana	45.4	1.1
Ethiopia	17.0	68.7	Cote, dIvoire	47.3	11.1
Zambia	18.8	10.5	Cameroon	48.7	10.0
Madagascar	19.0	15.9	Nigeria	50.6	76.4
Togo	20.0	5.3	Ghana	60.5	9.4
Benin	24.8	6.7	Mauritius	99.4	0.0
Angola	26.2	13.7	**SSA region**	**30.5**	**585.2**

Source: Hailu (2012: 57) cited in WEO (2011).

The other challenges facing the power sector in the SSA region (KPMG, 2014: 7) are as follows:

- Under-utilisation of generation capacity due to low maintenance of assets.
- High primary energy costs and securing resources at reasonable prices to fuel current and new build assets.
- Loss-making power utilities due to low collection rates and high operational inefficiencies.

- Ineffective transmission infrastructure and high transmission losses of up to 25%.
- Ineffective and missing distribution infrastructure.
- In some countries low, sub-economical regulated or political influenced tariffs.
- Policies and regulations that is not always conducive to private sector investment into the power industry.
- Changes to environmental emission legislation and standards, requires additional capital to make assets compliant.
- Lack of funds to cover development costs of potential projects, thereby compromising bankability.
- Inadequate skills to develop and implement projects.

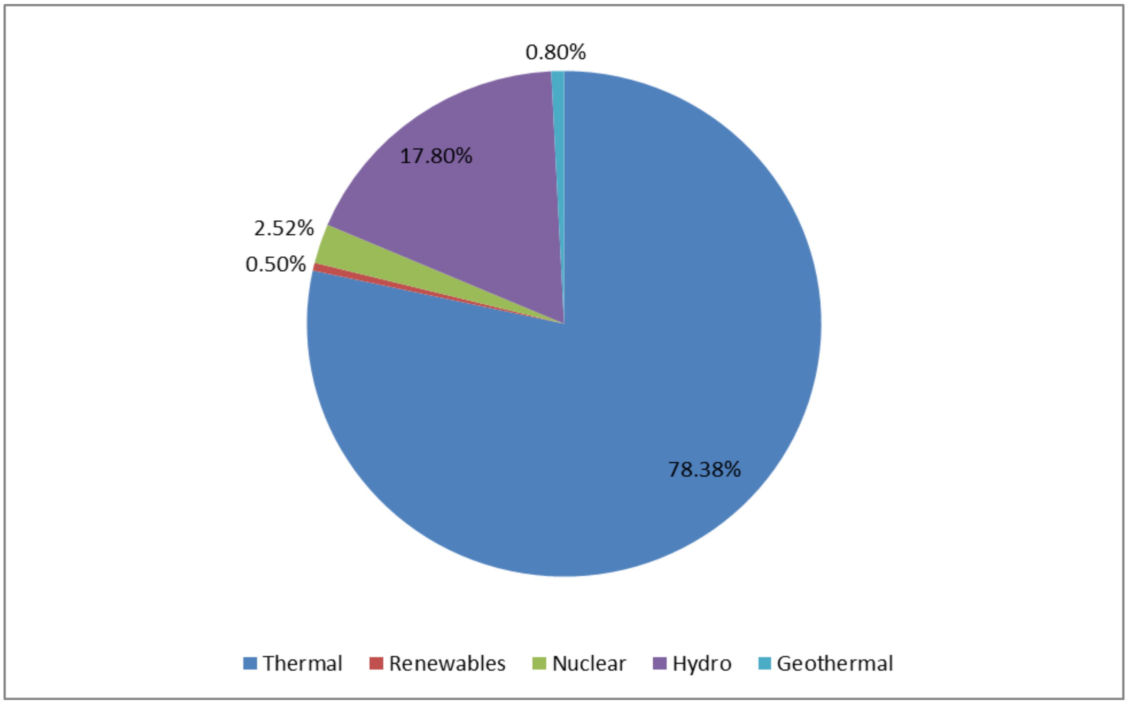
3.3.1 Meeting energy needs through renewable energy in the SSA region

Superficially, both geography and history appear to have made Africa particularly well-suited for green energy, sunshine, water, land, forests and all offer significant advantages to Africa (Collier and Venables, 2012). However, energy generation and usage are economic activities that are intensive. In particular, energy generation, energy saving and carbon capture are intensive in capital, governance capacity and skills, and unfortunately, all of these factors are scarce in Africa (Collier and Venables, 2012; Oseni, 2012). Promoting renewable energy technologies and a flexible mix of on-grid and off-grid solutions can improve access to modern energy; sustainably avoid the environmental problems of unsustainable energy sources and unnecessary cost of long distance transmission lines to remote areas (Nganga, Wohlert and Woods, 2013).

The proportion of electricity production in SSA indicates that the usage of hydro energy totals to 17.80%; 2.52% nuclear; 0.80% geothermal; 0.52%

renewables (solar) and 78.38% generated from thermal sources in the region (Nkwetta et al., 2010). Solar energy, wind and small scale hydro systems can provide energy in rural areas, including agricultural activities like on-farm as well as off-farm energy resources (Nnadi et al., 2011). Figure 3.3 illustrates the proportion of electricity production in SSA.

Figure 3.3: Proportion of electricity production in SSA



Source: Nkwetta et al. (2010: 4)

At the fall of Apartheid South Africa in the 1990s, there was much excitement and anticipation from a number of SSA countries, utilities particularly in East and Central Africa about the prospect of joining of the SAPP (Sebitosi and Okou, 2010). The reason for the anticipation was an apparent belief that they would be tapping into an unlimited electricity supply pool anchored by the South African giant utility (ESKOM).

When compared to the typical national utility capacities of countries like Kenya (with 1 000 MW), Uganda (300 MW) and Tanzania (700 MW) the notion of linking up with a 40 000 MW ESKOM was very tempting and promising (Sebitosi and Okou, 2010). Further challenges to secure energy supply in the SSA region (KPMG, 2014: 9) are:

- Ability of utilities to manage planned and unplanned outages and maintenance.
- Ability of SSA countries to deliver new build projects on time and within budget.
- Securing funding for new generation projects in Africa.
- Securing resources in order to fuel current and new build projects to sustain demand.
- Quality of resources to fuel power generation, especially coal.

3.4 ENERGY ACCESS SITUATION IN THE SADC REGION

The SADC region is comprised of the following 15 member countries: South Africa, Angola, Botswana, DRC, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland, Tanzania, Zambia and Zimbabwe. The region consist of mainland and small islands member countries. Mainland countries have an estimated population of 240 million people (Hammons and Musaba, 2012). South Africa is considered to have the highest energy production and consumption in Africa (Odhiambo, 2010).

SADC Member States, comprising of 280 million people in 15 nation countries with widely varying geographic, economic and political conditions, natural resource endowments, and levels of modern energy access, have long depended on renewable energy from biomass for cooking and heating (SACREEE, 2013: 10).

According to the Regional Infrastructure Development Master Plan (RIDMP) (2012: 20) observes that access to electricity is still limited in the region as seen by the low access to electricity in rural areas. The region is endowed with abundant resources of energy in the form of coal, hydro, natural gas, oil, solar, wind, biomass and nuclear and their distribution across the region is highly uneven, hydro resources are in the north while coal resources are mainly in the central and southern part of the region (DBSA, 2014; RIDMP, 2012). A breakdown of the SADC regional electricity generation sources shows that: coal contributes 74.3%, hydro 20.1%, nuclear 4% and gas/diesel 1.6%, the region has adequate fuel supply (coal reserves) to cover the lifetime of all existing fossil plants as well as that of future generation for several decades (DBSA, 2014).

During the preparations for the establishment of SACREEE in the year 2013 in Botswana, access to electricity in rural areas was estimated to be less than 30%, while 42% of the region's residents were estimated to have access to modern energy services. Improving energy access and energy security is vital for achieving sustainable development and poverty reduction in the SADC region (SACREEE, 2013: 11). There has been a shift from oil and gas-fired generation to coal-fired supply, encouraging greater usage of the abundant coal resources in an environmentally sustainable way.

RIDMP (2012) indicates that there are also shortfalls in the "soft" infrastructure such as a lack of co-ordinated planning, required policy and regulatory frameworks, institutions and capacity requirements, financing and investment in the region. Most countries in the SADC region have unstable grid networks; the problem is further compounded by the region's dilapidated electricity distribution network infrastructure (Mpholo, Mathaba and Letuma, 2012). Dames (2011) indicates that renewable energy resource potential that could be developed in the SADC region and the biggest constraint is transmission networks; it is critical to pre-invest in the key transmission corridors.

It is important to note that it is through the development of appropriate transmission infrastructure that the electricity potential could be delivered to where the demand is (Dames, 2011; DBSA, 2014). South Africa also represents the largest market for electricity, natural gas and liquid fuels; clean hydro electric imports are from Mozambique (1 400 MW) and the DRC (100 MW) and the current electricity growth rate is over 4% and the level of access to electricity is now about 73% (Musango and Brent, 2011; DBSA, 2014). RIDMP (2012: 20) indicates that access in these areas is below 30% for eight of the 12 SADC States on the mainland. Table 3.5 presents the characteristics of Southern African countries' energy sector in 2011.

Table 3.5: Characteristics of Southern African countries' energy sector

Country	Size in square kilometre (km^2)	Population (millions)	Renewable Energy Production (%)	Electrification Rate (%)
Angola	1.246,700	18.02	90	26.2
Botswana	582.000	1.92	0	45.4
Lesotho	30.355	2.02	0.9	16.0
Malawi	118.484	14.85	86.1	9.0
Mauritius	2040	1.28	3.3	99.4
Mozambique	801.590	21.78	100	11.7
Namibia	824.116	2.13	94	34.0
South Africa	1.219.090	48.69	2	85
Swaziland	17.364	1.168	36	27
Zambia	752.612	12.62	99	18.8
Zimbabwe	390.757	12.46	56.8	41.5

Source: Musango and Brent (2011: 147) and Hailu (2012: 57) cited in (WEO, 2011).

According to SAPP (2013a) present power generating capacity in Southern Africa indicates that the bulk of the 57 GW of current power generation capacity in SADC is from coal (70%), mainly in South Africa; hydro power (21%) comes mainly from the Zambezi River and Congo River basins. Distillate oil (5%), nuclear (3%) and gas (1%) make up the rest. The bulk of the generation is based on fossil fuels and located in South Africa where there is a highest demand. Table 3.6 presents SAPP 2013 generation statistics.

Table 3.6: Year 2013/14 installed capacity versus supressed

No.	Country	Utility	Installed Capacity [MW] As at Feb 2014	Available Capacity [MW] Feb 2014	Forecast Demand	Capacity Shortfall including reserves, MW
1	Angola	ENE	2,028	1,805	1333	
2	Botswana	BPC	892	460	580	
3	DRC	SNEL	2,442	1,268	1342	
4	Lesotho	LEC	72	72	138	
5	Malawi	ESCOM	351	351	323	
6	Mozambique	EDM /HCB	2308	2,279	763	
7	Namibia	NamPower	501	392	635	
8	South Africa	Eskom	44,170	41,074	38775	
9	Swaziland	SEC	70	70	222	
10	Tanzania	TANESCO	1380	1,143	898	
11	Zambia	ZESCO / CEC/LHPC	2,128	2,029	2287	
12	Zimbabwe	ZESA	2,045	1,600	2267	
TOTAL SAPP			58,387	52,543	49,563	(4,278)
Total Interconnected SAPP			54,628	49,244	47,009	(2,661)

Source: SAPP (2014: 39)

In comparison to other RECS, SAPP's access to electricity at 24% lags behind that of EAPP (36%) and WAPP (44%). These circumstances dictate the electricity infrastructure that is needed for the region (RIDMP, 2012). As at 31st March 2014, SAPP had an available capacity of 52 405 MW against a demand of 49 563 MW that includes peak demand, suppressed demand and reserves, this gives a regional capacity shortfall of 4 592 MW (SAPP, 2014: 5).

3.4.1 SADC region's protocol on energy

The region has an energy protocol that is earmarked to accelerate access to energy in the region. The SADC Energy Protocol provides for accelerated reforms in the energy sector with reforms bordering around the broad governance of the sector, and the protocol promotes private sector participation and encourages the SADC member states to create an enabling environment for private investment (DBSA, 2014). In 1996 twelve SADC countries crafted an energy protocol namely: Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe (Protocol on energy, 1996). According to the Protocol on energy (1996: 7), for the purpose of the protocol member states shall:

- Use energy to support economic growth and development, alleviation of poverty and the improvement of the standard and quality of life throughout the region.
- Use energy to promote collective and self-reliance among member states.
- Ensure that the development and use of energy takes cognisance of the gender realities in the region.
- Encourage the development and transfer of science and technology to energy through the promotion of R&D and the evolution and use of comparable methods and standards.

- Fully accept the responsibilities to share the costs associated with institutional mechanisms created for the effective implementation of this protocol.
- Settle all disputes peacefully and amicably.
- Promote and encourage the direct participation of citizens and communities in the development and use of energy.
- Ensure that the development and use of energy is environmentally sound.
- Create a favourable environment for the private sector to participate fully in energy development in the region.
- Ensure that sectorial and sub-sectorial regional energy policies and programmes shall be in harmony with the overall policies programmes of the SADC and with the strategies and programmes of other SADC sectors.

3.4.1.1 SADC regional energy planning and access strategy

According to SADC (2010) the goals of the SADC energy access strategy are at the strategic level to harness regional energy resources to ensure, through national and regional action, that all the people of the SADC region have access to adequate, reliable, least cost, environmentally sustainable energy services, and at the operational level that the proportion of people without such access is halved within 10 years for each end use and halved again in successive 5 year periods until there is universal access for all end uses. SADC (2010: 6) advocates for the framework for achieving the above goals consists of the following 7 elements:

- Statistics: improved systems of providing accurate information, especially quantitative data, on energy access.
- Applications: focus on energy end-uses rather than technologies.

- Biomass: recognition of the dominant role of biomass in the present and projected energy balance of most SADC countries.
- Prices: cost-reflective but competitive prices.
- Subsidies: prioritise access over consumption subsidies.
- Development: focus on use of energy to enhance economic productivity for poverty reduction and enhanced quality of life.
- Capacity: ability and willingness to implement operate and maintain energy access projects and programmes.

Energy access is primarily a national responsibility, rather than a regional one and the member states are responsible for a number of primary activities in the action plan that are laid out in the plan. SADC (2010: 157) advances the following factors to be in place or have to be developed at the same time to implement the pro-poor energy programmes successfully:

- Political will.
- Policies and strategies.
- Financial plans.
- Availability of power or alternative energy.
- Capacity of the utility or other service providers to implement.
- Adaptation of electricity and alternative energy prices to the ability of the poor.

Energy planning processes in most countries have historically conducted on the basis of satisfying their own national demand, and countries still develop projects that suit their national priorities (IRENA, 2015).

According to IRENA (2015: 29) the generic planning process at national or regional level follows stages outlined below:

- Identification and prioritisation of needs or objectives. For electricity planning, the power and energy demand forecasts identify the need to be met over a defined time horizon. The demand must reflect the ability and willingness to pay by the target beneficiaries.
- Policy interventions such as universal access targets help define the time horizon and interventions to influence ability and willingness to pay. Because of conflicting interests, selection and ranking criteria must be set using a needs identification process. Criteria such as security, reliability and affordability need to be clearly defined in order to guide the selection and ranking of options and plans.
- Identification and prioritisation of options to fulfil needs. Options are identified on the basis of several criteria such as size, energy technology (renewable, fossil, nuclear), geographical location (national or regional), environmental, social and economic impacts. Ideally the options must be evaluated on the basis of information derived from available feasibility studies of similar quality. Only acceptable options are used in the final stage as candidate projects.
- Identification of the optimum plan (combination of options). The selected plan must reflect the optimum combination of acceptable options identified on the basis of criteria that best fulfil the needs. The complementary transmission plan is then developed to facilitate the necessary power flows from generation to load centres. National plans are completed first and used as inputs for the regional plan. Ideally the regional plan should in turn be used as input for a second iteration of the national plans so that the national plans are then aligned to the regional plans. The current master plans illustrate the actual planning processes that have been followed in the regions.

3.4.1.2 SADC region's plans for new and renewable energy sources (NRSE)

Protocol on energy (1996: 31) lists the guidelines of a strategy to promote increased production and use of renewables in an economically and socially acceptable:

- The commission shall develop appropriate financial mechanisms suitable for the development of NRSE.
- Member states shall consider the implementation of suitable tax regimes that promote the development and use of NRSE.
- Member states shall thrive to create an enabling environment for private sector involvement in NRSE.
- The commission shall provide, upon request and to the extent possible, technical support to governments and NGOs involved in NRSE sub-sector.
- Member states shall include cost-effective NRSE applications in their public investments programmes.

3.4.1.3 Energy regulation in the SADC region

Broadly, the energy sector in each country in the region is governed by a number of Acts, Bills and Charters that have been enacted by Government to guide the sector, primarily, the Electricity Act, Renewable Energy Act, Bill for Liquid Fuels and Pipelines (DBSA, 2014). Efforts are being made to harmonise energy regulations to complement countries in the region. RIDMP (2012: 32) indicates that nine countries have regulatory agencies that are members of the Regional Electricity Regulators Association (RERA); four countries (Botswana, DRC, Mauritius and Seychelles) were in the process of establishing regulators.

During the same period, the seven countries still only had electricity regulators, while three had energy regulators and one a multi-sector regulator (energy and water) and the trend is however that most countries are transforming the electricity regulators into energy or multi-sector regulators (RIDMP, 2012). At regional level, lack of coherent regulations and policy frameworks prompted the SADC countries to harmonise cross-border policies and regulations for renewable energy in the region in the coming years. RERA is supporting the harmonisation of the regulatory and national electricity policy frameworks and is working towards the standardisation of PPAs (RIDMP, 2012).

Harmonisation will be done in conjunction with Member States, SAPP, and the Regional Electricity Regulators Association (RIDMP, 2012). RERA has championed the development of the guidelines for regulating cross-border power trading, which provides an enabling framework for cross-border trade and investment in infrastructure that reduce some of the uncertainties that were deterring investment and undermining efforts to improve security of supply through cross-border trade (RIDMP, 2012).

The guidelines for regulating cross-border power trading have been adopted by SADC region and are now in operation. Some of SADC region's countries are at advanced stages in the implementation of regulatory initiatives; States such as Mauritius and South Africa have put in place strategies and action plans for renewable energy; in South Africa, renewable energy is included in the 2010 Integrated Resource Plan (Baleni, 2014). DBSA (2014) observes that regulatory reforms in the power sector have resulted in restructuring of the electricity supply industry (ESI) in order to encourage a competitive market and to provide customers with choice whilst providing a safe and reliable quality of supply.

3.4.1.4 Energy policy environment in the SADC region

In order to realise the full potential of renewables, governments will have to provide an enabling policy environment, encouraging and supporting wide-spread investment. In a market economy, the effectiveness of policies aimed at mobilising renewable energy investments is critically dependent upon their impact on investors' behaviours (Masini and Menichetti, 2012).

To maximise the impact of future policies, policy makers need to get a better understanding of how investors behave, and of how they take their decisions, particularly in regards to the key psychological factors that may influence their behaviours and actions (Masini and Menichetti, 2012). IRENA (2015: 26) argues that there is no policy or legal barrier to cross-border trading in any of the countries in electricity and in renewable energy project development, however, different interpretations of contractual obligations and the absence of explicit renewable energy policies and targets can be significant barriers in practice. They are a source of investor insecurity. This is where the role of the regional co-ordinating bodies is critical. It ensures that policy and regulatory frameworks are harmonised across borders.

Energy policies situation in the Southern African context, according to (Musango and Brent, 2011) is that there is no formal and coherent approach to energy technology needs assessment from a sustainability perspective and governments in the region are finding it challenging to establish national policies concerning energy technology assessment. Efforts to develop a more supportive policy environment for the development of a formalised renewable energy source like, biomass energy industry are often thwarted by entrenched anti-biomass sentiment at high level (Owen, Van der Plas and Sepp, 2013). Political commitment and support for the development of the necessary regulatory instruments for the advancement of renewable energy industry is imperative (Jumbe and Mkondiwa, 2013).

At member state level, eight countries have an energy policy and nine have an energy master plan, and when regional strategies and master plans such as this ESP are developed, Member States benefit by developing their roadmaps from the regional plans/strategies. It is envisaged that the ESP will impact on the development of future energy master plans of Member States, particularly those that have not yet developed their own plans (RIDMP, 2012). Table 3.7 presents a summary of status of the policy framework of the SADC member states.

Table 3.7: Summary of status of the policy framework of the SADC member states

Country	Energy policy/strategies	Energy master plan	Energy/electricity regulator
Angola			√
Botswana	Draft	√	In progress
DRC			
Lesotho			√
Malawi			√
Mauritius	√	√	
Mozambique	√	√	√
Namibia	√		√
Seychelles			
South Africa	√	√	√
Swaziland	√		
Tanzania	√		√
Zambia	√	√	√
Zimbabwe	√	√	√
SADC	√	Under development	√

Source: RIDMP (2012: 36)

According to Khennas (2012) only a fraction of the rural electricity needs can be met from renewable, on a commercial basis, in the short and mid-terms, subsidies on a large scale within a comprehensive and long-term strategy including local manufacturing of some components are necessary to lift out of the energy poverty trap the majority of rural population.

3.4.1.5 SADC region energy governance and institutional arrangements

According to RIDMP (2012: 34) key SADC institutions that are mandated to drive infrastructure development in the SADC region are the SADC Secretariat (policy harmonisation and resource mobilisation), SAPP (operation, largely co-ordination, and electricity trading) and RERA (regulatory harmonisation). RIDMP indicate that the SADC renewable energy sub-sector has not made much progress in establishing institutions similar to SAPP and RERA, a regional energy access strategy and action plan proposal called for the establishment of a renewable energy centre of excellence, similar to ECOWAS. The establishment of a SADC region's renewable centre of excellence is explained in detail in paragraph 3.4.1.6. Some of the governance and institutional bottlenecks impacting on efficient management of energy issues according to RIDMP (2012: 35) are:

- The actual implementation of energy infrastructure projects is being done at Member State level by utilities and IPPs with support from governments. Currently SADC institutions cannot implement infrastructure projects, because they do not have the mandate to do so.

- Unlike WAPP that is mandated by governments to raise funding and implement projects,

- SAPP is a co-ordinating and planning body also tasked with running a competitive electricity market in the form of a Day Ahead Market (DAM).

- RERA is an association of regulators and has no regional regulatory authority over its members; ECOWAS also provides good lessons, as they have a Regional Electricity Regulatory Authority that can regulate cross-border exchanges between Member States.

- Low staffing levels in the Energy Division of the SADC Secretariat renders it incapable of adequately performing its full complement of duties; additional positions supported by Member States have not yet been approved by Council owing to budgetary constraints.

3.4.1.5.1 Southern African Power Pool (SAPP)

Before the conception of SAPP, electricity trading in Southern Africa started in the early 1960s as bilateral trade after the commissioning of the Kariba hydro power station situated on the border between Zambia and Zimbabwe (Musango and Brent, 2011). SAPP was created in August 1995 at the SADC summit held in Kempton Park, South Africa, when member governments of SADC (excluding Mauritius) signed an Inter-Governmental Memorandum of Understanding for the formation of an electricity power pool in the region under the name of the SAPP (SAPP, 2013a).

Motivation for the diffusion of renewable energy technology varies between countries, although the use of renewable energy sources provides benefits such as reduced carbon emissions and in some cases improved energy security (Popp, Hascic and Medhi, 2011). The aim was to support SADC's objective to promote economic cooperation among the then 12 member countries, namely, Angola, Botswana, DRC, Lesotho, Malawi, Mozambique, Namibia, the Republic of South Africa (RSA), Swaziland, Tanzania, Zambia and Zimbabwe. Table 3.8 presents members of SAPP 2011.

Table 3.8: Members of SAPP 2011

Country	Name of Utility	Status	Installed Capacity (MW)
Angola	Empresa Nacional de Electricidade (ENE)	Non- operating	1187
Botswana	Botswana Power Corporation (BPC)	Operating	202
DR Congo	Societe Nationale d' Electricite (SNEL)	Operating	2442
Lesotho	Lesotho Electrical Company (LEC)	Operating	72
Malawi	Electricity Supply Commission(Escom)	Non- operating	287
Mozambique	Electricidade de Mocambique(EDM)	Operating	233
Mozambique	Hydroelectricica de Cahora Bassa (HCB)	Operating	2075
Namibia	Namibia Power Cooperation (Nampower)	Operating	393
South Africa	South Africa Electricity Supply Commission (Eskom)	Operating	44170
Swaziland	Swaland Electrical Company (SEC)	Operating	70
Tanzania	Tanzania Electrical Supply company (Tanesco)	Non- operating	1008
Zambia	Copperbelt Energy Cooperation	Independent*	80
Zambia	Zambia Electricity Supply Coorporation (ZESCO)	Operating	1812
Zimbabwe	Zimbabwe Electricity Supply Authority (ZESA)	Operating	2045

* Independent transition company

Source: Du Pisani, Erasmus and Hartzenberg (2013: 126)

3.4.1.6 SADC Center for Renewable Energy and Energy Efficiency (SACREEE)

The establishment of SACREEE as a subsidiary organisation of SADC is underway. The SACREEE aims at the following overall objective: contribute towards increased access to modern energy services and improved energy security across SADC region by promoting market based uptake of renewable energy and energy efficient technologies and energy services (SACREEE, 2013: 22). The mandate of the organisation according to SACREEE (2013: 24) will cover the following renewable energy and energy efficiency technologies and measures:

- Grid-connected renewables including solar PV, Concentrated Solar Power (CSP), Wind, Biomass cogeneration, hydro power up to 30 MW, biomass, biomass co-firing with coal, geothermal.
- Off-grid renewables for mini-grids (including hybrids, e.g., renewable-diesel).
- Independent (decentralised) such as solar-PV based systems for household, small business, industry, or agricultural use.
- Renewables for energy services for remote social services such as health centers, schools, community centers, water supply and sewerage treatment.
- Biofuel projects which prove to be sustainable.
- Biogas (domestic and industrial scale), waste to energy.
- Biomass for industrial electrical and thermal applications.
- Solar thermal systems for warm water generation for use in buildings as well for industrial process heat and cooling purposes.
- Ocean related energy forms.

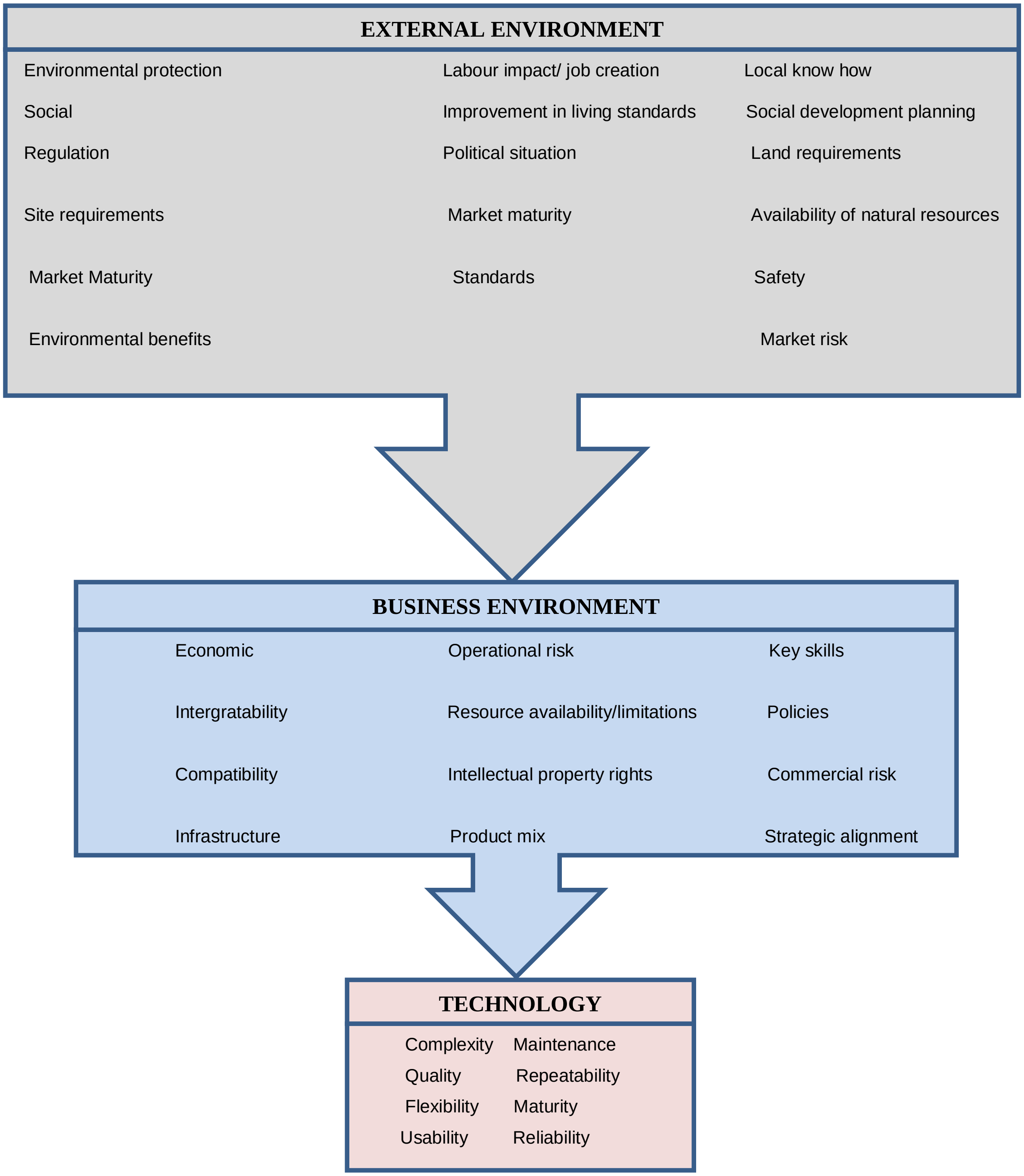
3.4.1.7 Green energy technology innovation

Renewable energy technologies have impediments to break through in the energy market dominated by fossil fuel technologies that reap the benefits from economies of scale, long periods of technological learning and socio-institutional embedding (Negro, Alkemade and Hekkert, 2013). Rao and Kishore (2010) indicate that renewable energy technologies are mainly driven by impending environmental and energy security considerations arising from use of fossil fuel based energy (from coal, oil and gas) and the fact that fossil based energy sources are not infinite.

Technology innovation is a gradual process and evolves through different stages; in the early stages, innovation process typically has significantly higher unit costs than the established alternatives (Liu and Liang, 2013). Liu and Liang (2013) observe that challenges for innovation for renewable energy technology are common to all countries; they are especially acute in developing countries and they include: Vision, strategy, and policy framework; Intellectual property rights protection; Infrastructure constraint; Human and institutional capacity

Renewable energy sources, which are often (but not always) carbon-free, are among the technology options available to reduce carbon emissions in the electricity sector however, these technologies are also more costly to use than traditional fossil fuels (Popp, Hascic and Medhi, 2011). Technology selection must be suitable to the local conditions; the success and failure will be influenced by the external environment and local business environment. Renewable energy sector depends on technological innovations for the sustainable production of energy, and utility firms act as agents of change and innovation (Nisar, Ruiz and Palacios, 2013). Figure 3.4 illustrates a summary of generic technology selection factors.

Figure 3.4: Summary of generic technology selection factors



Source: Adapted from Barry (2011: 30)

3.4.1.8 Human capacity development

Shortage or lack of skilled staff is an obstacle to the augmentation of renewable energy in the developing countries (Negro, Alkemade and Hekkert, 2013). A key difficulty in ensuring an adequate supply of skills for renewable energy is that the sector requires substantial numbers of engineers and technicians; shortages in these occupations are common in developed countries and can easily occur in developing countries when there is a sudden increase in demand (International Labour Office, 2011).

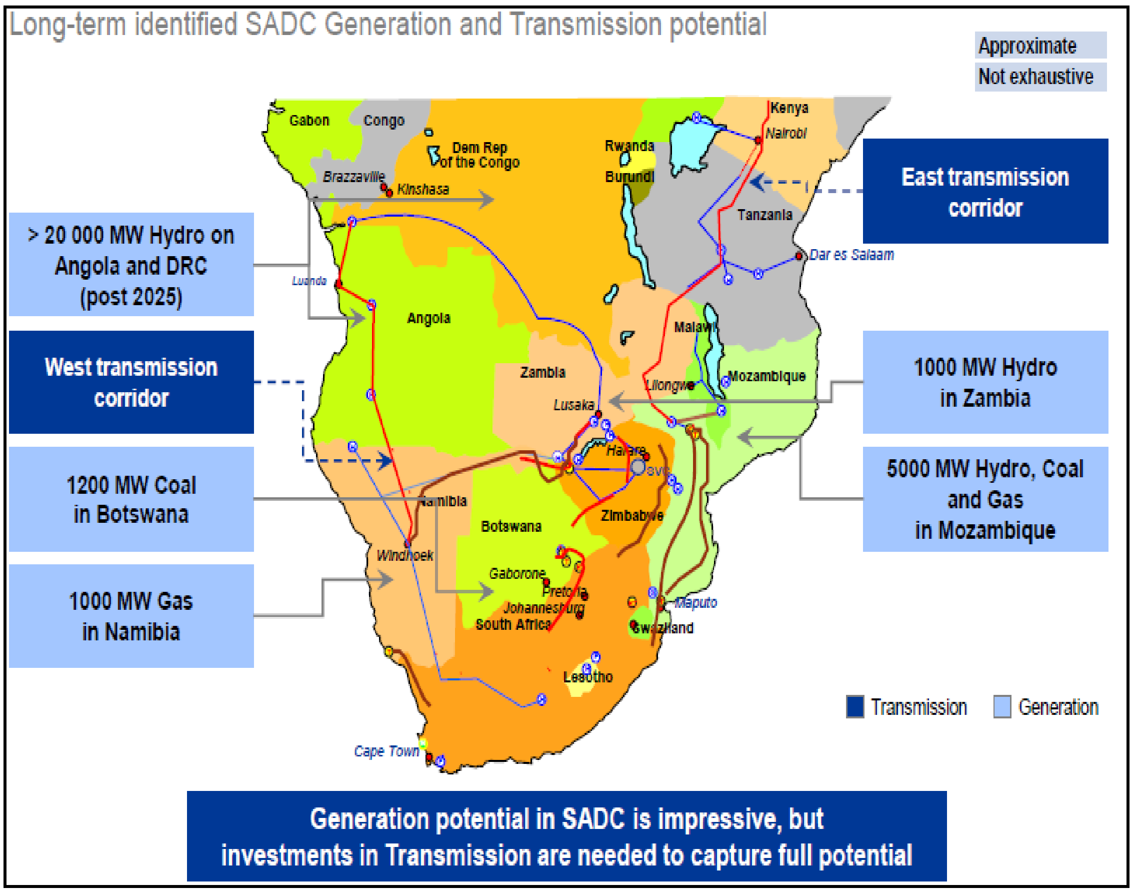
Training and skills development of communities can also alleviate the lack of user acceptance and also ensure that the skills base of the community can be improved to help maintain the technology. It is important that governments also create consumer awareness through information programmes to educate the potential users on the advantages of renewable energy technologies (RIDMP, 2012). Capacity building and institutional strengthening of various energy institutions is necessary to ensure sustainability of the infrastructure developed (Negro, Alkemade and Hekkert, 2013; KPMG, 2014).

3.4.1.9 Green energy infrastructure development

DBSA (2014) recommends an interconnectivity and trade in electricity; oil and natural gas through grid connections and pipeline development presents opportunities for sharing resources, creating economies of scale and realising significant savings on investments. The existing transmission infrastructure is old and mainly insufficiently maintained and not able to deal with the growth of generation, especially not with the planned new builds in most of the countries and not with the need for transmission through the introduction of renewable energy (KPMG, 2014).

Dames (2011) indicates that existing networks are not only constrained but also require rehabilitation. Investing in transmission networks must be biased to advantage the connection multiple IPP's. Longterm SADC region generation and transmission potential will be facilitated by east and west transmission corridors (Dames, 2011). Figure 3.5 illustrates long-term identified SADC generation and transmission potential.

Figure 3.5: Long-term identified SADC generation and transmission potential



Source: Dames (2011:13)

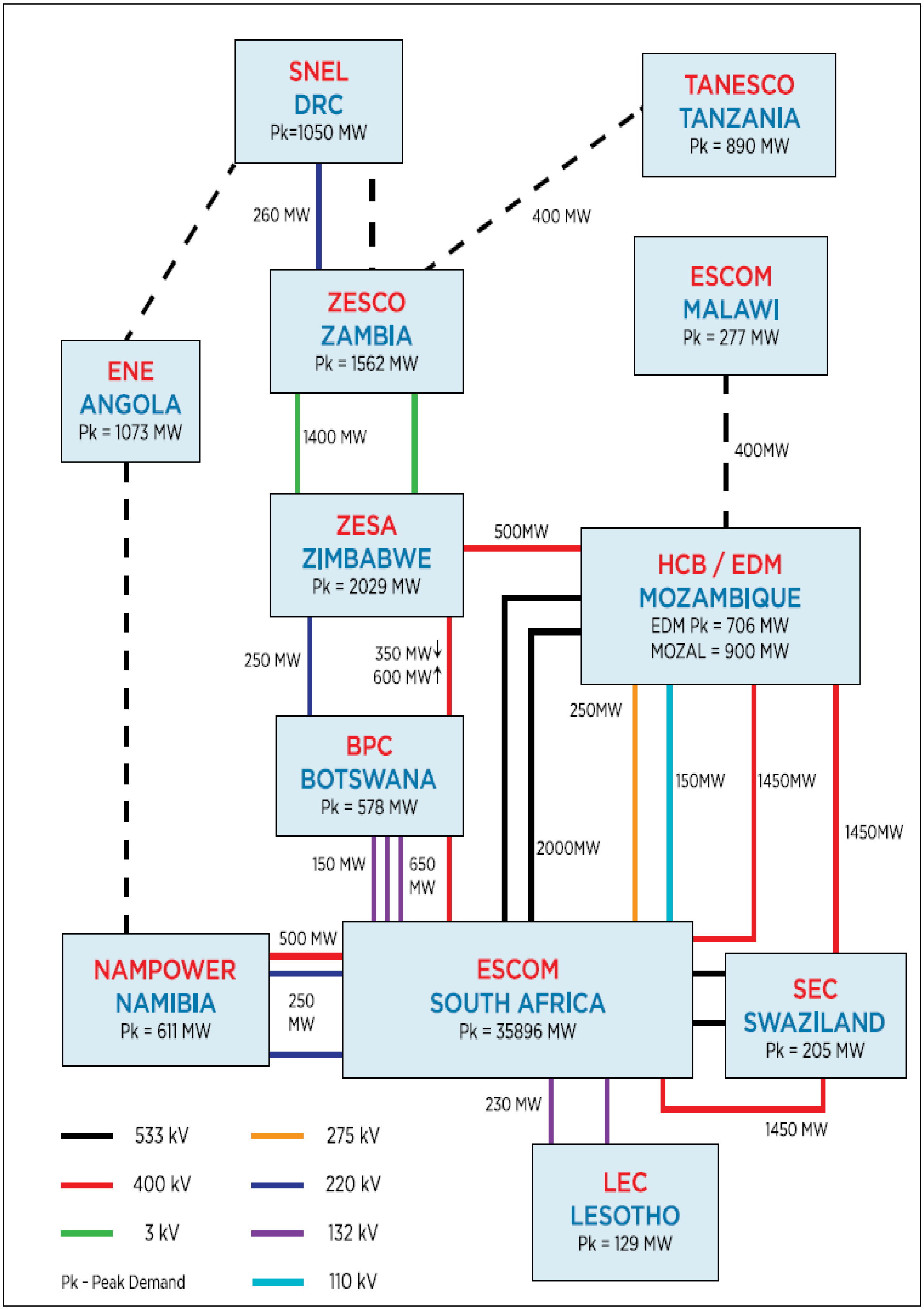
RIDMP (2012) points out that "hard" projects have been identified in the context of developing the Energy Sector Plan (ESP). The ESP is designed to address four key strategic objectives that are paramount in the energy sector of SADC namely, ensuring energy security, improving access to modern energy services, tapping the abundant energy resources and achieving financial investment and environmental sustainability (RIDMP, 2012).

To improve access to renewable energy the networks must be routed strategically, for example to produce CSP in Botswana to be delivered by grid to Zimbabwe (Dames, 2011). These strategic objectives collectively contribute to the SADC energy vision of achieving adequate, reliable, least cost, environmentally sustainable energy services for economic growth and poverty eradication (RIDMP, 2012).

Another challenge for the transmission infrastructure, and consequently also for the distribution grid, is that all the renewable energy projects are being developed in areas favouring the source of renewable energy, such as sunny and windy areas (KPMG, 2014). These areas are not always necessarily the closest to the existing infrastructure; a contribution from the renewable projects to the grid development or coupled projects could also improve the situation (KPMG, 2014).

The existing power interconnections cover nine of the 12 member countries (SAPP, 2013a). The most tightly interconnected country is South Africa. The highest transmission voltages are 533 kV HVDC (South Africa to Mozambique and within DRC and Namibia), 400 kV (between and within South Africa, Botswana, Namibia, Zimbabwe, Swaziland and Mozambique) and 330 kV (between and within Zimbabwe and Zambia). Recent 330 kV projects are designed for ease of upgrading to 400 kV. South Africa has some lines designed for 765 kV, but still operating at 400 kV. Figure 3.6 illustrates existing SAPP interconnections.

Figure 3.6: Existing SAPP interconnections



Source: SAPP (2013b: 71)

3.4.1.10 Green energy projects financing in the SADC region

SACREEE (2013:19) indicates that limited finance is available to finance renewable energy projects in the form of loans that have affordable interest's rates by commercial banks. Banks are not favourable to renewable energy investments as they are perceived to be risky. PIDA (2011) indicates that behind the under exploitation of energy resources in Africa, lies poor capacity to mobilise financing for investment, especially from private sources, owing to the poor creditworthiness of countries and utilities and high political risks. Investments in renewable energy technologies yield lower returns compared to investments in conventional energy systems. Energy analysts estimate that huge additional investments are needed to realise that transition to a low carbon economy (Masini and Menichetti, 2012).

The main conclusions of the Africa Energy Outlook 2040 in terms of spending needs according to PIDA (2011: 26) shows that an estimated U$43.6 billion per year will be needed to meet forecast energy demand for Africa to the year 2040 as follows:

- The average annual investment needs for the power sector are estimated at U$42.2 billion, with U$33.1 billion for generation, U$5.4 billion in interconnections, and U$3.7 billion in access.

- Interconnection investment is urgent and needed up front to meet the forecast energy demand in 2020 for an average of U$5.4 billion per year.

- A relatively small investment of U$3.7 billion per year is needed to ensure no country has an access rate below 60% by 2040.

- An estimated U$1.3 billion per year will be needed for gas and petroleum product pipelines.

- No significant increase in average wholesale tariff is required to finance the sector programme, which would remain around U$0.10/kWh.

- The main challenge will be financing the large capital investment requirements of the power sector, especially the need to increase private sector financing and sector cash flow by some 7–10 times their current levels.

- Tapping into climate funds should be considered and therefore capacity developed to access innovative financing mechanisms.

The total estimated cost of electricity in the SADC region according to RIDMP (2012: 9) is:

- A minimum of U$114 billion and a maximum of U$233 billion between 2012 and 2027 and the related transmission investment costs to support new generation capacity are in the region of U$540 million.

- The total cost of the prioritised projects (>50% score) would range from U$42 billion to U$122 billion. The planned projects that scored below a figure of 50% score of various sizes would cost a minimum of US$50 billion and a maximum of U$90 billion.

- The grand total of all these projects to be implemented from 2015 to 2027 would cost in the region of U$93 billion to U$212 billion, which is close to the budget for all the planned projects.

- SAPP has earmarked eleven priority transmission projects but only 5 have been "costed" totalling about U$3 billion and these are Zimbabwe/Zambia/Botswana/Namibia (ZIZABONA) (U$225 million), Zimbabwe Central Transmission Corridor (U$100 million), Zambia/Tanzania and Kenya Interconnector (U$860 million) and Mozambique Transmission Backbone Project (U$1 700 million).

- All these projects are expected to be accomplished by 2017, the amount of funds will be spent on both electricity generation and transmission infrastructure. Table 3.9 presents SAPP prioritised projects 2015–2027.

Table 3.9: SAPP prioritised projects 2015–2027

Generation projects	Min US$ million	Max US$ million	Period
>50% & capacity >1000MW	4 845	12 155	2017
	5 920	17 760	2022
	24 735	74 140	2027
Subtotal	35 500	104 055	2015 – 2027
>50% score and <1 000MW	5 134	12 251	2017
	1 305	3 915	2022
	543	1 629	2027
Subtotal	6 982	17 795	2015 – 2027
Total >50%	42 482	121 850	2015 – 2027
<50% score	50 392	89 964	2015 – 2027
Grand total	**92 873**	**211 814**	**2015 – 2027**

Source: RIDMP (2012: 9)

A Programme for Infrastructure Development in Africa (PIDA) (2011: 66) estimate that an action plan for priority projects up to 2020 that affect SADC countries amount to U$28.5 billion; these projects include:

- Four generation plants namely Mpanda-Nkuwa Hydro power Plant in Mozambique (1 500 MW), the INGA III Hydro in DRC (4 200 MW).

- The Batoka Hydro electric Plant on the Zambezi River (1 600 MW) and the Lesotho Highlands Water Project Phase II hydro power component (unspecified capacity).

- Two transmission lines, the North-South Power Transmission Corridor (8 000 km) and the Central African Interconnection (3 800 km); the transmission lines extend beyond the SADC region but the involved countries would participate in the sections of the transmission lines that pass through their countries.

3.4.2 Increasing energy generation capacity in the SADC region

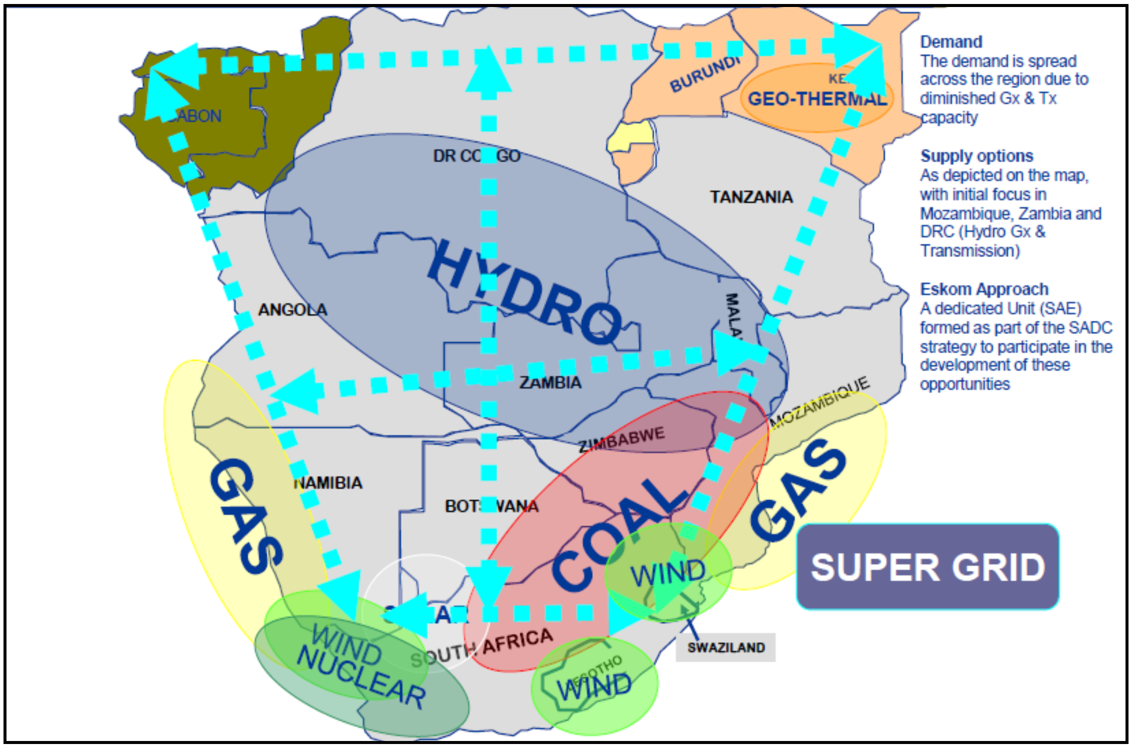
Power shortages have impacted most countries at varying degrees but more prominently in Botswana, Namibia, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe (DBSA, 2014). Generally, the region is facing acute challenges in the availability of commercial energy. Major reasons for the diminishing generation capacity according to DBSA (2014: 1) in the SADC region are primarily due to:

- An increase in electricity demand; unexpected high industrial growth.
- Economic expansion.
- High growth in population.
- Uneconomic tariffs that do not support the capital and operational cost for investment in power generation.
- Lack of capital injection into new generation projects by both the public-private sector.

Indications are that SADC has sufficiently planned to meet energy demand for the 3% growth rate but additional preparedness is required if SADC grows at both 5% and 8% (RIDM, 2012).

SAPP (2014: 5) indicates that the region will have sufficient generation capacity after 2017 if all the planned projects are commissioned. Energy adequacy will be achieved in 2018. Generation reserve margin will reach 12.6% in 2016, 17.2% in 2017 and 23.8% in 2018. Figure 3.7 illustrates potential energy future – 2030.

Figure 3.7: Potential energy future – 2030



Source: Dames (2011: 4)

According to RIDMP (2012: 8), projections for energy demand for electricity, petroleum and gas, coal and renewable energy were therefore done at 3%, 5% and 8% and the expected infrastructure requirements estimated. All scenarios were taken forward to guide the necessary preparedness that is required should the region grow at these growth rates without selecting one scenario, as to do so is to presume a particular growth rate.

Projections and gap analysis according to RIDMP (2012: 7) for energy demand projections to 2027, three scenarios were developed:

- Where the SADC economy develops at 3%, which is what is considered to be the current expected rate of growth.
- The region is also expected to grow at 5-6%, if its potential is not constrained.
- If the region is to eradicate poverty and achieve the Millennium Development Goals the region should grow at 7-8%. Table 3.10 illustrates the summary of the gap analysis in terms of the deficits that are expected to occur at the three economic growth rates.

Table 3.10: Summary of gap analysis in terms of the deficits that are expected to occur at the three economic growth rates

Electricity	Growth rate	2010	2017	2022	2027
	Generation capacity (TWh)	284	405	448	487
	Generation capacity (GW)	48	69	80	100
	3% (TWh)		349	405	469
	3% (GW)		69	74	86
	5%(TWh)		400	510	651
	55(GW)		72	93	117
	8%(TWh)		487	715	1050
	8%(GW)		85	125	184
Petroleum and gas	Growth rate	2007	2017[2]	2022	2027
Additional capacity of fuel types	Average growth rate baseline				
	Petrol-million kl	4.1	6.2	4.0	4.6
	Diesel-million kl	7.9	6.0	3.8	4.4
	Jet A1-million kl	1.1	2.2	1.5	1.9
	Paraffin-million kl	0.39	0.34	0.21	0.25
	LPG-million tonnes	0.14	0.43	0.35	0.50
	5% petrol-million kl		10.6	7.6	9.7
	Diesel-million kl		10.7	7.7	9.8
	Jet A1-million kl		2.5	1.8	2.3
	Paraffin-million kl		0.60	0.43	0.55
	LPG-tons		0.28	0.20	0.25
	8%-petrol-million kl		19.5	17.0	25.0
	Diesel-million kl		19.8	17.3	25.4
	Jet A1-million kl		4.6	4.0	5.9
	Paraffin-million kl		1.1	1.0	1.4
	LPG-tons		0.51	0.44	0.65
Coal	Growth rate	2010	2017	2022	2027
	Baseline production Mt	259	309	350	397
	3% Mt		321	373	434
	5% Mt		361	451	565
	8% Mt		430	606	861
Renewable energy	Growth rate	2010	2017	2022	2027
	RE capacity additions (MW)		+13 719	+10 345	+8 243

Source: RIDMP (2012: 8)

The strategy for addressing gaps for some of the priority goals according to RIDMP (2012: 55) are:

- Exploiting abundant renewable energy resources, increasing clean energy in the generation mix and also contributing to clean energy access.
- Regional manufacturing of renewable energy products.
- Adequate grid capacity for connection of renewable energy plants.
- Dedicated institutional framework for renewable energy and energy efficiency.
- R&D and testing facilities for renewable energy.
- Co-ordinated planning and guidelines for biomass resource/biofuels use.
- Harmonised policy on renewable energy tariff setting and PPA standardisation.
- Investment and financial plan (similar to electricity).

3.4.2.1 Biomass energy potential

Biomass is SSA's dominant source of energy, and will remain so for the foreseeable future. Owen, Van der Plas and Sepp (2013) observe that demand for biomass energy is expected to rise significantly; despite major electrification programmes that governments mistakenly believe will provide a substitute. In order to realise the full potential of biomass energy for poverty alleviation and the creation of employment and business opportunities, prevailing informal production and distribution of solid biomass must be replaced with economically viable and socially equitable arrangements in a more modern and organised fashion (Owen, Van der Plas and Sepp, 2013).

Biofuels enhancement as a source of energy provides a potential catalyst for economic growth, poverty alleviation and security of energy supply. Jumbe and Mkondiwa (2013) stress the importance of clear, visionary policies and institutional frameworks for the development of the biofuels industry in SSA present opportunities that can be used for biofuels and benefit from the carbon markets. It is imperative that policies to stimulate biomass industry, energy demand management, energy supply enhancement and fiscal measures for modernisation of the biomass energy sector are embedded in the dynamics of the decentralisation processes (Owen, Van der Plas and Sepp, 2013).

3.4.2.2 Hydro electrical power potential

Large scale hydro is the most inexpensive, efficient and affordable form of renewable energy, with a large potential yet to develop in Africa (only 7% potential developed which is the lowest rate of the world's regions) (World Energy Council, 2013b). Africa has a major natural advantage in hydro power because it has immense high-altitude areas on to which the water vapour gathered over the Atlantic falls.

The run-off from this rainfall through the Congo, Niger and Zambezi rivers could support several mega-dams, significant projects in the upper Nile (Ethiopia and Uganda), and numerous smaller schemes (Collier and Venables, 2012). The most notable example of investments that are blocked through political obstacles include the Grand Inga hydro electric project on the River Congo; this hold up has deterred private investment for decades (Sebitosi and Okou, 2010; Collier and Venables, 2012).

3.4.2.2.1 The grand Inga project

Kammen and Kirubi (2008) argue that the DRC emerges as a potentially significant exporter of electricity and it can be a net exporter almost four times larger than its domestic consumption and continue supply hydro power through Namibia, Botswana, Zimbabwe, Mozambique and Lesotho. The Congo River is currently the world’s second largest in terms of its flow (Odhiambo, 2010; World Energy Council, 2013a). Scholars estimate the potential for hydro electric capacity at approximately 100 000 MW, which can be exploited to benefit the whole of central African region (Odhiambo, 2010).

Inga in the DRC is one of the largest hydro electrical resources in the world with a potential of over 100 000 MW. This resource can light up the African continent and west Europe (DBSA, 2014). Only a fraction of hydro electric power has been developed in DRC and this has been largely due to the political uncertainties that have ravaged the country and scared potential investors over the years. Odhiambo (2010) points out that in 2003 the DRC had a total generating capacity of about 2 568 MW, but only produced between 600 and 700 MW because two-thirds of the turbines were dysfunctional. First studies were done in the 1960s (OFID, 2008). These site development studies recommended the construction of four hydro electric power stations in two phases.

DBSA (2014) indicates that the World Bank is currently conducting feasibility studies on the rehabilitation of Inga 1 and 2 power stations, which will involve the rehabilitation of four power generating units, construction of a transmission line between Inga power station and Kinshasa town, as well as the rehabilitation of the distribution network in Kinshasa at an estimated cost of about the project is about US$430 million. The Inga Hydro Power Project has been under discussion for a long time.

The Inga mega–project (which includes the related Inga 3 project) is one of the highest priorities for the New Partnership for African Development (NEPAD), the Southern Africa Development Community (SADC), and Eskom, Africa's largest power company (Hathaway, 2005). The first phase concerned the building of three power stations in the Nkokolo Valley, apart from the two existing sites and the one currently under development, the total potential of the Grand Inga Project amounts to about 39 000 MW (OFID, 2008).

In line with NEPAD vision, it is concluded that the challenges and security of electric power to SSA countries could be met through power trading (Tshombe, Ferreira and Uken, 2007). This should be based on the development of the Inga 3 and Grand Inga hydro power schemes in the DRC. Meaningful power trading between the WAPP, the EAPP and the SAPP is feasible and recommended (Tshombe, Ferreira and Uken, 2007). Power generated from the Inga dam can provide sufficient electricity to the African continent and it could help Africa export energy through possible interconnection links to Southern Europe (OFID, 2008). The Inga mega–project would centralise much of Africa's electricity source and require a grid of transmission lines through many of Africa's most politically unstable regions; power plants, and transmission lines are often made targets in political conflicts (Hathaway, 2005).

The dependence of more countries' economies on Inga would increase its attractiveness as a target for sabotage by rebel groups; years ago (in 1998), rebels seized Inga II and cut its power to Kinshasa, the capital of DRC (Tshombe, Ferreira and Uken, 2007; Hathaway, 2005). New generation from Inga 3 of about 3 500 MW has been dedicated to the WESTCOR project which involves five countries, namely: Angola, Botswana, DRC, Namibia and South Africa (DBSA, 2014).

3.4.2.3 Solar energy potential

Superficially, the most promising new green energy technology for Africa is solar power. It fits Africa's natural endowment of strong sunlight distributed evenly throughout the year. Collier and Venables (2012) and Shukla, Dhar and Fujino (2010) observe that solar energy sources, have the potential to improve access to modern energy, though photovoltaic (PV) or CSP. Attempts to disseminate solar PV technology alone, with emphasis on electrification of rural households, are unlikely to succeed and would not address the needs of the rural poor in SSA if this technology does not quickly increase incomes of the rural poor in SSA (Otiti and Soboyebo, 2006).

According to Nkwetta et al. (2010) the use of solar thermal systems in particular should enable SSA countries to meet a large proportion of the energy demand via renewable energy sources, avoiding the social, economic, and environmental downsides resulting from the use of fossil fuel energy sources. Otiti and Soboyebo (2006) indicate that PV technology is ideal for dispersion and decentralisation to rural households of developing countries and is, in the long-term, a cheaper option than conventional grid biased electricity; thus, many national renewable and rural energy strategies must give priority to the dissemination of PV and CSP technology.

3.4.2.4 Wind energy potential

Wind is an attractive option for countries with abundance of wind, particularly the coastal areas in the SADC region, as it can be installed quickly in areas where electricity is urgently needed; in many instances it may be a cost effective solution if fossil fuel sources are not readily available, or are expensive (Sartipipour, 2011). In addition there are many applications for wind energy in remote regions; it can transform energy access for supplying farms, homes, and other installations on an individual basis (Milborrow, 2011).

Wind turbines in rural areas can be used for pumping drinking water needed for livestock and poultry, farm irrigation, and for supplying the required domestic water. Moreover, wind turbines can be used to generate electricity in areas far from urban electricity grid as well as far flung villages (Sartipipour, 2011). Wind electrical generation is hindered by lack of skills and spare parts manufacturing industries in developing countries and this must be addressed as a matter of urgency (IEA, 2012a).

3.4.2.5 Nuclear energy potential

RIDMP (2012: 30) indicates that nuclear power is considered an important fuel in the global electricity generation mix. It is viewed as a solution for climate change, but recent disasters and the constant fear of managing nuclear waste prevents it from being a popular solution. In the SADC region, the share of nuclear, which is only found in South Africa, is 1.6%. South Africa has been reluctant to implement further nuclear power stations using its Pebble Bed Technology (RIDMP, 2012: 30). There is strong opposition from the NGO community, and proliferation of nuclear energy is not likely to happen as government stopped funding the project due to financial constraints. However, South Africa only plans to add nuclear capacity in 2023, perhaps hoping that the option will be more acceptable then. Globally, the annual generation of nuclear power has been on a slight downward trend since 2007, decreasing by 1.8% in 2009 to 2 558 TWh14 (RIDMP, 2012: 30).

3.4.3 SADC region energy market structure

SACREEE (2013:18) observes that markets for renewable energy technologies and energy services in the SADC region tend to be fragmented along national boundaries. Such markets follow polices and strategies that are developed and implemented at national levels.

Given the sizes of the markets in each SADC member states, economies of scale are rarely achieved as the markets at national levels tend to be small. Accordingly, developing markets across the region would create competitive markets and competition that would bring about improved energy services and more benefits to SADC populace. According to (IRENA, 2015: 29) internationally and regionally, electricity market structures have been evolving according to the models listed below:

- Stage I - vertically integrated monopoly. A single entity is responsible for generation, transmission, distribution and retail. The regulation function is jointly exercised with the energy ministry where the utility has the authority to make recommendations. This is a kind of self-regulation. The power pools were established when almost all countries had this traditional structure.

- Stage II – vertically integrated single buyer with IPPs. Multiple generating companies compete to supply power to the vertically integrated utility. The utility’s regulatory powers are confiscated to avoid conflict of interest from its role both as referee and player. The regulatory functions should ideally be vested in an independent regulatory agency in order to minimise political interference, especially in tariff setting and revenue collection.
- In practice it takes time for governments to have sufficient trust to grant full independence to regulatory agencies. The regulatory agencies usually start as semi-independent entities, notwithstanding the legal provisions.

- Stage III - unbundled industry with wholesale competition. Separate entities are in place for generation, transmission, distribution and retail electricity supply. Independent regulatory agencies and system and market operators are introduced.

- A competitive wholesale market is established for large customers, distributors and retailers who are connected at high and medium voltages.

- Open access to transmission and sub-transmission lines is necessary. This structure would provide better support of the power pools as they move from shallow to deep regional integration.

- Stage IV - unbundled industry with retail competition. This is similar to the previous structure with expansion of choice to retail customers. Open access to transmission, sub-transmission and distribution lines is necessary. This is the final stage of competition already expressed in the SAPP vision statement.

- Although member states are at the second stage, the power pools are planning to operate at the third stage by introducing wholesale competition at regional level.

- Countries could keep pace by ring-fencing their transmission, system and market operations and getting these to operate at arm's length from the generation and distribution businesses.

According to Dames (2011: 10) in order for renewable energy sector to thrive, a stable tariff regime, regulatory environment is mandatory and this can be stimulated by:

- Encourage and facilitate the entry of IPP's through ensuring an appropriate enabling environment, as differences in policies and legislation in different countries can causes delays in concluding Power Purchase Agreements (PPAs).

- Invest more in defining and streamlining processes and legislation that will see the participation of IPPs fast tracked.
- Tariff regime that encourages investors to be interested in renewable energy to ensures successful projects and delivering of multiple benefits and economic value.
- An energy system that will lower wholesale electricity prices over time and also lowering the risk to all parties – financiers, government, consumers, investors.
- Ensuring that there is fairness transformation of the energy system. Renewable energy projects can be used to stimulate enterprise development and entrepreneurship.
- Providing access to finance and micro finance loans for women and people with disabilities owned enterprises and support and mentoring for start-up and expanding enterprises.
- Fostering local entrepreneurship business training for local business owners. Another option is the development of a local community trust where ownership of renewable energy projects can target citizens within a certain km radius from the project.

According to Pricewater House Coopers (PWC) (2014: 3) five value drivers will be fundamental in the future utility market:

- Customers are looking to take control over their energy supply and demand – they will look to manage their energy far more effectively than they can today.
- Power generation and networks will be transformed – the energy value chain is currently subject to disruption, and this will accelerate over the next five years – those that innovate will protect and increase their value.

- The role of the utility will transform into that of a service company that enables 'energy solutions' and in many cases 'home solutions' – this will require major transformation of business and operating models.
- Data will play a dominant role in the future energy value chain – new value will be found within the data underlying customer energy usage patterns.
- Governments and regulators will need to reshape energy and related services markets to keep pace with customer and 'energy enabler' needs.

3.4.4 Baseline energy situation summary in the SADC region

3.4.4.1 Angola

Angola is a Southern African country bordering the South Atlantic Ocean, Zambia to the East, Namibia to the South and the Democratic Republic of the Congo to the North (Barros and Managi, 2009; Solarin and Shahbaz, 2013). Upon gaining independence from Portugal on November 11, 1975, the country immediately plunged into a protracted civil war that continued for 27 years; during the civil war (of which almost 1.5 million died and 4 million people were displaced), existing infrastructural facilities, including infrastructure in the electricity sector, were damaged (Solarin and Shahbaz, 2013).
Angola has exceptional potential wealth of raw materials, particularly oil and diamonds; present day Angola, with a democratically elected government, is well placed to embark upon a process of growth.

The country is currently the world's fourth largest producer of diamonds and the second-largest producer of oil in SSA after Nigeria (Barros and Managi, 2009; Solarin and Shahbaz, 2013). Most of Angola's income is generated through oil exports and diamonds; the output in 2005 rose to 1.3 million barrels per day, providing 91.94% of Angola's total export revenues (Solarin and

Shahbaz, 2013). However, Angola remains prone to widespread corruption on a grand scale, with particular regard to its oil wealth. Much needs to be done to counter cronyism and corruption in the country (Barros and Managi, 2009). Angola has an electrification rate of about 26.2% (Hailu, 2012). About 90% of electricity is generated from renewable energy sources (Musango and Brent, 2011). Angola national energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 498.1 PJ – of which renewables: 310.8 PJ (62.4%)
- Energy self-sufficiency: 8487%
- Fuel imports: Not available
- Electricity generation: 4 172 GWh - of which renewables: 3 173 GWh (76.1%)
- Electricity generation: 4 172 GWh - of which renewables: 3 173 GWh (76.1%)
- Electricity use per capita: 203 kWh
- Electrical capacity*: 1 155 MW - of which renewables: 498 MW (43.1%)
- Electricity access rate: 30.0%
- Share of population using solid fuels: 48%

***** 2008

3.4.4.2 Botswana

Botswana is flat, and about 70% is covered by the Kalahari Desert. It is bordered by South Africa to the south and southeast, Namibia to the west and north and Zimbabwe to the northeast (Ketlogetswe, Mothudi and Mothibi, 2007; Javadi et al., 2013). Botswana has about two million people and is one of the most sparsely populated countries in the world (Musango and Brent, 2011). Most of the poor households, who live in rural areas do not have electricity, and tend to use paraffin for lightening (Javadi et al., 2013).

Botswana does not generate electricity through renewable energy sources (Musango and Brent, 2011). The country is endowed with sunshine that can enhance socio-economic benefits, and to foster sustainability by using PV solar power generation systems in rural communities in Botswana, authorities should increase the level of subsidy on the use of solar technology (Ketlogetswe and Mothudi, 2009). Botswana national energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 85.8 PJ - of which renewables: 20.2 PJ (23.6x587%)
- Energy self-sufficiency: 45.8%
- Fuel imports: U$625 million (13.2 % of total imports)
- Electricity generation: 444.0 GWh (excludes emergency generation from diesel) – of which renewables: 0.0G Wh (0 %)
- Electricity use per capita: 1 528 kWh
- Electrical capacity*: 292 MW - Of which renewables: 0 MW
- Electricity access rate: 45.4%
- Share of population using solid fuels: 40%

***** 2008

3.4.4.3 Democratic Republic of the Congo (DRC)

The Democratic Republic of the Congo is a country located in the African Great Lakes region of Central Africa. DRC is the second largest country in Africa by area and the eleventh largest in the world having a population of over 75 million (Odhiambo, 2010). The Democratic Republic of the Congo is the the fourth most populous nation in Africa (Javadi et al., 2013). It borders the Central African Republic and South Sudan to the north; Uganda, Rwanda and Burundi in the east; Zambia and Angola to the south; the Republic of the Congo, the Angolan exclave of Cabinda and the Atlantic Ocean to the west; and is separated from Tanzania by Lake Tanganyika in the east.

Overall, the energy sector in the DRC is largely dominated by the high consumption of wood and bio-mass energy: it is estimated that only about 6% of the country's population has access to electricity (Odhiambo, 2010; Javadi et al., 2013). Despite the fact that the country has extensive potential hydro electric capacity of approximately 100 000 MW, only a fraction of its hydro electric power has been developed (Odhiambo, 2010).

In 2003 the DRC had a total generating capacity of about 2 568 MW, but only produced between 600 and 700 MW because two-thirds of the turbines were dysfunctional. The DRC exports nearly one-third of the electricity consumed to the Republic of Congo-Brazzaville along a 220 kV connection; Zambia, the CAR and Angola, among others. The electricity in the DRC is SNEL (Odhiambo, 2010; Javadi et al., 2013). About 60% of the total land area of the region representing about 18% of the world's tropical forests (a forest area of around 227 million hectares (Somorin, Brown, Visseren-Hamakers, Sonwa, Arts and Nkem, 2012). DRC has about 11.1% electrification rate, mainly from hydro electrical generation from Congo River (Hailu, 2012).

DRC national energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 959.7 PJ - of which renewables: 927.1 PJ (96.6%)
- Energy self-sufficiency: 101.9%
- Fuel imports: Not available
- Electricity generation: 7.8 TWh - of which renewables: 7.8 TWh (99.6%)
- Electricity use per capita: 101 kWh
- Electrical capacity*: 2 475 MW - of which renewables: 2 442 MW (98.7%)
- Electricity access rate: 11.1%
- Share of population using solid fuels: > 95%

* 2008

3.4.4.4 Lesotho

Lesotho is a land locked within South Africa; it is a relatively a small country (30 355 km^2) with an estimated population of just over 2 million; two-thirds of the country is sparsely inhabited, comprising of rugged mountains and deep valleys with small, scattered villages on mountain sides (Mpholo, Mathaba and Letuma, 2012; Taele, Mokhutsoane, Hapazari, Tlali and Senatla, 2012). The majority of the population (76%) lives in rural areas, but has strong links to urban centres in both Lesotho and neighbouring South Africa. The houses are mostly single-room round huts with stone or mud and wattle walls and thatched roofs (Mpholo, Mathaba and Letuma, 2012). Lesotho's energy profile is characterised by a predominance use of traditional biomass energy (wood) to meet the energy needs of the rural households and a heavy dependence on imported petroleum for the modern economic sector needs (Taele et al., 2012).

The majority of the villages lack electricity and the probability of connecting them with grid electricity in the foreseeable future is very low. The daily average energy demands in these villages are generally low, varying between 0.5 and 1.5 kWh per household (Mpholo, Mathaba and Letuma, 2012). Lesotho has an electrification rate of about 16% (Hailu, 2012). About 0.9% is generated from renewable energy sources (Musango and Brent, 2011). Economic growth and increased access has meant that during peak times (especially in the winter months) demand can be as high as 120 MW; so far, the deficit is offset by supply imported from Eskom (South African power utility), and more recently from EDM (Mozambique power utility) (Mpholo, Mathaba and Letuma, 2012). Lesotho national energy profile in 2008 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 37.2 PJ - of which renewables: 33.4 PJ (89.7%)
- Energy self-sufficiency: 89.7%

- Fuel imports*: U$125 million (6.4% of total imports)
- Electricity generation: 522.3 GWh - of which renewables: 519.8 GWh (99.5%)
- Electricity use per capita: 253 kWh
- Electrical capacity: 76 MW - of which renewables: 76 MW (100%)
- Electricity access rate*: 16.0%
- Share of population using solid fuels: 71%

* 2009

Targets: 35% of rural electrification to come from renewables by 2020.

3.4.4.5 Madagascar

Madagascar is an island located in the Indian Ocean of Southern Africa, east of Mozambique. It has a total land area of 581 540 km^2 (about the size of France (KPMG, 2013). Madagascar has a tropical climate along the coast, but is temperate in the inland areas and arid in the south (KPMG, 2013). The country's natural resources include graphite, chromite, coal, bauxite, salt, quartz, tar sands, semiprecious stones, mica, fish and hydro power. Madagascar is the world's fourth-largest island and occupies a strategic location along the Mozambique Channel. Madagascar's natural hazards include periodic cyclones, drought, and locust infestations (KPMG, 2013).

According to the (Energypedia, 2014: 1) Madagascar's energy balance shows that about 80% of its overall energy consumption is based on biomass (mainly firewood 68%, charcoal 10% and other biomass 2%), 17% on petrol (transport), 2% on electricity (hydro power and diesel power plants) and 1% on coal. Until today the petroleum products are all imported. Even though Madagascar has oil in place the oilfields are not being exploited yet. The installed capacity of electricity production in Madagascar accounts accordingly for some 650 MW only (production in 2008 = 486 GWh).

The currently utilised capacity is even lower due to the poor efficiency following the lack of rehabilitation of some of the large hydro power plants. Six big hydro power plants (the biggest with an installed capacity of two times 30 MW) provide the largest portion of the electricity production. Hydro power in general provides approximately 68% of the country's electricity; the rest is produced by close to 100 diesel power plants. There is only a very limited national electricity grid between the capital Antananarivo and the city of Antsirabé with an overall length of approximately 180 km.

The rest of the electrified cities and villages rely on isolated small and mini grids. According to the United Nations Industrial Development Organisation (UNIDO) and International Center (2013), the theoretical overall hydro power potential of Madagascar has been estimated at 7 000 GW of installed capacity, the economically feasible potential has not yet been determined. Barriers to small hydro power development according to UNIDO and International Center (2013: 2) are:

- Lack of funding for private investments and lack of a transparent model for commercialisation are important small hydro power development.
- The fact that the country does not have an electricity network is another barrier to small hydro power development.
- At least in the coming decade, small hydro power projects will typically not feed into a grid, which is detrimental to the financial viability of these types of projects.
- Long distance between consumption points and potential sites.
- Low population density and low electricity demand.
- Low utilisation factor.
- Prohibitive high capital costs.
- Lack of capital and liquidity by entrepreneurs.

Madagascar national energy profile in 2008 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 274.2 PJ - of which renewables: 248.5 PJ (90.6%)
- Energy self-sufficiency: 90.6%
- Fuel imports*: U$327 million (10.2% of total imports)
- Electricity generation: 1 104 GWh - of which renewables: 699.7 GWh (63.4%)
- Electricity use per capita: 45 kWh
- Electrical capacity: 246 MW - of which renewables: 124 MW (50.4%)
- Electricity access rate*: 19.0%
- Share of population using solid fuels: > 95%

* 2009

Targets: 54% of final energy from renewables by 2020; 75% of electricity generation from renewables by 2020.

3.4.4.6 Malawi

The Republic of Malawi is a small country in Southern Africa; it shares borders with Zambia, Tanzania and Mozambique and is one of the least developed countries in the world, ranking 168 out of a total of 174 countries (Barry, Steyn and Brent, 2011). The population of Malawi is currently about 15 million (Gregory, Hui and Peng, 2013b). Malawi is one of the poorest countries in the world; more than 90% of the export revenue of the country comes from agricultural products with GDP based on purchasing-power parity per capita GDP of about U$ 900 in 2010. GDP composition by sector is 35.5% agriculture, 19.9% industry and 44.6% services (Gregory, Hui and Peng, 2013b; Barry, Steyn and Brent, 2011).

Malawi's energy supply is dominated by biomass, constituting 88.5% of energy supply for Malawi in 2008. Petroleum products contributed 6.4%, electricity contributed 2.8%, and coal contributed 2.4% and negligible amount of renewable energy (Gregory, Hui and Peng, 2013a; Javadi et al., 2013). In terms of capacity Malawi has got a small electricity supply system of 302 MW when compared to her neighbours: Mozambique, Tanzania and Zambia whose electrical power capacities are 2 483 MW, 1 186 MW and 1 737 MW respectively (installed capacities as of 2008). Electrical energy supply is provided by a government owned company called Electricity Supply Corporation of Malawi (Gregory, Hui and Peng, 2013a).

The deforestation rate in Malawi is 2.8% per year and is the highest in Africa which is contributed by the fact that Malawi's primary energy supply of about 90% of total energy is from biomass, mainly in the form of firewood and charcoal (Barry, Steyn and Brent, 2011). The analysis of the small-scale hydro power potential sites indicates that the country has considerable potential for decentralised hydro power generation, which if fully exploited can contribute to the country's electricity and power supply especially for rural electrification (Kaunda, 2013). Just about 1% of the rural population has access to the national electricity grid and this will remain the case for the foreseeable future (Gamula, Hui and Peng, 2013). Malawi has an electrification rate of 9 % (Hailu, 2012). About 86% is derived from renewable sources (Musango and Brent, 2011). Malawi national energy profile in 2008 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 134.0 PJ - of which renewables: 118.0 PJ (88.1%)
- Energy self-sufficiency: 89.1%
- Fuel imports*: U$211 million (11.7% of total imports)
- Electricity generation: 1 801GWh - of which renewables: 1 544 GWh (85.7%)

- Electricity use per capita: 85 kWh
- Electrical capacity: 315 MW - of which renewables: 290 MW (92.1%)
- Electricity access rate*: 9.0%
- Share of population using solid fuels: > 95%

* 2009

Targets: 7% of primary energy from renewables by 2020.

3.4.4.7 Mauritius

Mauritius is the only country in SSA with an electricity access rate of 100%, or 94%, if the IEA data is used, which compares well with most of the countries in North Africa (99% in Tunisia, 98% in Algeria and Egypt and 97% in Libya) (Brew-Hammond, 2010; Adkins, Oppelstrup and Mod, 2012; Khennas, 2012). Mauritius is a tropical island situated in the south-west Indian Ocean about 855 km east of Madagascar with a surface area of 1 864 km^2 and it also several outlying islands. The population of Mauritius is approximately 1.2 million (Weisser, 2004). Taken within the context of all the issues around power sector performance and affordability, 100% electrification in every African country by 2030 will be unlikely to be achieved (Brew-Hammond, 2010).

Many SIDS like Mauritius are heavily dependent on fossil fuel imports, with prices for their energy supplies being some of the most expensive in the world due to high transportation and distribution cost (Weisser, 2004). Mauritius has no known oil, coal or gas reserves and is heavily dependent on imported sources of energy. More than 70% of the country's electricity requirements were met from oil in the 80's (Nganga Wohlert and Woods, 2013). The Mauritian government has set an ambitious goal to generate 35% of its energy from renewable resources, by 2025 (Nganga, Wohlert, and Woods, 2013).

Mauritius national energy profile in 2010 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 59.0 PJ - of which renewables: 11.3 PJ (19.1%)
- Energy self-sufficiency: 19.1%
- Fuel imports*: U$561 million (15% of total imports)
- Electricity generation: 2 577 GWh - of which renewables: 608.9 GWh (23.6%)
- Electricity use per capita: 1 870 kWh
- Electrical capacity: 739 MW - of which renewables: 59 MW (8%)
- Electricity access rate: 99.4%
- Share of population using solid fuels: < 2%

* 2009

3.4.4.8 Mozambique

Mozambique is located in the eastern part of Southern Africa and comprises a land surface of about 800 000 km^2 with a 2 500 km long coastline as well as borders with Tanzania, Malawi, Zambia, Zimbabwe, South Africa and Swaziland (Sebitosi and Pillay, 2005). The country has about 20 million inhabitants (Sebitosi and Pillay, 2005; Mulder and Tembe, 2008). It gained independence from Portuguese colonial rule in 1975, soon to be followed by a protracted and devastating civil war that was ended in 1992 and after its first democratic elections in 1994 the country enjoys political stability and rapid economic growth, averaging circa 7.5% over the last decade (Sebitosi and da Grac, 2009). Nevertheless it is still one of the poorest countries in the world and it is highly dependent on foreign aid, which currently comprises approximately half of the government budget (Mulder and Tembe, 2008).

Mozambique has vast and largely untapped natural resources, including circa 12 500 MW hydro potential, 127 billion cubic metres (m^3) of natural gas reserves, and 13.1 billion tonne of proven coal reserves. Until the end of the 1990's the energy sector was characterised by decline, disruption and initial post-war reconstruction (Mulder and Tembe, 2008; Arthur, Bond and Willson, 2012). Mozambique has abundant and yet largely unexplored natural resources, with one of the largest hydro power installations in Africa, the Hydro Cahora Bassa dam, with 2 075 MW of capacity, Mozambique could build another 5 000 MW of hydro power (KPMG, 2014; Cuvilas, Jirjis and Lucas, 2010).

In Mozambique electricity is almost exclusively supplied by the 2 075 MW hydro power station Cahora Bassa, situated in the north-western part of the country (Ahlborg and Hammar, 2012). In addition to Cahora Bassa, there are only a few smaller hydro power stations and a back-up supply of coal power (Ahlborg and Hammar, 2012; Cuvilas, Jirjis and Lucas, 2010). The Mozambican renewable energy level is not well established but is probably in the order of 5%, based on provincial statistics and due to the long distances, transmission losses are significant and the power supply becomes fragile at the outskirts of the grid (Ahlborg and Hammar, 2012).

Firewood and charcoal are used by the majority of Mozambican households and show lower demand elasticities to price and income variations (Arthur, Bond and Willson, 2012). The bulk of this energy (85%) is exported but the revenue raised does not appear to have any appreciable impact on the host economy, moreover it is estimated that a further 10% of the generated energy is lost along the 1414 km long transmission line to South Africa (Sebitosi and Pillay, 2005; Javadi et al., 2013). Table 3.11 presents Mozambique national energy profile in 2014.

Table 3.11: Mozambique national energy profile in 2014

Indicator	2014	2023
GDP per capita (U$)	17.4	58.8
GDP annual growth rate (%)	590	1 791
Population (million)	25.8	32.8
Installed capacity (MW)	4 110	6 410.1
Power produced (TWh)	23 715	35 748
Access to electricity (%)	34	n/a
Annual KWh per capita	527.7	948.9

Source: KPMG (2014: 6)

3.4.4.9 Namibia

Namibia was colonised by South Africa, and it was transformed from being a colony to an independent nation in 1990; prior to independence the energy policies of the colonial South African government were supply orientated (Vita, Endresen and Hunt, 2006). Namibia has a population of about 2 million people spread over a land area exceeding 800 000 km² (Von Oertzen, 2010). The renewable energy sector offers very significant and untapped opportunities for investment, development and expansion.

Namibia has an average daily solar radiation of 6 kWh/m² (amongst the world's best); on-land wind energy sites, capacity exceeding 100 MW biomass potential; hydro electric potentials exceed 350 MW; geothermal potential is estimated to exceed 100 MW, and tidal and wave energy potentials of more than 200 MW (Von Oertzen, 2010; Nganga Wohlert and Woods, 2013). The new Government opened up Namibia's interaction with the outside world, and has been successful in attracting significant foreign investments in oil and gas exploration (Vita, Endresen and Hunt, 2006). Namibia has an electrification rate of 34% (Hailu, 2012).

About 94% is derived from renewable sources (Musango and Brent, 2011). Namibia national energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 71.7 PJ - of which renewables: 13.8 PJ (19.2%)
- Energy self-sufficiency: 19.2%
- Fuel imports: U$374 million (7.5% of total imports)
- Electricity generation: 1 742 GWh - of which renewables: 1 429 GWh (82%)
- Electricity use per capita: 1 628 kWh
- Electrical capacity*: 264 MW - of which renewables: 249 MW (94.3%)
- Electricity access rate: 34.0%
- Share of population using solid fuels: 57%

* 2008

Targets: 40 MW of renewable capacity (excluding hydro) by 2011.

3.4.4.10 Seychelles

According to Seychelles Energy Commission (2014: 7) “The Seychelles is an island nation in the Western Indian Ocean located approximately 1,000 kilometres east of mainland Africa. The country has a total landmass of 455 square kilometres, spread among 115 islands, of which 42 are granitic and the remainder are coralline. The main granitic islands, also known as the inner islands, in descending order of size, are Mahé, Praslin, Silhouette and La Digue, and together these islands support approximately 95% of the population of 86,525 (as of 2010)”. Seychelles has legislated the energy sector extensively.According to Seychelles Energy Commission (2014: 10), legislations relevant to the energy sector in Seychelles and the legal instrument date of enactment are:

- Public Utilities Corporation Act 1985
- Occupational Safety and Health Decree 1991
- Public Health Act 1991
- Road Transport Act 1991
- State Land and River Reserves Act 1991
- Town and Country Planning Act 1991
- Environment Protection Act 1994
- Environment Protection (Standards) Regulations 1995
- Noise Pollution Standards SBS 1998
- Seychelles Energy Commission Act 2010

Seychelles Energy Commission (2014:13) indicates that Seychelles depends on imported petroleum fuel to meet all of its energy needs. In 2009, its primary energy consumption was 158,629 TOE (tonne of oil equivalent), out of which 59,572 TOE was used for electricity generation. The country does not have any significant renewable energy production at this time, although potential exists for solar, biomass, wind and micro-hydro power. Seychelles national energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply: 10.1 PJ of which renewables: 0.0 PJ (0.0%)
- Energy self-sufficiency: 0.0%
- Fuel imports: U$205 million (25.4% of total imports)
- Electricity generation: 275.7 GWh - of which renewables: 0.0 GWh (0%)
- Electricity use per capita: 2 660 kWh
- Electrical capacity*: 95 MW - of which renewables: 0 MW (0%)
- Electricity access rate: 96.0%
- Share of population using solid fuels: < 5%

* 2008

Targets: 5% of electricity generation from renewables by 2020 and 15% of electricity generation from renewables by 2030.

3.4.4.11 South Africa

South Africa is a country located at the southern tip of Africa. It has 2 798 km (1 739 miles) of coastline that stretches along the south Atlantic and Indian oceans (Rosnes and Vennemo, 2012). To the north lie the neighbouring countries of Namibia, Botswana and Zimbabwe; to the east are Mozambique and Swaziland; and within it lies Lesotho, an enclave surrounded by South African territory (Rosnes and Vennemo, 2012). South Africa is the 25th-largest country in the world by land area, and with close to 53 million people, is the world's 24th-most populous nation (Deichmann et al., 2011; Rosnes and Vennemo, 2012; Nganga, Wohlert and Woods, 2013).

South Africa is Africa’s second largest economy. Its key economic sectors are mining, transport, energy, manufacturing (including vehicle assembly and manufacturing and food processing), tourism, telecommunications, financial services, agriculture and fisheries (KPMG, 2014). South Africa is a mineral rich country with enormous reserves in low grade coal. Research conducted by the Department of Minerals and Energy (DME) indicate that the 68% of electricity produced comes from coal powered plants and other energy supplying resources within South Africa include crude oil (19%), natural gasses (2%), nuclear power plants (3%), hydro power plants (0.1%) and renewable energy sources (8%) (Nthontho, Chowdhury and Chowdhury, 2012).

South Africa is by far the most heavily industrialised country and consumes the most electrical energy in the African continent. Deichman et al. (2011) indicate that consumption sectors within South Africa include industry (36.2%), commerce (6.7%), residential (17.9%), mining (7.00%), agriculture (2.9%), transport (25.7%), non-specified (0.70%) and non-energy use (2.9%). The

Republic of South Africa has major coal reserves attempting to ensure that it continuously meets its energy demand (Rosnes and Vennemo, 2012).
The rest of the electricity supply is provided by municipalities and private sectors (Thiam, Benders and Moll, 2012; Molteno, 2008).

3.4.4.11.1 South Africa's energy dominance

Although many of the poorer areas in South Africa do not yet have electricity, electricity consumption in the country is increasing steadily as the government continues to electrify more and more households (Molteno, 2008). South Africa is still characterised by sharp inequalities between urban and rural poor largely due to the legacy of the apartheid policy (Khennas, 2012). At the end of the apartheid era in 1994, 36% of the country had electricity, while in 2008 electricity was available to more than 70% (Molteno, 2008).

Eskom's principal generation technology is pulverised coal with approximately 90% of its current generating capacity lying in coal-fired power stations. Just less than 6% of Eskom's total installed capacity is contributed by liquid fuelled power stations, predominantly located on the Western and Eastern Cape (KPMG, 2014; Deichman et al., 2011). These liquid fuelled power stations form part of the peaking electricity generation fleet. Peaking power stations operate during peak periods or during times when demand is higher than that which the base load power stations (that operate continuously) can supply (Thiam, Benders and Moll, 2012; Molteno, 2008).

3.4.4.11.2 New build programme

The three new power plants, which are nearing completion, include the Medupi plant, the Kusile plant and Ingula plant; both the Medupi and the Kusile plants will be coal powered plants while the Ingula plant is based on a pumped storage scheme (Nthontho, Chowdhury and Chowdhury, 2012). South Africa's energy needs are mostly met by coal and oil.

Only a small percentage of the energy consumption mix comprises of natural gas, hydro, biomass and nuclear (Donev, van Sark, Blok and Dintchev, 2012). Successful transition to renewable energy will entail implementation of new policies or initiatives that may support socio-economic and environmental sustainability; an abundance of natural resources paired with available and underutilised labour, and regional geopolitical significance (Krupa and Burch, 2011).

The total area of high radiation in South Africa amounts to approximately 194 000 km^2 including the Northern Cape, one of the best solar resource areas in the world. If the electricity production per square kilometre of mirror surface in a solar thermal power station is 30.2 MW and only 1% of the area of high radiation is available for solar power generation, then generation potential is already about 64 GW, area of high radiation could thus meet projected South African electricity demand in 2025 (80 GW) (Pegels, 2010).

One important aspect of the Renewable Energy IPP Procurement Programme is the, first phase of bidding for 3 750 MW of renewable energy is expected to come online by 2016; the government received more than 400 applications 16 of these, 28 bidders and 1 400 MW were approved followed by a further 19 projects totalling 1000 MW in phase two, spread among wind (mainly off-shore), solar PV, CSP and small hydro (1-10 MW) (Pegels, 2010; Nganga, Wohlert and Woods, 2013). South Africa has a potential for CSP and that the potential sites are not only located in the Northern Cape but also in the Free State, the Western Cape and to a minor degree, in the Eastern Cape and the total potential CSP generation capacity for South Africa is 547.6 GW (Fluri, 2009; Donev et al., 2012).

3.4.4.11.3 South African regulatory framework for renewable energy

According to the DBSA (2014) NERSA was established in 2005 and regulates electricity, gas and liquid pipelines. Regulation includes the issuing of generation licenses and levelling the playing field in the energy sector, by guarding against monopolies. Baleni, 2014) indicates that in the White Paper on Renewable Energy Policy of the Republic of South Africa of November 2003: a target of 10 000 GWh renewable energy contributions to final energy consumption by 2013 was to be produced mainly from biomass, wind, solar and small-scale hydro. One of the key regulation include the Electricity Regulation Act No.4 of 2006 as Amended, the objectives of this Act include:

- To achieve the efficient, effective, sustainable and orderly development and operation of electricity supply infrastructure in South Africa.
- To promote the use of diverse energy sources and energy efficiency.
- To promote competitiveness, customer and end-user choice.
- To facilitate a fair balance between the interests of customers and end users, licensees, investors in the electricity supply industry and the public.

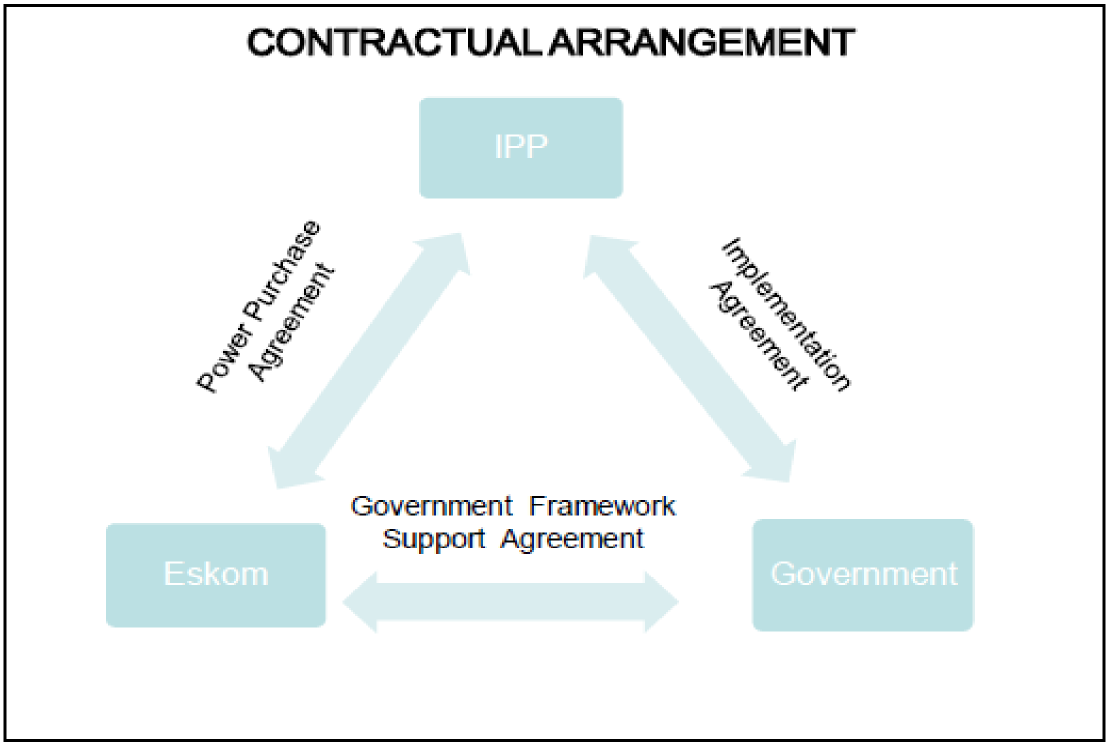
In terms of 2011 New Generation Capacity Regulations, the Minister may, in consultation with the Regulator determine that new generation capacity is needed to ensure the continued sustained supply of electricity and determine the types of energy sources from which electricity must be generated, and the percentages of electricity that must be generated from such sources (Electricity Regulation Act No.4 of 2006). South Africa's generation capacity is expected to increase from approximately 4 400 MW to 80 000 MW between 2012 and 2030 to meet the projected demand growth and the projected electricity consumption rate, estimated to be going to increase by an average of 2.7% per annum over the next nine years (KPMG, 2014).

3.4.4.11.4 Renewable energy policy implementation and IPP procurement

In 2007 NERSA appointed consultants to develop the Renewable energy framework in order to promote renewable energy in South Africa (Baleni, 2014). The REFITs was recommended and adopted by NERSA as the best mechanism. REFIT was developed in two phases, according to Baleni (2014) the procurement document released on 3rd August 2011 provided for procurement of 3 725 MW in five different bidding phases 100 MW of the 3 725 MW for small-scale. Renewable Energy programme i.e. capacity range of 1–5 MW and a hybrid procurement method (i.e. price competition within a prescribed ceiling price) was adopted by the DoE which are:

- Phase 1: On 7 December 2011, 28 preferred bidders were selected from a total of 53 bids. Energy Regulator approved 28 generation licenses on 26 April 2012.
- Phase 2: On 21 May 2012, 19 preferred bidders were selected from a total of 79 bids. Energy Regulator approved 19 generation licenses in September 2012.
- Phase 3: On 4 November 2013, 17 preferred bidders selected from total of 93 bids. Energy Regulator approved 17 generation licenses in March 2014. The contractual agreement involves the govement putting a regulatory framework and facilitating the bidding process. Eskom sign a power purchase agreement with IPPs. IPPs implement the project. Figure 3.8 presents South African Department of Energy IPP procurement framework.

Figure 3.8: South African Department of Energy IPP procurement framework



Source: Baleni (2014: 27)

3.4.4.11.4.1 Funding challenges that IPP enterprises face in South Africa

New energy enterprises do not have extensive internal funds to contribute their share of the equity and project implementation. Baleni (2014) indicates that most enterprises depend on loans to raise their equity contribution 20 years Power Purchase Agreement (PPA). This makes it very difficult to raise the funds required. It will be more practical if PPA length should be at least 25 years – but preferably 30 years. A better approach to address PPA's will contribute to growth of strong local firms and it will localise the technologies i.e. it will bring the price down over a period of time. Table 3.12 presents South Africa National Energy Profile in 2014.

Table 3.12: South Africa national energy profile in 2014

Indicator	2014	2023
GDP per capita (U$)	340.9	900.1
GDP annual growth rate (%)	6 416	16 054
Population (million)	53.1	56.1
Installed capacity (MW)	49 578.9	61 793.7
Power produced (TWh)	251 328	317 501
Access to electricity (%)	85	n/a
Annual KWh per capita	4 241.3	5 093.5

Source: KPMG (2014: 6)

3.4.4.12 Swaziland

Swaziland is a land-locked country, bordering South Africa and Mozambique, and has an area of 17 400 km^2 (Mwendera, 2006). The electricity sub-sector in Swaziland is divided into two segments. The commercial supply through the national grid is the responsibility of the Government's owned parastatal Swaziland Electricity Board (SEB), which delivers about 70% of the country's electricity for final consumption (Sebitosi and Okou, 2010). The remaining 30% is self-generated by establishments in industry, agriculture and service sectors for their operational requirements (Sebitosi and Okou, 2010; Mwendera, 2006). In 2011 Swaziland generated about 70 MW and imports the rest of electricity from South Africa (Du Pisani, Erasmus and Hartzenberg, 2013).

Total electricity consumed in Swaziland in 2004 was about 868.7 GWh of which 12% was locally generated and 88% was imported from South Africa. SEB electricity production in 2004 was generated from four hydro power plants; additional electric power requirements are provided through imports from the Republic of South Africa (ESKOM). Swaziland currently imports about 90% of its electricity from ESKOM in South Africa (Mwendera, 2006).

About 36% of electricity is generated from renewable energy sources (Musango and Brent, 2011). National energy profile in 2009 according to IRENA (2010: 1) includes:

- Total Primary Energy Supply*: 94.0 PJ – of which renewables: 57.1 PJ (60.8%)
- Energy self-sufficiency*: 88.3%
- Fuel imports: U$225 million (14.1 % of total imports)
- Electricity generation: 733.4 GWh - of which renewables: 650 GWh (88.6%)
- Electricity use per capita: 943 kWh
- Electrical capacity: 130 MW - of which renewables: 120 MW (92.3%)
- Electricity access rate: 45.0%
- Share of population using solid fuels: 58%

***** 2008

Targets: 20% of all public buildings installed with solar water heaters by 2014; develop solar water heater standards by 2012; establish fiscal incentives to promote renewable energy by 2013 and establish a demonstration centre for renewable energy technologies by 2015.

3.4.4.13 Tanzania

Tanzania has a population of more than 40 million people and 80% of the population is involved in agricultural activities (Barry, Steyn and Brent, 2011). The main source of electricity in Tanzania is hydro electric plants with over 90% of the energy by thermal plants supplying for peak loads (Odhiambo, 2009; Barry, Steyn and Brent, 2011). The Tanzania Electricity Supply Company is primarily responsible for power generation and supply (KPMG, 2014). The main sources of energy in Tanzania include biofuel, wood fuel, hydro electric power, natural gas, biogas, coal reserves, wind and solar energy (Javadi et al., 2013; Odhiambo, 2009).

The most exploited energy source is wood fuel, which is considered to be cheap and accessible to the majority of Tanzanians who live mainly in rural areas (Odhiambo, 2009). In terms of household energy consumption, 97.7% of all household energy for cooking, heating and lighting is derived from biomass; petroleum and hydro electric power on the other hand, account for 8% and 1.2% respectively and the remaining energy sources, such as solar energy, wind, etc. account for only 0.8% (Barry, Steyn and Brent, 2011). Hydro power is currently Tanzania's main source of power but it is often unreliable due to the effects of drought. Dependency on hydro power is, however, reducing and the country aims to improve diversification in its energy mix. Gas-fired power stations will be the key to the diversification plans (KPMG, 2014). About 39% of the urban population has access to electricity, only 2% of the rural population have access to electricity (Odhiambo, 2009).

Traditional biomass fuels are the dominating energy source, accounting for over 90% of the total energy consumption; commercial energy sources account for 10% of consumption, of which electricity accounts for only 2%, accordingly, the levels of electricity consumption per capita are among the lowest worldwide (Terrapon-Pfaff, Fischedick and Monheim, 2012). Transmission and distribution systems remain under-developed and regional interconnection along with rural electrification are key obstacles to overcome, and electrification levels are low at around 18% and approximately 85–90% of the population are not connected to the electricity grid (KPMG, 2014).

In rural areas, where grid extension is not feasible, renewable energies are regarded as a particularly promising option for decentralised electricity generation (Terrapon-Pfaff, Fischedick and Monheim, 2012; Odhiambo, 2009). Power demand in general exceeds generation capacity and power demand is estimated to be rising at a rate of approximately 10–15% per-annum. Tanzania has sufficient resources to provide the country with sufficient electricity supply (KPMG, 2014). Table 3.13 presents Tanzania National Energy Profile in 2014.

Table 3.13: Tanzania national energy profile in 2014

Indicator	**2014**	**2023**
Indicator	38.6	94.3
GDP per capita (US$)	759	1 437
GDP annual growth rate (%)	7.2	9.7
Population (million)	50.8	65.6
Installed capacity (MW)	1 589	3 543
Power produced (TWh)	5 196	11 573
Access to electricity (%)	18	n/a
Annual KWh per capita	79.8	154

Source: KPMG (2014: 6)

3.4.4.14 Zambia

Zambia has a population of almost 12 million, more than half of which lives in rural areas, while an estimated 18% of the total population has access to grid electricity, only 2% of those living in rural areas have grid access; Zambia is known as the country with the least access to electricity in the world (Kornbluth, Pon and Erickson, 2012). At peak, there is approximately a 175 MW power deficit and currently, it is estimated that only 30% of the Zambian population has access to electricity and rural areas are virtually disconnected from the national electrical grid (KPMG, 2014). With only 2% access to electricity in 2005, so far, expanding rural electrification through expansion of the grid was not successful in this country (Javadi et al., 2013).

Zambia, like many countries in the region, faces power challenges that result from decades of underinvestment in generation and transmission capacity; this has resulted in electricity supply constraints (KPMG, 2014). There is a rising demand for electricity, which has been increasing by 4% annually since 2005 and it is set to increase by over 28% within the next five years on the back of strong projected growth (KPMG, 2014).

Zambia is well endowed with hydro power and other energy resources, which could facilitate production of electricity for both urban and rural areas of the country. Approximately 95% of Zambia's 1 800 MW electricity capacity is generated through hydro. Zambia has close to 6 000 MW of hydro potential, of which only 32% is installed; it is expected that the share of hydro power in the overall energy mix in Zambia will continue to rise in the next decade. Several hydro power projects are in the pipeline (KPMG, 2014). Rural electrification faces many challenges such as long distances from existing power stations to targeted rural areas, low population densities, high poverty levels and low skills availability (Kornbluth, Pon and Erickson, 2012).

Measures so far undertaken to facilitate access to electricity in rural areas of Zambia include the adoption of a new National Energy Policy (NEP) in 1994. With regard to the electricity sector and rural electrification in particular, the NEP was aimed at facilitating increased access by liberalising and restructuring the electricity market and promoting the use of low-cost technologies and decentralised renewable energies (Haanyika, 2008; Kornbluth, Pon and Erickson, 2012). Table 3.14 presents Zambia national energy profile in 2014.

Table 3.14: Zambia national energy profile in 2014

Indicator	2014	2023
GDP per capita (US$)	24.7	68.3
GDP annual growth rate (%)	1,642	6.8
Population (million)	15.0	20.1
Installed capacity (MW)	2 130	2 837

Power produced (TWh)	12 742	20.246
Access to electricity (%)	12	n/a
Annual KWh per capita	708.8	842.6

Source: KPMG (2014: 6)

3.4.4.15 Zimbabwe

Zimbabwe is a landlocked country located in southern Africa, between the Zambezi and Limpopo rivers, It is bordered by South Africa to the south, Botswana to the southwest, Zambia to the northwest and Mozambique to the east (Batidzirai, Lysen, Van Egmond and Van Sark, 2009). Several types of energy are in use in Zimbabwe. The country's primary energy base consists of coal, thermal and hydro power, biomass and solar energy and over 76% of the country's population relies on biomass as an energy carrier. In addition, biomass accounts for about 47% of the energy supply in Zimbabwe (Jingura and Matengaifa, 2008).

About 41% of the country's population has access to electricity, i.e. is connected to the national grid and the urban electrification level is about 85% while the rural population connected to the national electricity grid is about 25% (Batidzirai et al., 2009). Shortages of modern energy carriers have become a major obstacle to economic growth in Zimbabwe. Energy imports and infrastructure continue to drain scarce convertible currency (Bawakyillenuo, 2012).

Zimbabwe has been importing between 35% and 60% of its electricity requirements since 1996 because of inadequate internal power generation capacity. While available power plant capacity declined by at least 15%, maximum demand has increased by 25% since 1990. Demand was forecasted to grow from 2 000 MW - 3000 MW by 2010 and over 4 000 MW by 2020 (Batidzirai et al., 2009; Bawakyillenuo, 2012).

3.4.4.15.1 Renewable energy feed-in tariff

Magombo (2014) indicated that Zimbabwe Energy Regulatory Authority has developed REFIT scheme which is yet to be implemented. The feed-in tariffs were developed for renewable energy technologies applicable to Zimbabwe such as Solar PV, Small hydro, biomass and biogas. The renewable energy policy formulation is in progress and is expected to address most of the challenges and issues in the renewable (clean) energy. Zimbabwe national energy profile in 2009 according to IRENA (2010: 1):

- Total Primary Energy Supply: 398.3 PJ - of which renewables: 276.2 PJ (69.4%)
- Energy self-sufficiency: 89.7%
- Fuel imports: U$454 million (15.7% of total imports)
- Electricity generation: 7.9 TWh - of which renewables: 4 202 GWh (53.3%)
- Electricity use per capita: 1 022 kWh
- Electrical capacity*: 2 099 MW - of which renewables: 754 MW (35.9%)
- Electricity access rate: 41.5%
- Share of population using solid fuels: 71%

* 2008

3.4.5 Summary of energy access challenges identified in the SADC region

DBSA (2014) summarises key challenges as:

- The growing demand for energy services; evidence of credible off-takers for power; and the changing regulatory environment, a large number of projects have still not materialised.

- Energy sector projects tend to have very long lead times averaging 4–5 years for preparation and development and 5–10 years for implementation depending on the size and nature of the project.

DBSA (2014) attributes declining investment flows in the SADC region to:

- Pessimism about emerging markets, in particular perceptions associated with wars and political unrest.
- Heavy political presence and public sector involvement.
- Reduced investments from the traditional multilateral funding agencies.
- Lack of project development from feasibility to bankability.
- No new capital for new power generation.
- Lack of project sponsors and developers including changes in their strategies and profiles.
- Conflicting vested interest, as in the case of Inga with a wide range of interested parties.
- Disappointing returns from some projects.
- Tariff-setting that is not cost-effective to attract new investment.
- Legal and regulatory framework for private participation not in place.

Baleni (2014) identifies key challenges to be:

- Renewable energy has high upfront costs: most renewable energy equipment is imported and there is a need to localise manufacturing.
- Grid may not be able to accommodate large-scale energy projects.
- Research, development, and production of renewable energy infrastructure occur outside the region and there are no localisation strategies in place.
- Renewable energy depends heavily on donor subsidies at present.
- There is a need to have mix of renewable energy sources in SADC region.

RIDMP-Energy Sector Plan (2012: 20) identifies planned projects implementation challenges to increase generation capacity to be:

- Delays in commissioning projects: largely due to failure to prepare bankable projects and to secure funding for both project preparation and implementation.
- The failure is also linked to a lack of legal and regulatory frameworks in some countries and non-cost reflective tariffs which do not attract investors: as a result, the SAPP remains largely unimplemented. The resultant situation is that there has been virtually no significant new project implementation in the last 10-20 years in the region due to financial constraints.

3.5 CHAPTER SUMMARY

This chapter exposed the energy situation of the African continent, SSA and the SADC region. The sustainable development of green energy assets will ensure that resources are managed to meet the needs of the present and succeeding generations in order to address power generation. There is an urgent need to integrate energy policies into broader development strategies in SADC region countries, while at the same time encouraging regional integration. Pro-poor and public-private partnerships are one of the best mechanisms needed to develop green energy for widening access to energy services, especially to the poor. Green energy expansion can only be achieved by sound policy and regulatory framework stimulated by industry stakeholders cooperating. Green energy can improve the socio-economic development of the region. Both low carbon energy development paths though green energy projects and climate change challenge can be addressed simultaneously in the region. Access to modern energy needs to be incorporated in the national development plans of member states and promoted at SADC level and must receive adequate financial support.

4 CHAPTER 4: A THEORETICAL MODEL OF GREEN ENERGY ACCESS FOR THE SADC REGION

4.1 INTRODUCTION

At the most basic level, a model can be defined as a statistical statement about the relations among variables (Nachtigall, Kroehne, Funke and Steyer, 2003). A sound model is theory based on findings in the literature, knowledge in the field, or one's educated guesses, from which causes and effects among variables within the theory are specified (Lei and Wu, 2007). Literature reviews in the previous chapters have revealed critical factors that enhance widespread access to modern energy services through green energy in developing countries. Energy is a vital input for industrial production at any scale, and it improves the quality of life. Literature reviews also debunked the fact that development of developed countries around the world has been energised by reliable and secured energy supply of modern energy.

While there are no fundamental technical obstacles preventing universal energy access, there is, however, a lack of effective institutions, good business models, transparent governance, and appropriate legal and regulatory frameworks (Liu and Liang, 2013; Bazilian et al., 2012; Khennas, 2012). A similar view about poor access to energy is argued by Lior (2012) who indicates that obstacles to widespread energy access are largely well known and attribute it to financing, planning, governance, and human and institutional capabilities. This chapter focuses on the development of the proposed theoretical model of selected variables which influence the dependent variable. The dependent variable and independent variables are presented in the model with their hypothesised relationships. The relationships are based on the discussion of the factors that influence the augmentation of green energy leading to the reduction of energy poverty and enhance improved access to modern energy services as presented in the previous chapters.

The study mainly focused on widespread access to electrical energy. Models are commonly conceptualised and communicated in graphical forms and in these graphical forms; a directional arrow (→) is universally used to indicate a hypothesised causal direction (Lei and Wu, 2007). In intellectual literature variables to which arrows are pointing are commonly termed endogenous variables (or dependent variables) and the variables having no arrows pointing to them are called exogenous variables (or independent variables); unexplained covariance among variables are indicated by curved arrow. Observed variables are commonly enclosed in rectangular boxes and latent constructs are enclosed in circular or elliptical shapes (Lei and Wu, 2007).

4.2 THE MODEL

The investigation of the relationship between green energy access and certain aspects of green energy in the SADC region is modelled and the dependent variable is perceived success of access to green energy. Selected independent variables are: strategic green energy planning, green energy economic augmentation, environmental pollution mitigation, green energy governance, green energy technology innovation, green energy policy alignment, green energy projects financing, green energy human capacity development, green energy infrastructure development and green energy local market development. The following hypotheses derived from the model will be tested:

H_6: There is a significant positive relationship between strategic green energy planning and the perceived access success to green energy in the SADC region.

H_7: There is a significant positive relationship between green energy economic augmentation and the perceived access success to green energy in the SADC region.

H_{8}: There is a significant positive relationship between environmental pollution mitigation and the perceived access success to green energy in the SADC region.

H_{9}: There is a significant positive relationship between green energy governance and the perceived access success to green energy in the SADC region.

H_{10}: There is a significant positive relationship between green energy technology innovation and the perceived access success to green energy in the SADC region.

H_{11}: There is a significant positive relationship between green energy policy alignment and the perceived access success to green energy in the SADC region.

H_{12}: There is a significant positive relationship between green energy projects financing and the perceived access success to green energy in the SADC region.

H_{13}: There is a significant positive relationship between green energy human capacity development and the perceived access success to green energy in the SADC region.

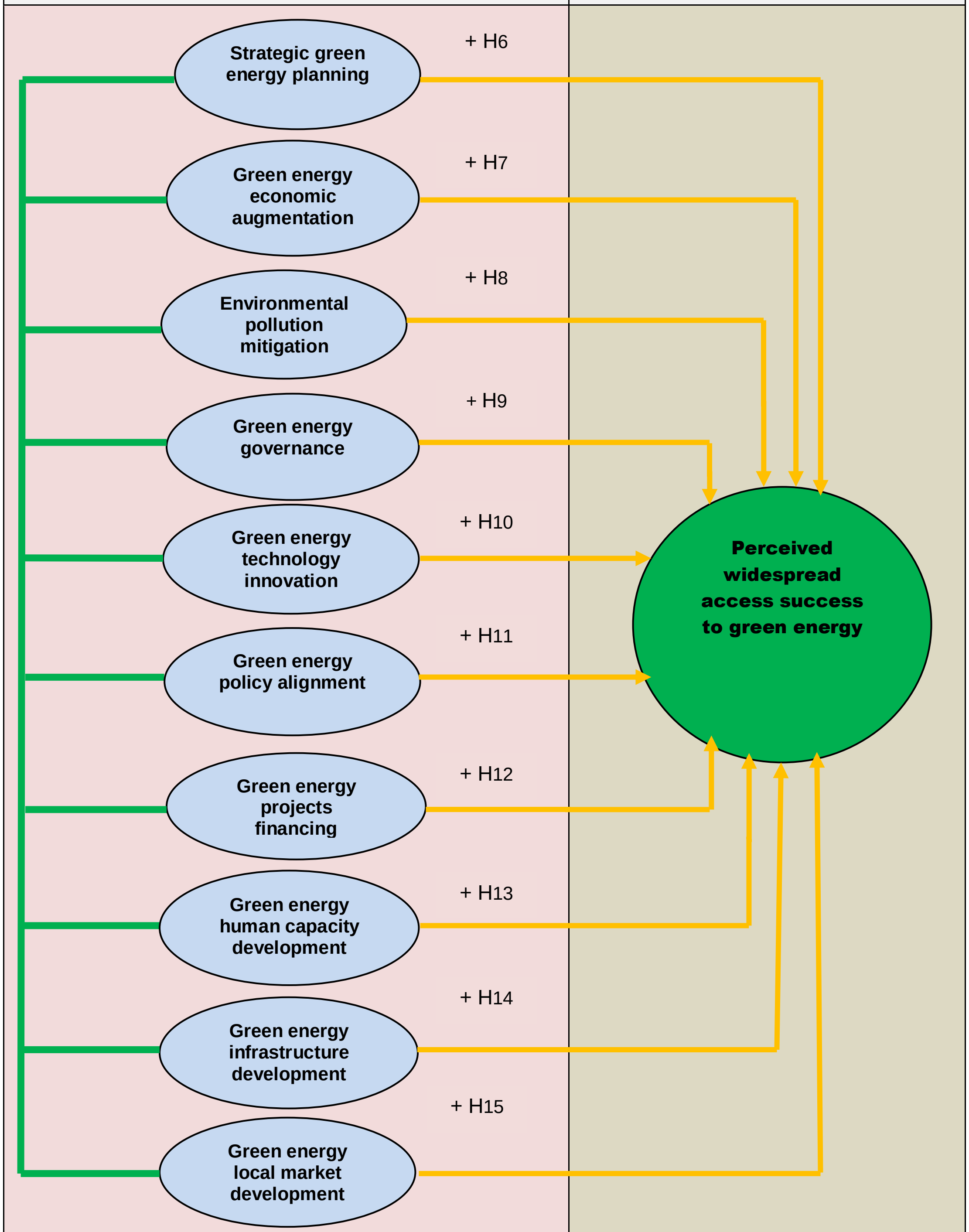
H_{14}: There is a significant positive relationship between green energy infrastructure development and the perceived access success to green energy in the SADC region.

H_{15}: There is a significant positive relationship between green energy local market development and the perceived access success to green energy in the SADC region

The hypothesised relationship of variables is illustrated by a conceptual theoretical model in Figure 4.1.

Figure 4.1: A conceptual theoretical model of green energy access for the SADC region

INDEPENDENT VARIABLES	DEPENDENT VARIABLE



Source: Researcher's own construction

4.2.1 Independent variable 6: Strategic green energy planning

An integrated approach to energy planning is imperative for increased access to electricity and modern energy services (Brew-Hammond, 2010). Energy systems planning in any country plays a critical role in setting up the framework for developing long-term policies of energy activities to help guide the future of a local, regional or national energy system and to meet the demand and supply requirements (Qin, Xu and Yu, 2012; Hiremath, Kumar, Balachandra and Ravindranath, 2010; Haydt, Leal, Pina and Silva, 2011). Countries with adequate energy planning capacity have the ability to anticipate and respond to rapid changes occurring, new issues and opportunities arising (Bazilian et al., 2012).

Hiremath et al. (2010) state that decentralised energy planning is one of the viable options to meet the rural and small-scale energy needs in a reliable, affordable and environmentally sustainable way. Inadequate national planning capability and consequent poor policy and investment decisions in the past have led to disparate level of access to modern energy services, particularly in developing countries (Bazilian et al., 2012). Poor access to energy can be attributed to inadequate planning, which ignores energy needs of the rural communities and the poor, and these results in environmental degradation (Hiremath et al., 2010).

DEP should be integrated into the national planning process, particularly to foster the development of renewable sources, which according to Brandoni and Polonara (2012) are generally characterised by:

- Low energy flux.
- Dramatically changing availability from one place to another.
- Expensive energy conversion technologies, which require the identification of sites to be able to maximise economic benefits.

A coherent energy planning approach can provide a framework for estimating the demand side planning and supply-side planning and ensure widespread access success to modern energy services (Campbell, Montero, Pérez and Lambert, 2011). The central theme of energy planning at a decentralised level can be made to meet energy needs and development of alternate energy sources at a least cost to the economy and environment (Hiremath, Kumar, Balachandra and Ravindranath, 2011). Local planning authorities, regional stakeholders and local strategic partnerships roles should also include fostering community involvement in renewable energy projects and seek to promote knowledge of and greater acceptance by the public of prospective renewable energy developments that are appropriately located (Upham and Shackley, 2006). Intermittent renewables pose another challenge in terms of meeting the demand for energy services.

Planning is critical if demand and supply of electricity is to be met especially in the long run in the SADC region (Haydt et al., 2011). Enhanced local participation in renewable energy planning and enhanced accountability is likely to lead to more widely acceptable development outcomes (Upham and Shackley, 2006). Tribes that are already developing energy resources in tribal lands without a strategic energy plan in place should consider developing a plan to help ensure that tribal energy goals and other related goals (such as economic development and sustainability) are met while developing their energy resources (Brookshire and Kaza, 2013).

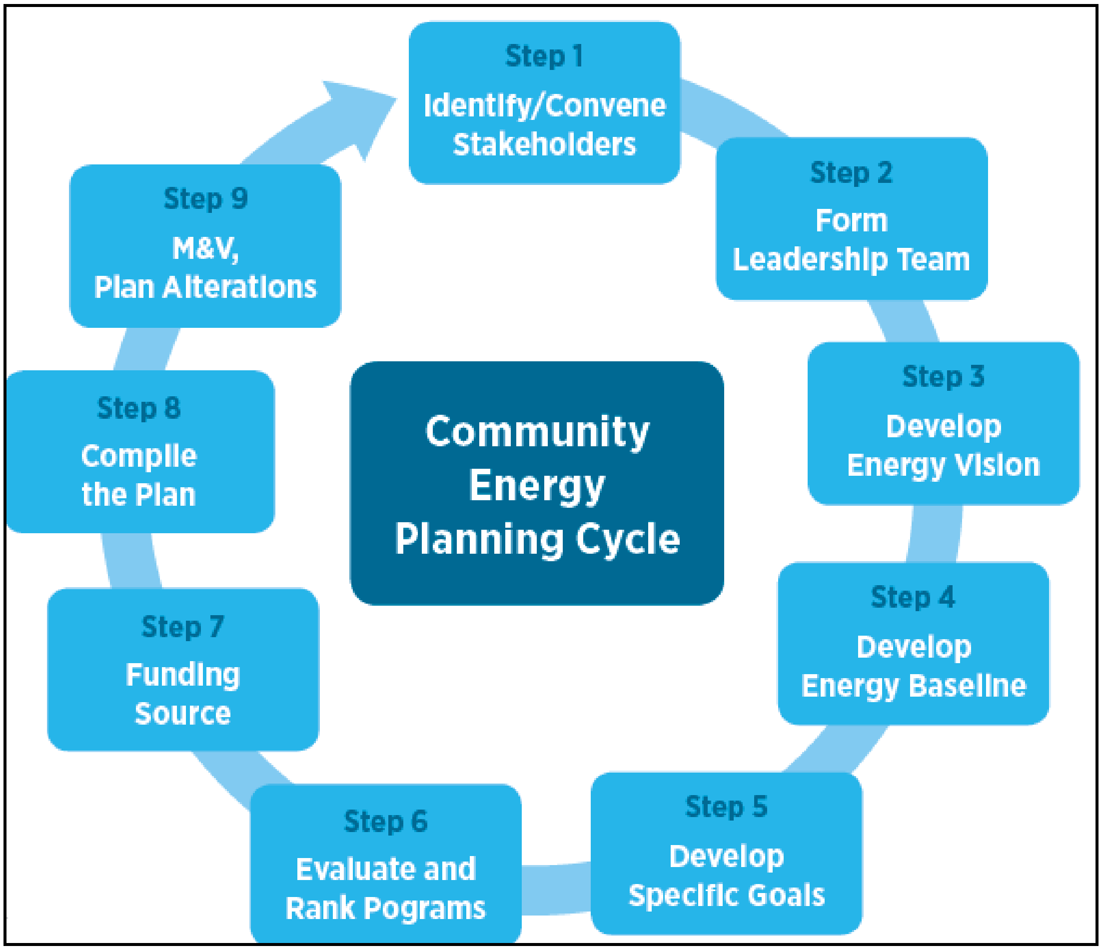
A more thorough and engaging process of local community and stakeholder participation is critical for a successful energy planning process (Upham and Shackley, 2006). Energy planning is becoming crucial to address the complexity and multiple interactions with other key issues such as climate and land-use (Pasimeni et al., 2014). Conflicting economic needs of the society are clouding planning decisions.

Energy planners and decision makers have to take into consideration several conflicting objectives because of the increasingly complex, social, economic, technological and environmental factors that are present (Cristóbal, 2011). The real-time control strategies and day-ahead optimal scheduling should be combined to establish a robust energy management method that provides good performance even when the forecast renewable energy value deviates significantly from the real value (Gu et al., 2014). Energy demands are increasing rapidly, both in developed and developing countries resulting in an exponential increase in environmental pollution and global warming (Hafez and Bhattacharya, 2012).

To ensure widespread energy access in the SADC region, energy planning processes must appreciate the energy demand situation in the region and aim for the satisfaction of future needs, and environmental challenges they pose (Mourmouris and Potolias, 2013). These days renewable energy is catching the attention of energy developers for remote and rural isolated power systems; renewable energy sources are being increasingly recognised as cost-effective generation sources in many parts of the world (Hafez and Bhattacharya, 2012). Meeting the needs of rural communities in developing countries can be attained through decentralised energy for meeting the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way.

The current pattern of commercial energy oriented development, particularly focused on fossil fuels and centralised electricity generation, has resulted in inequities, particularly in developing countries, external debt and environmental degradation, for example, large proportions of rural populations and urban poor continue to depend on low quality energy sources and inefficient fuel consuming devices, leading to low a quality of life (Hiremath et al., 2011). Figure 4.2 presents the step process for community strategic energy planning processes.

Figure 4.2: Step process for community strategic energy planning processes.



Source: United States Department of Energy (2009: 2).

Energy planning is also a matter that extends beyond national borders, especially for smaller countries with underdeveloped energy resource potentials (e.g. hydro power) or where sharing infrastructure with neighbours would provide economies of scale (Bazilian et al., 2012). The process to select criteria for best exploitation of renewable energy sources in a region, according to Mourmouris and Potolias (2013), needs to meet the following requirements:

- Compatibility with environmental and ecological constraints.
- Compatibility with economic, political, legislative, and financial situation at regional level.

- Compatibility with the local socio-economic conditions.
- Consistence with the technical conditions of the area under consideration and technology of the renewable energy sources facilities.

To expedite the usage or low carbon technologies, Brandoni and Polonara (2012) recommend the development of the Energy Master Plan implemented with the aim of curbing regional greenhouse gas emissions. In many parts of the world, the creation of sustainable energy and climate action plans at the local level show increasing local commitment and during the last decade, several municipalities have started to develop plans (Neves and Leal, 2010).

It is therefore hypothesised that:

H_6: There is a significant positive relationship between strategic green energy planning and the perceived access success to green energy in the SADC region.

4.2.2 Independent variable 7: Green energy economic augmentation

Modern energy access can provide significant improvements in key socio-economic and human development indicators including more equitable economic growth, healthcare services, infrastructure and industrial development (Gujba et al., 2012). The Renewables Global Status Report showed that during the period 2008-2011, renewable energy projects helped to create more than 3.5 million jobs in the renewable energy industries world-wide. Thus, the increase in the investment in the renewable energy projects can help increase the level of employment (Al-Mulali et al., 2013). The low levels and lack of access to modern energy services for productive activities has also impacted negatively on development and entrenched poverty in developing countries, particularly the African continent.

The residential sector accounts for about 60% of the total energy consumption in Africa, suggesting limited or low level of energy supplies for productive applications (Sokona, Mulugetta and Gujba, 2012). The agricultural sector is highly reliant on human and animal labour implying mechanical energy efficiencies in this sector are low, resulting in depressed agricultural yields and ultimately limited income for a majority of the continent's working population (Birol, 2012; Sokona, Mulugetta and Gujba, 2012). The significant correlation from the respondent's perception is the understanding that Africa's long-term economic growth and competitiveness fundamentally depends on reliable access to energy services, despite reforms and other measures to scale up electricity access, SSA region in particular has not succeeded in dramatically expanding access to electricity (Onyeji, Bazilian and Nussbaumer, 2012).

Arbex and Perobelli (2010) argue that the impact of energy use on growth will depend on the structure of the economy, energy intensity and the stage of economic growth of the country concerned, moreover, if energy use and environment policies affect the rate of productivity and the economic growth of the population. Access to modern forms of energy in Africa would enable living conditions to be transformed and boost industrial, agricultural, urban and rural development triggering the establishment of many commercial enterprises (Bazilian et al., 2012; Athanas and McCormick, 2013; Sokona, Mulugetta and Gujba, 2012).

For Africa to meet its energy needs Brew-Hammond (2010) suggests that, greater emphasis must be placed on productive uses of energy and energy for income generation in order to break the vicious circle of low incomes leading to poor access for modern energy services. To improve access to renewable energy the networks must be routed strategically to offer the best possibility of collecting and transmitting power from various locations and deliver it to where the demand is (Dames, 2011).

The growth of the economy is important, for a sustainable green energy sector in the SADC region, without demand, there cannot be supply. Arbex and Perobelli (2010) observe that the process of economic development involves a strong growth of energy demand; growth projections are essential for estimates of future demand and supply of energy. Andersen and Dalgaard (2013) argue that if all African countries had experienced South Africa's power quality, the continent's average annual rate of real GDP per capita growth would have been increased by 2% points and measured by the coefficient of variation, the cross country variation in growth rates would have been reduced by around 20%. Without green energy innovation initiatives SSA region will remain one of the poorest regions in the world (Onyeji, Bazilian and Nussbaumer, 2012).

It is therefore hypothesised that:

H_7: There is a significant positive relationship between green energy economic augmentation and the perceived access success to green energy in the SADC region.

4.2.3 Independent variable 8: Environmental pollution mitigation

The dilemma of addressing energy poverty and mitigation of climate change are proving to be a problematic. Oldfield (2011) argues that low carbon energy solutions to help alleviate rural and urban energy poverty is key; fossil fuel combustion for power generation if left unabated will have serious negative consequences on global economy, natural and built environments, food production, mobility, health and social well-being. Emerging challenges threaten to slow progress and undo successes thus far, including climate change impacts on vulnerable populations and economic losses from natural disasters that are increasing globally, with higher mortality and economic losses experienced by lower income countries which are predominantly developing countries (Oldfield, 2011; Abanda et al., 2012).

The impacts from climate change affect the most vulnerable populations that have contributed the least amount of greenhouse gas emissions globally, and annual CO2 emissions have surpassed 30 billion metric tons globally, a 35% increase from 1990 levels (Oldfield, 2011; Abanda et al., 2012; Nkwetta et al., 2010). Climate change continues to gain more momentum as a national security issue and (Schaefer, 2010) warns that as the climate changes, the potential for conflict over scarce natural resources will increase and as many as eight hundred million more people will face water or cropland scarcity in the next fifteen years.

Climate change will possibly act as a trigger for instability in some of the most volatile regions of the world by amplifying existing problems such as social tensions, poverty, deforestation, and weak political institutions (Fouquet, 2011; Schaefer, 2010). Poor communities suffer the life-endangering pollution that results from inefficient combustion resulting from fossil fuels and biomass burning (Sovacool, 2012). Large-scale renewable infrastructure projects need to be accompanied by adequate environmental and social impact assessments (Athanas and McCormick, 2013).

It is therefore hypothesised that:

H_8: There is a significant positive relationship between environmental pollution mitigation and the perceived access success to green energy in the SADC region.

4.2.4 Independent variable 9: Green energy governance

Coordinated regional energy governance can ensure that players share experience between local councils who are pioneering, struggling or indifferent towards renewable energy (Smith, 2007). Access to modern energy services can be facilitated by the establishment of partnerships between the public and private sector (Apergis and Payne, 2010).

Widespread energy access provision to the population in the SADC region countries will require effective leadership, strong commitment and a fruitful collaboration among governments, the private sector, the donor/lender community, civil society as well as the international community (Onyeji, Bazilian and Nussbaumer, 2012). Energy governance is critical for a sustainable energy access. Florini and Sovacool (2009) argue that if the world is ever to enjoy energy security, reliable, affordable, and efficient access to energy services, and make the transition to a low-carbon energy system without extra-ordinary disruption and human suffering, particularly in developing countries, a full assortment of global governance mechanisms will need to come into play.

The advent of renewable energy projects is introducing unfamiliar demands upon existing institutions in planning control, skills provision, infrastructure investment, control systems, and a need for a coherent energy governance (Smith, 2007). Improving regional access to modern energy services through renewable requisite sanction by local planning authorities, regional stakeholders and Local Strategic Partnerships should foster community involvement in renewable energy projects (Upham and Shackley, 2006). The urgency of dealing effectively with global energy policy to confront climate change, geopolitical tensions, and economic vulnerabilities, an effective collaboration between energy policy researchers and global governance scholars is long overdue (Florini and Sovacool, 2009). Policy makers in the SADC region have an important responsibility of encouraging a multilateral effort to promote renewable energy and energy efficiency in the region (Apergis and Payne, 2010).

In the recent years, several regional and international initiatives, institutions and financial mechanisms around the world have been striving to address the diffusion and implementation of renewable energies and the establishment of a low-carbon economy (Fritzsche, Zejli and Tanzler, 2011).

Developing countries, particularly the SSA region are overwhelmed by lack of access to modern energy services and none of the existing forms of global governance adequately match the nature and scope of global energy challenges (Florini and Sovacool, 2009). Lack of accountability by regional institutions due to the absence of a well-honed mechanism for holding institutions to account is responsible for failure in increasing energy access and a cycle of ever increasing distrust between affiliated countries (Upham and Shackley, 2006).

Efficient regional renewable energy governance can accelerate the deployment of renewable energy through the planning process while translating general policy goals into more defined strategies (Smith, 2007). Regional energy governance can improve various aspects and challenges of implementing and fostering renewable energies, such as knowledge transfer, capacity-building or financing (Fritzsche, Zejli and Tanzler, 2011). One of the major obstacles to the dissemination of renewable energy is because national governments see energy services as crucial to national security and national power; they intervene in the sector to promote energy ‘‘independence’’ or at least to assure supplies (Florini and Sovacool, 2009). Regional integration and energy governance can expose companies in the region to business opportunities identified regionally in a way not available to local or central levels (Smith, 2007).

Regional cooperation on the development of renewable energy markets between public and private sector stakeholders could begin with sharing information in the SADC region with respect to on-going projects, technologies, as well as financing and investment strategies (Apergis and Payne, 2010). The exploitation of business opportunities is hindered by the fact that nationally, few if any governments are well structured to govern energy issues. Energy is governed piecemeal, resulting incoherent policy landscape littered with uncoordinated efforts (Florini and Sovacool, 2009).

It is therefore hypothesised that:

H_9: There is a significant positive relationship between green energy governance and the perceived access success to green energy in the SADC region.

4.2.5 Independent variable 10: Green energy technology innovation

Green energy technology innovation illustrates innovation progression, which incorporate rural energy adaptations of integrated renewable energy systems from incremental cost-saving improvements in materials, labour and to streamlined business models that speed the deployment of renewable energy (IRENA, 2013a). In the early stages, innovation process typically has significantly higher unit costs than the established alternatives (Liu and Liang, 2013). In order to derive technical benefits from the application of energy innovation technologies in poorer areas, Alazraque-Cherni (2008) advises that innovation must be positioned in conjunction with other aspects of sustainability to ensure environmental improvements. Energy efficiency initiatives are part of energy innovation that can benefit developing countries. Failure to implement energy efficiency and energy conservation policies can also impede economic growth leading to relatively lower growth rates (Tsani, 2010).

The erratic nature of some of the renewable energy sources and their role in sustaining economic growth is a source of another debate (Warr and Ayres, 2010). There are three key arguments for building a domestic clean energy industry according to Wei, Patadia and Kammen (2010), and it includes:

- Improved energy security.
- Environmental protection.
- Potential engine for economic growth.

There is consensus that access to modern energy services is an important component to strategies that aim, amongst others, to mitigate poverty, expand healthcare and education services, address food insecurity, mitigate climate change, job creation and enhance economic development (Hailu, 2012; Wei, Patadia and Kammen, 2010; Arbex and Perobelli, 2010). In their study to explore the effect of renewable and non-renewable electricity consumption on economic growth in 18 Latin American countries Al-Mulali, Fereidouni and Lee (2014) infer that renewable electricity consumption is more significant than non-renewable electricity consumption in promoting economic growth in the long run.

Despite direct policy efforts and inherent environmental and socio-economic advantages of renewable energy technologies, diffusion of these alternative forms of energy has been very limited in many parts of the world (Rao and Kishore, 2010). In order to stimulate the augmentation of renewable energy technology, policies encouraging technology transfers, economies of scale, must be developed in developing countries (Voigt, De Cian, Schymura and Verdolini, 2014). To enhance a diffusion of renewable energy technologies, policy makers must appreciate both external and a mix of policies to increase the installed capacity and energy generation from renewable energy technologies, reductions in cost and price, domestic manufacturing capacity, related jobs and public acceptance (Aslani, Naaranoja and Wong, 2013).

Adopting new technology is not a straight forward decision for both public and private utilities, many of the utility firms that operate within a specific market seek to adopt these new technologies to be competitive in the market place technologies against their competitors and other utility firms are not keen to adopt these new technologies, as these firms have traditionally been operating efficiently with a more conventional form of technology that, as a result, has become embedded in the organisational routine technologies (Nisar, Ruiz and Palacios, 2013).

Large scale development of green energy structures often occurs in relatively undeveloped and rural landscapes; however, research shows increased conflicts as structures become more numerous (McPartland, 2012). The potential for future conflicts due an unpopular technology selection between renewable energy developers and communities will increase proportionately with expanded development (McPartland, 2012). Huge investments are necessary to expand energy access, develop new energy technologies, replenish aging infrastructure and build new energy infrastructure assets and associated supply chains (Khennas, 2012; World Energy Council, 2012c). The lack of investment in generation, transmission, and distribution is the greatest challenge encountered by electric utilities in developing countries region (Sanoh et al., 2014).

The ultimate success or failure of technology selection is not dependent on technology factors only; it is also influenced by factors of the business environment and the external environment (Barry, 2011). These factors that facilitate or hinder diffusion and drive the process are inter-linked making diffusion a complex phenomenon (Rao and Kishore, 2010). Without innovation, technology cost will remain high, unfortunately developing countries are generally not in a strong position to assume the additional risks associated with technology innovation, create new market demands and new industries expected to lead the future economic growth and social development (Liu, and Liang, 2013).

It is therefore hypothesised that:

H_{10}: There is a significant positive relationship between green energy technology innovation and the perceived access success to green energy in the SADC region.

4.2.6 Independent variable 11: Green energy policy alignment

Widespread energy access calls for policy frameworks that seek to stimulate a sustainable energy supply and that addresses key national goals like sustainable development, efficient technologies, energy security, local economic development, and improves the quality of the environment (Campbell et al., 2011; Lehmann et al., 2012; Bazilian et al., 2012). Energy policy making is not coherent and it tends to be highly disjointed at the national level in Africa, particularly SSA region, even more so at the international level (Florini and Sovacool, 2009).

The energy planning system will not be successful if it is not immersed in an environment of appropriate energy policies (Campbell et al., 2011). Examples of specific policy instruments, which have been implemented successfully to increase access to electricity, according to Brew-Hammond (2010) are as follows:

- Electricity laws/bills that support distributed generation using both renewable and non-renewable energy sources through de-licensing, technical standards and ball-park tariff recommendations.

- Licensing regulations that differentiate between small and large-scale distributed generation and grid connected schemes.

- Removal of licensing barriers to encourage owners of small generators/IPPs to invest in distributed generation's systems in rural areas.

- The distribution of energy efficient lighting as a demand side management measure especially in urban and peri-urban areas.

- Smart subsidies drawn from rural electrification.

- Lifeline tariffs whereby the first 50 kWh of electricity (or a similar small amount of energy) is provided at a subsidised rate to benefit the poor.

- Embedded generation tariffs that amongst others reward small IPPs for system reinforcement and technical loss reduction.

A key element of renewable energy policies is the creation of economic incentives to promote renewable energy installation and generation from large renewable energy facilities to community- and micro-scale (household level) installations Eyraud, Clements and Wane (2013). An analysis of effective energy policies by Campbell et al. (2011) suggest that a standard approach whether taxation or subsidy based may discourage some individuals from becoming active investors whilst encouraging others; and that greater participation may be gained by developing economic incentives that take into account, individualist preferences for competitive markets; hierarchist preference for taxation and egalitarian views that government needs to subsidise renewable energy.

The difficulties of creating such hybrid incentives within a single economic instrument means that a combination of policies is likely to be more coherent than a single ‘compromise’ policy (Bazilian et al., 2012). According to Eyraud, Clements and Wane (2013) the most common forms of policy support for renewable electricity generation are feed-in tariffs. Energy security can stimulate economic growth and triggers the creation of jobs or expansion of business activity, which increases personal and household incomes and in turn, the local or state tax base and larger macroeconomic indicators such as GDP and industry growth as defined through increased revenues (Campbell et al., 2011; Warr and Ayres, 2010).

Low carbon economy can be stimulated by improving the efficiency of energy, leading to increases in productivity and consequently output growth (Warr and Ayres, 2010). Jewell, Cherp and Riahi (2014) observe that energy security is about protecting energy systems whose failure may disrupt the functioning and stability of a society. Energy systems can be defined in terms of their geographic boundaries (national, sub-national, regional or the world as a whole) or in terms of their sectorial boundaries (a primary energy source such as crude oil, an energy carrier such as electricity or an energy end-uses such as transportation) (Jewell, Cherp and Riahi, 2014).

According to Jewell, Cherp and Riahi (2014) the low carbon scenarios fall into three groups:

- Efficiency scenarios where the focus of policy and investment is on energy efficiency improvements resulting in significantly suppressed overall energy demand due to lower energy intensity.
- Supply scenarios where policy and investments are focused on low carbon energy supply technologies resulting in more rapid transformation of the energy mix and relatively fast growth in energy demand.
- Mix where equal focus is given to supply- and demand-side policies and investments.

New energy technologies for renewable energy represent alternatives that could inherently have a tremendous impact on a global level given their innovation, commercialisation strategies and policies are required to bring these technologies into large-scale use (Lund, 2011). The success of renewable energy policy instruments can be determined by the cost-effectiveness of the support for renewable, together with effectiveness of the implementation and how aligned they are to a goal of exploiting renewable energy resources (Del Río and Cerdá, 2014).

German renewable energy is widely appraised and it is attributed to the politics behind the energy policy (Huenteler, Schmidt and Kanie, 2012). The renewable energy policy landscape across African states is sketchy and it has resulted in limited access to modern energy services to the vast majority in the continent (Hailu, 2012).

It is therefore hypothesised that:

H_{11}: There is a significant positive relationship between green energy policy alignment and the perceived access success to green energy in the SADC region.

4.2.7 Independent variable 12: Green energy projects financing

Impoverished countries cannot afford to invest in green energy sources. Ocal and Aslan (2013) state that renewable energy is an expensive energy source for developing countries, as abundant research studies have revealed that increase in income is a vital supporter behind increased renewable energy consumption. The shift to renewable energy is driven by a number of considerations, one being that many developing countries are struggling to meet fast growing energy demand (UNDP, 2013). Brew-Hammond (2010) argues that achieving between 50% and 100% access to modern energy services by 2030 in Africa will require more effective mobilisation and use of both domestic and external funding.

In some schemes, tariffs are adjusted over time to prevent consumers from paying unnecessarily high prices and to allow for technology learning curves (Boomsma, Meade and Fleten, 2012). However, these adjustments must be predictable if investment certainty is to be maintained (Pegels, 2010). Furthermore, the implicit or explicit subsidisation of fossil fuels must be reviewed, even if this is strongly opposed by both powerful interest groups and the general public (Pegels, 2010).

Poor countries cannot afford, in most cases, to pay for the initial capital cost to access decentralised modern forms and low carbon content energy options (Khennas, 2012). A feed-in tariff involves a payment to the renewable electricity producer proportional to the volume fed into the grid (Boomsma, Meade and Fleten, 2012). This can be implemented as a fixed tariff for electricity or as an electricity price premium. This creates a basis for long-term investment planning, since revenues are known and guaranteed in advance (Pegels, 2010).

Under a fixed feed-in tariff, the renewable producer power producer receives a fixed payment that is independent of the electricity spot price, whereas under a price premium, a power producer receives a payment on top of this price (Boomsma, Meade and Fleten, 2012). Given that renewable energy provides substantial ancillary benefits such as reduction of local air pollution, an equitable approach would not cover the entire cost differential through subsidies; effective financial mobilisation is critical (Michaelowa et al., 2013). Edenhofer et al. (2013) suggest that renewable energy should only be subsidised if their social returns on investment are:

- Higher than their private returns on investment and at the same time.
- Lower than investments in other technologies.

Developing countries face an uphill of augmenting renewable energy due to lack of funding. Africa’s energy problems cannot be addressed without significant doses of local financing, the whole range of public sector resources (national budgets, electrification/energy funds based on levies and surcharges, debt relief, etc.) will need to be mobilised (Brew-Hammond, 2010). Investments in renewable energy is most extensively employed through support schemes, namely, feed-in tariffs and renewable energy certificate trading (Boomsma, Meade and Fleten, 2012; Pegels, 2010).

These two regimes may differ in terms of the level of subsidy payments but also in the degree of risk exposure to an investor (Boomsma, Meade and Fleten, 2012). Through the implementation of feed-in tariffs, electricity market price risk is either completely removed or the investor is exposed to electricity market price risk only (with what is known as a price premium). In contrast, the implementation of renewable energy certificate trading allows for a significant risk from market prices of both electricity and the certificates themselves (Boomsma, Meade and Fleten, 2012).

As the unavailability of domestic finance is often a key barrier to rolling out renewable energy in developing countries, there have been several attempts to introduce an international support scheme (Sanoh et al., 2014). Financing cost is the primary determinant of generation cost for renewable sources, as renewable energy (other than biomass and biofuel) has no fuel cost but does have high upfront investment costs. However, project developers in developing countries often struggle to access the large quantities of financing they need (UNDP, 2013). Belke, Dobnik and Dreger (2011) state that only the common components of energy consumption; economic growth and energy prices are integrated.

It is therefore hypothesised that:

H_{12}: There is a significant positive relationship between green energy projects financing and the perceived access success to green energy in the SADC region.

4.2.8 Independent variable 13: Green energy human capacity development

A thriving and sustainable low carbon energy sector can only be realised through institutional and human capacity equipped with skills and knowledge to drive the implementation of programmes aimed at growing the sector.

Liu and Liang (2013) argue that human and institutional capital is an essential building block for green energy technology and innovation. Shortage or lack of skilled staff is an obstacle to the augmentation of renewable energy in the developing countries (Negro, Alkemade and Hekkert, 2013). Communities to be serviced by renewable energy technologies must be empowered with adequate knowledge to avoid political difficulties that can arise when the concerns of local people are not seriously addressed at an early stage of renewable energy project (Upham and Shackley, 2006).

The priority in developing countries must entail development of human skills in research, as well as strengthening those institutions that focus on educating the next generation of researchers, policymakers, entrepreneurs and professionals for promoting renewable energy innovation (Liu and Liang, 2013). Access to modern energy services can be facilitated by the establishment of partnerships between the public and private sector to facilitate the technology transfer process of bring renewable energy projects to market (Apergis and Payne, 2010). Negro, Alkemade and Hekkert (2013) identify obstacles that are associated with lack of capabilities/capacities, that withhold innovation to improve access to renewable and they include:

- Lack of technological knowledge of policy makers and engineers.
- Lack of ability of entrepreneurs to pack together, to formulate a clear and realistic message and to lobby to the government.
- Lack of capabilities by users to formulate demand.
- Lack of skilled staff, lack of technological knowledge, examples: wrong technological choices, poor designs and malfunctioning technology.

It is therefore hypothesised that:

H_{13}: There is a significant positive relationship between green energy human capacity development and the perceived access success to green energy in the SADC region.

4.2.9 Independent variable 14: Green energy infrastructure development

Transforming the energy infrastructure towards low-carbon technologies in both industrialised and developing countries is a critical part of the global greenhouse gas mitigation and improved widespread energy access in developing countries (Onyeji, Bazilian and Nussbaumer, 2012; Khennas, 2012). Building up the energy infrastructure like power plants, grid interconnections and small-scale decentralised energy options in Africa's rural areas is a pre-condition for economic growth and ultimately for energy access (Khennas, 2012).

Governments of SSA region where a dominant fraction of the population does not have access to grid electricity are now emphasising the critical role that electricity services play in promoting human development (Zvoleff, Kocaman, Huh and Modi, 2009). There is a need for new policies and institutions that can foster new investments in generation and cross country transmission capacities in large-scale, national, and regional planning and optimisation of energy networks supporting rural electrification (Sanoh et al., 2014; Zvoleff, Kocaman et al., 2009).

In some parts of the SSA region, political strife hamper the rehabilitation of the existing installations and construction of new power generation facilities and transmission lines (Sebitosi and Okou, 2010). Technology differs somewhat in their vulnerabilities to attacks and sabotage; a PV facility can be repaired more quickly than wind or CSP facilities. While off-shore wind parks are possibly the least vulnerable to attack (Lacher and Kumetat, 2011). Security risks to energy infrastructure or sabotage remains a challenge in Africa; grid lines are the most vulnerable component of such an infrastructure (Lacher and Kumetat, 2011). Attacks on electricity generation facilities are significantly less likely, as such sites can be protected more easily (Lacher and Kumetat, 2011).

Sanoh et al. (2014) observe that the rationale for grid inter-connection in Africa is twofold: high consumption countries do not have the highest supply potential, and a number of small countries have small markets for which high investment is unfeasible. Substantial expansion in quantity, quality, and access to energy infrastructure services are essential to rapid and sustained economic growth, employment generation, poverty reduction and overall wellbeing of a country where greater portion of its population resides in the rural areas (Khennas, 2012). A sustainable supply of energy resources requires an effective and efficient utilisation of energy resources (Yildirim, Sarac and Aslan, 2012).

It is therefore hypothesised that:

H_{14}: There is a significant positive relationship between green energy infrastructure development and the perceived access success to green energy in the SADC region.

4.2.10 Independent variable 15: Green energy local market development

Main factors that have impacted in the sustainable investments against the sustainability of clean and decentralised technologies in rural poor areas are maintenance and cost, information, remoteness, poor information, and gender bias (Alazraque-Cherni, 2008). The cost of renewable energy technologies is initially high, as they have not undergone improvements through market experience (both from the suppliers' learning curve and from user-driven experience). With increasing cumulative installation and market experience, the costs of new technologies are expected to fall in complementary fashion (Shum and Watanabe, 2009). In order to ensure the sustainability of the energy sector, access to electricity should be increased both at urban and rural levels; the share of renewables in the power supply mix should be increased to meet these aims.

The following recommendations have been suggested (Nkwetta et al., 2010):

- Awareness among policy makers on the methods to improve the sustainability of the energy sector, such as the use of green energy technologies and attractive tariffs needed to provide a platform for sustainable energy generation.
- Integration of socio-economic, environmental and energy sector reforms and environmental impact assessments carried out prior to any major electricity generation, transmission and distribution project.
- Awareness of large-scale hydro power plant, development and the potential environmental destruction associated with the development of large green energy infrastructure.
- Regulatory agencies should be created and given independence; where regulatory agencies exist, they have done little to ensure sustainability since they have not been given significant capacity and where capacity exists, and their ability to carry out their duties has been compromised by its lack of the requisite independence since members are politically appointed.
- Most solar thermal energy systems in SSA countries are used for basic human necessities including health, education, and water supply.

According to Lehmann et al. (2012) risk premiums required on capital markets for renewable energy projects are usually higher than those for fossil-fuel technologies due to higher uncertainties associated with a relatively immature renewable energy technologies and exogenous risks such as wind speed or sunshine duration (Fadel et al., 2013; Lehmann et al., 2012). Less experience on the lender side with renewable energy technologies will also result in higher risk premiums (Fadel et al., 2013). The lack of experience includes technological, operational, and regulatory questions.

Green energy projects cannot succeed if there are public reservations about landscape change caused, particularly when such change disrupts the established ways of life for those who are nearby (Pasqualetti, 2011). For much of the last 200 years, the steady growth in modern energy consumption has been closely linked to rising levels of prosperity and economic opportunities across the globe and low modern energy consumption characterises most of developing countries (Sokona, Mulugetta and Gujba, 2012).

It is therefore hypothesised that:

H_{15}: There is a significant positive relationship between green energy local market development and the perceived access success to green energy in the SADC region.

4.3 CHAPTER SUMMARY

The theoretical conceptual model of access success to green energy in the SADC region has been developed; it is presented in Figure 4.1. Factors that influence the sustainable widespread access success to green energy were analysed through literature reviews. The model is empirically tested in Chapter 6. A total of 10 hypotheses emanating from the conceptual theoretical model are proposed. The hypothesised variables are: strategic green energy planning, green energy economic augmentation, environmental pollution mitigation, green energy governance, green energy technology innovation, green energy policy alignment, green energy projects financing, green energy human capacity development, green energy infrastructure development and green energy local market development. Chapter 5 discusses the research design, methodology and instruments used to test the conceptualised theoretical model.

5 CHAPTER 5: RESEARCH DESIGN AND METHODOLOGY

5.1 INTRODUCTION

Chapter 4 presented the conceptual theoretical model framework of selected independent variables hypothesised to determine the significance of their inter-relatedness to each other and the significance of their relationship to the dependent variable (perceived access success to green energy). Literature reviews about the energy situation in the African continent, SSA region and the SADC region were appraised to develop the conceptual theoretical model and the research instrument. All identified variables in Chapter 4 are operationalised to define their meaning in the context of the study in Chapter 5.

This research is aimed at developing a green energy model for the SADC region in the context of increasing widespread access to modern energy services to a larger population in the region. As indicated in Chapter 1, the research problem incorporated identifying factors that can influence green energy widespread access success in the SADC region. Addressing the research problem involved theoretical model building, followed by an empirical assessment of the proposed model. This chapter focused on the research design, definition of the population studied, the reliability and validity of the measurement instrument, sampling methodology, data collection and data analysis methods used and the statistical techniques applied to analyse the data.

5.2 RESEARCH DESIGN AND METHODOLOGY SELECTED

5.2.1 Research design

A research design constitutes a blue print for the collection, measurement and analysis of data (Blumberg, Cooper and Schindler, 2008; Mouton, 2004).

Research design provides the overall structure for the procedure the researcher follows and the plan of investigation used to obtain empirical evidence in relation to the problem under study (Leedy and Ormrod, 2005). The main aim of this section was to describe the research stages, provide details about the nature of empirical evidence required to address the main research question, described in chapter 1. Table 5.1 summarises the research design steps followed by the research.

Table 5.1: Research design steps followed by the research

NO.	STEP	RESEARCH DESIGN
1	Identification and collection of primary and secondary literature sources about green energy	Secondary research
2	Literature reviews that focused on green energy	Qualitative research design by means of interpretation
3	Identification of variables that are perceived to influence widespread access success to green energy, in developing countries, focusing in the African continent, SSA and SADC region	Qualitative research design by means of interpretation
4	Based on literature reviews develop a research instrument to test the hypotheses constructed based on identified factors	Qualitative research design by means of interpretation
5	Test the measuring instrument through a pilot study: target a minimum of 30 respondents	Quantitative design by means of survey research
6	Adapt the measuring instrument where necessary and distribute it to identified groups in the SADC region: target a minimum of 250 respondents	Quantitative design by means of survey research
7	Data analysis and hypotheses testing	Quantitative design
8	Draw conclusions and recommendations	Interpretation of quantitative and qualitative data

5.2.2 Research methodology

A research methodology is the general approach the researcher takes in carrying out the research project, to some extent, this approach dictates the particular tools the researcher selects (Leedy and Ormrod, 2005: 12). This section provides information on how the research design was executed. This includes data collection methods, population and sampling methods, explaining how the research instrument was designed and the nature of the instrument, population and sampling methods, data collection and analysis, as well as process and procedure followed (Leedy and Ormrod, 2005).

5.2.2.1 Method of data collection

The two methods employed for data collection are primary and secondary research. Secondary research is information or data that has already been collected and recorded by someone else, usually for other purposes (Blumberg, Cooper and Schindler, 2008). According to Mouton (2004) primary data is data that the researcher has to collect for the research. Data collection using both methods and the description of how the data was collected is explained in sections that follow.

5.2.2.1.1 Secondary research

Relevant literature was reviewed and this included books, journals and articles on green energy. The main aim of primary sources literature reviews was to establish the extent of the green energy access problems in developing countries. Successful implementation of green energy sector's best practices around the world was also studied from literature. Research work and relevant studies conducted on the topic in the SADC region were also reviewed. Research work reviewed was mainly research reports on renewable energy in the SADC region.

Review of published reports from SADC region's governments included reports from power utilities, IPP, energy research institutions and non-governmental institutions that are involved in energy matters. Reports included annually published reports on renewable energy projects, completed and planned energy projects for the future. A comprehensive review of research work related to the topic was conducted on all elements of the problem statement in order to achieve the objectives stated in Chapter 1.

Attempts were made to review case studies of successfully implemented green energy projects in other regions around the world, several international bodies' research work in the energy sector in developed and developing countries were reviewed. These include reports from the International Energy Agency (IEA), IRENA, the World Energy Council, SAPP and the New Partnership for Africa's Development (NEPAD). In addition, the research also focused on how existing power utilities supplying power in the region are planning future power generation with both fossil fuel sources and green energy sources.

Non-academic published documents on the topic were also reviewed including annually published reports about energy by corporate companies, energy regulatory bodies, banks, non-governmental bodies involved in the sector and other energy stakeholder's published materials. Comprehensive reviews of secondary sources were also conducted using international and national data searches through the library of NMMU and Rhodes University. This included reviewing research projects saved in among research data bases and research journals published in the websites of Science Direct and Google scholar.

5.2.2.1.2 Primary research

As indicated in Table 5.1, primary research employed both qualitative and quantitative research design. Qualitative methods are ways of collecting data which are concerned with describing the meaning, rather than with drawing statistical inferences (Leedy and Ormrod, 2005). Quantitative research involves either identifying the characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena (Leedy and Ormrod, 2005; Blumberg, Cooper and Schindler, 2008). The sections that follow discuss primary research.

5.2.2.1.2.1 Qualitative research design

A content analysis approach was adopted for qualitative design. Leedy and Ormrod (2005) indicate that content analysis is a detailed and systematic examination of the content of a particular body of material for the purpose of identifying patterns, themes or bias. Content analysis was examined in relation to the research question stated in Chapter 1. Literature reviews focused on themes that explored green energy as a source of energy to address energy access challenges.

Primary literature review exposed factors that must be implemented to achieve successful widespread access to green energy namely: strategic green energy planning, green energy economic augmentation, environmental pollution mitigation, green energy governance, green energy technology innovation, green energy policy alignment, green energy projects financing, green energy human capacity development, green energy infrastructure development and green energy local market development. From the identified variables, ten hypotheses were formulated and a measuring instrument was constructed to measure these variables.

5.2.2.1.2.2 Quantitative research design

Quantitative research involves either identifying characteristics of an observed phenomenon or exploring possible correlations among two or more phenomena (Leedy and Ormrod, 2005). The descriptive research approach was employed to describe the demographic profile of respondents. It was aimed at describing correlations between respondents' responses and their relationship with the independent and the dependent variable. Data collection was conducted via quantitative methodology.

Quantitative methodology has an advantage of offering the highest measurements because of its ability to obtain metric data which can be analysed using parametric statistics (Diamantopoulos and Schlegelmilch, 2006). Access to energy in the SADC region can be attributed to a number of factors identified in the previous chapters through literature review. Quantitative design has strengths and weaknesses. Mouton (2004); Leedy and Ormrod (2005); Blumberg, Cooper and Schindler (2008) identify some of the critical strengths and weaknesses of quantitative research, namely:

➢ Strength

- The researcher is independent and less biased because he/she stands outside of the research question and reports the findings in an impersonal and formal language.

- Quantitative research questions focus on predicting outcomes, are deductive and the results can be generalised to the larger population.

➢ Weaknesses

- The inability of the researcher to ensure a sufficiently high return rate of questionnaires is a problem that researchers face.

- Low returned questionnaires mean results may not be representative of the sample originally selected for the specific discipline; this may impact on the relevance of the research findings.

5.2.2.1.2.3 Survey research

According to Leedy and Ormrod (2005), survey research involves acquiring information about one or more groups of people, perhaps about their characteristics, opinions, attitudes or previous experiences and by asking them questions and tabulating their answers. The researcher poses a series of questions to willing participants, summarises their responses in percentages, frequency counts or more sophisticated statistical indexes.

A survey research methodology was adopted for the study. Survey research is usually quantitative in nature and aims to provide a broad overview of a representative sample of a large population (Mouton, 2004). The SADC region is comprised of 15 sovereign states with varying energy access rates and challenges. Survey research methodology is appropriate for a study of this nature, due to the large geographic scope of the study.

5.3 QUANTITATIVE TESTING AND ANALYSIS

Leedy and Ormrod (2005) indicate that a quantitative research process is more rigorous, systematic and well planned in order to obtain an objective description of a phenomenon. Quantitative research methodology is well-suited to meet the primary objective of the study, namely: to debunk how widespread access to green energy can be increased by investing into the green energy sector in the region. The vast size of the SADC region necessitated quantitative testing and analysis. The sections that follow provide an overview of the population studied; the sampling method employed; instrument development; administration of the questionnaire. It also presented the method of data analysis adopted.

5.3.1 Population studied

A population under study is the totality of entities in which the researcher has interest, i.e. the collection of individuals, objects or event in which inferences are to be made (Diamantopoulos and Schlegelmilch, 2006). The composition of the targeted population proposed for this study included a sample of energy practitioners from various sections of the energy sector which included energy ministries in the SADC region, non-governmental institutions, private companies, energy researchers, academics and energy specialists.

5.3.1.1 Continental and regional energy institutions

The region has a number of energy institutions that oversee the implementation of various programmes that are aimed at expediting energy access in the region. The main energy institutions that represent energy ministries and other stakeholders are described below.

5.3.1.1.1 Southern African Power Pool affiliated energy ministries

SAPP is a regional body comprised of 12 member countries. It supports SADC's energy objective to promote economic cooperation among the then 12 member countries. Member countries are namely: Angola, Botswana, DRC, Lesotho, Malawi, Mozambique, Namibia, the Republic of South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. At the time of SAPP creation, SADC governments agreed to allow their national power utilities to enter into the necessary agreements that would regulate the establishment and operation of the SAPP (Sebitosi and Okou, 2010).

For many years SAPP has coordinated energy demand and forecasting in the region. The core objective of the SAPP is to provide a forum for the development of stable interconnected electricity supply system in the region (Ketlogetswe, Mothudi and Mothibi, 2007). SAPP member countries database was obtained from the official website and leaders and members of the organisation were sent the questionnaires.

5.3.1.1.2 Renewable energy associations in the African continent and SADC region

There are a number of associations that endeavor to promote a transition from fossil fuel energy generation to green energy sources. Members of these organisations were contacted and sent questionnaires. The organisations are described in sections that follow.

5.3.1.1.2.1 Southern African Alternative Energy Association (SAAEA)

According to SAAEA (2015) this organisation represents and actively promotes renewable alternative energy solutions in the SADC region.

It is a non-governmental organisation that advocates policy development on the behalf of its members at decision making government level. Their members include research institutes, developers, contractors, consultants, suppliers and members of the public dedicated to building a greener planet. Their projects include making information available on global warming issues, sustainable solutions/technologies to counter harmful carbon emission.

5.3.1.1.2.2 Sustainable Energy Society of Southern Africa (SESSA)

SESSA (2015) indicate that this is a non-governmental organisation dedicated to the use of renewable and energy efficiency. The inter-disciplinary nature of SESSA attracts membership of industry, scientists, researchers, developers and the general public. SESSA was founded in 1974 and is one of 50 national sections of the International Solar Energy Society (ISES). ISES is regarded as the premier body in solar energy with members in over 100 countries. SESSA is the duly appointed African office of ISES.

5.3.1.1.2.3 African Sustainable Energy Association (AFSEA)

According to AFSEA (2014), the organisation represents and actively promotes renewable energy solutions to the African continent. AFSEA's focus is on the whole industry, rather than one sector. The mission of AFSEA is to provide great insight into the African sustainable energy market by bringing companies from around the world together so they may prosper and gain the knowledge needed to expedite the implementation of renewable energy as a significant source of energy. AFSEA advocates policy development on the behalf of their members at decision making government level.

5.3.1.1.3 Fossil fuel energy sector

A number of organisations generate electricity from fossil fuels which include coal, diesel, etc. Respondents who are associated with the fossil fuel energy generation sector were identified and given questionnaires. The main aim was to gauge their views in relation to initiatives to generate energy from non-fossil fuel sources. The largest quota of respondents was obtained from South Africa. Most of the electricity generated through fossil-fuel energy is generated in South Africa. The country has the most advanced power market in Africa and is sometimes coined “the powerhouse of Africa” (KPMG, 2014).

Eskom, a parastatal responsible for the supply of electricity in South Africa, is estimated to generate about two-thirds of the total SSA electricity output and 80% of the total Southern African output, with a generating capacity of about 41 000 MW and 359 337 km power lines and 232 179 megavolt volt ampere sub-stations (KPMG, 2014). The main energy source in South Africa is coal, which contributes about 88% of the country’s total electricity generation (Barry, Steyn and Brent, 2011; Pegels, 2010). Nuclear power represents around 5% of the total generation capacity by Eskom which operates around 92% of the electricity generation capacity in South Africa (Thiam, Benders and Moll, 2012).

5.3.1.1.4 Energy researchers and scholars

Green energy researchers and scholars were also identified from engineering and science faculties at various universities in the SADC region. This included energy experts who are in various sections of the sector that include: contractors, consultants, suppliers and members of the public who are involved in the green energy industry. Experts were identified from these institutions and requested to participate in the study.

Research institutions that were sent questionnaires included universities and public and private research institutes identified in the region. Examples of research institutions that were sent questionnares include: University of Cape Town energy research centre; The Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University; Council for Scientific and Industrial Research (CSIR) and Scientific and Industrial Research and Development Centre (SIRDC) in Zimbabwe and others.

5.3.1.2 Categories of respondents and hypotheses testing

From the identified population, respondents were further categorised into groups for analysis and hypotheses were formulated and tested. The categorised groups and tested hypotheses are listed below.

5.3.1.2.1 Categories of respondents

Categories of respondents are namely:

- Less experienced (1-6 years)/experienced (> 6 years) energy practitioners
- Junior management/middle management and senior management
- Fossil fuel sector/renewable energy sector
- Energy researchers (scholars)/energy industry practitioners
- South Africa based and based in other SADC countries

5.3.1.2.2 Hypotheses tested by the study

A total of 16 hypotheses were tested by the study as presented in Table 5.2.

Table 5.2: Hypotheses that are tested by the study

Hypotheses	Statistical test
H1. There is a significant difference in support for green energy based on years of experience (1-6 years and > 6 years).	Multivariate analysis of variance and univariate analysis of variance.
H2. There is a significant difference in support for green energy based on the energy sector base (fossil fuel and renewable energy).	Multivariate analysis of variance and univariate analysis of variance.
H3. There is a significant difference in support for green energy based on the role in the sector (researchers and industry practitioners).	Multivariate analysis of variance and univariate analysis of variance.
H4. There is a significant difference in support for green energy based on a location that serves as a base country (South Africa and SADC countries).	Multivariate analysis of variance and univariate analysis of variance.
H5. There is a significant difference in support for green energy based on the position held (senior manager; middle manager and junior manager).	Multivariate analysis of variance and univariate analysis of variance.
H6. There is a significant relationship between strategic green energy planning and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H7. There is a significant relationship between green energy economic augmentation and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H8. There is a significant relationship between green energy environmental pollution mitigation and the perceived success of access success to green energy in the SADC region.	Pearson Product Moment Correlation
H9. There is a significant relationship between green energy governance and the perceived success of access to green energy in the SADC region.	Pearson Product Moment Correlation

H10. There is a significant relationship between green energy technology innovation and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H11. There is a significant relationship between green energy policy alignment and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H12. There is a significant relationship between green energy projects financing and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H13. There is a significant relationship between green energy human capacity development and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H14. There is a significant relationship between green energy infrastructure development and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H15. There is a significant relationship between green energy local market development and the perceived access success to green energy in the SADC region.	Pearson Product Moment Correlation
H16. There is a significant difference in support for viability of various green energy sources amongst different groups in the SADC region: (1-6 years and > 6 years); (fossil fuel and renewable energy); (researchers and industry practitioners); (South Africa and other SADC countries) and (senior manager, middle manager and junior manager).	Multivariate analysis of variance and univariate analysis of variance.

5.3.2 Sampling method

The SADC region is vast and it was not practical to meet all the respondents from different parts of the region. According to Diamantopoulos and Schlegelmilch (2006: 18), practical considerations entail issues of resource availability in terms of time, money and personnel availability that can influence a sample size. Invitations to participate in the research were directed at the identified potential respondents by means of direct interviews, electronic email and direct telephonic calls.

A database of email addresses and contact numbers were compiled from official websites of various institutions and requests to complete the questionnaire were sent to the targeted respondents.

Questionnaires were distributed both through emails and hand delivery to identified respondents in all parts of the SADC region. Renewable energy forums and conferences in the region were identified and visited based on the convenience of a visit. Potential respondents were given options of completing the electronic or hard copies of questionnaires handed to them physically.

Sampling by definition means that certain population elements will be excluded from the sample and this causes a sampling error (the difference between a result based on a sample and that which would have been obtained if the entire population were studied) (Diamantopoulos and Schlegelmilch, 2006).
Sampling error is a function of sample size (as the sample size increases, a sampling error decreases) (Diamantopoulos and Schlegelmilch, 2006: 13). The sample size is explained in detail in section 5.4.3.1.

5.3.2.1 Quota sampling

Sampling was conducted within a premise of quota sampling. This method of sampling is used to improve representativeness and the logic behind it is that certain relevant characteristics describe the dimensions of the population, ensuring that the various subgroups in a population are represented on pertinent sample characteristics according to criteria set by the researcher (Blumberg, Cooper and Schindler, 2008). The sampling criteria for this study took cognisance of the fact that there are vast disparities in energy generation in the region.

Potential respondents were targeted based on the energy situation of the region. South Africa has the largest economy in the region with an installed electrical capacity and produces over 80% of the regions power supply with predominantly coal-fired generation (DBSA, 2014). Eskom, a South African power utility, generates, transmits and distributes electricity throughout South Africa and neighbouring countries which include Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia and Zimbabwe (Musango and Brent, 2011; DBSA, 2014). Sampling method selected above enabled the researcher to get a representative opinion from the selected population under study. The researcher was mindful of the weaknesses of quota sample as indicated by Blumberg, Cooper and Schindler (2008: 254) namely:

- The idea that quotas in some variables assume representativeness on others is an argument by analogy.
- It gives no assurance that the sample is representative of the variables being studied.
- Often, the data used to provide controls can also be outdated and inaccurate.
- There is also a practical limit on the number of simultaneous controls that can be applied to ensure precision.

- The selection of subjects is left to the fieldworkers to make a judgement basis: they may choose for example only friendly looking people, people who are convenient to them etc.

5.3.3 The research instrument

In order to collect data, a measuring instrument was used. The researcher has two choices according to Mouton (2004), either to develop the instrument or to use an existing instrument. Based on literature reviews about green energy access in the previous chapters, a structured questionnaire was developed to source the primary data and to test the hypothesised relationships depicted in the theoretical conceptual model. The research instrument is displayed in Annexure 1.

5.3.3.1 Questionnaire design

The questionnaire developed for the study comprised of a covering letter and an additional section giving clear instructions with regard to the completion of the questionnaire. The covering letter introduced the researcher and provided details concerning the purpose of the study. In addition, assurance of confidentiality was also provided. The covering letter also included the emblems of (NMMU) and NMMU's Business School. In an attempt to assure respondents, contact details of the researcher and the study supervisor were provided.

The questionnaire had an instruction section where it stipulated how the 7 point Likert-type interval scale were to be used and respondents were guided to indicate their extent of agreement or disagreement with regard to each statement, which range from 1 (strongly disagree) to 7 (strongly agree). The covering letter of the research instrument is also shown in Annexure 1.

The Likert scale questions were from 1–7 where 1 = strongly disagree; 2 = disagree; 3 = somewhat/slightly disagree; 4 = neither agree nor disagree (neutral); 5 = somewhat/slightly agree; 6 = agree; 7 = strongly agree.

5.3.3.1.1 Qualifying questions

This section presents qualifying questions for section A and B of the questionnaire.

5.3.3.1.1.1 Section A: Demographic information about the respondent

Section A of the questionnaire was formulated to establish the demographic details of the respondent. Although most of the respondents were to be obtained from official web site databases of institutions they are affiliated to, information about the respondent's name, contact details, number of years in the industry and the institution which the respondents work or associated with the energy sector were asked in order to determine the level of experience and the position. The energy sector that a respondent is associated with was already established from the official database.

5.3.3.1.1.2 Section B: Likert type of questions

A measurement instrument provides the basis from which the whole research rests (Leedy and Ormrod, 2005). Respondents were requested to make a choice based on specific green energy programme/projects that they have been involved or familiar with, within the last five years and were requested to indicate to what extent they agreed or disagreed with the statements by using the indicated scales and marked the appropriate box next to the number in each row. The final questionnaire consisted of 72 worded statements.

5.3.3.1.2 Operationalisation of variables

Operational definition is a definition stated in terms of specific testing or measurement criteria, the purpose is to provide a way of understanding and measuring concepts (Blumberg, Cooper and Schindler, 2008). All identified factors (variables) were operationalised to give them context to the study and to generate questions that are suitable for the study. Operational definition of variables describes the meaning of a concept through specifying the procedures or operations necessary to measure it, the operational definition aims to translate the concept into observable events specifying what the investigator must do in order to measure the concept concerned (Diamantopoulos and Schlegelmilch, 2006: 1). Operationalisation of variables is in the section that follows.

5.3.3.1.2.1 Strategic green energy planning

In this study, a strategic energy plan refers to a roadmap to achieving community energy goals in both the near and long-term (US Department of Energy, 2009; Bazilian et al., 2012). Energy planning is aimed at determining the optimal mix of energy sources to satisfy a given energy demand and in the past, energy planning was guided only by technical and economic criteria and there were no climate change considerations (Mourmouris and Potolias, 2013; Yuan, Xu, Zhang, Hu and Xu, 2014). The goals are determined by stakeholder input, so the plans are inherently local and have stakeholder buy-in, leading to a greater likelihood of success of the plan over time (US Department of Energy, 2009; Bazilian et al., 2012). A strategic energy plan can be part of a greenhouse gas emission plan, a greening plan, or a community master plan (US Department of Energy, 2009). Deichmann et al. (2011) argue that western models of universal grid expansion are unlikely to be the most cost effective approach in Africa. Currently, 16% of the SSA states have mechanical power access targets for rural population (Hailu, 2012).

Widespread access to energy can be facilitated by diffusion of environmentally sound technologies which responds positively to socio-economic, technological, political and institutional factors (Rao and Kishore, 2010). A transition from traditional to more modern forms of energy is possible in households, communities, and small industries in most developing countries (Khennas, 2012). Accelerating green energy to improve energy access must be aligned to the political system needed to support rapid and effective movement along the new paths (Lior, 2012).

Achieving sustainable growth and wider energy access require a comprehensive strategy encompassing the energy system as a whole with a logic articulation between the various components and interventions on the supply and the demand side management in both urban and rural areas (Khennas, 2012). According to Suganthi and Samuel (2012) energy demand management should help in planning for the future requirement, identifying conservation measures indicating measures to consider in order to meet energy demands, which include:

- Identification and prioritisation of energy resources, optimised energy utilisation, strategies for energy efficiency improvements.
- Framing policy decisions.
- Identification of strategies for reduced emission.

5.3.3.1.2.2 Green energy economic augmentation

Africa's long-term economic growth and competitiveness fundamentally depends on reliable access to energy services, despite reforms and other measures to scale up electricity access, SSA region in particular has not succeeded in dramatically expanding access to electricity (Onyeji, Bazilian and Nussbaumer, 2012).

Arbex and Perobelli (2010) argue that the impact of energy use on growth will depend on the structure of the economy, energy intensity and the stage of economic growth of the country concerned, moreover, when energy use and environment policies affect the rate of productivity and the economic growth of the population. Access to modern forms of energy in Africa would enable living conditions to be transformed and boost industrial, agricultural, urban and rural development triggering the establishment of many commercial enterprises (Bazilian et al., 2012; Athanas and McCormick, 2013; Sokona, Mulugetta and Gujba, 2012).

For Africa to meet its energy needs Brew-Hammond (2010) suggests that greater emphasis must be placed on productive uses of energy and energy for income generation in order to break the vicious circle of low incomes leading to poor access to modern energy services. While the developed nations of the world enjoy secure uninterrupted power supplies, with significant utilisation of renewable energy, many developing countries like SSA countries have acute power shortages related to demand, as well as underutilisation of renewable resources (Nkwetta et al., 2010).

5.3.3.1.2.3 Environmental pollution mitigation

Conventional electrical generation using fossil fuels produces large quantities of carbon, sulphur and nitrogen compounds, which have adverse environmental problems such as global warming and ozone layer depletion (Kathirvel and Porkumaran, 2011). The inaccessibility of adequate energy sources and climate change mitigation are the major challenges to the development process in many developing countries (Maslyuk and Dharmaratna, 2013).

Overall, the global average concentrations of various greenhouse gases in the atmosphere have been continuously increasing since records began and most of CO_2 emissions come from energy production, with fossil fuel combustion representing two-thirds of global CO_2 emissions (Marchal et al., 2011). Global warming is one of the most critical environmental problems threatening the existence of human kind and it has become renowned as one of the gravest environmental issues to catch the attention of the globe in recent decades (Pegels, 2010; Lau, Lee and Mohamed, 2012).

Power production in many parts of the world generates GHG leading to climate change. GHG emissions include CO_2, CH_4, nitrous oxides, sulphur, CFC gas, and other gases and upon their release, contribute to heating up the lower layers of the atmosphere leading to global warming (Karakosta et al., 2013; Porate, Thakre and Bodhe, 2013). Reducing GHG emissions to combat climate change, while producing cleaner energy to meet growing demand, especially for developing economies, is a global challenge requiring leadership, vision, and collaborative strategies including regional stakeholder engagement in planning energy efficiency and demand response measures (Oldfield, 2011).

Climate change is likely to pose severe impacts upon SSA countries. Nkwetta et al. (2010) warn that SSA countries' average temperatures and rainfall are likely to change significantly so much so that fertile soil will no longer exist, affecting crop production and leading to famine due to increased droughts and floods. The other likely impacts range from changes in water availability, extreme weather events, sea level rise and adverse health impacts to people (Pegels, 2010). High levels of poverty and lack of adequate public infrastructure will make it very difficult for SSA countries to adapt to climate change, and they may be unable to stand these impacts if nothing is done now (Nkwetta et al., 2010).

The impacts of climate change will differ in the various African regions. In Southern Africa, water supply is a particularly vulnerable area with respect to climate change, increase demand for water and deterioration of water quality (Nkwetta et al., 2010; Abanda et al., 2012). Desertification may thus be exacerbated, particularly because much of Southern Africa being arid and subject to droughts and floods, agricultural output, which needs to increase to meet the needs of a growing population, can be expected to decline unless corrective measures are taken (Pegels, 2010; Abanda et al., 2012).

5.3.3.1.2.4 Green energy governance

In this study green energy governance refers to any of the myriad processes through which a group of people set and enforce the rules needed to enable that group to achieve desired outcomes (Florini and Sovacool, 2009). Coordinated regional energy governance can ensure that players share experience between local councils who are pioneering, struggling or indifferent towards renewable energy (Smith, 2007).

Lack of regional integration affects the dissemination of renewable energy across regions due to enormous gaps in the international system's capacity to manage energy commodities, address their externalities, and ensure a successful transition over time to low-carbon sources in both developed and developing countries (Florini and Sovacool, 2009). Consideration must be given to engaging citizens far more pro-actively in negotiating sub-regional renewable energy strategies, and also deepen public consultation as a means of facilitating developments that have a higher degree of local acceptance for renewable energy projects (Upham and Shackley, 2006).

5.3.3.1.2.5 Green energy technology innovation

Bayer, Dolan and Urpelainen (2009) define renewable energy innovation, as processes by which new energy technologies are invented and technically improved for commercial use. Energy innovation functions within the sphere of an innovation system. An innovation system involves the flow of knowledge and influence, as well as market transactions, between the different actors and institutions within the innovation system's four major types of players in development, commercialisation and diffusion of renewable energy technologies (Jagoda, Lonseth, Lonseth and Jackman, 2011).

The search for innovative ways of expanding energy access in Africa has intensified in recent years and the current dependence of most African countries on fossil fuel imports is not addressing the pressing need of widespread access to modern sources of energy, providing powerful arguments in favour of sustainable energy innovations (Agbemabiese, Nkomo and Sokona, 2012). Yadoo and Cruickshank (2012) identify various ways that can be used to increase access to electricity by using renewable energy and these include:

- More renewable energy sources can be integrated into the generation mix of the national grid network and the grid can be extended to rural areas.
- Alternatively, an off-grid renewable energy resource and technology can be installed at the local level.
- The systems could either be linked to an individual household, or connected to a local distribution network.
- An off-grid power generation system that is reliant on one (or several different) renewable energy source(s) and distributes power through a local grid network is often known as a renewable energy mini-grid.

In this study green energy technology refers to technologies that considerably reduce GHG and will play a key role in sustainable green energy scenarios in future. Demand is likely to be the foremost factor that will determine the specific role of green energy technologies and the current shortfall in energy access is likely to be addressed significantly through these technologies which will be able to produce green energy from renewable energy sources such as hydraulic, solar, wind, geothermal, wave, biomass, etc. (Midilli, Dincer and Ay, 2006; Thiam, Benders and Moll, 2012). Innovation in renewable energy is now widely regarded as the key to sustaining and improving the quality of life for current and future generations (Nesta, Vona and Nicolli, 2014).

Successful diffusion of renewable energy requires consideration for many factors including social, economic, and technical ones (Aslani, Naaranoja and Wong, 2013). On establishing the future trend of individual renewable energy, the technology that would succeed in the market could be identified and thus, become a strategic target (Huh and Lee, 2014). In addition, policies and strategies suitable to the renewable energy life cycle can be designed on the basis of an accurate forecast (Huh and Lee, 2014). Shi and Lai (2013) observe that green and low carbon technology innovation cannot be isolated from the policy or regulation regime.

For many developing countries with remote rural populations, off-grid electrification solutions (powered by a low carbon energy source or diesel) represent the optimal means of extending electricity provision in terms of the required investment, efficiency and quality of service (Yadoo and Cruickshank, 2012). Sustainable energy innovations are also necessary if African countries are to successfully deploy low-carbon development strategies. Although Africa’s energy sector contributes little to global GHG emissions, there are sound empirical and theoretical arguments for pursuing a low-carbon path (Agbemabiese, Nkomo and Sokona, 2012).

Strategic deployment of low carbon energy can accelerate the installation process and continues until the cost of a new renewable technology becomes competitive with conventional complementary technology (Shum and Watanabe, 2009). Accordingly, measures to promote the deployment of renewable energy, especially in countries that have historically had little capacity, as it is the case in Africa, could contribute to both production and innovation (Bayer, Dolan and Urpelainen, 2009). Technology transfer is the key for innovation diffusion, the policy incentive, environment aids, organisation learning capability, patent protection and for effective technology adoption (Shi and Lai, 2013).

Jagoda et al. (2011: 1267) identify innovative approach to successful diffusion of green energy to include:

- Policy support players: that includes governments and international institutions that can play a major role in shaping energy.
- On the demand side: utility and consumers play a major part.

- Support infrastructure: consists of various players who provide financial, technological and market assistance in research, development, commercialisation and diffusion of renewable energy technologies.
- Citizens and interest groups: play a significant role by providing awareness of renewable energy technologies, as well as influencing the policies and procedures of other players.

5.3.3.1.2.6 Green energy policy alignment

In this study energy policy refers to the manner in which a given entity (often governmental) has decided to address issues of energy development including energy production, distribution and consumption (Campbell et al., 2011; Lehmann et al., 2012 ; Bazilian et al., 2012).

The attributes of energy policy may include legislation, international treaties, incentives to investment, and guidelines for energy conservation, taxation and other public policy techniques (Bazilian et al., 2012). Renewable energy policy frameworks seek to stimulate a sustainable energy supply and address key national goals like sustainable development, efficient technologies, energy security, local economic development, and improve the quality of the environment (Campbell et al., 2011; Lehmann et al., 2012; Bazilian et al., 2012). The policy landscape in developing countries is unclear, particularly related to access, the diversity in the policy, regulatory and energy source structure of states require a degree of sensitivity in performance evaluation (Hailu, 2012).

Policymakers must establish coherent, long-term, accessible, predictable, and transparent policies that rise above narrow interests of a country to respond to energy needs holistically (World Energy Council, 2012b). Predictable, sound and coherent policies that are oriented toward results rather than around the types of energy or technology used to achieve them can enable the world to achieve energy sustainability (World Energy Council, 2012b). Access to affordable and reliable energy services is fundamental for reducing poverty, promoting economic growth and development.

At currently expected investment rates, Birol (2012) paints a grim energy access future, where the absolute number of people without access to modern energy services is expected to decline only slightly, and in some areas even increase. In the absence of major new policies, an annual investment in energy access through 2030 the investment to energy is projected to average about US$14 billion, most of which will continue to go to grid electricity connections in urban areas (Birol, 2012).

At this level of investment, the share of population without access to modern energy services will fall, but the absolute numbers of those without access will decline only slightly, still leaving about 1 billion people without electricity in 2030 and this will predominantly be in developing countries (Sokona, Mulugetta and Gujba, 2012; Birol, 2012). A prudent response to climate change demands an ambitious mitigation policy to reduce further climate change, and timely adaptation policies to limit damage from the impacts that are already inevitable (Marchal et al., 2011). African governments need to establish appropriate legal and regulatory frameworks that support the implementation of renewable energy technologies. They can encourage the uptake of renewable energy technologies by removing taxes and duties to exempt components or such technologies that are imported and establish a specialised agency to plan and promote renewable energy technologies (Barry, Steyn and Brent, 2011).

5.3.3.1.2.7 Green energy projects financing

In this study green energy financing mechanism refers to incentive schemes that are adopted by a country to stimulate investment to finance green energy projects. The unavailability of domestic finance is often a key barrier to rolling out renewable energy in developing countries. There have been several attempts to introduce an international support scheme (Sanoh et al., 2014). There is also a perception that, in spite of the flexibility of the investment, most likely, the costs of a renewable energy project cannot be recovered once the project is carried out (Boomsma, Meade and Fleten, 2012). Khennas (2012) indicates that the centralised renewable energy bears high upfront costs although running costs are very low. Renewable energy projects developers in developing countries often struggle to access the large quantities of financing they need (UNDP, 2013). Investments in renewable energy is most extensively employed through support schemes, namely, feed-in tariffs and renewable energy certificate trading (Boomsma, Meade and Fleten, 2012; Pegels, 2010).

These two regimes may differ in terms of the level of subsidy payments but also in the degree of risk exposure to an investor (Boomsma, Meade and Fleten, 2012). The profitability of most renewable electricity investments strongly depends on public incentives, the value of a renewable energy project further depends on the flexibility of the investment (Boomsma, Meade and Fleten, 2012; Pegels, 2010). With costs that cannot be recovered once the project is carried out and high uncertainty about its future profits, there can be a significant value to postponing the investment, also referred to as a value of waiting (Boomsma, Meade and Fleten, 2012). This can be implemented as a fixed tariff for electricity or as an electricity price premium.

Under a fixed feed-in tariff, the renewable producer power producer receives a fixed payment that is independent of the electricity spot price, whereas under a price premium, he/she receives a payment on top of this price (Boomsma, Meade and Fleten, 2012). Renewable energy certificates are issued to the renewable power producer in proportion to the volume generated and traded when portfolio standards or quotas obligate suppliers or consumers to produce or use a certain share from renewable energy sources and demonstrate compliance with a required number of certificates (Boomsma, Meade and Fleten, 2012).

African governments rely upon aid, but this is likely to become more limited due to the chronic fiscal problems, their access to international private finance is expensive, and limited following the region's recent history of default and debt forgiveness (Collier and Venables, 2012). Despite its enormous potential, financing for renewable energy in developing countries has been limited. Much of the early financing for renewable energy projects was in the form of development assistance focused on providing technology in demonstration projects (Nkwetta et al., 2010).

Companies have to decide whether an investment will generate sufficient cash flows in the future, for which they need to assess both the expected market development and the investment strategies of their competitors (Fagiani, Barquı´n and Hakvoort, 2013). Investments in low carbon energy initiatives in Africa in particular have been far below the needs due to lack of enabling policies that foster trade and investment, low levels of in-country technical skills, etc. (Nkwetta et al., 2010). These barriers have left a large financing gap for low carbon energy initiatives and enterprise development on the continent (Kammen and Kirubi, 2008).

5.3.3.1.2.8 Green energy human capacity development

Shortage or lack of skilled staff is an obstacle to the augmentation of renewable energy in the developing countries (Negro, Alkemade and Hekkert, 2013). A key difficulty in ensuring an adequate supply of skills for renewable energy is that the sector requires substantial numbers of engineers and technicians, shortages in these occupations are common in developed countries, and can easily occur in developing countries when there is a sudden increase in demand (International Labour Office, 2011). Training and skills development of communities will alleviate the lack of user acceptance and also ensure that the skills base of the community can be improved to help maintain the technology (Barry, Steyn and Brent, 2011).

It is important that governments create consumer awareness through information programmes to educate the potential users on the advantages of renewable energy technologies. Collier and Venables (2012) strongly argue that the energy sector is intensive and requires highly-skilled labour and Africa is the most skill-scarce region and this can be attributed to:

- The continuing shortage of power generation implies that there has been little on-the-job training.

- The region's tertiary education sector is tiny and of low-quality.

- The region outflows its limited skilled workforce to other regions which, due to higher private incomes and more abundant public goods, offer skilled immigrants a far higher quality of life.

Lack of capacity and political economy difficulties faced by African governments have made decentralising green energy dysfunctional resulting in under-investment, lack of maintenance, and severe and persistent power shortages (Collier and Venables, 2012). Training of personnel and setting of technical standards also help overcome the difficulties of the general lack of skills in Africa (Barry, Steyn and Brent, 2011).

5.3.3.1.2.9 Green energy infrastructure development

In this study green energy infrastructure refers to the facilities for green energy production such as plants, structures, solar panels, wind turbines, biomass plants etc, however as energy is grid dependent, the facilities for distributing and handling energy have to be considered as part of the infrastructure for renewable energy as well. A lack of network capacity can become a barrier to new projects. Furthermore, even if capacity is available, significant cost of network connection, for example: offshore wind, can be a significant barrier to renewable energy (Lehmann et al., 2012).

Lack of access to modern forms of energy as a result of the poor infrastructure explains to a large extent the under-development of rural area economies and the rural poverty (Khennas, 2012). Policy can have a huge impact on the timing and path taken, developing countries in SSA, South East Asia, and Latin America need to build out their energy infrastructure to increase access to electricity and ensure reliable energy supply to support economic growth (World Energy Council, 2012b).

Government has an unavoidable role in the generation of power, and in Africa this role is wider than in most other regions, this involvement stems from scale economies in generation and the need for a grid (Collier and Venables, 2012). Under these conditions private provision tends rapidly to monopoly unless regulated. Historically, the most common solution to this problem has been to place power generation in the public sector, and this was the system inherited in Africa from colonial times. The severe capacity and political economy difficulties faced by African governments have made this approach dysfunctional resulting in under-investment, lack of maintenance, and severe and persistent power shortages (Collier and Venables, 2012).

5.3.3.1.2.10 Green energy local market development

SACREEE (2013:17) states that there is limited capacity and awareness by local manufacturers, construction companies, consultants, finance institutions, of the technical and economic possibilities of renewable energy technologies and their applications in SADC region. Access to modern energy services can be facilitated by the establishment of partnerships between the public and private sector to facilitate the technology transfer process of bringing renewable energy projects to a market (Apergis and Payne, 2010). Ping and Spigarelli (2015) infer that to some extent the investment pairs in renewable energy sectors reflect duality, which means that renewable energy firms tend to seek countries that have similar environment compared with their origin regions when investing abroad.

Countries with weak and immature institutional environment are attractive for immature and inexperienced (Ping and Spigarelli, 2015). For much of the last 200 years, the steady growth in modern energy consumption has been closely linked to rising levels of prosperity and economic opportunities across the globe and low modern energy consumption characterises most of developing countries (Sokona, Mulugetta and Gujba, 2012).

Increased access to modern energy services in the future will be driven largely by rapid economic growth in several developing countries, accompanied by rapid urbanisation in some cases (Birol, 2012). Population situated in remote areas, with low consumption potential is deprived of electrical power because of high transmission costs and low revenue and small generating plants can provide sufficient electrical power to them at low cost (Katre and Patil, 2013). Costs of hydro power for example can remain low and quite competitive compared with the much more polluting coal-fired stations (Vermeer, 2011). Small hydro electric power plants are used for lighting and low voltage applications (like communication systems, small manual tools, etc.) and also for generation of electromotive force for small industries (with electric motors) (Sartipipour, 2011).

In order to generate sustainable welfare benefits and contribute to the human and economic development of the rural poor, all dimensions of sustainability (technical, economic, social, environmental and institutional) must be considered in the project planning and implementation stages of green energy projects (Yadoo and Cruickshank, 2012). The establishment of an efficient energy market requires the harmonised collaboration of the stakeholders in both urban and rural community (Thiengkamol, 2011). There are public reservations about landscape change caused by renewable energy projects and the consequent disruption such change produces to established ways of life for those who are nearby (Pasqualetti, 2011).

5.3.3.1.3 Operationalisation of the dependent variable

Increasing energy access through low-carbon technologies in both industrialised and developing countries is a critical part of the global greenhouse gas mitigation and improved widespread energy access in developing countries (Onyeji, Bazilian and Nussbaumer, 2012; Khennas, 2012). The section that follows operationalises the dependent variable.

5.3.3.1.3.1 Perceived access success to green energy

In this study perceived widespread access success to green energy refers to access to reliable, affordable, economically viable, socially and environmentally acceptable energy (Oldfield, 2011; United Nations, 2012; EIA, 2013). The United Nations has called upon world leaders to adopt universal access to modern energy services by 2030 as a critical long-term priority and a catalyst that can be attained by investing in renewables particularly in developing counties (United Nations, 2012). Even though its energy consumption in general and electricity consumption in particular remains low (approximately 8% of global electricity consumption), Africa possesses immense energy potential in the form of renewable energy sources (Sanoh et al., 2014). Tapping into renewable energy production can significantly increase the available capacity, and increase the electrification rate to above 50%. Currently only Mauritius and South Africa have an electrification rate of 100% and 85% repetitively (Musango and Brent, 2011; Hailu, 2012).

Improved access to energy for poorer and marginalised communities would make a significant difference in the fight against poverty and would enable living conditions to be transformed and boost industrial, agricultural, urban and rural development (Sokona, Mulugetta and Gujba, 2012). The political economy of African energy policies can be conceptualised as two games, according to Collier and Venables (2012), one played between the government and citizens, and the other between government and investors. The game between government and citizens concerns the pricing of energy. African governments are distinctive in that urban electorates hold them responsible for this price. The origins of this exaggerated responsibility stem from public ownership of energy generation and distribution, compounded by policies of generalised price controls which lingered in Africa long after they had been abandoned elsewhere.

Africa's recent wave of democratisation has compounded this problem, making governments wary of price decontrol (Collier and Venables, 2012). African governments lack the resources to finance major energy investments. Not only is the underlying household sector poor, but governments have not built effective tax systems and so their revenue base is inadequate for capital investment internationally (Collier and Venables, 2012). Despite rapid rural urban migration and the growth in urban population, the absolute number of rural people is also likely to continue to grow.

Household energy consumption in rural areas is characterised by a very high consumption of traditional biomass, poor infrastructure and low GDP per capita (Khennas, 2012). Policy work should focus on raising awareness about renewable energy mini-grids, improving institutional, technical and regulatory frameworks and developing innovative financing mechanisms to encourage private sector investments (Yadoo and Cruickshank, 2012).

5.3.3.1.3.2 Viability of various green energy sources in the SADC region

Insufficient mapping of renewable energy resources is a challenge that must be addressed urgently; there is still need for regional resource maps that could be useful in assessing potential for regional projects (SACREEE, 2013: 17). Large scale hydro is the most inexpensive, efficient and affordable form of renewable energy, with a large potential yet to develop in Africa (only 7% potential developed the lowest rate of the world’s regions) (World Energy Council, 2013b). Africa has a major natural advantage in hydro power because it has immense high-altitude areas onto which the water vapour gathered over the Atlantic falls.

The run-off from this rainfall through the Congo, Niger and Zambezi rivers could support several mega-dams, significant projects in the upper Nile (Ethiopia and Uganda), and numerous smaller schemes (Collier and Venables, 2012). Superficially, the most promising new green energy technology for Africa is solar power. It fits Africa's natural endowment of strong sunlight distributed evenly throughout the year. Collier and Venables (2012) and Shukla, Dhar and Fujino (2010) observe that solar energy sources have the potential to improve access to modern energy, though photovoltaic (PV) or CSP.

Wind is an attractive option for countries with abundance of wind particularly the coastal areas in the SADC region, as it can be installed quickly in areas where electricity is urgently needed, in many instances it may be a cost effective solution if fossil fuel sources are not readily available, or are expensive (Milborrow, 2011; Sartipipour, 2011). In addition there are many applications for wind energy in remote regions; it can transform energy access for supplying farms, homes, and other installations on an individual basis (Milborrow, 2011).

Wind turbines in rural areas can be used for pumping drinking water needed for livestock and poultry, farm irrigation, and for supplying the required domestic water. Moreover, wind turbines can be used to generate electricity in areas far from urban electricity grid as well as far flung villages (Sartipipour, 2011). Wind electrical generation is hindered by lack of skills and spare parts manufacturing industries in developing countries, which must be addressed proactively (IEA, 2012a). Renewable sources are expected to increase in future as the SADC region intends to increase the share of renewable energy in the grid to 21% by 2017, 33% by 2022 and 37% by 2027 (Baleni, 2014; DBSA, 2014).

The disparities in energy resources and consumption were identified as a strong rationale for the integration of the sector and for the promotion of regional energy trade (Musango and Brent, 2011). Commercial forms of energy producing electricity are considered to be the most critical to the realisation of major economic development even though the projects are large, capital-intensive and with long lead times (DBSA, 2014).

5.4 ADMINISTRATION OF THE QUESTIONNAIRE

5.4.1 Pilot study

It is essential that a questionnaire is piloted before it is distributed widely to a larger population of respondents to eliminate concealed errors and ambiguities of questions. Blumberg, Cooper and Schindler (2008) caution that piloting questionnaires has saved countless survey studies from disaster by using the suggestions of the respondents to identify and change confusing, awkward and offensive questions and techniques that were adopted by researchers. For this research, a pilot survey was conducted to test the questionnaire amongst a sample of conveniently obtained respondents associated with renewable and fossil-fuel energy sectors.

Forty questionnaires were distributed and 31 respondents participated in the pilot study. The responses were then reviewed and statistically analysed to test for ambiguously worded questions. Minor changes were made to the final questionnaire and the final questionnaire items were coded. Table 5.3 illustrates the pilot study's number of respondents from various energy organisations.

Table 5.3: Number respondents of the pilot study

No	Regional energy bodies	Number of respondents
1	SAPP	2
2	SAAEA	0
3	SESSA	11
4	Energy researchers and practitioners in the region	18
TOTAL		**31**

5.4.2 Validity and reliability of the data

The validity and reliability of measurement instruments influence the extent to which a researcher can learn something about the phenomenon under investigation, the probability that the researcher will obtain statistical significance in any data analysis, and the extent to which the researcher can draw meaningful conclusions from the data (Leedy and Ormrod, 2005).

5.4.2.1 Validity of the research instrument

The validity of the research instrument is the extent to which the instrument measures what it is supposed to measure (Leedy and Ormrod, 2005; Blumberg, Cooper and Schindler, 2008). According to Diamantopoulos and Schlegelmilch (2006: 33), the extent to which a particular measure is free from both systematic and random error indicates the validity of the measure. According to Leedy and Ormrod (2005) the research approach selected must be validated for the accuracy, meaningfulness and credibility of the research approach and this can be addressed through internal and external validity. Elements of research questionnaire validity are: face validity, content validity, criterion validity, and construct validity (Blumberg, Cooper and Schindler, 2008; Leedy and Ormrod, 2005). Face validity is the extent to which, on the surface, an instrument looks like it is measuring a particular characteristic and because it relies on subjective judgement it does not provide evidence to confirm that the instrument is measuring what it is supposed to measure (Leedy and Ormrod, 2005). Content validity of the research instrument is the extent to which it provides adequate coverage of the investigative questions guiding the study (Blumberg, Cooper and Schindler, 2008).

Criterion validity is the extent to which the results of an assessment instrument correlate with another, presumably related measure and it also reflects the success of measure used for prediction or estimation (Blumberg, Cooper and Schindler, 2008; Leedy and Ormrod, 2005). Construct validity is the extent to which the instrument measures a characteristic that cannot be directly observed but must instead be inferred from patterns in people's behaviour (Leedy and Ormrod, 2005: 92). This empirical study validated the content, criterion and construct validity, it is explained in detail in Chapter 6.

5.4.2.2 Reliability of the research instrument

Hair, Black, Babin, Anderson and Tatham (2006) indicate that the reliability of a research instrument is the assessment of the extent to which all the items in a test, measure the same concept or construct in order to determine the degree to which the test scores are accurate and consistent. All formulated questions are based on the literature review reported in the previous chapters, which were relevant in formulating the theoretical model of the perceived widespread access success to green energy for the SADC region.

Cronbach alpha coefficients were calculated to assess the degree of reliability of the variables proposed in the theoretical conceptual model. The reliability of the measuring instrument was tested for internal consistency for survey constructs using Cronbach's alpha coefficients for the factors. According to Christmann and Van Aelst (2006: 1660) Cronbach’s alpha is a popular method to measure reliability, e.g. in quantifying the reliability of a score to summarise the information of several items in questionnaires.

5.4.3 Main study

After satisfactory results were obtained from a pilot study, the main study was conducted within the context of quantitative approach, and this involved distributing questionnaires to targeted respondents in the SADC region. The researcher who conducts a descriptive study wants to determine the nature of how things are and describe data and characteristics about the population or phenomenon being studied (Leedy and Ormrod, 2005). According to Blumberg, Cooper and Schindler (2008) contrary to exploratory approach, descriptive studies are typically structured with clearly stated hypothesis or investigative questions. Blumberg, Cooper and Schindler (2008) observe that quantitative research answers the questions who, what, where, when and how and the main advantage of this research approach is that data description is factual, accurate and systematic. The response rate, sample size and method of data analysis are explained in the sections that follow.

5.4.3.1 Sample size

Sample size usually has a direct impact on the findings of the study, a sample size that is too small, can substantially reduce the likelihood of finding important differences (Nisen and Schwertman, 2008: 4903).

Sampling size determination according to Diamantopoulos and Schlegelmilch (2006: 17) is a complex issue involving both statistical and practical considerations, which include:

- Degree of variability in the population: The more heterogeneous the population the larger the sample size needed to capture the diversity in the population
- The degree of precision associated with population estimates based on a sample: The greater the precision required the greater the sample size needed
- The desired degree of confidence associated with any estimates made: A larger sample size will be required to obtain a higher precision by obtaining a higher value of representation in a population leading to a higher confidence
- The extent to which the intended analysis will improve the use of sub-samples for cross-classification purposes of the use of statistical techniques which assume a minimum sample size to produce meaningful results: If a researcher is interested in an overall picture, a small size of a sample will be required unless the researcher wants to cross tabulate other characteristics in the sample

The SADC region is vast and given a large geographic scope of the region, a minimum of 250 respondents were targeted and a total of 301 responses were received by the closing date. Nisen and Schwertman (2008: 4903) indicate that the appropriate sample size is a function of the variability, desired significance level and the power of the test to detect a meaningful difference as well as the test statistic that is used. It was not possible to determine the actual response rate due to the sampling methodology adopted.

5.4.4 Method of data analysis

Existing data analysis includes secondary data analysis, modelling and simulation studies, historical studies, content analysis and textual studies (Mouton, 2004). Data for this research was analysed quantitatively. According to Leedy and Ormrod (2005) in the analysis of quantitative research data characteristics are reduced to variables which are analysed using statistical univariate and multivariate data analysis techniques. STATISTICA (data analysis software system), version 12 (www.statsoft.com) and the VBA application developed on an Excel platform by a statistician at NMMU university (Dr Danie Venter) were used for the analysis. Statistical analysis incorporated tests employed to test for internal consistency and reliability of the measuring instrument and to analyse the empirical data collected. Statistica 12 provided descriptive statistics for the whole group, giving an overall statistical profile of respondents. The analyses conducted are detailed in the sections that follow.

5.4.4.1 Pearson Product Moment Correlation coefficient

Correlation analysis according to Leedy and Ormrod (2005) involves an investigation of the relationship between two or more variables; it focuses at the surface relationships but does not necessarily prove causal reasons underlying them. Diamantopoulos and Schlegelmich (2006: 206) caution that interpreting correlational results as causal relationships can be erroneous and misleading; any notion of causality must come from practical knowledge or theoretical insights into the subject area. Pearson Product Moment Correlation (Pearson r) was employed to determine correlations between variables and to test whether sufficient evidence existed to make conclusions about hypotheses 6 to 15, relating to significant relationships between selected independent variables and a dependent variable for the study.

5.4.4.2 T-tests

According to Ettarh (2004: 300), the mean value for any set of data represents a way of describing that set of data as a single value. It is a descriptive measure and being able to obtain a mean value is useful because in addition to other uses, it at least allows a simple comparison between groups of data. The standard deviation indicates the extent of variability within the group of data associated with its mean value and using the standard deviation.

It is possible therefore to have 2 different groups of data with identical mean values but which have differing variability's when the actual data are considered (Ettarh, 2004: 300). One-sample T-tests and T-tests to make inferences about the views of categories of respondents with regard to the 12 identified variables were conducted for variables A to L to determine the population mean values. This served to determine whether the difference between the hypothesised population parameter and sample result was significant and not as a result of chance. Cohen's d statistics, a standardised mean difference, were also calculated to determine the practical significance of T-test results.

5.4.4.3 Multivariate analysis of variance (MANOVA) and univariate analysis of variance (ANOVA)

Leedy and Ormrod (2005) observe that in the analysis of quantitative research, data characteristics are reduced to variables which are analysed using statistical univariate and multivariate data analysis techniques. MANOVA and ANOVA were employed to determine whether sufficient evidence existed to make conclusions about hypotheses 1 to 5 and 16 of the study. These hypotheses relate to the differences in opinions between categories of respondents.

Categories of respondents tested are: respondents with less work experience (1-6 years) and more experienced respondents (> 6 years); junior management/middle management and senior management; fossil fuel sector/renewables sector; energy researchers and scholars/energy industry; South Africa based and other SADC countries based. Multivariate normal distribution is central to multivariate analysis; commonly used assessments of multivariate normality or non-normality of a random vector include a variety of approaches based on linear combinations of variates (Shao and Zhou, 2010: 2637). In particular, many types of univariate-based plots are both easy to make and simple to use for detecting skewness, outliers, and other departures from multivariate normality (Shao and Zhou, 2010: 2637).

ANOVA tests are used to compare 3 or more unmatched groups of data; the data should have been taken from a population which is assumed to be normally distributed (the Gaussian distribution) (Ettarh, 2004: 301). Obtaining single numerical descriptions about groups of data is useful if the aim is to understand the data and the information it contains (Ettarh, 2004: 301). The MANOVA tested differences between factor profiles, i.e. all 12 factors, while the univariate ANOVAs test for differences for each factor individually.

5.5 CHAPTER SUMMARY

This chapter described in detail the research design and methodology followed to address the primary research objective and to test the proposed theoretical conceptual model. The population studied was also described, as well as the sampling technique adopted. Independent and dependent variables were operationalised with clear and concise definitions applicable to this study. Detailed explanation was provided on how the measuring instrument was developed and administered.

The research design and methodology adopted was found to be suitable for the study. The empirical results for the study are reported in Chapter 6.

6 CHAPTER 6: EMPIRICAL RESULTS

6.1 INTRODUCTION

Literature reviews in the previous chapters have revealed factors that have an influence on the dependent variable (perceived widespread access success to green energy). In Chapter 4 a theoretical model of green energy access for the SADC region was proposed. The hypothesised relationship was illustrated, followed by the discussion of the research design and methodology in Chapter 5. This quantitative study was conducted through a survey questionnaire that involved acquiring information from respondents. The composition of the targeted population included a sample of energy practitioners that were made up of African and regional energy bodies, regional energy ministries and industry's practitioners and energy researchers.

This chapter presents empirical results of the study, with a focus on the primary research question supported by secondary questions. The primary objective of this research is to debunk how widespread access to green energy can be increased by investing into the green energy sector in the SADC region. It is supported by sub-objectives and secondary objectives. Reliability and validity of the research instrument is also presented, STATISTICA (data analysis software system, version 12. www.statsoft.com) was employed to analyse the relationship between variables and responses between identified groups and finally conclusions are made about the stated hypotheses.

6.2 RELIABILITY OF THE MEASURING INSTRUMENT

According to Hair et al. (2006) the purpose of a research instrument reliability assessment is to ensure that responses have internal consistency and are not too varied at different points in time. STATISTICA 12 was used to test for internal reliability of the measuring instrument in order to determine the degree to which the test scores were accurate and consistent. Perceptions about green energy economic augmentation and environmental pollution mitigation were not tested for internal consistency because there were no enough items included in the survey instrument to measure them. Cronbach alphas for these variables are indicated as: not applicable (n.a).

Christmann and Van Aelst (2006: 1661), caution that Cronbach's alpha can be completely misleading as soon as some mistaken observations are present and to avoid this problem they propose a robust Cronbach's alpha estimate that is able to resist outliers and thus measures the internal consistency of the most central part of the observations. Cronbach alpha values with 0.7 and above are considered as highly reliable (Hair et al., 2006).

Three variables showed moderate reliability with Cronbach's alpha values greater than 0.5, a similar number of variables had Cronbach alpha values greater than 0.6 with 4 variables showing Cronbach alpha of 0.7 and greater. A Cronbach's alpha value 0.46 was noted for one variable (strategic green energy planning) which indicates a non-significant correlation. In general, there is an acceptable internal consistency among the variables. Table 6.1 illustrates Cronbach's alpha assessments for the study.

Table 6.1: Internal consistency of survey constructs using Cronbach's alpha coefficients

Factors	**Cronbach's alpha** ($\propto$) **coefficients**
A. Strategic green energy planning	0.46
B. Green energy economic augmentation	0.70
C. Environmental pollution mitigation	na
D. Green energy governance	0.74
E. Green energy technology innovation	na
F. Green energy policy alignment	0.65
G. Green energy projects financing	0.53
H. Green energy human capacity development	0.71
I. Green energy infrastructure development	0.66
J. Green energy local market development	0.53
K. Perceived widespread access success to green energy	0.70
L. Viability of various green energy sources	0.66

6.3 VALIDITY OF THE RESEARCH INSTRUMENT

The content validity was enhanced by conducting extensive literature reviews and a questionnaire gathered relevant information. Questions in the questionnaires were probing in nature; similar questions were rephrased and presented in different ways in order to detect whether respondents were showing a consistent pattern of responses.

SADC region's energy publications were also perused to identify barriers to energy access in the region. Questions in the research instrument were investigative in nature in order to elicit views of respondents about the specific energy access challenges faced by the region. During the pilot study respondents were asked to comment about the questions in the questionnaire and valuable inputs were included in the questionnaire. The instrument had a total of 72 questions. The instrument is found to have a high content validity based on the 301 respondents who attempted to give feedback on all questions. Blumberg, Cooper and Schindler (2008) argue that construct validity measure and infer the presence of abstract characteristics for which no empirical validation seems possible.

In order to enhance the criterion validity, probing questions about both fossil fuels and renewable energy sources preference were posed in the research instrument. Previous research work that focused on other aspects of energy in the SADC region was perused in order to guide the construction of the research instrument. Suggested energy access solutions in literature were also probed in the research instrument. The Pearson Product Moment Correlation (Pearson r) was employed to determine correlation amongst individual variables. Variables were found to have significant correlations between them. The instrument was also found to be relevant and reliable without bias.

The study is applicable across different categories of respondents in the energy sector hence the study is found to have a high criterion validity. The construct validity was enhanced by identifying independent and dependent variables selected from literature and by operationalising them to define their specific meaning in the context of the study. The research instrument inclusion of Likert scale questions, demographic questions and having different questions which measure different dimensions of green energy, enhanced the construct validity. The study has high construct validity, given the high responses that were received.

6.4 STATISTICAL OVERVIEW OF THE WHOLE GROUP

A total of 301 energy practitioners with various roles in the energy sector levels participated in the survey. In order to obtain the demographic profile of the respondents, descriptive statistics were employed. Descriptive studies is also known as statistical research, this approach describes the data and characteristics about the population or phenomenon being studied (Mouton, 2004; Leedy and Ormrod, 2005; Blumberg, Cooper and Schindler, 2008). Questionnaires where in respondents did not indicate their biographical information were not included in the applicable analysis particularly instances where biographical information of a respondent could not be ascertained or verified. In Section 6.4.1 the demographic profile of respondents is discussed and descriptive statistics analysis is presented in figures and tables for the whole sample followed by sections that present a summary of statistics analysing the relationship between variables and hypotheses testing.

6.4.1 Demographic profile of respondents

A Population of respondents was made up of regional energy industry authorities in the region, governmental and non-governmental institutions, private companies and energy researchers. Given the large geographic scope of the SADC region, a minimum of 250 respondents were targeted. A total of 301 responses were received. A total of 114 respondents responded electronically through emails and 187 respondents completed the questionnaires physically after they were hand delivered to them. The composition of respondents who responded electronically to the questionnaires include: SAPP member countries' respondents, respondent's contact details were obtained from SAPP database.

Other respondents' contact information were obtained through the official websites of SAAEA; SESSA and AFSEA and energy enterprises which include energy enterprises (contractors, consultants and suppliers) that operates within the SADC region's energy sector. Table 6.2 illustrates questionnaires that were distributed and received electronically.

Table 6.2: Electronically distributed questionnaires

No.	Name of organisations/ participants	Electronic respondents received	%
1	SAPP	8	7
2	AFSEA	4	9.7
3	SAAEA	8	7
4	SESSA	11	3.5
5	Research and Academic Institutions	47	41.2
6	Energy enterprises	36	31.6
Total		**114**	**100%**

A total of eight responses were received from SAPP; eight responses from SAAEA; eleven responses from SESSA; four responses from AFSEA. From the total of 114 electronic respondents, about 47 responses are from energy practitioners who are based in academic institutions (universities) and energy research institutes whose activities are within the SADC region. A total of 16 respondents were identified to be at a level of universities' doctors/professors from the 47 respondents. They constitute the highest percentage, (41.2%); followed by energy enterprises 31.6%; SESSA 3.5%; SAPP and SAAEA 7% and AFSEA 9.7%. The 187 questionnaires were physically completed. They included respondents from different countries in the region who were met in renewable energy conferences and forums that the researcher attended and participated in. The researcher participated in the Clean Energy Week-Conference 23rd September–27th September 2014 held in Zimbabwe; this conference had delegates from the SADC region's countries and other countries around the world.

The researcher also attended the Southern Africa Solar Thermal and Electricity Association conferences held in South Africa. Employees and independent companies providing services at the South African electricity parastatal (Eskom) were visited and handed questionnaires. About 13 questionnaires were completed physically at the Clean Energy Conference in Zimbabwe, 144 were completed by respondents associated with Eskom Power utility and 30 were completed by energy enterprises that were visited by the researcher. Table 6.3 illustrates responses from questionnaires that were physically completed.

Table 6.3: Physically completed questionnaires

NO.	Name of organisations/ participants	Hand received responses	%
1	Clean Energy Conference (Zimbabwe)	13	7
2	Respondents associated with Eskom (employees and service providers)	144	77
3	Energy enterprises (independent constructors, consultants and suppliers)	30	16
Total		**187**	**100%**

About 7% were completed at the Clean Energy Conference in Zimbabwe, 77% of questionnaires were completed by respondents associated with Eskom power utility, and 16% were completed by respondents who are associated with other energy enterprises. In terms of work experience, a total of 279 respondents out of a total of 301 indicated their years of work experience in the energy sector, 13% of respondents have between 1-2 years of experience; 22% have 3-4 years of experience; 30% of respondents have between 5-9 years of experience.

About 18% have 10-19 years of experience and about 18% have 20-60 years of experience. Table 6.4 illustrates frequency distribution in years.

Table 6.4: Frequency distribution: Years

			Cumulative	
1 to 2	36	13%	36	13%
3 to 4	60	22%	96	34%
5 to 9	84	30%	180	65%
10 to 19	50	18%	230	82%
20 to 60	49	18%	279	100%

A total of 259 respondents indicated their positions. 10% of the respondents are at a junior level position, 41% are at a middle management positions and 49% are at senior management level. Table 6.5 illustrates the frequency distribution per position.

Table 6.5: Frequency distribution: Position

Junior Management	26	10%
Middle Management	106	41%
Senior Management	127	49%
Total	259	100%

A total of 279 respondents indicated their years of experience. About 141 respondents (51%) have 6 years and below years of experience, and 138 (49%) have above 6 years' experience. Table 6.6 illustrates the frequency distribution: per years of experience.

Table 6.6: Frequency distribution: Years of experience

<= Median 6	141	51%
> Median 6	138	49%
Total	279	100%

A total of 301 energy respondents' energy sector association was ascertained. About 167 respondents (55%) are associated with fossil fuel energy generating activities, and 134 (45%) are associated with renewable energy activities. Table 6.7 illustrates the frequency distribution: per energy sector.

Table 6.7: Frequency distribution: Energy sector

Fossil Fuel	167	55%
Renewables	134	45%
Total	301	100%

A total of 301 respondents' role in the energy sector was ascertained. About 38 respondents (13%) are associated with research activities, and 263 (87%) are associated with conducting their activities in the energy industry. Table 6.8 illustrates the frequency distribution: role in the energy sector.

Table 6.8: Frequency distribution: Role in the energy sector

Researchers	38	13%
Industry	263	87%
Total	301	100%

A total of 301 respondents' base country was ascertained. About 245 respondents (81%) are based in South Africa, and 56 (19%) are in other countries in the SADC region. Table 6.9 illustrates the frequency distribution: base country.

Table 6.9: Frequency distribution: Region

South Africa	245	81%
Other SADC	56	19%
Total	301	100%

A total of 278 respondents indicated their gender in the demographic section of the questionnaire. About 193 respondents are male respondents and they constitute 69% and female respondents are 31%. Table 6.10 illustrates the frequency distribution by gender.

Table 6.10: Frequency distribution: Gender

Male	193	69%
Female	85	31%
Total	278	100%

6.4.2 Profile of responses per variable for the whole sample

This section profiles responses per variable for the whole sample. The questionnaire as discussed in the questionnaire design Section 5.3.3, had 7 point Likert-type interval scale used and respondents were guided to indicate their extent of agreement or disagreement with regard to each statement, which range from 1 (strongly disagree) to 7 (strongly agree).

The Likert scale questions were from 1–7 where 1 = strongly disagree; 2 = disagree; 3 = somewhat/slightly disagree; 4 = neither agree nor disagree (neutral); 5 = somewhat/slightly agree; 6 = agree; 7 = strongly agree. A detailed frequency distribution of responses per factor is illustrated in Annexure 3. Table 6.11 illustrates the profile of responses per variable.

Table 6.11: Profile of responses per variable

VARIABLES	Very Negative & Negative [1.00 to 3.57]		Neutral [3.57 to 4.43]		Very Positive & Positive [4.43 to 7.00]	
A	52	17%	95	32%	154	51%
B	21	7%	54	18%	226	75%
C	18	6%	41	14%	242	80%
D	168	56%	92	31%	41	14%
E	213	71%	34	11%	54	18%
F	127	42%	103	34%	71	24%
G	257	85%	34	11%	10	3%
H	235	78%	41	14%	25	8%
I	248	82%	45	15%	8	3%
J	176	58%	96	32%	29	10%
K	40	13%	32	11%	229	76%
L	88	29%	133	44%	80	27%

A. Strategic green energy planning

The importance of strategic energy planning is a catalyst to green energy access. Total number of 154 (51%) of respondents agree, 95 (32%) were neutral and 52 (17%) disagree with the statement.

B. Green energy economic augmentation

The influence green energy to economic augmentation was confirmed by respondents, 226 (75%) agree, 54 (18%) were neutral and 21 (7%) disagreed.

C. Environmental pollution mitigation

A total of number of 242 (80%) agreed that a successful greed energy access will be characterised by alleviation of pollution, 41(14%) were neutral and 18 (6%) disagreeing.

D. Green energy governance

Generally only 41 (14%) agree that the current structures governing energy cannot successfully augment green energy exploitation, 92 (31%) are neutral and 168 (56%) are negative; they are agreeing that governance structures are adequate.

E. Green energy technology innovation

About 213 (71%) disagree that current green energy technology innovation can successfully augment green energy exploitation, 34 (11%) are neutral and 54 (18%) are in agreement.

F. Green energy policy alignment

Only 71 (24%) agree that the region's policy alignment currently can enhance widespread access to green energy, 103 (34%) are neutral and 127 (42%) are negative.

G. Green energy projects financing

About 257 (85%) respondents are not in agreement that there is adequate funding earmarked for green energy projects financing, 34 (11%) had a neutral view with 10 (3%) in agreement with the statement.

H. Green energy human capacity development

Skills to drive the green energy sector are inadequate in the region, 235 (78%) of respondents agreed with the statement, 41(14%) had a neutral view with 25 (8%) agreeing with the statement.

I. Green energy infrastructure development

Existing energy infrastructure supports the diffusion of green energy in the region. Only 8 (3%) of respondents agreed with the statement, 45 (15%) had a neutral view and 248 (82%) did not agree with the statement.

J. Green energy local market development

About 176 (58%) of respondents do not agree that currently green energy market development can facilitate access to green energy in the region, 96 (32%) had a neutral view with 29 (10%) are in agreement with the statement.

K. Perceived widespread access success to green energy

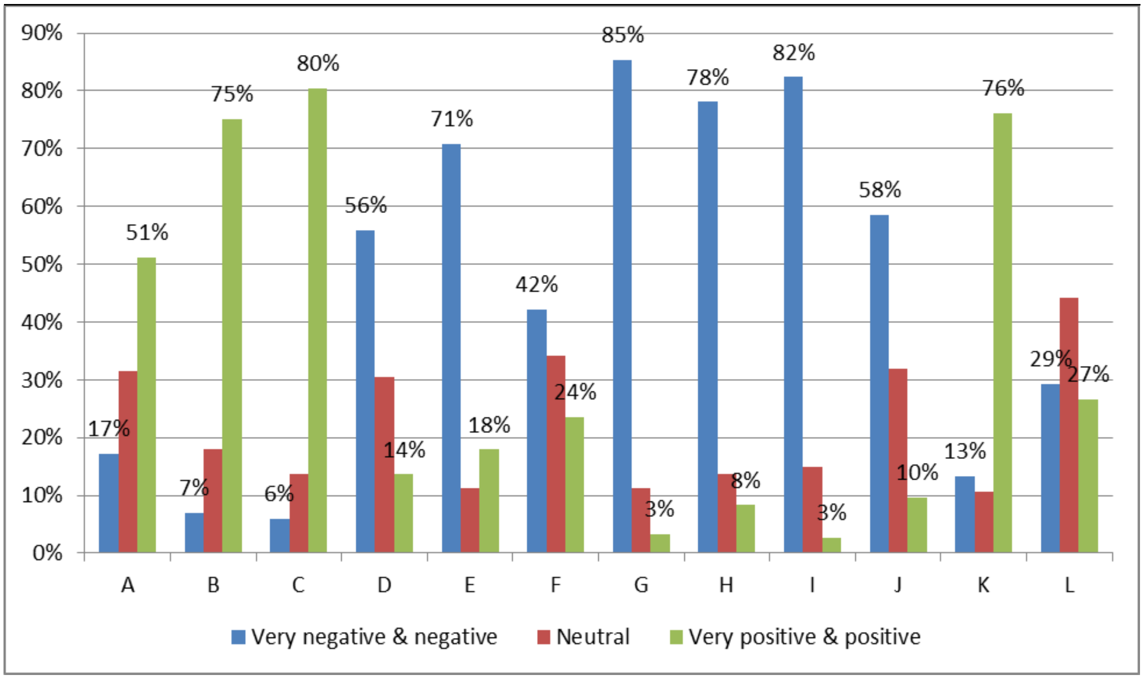
A total of 229 (76%) agreed with the view that widespread access to modern energy sources will be facilitated by the diffusion of green energy in the region, 32 (11%) had a neutral view and 40 (13%) did not agree with the statement.

L. Viability of various green energy sources

The viability of various green energy sources identified in the region, 133 (44%) of respondents were neutral about the green energy sources identified (listed in the questionnaire), 80 (27%) were in agreement with the statement and 88 (29%) did not agree with the statement.

Trend analysis indicate that majority of respondents were in agreement and positive about factor A (51%); B (75%); Variable C (80%) and Variable K (76%). The majority of respondents were negative about variable D (56%); E (71%); G (85%); H (78%); I (82%) and J (58%). Figure 6.1 presents frequency distributions: variables in percentages.

Figure 6.1: Frequency distributions: Variables in percentages



6.5 RELATIONSHIP BETWEEN VARIABLES

6.5.1 Pearson Product Moment Correlation coefficient analysis (Pearson r)

Pearson r was employed to determine whether sufficient evidence existed to make conclusions about hypotheses six (6) to fifteen (15). It also tested relationships between the selected independent variables for the study and the dependent variable.

Pearson r tested for both statistical and practical significance; it determined whether variables are related and to what degree the variables were related. According to Gravetter and Wallnau (2009: 534) correlations are statistically significant at 0.05 levels. For n = 301 if |r| >= 0.113 and practically significant if |r| >= 0.300, thus significant (both statistically and practically) if |r| >= .300. Table 6.12 demonstrates the correlation analysis of the relationship between the variables.

Table 6.12: Correlation analysis results

Variables	**A**	**B**	**C**	**D**	**E**	**F**
A. Strategic green energy planning	-	***.451***	.178	.296	-.061	.221
B. Green energy economic augmentation	***.451***	-	***.338***	.071	-.180	.060
C. Environmental pollution mitigation	.178	***.338***	-	-.050	-.178	.020
D. Green energy governance	.296	.071	-.050	-	.081	***.669***
E. Green Energy technology innovation	-.061	-.180	-.178	.081	-	.030
F. Green energy policy alignment	.221	.060	.020	***.669***	.030	-
G. Green energy projects financing	-.275	***-.320***	***-.357***	.044	.168	.012
H. Green energy human capacity development	***-.361***	***-.306***	-.254	.030	***.349***	-.002
I. Green energy infrastructure development	-.246	***-.421***	***-.409***	.110	.278	-.032
J. Green energy local market development	-.087	-.155	-.081	***.389***	.198	.296
K. Perceived widespread access success to green energy	***.400***	***.553***	***.404***	.062	-.217	.061
L. Viability of various green energy sources	.300	.189	.030	***.338***	.007	***.320***

	G	**H**	**I**	**J**	**K**	**L**
A. Strategic green energy planning	-.275	***-.361***	-.246	-.087	***.400***	.300
B. Green energy economic augmentation	***-.320***	***-.306***	***-.421***	-.155	***.553***	.189
C. Environmental pollution mitigation	***-.357***	-.254	***-.409***	-.081	***.404***	.030
D. Green energy governance	.044	.030	.110	***.389***	.062	***.338***
E. Green Energy technology innovation	.168	***.349***	.278	.198	-.217	.007
F. Green energy policy alignment	.012	-.002	-.032	.296	.061	***.320***
G. Green energy projects financing	-	***.453***	***.555***	***.301***	***-.345***	-.068
H. Green energy human capacity development	***.453***	-	***.407***	***.401***	***-.306***	-.196
I. Green energy infrastructure development	***.555***	***.407***	-	.237	***-.352***	-.099
J. Green energy local market development	***.301***	***.401***	.237	-	-.154	-.001
K. Perceived widespread access success to green energy	***-.345***	***-.306***	***-.352***	-.154	-	.090
L. Viability of various green energy sources	-.068	-.196	-.099	-.001	.090	-

6.5.1.1 Relationship between variables

Variable A has a significant positive correlation with variable B (green energy economic augmentation) with Pearson r 0.451 value. There is also a significant positive correlation between variable A and the dependent variable K and variable L (viability of various green energy sources) with the Pearson r 0.400 and 0.300 respectively.

Variable B has a significant positive significant correlation with variable A and K with Pearson r 0.451 and 0.553. The correlation between variable B and variable G, H, and I are significantly negative and have the Pearson r -0.320, -0.306 and -0.421 respectively.

Variable C has a significant positive correlation with variable B and K with Pearson r 0.338 and 0.404 respectively. The correlation between variable C and variable G and I and are significantly negative and has the Pearson r -0.357 and -0.409 respectively.

Variable D has a significant positive correlation with variable J and L with Pearson r 0.389 and 0.338 respectively.

Variable E has a significant positive relationship with variable H with a Pearson r 0.349.

Variable F has a significant positive correlation with variable D and L with Pearson r 0.669 and 0.320 respectively.

Variable G has a significant positive correlation with variable H, I and J with Pearson r 0.453, 0.555 and 0.301 respectively.

The correlation between variable G and variable B and K are significantly negative and has a Pearson r -0.320 and -0.345 respectively.

Variable H has a significant positive correlation with variable E; G; I and J with Pearson r 0.349, 0.453, 0.407 and 0.401 respectively. The correlation with between variable H and variable A; B; and K and are significantly negative and has the Pearson r -0.361, -0.306 and -0.306 respectively.

Variable I has a significant positive correlation with variable G and H with Pearson r 0.555 and 0.407 respectively. The correlation with between variable I and variable B, C and K are significantly negative and has the Pearson r -0.421, -0.409 and -0.352 respectively.

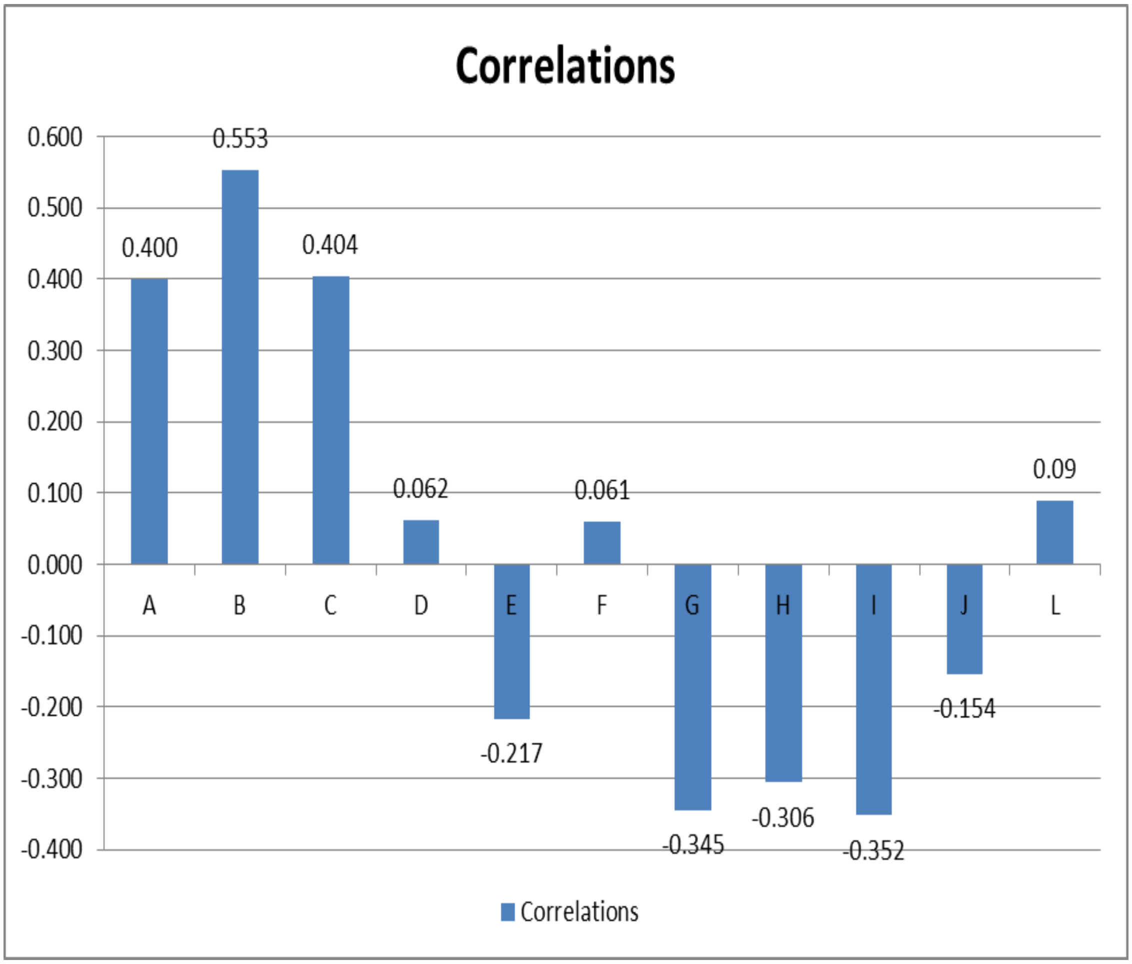
Variable J has a significant positive correlation with variable D, G and H with correlation coefficient 0.389, 0.301 and 0.401 respectively.

Finally Variable L has significant positive correlation with variable A, D and F Pearson r 0.300, 0.338 and 0.320 respectively.

6.5.1.2 The relationship between dependent and independent variables

Variable K is a dependent variable (perceived widespread access success to green energy). It has a significant positive correlation with variable A, B and C with Pearson r 0.400, 0.553 and 0.404 respectively. The correlation between variable K with variables G, H and I are significantly negative and have the correlation coefficient -0.345, -0.306 and -0.352 respectively. Figure 6.2 illustrates Pearson r between the dependent and independent variables.

Figure 6.2: Pearson Product Moment Correlation coefficients between the dependent and independent variables.



6.5.1.3 Conclusions about hypotheses number six (6) to fifteen (15)

Conclusions about the relationships between the dependent variable (perceived widespread access success to green energy) and independent variables are illustrated in Table 6.13.

Table 6.13: Hypotheses 6-15 testing conclusions

Hypothesis tested	Accepted or Rejected
H_6: There is a significant positive relationship between strategic green energy planning and the perceived access success to green energy in the SADC region.	Accepted
H_7: There is a significant positive relationship between green energy economic augmentation and the perceived access success to green energy in the SADC region.	Accepted
H_8: There is a significant positive relationship between environmental pollution mitigation and the perceived access success to green energy in the SADC region.	Accepted
H_9: There is a significant positive relationship between green energy governance and the perceived access success to green energy in the SADC region.	Neither accepted nor rejected
H_{10}: There is a significant positive relationship between green energy technology innovation and the perceived access success to green energy in the SADC region.	Neither accepted nor rejected
H_{11}: There is a significant positive relationship between green energy policy alignment and the perceived access success to green energy in the SADC region.	Neither accepted nor rejected
H_{12}: There is a significant positive relationship between green energy projects financing and the perceived access success to green energy in the SADC region.	Rejected
H_{13}: There is a significant positive relationship between green energy human capacity development and the perceived access success to green energy in the SADC region.	Rejected
H_{14}: There is a significant positive relationship between green energy infrastructure development and the perceived access success to green energy in the SADC region.	Rejected
H_{15}: There is a significant positive relationship between green energy local market development and the perceived access success to green energy in the SADC region.	Neither accepted nor rejected

6.6 ONE SAMPLE T-TEST FOR THE WHOLE SAMPLE

One sample T-tests were conducted for variables A to L to determine whether the population mean values for these variables can be regarded as either positive (μ > 4.43), neutral (3.57 < μ < 4.43) or negative (μ < 4.43). The one-sample T-test results are summarised in Table 6.14.

Table 6.14: One-sample T-Tests: Factors A to L

Factor	Mean	S.D.	p (μ=3.57)	Cohen's d	p (μ=4.43)	Cohen's d	Test Outcome
C	5.61	1.34	<.0005	1.52	**<.0005**	**0.88**	Positive
K	5.11	1.27	<.0005	1.21	**<.0005**	**0.54**	
B	4.96	0.97	<.0005	1.43	**<.0005**	**0.54**	
A	4.53	1.09	<.0005	0.88	.122	n/a	Undecided[1]
L	3.97	0.94	<.0005	0.42	<.0005	0.49	Neutral
F	3.78	0.89	<.0005	0.24	<.0005	0.73	
D	3.54	0.83	.487	n/a	<.0005	1.07	Undecided[2]
J	3.37	0.80	**<.0005**	**0.26**	<.0005	1.33	Negative
E	2.91	1.63	**<.0005**	**0.40**	<.0005	0.93	
H	2.80	1.16	**<.0005**	**0.66**	<.0005	1.40	
I	2.69	0.92	**<.0005**	**0.96**	<.0005	1.89	
G	2.48	1.00	**<.0005**	**1.09**	<.0005	1.94	

[1] Undecided, either positive or neutral but not negative
[2] Undecided, either negative or neutral but not positive

Variable B, C and K have a high mean score of 4.96, 5.61 and 5.11. These high mean score indicate that the majority of respondents are in agreement and positive about green energy economic augmentation, green energy environmental pollution mitigation and the perceived widespread access success to green energy. Variable A has a mean score of 4.53 and this indicates that the majority of respondents are undecided, and they are either positive or neutral but not negative about the need of strategic green energy planning. Variable F and L mean score are 3.78 and 3.97 and this indicate that the majority of respondents have a neutral view about green energy policy alignment and viability of various green energy sources in the region.

Variable D has a mean score of 3.54 and this indicates that the majority of respondents are undecided, and are either negative or neutral but not positive about the state green energy governance in the region. Variable E, G, H, I and J have mean scores of 2.91, 2.48, 2.80, 2.69 and 3.37 respectively. This mean scores indicate that the majority of respondents have a negative view about green energy technology innovation, green energy projects financing, green energy human capacity development and green energy infrastructure development.

No significant differences were found, with p (μ=3.57) amongst the variables, with the exception of variable D (green energy governance), the p value = 0.487. Cohen's d statistics for practical significant mean differences indicate that there is significant mean differences amongst the variables, with the exception of B and K with a Cohen's d value = 0.54. Annexure 2 illustrates the central tendency and dispersion of factors in detail.

6.7 ADVANCED STATISTICAL ANALYSIS OF VARIABLES PER CATEGORY

T-tests inferences about the views of categories of respondents with regard to the 12 identified variables and categories of respondents.

6.7.1 Bivariate T-tests for the variables according to respondents' work experience

Bivariate T-tests were conducted on energy practitioners who are less experienced (1-6 years) and experienced (> 6 years). This served to determine whether the difference between the hypothesised population work experience parameter and sample result was significant and not as a result of chance. Table 6.15 illustrates T-tests of factor A to L by years of experience category.

Table 6.15: T-tests of factor A to L by years of experience

Variable	Years. Cat	n	Mean	S.D.	Difference	t	Degree of freedom (d.f.)	P (d.f.=277)
A	<= Median 6	141	4.52	1.04	-0.01	-0.05	277	.961
	> Median 6	138	4.53	1.16				
B	<= Median 6	141	4.95	0.98	-0.04	-0.37	277	.714
	> Median 6	138	5.00	0.95				
C	<= Median 6	141	5.48	1.47	-0.31	-1.95	277	.053
	> Median 6	138	5.80	1.22				
D	<= Median 6	141	3.55	0.87	0.05	0.54	277	.589
	> Median 6	138	3.50	0.80				
E	<= Median 6	141	3.02	1.73	0.26	1.33	277	.183
	> Median 6	138	2.76	1.53				
F	<= Median 6	141	3.78	0.92	0.00	0.00	277	.999
	> Median 6	138	3.78	0.87				
G	<= Median 6	141	2.54	1.08	0.16	1.32	277	.187
	> Median 6	138	2.38	0.93				
H	<= Median 6	141	2.81	1.17	0.06	0.42	277	.672
	> Median 6	138	2.75	1.13				
I	<= Median 6	141	2.76	0.96	0.20	1.85	277	.066
	> Median 6	138	2.55	0.86				
J	<= Median 6	141	3.32	0.79	-0.09	-0.98	277	.326
	> Median 6	138	3.42	0.83				
K	<= Median 6	141	5.04	1.29	-0.16	-1.02	277	.308
	> Median 6	138	5.19	1.27				
L	<= Median 6	141	4.05	0.97	0.21	1.89	277	.060
	> Median 6	138	3.84	0.88				

Variable A has a high mean score of 4.52 and 4.53 for respondents with work experience of between 1-6 years and experienced (>6 years) respectively. The mean values indicate that respondents are positive about strategic green energy augmentation. Variable B also has a high mean score of 4.95 and 5.00 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are positive about green energy economic augmentation.

Variable C has the highest mean scores of 5.48 and 5.80 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are positive about green energy environmental pollution mitigation**.** Variable K has mean scores of 5.04 and 5.19 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are positive about perceived widespread access to green energy.

Variable F has equal mean scores of 3.78 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are neutral about green energy policy alignment. Variable D has a mean score of 3.55 and 3.50 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy governance. Variable L has a mean score of 4.05 and 3.84 respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are neutral about viability of various identified green energy sources in the questionnaire.

Variable E has a mean score of 3.02 and 2.76 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy technology innovation.

Variable G has a mean score of 2.54 and 2.38 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy projects financing. Variable H has a mean score of 2.81 and 2.75 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy human resources capacity. Variable I have a mean score of 2.76 and 2.55 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy infrastructure development.

Variable J has a mean score of 3.32 and 3.42 for respondents with work experience of between 1-6 years and respondents with more than 6 years respectively. The mean values indicate that respondents are negative about green energy local market development. Cohen's d statistics for practical significant indicate that there are significant mean differences.

6.7.2 Bivariate T-tests for the variables by their energy association

Bivariate t-tests were conducted on energy practitioners' respondents who are associated with fossil fuels or renewable energy. This served to determine whether the difference between the hypothesised population energy sector association parameter and sample result was significant and not as a result of chance. Table 6.16 illustrates T-tests of factor A to L by energy association category.

Table 6.16: T-tests of factors A to L by energy association

Variable	Energy Sector	n	Mean	S.D.	Difference	t	d.f.	P (d.f.=299)	Cohen's d
A	Fossil Fuel Renewables	167 134	4.53 4.52	1.06 1.14	0.02	0.12	299	.903	n/a
B	Fossil Fuel Renewables	167 134	4.76 5.19	0.93 0.97	-0.43	-3.90	299	**<.0005**	**0.45 Small**
C	Fossil Fuel Renewables	167 134	5.41 5.86	1.38 1.26	-0.45	-2.93	299	**.004**	**0.34 Small**
D	Fossil Fuel Renewables	167 134	3.69 3.35	0.76 0.87	0.33	3.53	299	**<.0005**	**0.41 Small**
E	Fossil Fuel Renewables	167 134	2.92 2.91	1.60 1.67	0.01	0.03	299	.976	n/a
F	Fossil Fuel Renewables	167 134	3.83 3.72	0.90 0.87	0.11	1.08	299	.280	n/a
G	Fossil Fuel Renewables	167 134	2.60 2.33	0.98 1.01	0.27	2.29	299	**.022**	**0.27 Small**
H	Fossil Fuel Renewables	167 134	2.82 2.79	1.11 1.22	0.03	0.23	299	.821	n/a
I	Fossil Fuel Renewables	167 134	2.86 2.47	0.90 0.91	0.40	3.77	299	**<.0005**	**0.44 Small**
J	Fossil Fuel Renewables	167 134	3.37 3.36	0.78 0.83	0.01	0.10	299	.923	n/a
K	Fossil Fuel Renewables	167 134	4.94 5.34	1.24 1.28	-0.40	-2.73	299	**.007**	**0.32 Small**
L	Fossil Fuel Renewables	167 134	4.07 3.84	0.94 0.94	0.23	2.09	299	**.037**	**0.24 Small**

Variable A has a high mean score of 4.53 and 4.52 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are positive about strategic green energy planning.

Variable B has a high mean score of 4.76 and 5.19 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are positive about green energy economic augmentation.

Variable C has a high mean score of 5.41 and 5.86 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are positive about green energy environmental pollution mitigation.

Variable F has a mean score of 3.83 and 3.72 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are neutral about green energy technology innovation.

Variable L has a mean score of 4.07 and 3.84 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are neutral about the viability of various green energy sources.

Variable D has a mean score of 3.69 and 3.35 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively; respondents associated fossil fuels sector are neutral and respondents associated with renewable energy are negative about green energy governance.

Variable E has a mean score of 2.92 and 2.91 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are negative about green energy technology innovation.

Variable G has a mean score of 2.60 and 2.33 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are negative about green energy projects financing.

Variable H has a mean score of 2.82 and 2.79 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are negative about green energy human capacity development.

Variable I have a mean score of 2.86 and 2.47 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are negative about green energy infrastructure development.

Variable J has a mean score of 3.37 and 3.36 for respondents associated with fossil fuel energy industry and renewable energy respondents respectively. The mean values indicate that respondents are negative about green energy local market development.

Variable B has a high mean score of 4.76 and 5.19 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are positive about green energy economic augmentation.

Variable C has mean scores of 5.41 and 5.86 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are positive about green energy environmental pollution mitigation.

Variable K has high mean scores of 4.94 and 5.34 for respondents who are associated with research activities in the energy sector and the industry's practitioner's respectively. The mean values indicate that respondents are positive about the viability of various green energy sources.

6.7.3 Bivariate T-tests of respondent energy researchers and industry

Bivariate t-tests were conducted on energy practitioners' respondents who are associated with energy research activities and those who work in the industry. Table 6.17 illustrates T-tests of factors A to L by researcher and industry practitioners.

Table 6.17: T-tests of factors A to L by researcher and industry practitioners

Variable	Researcher. Industry	n	Mean	S.D	Difference	t	d.f.	p(d.f.=299)	Cohen's d
A	Researchers Industry	38 263	4.34 4.55	1.34 1.05	-0.21	-1.11	299	.267	n/a
B	Researchers Industry	38 263	5.23 4.92	0.96 0.96	0.32	1.90	299	.059	n/a
C	Researchers Industry	38 263	5.84 5.57	1.28 1.35	0.27	1.15	299	.251	n/a
D	Researchers Industry	38 263	3.32 3.57	0.74 0.84	-0.25	-1.78	299	.077	n/a
E	Researchers Industry	38 263	2.89 2.92	1.86 1.60	-0.02	-0.08	299	.939	n/a
F	Researchers Industry	38 263	3.61 3.81	0.85 0.89	-0.20	-1.28	299	.200	n/a
G	Researchers Industry	38 263	2.46 2.48	1.05 1.00	-0.03	-0.16	299	.873	n/a
H	Researchers Industry	38 263	2.66 2.82	1.19 1.15	-0.16	-0.78	299	.433	n/a
I	Researchers Industry	38 263	2.28 2.74	0.88 0.92	-0.46	-2.91	299	**.004**	**0.50 Medium**
J	Researchers Industry	38 263	3.51 3.35	0.82 0.80	0.16	1.16	299	.246	n/a
K	Researchers Industry	38 263	5.43 5.07	1.41 1.25	0.37	1.66	299	.097	n/a
L	Researchers Industry	38 263	3.65 4.01	0.85 0.95	-0.36	-2.22	299	**.027**	**0.38 Small**

Variable A has mean scores of 4.34 and 4.55 for respondents who are associated with research activities in the energy sector and the industry practitioner's respondents respectively. The mean values indicate that respondents that are associated with research activities in the energy sector are negative and the industry practitioners are positive about strategic green energy planning.

Variable D has mean scores of 3.32 and 3.57 for respondents who are associated with research activities in the energy sector and the industry practitioner's respondents respectively. The mean values indicate that respondents that are associated with research activities in the energy sector are negative and the industry practitioner's respondents are positive about green energy governance.

Variable F has a high mean score of 3.61 and 3.81 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are neutral about green energy policy alignment.

Variable L has a high mean score of 3.65 and 4.01 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are neutral about the viability of various green energy sources.

Variable E has a high mean score of 2.89 and 2.92 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are negative about green energy technology innovation.

Variable G has a high mean score of 2.46 and 2.48 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are negative about green energy projects financing.

Variable H has a high mean score of 2.66 and 2.82 for respondents who are associated with research activities in the energy sector and the industry practitioner's respectively. The mean values indicate that respondents are negative about green energy human capacity development.

Variable I has a high mean score of 2.28 and 2.74 for respondents who are associated with research activities in the energy sector and the industry practitioner's respondents respectively. The mean values indicate that respondents are negative about green energy infrastructure development.

Variable J has a high mean score of 3.51 and 3.35 for respondents who are associated with research activities in the energy sector and the industry practitioner's respondents respectively. The mean values indicate that respondents are negative about green energy local market development.

6.7.4 Bivariate T-tests of respondents based in South Africa and in other SADC countries

Bivariate t-tests were conducted on energy practitioners' respondents who are based in South Africa and those who are based in other SADC countries. This served to determine whether the difference between the hypothesised population of energy sector base country parameter and sample result was significant and not as a result of chance. Table 6.18 illustrates T-tests of factors A to L by region.

Table 6.18: T-tests of factors A to L by region

Variable	Region	n	Mean	S.D	Difference	t	d.f.	p(d.f.=299)	Cohen's d
A	South Africa Other SADC	245 56	4.47 4.79	1.08 1.09	-0.33	-2.03	299	**.043**	**0.30** **Small**
B	South Africa Other SADC	245 56	4.84 5.46	0.94 0.95	-0.62	-4.47	299	**<.0005**	**0.66** **Medium**
C	South Africa Other SADC	245 56	5.51 6.05	1.39 1.02	-0.55	-2.78	299	**.006**	**0.41** **Small**
D	South Africa Other SADC	245 56	3.56 3.43	0.82 0.88	0.14	1.12	299	.265	n/a
E	South Africa Other SADC	245 56	2.96 2.70	1.62 1.66	0.27	1.11	299	.269	n/a
F	South Africa Other SADC	245 56	3.79 3.74	0.89 0.86	0.06	0.44	299	.663	n/a
G	South Africa Other SADC	245 56	2.58 2.04	1.00 0.89	0.55	3.75	299	**<.0005**	**0.56** **Medium**
H	South Africa Other SADC	245 56	2.88 2.47	1.16 1.12	0.40	2.38	299	**.018**	**0.35** **Small**
I	South Africa Other SADC	245 56	2.75 2.41	0.93 0.87	0.33	2.46	299	**.014**	**0.37** **Small**
J	South Africa Other SADC	245 56	3.36 3.41	0.82 0.73	-0.05	-0.43	299	.666	n/a
K	South Africa Other SADC	245 56	4.98 5.72	1.24 1.24	-0.75	-4.07	299	**<.0005**	**0.60** **Medium**
L	South Africa Other SADC	245 56	4.01 3.78	0.94 0.93	0.22	1.61	299	.109	n/a

Variable A has high mean scores of 4.47 and 4.79 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents are positive about strategic green energy planning.

Variable B has high mean scores of 4.84 and 5.46 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents are positive about green energy economic augmentation.

Variable C has highest mean scores of 5.51 and 6.05 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents are positive about green energy environmental pollution mitigation.

Variable K has high mean scores of 4.98 and 5.72 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents are positive about perceived widespread access success to green energy.

Variable F has high mean scores of 3.79 and 3.74 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents are neutral green energy policy alignment.

Variable L has high mean scores of 4.01 and 3.78 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents have a neutral view about the viability of various green energy sources.

Variable D has high mean scores of 3.56 and 3.43 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based have a neutral view and respondents who are based in other SADC countries are negative about green energy governance.

Variable E has high mean scores of 2.96 and 2.70 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based and those who are based in other SADC countries are negative about green energy technology innovation.

Variable G has high mean scores of 2.58 and 2.04 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based and those who are based in other SADC countries are negative about green energy projects financing.

Variable H has high mean scores of 2.88 and 2.47 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based and those who are based in other SADC countries are negative about green energy human capacity development.

Variable I has high mean scores of 2.75 and 2.41 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based and those who are based in other SADC countries are negative about green energy infrastructure development.

Variable J has high mean scores of 3.36 and 3.41 for respondents who are based in South Africa and in other countries of the SADC region respondents respectively. The mean values indicate that respondents who are South African based and those who are based in other SADC countries are negative about green energy local market development.

6.8 TEST RESULTS FOR HYPOTHESES ONE (1) TO FIVE (5) AND SIXTEEN (16)

A series of MANOVA analyses were conducted to test for differences between all factors and ANOVAs were conducted on factors individually. Table 6.19 illustrates the Multivariate ANOVA Statistics - Variables A to L.

Table 6.19: Multivariate ANOVA statistics - variables A to L

Effect	F	D.F.	p
Intercept	**802.93**	**12; 232**	**<.0005**
Years. Cat	0.39	12; 232	.968
Energy Sector	1.23	12; 232	.265
Researcher. Industry	1.47	12; 232	.136
Region	**2.96**	**12; 232**	**.001**
Position	**2.14**	**24; 464**	**.001**

The MANOVA statistics analysis revealed that there are significant differences in responses between respondents based on the region respondents are based in (South Africa/other SADC countries) (p=0.001). There are also significant differences in responses between respondents based on their position (junior management/middle management/senior management) (p=0.001). There are no significant differences with regard to years of experience in the energy sector (1- 6 years and > 6 years); energy sector (fossil fuel/renewable energy) and the role of the energy practitioner (researchers/industry).

6.8.1 ANOVA results

ANOVAs that were conducted on factors individually reveal that there is a significant difference in responses for the independent variable A (strategic green energy planning), difference between respondents in terms of the region they come from (South Africa and other SADC countries). Post hoc results indicate that p=0.002. ANOVA analysis for the independent variable B (green energy economy augmentation) indicates that there is a significant difference in terms of region and positions of respondents (senior management/middle management/junior management). Post hoc results of middle management/junior management indicate that, p=0.004. Annexure 4 illustrates the Univariate ANOVA results of variable A and B and post-hoc results A and B.

ANOVA results indicate that there is a significant difference in responses for the independent variable C (environmental pollution mitigation) in terms of position and region. Post hoc results indicate that there is differences in the region p=0.036. Senior management/junior management, p= 0.001 and middle management/senior management, p= 0.012. ANOVA results indicate that there is a significant difference in responses for the independent variable D (green energy governance). There is deference in terms of the energy sector the respondents is associated with (fossil fuel/renewable energy) and the position. Post hoc results indicate that in terms of the energy sector p= 0.043. In terms of position, middle management/junior management, p= 0.001 and middle management/senior management, p= 0.001. Annexure 5 illustrates the Univariate ANOVA results of variable C and D and post-hoc results C and D.

ANOVA results indicate that there is a significant difference in responses for the independent variable E (green energy technology innovation) in terms of position and region.

Post hoc results indicate that in in terms of position, junior management/senior management, p= 0.016. There is no significant deference in terms of independent variables F (green energy policy alignment). Annexure 6 illustrates the Univariate ANOVA results of variable E and F and post-hoc results E and F.

ANOVA results indicate that there is a significant difference in responses for the independent variable G (green energy projects financing), in terms of region. Post hoc results indicate that in terms of the region, p= 0.001. There are also significant differences in terms of the region for independent variable H (green energy human capacity development). Post hoc results indicate that in in terms of the region, p= 0.017. Annexure 7 illustrates the Univariate ANOVA results of variable G and H and post-hoc results G and H.

ANOVA results indicate that there is a significant difference in post hoc results for the independent variable I (green energy infrastructure development) in terms of position. Junior management/senior management, p= 0.029. Middle management/senior management, p= 0.010. There is no significant deference in terms of dependent variables J (green energy local market development). Annexure 8 illustrates the Univariate ANOVA results of variable I and J and post-hoc results I and J.

ANOVA results indicate that there is a significant difference in responses for the dependent variable K (perceived widespread access success to green energy) in terms of the region and position. Post hoc results indicate that in terms of the region, p <0.0005 and in terms of position (junior management/senior management), p= 0.042. The post hoc results for the independent variable L (viability of various green energy sources) indicate that in terms of position (junior management/senior management), p= 0.012. Annexure 9 illustrates the Univariate ANOVA results of variable K and L and post-hoc results K and L. Hypotheses conclusions are in Table 6.20.

Table 6.20: Tested hypotheses 1-5 and hypothesis 16

Hypotheses	Hypothesis accepted or rejected
H_1. There is a significant difference in support for green energy based on years of experience (1- 6 years and > 6 years).	Rejected
H_2. There is a significant difference in support for green energy based on the energy sector base (Fossil fuel and renewable energy).	Rejected
H_3. There is a significant difference in support for green energy based on the role in the sector (researchers and industry practitioners).	Rejected
H_4. There is a significant difference in support for green energy based on a location that serves as a base country (South Africa and other SADC countries).	Accepted
H_5. There is a significant difference in support for green energy based on the position held (senior managers; middle managers and senior manager).	Accepted
H_{16}. There is a significant difference in support for viability of various green energy sources amongst different groups in the SADC region: (1-6 years and > 6 years); (fossil fuel and renewable energy); (researchers and industry practitioners); (South Africa and other SADC countries) and (senior manager, middle manager and junior manager).	Rejected

6.9 CHAPTER SUMMARY

This chapter presented the empirical results of the study and focused on the primary research question supported by secondary questions. Reliability and validity of the research instrument were presented, STATISTICA 12 was employed to analyse the relationship between variables and responses between identified groups and finally conclusions were made about the proposed hypotheses. In order to obtain the demographic profile of the respondents, descriptive statistics was employed. Pearson r was employed to determine whether sufficient evidence existed to make conclusions about hypotheses six 6 to 15, relating to significant relationships between the selected independent variables and the dependent variable (perceived success of access to green energy in the SADC region). Pearson r tested for both statistical and practical significance.

T-tests were employed to make inferences about the views of various identified categories of respondents with regard to the 12 identified variables. This served to determine whether the difference between the hypothesised population parameter and sample result was significant and not as a result of chance. T-tests provided Cohen's d statistics, a standardised mean difference to compare groups and the standard deviation to determine whether sample differences were large enough to have a practical significance.

MANOVA examined associations between the independent variables and the dependent variable. A series of ANOVA analyses were conducted with the same categories of respondents with independent and dependent variables. MANOVA and Anova analyses were employed to determine whether sufficient evidence existed to make conclusions about hypotheses 1 to 5 and hypothesis 16 of the study.

A summary of the study, conclusions and recommendations is presented in Chapter 7. The Chapter also summarised how the objectives of the study were met, how research questions are answered and also presented recommendations for future research.

7 CHAPTER 7: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This final chapter provides a summary, conclusions and recommendations of the research. A clear link should always be established between the original study objectives and respective conclusions (Diamantopoulos and Schlegelmilch, 2006). Research question Q_{10} and Q_{11} and research objective O_{10} and O_{11} are addressed in this chapter. Empirical results data from Chapter 6 are also interpreted and evaluated in this chapter, including conclusions about hypotheses that were tested by the study. Data interpretations involve synthesis of one's data into a larger coherent whole (Mouton, 2004). The summary is a brief statement of the essential findings and conclusions representing inferences drawn from the findings (Blumberg, Cooper and Schindler, 2008).

Recommendations based on contemporary literature and empirical findings in the current study are made. The three final steps in concluding a research report according to Leedy and Ormrod (2005: 287) include stating whether the hypotheses have been supported or not, identifying possible practical implications of the results and making recommendations for additional study perhaps in those areas related to the problem that during the research, the researcher recognised as worthy of further investigation. The final part of the chapter highlights the implications of the research results, followed by a discussion about the limitations of the study.

7.1 OVERVIEW OF THE RESEARCH

The research is concerned with the perceived access success to green energy in the SADC region. It introduced the problem statement and the background to the study in Chapter 1.

The research problem was introduced as follows: "**High dependence on fossil fuels sources of energy for electricity generation is not improving widespread access to modern energy to the vast majority of SADC region's citizens, despite the endowment of the region with green energy sources"**. In order to address the research question, the study focused on four key energy sector challenges identified by the UNEP (2011) that includes:

- Concerns about energy security
- Combating climate change
- Reducing pollution and public-health hazards
- Addressing energy poverty

The four key concepts are identified and explained to represent the study's research problem pertaining to poor green energy access. A theoretical rationale of the study was developed and premised on population growth, leading to an increased need for energy supply and meeting energy needs through increased exploitation of green energy as opposed to fossil fuel sources. The rationale postulated that increasing access to modern energy services through green energy will lead to widespread access success to modern energy services and an improved quality of life. The observation made by World Energy Council (2012b) indicates that developing countries struggle with providing electricity access and energy services for their growing populations.

The research problem was further categorised into a set of research questions. The primary research question is stated as follows: "How can the SADC region intensify the exploitation of green energy sources, by doing so contribute to widespread access to modern energy to a larger population in the region.

The primary objective of this research was to debunk how widespread access to green energy can be increased by investing into the green energy sector in the SADC region. It is supported by sub-objectives and secondary objectives. Contributions of the study, delimitation of the study, structure of the thesis, followed by assumption made are also stated in Chapter 1. In order to address the research problem, literature was reviewed and discussed in Chapter 2, including the global energy situation and climate change. The key focus for global energy situation was discussed under topics that include: global universal energy access by 2030 and beyond, alternative energy sources, transition to low carbon solutions, the role of energy in society, barriers to the transition to low carbon energy solutions and sustainable energy solution. Climate change literature reviews focused on the impact of climate change in the world, forums established to address global warming, Lima negotiations (COP 20 outcome) and preparations for Paris COP (21).

Chapter 2 exposed the essential role that green energy plays in improving access to modern energy and powering economic development. Literature identified factors that have an influence on perceived widespread access success to green energy in the SADC region; factors were identified and presented in a theoretical conceptual model in Chapter 4. Energy situation, access challenges and climate change discussions were narrowed to the African continent, SSA and the SADC region in Chapter 3.

Literature reviews made an assertion that suggested an urgent need to integrate energy policies into broader development strategies in African countries, while at the same time encouraging regional integration. The other critical element addressed by literature was the recognition of a need for pro poor PPP. Green energy was found to be a solution that can improve the socio-economic development of the region.

Chapter 4 presented the conceptual framework of selected independent variables hypothesised to determine the significance of their inter-relatedness to each other and the significance of their relationship to the dependent variable (perceived widespread access success to green energy). Factors that influence the widespread access success to green energy were identified through literature reviews. The model was empirically tested. A total of 10 hypotheses emanating from the conceptual theoretical model were proposed. The hypothesised factors are: strategic green energy planning, green energy economic augmentation, environmental pollution mitigation, green energy governance, green energy technology innovation, green energy policy alignment, green energy projects financing, green energy human capacity development, green energy infrastructure development and green energy local market development.

Chapter 5 discussed the research design, methodology and instruments to be used to test the proposed conceptual model. This chapter described in detail the research design, methodology followed and instruments used to test the proposed conceptual model. The population studied was also described, as well as the sampling technique adopted. Independent and dependent variables were operationalised with clear and concise definitions applicable to the study. Explanation was provided on how the measuring instrument was developed and administered. Statistical analysis to be performed to ensure the validity and reliability of the results was also explained in detail. It was concluded that the selected data collection method was an objective and appropriate means of obtaining valid statistics on stakeholders in the energy sector.

Chapter 6 presented empirical results of the study and addressed the primary research questions supported by secondary questions. Reliability and validity of the research instrument were also presented.

STATISTICA 12 was employed to analyse the relationship between variables and responses between identified categories of respondents, and finally conclusions were made about the proposed hypotheses. In order to obtain the demographic profile of the respondents, descriptive statistics was employed. Pearson r was employed to determine whether sufficient evidence exists to make conclusions about hypotheses 6 to 15, relating to significant relationships between the selected independent variables for the study and the dependent variable. Various categories of respondents analysed per variable were: Less experienced (1-6 years) and more experienced (> 6 years) energy practitioners, junior management/middle management and senior management, fossil fuel sector/renewables sector, energy researchers and scholars/energy industry, South Africa based and other SADC countries based.

Pearson r tested for both statistical and practical significance; it determined the degree of the relationship between variables. One-sample T-tests were conducted for variables A to L to determine whether the population mean values for these variables could be regarded as either positive ($\mu > 4.43$), neutral ($3.57 < \mu < 4.43$) or negative ($\mu < 4.43$). T-tests were employed to make inferences about the views of categories of respondents with regard to the 12 identified variables. This served to determine whether the difference between the hypothesised population parameter and sample results were significant and not as a result of chance. Cohen's d statistics, a standardised mean difference, were calculated to determine the practical significance of T-test results.MANOVA and ANOVA were employed to determine whether sufficient evidence existed to make conclusions about hypotheses 1 to 5 and 16 of the study. These hypotheses relate to the differences in opinions between categories of identified respondents.

Chapter 7 provides an overview of the study; it summarises how the objectives of the study were met, clarifies how research questions were answered; indicates how the objectives of the study were met; and recommendations are also made. It further sets out the contribution and limitations of the study and suggests areas to be considered for future research.

7.1.1 Conclusions about the research methodology

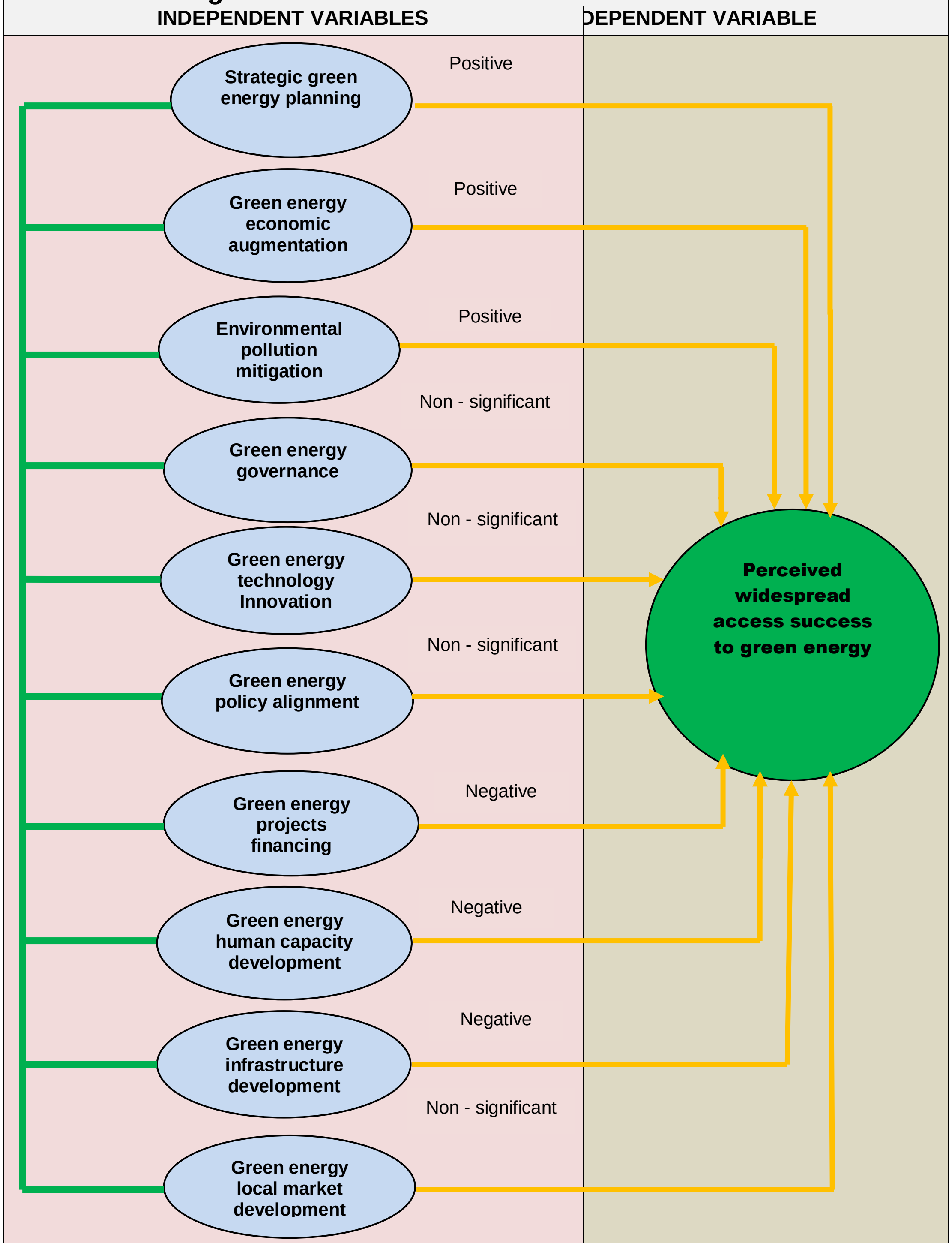
After literature review, 12 variables that can potentially influence widespread access success to green energy in the SADC region were identified and included in the proposed theoretical model. A 13th variable was added to determine if there were significant differences in support for the viability of (identified in the questionnaire) green energy in the region amongst different categorised groups in the SADC region. Variables were operationalised before they were included in the measuring instrument. To validate the identified variables, a pilot survey was completed to test the questionnaire amongst a sample of conveniently obtained respondents associated with renewable and fossil-fuel energy sectors. A total of 40 questionnaires were distributed and 31 respondents completed the pilot study. Their responses were then reviewed and statistically analysed to test for ambiguously worded questions. Minor changes were made to the final questionnaire.

The final questionnaire items were coded and then randomly positioned in the questionnaire. Sampling was conducted within a premise of quota sampling. The sampling criteria for this study took cognisance of the fact that there are vast disparities in energy generation in the region. Potential respondents were targeted based on the energy situation of the region. South Africa has the largest economy in the region with an installed electrical capacity and produces over 80% of the SADC region’s power supply with predominantly coal-fired generation (DBSA, 2014).

Sampling methods selected above enabled the researcher to get representative opinions from the selected population under study. The population of respondents was made up of regional energy industry authorities in the region and respective government's energy ministries in the SADC region, governmental and non-governmental institutions, private companies and energy researchers. Given a large geographic scope of the SADC region, a minimum of 250 respondents were targeted and a total of 301 responses were received. A total of 114 respondents responded electronically through emails and 187 respondents completed the questionnaires physically after they were hand delivered to them. The composition of respondents who responded to the questionnaires include: SAPP member countries respondents. Respondents' contact details were obtained from SAPP official website database. Other official websites for organisations that formed the sampled population were accessed, namely: SAAEA; SESSA and AFSEA and energy enterprises which include contractors, consultants, power utilities and suppliers that operate within the SADC region's energy sector.

STATISTICA 12 was used to test for internal reliability of the measuring instrument in order to determine the degree to which the test scores were accurate and consistent. Perception about green energy economic augmentation and environmental pollution mitigation, were not tested for internal consistency because there were no enough items included in the survey instrument to measure them. Cronbach alphas for these variables are indicated by (n.a.). Three variables showed moderate reliability with Cronbach's alpha values greater than 0.5, a similar number were greater than 0.6 with 4 variables showing Cronbach alpha greater 0.7. A Cronbach's alpha value 0.46 was noted for one variable (strategic green energy planning) which indicates poor correlation. In general, there is an acceptable internal consistency among the variables. Figure 7.1 illustrates an empirical model of the relationship of factors that influence the perceived widespread access success to green energy in the SADC region.

Figure 7.1: An empirical model of the relationship of factors that influence the perceived widespread access success to green energy in the SADC region.



Source: Researcher's own construction

7.2 INTERPRETATION AND DISCUSSION OF EMPIRICAL RESULTS

This section presents the interpretations and recommendations in respect of all factors found to have a significant influence on the dependent variable (perceived widespread access success to green energy). Recommendations are made indicating how widespread access success to green energy can be advanced in the region in Section 7.7.

7.2.1 Strategic green energy planning

A total number of 154 respondents (51%) are in agreement that strategic green energy access planning can potentially influence widespread success of access to green energy in the region. A significant positive correlation between the variable and the dependent variable K was found, with a Pearson r of 0.451. Variable A has a mean score of 4.53 and this indicates that the majority of respondents are either positive or neutral but not negative about the need of strategic green energy planning. Coordinated energy planning at the national, regional and local level is needed to address energy poverty issues in the SADC region, combining a centralised and decentralised approach can help to better identify energy saving measures, technologies and alternative sources that are most suitable for specific regions (Bazilian et al., 2012; Brandoni and Polonara, 2012; Cristóbal, 2011).

There is some level of energy planning in the SADC region, and because of disparities in energy access, energy plans are not integrated because countries prefer to craft their own plans in order to address their energy security issues. The region can benefit in terms of widening energy access through a coordinated integrated energy planning approach. Regions with more water resources can generate electricity that can benefit drier regions, and regions which have drier conditions can exploit solar energy to the benefit of other parts of the region.

The same can be the case with other sources of green energy. Benefits of green energy exploitation can be shared amongst the countries in the region which is currently not the case.

7.2.2 Green energy economic augmentation

The influence of green energy on economic augmentation was confirmed by the majority of respondents, 226 (75%) agree and 54 (18%) were neutral and 21(7%) disagreeing. Variable B has significant positive significant correlation with the dependent variable, with Pearson r of 0.553. Variable B has a high mean score of 5.61. These high mean scores indicate that the majority of respondents are in agreement and positive about the potential of green augmenting economic benefits in the region. The majority of rural population live on less than $1 per day and many utilities are reluctant to extend energy services to rural areas in many developing countries (Onyeji, Bazilia and Nussbaumer, 2012). Electrification is one of the most promising services that can significantly affect decreasing energy poverty, improving life quality, reducing migration from the rural area to the towns and developing sustainable socio-economic growth (Javadi et al., 2013).

In rural communities in particular, access to economic activities is severely curtailed by lack of access to energy. Agricultural production can be enhanced through access to green energy as is the case in some of the SADC region's countries currently enduring subsistence farming. In urban area green energy can also transform the lives of poor communities who still depend on biomass and fossil fuels like coal. In many parts of the region, low access to modern energy impact largely on females who collect firewood to use for cooking and heating. Access to green energy can significantly improve the socio-economic status of women in general, particularly with regard to education and healthcare access.

7.2.3 Environmental pollution mitigation

A total of number of 242 (80%) agreed that green energy can contribute to the alleviation of noxious gases, 41(14%) were neutral and 18 (6%) disagreed. This variable has significant positive correlation with the dependent variable with correlation coefficient of 0.404. It has a high mean score of 5.11. The high mean score indicates that the majority of respondents are in agreement and positive about green energy's potential to mitigate emissions and other pollution. Alleviation of toxic gases from fossil fuels will characterise widespread success of access to green energy. Fumes also impact upon human health in many parts of the region.

The African continent is regarded by the United Nations as one of the continent's most vulnerable to the impacts of climate change as a consequence of its high dependency on agriculture and the water shortages from which it already suffers (Pegels, 2010; Abanda et al., 2012). The impact of fossil fuels particularly upon human health is a challenge that the SADC region, like other parts of the world is to be faced with. A number of researches have confirmed that excessive exposure to toxic fumes from biomass and fossil fuels like coal and diesel both within the household and from fossil fuel power generating stations is impacting human health. Green energy can mitigate the exposure to toxic fumes significantly.

7.2.4 Green energy projects financing

About 257 (85%) respondents are not in support of the view that green energy projects financing is impeding widespread success of access to green energy, per se, 34 (11%) had a neutral view with 10 (30%) in agreement with the statement. The correlation between the independent variable and the dependent variable is negative and has correlation coefficient of -0.345. The low mean score of 2.48 means that respondents have a negative view.

During the past decade, the means of financing green energy projects has developed in a variety of directions in many parts of the world, depending on the political situation of the countries and other socio-economic factors (Ming, Ximei, Yulong and Lilin, 2014). Renewable energy investments must be conducted with caution because they are characterised, by irreversibility of the investment, an uncertainty environment and flexibility in the decision process (Ming, Ximei, Yulong and Lilin, 2014; Boomsma, Meade and Fleten, 2012). Uncertainty about financing of green energy projects brought negativity as reflected by the results. A market structure that encourages competitive bidding and guaranteed tariff can attract many investments in the region, which will bring the cost of capital down to levels of a government bond (in the large IPP case) or to a home loan (in the residential case).

The off-take and the tariff can be guaranteed in the region, which will leave the investor with only the risks that investor can manage (project risk, technology risk, operations risk) and with the natural resources risk (wind, sun), which is fair enough. That again will bring the cost of capital down resulting in bringing the required tariff down (which is good for all the players in the region). Barry, Steyn and Brent (2011) argue that when implementing renewable energy technologies in informal rural communities the initial and operational costs of renewable energy technologies should be subsidised by government or donor agencies to ensure that renewable energy technologies can compete with conventional technologies.

7.2.5 Green energy human capacity development

A total of 235 (78%) disagree that green energy human capacity development is impeding the augment green energy exploitation, 41(14%) are neutral and 25 (8%) are in agreement. The correlation with the dependent variable is significantly negative and has the correlation coefficient of -0.306.

The mean score is low and it is 2.80. The low mean score indicates that respondents are negative. Respondents are indicating that currently the skill base that the region has to sustain the green energy sector is available in the region as a whole. In order to overcome skills shortages difficulties in the energy sector in Africa, it is important that training and education of communities, especially the poor, are undertaken before technologies are implemented (Barry, Steyn and Brent, 2011). Skills must be shared in the region. The development of productive uses and an enabling environment can be fostered by establishing joint technology and community engagement training centres (Yadoo and Cruickshank, 2012).

When renewables are first implemented, training and knowledge transfer needs to take place which means that resources, capital and time need to be expended (Barry, Steyn and Brent, 2011). Green energy projects at a large scale have not been mobilised fully yet in the region with the exception of South Africa where some projects are underway. It is imperative that implementation of renewable projects are preceded by training at ground level to ensure that there are enough skills to operate, maintain and manage grids with increased green energy access. The prospects of developing the other SADC countries can be enhanced by involving South African skill base to benefit other parts of the region.

7.2.6 Green energy infrastructure development

Only 8 (3%) of respondents agreed with the statement that existing energy infrastructure supports the diffusion of green energy in the region, 45 (15%) had a neutral view while 248 (82%) did not agree with the statement. The correlation between this variable and the dependent variable are significantlee negative and has the correlation coefficient -0.352. The mean score is 2.69 indicating that the majority of respondents are negative.

In developing countries, the bulk of the region's poor residents are dispersed in rural settlements, conventional grid electrification is considered too costly for most of rural communities and there is a need for collaboration between the developing countries to ensure that renewable energy technologies are properly utilised (Chineke and Ezike, 2010). The majority of SADC countries do not have networks that are suitable for green energy. The advent of green energy exploitation also makes it imperative that transmission networks development is ready as soon as the generation capacity is in place. According to SACREEE (2013: 17) the region has weak and limited electricity grid infrastructure that limits possible grid connection of renewable energy generated electricity, including "embedded generation.

7.3 THE ROLE OF NON-SIGNIFICANT RELATIONSHIPS

Statistically non-significant relationships that are presented in Figure 7.1 were assessed based on literature reviews. The view amongst energy practitioners is that once technology enables a move away from an energy sector that is being ruled by policy makers, centralists and regulators, you have a game changer in the energy sector.

Utilities around the world are changing their business models to ensure their sustainability in the face of these changes. Investment in green energy storage is suggested as a critical element to the successful access to green energy. This section presents a discussion of the possible reasons that lead respondents to indicate these variables as not significant.

7.3.1 Green energy governance

The African continent and the SADC region have regional institutions that are at the forefront of advocating for energy access, including the recently approved formation of SACREEE.

Most countries of the SADC region individually have a clear governance framework with respect to energy; the only challenge is that most of them are not geared to regional energy integration. Existing institutions in developing countries to date have failed to develop the necessary rules and channel the necessary resources to meet these challenges, moreover, many have limited membership or are mandated to address only a small subset of energy issues, and there is little coordination among them (Florini and Sovacool, 2009).

7.3.2 Green energy technology innovation

Empirical evidence indicated the factor as insignificant and not impeding widespread success of access to green energy. Most countries in the region have not yet assessed and mapped the potential of green energy in their countries. According to SACREEE (2013: 17) low R&D capacity and funding and little regional cooperation between R&D institutions in the region, the development of renewable energy and energy efficient sectors is contingent upon availability of requisite technical capacity to support the sectors.

There is consensus that anticipates a slow uptake of green energy, driven by low costs of fossils based sources, but this uptake will not grow exponentially to a point of driving industries in future. Literature revies have revealed that solar energy will be a preferred source for household needs, in the near future. Low carbon energy deployment particularly renewable energy needs to overcome various barriers before it can make its way into the mainstream; these barriers increasingly shift from the technical to the economic and institutional (Shum and Watanabe, 2009).

7.3.3 Green energy policy alignment

All countries in the region do have energy policies; a debatable issue is whether the current policy frameworks enhance the uptake of green energy to the benefit of the whole region and whether they are implemented accordingly. Policy makers are typically more concerned with immediate (rather than long-term) national (rather than global) effects of energy policies and one such immediate national issue is energy security (Jewell, Cherp and Riahi, 2014). Wandji (2013) indicates that an economic policy aimed at improving energy supply will not necessarily have a positive impact on economic growth in the short term. Government should play a central role in clean energy development by formulating and implementing a proper energy policy (Yuan et al., 2014). According to (SACREEE, 2013: 16) countries in the SADC region are in the process of developing various policies and strategies on renewable energy, these policies have tended to be more focused at country level. This has consequently led to opportunities of collaborating at regional level being missed.

7.3.4 Green energy local market development

The region lacks a comprehensive resource mapping of renewable energy resources, which is a crucial requirement in attracting huge investments in the sector (SACREEE, 2013: 17). The proliferation of green energy enterprises indicate that many countries in the region are exploring the possibility of investing in green energy. Regional planning to integrate the market can facilitate regional economic growth and development. To enhance the green energy market Dames (2011) states that development funding for energy access must be made accessible to IPPs to expedite faster delivery of projects. The market structure in the region must be unbundled to facilitate private sector participation.Currently the market structure is geared to sustain public utilities with a monopoly in energy generation.

7.4 THE DEPENDENT VARIABLE

7.4.1 Perceived access success to green energy

Literature refers to widespread access success to green energy access to be: reliable, affordable, economically viable, socially and environmentally acceptable energy (Oldfield, 2011; United Nations, 2012; EIA, 2013). The dependent variable has a significant positive correlation with variable A and B with correlation coefficient of 0.400 and 0.553 respectively. The correlation between variable K with variables G, H and I are significantly negative and have the correlation coefficient of -0.345, -0.306 and -0.352 respectively. The variable has a high mean score of 5.11 which means that respondents are in agreement that widespread access success to green energy can be attained in the region through green energy.

The SADC region has a number of countries with a large rural population, without access to modern energy services. Lior (2012) observes that there are no fundamental technical obstacles preventing universal energy access, however, a lack of effective institutions, good business models, transparent governance, and appropriate legal and regulatory frameworks are major obstacles. Lack of access to modern forms is not only confined to rural areas but it is having negative consequences on economic growth both in rural and urban areas, thus contributing to the vicious circle of poverty (Khennas, 2012).

SACREEE (2013) indicates that access to clean, reliable and affordable energy services for basic human needs at house hold level (e.g. cooking, refrigeration, heating, lighting and communication), health centres, schools and productive uses to improve productivity represent the minimum levels required to improve livelihoods in the poorest countries and to drive local economic development on a sustainable basis.

7.5 ADDRESSING THE RESEARCH QUESTIONS

7.5.1 Primary research question

The primary research question was stated as follows: **"How can the SADC region intensify the exploitation of green energy sources and by doing so contribute to widespread access to modern energy sources to the larger population in the region.**

A breakdown of the SADC regional electricity generation sources shows that: coal contributes 74.3%, hydro 20.1%, nuclear 4% and gas/diesel 1.6%. The region has adequate fuel supply (coal reserves) to cover the lifetime of all existing fossil plants as well as that of future generation for several decades (DBSA, 2014). Literature indicates that high dependence on fossil fuel sources of energy for electricity generation is not improving widespread access success to modern energy to the vast majority of SADC region's populace.

In order to address energy poverty in the region, literature reviews in the previous chapters have revealed critical factors that can positively enhance widespread access success through green energy in developing countries. Literature reviews also debunked the fact that development of developed countries around the world has been energised by reliable and secured energy supply of modern energy. The main research question was answered through the identification of factors that have significant influence on the widespread access success to green energy in Chapter 4. The primary research question is further supported by the secondary research questions that are answered in Table 7.1.

7.5.2 Secondary research questions

Table 7.1: Secondary research questions	
Q_1	The study identified factors that influence widespread access success to green energy and tested those factors from literature empirically to various categories of respondents who are based in the SADC region. Energy practitioner's views were tested to assess whether there were differences in their opinions about widespread access success to green energy.
Q_2	The study highlighted various reasons that are considered to be barriers to the transition to low carbon energy solutions and are impeding the augmentation of green energy access in the African continent, SSA region and the SADC region. Literature reviews indicate that if universal access to energy is to be achieved, the barriers are not insurmountable, but they will require the collective strengths of national governments, the private sector, and civil society to overcome.
Q_3	The study identified various economic and environmental benefits that can be obtained through a successful access to green energy in the region. Empirical evidence indicated that from a total of 301 respondents, 75% of respondents agreed that the success of widespread access success to green energy will be characterised by economic growth augmentation and 80% of respondents agreed that access will be charactarised by environmental pollution mitigation.
Q_4	The study discussed the importance of effective energy governance structures to ensure widespread access success to green energy in the region. A conceptual theoretical model was tested; green energy governance structures variable was empirically tested to ascertain their effectiveness in the SADC region currently. Empirical evidence indicated that the available governance structures were suitable to advance green energy access in the region.
Q_5	The study assessed the suitability of policy frameworks in the region and their alignment to the augmentation of green energy access in the region. The conceptual theoretical model was tested and empirical evidence indicated that policy alignment is not a significant factor. Slow implementation of energy policies geared to green energy is potentially a challenge that is impeding a high uptake of green energy.

Q_6	The study empirically tested green energy financing as a barrier to the successful access to green energy in the region. Green energy projects financing variable was found to be significantly negative.
Q_7	The need to have human capacity development to facilitate the augmentation of green energy access in the region was discussed and empirical tested. Respondents in the region did not consider lack of technical skills as a main factor responsible for poor access to green energy in the region currently. Empirical evidence indicated that the factor to be significantly negative.
Q_8	The study identified the impact of energy infrastructure development in the augmentation of green energy access in the region. Literature reviews indicate that suitable infrastructure for the augmentation of green energy is a necessity and it was confirmed by empirical evidence.
Q_9	Literature indicated that local market development can be a catalyst to a successful access to green energy in the region. The market for green energy exists and it is slowly growing. Empirical evidence found the variable to be non-significant in terms of influencing green energy access in the region currently.
Q_{10}	A conceptual theoretical model was developed that provided unambiguous definitions of green energy factors. The theoretical model was validated by empirical evaluation through a research instrument developed with a set of questions addressing the identified factors that can potentially influence widespread access success to green energy.
Q_{11}	Chapter 7 interpreted empirical results, made conclusion from empirical results interpretation, and presented recommendations to ensure widespread access success to green energy and also made recommendations for future research. The limitations of the study are also highlighted in this chapter.

7.6 MEETING THE OBJECTIVES

7.6.1 Primary objective

The primary objective of this research was to debunk how widespread access success to green energy can be increased by investing into the green energy sector in the SADC region.

Literature was reviewed and a research problem was identified as stated in Chapter 1. A plea was also noted in literature, made by the United Nations and other stakeholders in the energy sector with regard to energy poverty in developing countries. The United Nations had called upon world leaders to adopt universal access to modern energy services by 2030 as a critical long-term priority and a catalyst that can be attained by investing in renewable particularly in developing countries (United Nations, 2012). SE4ALL (2014: 115) argue that "achieving universal access in SSA region would depend more heavily than elsewhere on mini-grid and isolated off-grid solutions, where a relatively high proportion of those lacking electricity live in rural areas".

The primary objective of this study was achieved through literature reviews and an empirical investigation which measured perceived widespread access success to green energy as a dependent variable, to respondents in the energy sector in the SADC region (n=301). The empirical data collected were analysed using statistical tests which included hypotheses testing. Statistical tests indicated factors that are significantly positively correlated to the dependent variable; significantly negatively correlated to the dependent variable and variables that are not-significantly correlated to the dependent variable as indicated in Figure 7.1 above. Results were interpreted and conclusions are drawn in Chapter 7. The study also addressed secondary objectives identified in Chapter 1 as indicated in section 7.6.1. Table 7.2 presents secondary research objectives and how the objectives were met.

7.6.1 Secondary objectives

Table 7.2: Secondary research objectives		How the objective was met
O_1	To test the relationship of identified factors that are key drivers to widespread green energy access success according to literature and energy practitioners in the region.	Factors were identified in Chapter 4 and categories of respondents in the SADC region energy sector were identified in Chapter 5. The relationship between factors and views of different categories of respondents pertaining to identified factors were tested empirically in Chapter 6 and interpreted with conclusions drawn in Chapter 7.
O_2	To investigate barriers that impedes the augmentation of widespread access success to green energy in the SADC region.	Literature reviews in Chapter 2 analysed factors that are considered to be barriers to the widespread access success to green energy.
O_3	To give an overview of the economic and environmental benefits that can be attained from the widespread access success to green energy.	Literature reviews in Chapter 2 and Chapter 4 discussed economic and environmental benefits that can be attained from successful widespread green energy access in the region. This was also tested in Chapter 6.
O_4	Give an overview of existing energy structures in the SADC region and assess their effectiveness and adequacy in driving widespread access success to green energy.	Existing governance structures in the SADC region were discussed in Chapter 3, and the views of respondents about their effectiveness and adequacy were tested in Chapter 6.

O_5	Give an overview of existing energy policies in the SADC region and assess their alignment to enhance widespread access success to green energy.	Existing policy frameworks in the SADC region were discussed in Chapter 3; their alignment to enhance widespread access success to green energy was tested in Chapter 6.
O_6	Conduct an in depth assessment of how green energy projects financing is conducted around the world and how it impact the widespread access success to green energy.	An in-depth assessment of how green energy projects financing are conducted around the world is discussed in Chapter 2 and how it is impacting the success of widespread access success to green energy in the region was tested empirically in Chapter 6.
O_7	Investigate the impact of limited human capacity development in the widespread success of access to green energy in the SADC region.	The importance of human capacity development was discussed in Chapter 2 and Chapter 3. The empirical evaluation of the factor's impact to widespread access success to green energy in the SADC region was conducted in Chapter 6.
O_8	Investigate the impact of limited infrastructure development that can enhance the widespread success of access to green energy in the SADC region.	The importance of infrastructure development for green energy was discussed in Chapter 2 and Chapter 3. The empirical evaluation of the factor's impact on widespread access success to green energy in the SADC region was conducted in Chapter 6.

O_9	Conduct an in-depth assessment of how the development of a green energy market is impacting the success of widespread green energy access in the SADC region.	An in-depth assessment of how the development of a green energy market is impacting the widespread access success to green energy in the SADC region was discussed in Chapter 3 and empirically tested in Chapter 6.
O_{10}	To propose a model validated by empirical evaluation of variables for implementation in the SADC region.	The proposed theoretical model was developed in Chapter 4 and empirically tested amongst the respondents in the SADC region energy sector in Chapter 6.
O_{11}	To discuss and interpret empirical results of the research and to make appropriate and meaningful recommendations based on the results of the statistical analysis.	Empirical results were discussed and interpreted and specific meaningful recommendations were made in Chapter 7.

7.7 RECOMMENDATIONS TO ADVANCE SUCCESSFUL WIDESPREAD ACCESS SUCCESS TO GREEN ENERGY IN THE SADC REGION

The energy sector is on the brink of a major change in developing countries as the cost of green energy and storage facilities continue to drop. This section attempts to make recommendations to practitioners who are associated with the energy sector, governments and NGOs, policy makers, investors, private sector, academics and energy interested and affected stakeholders both inside and outside the SADC region. Based on literature review and empirical results the following recommendations are made.

7.7.1 Strategic green energy planning

Energy planners, policy makers and regulators will need to re-shape energy and related services markets to keep pace with customers and the energy value chain needs in order to meet customer needs. Planning must enhance the growth and integration of green energy into the current energy mix in the region. Empirical evidence reveals that strategic energy planning is critical for the realisation of widespread access success to green energy. The RIDMP (2012: 20) indicates that access to energy for eight of the 12 SADC states on the mainland is below 35%. According to SAPP (2013a), present power generating capacity in Southern Africa indicates that the bulk of the 57 GW of current power generation capacity in SADC is from coal (70%), mainly in South Africa, hydro power (21%) comes mainly from the Zambezi River and Congo River basins; distillate oil (5%), nuclear (3%) and gas (1%) make up the rest. As assessment of the green energy potential of various green energy sources is recommended as a starting point for each country.

Energy demand and supply constraint must be identified with specific programmes that are biased to rural communities. At a country's level there must be clear targets defined for green energy penetration into the market. Interaction between public and private sector is imperative in order to identify viable green energy sources to be prioritised. The SADC Energy Protocol provides for accelerated reforms in the energy sector with reforms focusing around the broad governance of the sector, and the protocol promotes private sector participation and encourages the SADC member states to create an enabling environment for private investment (DBSA, 2014). Enabling environment for private investment remains critical and programmes for implementation with clear actions and binding due dates for implementation is needed. Strategic green energy planning must incorporate green energy infrastructure development, projects finance and human capacity development as priorities amongst SADC region's member countries.

7.7.2 Green energy local market development and integration

Empirical evidence has revealed that the slow development of a green energy market is currently not impeding widespread access success to green energy in the SADC region. It is however imperative that the regional green energy power market is developed to benefit local IPPs that are capacitated by innovative financing structures and this would reduce the risks to green power investments. Dames (2011) points out that it is also critical that the local market green energy power projects are adapted to local conditions to optimise the profitability for green energy small and medium enterprises. The success of projects that have ensured regional integration interconnection of RSA, Botswana and Zimbabwe in 1995 allowed for diversification through integration of thermal and hydro resources are already in place.

According to Dames (2011) such projects integration offers access to larger market where potential exceeds the host country needs and assists in bankability of projects e.g. Apollo-Cahora Bassa scheme which allowed for hydro potential of the Zambezi to be developed, with power being delivered in SA and wheeled to Southern Mozambique. The same intervention is required for other energy sources that include solar and wind resources and hydro. Integrating the energy market will contribute substantially to green energy access success in the region.

7.7.3 Independent power producers

Competitive bidding and a drop of price in renewable energy is critical and addressing storage is the key to green energy successful access. Power supply is still largely the responsibility of the authority in most countries of the SADC region. This is mainly due to the association of power supply to the country's security.

Power generation in the region is largely generated by power utilities that have a monopoly with very limited scope of operation in the private sector. A recent IRENA study on the prospects for renewable energy in the Southern Africa Power Pool has found that if transmission and distribution infrastructure is systematically expanded to accommodate peak system demand, renewables could account for 46% of the regional generating mix by 2030 (IRENA, 2013b). Baleni (2014) indicates that SADC has identified four hydro power plants as priority areas in meeting these renewable energy targets: Mpanda-Nkuwa in Mozambique, Inga III in the DRC, Batoka Gorge project between Zambia and Zimbabwe as well as Lesotho Highlands Water Project Phase II in Lesotho. These projects, along with other projects are expected to meet the region's green energy requirements and to offer a sustainable alternative to the fossil fuel electricity generated. It is recommended that an enabling environment is created to facilitate the entry of IPP's and help them in concluding Power Purchase Agreements (PPA's) with relevant power utilities.

7.7.4 Regulatory and policy frameworks alignment

SACREEE (2013: 16) indicates that despite the commonalities in energy sector circumstances and needs across most of the countries, the policy measures being developed by the different countries are quite diverse and in some cases, work contrary to measures in the next country. Empirical evidence on green energy policy alignment in the region was found to be non-significant; this is primarily due to the fact that energy policies and regulation are in place in most countries in the SADC region. It is prudent that countries which are lagging behind in effecting reform and implementation in their energy policies are supported accordingly.

RIDMP (2012: 32) indicates that nine countries have regulatory agencies that are members of the Regional Electricity Regulators Association (RERA); four countries (Botswana, DRC, Mauritius and Seychelles) were in the process of establishing regulators. Due to the regularity reforms, the region is experiencing economic liberalisation, commercialisation, unbundling of state-owned monopolies and public utilities as well as opportunities for private sector participation in the sector (DBSA, 2014). Policy implementation is another critical area that the region must be decisive on to ensure that deadlines are met and the benefits of reforms become a reality. In some countries in the region, for example South Africa, regulatory reforms are also resulting in the unbundling of generation, transmission and distribution in the electricity sector including the introduction of independent power producers (IPPs), as well as an increase in the number of stakeholders in other sub-sectors, i.e. liquid fuels and renewable energy (DBSA 2014). Revision of the regulatory frameworks in relation to the participation of IPP's must be implemented without delay.

7.7.5 Governance (enabling institutional arrangements)

Empirical evidence indicates that governance was found to be non-significant factor primarily because the SADC region has established energy governance structures. With the recent establishment of SACREEE, the prospects for the uptake of green energy are boosted significantly.

7.7.6 Green energy projects financing

Lack of experience in financing renewable energy projects is a challenge. Financial services providers lack the skills to appreciate the business potential of renewable energy investment projects and project developers do lack skills to identify, develop and package projects in such a manner that financial services providers can get meaningfully engaged (SACREEE, 2013: 19).

Empirical evidence indicates that green energy financing is a negatively significant factor. PIDA (2011) indicates that behind the under exploitation of energy resources in Africa, lies poor capacity to mobilise financing for investment, especially from private sources, owing to the poor credit worthiness of countries and utilities and high political risks. In order to finance projects, the region needs secured off-take at guaranteed tariffs, not the approach of incentive schemes. These tariffs will be cost-competitive (incentive scheme can be misconstrued to be a subsidy). All that is required is to have them guaranteed for a certain period which should be linked to the lifetime of the assets for example, 20 years for wind, 25 years for PV. The longer the tariff is guaranteed for, the lower the tariff can be. Green energy technologies are capital intensive (the investor has to pay your fuel bill for the next 20 years upfront, today), but with the right off-take regime in place, significant amount of local funding can also be utilised, not only from banks, but also from private individuals (e.g. PV on rooftops).

Financing green energy projects in the SADC region will strongly depend on how the “incentive scheme” is structured. That is what make these technologies capital intensive (with capital representing 80-90% of the total discounted lifetime costs of these projects) whereas in the case of coal the capital can be estimated at 30-40% of the total lifetime costs. Microfinance is one of the best forms of financing for green energy projects in the region and trends indicate that carbon financing will form a crucial part for energy investments in Africa and this will certainly have implications for the region. The region must overcome the impression that donor funds are still largely channelled into research and pilot programmes and not enough to large scale implementation. Green energy investments can facilitate the reduction of electricity tariffs due to the competitive pricing that can be obtained from competitive bidding of IPP’s and there must be defined binding targets.

7.7.7 Green energy infrastructure development

Most countries in the SADC region have unstable grid networks; the problem is further compounded by the country's un-maintained electricity distribution network infrastructure. Development of green energy infrastructure can only be a benefit to the region, when these severely constrained transmission networks are refurbished. IPPs who are exploiting green energy can benefit substantially from these networks. The potential to trade with generated green energy will be severely hampered by the lack of transmission constraints. This is true for hydro power projects that include Cahora Bassa North Bank extension, Mozambique and the grand Inga project in the DRC.

7.7.8 Green energy technological innovation

Reliability and security of supply is central to any switch to an alternative energy source. Currently in the SADC region the use of wind, solar, may require one to have support of other sources such as nuclear or coal power to supply in case of emergency. Hydro will be a significant contributor in terms of base load, but it is not the only option in the region. There are no indications of a significant potential for cost-efficient use of wave energy on a large scale.

There is a serious challenge when it comes to security of infrastructure. FDI to Inga for example, will be a challenge given the political situation in some parts of the SADC region and guarantees will be necessary. Grand Inga is not a prerequisite for large-scale green-energy access in the SADC region; there are other viable options such solar. Lack of support for the small scale development of green technologies can have a detrimental impact in the development and growth of green energy in regions. The stand-alone or off-grid systems are the best choice of rural electrification when expanding the grid-connected electricity is not feasible.

Grid extension to the rural areas is faced with difficulties in most parts of the world such as extensive geographical area with dispersed communities and low electricity demand, which leads to an enhancement in installation cost. SACREEE (2013: 17) indicates that there are limited capacities to identify, develop, and implement innovative renewable energy projects. There are no platforms to identify innovators, develop their ideas and provide them with skill and knowledge and ultimately link them to financing so that new technologies could be developed and become main stream.

7.7.9 Human capacity development

Requisite technical skills are critical in order to sustain green energy sector growth. Shortage of technical skills is the root cause of the slow uptake of green energy; skills will come together with the investments, which will come after the right off-take regime is in place. One of the biggest challenges in the region is lack of adequate skills, linked particularly to decision-makers, hampering optimal decision-making and the optimal green energy plans implementation. Regional energy institutions must strive to attract much needed skills to maintain policy and regulatory stability and to plan, manage, construct, run and maintain green energy projects. Human capacity development to increase green energy investment in the region is critical across the value chain of the electricity generation, transmission and supply industry.

Skilled green energy practitioners will ensure that innovations through R&D are optimised, and ensure that green energy technologies are integrated in the regional and national grids. SACREEE (2013: 17) indicates that the region does not have critical mass of qualified engineers and technicians in these sectors; in addition, there is limited collaboration on R&D amongst universities within countries and in the SADC region.The region must facilitate the transfer of skills to where it is needed to manage projects.

7.7.10 Economic growth augmentation and environmental pollution mitigation

Empirical evidence revealed that both environmental and economic benefits are significantly correlated to widespread access success to green energy in the SADC region. Construction of energy infrastructure generates jobs and wealth to the community. Access to green energy will boost the development. The real driver of access success will be realised as soon as renewables are cost competitive. Significant positive relationships to the dependent variable are green energy economic augmentation and environmental pollution mitigation.These two factors are both the outcome benefits of a perceived widespread access success to green energy. The slow uptake of green energy can also be attributed to lack of full understanding of the required policies to foster the renewables growth most effectively and cost-efficiently.

Large scale hydro and other green energy resources can contribute to the reduction of GHG emissions in the region. Developing countries have recently received increased financial support from developed nations to help them effectively deal with climate change related issues (Abanda, 2012; Abanda et al., 2012). Climate change mitigation finance was one of the main items on the agenda of the recently held COP 17 in Durban South Africa.

Despite all these promising initiatives, some of the developing countries have had mixed opinions in terms of which the real beneficiaries of this global climate change strategies are. Carbon storage options must be explored extensively; this can be attained by investing in GHG resources and transmission networks. All stakeholders, including civic society, environmental activists and other interested and affected parties need to be kept informed about green energy developments through awareness programmes.

7.7.11 Perceived green energy access success

Empirical results and literature reviews have revealed that the success of green energy access will be influenced by an uptake of green energy in the energy mix; the supply will have to be reliable for daily peak and seasonal requirements. Affordability is critical particularly for rural communities. It is crucial that both household and commercial needs are met by the supply of green energy. It is imperative that energy is not wasted; measures to ensure that it is efficiently used must be implemented. Social acceptability is also key, nuclear energy, for example, suffers from credibility due to radioactive waste even though it is a low carbon energy resource. The success of accessing green energy can by gauged by the level of social acceptability by communities who are beneficiaries to a green energy technology.

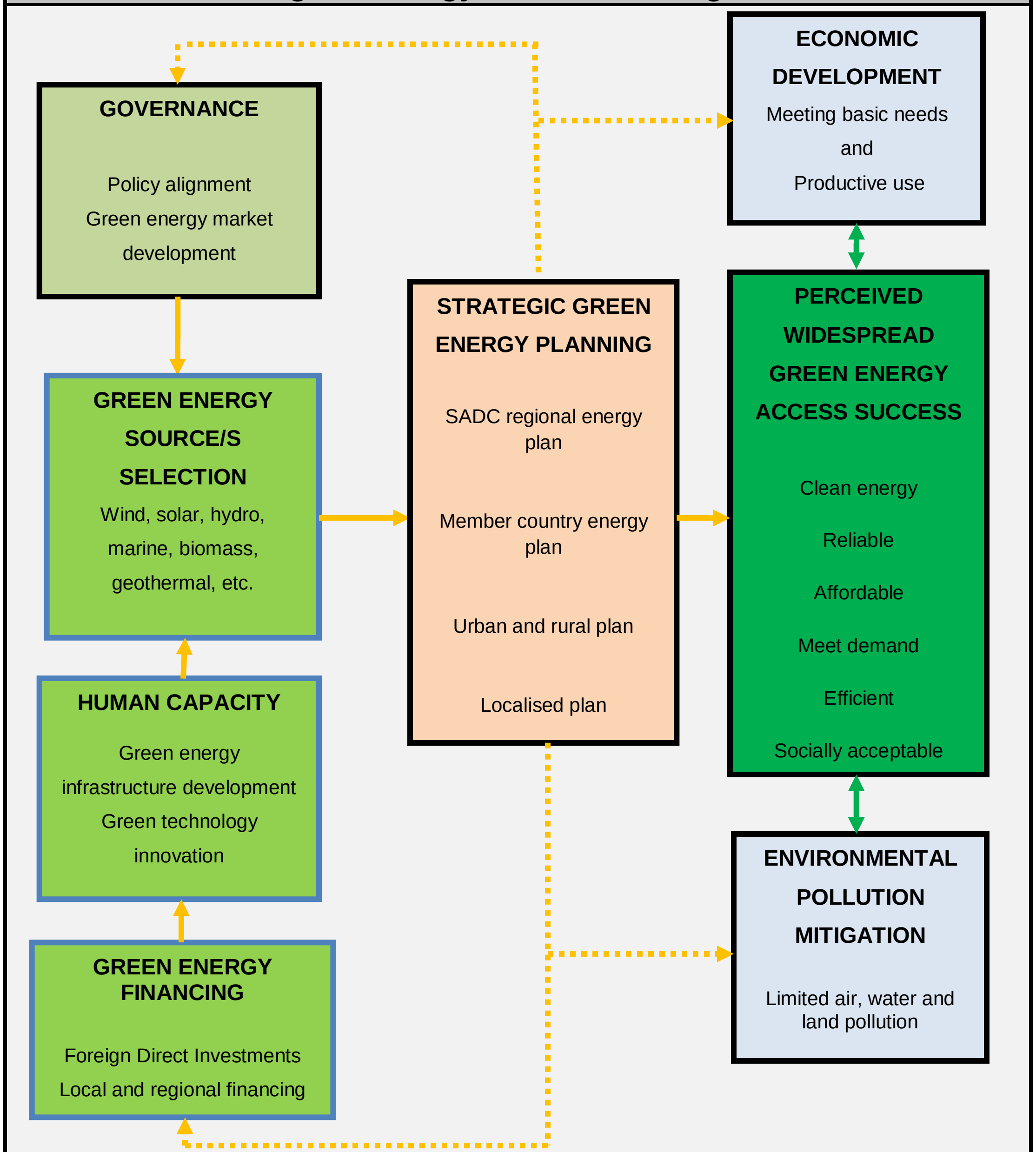
7.8 IMPLICATIONS OF THE STUDY ON THEORY AND BODY OF KNOWLEDGE

The study demonstrated that green energy presents an invaluable opportunity to address the dire energy access disparities in the region that has negatively impacted the quality of life for millions of people for decades. SADC region's newly SACREEE can benefit from the results of this study because it offers specific recommendations on how to enhance widespread access success to green energy that will transform millions lives particularly rural communities that have been trapped in a vicious cycles of poverty for generations. In summary, this research has provided a model framework that is specific to the SADC region's countries that can be used to unlock energy access opportunities through green energy exploitation.

Implications of this study in response to the United Nations (2012) call to countries' leaders to consider renewable energy as a solution to improve access to modern energy is that: other regional energy bodies in the African continent and other regions in developing countries can use the model framework in this study to explore applicable factors that can stimulate the uptake of green energy. Empirical results revealed factors that have significant positive and significant negative relationships, including factors that were found to have non significant relationships to the dependent variable as illustrated in Figure 7.1. These results influenced the construction of a recommended empirical model to augment widespread access success to green energy for the SADC region's countries. The outcome of the study was presented to energy specialists with the recommended empirical model for their input in order to validate the model. Most of the specialists are acknowledged in the acknowledgements section of the thesis. Their inputs were incorporated in the final recommended empirical model.

The recommended empirical model illustrates that green energy alternative choice involves a selection of a viable green energy source influenced by governance, policies and the market in a country. The selection is also influenced by the human capacity and the availability finance. The selected green energy source influences the project planning for implementation, whether it will be a national, regional or alocalised activity. The success of a green energy project hinges in the planning and execution of the plan. An executed plan leads to widespread green energy access success that stimulates economic development and also contributes to environmental pollution mitigation. Strategic green energy planning is a dynamic process that is influenced by changes in governance, availability of finance and human capacity to execute the project. Figure 7.2 illustrates a recommended empirical model to augment widespread access success to green energy for the SADC region's countries.

Figure 7.2: A recommended empirical model to augment widespread access success to green energy for the SADC region's countries



Source: Researcher's own construction

7.9 LIMITATIONS OF THE STUDY

Certain limitations should be taken into account in drawing conclusions about the study. The current study was conducted when many renewable energy projects and fossil fuel energy projects in many parts of the region are currently being constructed, some are being commissioned in piecemeal; this might affect the energy access situation indicated in the abstract section and can also misrepresent the actual SADC region's country's energy access percentages. Green energy was largely focused on electricity generation and access to other liquid fuels sources of energy were under explored in the study; the focus was primarily electricity energy access.

Efforts were made to solicit responses from island countries that are part of the SADC region, but because of time constraints and language barriers, no feedback was obtained from islands states. Respondents were mainly from mainland countries of the SADC region. Sampling was conducted within a premise of quota sampling with the aim to improve representativeness of respondents, a large number of enterprises sampled have head offices in South Africa and also operate in other parts of the SADC region. South Africa has the largest economy in the region with an installed electrical capacity and generates over 80% of the SADC's regions power and the biggest quota is comprised by respondents who are based in South Africa.

Perception about green energy economic augmentation and environmental pollution mitigation, were not tested for internal consistency because there were not enough items included in the survey instrument to measure them. Cronbach alphas for these two variables are indicated by (n.a). Three variables showed moderate reliability with Cronbach's alpha values greater than 0.5, a similar number were greater than 0.6 with 4 variables showing Cronbach alpha greater than 0.7.

A Cronbach’s alpha value of 0.46 was noted for one variable (strategic green energy augmentation) which indicate poor -moderate correlation.

7.10 RECOMMENDATIONS FOR FUTURE RESEARCH

Empirical results of this study have created opportunities for expanding this research. A number of factors were found to have non-significant relationship with the dependent variable, even though they were strongly supported by literature and they include: green energy governance, green energy technology innovation and green energy policy alignment and green energy local market development. The identified factors in the study can also be tested per country in the region to ascertain the nature of their influence in a country specific energy sector environment, including in islands states.

The same factors can also be examined to see if they have the same influence on liquid fuels that were not included in the scope of this study. There is also a need to consider other stakeholders, including civic society, environmental activists and other interested and affected parties who were not included in the identified categories of respondents about their view with regard to green energy developments. A similar study can also be conducted in other regions of the African continent and developing countries around the world.

7.11 CONCLUDING REMARKS

Access to green energy will not only improve the living conditions of the rural masses who do not have access to modern energy services in the region, but it will address one of the shortfalls in the supply of peaking power required to meet the daily (morning and evenings) and seasonal (winter) peaks when most power is required on the grid network in urban areas. Over the past three decades, very limited generation has come on energy stream.

No new power stations have been constructed over the past 30 years until recently when some power stations units and renewable energy projects are due to be commissioned soon in South Africa and other parts of the SADC region. The SADC region is endowed with vast green energy sources that remain largely untapped. The diversity in energy endowment of each country in the region provides a unique opportunity to benefit the whole region. A sustainable solution to energy poverty also lies in the engagement with the prospective recipients of green energy to prevent the risk of resistance to green energy technologies during the implementation of such projects.

The potential of green energy transformative impact to the socio-economic development and environmental pollution mitigation as revealed by the study can change the wellbeing and quality of life for the citizens of the region. Access to modern energy for rural communities can be a catalyst for economic development that improves the poverty situation that characterises both urban and rural citizens in the region. This research has exposed critical factors that have an impact to widespread access to energy and it is hoped that it will encourage more researchers to fill existing knowledge gaps in the area of green energy access in the region in order to persuade all role players to work towards the same objective of improving access to modern energy services. The potential of the green energy sector to inspire energy industrialists and IPPs and other entrepreneurs must be natured diligently to boost economic development and environmental protection in the region.

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ANNEXURE 1: A Survey covering letter and survey instrument

FINAL RESEARCH QUESTIONNARE

01 August 2014

Dear Respondent

RESEARCH PROJECT: THE DEVELOPMENT OF A GREEN ENERGY (RENEWABLES AND LOW CARBON ENERGY SOURCES) SECTOR MODEL FOR THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

I am a Doctoral degree in Business Administration (DBA) student and I am conducting research in conjunction with the Nelson Mandela Metropolitan University, on the above mentioned topic. The purpose of the research is to establish factors that influence access success to green energy in the SADC region. Kindly note that your anonymity is assured and all responses will be treated in the strictest confidence. We would be grateful if you could complete the questionnaire latest by 30th November 2014.

Thank you for your willingness to contribute to the success of this research project.

Yours faithfully,

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RESEARCH PROJECT: THE DEVELOPMENT OF A GREEN ENERGY SECTOR MODEL FOR THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC)

Dear Survey Participant

Only one answer is required per question. There are two sections and to ensure full accuracy of the survey results, we would like you to answer the questionnaire carefully and complete all questions. It should take about 15 minutes of your time.

SECTION A: Demographic Information (anonymity will be assured and responses will be treated with the strictest confidentiality)

Please complete the demographic section first

1	**Number of years working or affiliated to an energy organisation/related sector**	
2	**Position/ role (Optional)**	
3	**Gender (Optional)**	
4	**Email address (Optional)**	
5	**Contact numbers (Optional)**	

SECTION B: Questionnaire

A number of factors that can potentially influence widespread access of green energy and green energy sector development in the SADC region are listed below. With reference to specific successful green energy programmes/projects that you have been involved in, familiar with or associated with in the last five years, please indicate to what extent you agree or disagree with the statements by using the scales indicated below and marking the appropriate box ☒ next to the number in each row.

Please note that there are no correct or incorrect answers, we are only interested in your opinion. Please answer all questions.

1 = strongly disagree; 2 = disagree; 3 = somewhat/slightly disagree; 4 = neither agree nor disagree (neutral); 5 = somewhat/slightly agree; 6 = agree; 7 = strongly agree.

N0	REF	Statement	S disagree ◄──► S agree						
1	C	I fully identify with the view that widespread access to modern energy sources will be facilitated by the diffusion of green energy in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
2	A	Generally, generating electricity from green energy sources is well planned by most countries in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
3	B	Energy policies are generally earmarked for green energy exploitation in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
4	D	Existing energy infrastructure supports the diffusion of green energy in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
5	E	I am satisfied with the participation of local communities in green energy projects that I am familiar with	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
6	F	I fully support the provision of incentive schemes for independent power producers who generate electricity from green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
7	G	Skills to drive the green energy sector are inadequate in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
8	H	The region's energy governance structures are in place	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
9	M	I am convinced that widespread access to modern energy services in the region will be attained through the augmentation of green energy	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

10	D	Existing energy infrastructure cannot augment green energy access in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
11	CI	High upfront costs for green energy technologies are a detriment to the growth of a green energy sector in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
12	JM	I have noticed that access to green energy is improving the quality of life of rural communities in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
13	E	Green energy technology is tailored to suit local conditions in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
NO	**REF**	**Statement**	**S disagree ◄—► S agree**						
14	C	The region will depend on fossil fuels energy technologies for a considerably longer period	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
15	F	Green energy technologies receive less funding than fossil fuel technologies from donors to finance energy projects in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
16	HM	Interventions to augment green energy by regional organisations such as Southern Africa Power Pool (SAPP) is adequate	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
17	E	Consumers, suppliers, interested, affected parties and local authorities participate during the deployment of green energy projects	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
18	HM	Interventions by continental organisations such as the New Partnership for Africa's Development (NEPAD) to augment green energy access are adequate	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
19	A	I have observed that affordable energy services in rural parts of the region are being realised through green energy	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
20	G	Low levels of technical skills are one of the factors responsible for poor growth of the green energy sector in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
21	BI	Energy policies in the region generally do not prioritise green energy development	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

22	I	Political instability is one of the obstacles to green energy investments attraction in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
23	H	There are insufficient public and private partnerships to expedite the expansion of the green energy sector in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
24	AJ	I am convinced that strategic green energy planning will successfully address energy poverty in remote rural populations in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
25	I	Large scale development of green energy infrastructure is being resisted by local communities	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
26	GK	The region's green energy skills base is being drained by developed countries	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
27	M	I am satisfied with pronouncements by political leadership in the region encouraging the augmentation of green energy to improve access to energy	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
NO	**REF**	**Statement**	**S disagree ◄—► S agree**						
28	I	Lack of political will is impeding green energy sector growth in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
29	G	Limited number of institutions to train and develop green energy practitioners is delaying green energy sector growth in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
30	HK	I am aware of the role of SAPP in advancing energy access in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
31	A	Energy planning processes that I have been exposed to incorporated green energy augmentation in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
32	C	Technologies for generating green energy is being imported from developed countries	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
33	A	Energy demand in the region is unlikely to be met by electricity generated from green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

34	KM	I fully support the view that widespread green energy access in the SADC region lies with the development of the Grand Inga project in the Democratic Republic of Congo (DRC)	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
35	AB	By the year 2030 more than 50% of generated electricity will come from green energy sources in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
36	E	Green energy research and development initiatives are inadequate in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
37	IK	Intermittency (unreliability) of some green energy sources is discouraging investments into green energy sector	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
38	M	I am satisfied with interventions by governments in the region to optimally exploit electrical energy from green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
39	D	Electrical energy grids infrastructure needs revamping in order connect energy from green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
40	L	Nuclear energy is the most viable option to increase access to green energy on a large scale	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
41	B	Generally, energy legislation in the region promotes electrical generation through green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
42	F	Introduction of incentive schemes, namely feed-in tariffs and renewable energy certificates, are necessary to attract independent power producers into the green energy sector	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
NO	**REF**	**Statement**	**S disagree ◄──► S agree**						
43	L	Hydro energy is the most viable option in the region to increase access to green energy on a large scale	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
44	C	Fossil fuel energy technology is the preferred technology in the region to generate electricity	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

45	F	I fully support the argument that, investing in green energy is too risky and it is discouraging potential investors to invest in the sector	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
46	L	Wind energy is the most viable option to increase access to green energy on a large scale in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
47	B	Energy policy frameworks are fully geared to green energy exploitation	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
48	L	Solar energy is the most viable option to increase access to green energy on a large scale in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
49	EF	The risk of unsustainable revenues is an impediment to attract investors to fund green energy projects	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
50	L	Biomass is the most viable option to increase access to green energy on a large scale in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
51	D	Available energy facilities/infrastructure are poorly maintained in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
52	L	Wave energy is the most viable option to increase access to green energy on a large scale in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
53	EI	The profitability of an investment in green energy cannot be guaranteed in this region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
54	L	Geothermal energy is the most viable option to increase access to green energy	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
55	A	Strategic energy plans to accelerate access to green energy is being implemented in most countries in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
56	H	Monopolising the energy sector by governments in the region negatively impacts the growth of the green energy sector	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
57	B	Energy policies in the region have been influenced by the need to generate energy from green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

58	M	Green energy's potential in the region is adequately researched and documented	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
NO	**REF**	**Statement**	**S disagree ◄──► S agree**						
59	CM	I fully identify with low carbon energy technology to minimise the release of greenhouse gases in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
60	D	This region requires tailoring up of electrical grid infrastructure to transmit energy generated from both fossil fuel and green energy sources	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
61	J	Green energy projects are enabling job creation opportunities in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
62	F	A significant amount of external funding is required to finance the expansion of green energy in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
63	H	There are efficient energy governance structures to grow a green energy sector in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
64	G	I agree with the view that a lack of skills has affected the success of green energy projects in the past	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
65	H	Collaborations among governments in the SADC region to improve access to green energy is inadequate	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
66	KM	Political stability to enable the augmentation of green energy is satisfactory	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
67	J	Access to green energy by rural marginalised communities will boost industrial and agricultural development in the region	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
68	G	Adequate skills capacity is being developed to stimulate the growth of a green energy sector in the region.	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
69	D	Lack of infrastructure that supports green energy electricity generation is an impediment to green energy access augmentation	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

70	J	Access to electricity from green energy sources will enable efficient service delivery including health and education services provision in rural areas	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
71	F	I acknowledge the argument that a poorly developed financial sector in most countries in the region impacts negatively on investment in the green energy sector	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
72	JK	The threats of climate change and global warming are a main driving force behind the region's green energy considerations	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

ANNEXURE 2: Central tendency and dispersion of factors

Variables	Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
A. Strategic green energy planning	4.53	1.09	1.00	3.67	4.67	5.33	7.00
B. Green energy economic augmentation	4.96	0.97	1.33	4.50	5.00	5.67	7.00
C. Environmental pollution mitigation	5.61	1.34	1.00	5.00	6.00	7.00	7.00
D. Green energy governance	3.54	0.83	1.11	3.00	3.56	4.00	5.78
E. Green energy technology innovation	2.91	1.63	1.00	2.00	3.00	4.00	7.00
F. Green energy policy Alignment	3.78	0.89	1.67	3.17	3.83	4.33	6.00
G. Green energy projects Financing	2.48	1.00	1.00	1.67	2.33	3.00	7.00
H. Human capacity development	2.80	1.16	1.00	2.00	2.75	3.50	7.00
I. Green energy infrastructure development	2.69	0.92	1.00	2.00	2.60	3.40	6.40
J. Green energy local market development	3.37	0.80	1.43	2.86	3.29	3.86	6.29
K. Perceived widespread access success to green energy	5.11	1.27	1.00	4.50	5.00	6.00	7.00
L. Viability of various green energy sources	3.97	0.94	1.00	3.43	3.86	4.57	7.00

ANNEXURE 3: Frequency distribution of responses per factor

Variables	[1.00 to 1.86)		[1.86 to 2.71)		[2.71 to 3.57)		[3.57 to 4.43]		(4.43 to 5.29]		(5.29 to 6.14]		(6.14 to 7.00]	
A. Strategic green energy planning	2	1%	11	4%	39	13%	95	32%	74	25%	59	20%	21	7%
B. Green energy economic augmentation	3	1%	4	1%	14	5%	54	18%	108	36%	90	30%	28	9%
C. Environmental pollution mitigation	4	1%	6	2%	8	3%	41	14%	62	21%	86	29%	94	31%
D. Green energy governance	6	2%	44	15%	118	39%	92	31%	29	10%	12	4%	0	0%
E. Green energy technology innovation	60	20%	88	29%	65	22%	34	11%	24	8%	20	7%	10	3%
F. Green energy policy Alignment	5	2%	32	11%	90	30%	103	34%	53	18%	18	6%	0	0%
G. Green energy projects Financing	83	28%	113	38%	61	20%	34	11%	7	2%	2	1%	1	0%
H. Human capacity development	70	23%	79	26%	86	29%	41	14%	14	5%	6	2%	5	2%
I. Green energy infrastructure development	64	21%	89	30%	95	32%	45	15%	4	1%	3	1%	1	0%
J. Green energy local market development	6	2%	46	15%	124	41%	96	32%	28	9%	0	0%	1	0%
K. Perceived widespread access success to green energy	3	1%	11	4%	26	9%	32	11%	86	29%	80	27%	63	21%
L. Viability of various green energy sources	3	1%	19	6%	66	22%	133	44%	56	19%	18	6%	6	2%

ANNEXURE 4: Univariate ANOVA results A and B and post-hoc results A and B

Univariate ANOVA Results - A			
Effect	F-value	D.F.	p
Intercept	1380.534	**1; 249**	<.0005
Years.Cat	0.009	1; 249	.926
Energy Sector	0.15	1; 249	.699
Researcher.Industry	3.904	**1; 249**	.049
Region	9.636	**1; 249**	.002
Position	2.416	2; 249	.091

Post-hoc Results - A						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	4.51	-	<.0005	4.03
Years.Cat	<= Median 6	> Median 6	4.52	4.49	.926	0.02
Energy Se	Fossil Fuel	Renewables	4.50	4.51	.699	0.01
Researche	Researchers	Industry	4.34	4.54	.049	0.17
Region	South Africa	Other SADC	4.42	4.85	.002	0.39
Position	Junior Management	Middle Management	4.82	4.37	.176	0.47
	Junior Management	Senior Management	4.82	4.55	.521	0.22
	Middle Management	Senior Management	4.37	4.55	.466	0.16
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - B			
Effect	F-value	D.F.	p
Intercept	2371.092	**1; 249**	<.0005
Years.Cat	0.674	1; 249	.413
Energy Sector	1.905	1; 249	.169
Researcher.Industry	0.411	1; 249	.522
Region	12.856	**1; 249**	<.0005
Position	3.142	**2; 249**	.045

Post-hoc Results - B						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	5.00	-	<.0005	5.08
Years.Cat	<= Median 6	> Median 6	5.01	4.99	.413	0.02
Energy Sector	Fossil Fuel	Renewables	4.80	5.21	.169	0.36
Researcher.Industry	Researchers	Industry	5.23	4.96	.522	0.24
Region	South Africa	Other SADC	4.87	5.54	<.0005	0.61
Position	Junior Management	Middle Management	5.03	4.76	.423	0.28
	Junior Management	Senior Management	5.03	5.18	.758	0.12
	Middle Management	Senior Management	4.76	5.18	.004	0.38
* Scheffé Test if 3+ Levels, else t-Test						

ANNEXURE 5: Univariate ANOVA results C and D and post-hoc results C and D

Univariate ANOVA Results - C			
Effect	F-value	D.F.	p
Intercept	1392.323	**1; 249**	<.0005
Years.Cat	0.114	1; 249	.736
Energy Sector	0.172	1; 249	.679
Researcher.Industry	1.191	1; 249	.276
Region	4.425	**1; 249**	.036
Position	5.013	**2; 249**	.007

Post-hoc Results - C						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	5.68	-	<.0005	4.18
Years.Cat	<= Median 6	> Median 6	5.56	5.80	.736	0.22
Energy Sector	Fossil Fuel	Renewables	5.48	5.89	.679	0.37
Researcher.Industry	Researchers	Industry	5.84	5.66	.276	0.17
Region	South Africa	Other SADC	5.57	6.16	.036	0.54
Position	Junior Management	Middle Management	4.96	5.47	.218	0.52
	Junior Management	Senior Management	4.96	6.00	.001	0.85
	Middle Management	Senior Management	5.47	6.00	.012	0.48
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - D			
Effect	F-value	D.F.	p
Intercept	1637.435	**1; 249**	<.0005
Years.Cat	0.027	1; 249	.869
Energy Sector	4.125	**1; 249**	.043
Researcher.Industry	0.467	1; 249	.495
Region	1.621	1; 249	.204
Position	4.664	**2; 249**	.010

Post-hoc Results - D						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	3.50	-	<.0005	4.28
Years.Cat	<= Median 6	> Median 6	3.54	3.46	.869	0.07
Energy Sector	Fossil Fuel	Renewables	3.65	3.35	.043	0.27
Researcher.Industry	Researchers	Industry	3.32	3.53	.495	0.20
Region	South Africa	Other SADC	3.51	3.48	.204	0.02
Position	Junior Management	Middle Management	4.04	3.51	.011	0.55
	Junior Management	Senior Management	4.04	3.39	.001	0.54
	Middle Management	Senior Management	3.51	3.39	.520	0.11
* Scheffé Test if 3+ Levels, else t-Test						

ANNEXURE 6: Univariate ANOVA results E and F and post-hoc results E and F

Univariate ANOVA Results - E			
Effect	F-value	D.F.	p
Intercept	286.765	**1; 249**	<.0005
Years.Cat	0.2289	1; 249	.633
Energy Sector	2.3537	1; 249	.126
Researcher.Industry	0.3992	1; 249	.528
Region	1.8456	1; 249	.176
Position	4.4982	**2; 249**	.012

Post-hoc Results - E						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	2.92	-	<.0005	1.77
Years.Cat	<= Median 6	> Median 6	3.06	2.78	.633	0.25
Energy Sector	Fossil Fuel	Renewables	2.91	2.93	.126	0.02
Researcher.Industry	Researchers	Industry	2.89	2.92	.528	0.02
Region	South Africa	Other SADC	2.99	2.64	.176	0.31
Position	Junior Management	Middle Management	3.69	3.02	.174	0.69
	Junior Management	Senior Management	3.69	2.67	.016	0.84
	Middle Management	Senior Management	3.02	2.67	.288	0.31
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - F			
Effect	F-value	D.F.	p
Intercept	1391.993	**1; 249**	<.0005
Years.Cat	0.002	1; 249	.965
Energy Sector	0.09	1; 249	.764
Researcher.Industry	1.05	1; 249	.307
Region	0.164	1; 249	.686
Position	1.093	2; 249	.337

Post-hoc Results - F						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	3.75	-	<.0005	4.23
Years.Cat	<= Median 6	> Median 6	3.77	3.74	.965	0.02
Energy Sector	Fossil Fuel	Renewables	3.79	3.72	.764	0.06
Researcher.Industry	Researchers	Industry	3.61	3.78	.307	0.15
Region	South Africa	Other SADC	3.76	3.74	.686	0.02
Position	Junior Management	Middle Management	3.99	3.70	.343	0.30
	Junior Management	Senior Management	3.99	3.74	.451	0.20
	Middle Management	Senior Management	3.70	3.74	.930	0.04
* Scheffé Test if 3+ Levels, else t-Test						

ANNEXURE 7: Univariate ANOVA results G and H and post-hoc results G and H

Univariate ANOVA Results - G			
Effect	F-value	D.F.	p
Intercept	458.1015	**1; 249**	<.0005
Years.Cat	0.8622	1; 249	.354
Energy Sector	0.2473	1; 249	.619
Researcher.Industry	2.8295	1; 249	.094
Region	10.3606	**1; 249**	.001
Position	0.5229	2; 249	.593

Post-hoc Results - G						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	2.47	-	<.0005	2.41
Years.Cat	<= Median 6	> Median 6	2.54	2.39	.354	0.13
Energy Sector	Fossil Fuel	Renewables	2.57	2.36	.619	0.19
Researcher.Industry	Researchers	Industry	2.46	2.47	.094	0.01
Region	South Africa	Other SADC	2.57	2.04	.001	0.48
Position	Junior Management	Middle Management	2.62	2.58	.986	0.04
	Junior Management	Senior Management	2.62	2.35	.463	0.22
	Middle Management	Senior Management	2.58	2.35	.232	0.21
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - H			
Effect	F-value	D.F.	p
Intercept	373.3094	**1; 249**	<.0005
Years.Cat	0.8281	1; 249	.364
Energy Sector	0.6055	1; 249	.437
Researcher.Industry	0.092	1; 249	.762
Region	5.8141	**1; 249**	.017
Position	1.2528	2; 249	.288

Post-hoc Results - H						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	2.81	-	<.0005	2.40
Years.Cat	<= Median 6	> Median 6	2.86	2.76	.364	0.08
Energy Sector	Fossil Fuel	Renewables	2.79	2.83	.437	0.04
Researcher.Industry	Researchers	Industry	2.66	2.83	.762	0.15
Region	South Africa	Other SADC	2.89	2.49	.017	0.37
Position	Junior Management	Middle Management	2.53	2.84	.471	0.33
	Junior Management	Senior Management	2.53	2.84	.466	0.25
	Middle Management	Senior Management	2.84	2.84	.999	0.00
* Scheffé Test if 3+ Levels, else t-Test						

ANNEXURE 8: Univariate ANOVA results I and J and post-hoc results I and J

Univariate ANOVA Results - I			
Effect	F-value	D.F.	p
Intercept	635.5565	**1; 249**	<.0005
Years.Cat	0.3417	1; 249	.559
Energy Sector	0.7439	1; 249	.389
Researcher.Industry	0.7768	1; 249	.379
Region	0.8079	1; 249	.370
Position	2.155	2; 249	.118

Post-hoc Results - I						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	2.63	-	<.0005	2.82
Years.Cat	<= Median 6	> Median 6	2.73	2.53	.559	0.18
Energy Sector	Fossil Fuel	Renewables	2.79	2.46	.389	0.30
Researcher.Industry	Researchers	Industry	2.28	2.69	.379	0.36
Region	South Africa	Other SADC	2.69	2.37	.370	0.29
Position	Junior Management	Middle Management	2.95	2.80	.752	0.16
	Junior Management	Senior Management	2.95	2.43	.029	0.43
	Middle Management	Senior Management	2.80	2.43	.010	0.34
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - J			
Effect	F-value	D.F.	p
Intercept	1432.773	**1; 249**	<.0005
Years.Cat	0.153	1; 249	.696
Energy Sector	0.499	1; 249	.481
Researcher.Industry	0.257	1; 249	.613
Region	0.526	1; 249	.469
Position	1.1	2; 249	.334

ANNEXURE 9: Univariate ANOVA results K and L and post-hoc results K and L

Univariate ANOVA Results - K			
Effect	F-value	D.F.	p
Intercept	1345.239	**1; 249**	<.0005
Years.Cat	0.019	1; 249	.889
Energy Sector	0.169	1; 249	.681
Researcher.Industry	0.14	1; 249	.709
Region	12.511	**1; 249**	<.0005
Position	1.593	2; 249	.205

Post-hoc Results - K						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	5.11	-	<.0005	3.92
Years.Cat	<= Median 6	> Median 6	5.04	5.19	.889	0.13
Energy Sector	Fossil Fuel	Renewables	4.91	5.33	.681	0.37
Researcher.Industry	Researchers	Industry	5.43	5.05	.709	0.34
Region	South Africa	Other SADC	4.94	5.81	<.0005	0.79
Position	Junior Management	Middle Management	4.65	4.94	.591	0.29
	Junior Management	Senior Management	4.65	5.34	.042	0.56
	Middle Management	Senior Management	4.94	5.34	.062	0.36
* Scheffé Test if 3+ Levels, else t-Test						

Univariate ANOVA Results - L			
Effect	F-value	D.F.	p
Intercept	1448.886	**1; 249**	<.0005
Years.Cat	0.803	1; 249	.371
Energy Sector	0.486	1; 249	.486
Researcher.Industry	0.822	1; 249	.365
Region	0.214	1; 249	.644
Position	2.5	2; 249	.084

Post-hoc Results - L						
Effect	Level 1	Level 2	M_1	M_2	p*	Cohen's d
Intercept	-	-	3.91	-	<.0005	4.23
Years.Cat	<= Median 6	> Median 6	4.01	3.82	.371	0.17
Energy Sector	Fossil Fuel	Renewables	4.02	3.80	.486	0.20
Researcher.Industry	Researchers	Industry	3.65	3.96	.365	0.28
Region	South Africa	Other SADC	3.96	3.74	.644	0.19
Position	Junior Management	Middle Management	4.40	3.91	.056	0.50
	Junior Management	Senior Management	4.40	3.81	.012	0.48
	Middle Management	Senior Management	3.91	3.81	.703	0.09
* Scheffé Test if 3+ Levels, else t-Test						