UNIVERSITY OF KWAZULU-NATAL

SOCIO-ECONOMIC BENEFITS OF METEOROLOGICAL SERVICE IN THE SOUTH AFRICAN ENERGY (POWER GENERATION) SECTOR

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A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Business Administration

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Year of submission
2016

University of KwaZulu-Natal
Faculty of Management Studies
Graduate School of Business

Supervisors permission to submit for examination

Date:	25 November 2016
Student Name:	Nomalungelo N. Simelane
Student no.:	213572236
Dissertation Title:	SOCIO-ECONOMIC BENEFITS OF METEOROLOGICAL SERVICE IN THE SOUTH AFRICAN ENERGY (POWER GENERATION) SECTOR

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Acknowledgements

I wish to express my sincere appreciation and gratitude to the following individuals, without whose assistance, this study would not have been possible:

- Professor Elias Munapo my supervisor
- Mr Alec Bozas my co-supervisor
- Dr Sandile Simelane my husband and supervisor
- Ms Penelope Mkhwanazi my cousin and editor of the document
- The National Energy Regulator of South Africa who agreed that I may contact its licensees to conduct this study and also funded the entire MBA programme.
- Electricity Producers of South Africa who are the respondents for this research and their contributions have made it a success
- The South African Weather Services for suggesting this topic for research
- My friends and family (especially Philile Hlophe) who believed in me and encouraged me to see this research project through.
- My group members who made an effort to ensure that we succeed throughout our coursework.

Abstract

As a public good, meteorological services are funded by the state in most countries and are available freely to the public. In some cases, there is a need for tailoring information to suit users' needs. These specialised services are then available at a fee. Some sectors such as the energy sector are heavily dependent on weather and climate information to plan production. Accuracy and timeliness of this information may increase the productivity of electricity producers. The aim of this study was to assess the benefits of weather and climate services in the energy sector, focusing on electricity generation in South Africa. With the recent scrutiny on how public funds are utilised there has been a growing need to prove to the government the benefits that accrue to society if meteorological services, especially its infrastructure, technology and research, are properly funded.

The study assessed three main objectives: firstly, it assessed the usefulness of information generated by the meteorological services; secondly, it assessed the value placed by electricity generators on services provided by the meteorological services; and lastly, it assessed the need to update technology and infrastructure to ensure that weather and climate information meets user needs. Due to the dispersed geographic location of the targeted respondents, data was collected through the administration of structured questionnaire via email. The respondents are the 45 licensed electricity generators obtained from the National Energy Regulator of South Africa.

The results of the study show that: first, the electricity generators found the services provided by the national meteorological service to be valuable. Second, the information provided by the meteorological services was found by the electricity generators to be useful for planning their operations. Last, the results showed that there is need for the meteorological services to update its technology and infrastructures. It is hoped that the results generated here will provide decision makers with concrete evidence for the need to invest in meteorological services infrastructure, technology and research and development. It is recommended that another study is conducted to assess socio-economic benefits of meteorological service in the other sectors such as aviation, transport and agriculture to mention a few.

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CHAPTER ONE: OVERVIEW OF THE STUDY

1.1. Introduction

The aim of this study is to evaluate the socio-economic benefits of meteorological services in South Africa, focusing on the energy sector, specifically on electricity generation. A meteorological information service is a service that delivers to the public (and specialised users) data on the state of the atmosphere, such as wind speed, rainfall, temperature and snowfall (Lee, Jang, Ko, & Cho, 2014), in order to predict future weather. All the electricity producers, regardless of type of technology used, rely heavily on weather and climate conditions. Therefore, they are users of the meteorological services provided by the National Meteorological Services (NMS). In South Africa this service is provided by the South Africa Weather Services (SAWS). This chapter first provides the motivation for the study; secondly it outlines the focus area of the study and thirdly it provides the problem statement. This is followed by the objectives of the research and the research questions in the fourth and fifth sections of the chapter. The conclusion of the chapter is a discussion of the limitations of the study.

1.2. Motivation for the Study

This study sought to build a case for support and expansion of meteorological services in South Africa by evaluating the socio-economic benefits of the services in the energy sector of the country.

The energy sector was selected as a focal area for this study due to its role as one of the critical economic infrastructures in South Africa (National Planning Commission 2011). The country's national development plan highlights the importance of adequate supplies of affordable and reliable electricity and liquid fuels in ensuring; (1) economic growth and development; (2) social equity and (3) environmental stability.

The reason for focusing on socioeconomic benefits of meteorological services in energy generation derives from the fact that the energy sector is heavily dependent on climate information which is why important regional bodies such as the East African Commission have gone on record to have pronounced that meteorological information is essential for adequate planning and management of power generation, especially from renewable energy sources (EAC 2008).

It is hoped that the results generated here will provide decision makers with concrete evidence for the need to invest in meteorological services infrastructure, technology and research and development.

1.3. Focus of the Study

The study focuses on nationwide users of meteorological services in the electricity generation industry. These include all electricity producers licensed by the National Energy Regulator of South Africa (NERSA). NERSA has licensed 45 electricity producers in the country.

1.4. Problem Statement

Weather and climate related hazards can be very costly for any society. These hazards require efficient and effective meteorological services that provide forecasted information on weather and climate to enable planning for suitable interventions to alleviate disasters. As is common to developing countries, obsolete technologies are limiting the capacity of Weather and Climate services to undertake the continuous modernisation resulting from rapid advances in the science and technology (EAC, 2008; AMCOMET, 2012). Furthermore, low staff competency hampers delivery of adequate services and currently the weather observation stations are not of the required standard to inform research, policy solutions and decisions at the detail that policy makers require (EAC, 2008).

Similar to many developing countries, South Africa's Weather and Climate Services are facing a challenge of low funding and investment from government to support the delivery of weather and climate services (Dougill, Dixon, Stringer & Cull, 2015; Hansen, Mason, Sun & Tall, 2011; Haile, 2005). According to Rogers and Tsirkunov (2013) support from governments is required to ensure that the national meteorological service are able to: firstly, conduct frequent maintenance and efficiently operate the meteorological and hydrological networks; secondly, ensure effective provision of forecasts extreme meteorological and hydrological events; thirdly, ensure that early warnings are issued accurate and timely; and lastly, ensure that critical information is effectively communicated to stakeholders and the public. Once the challenges of outdated observing systems and forecasting tools, low staff competency and obsolete infrastructure of observing stations are resolved, weather and climate services provision in the country should be able to ensure sustainable development in terms of climate mitigation and adaptation, reduction in poverty resulting from weather and climate related disasters. This research focused on the problem of the under resourced meteorological and hydrological network in South Africa to ascertain where and how the system could be improved.

1.5. Objectives

The following objectives were sought to be achieved by the study; namely to assess the:

- Usefulness of information generated by the meteorological services;
- Value placed by electricity generators on services provided by the meteorological services; and
- Need to update technology and infrastructure to ensure that weather and climate information meets user needs.

1.6. Research Questions

a) How useful do electricity generators find the information generated by the meteorological services?

b) What value do electricity generators place on services provided by the meteorological services?

c) What technology and infrastructure updates are necessary to ensure that weather and climate information meets user needs?

1.7. Scope and Limitations of the Study

The study focuses on the assessment of socio-economic benefits of weather and climate services in the South African energy (electricity generation) sector. The major limitation of the study is that not all targeted respondents participated in the study. Still, among those that participated, some did not answer all the questions in the questionnaire. The study also experienced budgetary constraints. As a result the researcher could not conduct telephonic follow-ups to respondents due to cost limitations. More details about the limitations of the study are provided in chapter 5.

1.8. Significance of the study

This study will be of interest to the South African Weather Services as a provider of meteorological service to understand the needs of their users in the electricity generation industry. Also this study will provide evidence that public funding is required by the SAWS to support and invest on the upgrade and maintenance of the meteorological infrastructure and technology required to meet the needs of users of the meteorological services. This study will further, form basis for the further research on the assessment of the benefits of meteorological services in the other sectors not covered by this research.

1.9. Outline of the study

The study is presented in five chapters as follows:

- Chapter one provides an introduction to the research problem, the motivation, focus of the study, the objectives and research questions, the scope and limitations of the study and the significance of the study.
- Chapter two presents the literature review on socio-economic benefits of meteorological services. It discusses the importance of meteorological services in society at large and on the electricity generation in particular. The chapter further outlines why the information generated by the meteorological services is useful and it discusses the value placed by different by different socio-economic sectors on the meteorological service. Furthermore, it outlines the opinions of the users, in this case the electricity generators, on the need to update the information and infrastructure.
- Chapter three discusses the various research methods utilised in this study and it presents the rationale of using the chosen methods. The chapter further outlines the limitations of the research methodology.
- Chapter four presents results of the study.
- Chapter five presents the discussion of the results, draws conclusions of the study, presents the limitations of the study and also offers recommendations to further research.

1.10. Chapter Summary

This chapter introduced the research on socio-economic benefits of weather and climate services with focus on electricity generation in South Africa. The approach followed by the research outlining the purpose and the focus of the study is provided. The chapter further provided the problem statement and highlighted the objectives of the study from which the research questions were developed. Finally, the chapter presented the scope and limitations of this study. Review of literature which formed the basis for the empirical study is the focus of the next chapter.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviews studies on socio-economic benefits of meteorological services. The main purpose of the literature review is to place the current study within a broad context in order to show the reader how it fits in with the work that has already been done on the topic (Kothari, 2004; Kumar & Phrommathed, 2005; Saunders, Lewis & Thornhill, 2007; Leedy & Ormrod, 2010; Ramdhani, Ramdhani, & Amin, 2014; Booth, Sutton, & Papaioannou, 2016. Ridley, 2012). According to Saunders et al., (2007), research questions and any hypotheses designed to be tested by research may be informed directly by literature review. A particular research strategy, approach and data collection technique can be suggested by the hypotheses (Saunders et al., 2007). This research will therefore replicate a research project in a different setting as there are similar studies undertaken on the topic in other countries but focusing at different industries.

This chapter begins with a definition of the notion of "socio-economic benefit" because it is the key concept of the study. The chapter then provides a discussion of the reasons why meteorological services are critical society at large and the electricity industry in particular. Thereafter, a discussion of general challenges facing meteorological services, particularly in developing countries, follows. The review then covers literature that relates to the three research objectives of the present study, namely: (1) literature on the usefulness of information generated by the meteorological services in energy generation; (2) literature on the value placed by the different socio-economic sectors on services provided by the meteorological services; and (3) literature on the opinions of electricity generator on need to update technology and infrastructure to ensure that weather and climate information meets user needs.

2.2 Socio-economic Benefit Defined

Before discussing documented evidence of socio-economic benefits obtained from functional meteorological services, it is proper to first define the concept of "socio-economic benefit". One practical definition, in the context of meteorological services, is presented by von Gruenigen, Willemse & Frei (2014) who argue that financial and related outcomes as a result of weather forecasts can be regarded as the economic value or benefit of the service. In this conceptualization Frei et al., (2014) consider outcomes of decisions that are linked to weather and climate conditions to produce better results if they are based on availability of appropriate weather information than otherwise. This line of thought is also expressed by Morss, Brown, Brooks, Ganderton & Mills (2008), Freebairn & Zillman (2002) and Nguyen, Robinson, Kaneko & Komatsu (2013) but their conceptualization goes beyond the consideration of economic benefits and covers social benefits as well. Specifically, Nguyen et al., (2013) highlight improved safety and peace of mind, for both present and future generations, resulting from usage of meteorological information as an example of a social benefit of meteorological services. Furthermore, the authors argue that reduction of public expenditure on unnecessary weather related evacuations and minimization of weather related destruction of public infrastructure can be regarded as a governmental benefit from the weather and climate services.

A survey was carried out to assess socio-economic benefits of weather and climate information among 50 of the WMO members. According to Perrels, Frei, Espejo, Jamin & Thomalla (2013) this survey revealed that in the case of most of the respondents (84%), their National Meteorological Services regularly conducted user group surveys that enabled them to plan for user needs and benefits.

Studies on socio-economic benefits of meteorological services are carried out (according to Perrels et al. 2013) for several reasons, such as to: substantiate the need for funding from the government; stimulate interest of new users of the services; and use results to support the decision to prioritise investment. Several studies that assess the benefit of meteorological services have been conducted (e.g. Perrels et al., 2013; Shreve & Kelman, 2014).

The World Meteorological Organisation has published several case studies outlining various socio-economic benefits derived from climate and weather services. The author did not find any research that assessed the socio-economic benefits of weather and climate services in the electricity sector in South Africa.

2.3 Why Meteorological Services Are Critical for Society

Inclement weather conditions are known to cause severe impact on the general functioning of society and on the economy at large. Different authors (Freebairn & Zillman, 2002; Leviäkangas & Hautala, 2009; Nelson et al., 2013; Nguyen et al., 2013; Graham, Yun, Kim, Kumar, Jones, Bettio, Gagnon, Kolli & Smith, 2011; Nurmi et al., 2012) allude to weather and climate related hazards which could be very costly. Meteorological services are meant to provide reasonably accurate weather predictions in order to prepare for and mitigate or alleviate the impact of these hazards to communities.

This information according to Freebairn & Zillman (2002) also pertains to land surface, underlying ocean and inland waters and can be used to facilitate planning for effective interventions when disasters strike. Weather and climate forecasts that are based on proficient meteorological data processing and forecasting systems, therefore, have far reaching impact on social and economic development activities (EAC, 2008). According to Brooks (2013) problems of climate sensitive clients are solved in new ways with new data products and services, generate new industries, new businesses, and economic growth with the same impact that weather services have had on spurring economic development.

Given the increased importance of climate change in the global development agenda in recent times, the World Meteorological Organisation (WMO) is actively promoting, through international climate conferences, advances in meteorological research and observational capacity. These advances enable national meteorological services to better equip governments to protect the lives and property of their citizens and reduce disaster-related risks. Meteorological services are designed such that information provided enable governments to develop strategies that enhance community resilience and reduce susceptibility to climate change (Stigter & Ofori, 2014; Vaughan & Dessai, 2014). Furthermore, researchers (Mylne, 2002; Regnier, 2008, Frei, 2010) agree that, in order for uncertainty to be reduced and decisions improved, the economic data and information on weather should form part of the elements in the decision-making process. In this regard, reliable and well-functioning NMHSs are crucial for society because without them it would be impossible to successfully adjust to the prevailing and imminent weather and climate changes (Rogers & Tsirkunov 2013).

2.4 Importance of Meteorological Services in Electricity Generation Industry

Over the last 20 years, access to electricity has formed an important part of the South African economic development programmes (De Groot, van der Veen & Sebitosi, 2013). South Africa relies heavily on coal for electricity production (Krupa, & Burch, 2011; De Jongh, Ghoorah & Makina, 2014). South Africa's electricity generation is dominated by Eskom and was mandated to ensure that the public is electrified. Eskom supplies more than 90% of electricity generated using coal-fired electricity stations (Creamer, 2013; De Groot, et al., 2013; Szewczuk, 2014; Fecher & Matibe, 2003). In recent years, electricity supply in South Africa has been constrained due to, among other things, obsolete electricity infrastructure and as a result of Eskom's failure to maintain its electricity network. The effect of this limited electricity production has been on-going load shedding in an effort to cope with the exponential increase in the number of electricity users. South Africa's economy is heavily dependent on energy production (Spalding-Fecher & Matibe, 2003). This is partly due to the abundance of this fossil fuel in the country and as a result, South Africa is among a small number of countries that are responsible for the emission of high levels of greenhouse gases (Pegels, 2010; Krupa, & Burch, 2011; Szewczuk, 2014).

In trying to mitigate the electricity supply constraints, the government of South Africa through the Integrated Resource Plan (IRP) 2010 has implemented a project to source independent electricity producers in the country. This plan takes into consideration the environmental concerns of the greenhouse gas emission resulting from using coal as primary energy. As stated by Kusakana & Vermaak (2013) the South African Government targeted electricity production of 10,000 Gigawatt hours (GWh) from renewable energy (solar, hydroelectricity, wind, and biomass) by 2013. According to the IRP2010, 45.9 % of capacity would be sourced from coal-fired facilities, envisaged to total 41 071 megawatt (MW) of the total electricity generated by 2030. Creamer (2013) reported that an additional 11 400 MW would be sourced from nuclear electricity amounting to 12.7 %. Renewable electricity sources should account for 21 %, comprising wind electricity amounting to 10.3 %, solar photovoltaic (PV) electricity amounting to 9.4 percent and concentrated solar electricity amounting to 1.3 %. Included would be hydroelectricity envisaged to amount to 5.3% (Creamer, 2013).

Although according to Fecher & Matibe, (2003), between 1993 and 1999, Eskom reduced the total particulate emissions and relative emissions from its power stations by 45% and 53% respectively. The latter was active to ensure better environment performance by the commissioning of new plants and modification existing plants. Due to the growing concern about the country's over-dependence on fossil fuels, cleaner technologies have been introduced in South Africa to enable the country to generate electricity using other sources such as hydroelectricity, wind energy and solar geothermal energy. Although there are other electricity producers such as municipalities (Fecher & Matibe, 2003) and other independent electricity producers, the majority of these entities produce the electricity only for own consumption. The promotion of renewable energy technologies can provide a solution to the problems of strained electricity supply and greenhouse gases emissions for the country's energy generation industry (Pegels, 2010).

The dramatic transformation of energy systems continually expands the relations between meteorology and energy (Troccoli, Audinet, Bonelli, Boulahya, Buontempo, Coppin, Dubus, Dutton, Ebinger, Griggs, Gryning, Gunasekera, Harrison, Haupt, Lee, Mailier, Mathieu, Schaeffer, Schroedter-Homscheidt, Zhu & Zillman, 2013). The energy sector which, according to Dubus (2010), includes both non-renewable and renewable resources are significantly impacted by climatic conditions and water resources. For instance, with the increase in the share of renewable energy in total energy production there will be an increase in the dependence on weather and climate information by of the energy systems (Dubus, 2010; Traunmüller & Steinmaurer, 2010; Frei 2010; EAC 2008). Frei (2010) elaborates further on the interlinkage between electricity generation and meteorological services and argues that timely and accurately estimated forecasts of weather and climate data are useful tools for planning, and optimising the distribution, generation, and transmission of electricity and for controlling energy demand. The increased dependence of energy generation on meteorological information will consequently require development of weather products that are tailor-made to suit assessment and management of the irregular nature of energy generation and consumption (von Gruenigen, et al., 2014). Vaughan & Dessai (2014) outline the important aspects of the customization process: first assessing whether the information is relevant or perceived to be relevant; second, assessing whether the information is accessible; and third assessing the impact of distribution to various groups. Moreover, meteorological information is essential for reducing energy pricing uncertainty and ensuring that energy system efficiencies are increased (Troccoli, et al., 2013). Thus, it is clear from the foregoing discussion that the energy sector requires specialised meteorological services to ensure stability of the electricity grid (Dutton, 2002; von Gruenigen, et al., 2014).

Since water resource management and energy generation have a close relationship, Weiher, Teisberg, & Khotanzad, 2005; Mukheibir, 2013) both sectors, are sensitive to climatic conditions. Also, electricity generation plants depend on adequate water supply for smooth operation (Wilbanks, Bhatt, Bilello, Bull, Ekmann, Horak, Huang, Levine, Sale, Schmalzer & Scott, 2008; Traunmüller & Steinmaurer, 2010). Water supply is currently a big concern for South Africa at the moment since many parts of the country are experiencing severe drought and therefore raising serious questions about optimal operation and cost-effectiveness of electricity plants. It is important that the electricity generation plants and the grid are optimally and cost-effectively managed. On account of the critical impact on political, economic and strategic decisions, electricity failure could harm industrial activity and competitiveness of the country (Troccoli, et al., 2013; von Gruenigen, et al., 2014).

Thus extensive weather information is required for electricity production and distribution. The main problems caused by extreme weather conditions are stated by von Gruenigen, et al. (2014) as, amongst others, the damages to buildings and plants, electricity supply failures and increased energy consumption. These issues become particularly important when considered in light of social and economic development which has led to improved living standards and a change in consumer attitudes which is reflected in, among other things, increased usage of air conditioners and electric heat sources during summer and winter months (Zhang, Gong & Ma, 2014; Dubus, 2010).

2.5 Challenges Facing Meteorological Services

Similar to other developing countries, South Africa is faced with challenges which are limiting the country's national weather and climate services in ensuring that policy makers and captains of industries are well prepared for adverse weather and climate conditions. These challenges include, poor observational climate and weather information; lack of capacity; inadequate weather observation stations; and limited resources to fund the meteorological services.

Other challenges are stated by Rogers & Tsirkunov (2013) to include: (a) limited understanding by government and development agencies of the value of the National Meteorological and Hydrological Services (NMHSs) which contributes to the insufficient commitment to maintain the operation of the NMHS; (b) lack of adequate training on the installation of hardware, lack of ongoing maintenance and technical support; (c) uncoordinated projects each with its own assistance policies, objectives, and equipment suppliers from different donors, which disregard the needs, circumstances, and priorities of individual NMHS; and (d) some projects are technically complex. As a result, international support and investment efforts in the modernization of NMHSs in developing countries largely unsuccessful thus far.

Below is a brief discussion of the main challenges that hamper smooth operation and continuous development of NMHSs in developing countries.

Poor observational climate and weather information

The standard of climate information provided by developing country NMHSs is affected by poor observational recording, poor simulation of climate variability, shortage of experienced climate scientists and inadequate investments (Vincent, Dougill, Dixon, Stringer & Cull, 2015). Furthermore, Vincent, et al., (2015), say there are insufficient empirical studies that assess how climate information is used, which consequently impede initiatives to adapt to climate change and development planning that is climate sensitive. This status quo is counter developmental in light of the well published and talked about “global climate change” which consequently makes strong NMHSs that are characterized by scientifically strong observation, forecasting, and service delivery capacity a prerequisite for climate resilient development according to Rogers & Tsirkunov (2013).

Lack of Capacity

As indicated above, inadequate staff competency in developing countries hampers delivery of adequate services as required by policy makers and other decision makers. This is supported by Rogers & Tsirkunov (2013) who state that in developing countries, despite their importance, many national meteorological services do not have sufficient resources to deliver even basic level of services. The impact lack of capacity among NMHSs in developing countries is captured by Vaughan & Dessai (2014) who argue that the NMHSs in these countries lack the full understanding of the contexts in which the information they generate to the public features in decision making and that, due to this lack of understanding the NMHSs unwittingly provide information in formats that are not user friendly. In order to meet the identified societal needs, Brooks (2013) suggests that climate service providers must have knowledge of current research, available datasets, applied tools, and products. Hence, the role of NHMSs will continually evolve in response to ever changing technology and user requirements and such evolution according to LU& IE (2007) requires high levels of competency and underlying knowledge among NMHSs.

Inadequate Infrastructure and technology

Most countries in the developing world are unable to cope with rapid advances in weather and climate observation, telecommunication, data processing and forecasting technologies (EAC, 2008). These inadequacies affect the meteorological services provision to the weather and climate dependent sectors, such as agriculture, water, energy and others, which, ironically, are closely connected to the drivers of the economies of the countries (EAC, 2008). Service delivery is reported by EAC (2008:4) to have been hampered by inadequate infrastructure and human capacity for most of the pre-processing of data; preparation of weather analyses; preparation of forecast products; preparation of ensemble prediction system products; preparation of specialized products; monitoring of observational data quality; post-processing of numerical weather prediction data; archival of data and data processing forecast system products; product research and development; climate related diagnosis; and data exchange.

Limited funding

Several studies (Vincent, et al., 2015; Hansen, et al., 2011; Haile, 2005) concur that limited funding and investment to initiatives that are required to maintain the infrastructure, observational systems and forecasting tools that support weather and climate services from governments in most developing countries, including South Africa, is a huge challenge. Rogers & Tsirkunov (2013) map out some of the impacts of the lack of adequate funding of NMHSs as being: the meteorological and hydrological observation networks and technology deteriorating; lack of support for research and development; insufficient modern equipment and forecasting methods; services that are of poor quality and loss of the workforce as a result of adequately trained specialists.

Since most countries public meteorological information services are provided by an institution sponsored by government (Freebairn & Zillman, 2002), therefore the role of modernising meteorological information services lies with the government (Lee, et al., 2014). In South Africa, as in other developing countries, meteorological service is funded and provided by the government. Consequently, the service is subject to scrutiny and budgetary pressure. This has led to the SAWS operating on obsolete technologies which hinder the organization from undertaking continuous modernisation as and when technological advances in the science require (EAC, 2008; AMCOMET, 2012). Therefore, to justify investment by government, it is important to measure meteorological information services effect on the public in terms of their quality of life and social welfare (Lee, et al., 2014).

According to Vaughan & Dessai, (2014), climate services have been to some extent relying on support from private sector, there appears to be agreement that some public funding must be provided to the climate services to ensure that knowledge is generated with political, intellectual and economic independence.

2.6 Usefulness of Information Generated by the Meteorological Services in Energy Generation

The variable nature of climate has significant effects on electricity power supply and consumption, and these effects have become increasingly predictable over time (Voisin, Hamlet, Graham, Pierce, Barnett & Lettenmaier, 2006). However, there are unexpectedly few studies that quantify the value of meteorological predictions to the energy sector, even in developed and energy-rich nations that are exposed to highly variable weather patterns (Davison, Gurtuna, Masse & Mills, 2012).

The price of energy is generally high and volatile because the costs associated with construction, management and maintenance of energy production facilities, transmission of the energy are very high, meaning there are potential annual aggregate monetary savings that can be derived from improved prediction and planning for weather changes (USAID, 2013). Several studies (e.g. Freebairn & Zillman, 2002; EAC, 2008; Vaughan & Dessai, 2014; Brooks, 2013) show that in most countries the energy sector generally uses specialised meteorological services[1]. In particular, forecasts made by the meteorological services are useful to

[1] Agriculture is another sector that requires specialised meteorological services. This information should ensure that weather and climate forecasts through agro-meteorological services equip farmers with sufficient data to inform decision-making on key farm management operations (Lybbert & Sumner, 2012; Maini & Rathore, 2011). Aviation is another sector where, apart from security and safety purposes, meteorological information enables

energy utilities for fuel acquisition, demand forecasting and system planning (USAID 2013). In order for electricity generation plants to operate efficiently, short-term forecasts, historical weather data, accurate demand forecasts and timely weather observations are critical (i.e. for planning of day to day operations, including risk management and coordination of the supply and demand of electricity services) (USAID, 2013). Hertzfeld, Williamson, & Sen (2004) put further clarity on the usefulness of meteorological services in the energy generation industry and state that one day forecasts are valuable for daily operations (i.e. decisions on management of daily demand levels) whereas 1 to 20 years forecast are valuable for long-term planning.

Likewise, various authors (EAC, 2008; Weiher, et al., 2005; Lee & Lee, 2007; Davison, et al., 2012) agree that daily forecasts are, amongst others, forecasts that could help energy producers and the society as a whole to adapt to the changing nature of energy markets effectively and to optimize operations. In the spot electricity market industry, 1-hour information is useful for decisions on purchasing and trading of electricity while information on monthly to a yearly outlook is useful for planning (Hertzfeld, et al., 2004). In a number of sectors in South Africa, the medium range (3–14 days) is popular and thus the effort to invested in improving this time scale forecasts is considerable (Tennant, Toth & Rae, 2007).

While certain types of meteorological information are generically important for the energy generation industry, (e.g. hourly and daily temperature forecasts are useful for predicting peak demand periods and therefore scheduling of electricity generating plants to meet demands in most cost effective means possible (Weiher, et al., 2005), the usefulness of certain types of weather services differs by type of electricity producer. For example, among wind energy producers it is information on hourly or daily wind velocity that is crucial because the unpredictable fluctuations in wind velocity in these time frames drive the variations in their power outputs (Roulston, Kaplan, Hardenberg & Smith, 2003). In the hydropower generation, on

airlines in their daily operation to make decisions on the optimisation of the economic efficiency, including strategic planning of flight routes (Frisvold & Murugesan, 2013; von Gruenigen et al., 2014; Nurmi et al., 2012). Meteorological services are also used in the tourism industry, where even general households may require such information to plan their vacations or ceremonies.

the other hand, information on precipitation levels is an important component (Weiher, et al., 2005).

As indicated above, there are few studies that have measured usefulness of meteorological services in the energy generation industry (Davison et al., 2012). Below is a brief discussion of some these studies, highlighting their research methodologies and key findings.

Hautala, Leviakangas, Rasanen, Oorni, Sonninen, Vahanne, Hekkanen, Ohlstrom, Saku, Tammelin & Venalainen (2008) assessed the effects of the weather information services several sectors including the energy production in South Eastern Europe using qualitative research methods. The study selected five countries namely Bosnia, Albania, Herzegovina, Moldova FYR, Montenegro and Macedonia. The results revealed that in Moldova tailor-made weather service could prevent up to an estimated 90% of damages resulting from bad weather condition and costs is assumed to be considerably lower than the savings in monetary terms. The study further revealed that the quality and lead time of data produced by the national meteorological services for the energy sector need improvement.

In Montenegro, according to Hautala, et al., (2008), meteorological and hydrological data provided by Hydrometeorological Institute of Montenegro is already used to control water levels of dams and plan production in the hydro power production. The electricity producer interviewed in the study mentioned that obtaining accurate meteorological forecast information and hydrological data assists in electricity planning consumption and production and controlling the production facilities (Hautala, et al., 2008). In addition, it was found that the collection of hydrological data and flood forecasts needed improving. Moreover, historical meteorological data is required by the electricity producer (Hautala, et al., 2008). There was willingness by the electricity producer to pay for tailor-made services on weather information such as 13 days expected hydrological forecasts, flood warnings, season weather forecasts and hydrological data available on-line (Hautala, et al., 2008). Although there were very few responses from FYR Macedonia, the study found that the weather services that were available included:

historical meteorological data, precipitation wind and forecasts on air temperature and hydrology (Hautala, et al., 2008).

Another study conducted by Hertzfeld, et al. (2004) in the U.S. found that there is economic significance to the electricity power industry resulting from weather forecasts of all types. The study used the case study methodology and a literature survey of industry experts and concluded that with improved weather forecasts, a utility can save up to hundreds of millions of dollars in avoided costs per year. The study also found that use of meteorological data in energy generation plants facilitates accurate forecasting of demand and, therefore, more effective day-ahead market trade by the utilities, efficient management of generating plants start-up and shutdown and greater assurance to plan for future capital expenditures. It was mentioned that improvements in two to five-day meteorological forecasts greatly improve the capability of energy utilities to forecast their future economic prospects and energy demand levels.

A study by Zhang, Gong & Ma (2014) using correlation and regression analysis methods found a strong relationship between meteorological factors (namely (wind speed, temperature, and relative humidity) and daily maximum electricity power load during summer months in Beijing, China. On the contrary, the study found that it is only temperature, and sunshine duration that showed significant correlation with electricity power load variability during winter months. The normal increase in energy consumption required for cooling purposes in summer and for keeping warm during winter explained these results.

2.7 Value Placed by Different Socio-economic Sectors on Services Provided by the Meteorological Services

The value of services is derived only when pertinent data and information about them are disseminated from diverse socioeconomic sectors in user friendly formats so as to enable end users to incorporate the information about services in their decision making processes (Hautala, et al., 2008). Put differently, the significance of services in society depends on the type of information delivered about the services, how it is delivered and how well the recipients or general population can employ the information to inform their decisions and meet their needs (Rogers & Tsirkunov, 2013; Lee & Lee, 2007; Leviäkangas & Hautala, 2009; Mylne, 2002; Regnier, 2008; Perrels et al., 2013; Vaughan & Dessai, 2014; Frisvold & Murugesan, 2013; Davison et al., 2012; Frei, 2010). In this light, and in relation to the objective of this study, Mason, (1966) in Davison et al., (2012) summarises the assessment of meteorological services in society at large, albeit from a financial perspective, by stating that it can be quantified by determining the added financial value derived by society from decisions that were made informed by meteorological information.

Below is a discussion of some literature on the value placed by energy producers on meteorological services. As was the case in the previous sub-section, the discussion briefly highlights the research methodologies and key findings of these studies. When evaluating the value of meteorological information, distinguishing the 'complete process' of converting improvements in precision, user friendliness, timeliness and quality of such information is essential to the users. Hooke & Pielke (2000) provide a simplified framework for such a 'complete process' (Table 2.1 below), identifying three comparable three dimensions (technical, communication and decision) with important feedbacks and their interrelationships (Gunasekera, 2004).

As shown in the framework, the transformation of meteorological information to users' value is multidimensional. Hence the value of meteorological information is not captured in full by any single aspect of the framework. Instead, in order to assess the three dimensions of the information, multiple approaches and measures are required. Generally, different groups in society tend to focus on different aspects of the framework for evaluating the value of meteorological information (Gunasekera, 2004).

With regards to assessment of value assigned to meteorological information from the technical perspective, the Hooke & Pielke (2000) framewok prescribes verification methodologies. For assessment of the value from the communication standpoint, the framework advocates for application of survey and interview methodology while recommending several methodologies for assessments (i.e.

contingent evaluation methods; conjoint methods; market based methods; descriptive behavioural methods, etc.) from the viewpoint of use/decision.

Table 2.1: Framework for a 'complete process' of transforming meteorological information to users' value

Sub-process	Outcome	Criteria for evaluation	Methods of evaluation
Prediction (data collection, analysis and forecasting)	Various meteorological information products	Skill, quality, timeliness, user friendliness	Verification
Communication (from NMS or other distributors)	Guidance	Information transfer	User surveys and interviews
Use (a multidimensional combination of heterogeneous users)	Decisions	Economic value	Market based approaches, normative or prescriptive models, descriptive behavioural models, contingent valuation methods, conjoint analysis, economy wide models

Source: Based on Hooke and Pielke (2000) and Lazo and Chestnut (2002)

Other frameworks for assessing the value placed by users on services provided by the meteorological services are found in Leviäkangas & Hautala (2009); Vaughan & Dessai (2014); and Davison et al., (2012). Leviäkangas & Hautala (2009), identifies two angles from which the value may be evaluated: (1) from the decision maker's point of view (i.e. subjective assessments as to whether or not he/she considers him/herself in a better-off or worse-off decision making position with availability of meteorological information); (2) from assessment of value realized through the impact emanating from the information. Vaughan & Dessai (2014) on the other hand approach the problem of assessment of value assigned to meteorological services by users of the services in a multidimensional framework similar to that of Hooke & Pielke (2000). They argue that the assessment is complex, comprises a wide range of different methodologies and involves differentiation between assessment of perceived local-level impact from aggregated impact and also differentiation by socio-economic status so that effective climate services targeted to poor population groups are not construed as low value. Like Hooke & Pielke (2000), Vaughan & Dessai (2014) mention methodologies such as contingent valuation methods, case studies, empirical modelling and user surveys, etc., that can be employed to assess the economic value of meteorological information. Lastly, Davison et al., 2012 add a social dimension in the consideration of the broader notion of value, extending the argument beyond quantification of profit maximization and cost reductions, to also include social benefits such as, for example, decreases in adverse health effects resulting from air pollution reductions.

Studies that have quantified the value of meteorological services, to users, include (Adams, et al., 1995; Anaman & Lellyett, 1996; Solow, et al., 1999; Leviakangas, et al., 2007; Brown, 2002; Lazo & Chestnut, 2002; Rollins, & Shaykewich, 2003). These studies were conducted in different settings and evaluated the value of meteorological services to different sectors.

The studies by Anaman & Lellyett, 1996; Brown 2002; Rollins & Shaykewich, 2003 applied the contingent valuation approach[2] and assessed willingness to pay for services. According to Perrels, et al. (2013), studies on willingness to pay studies provide the market value to be potentially charged for a certain weather service or product. Willingness to pay studies can be applied to existing free public service as well as to new service that are not yet provided (Perrels, et al., 2013).

Rollins, & Shaykewich, 2003, assessed the economic value of an Automated Telephone Answering Device (ATAD) provided by the Canadian Meteorological Services. Brown 2002, assessed the value of public daily forecasts among households in Ontario, Canada, whereas Anaman & Lellyett 1996 estimated the value of general public weather services in Sydney Australia.

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[2] According to Carson (2000) the contingent valuation (CV) is a survey-based method normally applied to determine monetary value for an environmental goods or services not available in the marketplace. The approach is applicable in the case of meteorological services because most products of the service are not traded on the open market but regarded as a public good (Carson, 2000; Breidert, Hahsler & Reutterer, 2006; Hausman, 2012). Typically the survey determine the value in monetary terms that people would be willing to pay (WTP) or willing to accept for a particular service (Carson, 2000; Breidert, Hahsler & Reutterer, 2006; Hausman, 2012).

Rollins, & Shaykewich, 2003 used the contingent valuation method to calculate the economic value of the ATAD to its commercial users, to determine how values differ among different user groups, and to predict in response to different fee structures how the number of users of the service would change. Extensive pre-testing and pilot surveys were conducted to develop the questionnaire wording and to determine the first- and second-level distributions for dollar amounts. The questionnaire was administered as a pilot version by intercepting a random sample of calls to the WeatherLine. Interviews were then conducted by a professional phone survey firm. The contingency valuation questionnaire was designed with the consideration of the substitutes available for the WeatherLine ATAD service, and to further determine how commercial users are characterised. Moreover, to assess the types of business decisions made as a result of the information from ATAD information, to determine the average numbers of calls made by the commercial sector per week, as well as the benefit per call for each sector.

The objective of the study was to assess the effect of the total number of calls per week in changing different prices for the service, by commercial sector. A total of 1,300 calls to the WeatherLine service were intercepted, with 1,117 callers agreeing to participate in the survey – an 85% response rate. The first fee per call dollar amount presented to each individual in the final version of the survey was drawn from $1.00, $2.00 or $3.00, randomly distributed over all respondents such that 40% of respondents received $1.00, 40% received $2.00 and 20% received $3.00. Given an individual respondent's answer to the first question, the respondent was asked whether she/he would continue to use the service if the fee was set at a higher or lower amount, randomly drawn from the amounts: $0.50, $1.00, $2.00, $3.00, $4.00, deleting those amounts that were too high or too low. The regression was run with dummy variables representing each commercial sector. WTP estimates for each commercial sector were calculated using the above procedure for the relevant sub-samples.

The results of the study established that other commercial sectors had statistically different levels of value per call (at the 95% level), for an average 'willingness to pay' of $1.20 per call for the sample, and a low of $0.60 per call for institutions including schools and hospitals. The benefit to the commercial users who use the services was estimated to be $16,500,000 for roughly 13,750,000 commercial calls per year. Although, about 40% of previous the number of calls was estimated to drop-off if a fee per call between $1.00 and $2.00 were to be charged.

The Anaman & Lellyett (1996) study had a realised sample of near 500 households. Its results that showed an overwhelming majority (about 63%) of the residents of the Sydney metropolitan area were not willing to pay for public meteorological services in 1996. The remaining 37% that reported being willing to pay for the services reported, an average amount of approximately A$2 per month (or A$24 per year). On the other hand, the study also found that the annual cost per taxpayer for generating the public weather services in Australia as a whole was estimated to be A$6. This implies that, the estimated annual WTP for meteorological services in Sydney (A$24) was four times the annual cost per taxpayer of providing the services during the study period.

Results for the study by Brown (2002), whose sample covered 1500 mailing addresses (with a 63% response rate), indicate that value of the overall public weather forecasts to the nearly 4 million households of Ontario amounted to approximately $1.26 billion per year in 2002. Likewise, the value of specific products to households in Ontario was estimated at approximately $8 million per year and $684 million per year for the 4 and 5-day outlook and the 2 to 5-day public weather outlook, respectively.

The studies by Adams et al (1995) and Solow et al (1999) applied the Bayesian decision theory to estimate the value assigned to meteorological services, by users of the services. Adams et al (1995) assess the value of improved ENSO forecasts to agricultural output in south eastern United States. The study by Solow et al. (1999) is an extension of Adams et al (1999) and it assesses the economic value of ENSO predictions to agricultural yields in the US as a whole.

The results of the analysis by Adams et al (1995), indicate that the estimated value of accurate ENSO forecasts to agriculture in 1990 was estimated to be approximately $145 million. The value of the forecast was estimated to be approximately $265 million when including the farm programs included in the analysis. Adams, et al. (1995) add to say that these estimates reflected aggregate gains of the total crop yield to be approximately 2 to 3 percent.

As expected, a larger the economic value of ENSO predictions was estimated in the study by Solow et al (1999), than that from the study by Adams et al (1995), even though the two studies are not directly comparable. Solow et al (1999) acknowledge that the increase in the valuation is partly attributable to the geographic scope and the agricultural activities between the two studies. The results show that, approximately $240 million as the value of 'modest' skill and $266 million as the value of 'high' skill ENSO forecast information estimated to United States' agriculture in 1990. Solow et al (1999) also indicate the net present value of nearly $2 billion over ten years is estimated if future benefits are at 6 percent discounted annual rate as a result of a 'high' skill ENSO prediction.

2.8 Opinions of Energy Generators on the Need to Update Technology and Infrastructure to Ensure That Weather and Climate Information Meets User Needs

Improved satellite weather observations, together with improved weather models, according to USAID (2013) can provide the foundation for more accurate forecasts and can potentially bring about significant savings in energy production costs. More useful products can possibly be generated through technological developments, to support the services provided by the national meteorological services (Rogers & Tsirkunov, 2013). Due to technological advances and breakthroughs in science, the weather forecasts and warnings produced by national weather services are becoming even more accurate and specific (Glahn & Ruth, 2003). New approaches for weather and climate information dissemination are enabled by information technologies (Dutton, 2002).

As pointed out earlier, the societal value of the information and services provided by the national meteorological services is unfortunately not understood by many governments. As a result, they do not prioritise investing in NMHSs, let alone investing in upgrades of the technologies that are used by the NMHSs yet, according to Rogers & Tsirkunov (2013), financial support and capacity building together with improved communication and advocacy campaigns are needed in this industry. Rogers & Tsirkunov, (2013) further state that research studies, such as the current study, that quantify the value of meteorological services are necessary to sensitize governments and the general public to the importance of the services in society. The authors also highlight the importance of the research studies in identifying gaps in the current system elements of a modernization that need to be prioritized and that advances meteorological technologies should be interactive so as to ensure that stakeholders' expectations are realistic.

A number of authors (Abrams, 2004; Dutton, 2002; Guiney, 2007), agree that delivery of meteorological service is increasingly dependent on sophisticated information technology. According to Guiney (2007), public weather services can be further integrated and enhanced by emerging information technology systems and applications which can impact the capabilities of the meteorological service delivery (Guiney, 2007). More accurate and specific weather forecasts and warnings produced by the national weather service are as a result of scientific breakthroughs and technological advances allowing weather information to be communicated to potential users more effectively (Guiney, 2007). However, successful large-scale deployment of renewable technologies must include an understanding of the impacts from weather and climate (Lynch & Ely, 2013).

Examples of studies that document benefits that accrue to society as meteorological services technology is improved include (Žagar, Kalin & Modrić, 2003; Abrams, 2004; Demuth, Morss, Lazo & Hilderbrand, 2013; Dempsey, Howard, Maddox & Phillips, 1998; Tennant, et al., 2007; Bonifacio, Barchyn, Hugenholtz, & Kienzle, 2015:14).

The study by Žagar, et al., 2003 was piloted in Croatia as a University project using a MIDlet application, developed for Java-enabled mobile devices, which has a complete weather forecast named CroWeather. The MIDlet application provides interactive access to weather forecasts through the intuitive interface, at any desired time and in every place and was successfully tested on several types of devices

(Žagar, et al., 2003). Real-time information such as data from automatic synop stations, radar and satellite images (every 15 and 30 minutes, respectively), special warnings, nowcastings etc. can also be retrieved by users. Users can access the desired information no matter where they are because the application uses data from the internet independently of the mobile provider (Žagar, et al., 2003). This is in line with (Dutton, 2002) observation that the national weather and climate services are becoming more widely accessible as a consequence of advancements in information technology. Moreover, data generated to provide for earlier and more accurate weather forecasts that are reliable is expected as a result of improved satellite system (Weiher, et al., 2005). Williamson, Hertzfeld & Cordes, (2002) state that additional socio-economic benefits could be achieved through new and more sophisticated observation technologies that in turn would assist in achieving a better understanding of weather and climate services.

The study by Demuth, et al. (2013) presents a case study on improvement of effectiveness of hazardous weather warnings that are delivered to the public by the US National Weather Service's (NWS) through their point-and-click (PnC) web page. The PnC webpage is the main medium through which NWS supplies meteorological information to users.

According to Demuth, et al. (2013), even though the service rendered through the PnC web page was greatly appreciated by users, with its capability to supply precise and up-to-date forecast for specific geographic areas in usable formats both at a glance and in greater detail being its trump card, it had a major weakness of not communicating certain aspects of hazardous weather risk information. Thus Demuth and colleagues sought to find ways to enhance the webpage's effectiveness in communicating risks about forecasted hazardous weather. Their methodology involved experimenting with different texts and graphics that convey information about threats associated with forecasted hazardous weather. They assessed effectiveness of these texts and symbols using a nationally representative sample of about 5 000 respondents. The results of the study showed that the combination of information about the start time and end time of a forecasted hazardous event is crucial for helping respondents identify the threat existence and understand the precise threat timing on the PnC web page. The results also underscored the importance of empirical evaluation of people's interpretations of risk information before implementation.

Dempsey, et al. (1998) discusses a study that was also conducted in the US by the Electric Power Research Institute (EPRI), the Salt River Project (SRP) and the National Severe Storms Laboratory (NSSL), between 1993 and 1997. A joint support by all three agencies was receive by this project and the objective of the project was to explore potential benefits to by realize by the power industry resulting from their operational decision-making process that incorporated new weather information and the modernization program of National Weather Service.

The SRP, was used to test a variety of techniques as an experiment that allowed to be emulated with easy in the future. During each summer of 1993-1996 staff from the NSSL with SRP's operational staff worked on site at SRP. Furthermore, interviews in a form of open discussions with supervisors (power and water) were conducted during 1994 and 1995. The real-time WSR88D was introduced as well as displays of product into the SRP's operational centres.

The results showed that, summer weather in central Arizona was monitored more carefully by the SRP users than before due to the timeliness and variety of the available displays, together with data manipulation capability. Results from the project also suggest due to the increased operational efficiency the annual fee charged for products provided by the NIDS vendors can be recouped within only a few events.

According to Stewart, Pielke Jr & Nath, 2004, the actual value of improved forecast technology can be obtained through: (a) a forecasting process that results from upgraded science and technology to better-quality forecast products targeted to user needs; (b) effectively communicating the forecast information in a timely fashion to users and in a useful form for sensitive weather information decision-making; and (c) the forecast product that is incorporated into users' decisions so that better choices are made.

For instance, the Canadian Climate Data Scraping Tool (CCDST) was developed to improve access to the Canada's National Climate Data and Information Archive (NCDIA) and simplification of climate data analysis, contributed in the automation of download and collation of climate data. The researchers and students can utilise this tool. The tool has features that enable it adapt to other Web-based geophysical data archive enabling data of interest to be separated on multiple Web pages (Bonifacio, et al., 2015).

While it will be the continuing advances in earth observation science and technology that will make it possible to obtain vastly more information on the state of the earth system over the next few decades, the delivery of that information and the provision of useful services based on it at the national level will continue to be a major challenge for many countries and organisations (Zillman, 2005:18).

2.9 Summary

This chapter firstly, it provided a brief definition of the key concept of the study "socio-economic benefit". The chapter then provided a discussion of the reasons why meteorological services are critical society at large and the electricity industry in particular. Thereafter, a discussion of general challenges facing meteorological services, particularly in developing countries, was provided. The review covered literature that relates to the three research objectives of the present study. First, the literature on the usefulness of information generated by the meteorological services in energy generation was provided. The literature revealed that meteorological information has been used to make decisions that are both economic and social. The literature on the value placed by the different socio-economic sectors on services provided by the meteorological services was discussed second. The review showed that there have been a number of studies conducted in the different sectors to evaluate the benefits of weather and climate forecasted information. These forecasts have been used in the different sectors for example, energy, agriculture, aviation, tourism amongst others. Lastly the review covered the literature on the opinions of electricity generator on need to update technology and infrastructure to ensure that weather and climate information meets user needs. Improvements in the climate forecasting systems and technologies have increased the benefits of the weather and climate information.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research plan, methodology and related issues. A good research project should be able to generate dependable data resulting from professionally conducted research (Creswell, 2013; Kothari, 2004; Saunders et al., 2007; Cooper & Schindler 2006 and Welman & Kruger, 2005; Allison, Hilton O'Sullivan, Owen & Rothwell, 2016). Therefore, research provides understanding of the methods and techniques used by the researcher/analyst.

During the research process the tools and methods are stated by the research methodology (Mouton 2001; Leedy & Ormrod, 2010). Thus selecting a method with a high potential to meet the objectives of the research is very important. A large body of literature refers to research methodology as the theory on the research undertaken including various systematic, detailed and transparent steps taken to ensure dependability of the data (Carter & Little, 2007; Creswell, 2013; Cooper & Schindler, 2006; Saunders et al, 2007; Welman & Kruger, 2005). According to Welman & Kruger (2005) and Allison, et al., (2016) the research procedure as described by the research methodology includes the overall research design, procedure for sampling, details on the process of collecting data, the field methods and the process of analysing data. Therefore, research must be driven by ethics to ensure credibility.

3.2 Research Methodology

A large body of literature refers to research methodology as the theory on the research undertaken, including various systematic, detailed and transparent steps taken to ensure dependability of the data (Carter & Little, 2007; Creswell, 2013; Cooper & Schindler, 2006; Saunders et al, 2007; Welman & Kruger, 2005; Mouton 2001; Leedy & Ormrod, 2010). Welman & Kruger (2005) state that a methodology describes the process followed when conducting research, which outlines the overall research design, procedure of sampling, collection of data including the field methods and the procedure followed when analysing data. Thus selecting a method with a high potential to meet the objectives of the research is very important. When collecting data, quantitative and qualitative research methods are considered the most common research approaches (Welman & Kruger, 2005).

Quantitative research involves collecting numerical data that is analysed statistically. This enables an objective reporting on the data that is in a scientific manner and numbers are analysed using statistics to ascertain the validity and reliability of data through an unbiased, objective manner. A deductive theory approach is used in a quantitative research. According to Field, (2009) and Welman & Kruger (2005), the design of the study and the results interpretation are such that the theory is tested and verified rather than developing one. According to Babbie & Mouton, 2007; Cooper & Schindler, 2006), a conceptual framework for the entire study is offered by the theory and its objective is to organise the model of the research questions or hypotheses and the whole processes of collecting data.

Whereas, in the qualitative research approach the researcher, according to Welman & Kruger (2005), records what people say and do as a result of the way they interpret the complexity" in the real sense of the world they live in. A qualitative research aims at exploring and discovering issues about the problem that usually there is uncertainty about its dimensions and characteristics as very little is known about the problem (Creswell, 2013; Domegan & Fleming, 2007:24). Therefore, an avenue that leads to the deeper meaning and understanding of participants is discovered. In the qualitative research method, data is collected through in-depth interviews with individuals, participants' observations or focus groups (Babbie & Mouton, 2007; Gravetter & Forzano, 2009:147; Kothari, 2004; Myers, 2009).

However, there is also a mixed research method which has recently gained popularity where both qualitative and quantitative research and data in the study are combined (Creswell, 2013; Tashakkori, & Creswell, 2007; Harwell, 2011). According to Harwell (2011), the mixed method research attempts to answer research questions using multiple approaches and it draws strength of both the qualitative and quantitative research methods.

This research used the quantitative research approach. The study used an electronically administered survey questionnaire as a tool to collect data to minimize costs since the study population (the licensed electricity generators) is dispersed in different areas in South Africa. Saunders et al., (2007) mention that some of the advantages of electronically administered questionnaires are that they are low cost; fast and have a global reach.

3.2.1. The Study Population

Population entails the entire group of people, events, or things of interest that are being studied by the researcher (Sekaran & Bougie, 2013). The target population according to Sekaran & Bougie (2013) must be defined in terms of elements (a single member or unit of the population), geographical boundaries and time. As mentioned above, the target population of the study was ALL electricity producers that are licensed by the National Energy Regulator of South Africa (NERSA). In total there are 45 such licensees. Thus in essence the study design was a purposive (or non-probability) selection of licensed electricity producers in the country.

3.2.2. Questionnaire as a Research Instrument

According to Kothari (2004), in order for the questionnaire to be effective in collection the relevant information and it must be carefully prepared. Questionnaires can either be structured or unstructured. There are several ways questionnaires in which can be administered, for instance; electronically using the internet or intranet, sent through mail where after completion respondents return them by mail or delivered to each respondent by hand (Saunders et al., 2007; Sekaran & Bougie, 2013).

Data for this study was collected via a structured questionnaire that was hosted in a web-based survey tool called Lime Survey that was emailed to all 45 licensees. The email approach was adopted because the participants are dispersed over a large geographic area covering the whole country, making it almost impossible (due to cost constraints) for the researcher to conduct face-to-face or even telephonic interviews. Data collection took place between September and November 2015 and responses were received from only 26 participants, meaning that the study recorded a response rate of 56%.

3.2.3. Questionnaire Design

A sound questionnaire design should, according to Sekaran & Bougie (2013) focus on three areas and these minimize biases in the research. The first area is the wording of the questions which entails appropriate: content of the questions; the type and form of questions asked; the wording and language complexity used of the questions; the sequencing of the questions; and the respondents' personal data. The second area of focus is referred to by Sekaran & Bougie (2013) as planning of issues in term of the categorisation, coding and scaling of variables from the received responses.

This study is descriptive in nature. Descriptive research also referred to as diagnostic research, according to Kothari (2004) includes surveys and different kinds of fact-finding enquiries. In this study the questionnaire as had twenty-two questions, the majority of which were Likert type rating scales.

As indicated in chapter 1, the study sought to address the following objectives:

- To assess the usefulness of information generated by the meteorological services;
- To assess the value electricity generators place on services provided by the meteorological services; and
- To assess the need to update technology and infrastructure to ensure that weather and climate information meets the needs of users.

For objective one, the usefulness of meteorological services to electricity generators was ascertained by asking respondents to:

1) Specify the sector of electricity generation in which they make use of meteorological services. In line with the major categorisations of electricity generators in the country, the question that collected this information required respondents to choose between PV solar electricity generation, hydro-electricity generation, wind electricity generation and other unspecified types of electricity generation[3];
2) Specify whether they use the meteorological services for own or commercial electricity generation;
3) Specify the meteorological services they use. The question that collected this information required respondents to choose between basic meteorological services only, special meteorological services only and both categories of meteorological services;
4) Specify the frequency at which they typically access the information provided by the Weather and Climate Services. Here the questionnaire required the respondents to choose between the following options (daily, weekly, monthly, several times a month, annually, several times a year and don't know);
5) Specify the weather and climate forecasts that they have recently used (used in a period of less than a year). The question that collected this information allowed respondents to choose between the following forecasts that are provided by the meteorological services: temperature (Max/Min) forecasts; chance (probability) of precipitation forecasts; wind (direction, speed) forecasts; cloud cover forecasts; dew point forecasts; wave height forecasts; river height forecasts; 1-4 week outlook for temperature and precipitation; 3-month drought outlook; and 3-month local temperature outlook.
6) Indicate whether or not the information provided by the Weather and Climate services assists them in decision planning. This question consisted on a dichotomous scale where respondents had to give a yes/no answer.
7) Rate on a scale of 1 to 10, a) the usefulness of the South African Weather Services' (SAWS) awareness and safety information in helping them to: a) prepare for or respond to hazardous weather-related threats; b) the likelihood of them taking action based on information they received from SAWS, where 1 is not probable and 10 is very probable; and c) the probability of them using

[3] The category "other" includes biomass, nuclear, coal and gas electricity producers.

SAWS as a source of weather and climate information. Again, 1 is not probable and 10 is very probable

The second objective of the study, i.e. to appraise the value provided by the meteorological services, was addressed through: (1) assessment of user perceptions about satisfaction with the meteorological services; (2) analyses of information about the amounts currently paid by the electricity producers for SAWS services; (3) examination of perceptions about the amounts that the electricity producers are willing to pay for improved meteorological services from SAWS (i.e. application of the contingent valuation approach); and (4) analysis of information about savings that are enjoyed by electricity producers by using SAWS meteorological services.

The study questionnaire contained 2 questions that solicited satisfaction of electricity producers with meteorological services. The first question asked respondents to rate the value of (1) SAWS' Climate products and services, (2) SAWS hydrological products and services and (3) Hazardous weather products and services on a scale of 1-10 where 1 is not valuable and 10 very valuable. The second question required respondents to rate their satisfaction levels with SAWS' officials in respect of: (1) accessibility, responsiveness, knowledge and professionalism. Again the rating scale ranged from 1 (unsatisfactory) to 10 (very satisfactory).

The third objective of the study (i.e. assessment of the need to update technology to ensure that weather and climate information meets the needs of users) was also addressed through four questions in the questionnaire. Specifically, respondents were asked to:

1) State whether there is a need for SAWS to update its technology and infrastructure to better serve its customers. This question required respondents to give a yes/no answer.
2) Rate on a scale of 1 to 10; a) the quality of radar data available through the SAWS website, and b) the quality of data available through the SAWS website.
3) State the types of communication channels they currently use to access SAWS information and further state the sources that they will most likely use to of

access SAWS' information as technology evolves. The question on currently used media for accessing SAWS information consisted of a multiple choice where respondents were to choose between the following: South African Weather Service (SAWS) Web Sources, Non-SAWS Web Sources, Mobile Service, TV, Radio, Newspaper, Other. This question was in a multiple choice format where respondents had to choose between the following: Desktop/laptop computers, Social Media (e.g. Facebook, Twitter), mobile devices, direct interaction with the SAWS staff (e.g. in-person, telephone, web chat).

A pilot study tests effectiveness of questionnaires therefore it is conducted to identify and eliminate questions that may cause problems and issues that might arise from the study by distributing it to a small sample of the respondents, representative of the target population to be studied (Hair, Money, Samuel & Page, 2007). By so doing the questionnaire responses can be crosschecked to test reliability of the survey instrument. A pilot study was performed on two people. No shortcomings were identified and the respondents confirmed face validity of the questionnaire.

3.2.4. Validation and Reliability of the Questionnaire

According to Leedy & Ormrod (2010), the probability that the data analysis obtains statistical significance and draws meaningful conclusions from the data is influenced by the validity and reliability of the measurement instruments. As the most critical criterion, validity is the degree to which what is intended to be measured, the measurement instrument measures (Kothari, 2004; Leedy & Ormrod, 2010; Saunders et al., 2007, Sekaran & Bougie, 2013; Allison, et al., 2016). For this study the research instrument was assessed to determine whether it measures what it was intended to measure and to ensure that the questions address the objectives of the study. The research instrument was found to be valid and adequately covering all the objectives of the study.

The reliability of the research instrument entails the consistency of the results given that the entity measured has not changed across time and various items (Leedy &

Ormrod, 2010; Sekaran & Bougie, 2013; Welman & Kruger, 2005). Therefore, the stability and consistency of the concept measured by the instrument and the goodness of measure are assessed by reliability (Sekaran & Bougie, 2013).

Reliability analysis of the data was conducted from the domains using Cronbach Alpha. There were four domains measured using the Likert type scale. These domains were: economic value [SAWS climate products and service, SAWS hydrological products and services, and hazardous weather products and services]; usability of information, level of satisfaction [accessibility, responsiveness, knowledge, and professionalism], and technology [the quality of radar data available through the SAWS website and the quality of data available through the SAWS website]. The reliability analysis showed that the data were reliable, with a Cronbach's Alpha value was 0.838 (Table 3.1), which signifies a very high level of reliability.

Table 4.1: Reliability analysis output

Number of Items	49
Domain	**Reliability coefficient**
Economic value	0.56
Level of satisfaction	0.96
Technology	0.93
Information usability	0.84
Cronbach's Alpha	0.838

The reliability coefficients of the instrument ranged from 0.56 to 0.96. The level of satisfaction domain has the highest reliability coefficient of 0.96 meaning the instrument was 96% reliable in this domain whereas the economic value domain reliability coefficient was the least, i.e. 0.56 meaning the instrument was 56% reliable in this area. The overall reliability of the rated items was 0.83 which implies that overall the instrument was 83% reliable.

3.2.5. Analytical Methods

The study used mainly contingency table analysis. The results are presented in bar graphs, line graphs and pie charts.

3.3 Limitations of the research methodology

This study used only a quantitative research method approach. Due to time and funding constraints, it was impossible to make telephone calls to each participant. It took too long for respondents to return their questionnaires. It was noted that the respondents did not immediately access the web-survey emailed to then. The following are the limitations pertaining to sampling, the research instrument and the data collection process.

3.3.1. Limitation in Sampling

The study focused on the electricity producers in South Africa and this proved to contribute to the limitation as the sample size was based on the 45 licensed distributors in South Africa. The sampling technique used was distributing the web-based questionnaire to all 45 licensees which utilized the entire target population. Out of the 45 licensees, only 25 licensees (consisting of different types of power generators: solar 32%, other 32%, 20% wind and 16% hydo) participated on the study. This made only 56% response rate.

3.3.2. Limitations of the Research Instrument

The administration of the questionnaire was another limitation. A web-based survey link was emailed to participants and it was noted that the respondents did not immediately access the link. Furthermore, the responses were anonymous therefore it was not easy to determine those that responded and those that did not respond making it difficult to directly follow up with those that did not respond.

3.3.3. Limitations of the Data Collection Process

The scope of the topic pertained to electricity producers only, which proved to be very narrow given the fact that each response will be vital and non-response impacted negatively on the response rate. Moreover, respondents were given four months to respond and 3 reminders where sent. The survey consisted of 22 questions and it was noted that it took too long for respondents to fill the questionnaire on the website. Almost half of the respondents (44%) did not fully complete the questionnaire. The following questions that pertained to objective two were not answered by most participants:

- analyses of information about the amounts currently paid by the electricity producers for SAWS services;
- examination of perceptions about the amounts that the electricity producers are willing to pay for improved meteorological services from SAWS (i.e. application of the contingent valuation approach); and
- analysis of information about savings that are enjoyed by electricity producers by using SAWS meteorological services.

3.4 Chapter Summary

This chapter discussed different research methods. The methodology used in this research was extensively discussed, especially the rationale behind the methods chosen for this study. The chapter further discussed the research instrument used, how it was administered and how data was analysed. Moreover, the chapter highlighted the limitation that identified. The next chapter presents and discusses the results of the study.

CHAPTER FOUR: PRESENTATION OF RESULTS

4.1. Introduction

This chapter presents findings of this study and discusses the socio-economic benefits of meteorological services in the electricity generation industry in South Africa. As indicated in chapter 1, this is established by addressing three objectives of the study. The descriptive statistics of the study population is discussed in Section 4.2. Section 4.3 presents results of the analyses that address the first objective of the study (i.e. assessment of usefulness of information generated by the meteorological services in the electricity generation industry). Analyses that address objectives 2 and 3 of the study are presented in sections 4.4 and 4.5, respectively. While an attempt is made in this chapter to link the results with the literature that is covered in chapter 2, a detailed integration of the study results with existing literature is presented in chapter 5.

4.2. Descriptive Statistics of the Study Population

Table 4.2 shows the distribution, by type of electricity generation, of all 45 electricity producers that are licensed by NERSA and the 25 that participated in the study. The data show that of the 45 licensees, 20 (44%) in PV solar power generation, 4 (9%) in hydro power generation, 7 (16%) in wind power generation and 14 (31%) in other power generation. The distribution of the 25 power generators that participated in the study is as follows (PV solar power generation = 8; hydro power generation = 4; wind power generation = 5; and other power generation = 8). Therefore, the highest response rates were realized among hydro and wind power producers (100% and 71%, respectively) and the lowest among PV solar and other electricity generators (40% and 56% respectively).

Table 4.2: Distribution, by type of power generation, of all 45 electricity producers that are licensed by NERSA and the 25 that participated in the study

Type	Number of Licensees	Number of Participants in the study	Participants as % of licensees
PV solar power generation	20	8	40%
Hydro power generation	4	4	100%
Wind power generation	7	5	71%
Other power generation*	14	8	57%
Total	**45**	**25**	**56%**

Notes: *See footnote 3 (in page 34) for description of “other” electricity generators

With an overall response rate of 56%, it is safe to conclude that the electricity generators that took part in the study are a fairly good representation of population of licensed power producers in South Africa as found in the NERSA database. According to Saldivar (2012) email and web based surveys generally tend to record low response rates compared to face-to-face and telephonic interviews however, response rates of more than 40% among email and web based studies are considered average to good.

Figures 4.1 to 4.4 show the demographic profile of the respondents disaggregated by gender, age, level of education, and primary use of electricity generation relative to the level of education. Although the focus of the study is on the electricity producers (entities/ companies) the researcher felt it is necessary to report on the selected demographics of the people that responded for the respective electricity producers that participated in the study. Figure 4.1 shows that a large proportion (71%) of the participants were male.

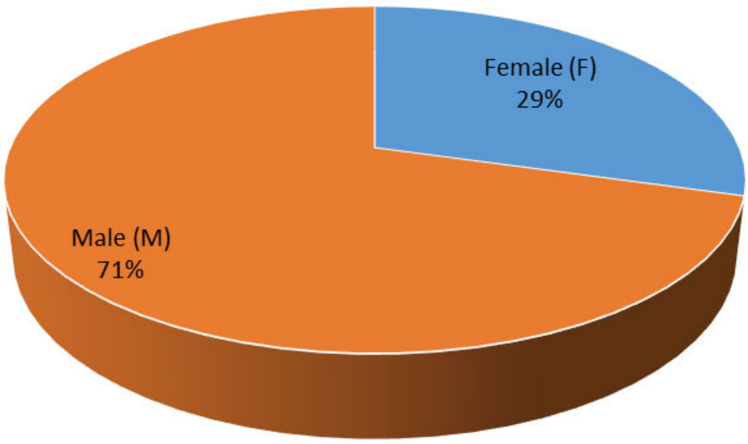


Figure 4.1: Distribution of participants by GENDER

Two-thirds of the participants (65%) were between the ages of 36 years and 55 years old (Figure 4.2).

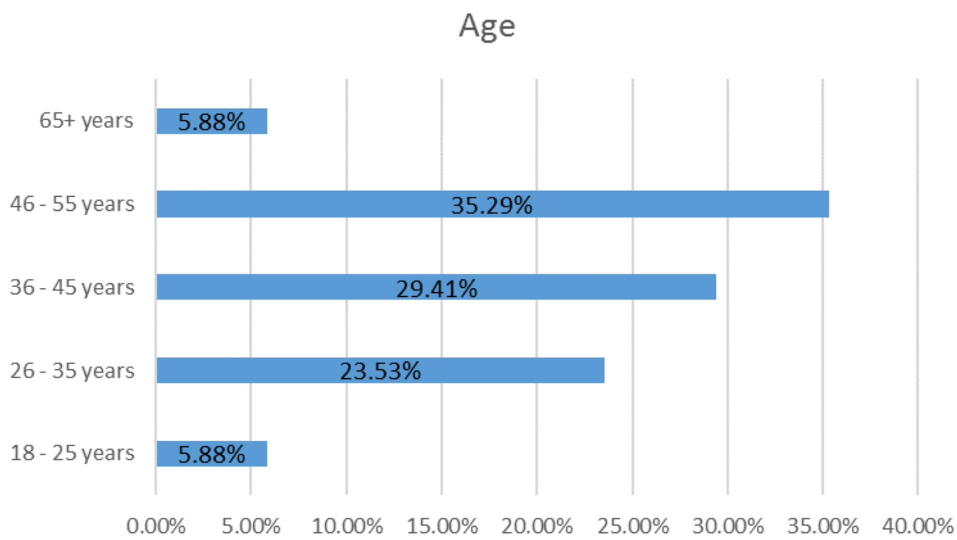


Figure 4.2: Age distribution of the participants

Almost half of the participants (42%) had masters' degrees (Figure 4.3).

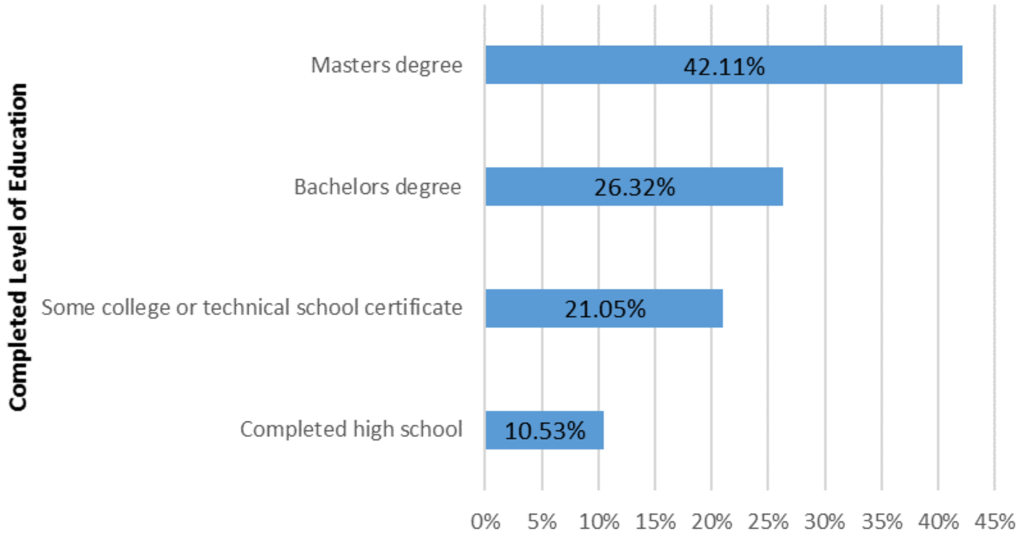
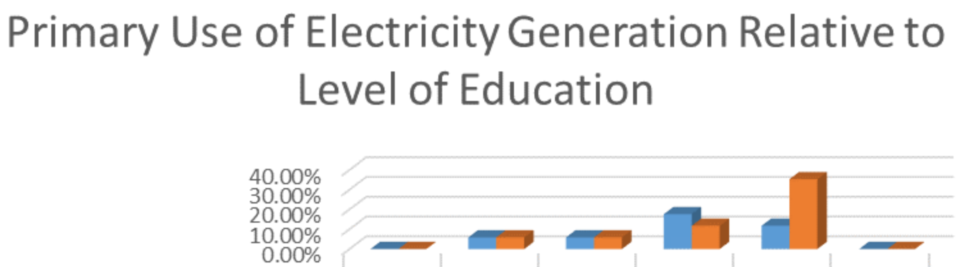


Figure 4.3: Participants' level of education

Figure 4.4 shows a significant number of commercial power generators (35%) to have completed a Master's degree.



	Did not complete high school	Completed high school	Some college or technical...	Bachelors degree	Masters degree	Professional degree or Doctor...
Own power generation	0.00%	5.88%	5.88%	17.65%	11.76%	0.00%
Commercial power generation	0.00%	5.88%	5.88%	11.76%	35.29%	0.00%

Figure 4.4: primary use of electricity generation relative to the level of education

The demographics of the participants in this study, is a reflection of the level of innovations that have been introduced in the electricity generation which include the renewable energies that require more technological sophistication hence the highest number of participants have completed their Masters' degree.

4.3. The Primary Use of Information by Sector of Electricity Generation

With regards to the investigation of usefulness of meteorological information in the energy generation industry, Figure 4.5 shows that almost half (44%) of PV solar electricity producers participating in the study mentioned that they used information provided by the Weather and Climate Services in their operations. The corresponding proportions of the 25 power producers that made use of meteorological information in their operations are hydro (9%) wind (16%) and other (31%) electricity generators. These results show considerable usefulness of the meteorological information provided by SAWS for all sectors of the electricity generation industry in South Africa.

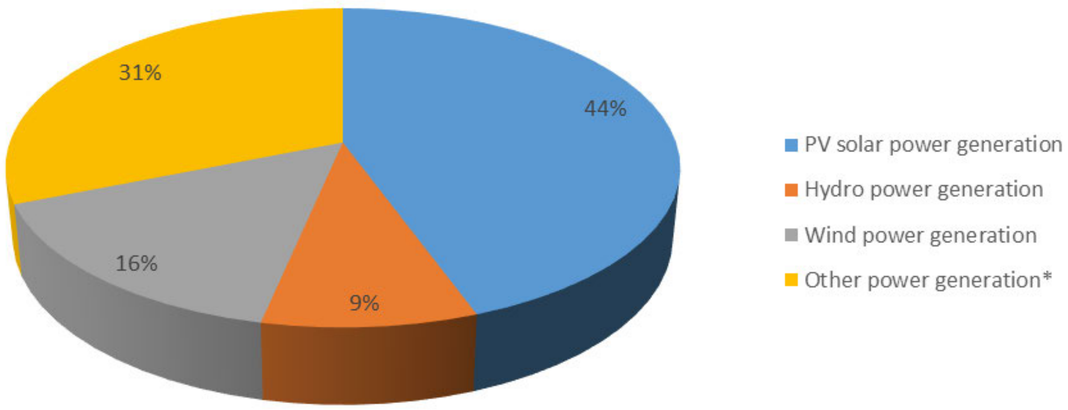


Figure 4.5: Distribution of electricity producers by primary use of information provided by the Weather and Climate Services

4.4. Objective 1: Assessment of usefulness of meteorological information in the electricity generation industry

As indicated in section 3, this objective is addressed in the study by answering 7 sub-questions. These include assessment of: (1) the primary use of information by sector of electricity generation; (2) usage of meteorological information by type of energy generation; (3) the category of meteorological services used; (4) the frequency at which information is accessed; (5) the types of weather and climate forecasts utilised; (6) usability of information generated by the meteorological services in the electricity generation industry; and (7) whether the information provided by the meteorological services assisted users in decision planning The analyses that cover the seven sub-questions are presented in section 4.4.1 – 4.4.6.

4.4.1. Usage of meteorological information by type of energy generation

Of the users of meteorological services who responded to the question whether the power they generate is for own consumption or for commercial purposes, more than half of the participants (59%) indicated that they used weather and climate information to produce electricity for commercial purposes (sold to the national grid) and the remainder (41%) generated power for own consumption (Figure 4.6). This finding is consistent with the aspirations of South African government's integrated resource plan (IRP2010) to increase the production of electricity from alternative energy sources to contribute to the capacity of megawatt hours produced by Eskom (Creamer, 2013) .

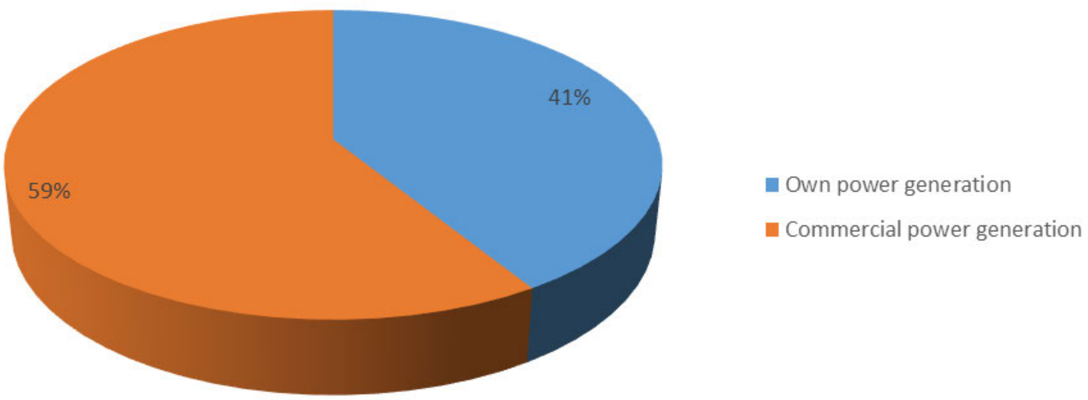


Figure 4.*6*: Usage of Weather and Climate Services by type of electricity generation

4.4.2. Category of meteorological services used

As indicated earlier, the meteorological information provided by the SAWS is categorised into two broad groups namely: basic meteorological services and special meteorological services. Figure 4.3 shows that 46% of the electricity producers that participated in the study used basic meteorological services only, 36% use both basic and special services and the remainder (18%) use special meteorological services only.

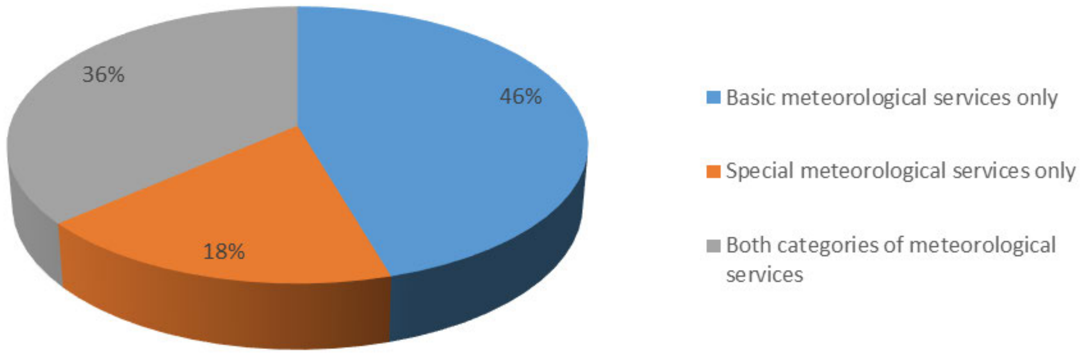


Figure 4.7: Category of meteorological services used

4.4.3. Frequency at which information was accessed

The respondents were given four options from which to select how frequent they accessed weather and climate information; results are depicted in Table 4.3. The largest proportion of electricity producers (40%) accessed meteorological information on a daily basis, whereas 30% access the information weekly, 20% monthly and 10% annually. The large proportion of daily users of meteorological information underscores the importance of this information in the electricity generation industry.

As stated in Chapter 2, daily forecasts are, amongst others, forecasts that could help energy producers and the society as a whole to adapt effectively to the changing nature of energy markets and to optimize operations (EAC, 2008; Weiher, et al., 2005; Lee & Lee, 2007; Davison, et al., 2012). However, this finding somewhat contradicts Tennant and colleagues' observation that, the medium range forecasts

(3–14 days) are the most popular in a number of sectors in South Africa (Tennant, et al., 2007).

Table 4.3: Frequency at which electricity producers' access information provided by the Weather and Climate Services

Period	%
Daily	40.0%
Weekly	30.0%
Monthly	20.0%
Annually	10.0%
Several times a month	0.0%
Several times a year	0.0%
Don't know	0.0%
Total	**100%**

4.4.4. Types of weather and climate forecasts utilized

Assessment of the type of weather and climate forecasts utilised by the power generators, shows that temperature forecast is the most widely used type of weather information in the electricity generation industry (Figure 4.8). The largest proportion (33.3%) of the study participants reported had used this information within the last 12 months before the study. This is followed by wind forecasts, chance of precipitation forecasts, and 1-4 weeks outlook for temperature and precipitation (all which were reported by 16.4% of the respondents). River height forecasts were utilised by 8.3% of the respondents and the cloud cover by only 4.2% of the respondents. Three-month temperature outlook, 3-month drought outlook, wave height forecasts and dew point forecasts were not utilised at all by the respondents.

The analysis in this sub-section was not disaggregated by type of energy producer. However, literature (e.g. Roulston, et al., 2003) indicates that wind energy producers mainly use wind velocity information for their operations while hydropower producers mainly use information on precipitation levels (Weiher, et al 2005).

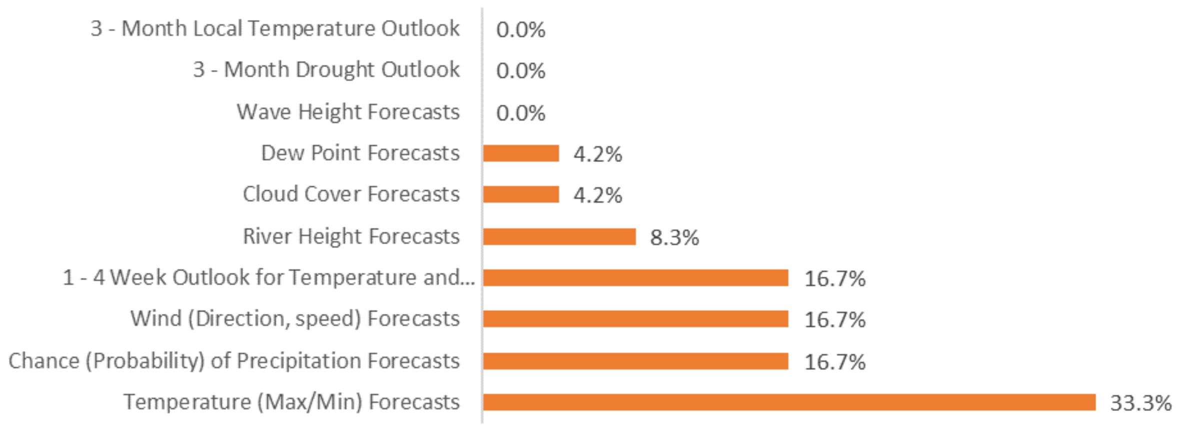


Figure 4.8: Types of weather and climate forecasts that have recently (less than a year) been used by electricity producers

4.4.5. Usability of information generated by the weather and climate services in the electricity generation industry

As indicated earlier, the study questionnaire included 3 questions that allowed for assessment of usability of the information that is generated by the weather and climate services in the power generation industry. These questions required respondents to rate, on a scale of 1-10: (1) how they perceived the usefulness of SAWS awareness and safety information in helping them prepare for or respond to hazardous weather-related threats; (2) the likelihood of using information from SAWS to inform their actions or operations; and (3), the probability of using SAWS as the service provider of choice for weather and climate information.

The results for the rating of perceived usefulness of SAWS awareness and safety information in helping electricity producers prepare for or respond to hazardous weather-related threats are shown in Figure 4.9. The 10-point rating scale is divided into 4 categories: *not useful* (rating scores ranging from 1 to 4); *somewhat useful* (rating score = 5); *useful* (rating scores ranging from 6 to 9); *very useful* (rating score =10). Figure 4.9 shows that the largest proportion (39%) of energy producers that participated in the study were of the opinion that the awareness and safety information they get from SAWS is useful in helping them prepare for or respond to hazardous weather-related threats. Respondents who felt the information is not useful made 23% while another 23% of the respondents did not respond to the question. Only 15%of the respondents regarded the information as somewhat useful and none considered the information very useful.

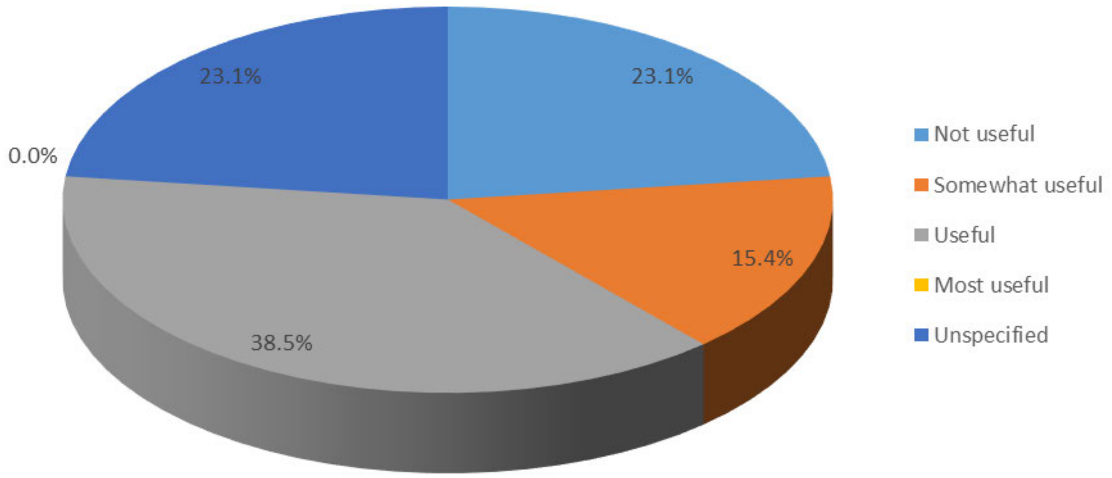


Figure 4.9: Rating of usefulness of SAWS awareness and safety information in helping prepare for or respond to hazardous weather-related threats

The results of the rating of perceived probability of electricity producers to take action from using the SAWS information are shown in Figure 4.10. Again, the 10-point rating scale is divided into 4 categories: *not probable* (rating scores ranging from 1 to 4); *somewhat probable* (rating score = 5); *probable* (rating scores ranging from 6 to 9); *very probable* (rating score =10). Figure 4.10 shows that the majority (54%) of energy producers that participated in the study thought that they would probably take action based on the information they get from SAWS. Only 8% of the respondents felt they were not likely to take action while 15% felt they are somewhat likely to take action based on such information. None of the respondents felt they were very likely to take action and about 23% did not respond to the question on the likelihood of using SAWS meteorological information to guide actions.

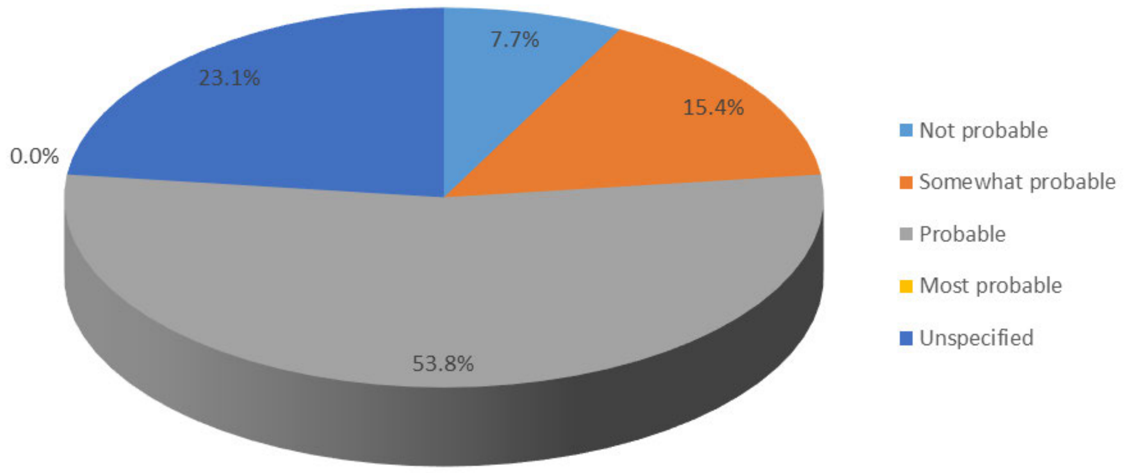


Figure 4.10: Rating of probability of SAWS information in influencing actions

The results for the rating of perceived probability of electricity producers using the South African Weather Services as a source for weather and climate information are shown in Figure 4.11. The 10-point rating scale is divided into 4 categories: *not probable* (rating scores ranging from 1 to 4); *somewhat probable* (rating score = 5); *probable* (rating scores ranging from 6 to 9); *most probable* (rating score =10). The majority (77%) of energy producers that participated in the study thought that they are likely to use the SAWS as a source of choice for weather and climate information. Only 8% felt it is somewhat probable that they would use the information. None of the respondents felt they are very likely as well as not likely to use SAWS as the source of weather and climate information. About 15% of the respondents did not respond to this question. This is underscored by literature (e.g. Troccoli, et al., 2013), that meteorological information is essential for reducing energy pricing uncertainty and ensuring that energy system efficiencies are increased.

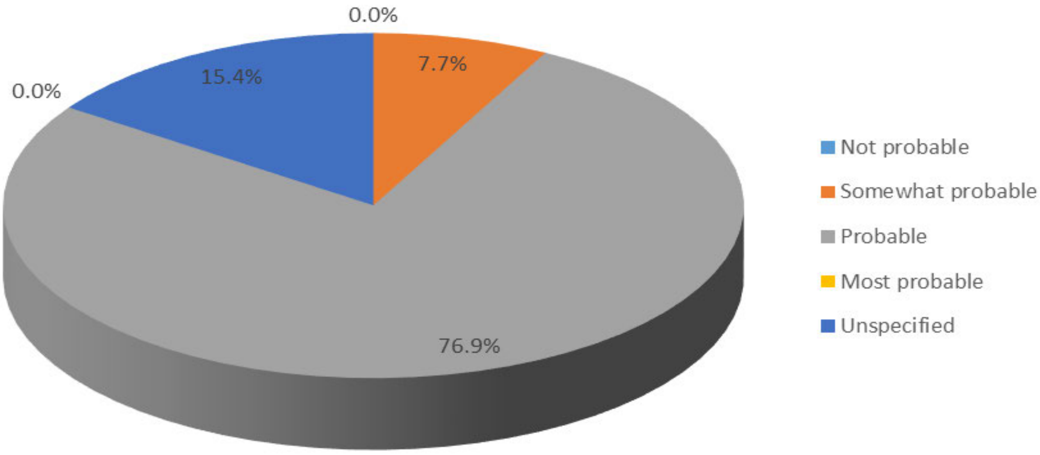


Figure 4.11: Rating of the likelihood/ probability of using the SAWS as a source for weather and climate information

4.4.6. Link between Meteorological Information and Electricity Producers' in planning decisions

Figure 4.12 shows the results of the analysis of information that assesses whether or not the Weather and Climate services provided by SAWS assisted electricity producers in decision making. In line with literature (e.g. Hautala, et al., 2008) the results show that the majority (79%) of energy producers that participated in the study reported that the information provided by the Weather and Climate Services assisted them in planning decisions.

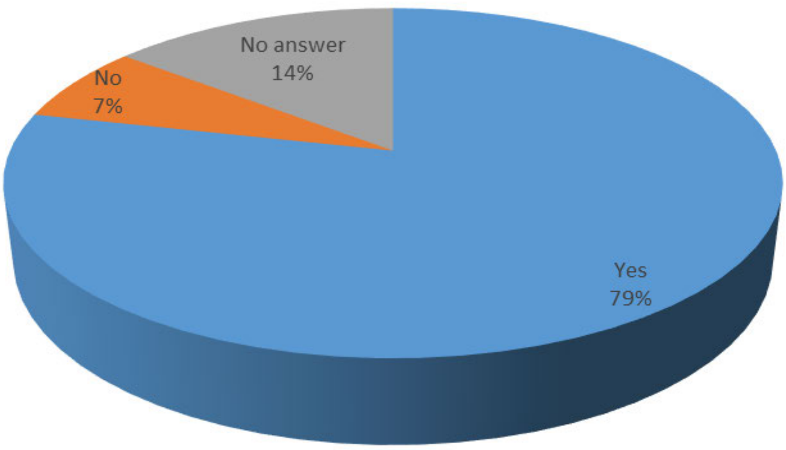


Figure 4.12: Distribution of respondents according to perceptions about whether [or not] information from SAWS assists in planning decisions

4.5. Objective 2: Assessment of the value that electricity generators place on services provided by the South African meteorological services

As indicated in chapter 3, the value placed by electricity producers on services provided by the South African Weather Services is assessed in this study by: establishing the electricity producers' satisfaction in 3 fronts. The first strand involves analysis of information collected by a question that asked respondents to- in a scale of 1-10, where 1 is not valuable and 10 very valuable: (1) provide an overall rating of the value of SAWS climate products and services, (2) rate the value they place on SAWS hydrological products and services and (3) rate the value they place on hazardous weather products and services. The second strand of the analyses involves analysis of information collected through a question that required respondents to rate their satisfaction levels with SAWS officials in respect of: (1) accessibility, responsiveness, knowledge and professionalism, again using a 10-point scale where 1 = unsatisfactory and 10 = very satisfactory. The third strand of the analysis involves: (1) assessment of information about the amounts currently paid by the electricity producers for SAWS services; (2) examination of perceptions about the amounts that the electricity producers are willing to pay for improved meteorological services from SAWS; and (3) analysis of information about savings that are enjoyed by electricity producers by using SAWS meteorological services.

4.5.1. Rating of value placed by electricity generators on products and services provided by the SAWS

In line with the analytical approach that was applied in section 4.5, the information that was gathered using the 10-point rating scale of value placed by electricity generators on (1) overall SAWS Climate products and services, (2) SAWS' hydrological products and services and (3) SAWS' Hazardous weather products and services is summarized into 4 categories: [*not valuable* (rating scores = 1 to 4);

somewhat valuable (rating score = 5); *valuable* (rating scores = 6 to 9); *most valuable* (rating score =10)].

Figure 4.13 shows that half (50%) of electricity producers that participated in the study reported that the SAWS climate products and services are valuable for their businesses. 14% of the respondents felt the products and services are very valuable. 7% felt the products and services are somewhat valuable. Another 7%of the respondents regarded the products and services not valuable. About 24% of the respondents did not respond to the questions.

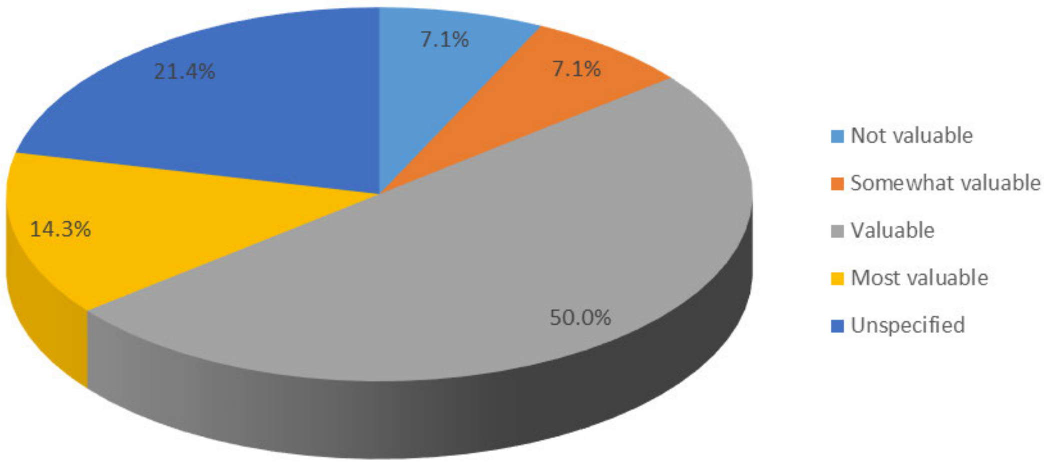


Figure 4.13: Rating of value placed on SAWS Climate products and service by electricity producers

Figure 4.14 shows the results for the rating of electricity producers' view on whether the hydrological products and services were of value. The largest proportion (29%) of energy producers that participated in the study regarded the SAWS' hydrological products and services did not find the products and services valuable. While 21% of the respondents deemed the hydrological products and services somewhat valuable. Another 21% of the respondents regarded hydrological products and services valuable to their businesses. Only 7% of the respondents felt the hydrological products and services were very valuable. 21% of the respondents did not respond to the relevant question.

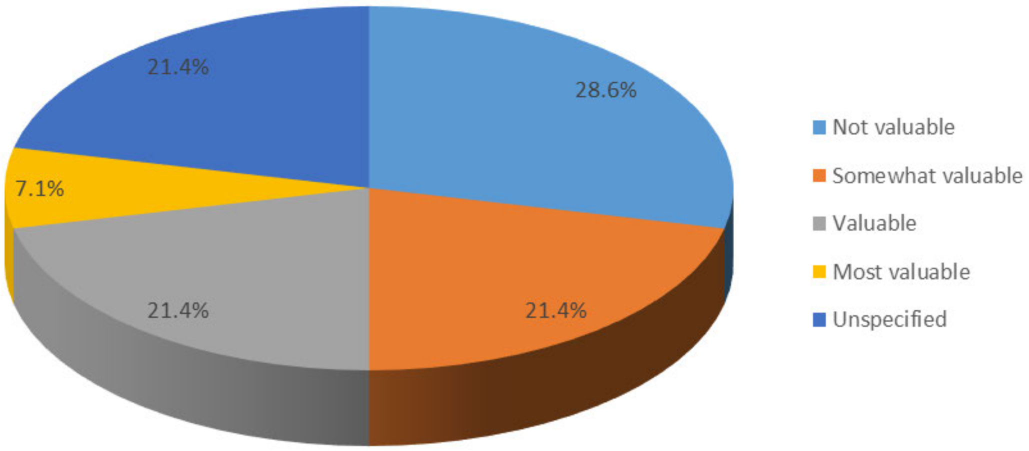


Figure 4.14: Rating of value placed on SAWS Hydrological products and services by electricity producers

Figure 4.15 shows the results for the rating of electricity producers' view on whether the hazardous weather products and services were of value. The majority (36%) of energy producers that participated in the study deemed the SAWS' hazardous weather products and services valuable for their businesses. Equal percentages of the respondents regarded the hazardous weather products and services as somewhat valuable or not valuable (both 21%). None of the respondents thought that hazardous weather products and services were most valuable. The remaining 21% of participants did not respond to the question.

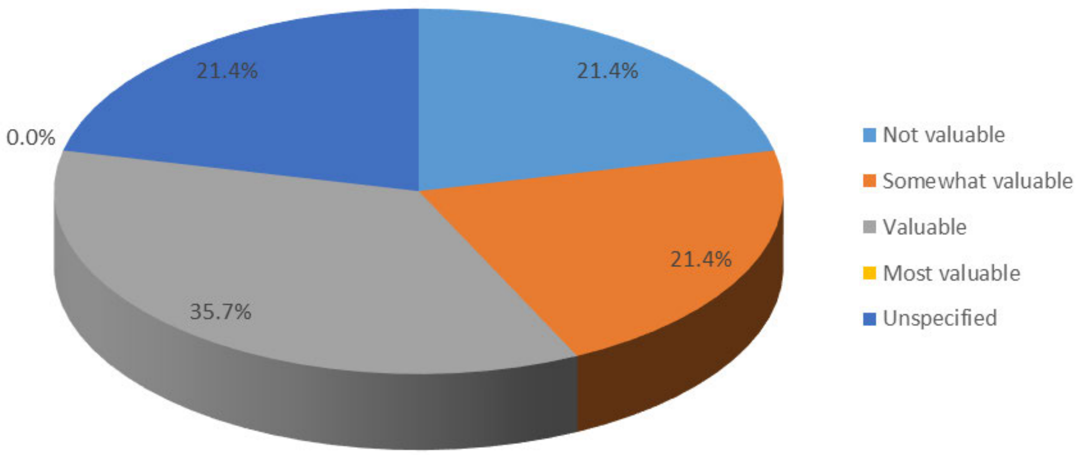


Figure 4.15: Rating of value placed on SAWS' Hazardous Weather products and services by electricity producers

4.5.2. Rating of SAWS' staff

The information that was collected using the 10-point rating scale of electricity generators' satisfaction with the performance of SAWS staff pertaining accessibility, responsiveness and professionalism is also collapsed into 4 categories— *not satisfactory* (rating scores 1 to 4); *somewhat satisfactory* (rating score = 5); *satisfactory* (rating scores 6 to 9); *very satisfactory* (rating score =10).

The results in figure 4.16 show that 29% of respondents were somewhat satisfied, 21% were satisfied and 14% were not satisfied with the accessibility of the SAWS staff (Figure 4.12). 7% of the respondents were very satisfied with the accessibility of the SAWS staff. Of the total number of participants 29% did not respond to this question.

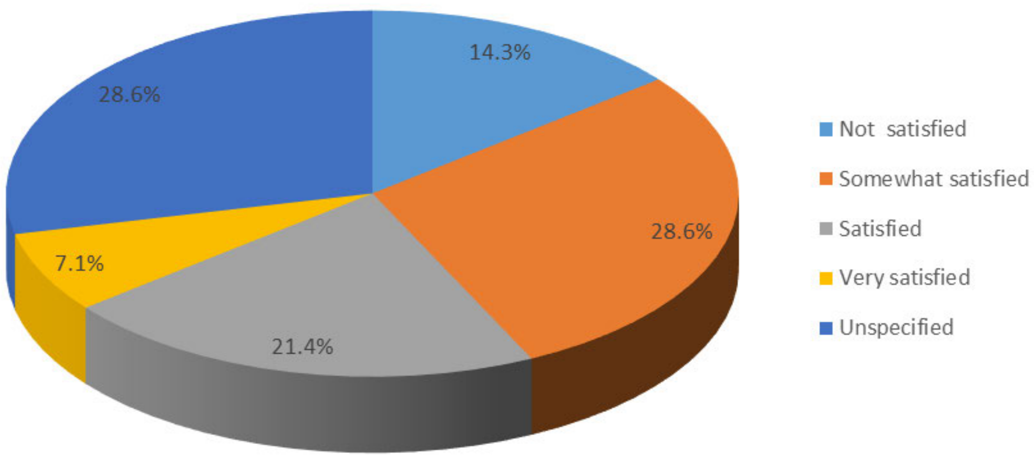


Figure 4.16: Rating of SAWS' staff on accessibility

Figure 4.17 shows that the 29% of the respondents were both somewhat satisfied and satisfied with the responsiveness of the SAWS staff. 14% of electricity generators were not satisfied with the responsiveness of the SAWS staff. None of the respondents were very satisfied with the accessibility of the SAWS staff. However, 29% of the participants did not respond to the question.

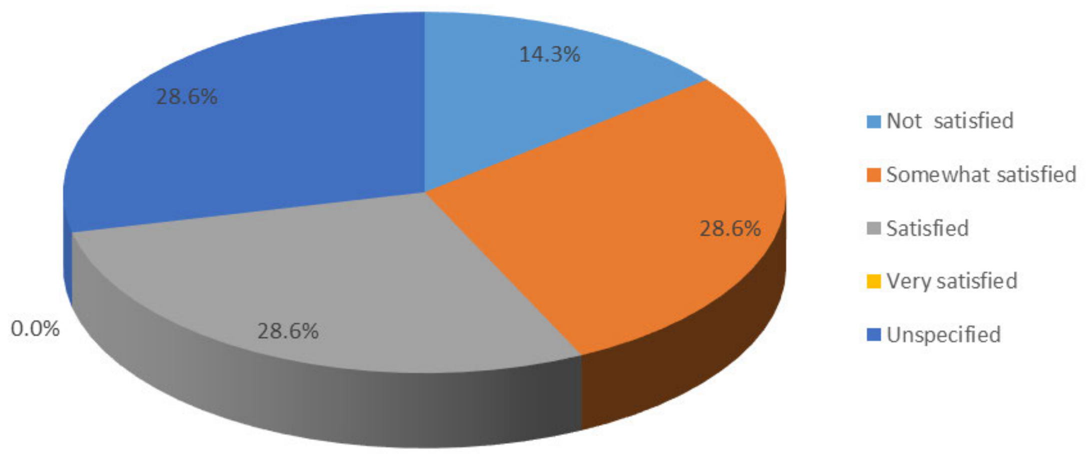


Figure 4.17: Rating of SAWS' staff on responsiveness

The results shown in Figure 4.18 reveal that 31% of the respondents were satisfied with the knowledge shown by the SAWS staff and 31% did not respond to the relevant question. Some 23% of electricity generators were somewhat satisfied with the knowledge shown by the SAWS staff and another 15% were not satisfied. None of the respondents were very satisfied with the knowledge of the SAWS staff.

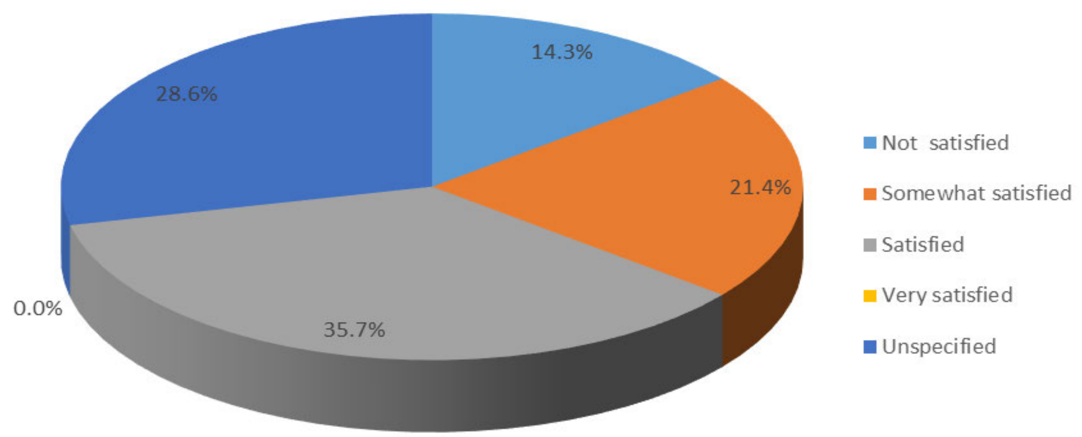


Figure 4.18: Rating of SAWS' staff on knowledge

With regards to the measure of professionalism of SAWS staff, 29% of the electricity generators were satisfied that SAWS staff were professional and another 21% were somewhat satisfied; 14% were not satisfied while 7% were very satisfied with SAWS staff's professionalism. The majority of electricity producers (29%) did not respond to the relevant question as shown by the results in Figure 4.19.

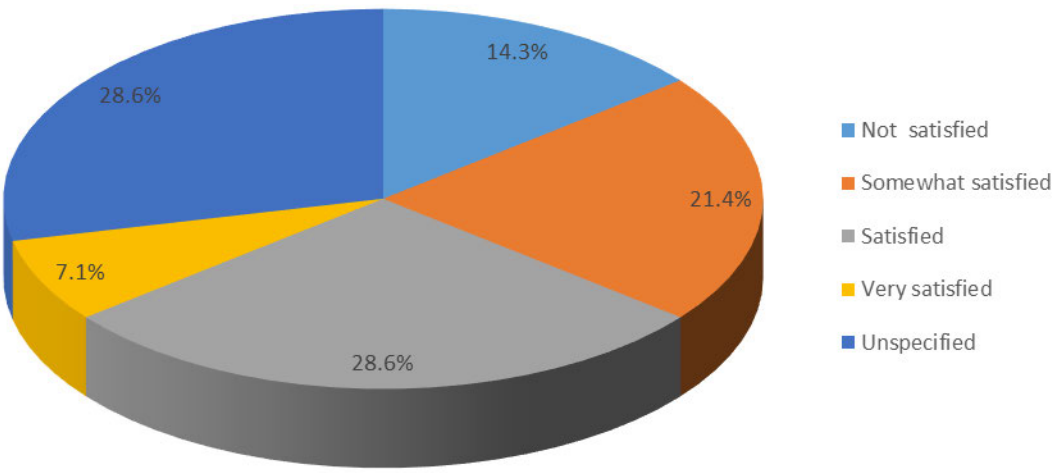


Figure 4.19: Rating of SAWS' staff on professionalism

4.5.3. Determining value through willingness to pay for meteorological services

To determine willingness to pay for meteorological services, the following was assessed: 1) the current amount users pay for weather and climate services; 2) whether respondents have saved a lot of money as a result of weather and climate information; and 3) the amount of money the respondents are willing to pay for improved meteorological services.

Only one participant responded to the question on the amount of money currently paid for weather and climate services and stated that they were currently paying R65. This information is therefore not useful for the study. However, two thirds of the participants (60%) reported that they did not save a lot of money as a result of the information provided by the SAWS (Figure 4.20)

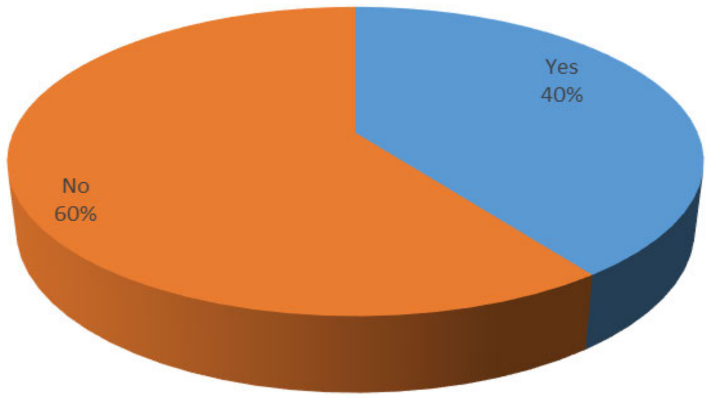


Figure 4.20: Distribution of respondents according to whether [or not] they have saved a lot of money as a result of the information provided by the SAWS

Participants were asked to indicate the amount they would be willing to pay for improved meteorological information provided by the SAWS. Figure 4.21 shows that 70% of the study participants did not respond to the question, meaning that only a few (6 to be specific) responded to the question. This makes it difficult to draw and conclusions about the perceptions of electricity producers on the amount of money they are willing to pay for SAWS services. Nonetheless, Figure 4.21 shows that among the electricity producers that responded the amount ranges from R65 to R5000.00 per annum.

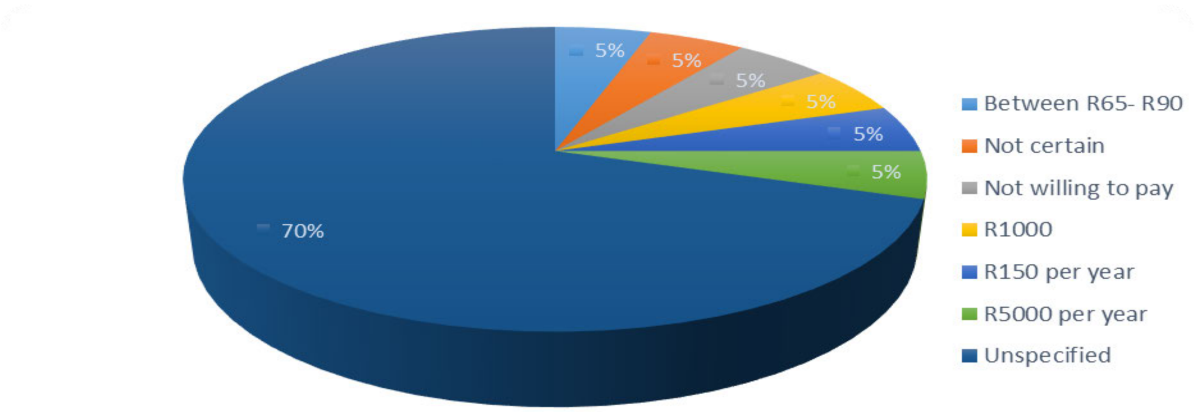


Figure 4.21: Distribution of respondents according to amount they are willing to pay for improved meteorological information provided by the SAWS

4.6. Objective 3: Assessment of the need to update technology and infrastructure to ensure that weather and climate information meets the needs of users

As indicated in the data and methods section, assessment of the need for improvement of SAWS' technology and infrastructure to better meet user needs in the electricity generation industry is achieved in the study by answering four questions. The first question required respondents to state, in a yes/no answer, whether [or not] there is a need for SAWS to update its technology and infrastructure to better serve its customers. The second question required respondents to rate in a scale of 1 to 10, 1 being *poor* and 10 being *excellent*: (a) the quality of radar data available through the SAWS website, and (b) the quality of data available through the SAWS website.

The third and fourth questions required respondents to state the types of communication channels they currently use to access SAWS information and further state the source(s) they will most likely use to access this information as technology evolves.

4.6.1. Need for technology and infrastructure update

Figure 4.22 shows that a majority of the electricity generators (69%) that participated in the study feel that there is a need for SAWS to update its technology and infrastructure to better serve its customers. This finding is congruent with the East African Community Secretariat's position that there is a need to improve the quality of technology used to provide weather and climate information (EAC 2008).

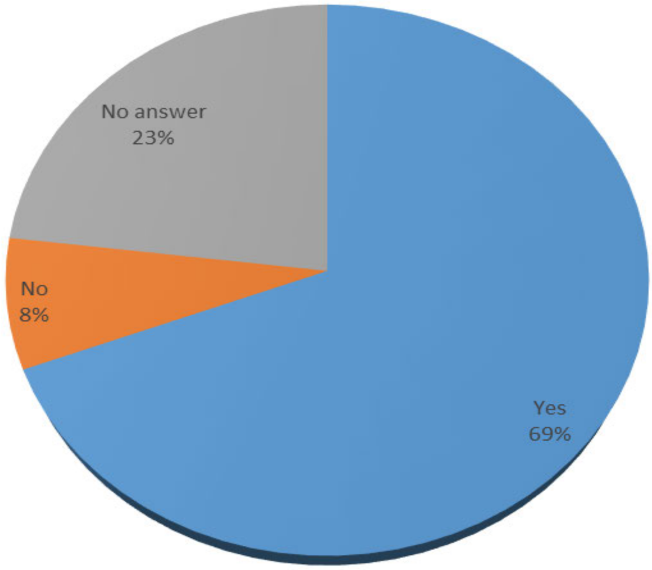


Figure 4.22: Distribution of respondents according to opinion on whether [or not] there is a need for SAWS to update its technology and infrastructure to better serve its customers

4.6.2. The quality of radar data and general meteorological data available through the SAWS website

Figures 4.23 and 4.24 show the ratings of the quality radar data and general meteorological data that are found in SAWS' website. The 10-point rating scale was divided into 4 categories: *poor* (rating scores ranging from 1 to 4); *fair* (rating score = 5); *good* (rating scores ranging from 6 to 9); *excellent* (rating score =10). Figure 4.23 shows that the largest proportion of electricity producers (46%) that participated in the study rated the quality of radar data available through the SAWS website as good and 31% regarded quality of radar data fair. Respondents who regarded the radar data available through the SAWS website poor amounted to 8%. 15% of the respondents did not respond to the question. Again, the finding made by the current study is in agreement with findings from other studies in literature (e.g Abrams, 2004; Dutton, 2002; Guiney, 2007), which also observed that the delivery of meteorological service is increasingly dependent on sophisticated information technology.

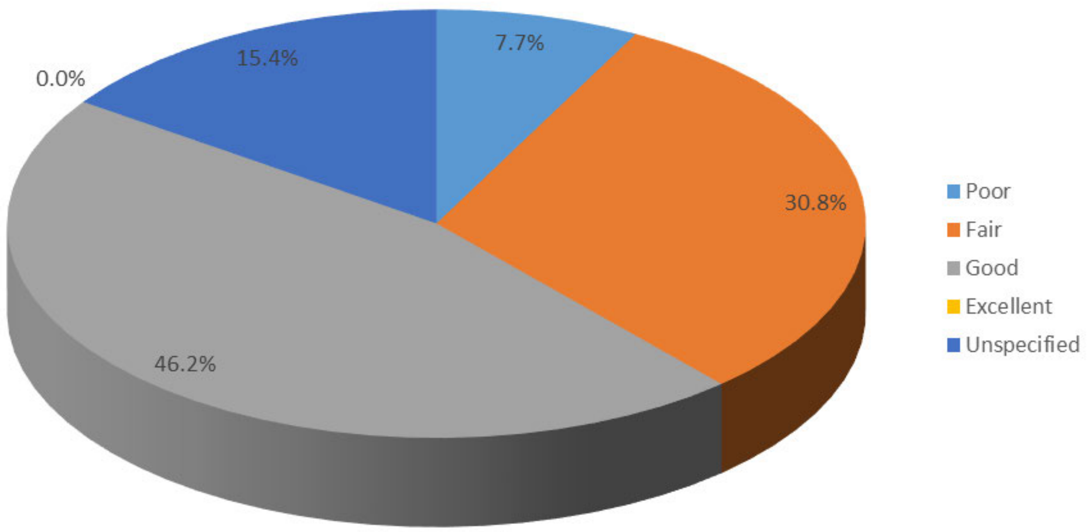


Figure 4.23: Distribution of respondents according to rating of the quality of radar data available through the SAWS website

The results in Figure 4.24 show that half of electricity producers (46%) who participate rated the quality of data available through the SAWS website as good. Those who rated the quality as fair amounted to 23% of data and only 8% of the electricity generators rated the data as poor. Another 8% of the electricity generators rated the data excellent. 15% of the participants did not respond to the question.

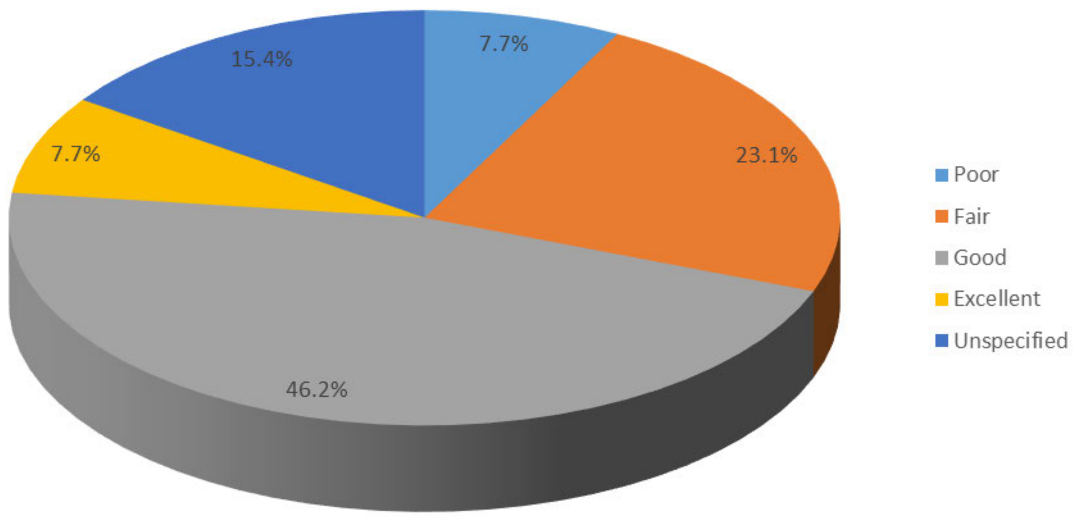


Figure 4.24: Distribution of respondents according to rating of the quality of data available through the SAWS website

4.6.3. Type of media currently used by electricity generators to access SAWS information

About half (46%) of the respondents reported that they currently access meteorological information from South African Weather Services (SAWS) using Web Sources followed by Non-SAWS Web Sources and Mobile Service (both 15%) (Figure 4.25). This means the internet is by far the most used source of meteorological information. This pattern is not unique to South Africa. As documented in chapter 2, similar conclusions have been made in other settings. In Canada, for example, a web based platform called the Canadian Climate Data Scraping Tool (CCDST) provides the public with free access to meteorological information (Bonifacio, et al., 2015).

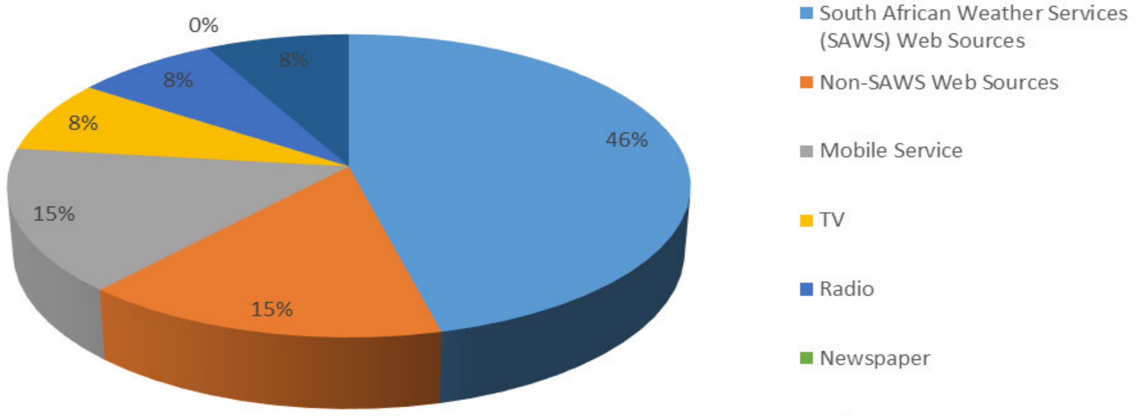


Figure 4.25: Distribution of respondents by medium of receiving information provided by the Weather and Climate Services

4.6.4. Sources most likely to be used as technology evolves

More participants (57%) reported that they are most likely to use desktop/laptop computers to get SAWS information and the remainder (43%) reported the use of mobile devices. It is interesting to note that none of energy producers that took part in the study mentioned use of social media (Figure 4.22). Although desktop/laptop computers was preferred by most of the respondents in the study, mobile devices allows interactive access to weather forecasts at any desired time and in every place (Žagar, et al., 2003).

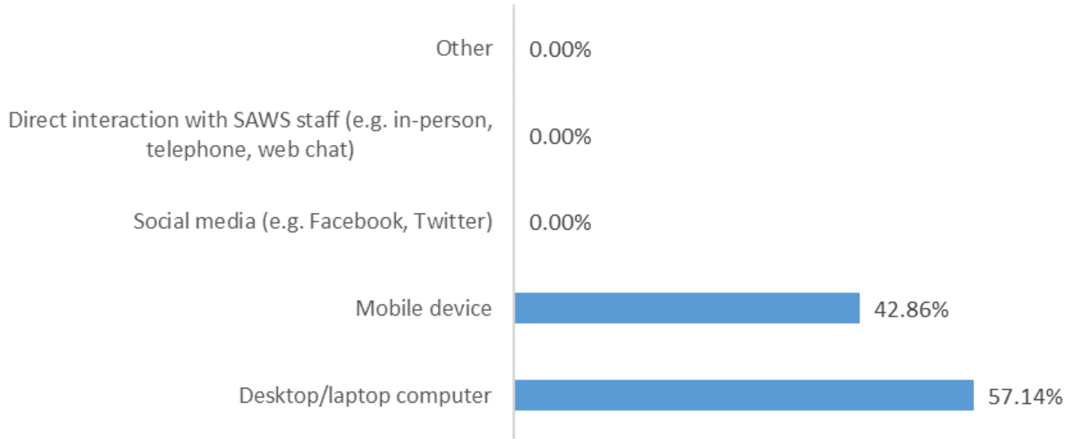


Figure 4.26: Distribution of respondents by type of source most likely to use to get the SAWS information as technology evolves,

4.7. Chapter Summary

This chapter presented results of analyses that was performed on the data that was collected from electricity generators that are registered with the National Energy Regulator of South Africa (NERSA) to address the three research objectives of this study as outlined in chapter one. Based on the results presented in this chapter, the next chapter provides a detailed discussion of the findings, conclusions and makes recommendations.

CHAPTER FIVE – DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

The purpose for this study was to assess the socio-economic benefits derived from meteorological service. This chapter provides an in-depth discussion of the results presented in chapter 4. Thereafter, it draws conclusions and makes recommendations for further research on socioeconomic benefits of meteorological services in South Africa.

5.2. Discussion

This section combines the objectives in Chapter One with the findings in Chapter Four of this study. The objectives of the study were answered by unpacking the responses from the questionnaires by the respondents.

5.2.1. Assessment of the usefulness of meteorological services to electricity generators

The first objective to assess the usefulness of meteorological services to electricity generators was answered using seven sub-objectives/ sub-questions. These included assessment of: (1) the primary use of information by sector of electricity generation; (2) usage of meteorological information by type of energy generation; (3) the category of meteorological services used; (4) the frequency at which information was accessed; (5) the types of weather and climate forecasts utilised; (6) usability of information generated by the meteorological services in the electricity generation industry; (7) whether the information provided by the meteorological services assisted users in decision planning.

Of the seven sub-questions, three yielded responses that directly answer the question of whether [or not] the meteorological information produced by SAWS is useful for electricity generators in South Africa. These are sub-questions 4, 6 and 7 above (i.e. the questions on (1) frequency at which meteorological information is accessed, (2) usability of information generated by the meteorological services in the electricity generation industry, and (3) whether [or not] the information provided by the meteorological services assisted users in decision planning). The majority of electricity producers that took part in the study responded affirmatively to these questions.

Specifically, on the question of usability of information generated by the meteorological services in the electricity generation industry the study the results indicated that: (a) a majority (54%) of electricity producers that participated in the study are more likely to use the meteorological information generated by SAWS to influence their actions; (b) a large proportion (39%) of the study participants perceived SAWS safety and awareness information as useful in helping them prepare for or respond to hazardous weather related threats. A further 15% of the respondents perceived this service from SAWS as somewhat useful; (c) a majority (77%) of the electricity producers that took part in the study reported that they are most likely to use SAWS as their supplier of choice when requiring meteorological information. The findings of the study provide strong evidence that meteorological information is crucial for the electricity generation industry in South Africa. This underscores the importance of climate scientists and services providers, as stated by Vaughan & Dessai (2014), to work closely with relevant users of the weather and climate information to ensure climate and weather services are more effective, more usable, and more suited to users' needs.

The study further revealed that the meteorological information does assist an overwhelming majority (79%) of electricity producers who participated in the study when making decisions. Studies on the value of information provided by weather and climate services (Lee & Lee, 2007; Leviäkangas & Hautala, 2009; Mylne, 2002; Regnier, 2008; Perrels, 2013; Vaughan & Dessai, 2014; Frisvold & Murugesan, 2013; Davison et al., 2012) agree that the value of information to the decision maker depends on the available weather and climate information, that is delivered. For electricity generation this information assists in the demand forecasting, system planning and fuel purchasing decisions.

Lastly on the sub-questions that directly address the first objective of the study, a large proportion (40%) of the electricity producers that participated in the study indicated that they accessed and therefore used meteorological information on daily basis. As pointed earlier, a large proportion of daily users of meteorological information emphasises the importance of this information in the electricity generation industry. Indeed, this point is also underscored in literature which asserts that daily forecasts specifically are amongst other forecasts that could help energy producers and users, corporate managers, and political leaders to adjust more effectively to the changing nature of energy markets (EAC, 2008) and to optimize operations (Lee & Lee, 2007). However, according Hautala, et al. (2008) 13 days expected hydrological forecasts were found to be forecasts that users in Montenegro, South Eastern Europe are willing to pay for. Also Tennant, et al. (2007) state that medium range (3–14 days) is particularly popular through a number of sectors in South Africa.

Indirect inferences about the importance of meteorological services in the operations of electricity generators can be drawn from responses to the sub-questions about: (1) usage of meteorological information by type of energy generation; (2) primary use of information by sector of electricity generation; (3) the category of meteorological services used; and (4) the types of weather and climate forecasts used.

With regard to usage of meteorological service by type of energy generation the findings of the study showed that it is mainly commercial electricity producers (59%) that use meteorological information and on the question of usage of meteorological services by sector of electricity generation the results of the study showed that slightly more than four in every ten (44%) of those who participated are PV solar electricity producers. This is in line with the report by Creamer (2013) that out of the 21% contribution from renewable energy, slightly more than half (51%) will be contributed by solar power and the rest will be contributed by wind power. The results also showed that meteorological information is considerably useful for all four sectors of the electricity generation industry in South Africa. This is in line with findings from other studies (e.g. Dubus 2010) that renewable resources are sensitive to climatic conditions, therefore use meteorological services.

The findings of the study on the category of meteorological services used by electricity generation industry showed that basic meteorological services is mostly used by electricity producers compared to specialised meteorological services. This finding is somewhat in contrast with findings from a large body of literature (e.g. Freebairn & Zillman, 2002: 46; EAC, 2008; Vaughan & Dessai, 2014), which shows that in most countries the energy sector generally uses specialised meteorological services albeit governments providing basic weather and climate information free of charge as a basic community necessity and a right or a public good. Lastly, on the results that provide indirect clues about the importance of meteorological services in the electricity generation sector of South Africa, the study showed that the majority of electricity producers require temperature forecasts for their operations. Due to electricity consumption that varies tremendously as a result of weather conditions, for instance the use of air conditioning during heat waves and heating during extreme cold periods (Davison et al., 2012), the energy sector values short-term and seasonal forecasts (e.g. for temperature and wind (direction and speed)) in order to accurately project peak loads and optimally schedule their electricity generating plants to meet demands at a lower cost (Weiher et al., 2005). Therefore, the provision of relevant forecasts helps as a contingency measure to cater for extreme weather and climate events (EAC, 2008).

5.2.2. Assessment of the value that electricity generators place on services provided by the South African meteorological services

The second objective to assess the value that electricity generators place on services provided by the South African meteorological services was answered using two sub-objectives/ sub-questions. These are: 1) rating of value placed by electricity generators on products and services provided by the SAWS by assessing: (a) overall SAWS Climate products and services, (b) SAWS' hydrological products and services and (c) SAWS' Hazardous weather products and services. 2) rating the electricity generators' satisfaction with the performance of SAWS staff with regards to (a) accessibility, (b) responsiveness, and (c) professionalism.

Half (50%) of the electricity generators that participated in the study rated the overall SAWS meteorological products and services as outright valuable for their businesses. However, there were differences in the rating of the two specialised services that were covered in the study. About 62% of the electricity generators that participated in the study rated hydrological products and services valuable. The results of the current study are consistent with findings in the literature as presented by von Gruenigen, Willemse & Frei (2014) that show that meteorological and hydrological services are used to keep the electricity grid stabilised at all times through controlling the impacts of changing weather conditions. Weather information such as hydrological forecasts, flood warnings, season weather forecasts and hydrological data are so valuable to some electricity producers that they even prefer to even pay for them so that they can get tailor-made services (Hautala, et al., 2008).

With regard to the rating of electricity generators' satisfaction with the performance of SAWS staff, the results do not really make sense. Maybe it is because the majority of the respondents, access meteorological information via the internet as shown in Chapter 4. On one hand the findings of the study showed that about a third (31%) of the electricity generators that took part in the study are outright satisfied with professionalism of SAWS employees. On the other hand, it is however, surprising that less than a quarter (23%) of respondents indicated that they are outright satisfied with accessibility and responsiveness of the SAWS' staff, respectively. One would expect the level of satisfaction with accessibility and responsiveness to be at the same level with that of professionalism if at all the respondents were genuine about the ranking of their satisfaction with professionalism of SAWS's staff. Nevertheless, the results of the study also found that 15% of the respondents indicated being dissatisfied while about a third (31%) reported being somewhat satisfied with accessibility and responsiveness of SAWS' staff, respectively most (31%) of respondents reported being outright satisfied when the rating SAWS' staff according to knowledge of their work. The findings of the study revealed that a considerable proportion of the study respondents rate SAWS' staff as knowledgeable and professional refute the findings of EAC (2008) that due to high levels of poverty in most African countries leading to sparse data networks, inadequate data processing and forecasting infrastructure and insufficiently skilled human resources the needs of users of weather and climate services are not met at a satisfactory level.

There were three questions asked to determine willingness to pay for the meteorological services and the results showed that:

1) The majority of respondents did not respond when asked to state the current amount they pay for the weather and climate services.
2) The majority of electricity generators indicated that they have not saved a lot of money as a result of weather and climate information.
3) The majority of electricity generators who participated in the study did not respond to the question on the amount they are willing to pay for improved meteorological information.

The high nonresponse rate for this question made it difficult to draw conclusions about the perceptions of electricity producers on the amount of money they are willing to pay for SAWS services. Nonetheless, if the reluctance of the majority of the study participants to respond to the question about the amount of money they are willing to pay for meteorological services, were to be understood to mean they want to access the services free of charge, that phenomenon would be in line expectations of some authors (e.g. Frei 2010) who argue that meteorological information should be made freely available to the public because they are public goods (they are not traded in markets). This phenomenon however, would, be in contrast with studies such as Hautala, et al., (2008) which have shown that there is willingness to pay for tailor-made services provided to electricity producers.

5.2.3. Assessment of the need to update technology and infrastructure to ensure that weather and climate information meets the needs of users

As indicated above, the first question required respondents to state, in a yes/no answer, whether [or not] there is a need for SAWS to update its technology and infrastructure to better serve its customers. The second question required respondents to rank in a scale of 1 to 10, 1 being *poor* and 10 being *excellent*: (a) the quality of radar data available through the SAWS website, and (b) the quality of data available through the SAWS website. The third question required respondents to state the types of communication channels they currently use to access SAWS information while the fourth required respondents to state the source(s) they will most likely use to access this information as technology evolves.

A majority (69%) of the electricity producers that participated in the study agreed that there is a need for SAWS to update its technology and infrastructure. In their report, EAC (2008:4) mention that some countries in Africa are “affected by the inability to cope with rapid advances in weather and climate observing, telecommunication, and data processing and forecasting technologies”. The results of the study concur with the report of the EAC, 2008 as a considerable proportion of electricity generators stated that there is a need to improve the quality of technology used in providing weather and climate information. As stated by a number of authors (e.g. Abrams, 2004; Dutton, 2002; Guiney, 2007), delivery of meteorological service is increasingly dependent on sophisticated information technology.

Despite the majority view that SAWS needs to update its technology and infrastructure, a significant proportion (46%) of electricity generators that responded to the study questionnaire rated the quality of the radar data and general meteorological data available through the SAWS website to be fair to good.

The results on the type of channel currently used by electricity generators to access meteorological information showed, as stated by Leviäkangas & Hautala (2009), that there are multiple channels through with meteorological information can be accessed and displayed at any time and in any place”. The current study specifically captured five different channels through which South African meteorological data can be accesses, namely; (1) the SAWS’ website; (2) non-SAWS websites; mobile devices; radio; television; newspapers; and other. Nearly half (46%) of the electricity generators that participated in the study access weather and climate information through the South African Weather Services (SAWS) Web sources. Another 15% access this information via other websites other than the SAWS’ website. Altogether, these results indicate that internet is by far the most widely used source for meteorological information.

With regards to sources of information likely to be used by electricity generators going forward, as technology evolves, the results of the study showed that the electricity generators will most likely to use laptop computer as a source to accessing the weather and climate information through the South African Weather Services' web sources. This can be explained by the ability to install software such as the CliDE on laptop computers which provides "statistical reports, graphical analyses, data extractions, climate summaries, and products that can provide input to public works planning, agriculture and health sectors" (Martin, Howard, Hutchinson, McGree & Jones 2015:273). Also the software tools such as the Canadian Climate Data Scraping Tool (CCDST) which has an "automated sequence that enhances access to climate data by substantially reducing the time needed to manually download data from multiple Web pages" (Bonifacio, et al., 2015:13).

5.2.4. Conclusions

The study was able to adequately address two of its three set objectives shown in chapter 1. These are objectives one (assessment of usefulness of meteorological services to electricity generators in South Africa) and objective three (assessment of the need to update technology and infrastructure to ensure that weather and climate information meets the needs of users). It did not do well on the assessment of the value placed by electricity generators on services provided by the South African meteorological services. Nonetheless, the study has put forward a strong case for the South African government to consider investing in the SAWS' meteorological services infrastructure, technology and research and development. This is more so because the energy sector, which is heavily dependent on meteorological information, has been identified by the country's national development plan as one of the most critical economic infrastructures.

With regards to the objective of assessing the usefulness of meteorological services to electricity generators in South Africa the study concludes that:

- Meteorological services are critically important for all four sectors of the electricity generation industry in the country (i.e. PV solar power; hydro power generation; wind power generation; and other power generation) and more so among commercial power generators compared to own consumption producers.

- The South African Weather Services (SAWS) is the preferred supplier of choice for meteorological services among the licensed energy generators that took part in the study.

- Basic (as opposed to specialized) meteorological information that is supplied by (SAWS) suffices for the daily operations of South Africa energy producers. This is in contrast with findings from other studies (e.g. Freebairn & Zillman, 2002: 46; EAC, 2008; Vaughan & Dessai, 2014), which show that in most countries the energy sector generally uses specialised meteorological services.

As indicated above, the study did not do well with regards to the assessment of value placed on meteorological services by South African energy producers. Nevertheless the study found out that half of the electricity generators that participated in the study rated the overall SAWS meteorological products and services as extremely valuable for their businesses.

With regards to the objective of assessing the need to update technology and infrastructure to ensure that weather and climate information meets user needs the study makes the following conclusions:

- A majority of the electricity producers that participated in the study agreed that there is a need for SAWS to update its technology and infrastructure. This is despite them also acknowledging that the technology currently used by SAWS is fairly good.

- The internet is the most widely used source for meteorological information among energy producers in South Africa.

5.3. Limitations of this study

All studies according to Heppner & Heppner (2004) have limitations and these may relate to sampling, the research instrument, the process of data collection and the research methodology. This was the first study conducted in South Africa on socio-economic benefits of weather and climate services, therefore no comparison with local studies was possible. Literature on socio-economic benefits of weather and climate services mainly pertains to other countries, especially developed countries, which posed a challenge.

5.4. Recommendations for Further Research

The research has not found previous research that compared the different types of power generation when assessing types of power generation that use meteorological information. This research is one the first that studied the socio-economic benefits of meteorological services to the electricity generation industry in South Africa.

The literature reviewed in this study has revealed that the electricity industry requires specialised meteorological services which are normally paid for. Further research to determine the rand value of the meteorological services using the contingent valuation method to assess willingness to pay is required. This may assist in funding the research and development of the meteorological information as well as the upgrade of infrastructure and technology found to be required in South Africa. More research is required to prove the effects of improved meteorological information on electricity planning and electricity operation decisions.

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APPENDIX 1 - QUESTIONNAIRE

Dear Respondent,

MBA Research Project
Researcher: Nomalungelo Natacia Simelane (083 974 5357)
Email Address: nomalungelo.simelane@nersa.org.zaa
Supervisor: Dr. Elias Munapo (0027 31 260 8943)
Email Address: munapoe@ukzn.ac.za
Research Office: Ms Mariette Snyman (0027 31 260 8350)
Email Address: Snymanm@ukzn.ac.za

I, Nomalungelo Natacia Simelane, (Student Number: 213572236), an MBA student at the Graduate School of Business and Leadership, of the University of KwaZulu-Natal, and also working as Senior Financial Analyst at the National Energy Regulator of South Africa. I invite you to participate in a research project entitled:

"Socio-economic Benefits of Meteorological Services in the South African Energy (Power Generation) Sector".

The Purpose of the Study: The aim is to evaluate the benefits of meteorological services to build a strong case for funding especially from government to upgrade infrastructure and technology to improve services provided by the National Meteorological Services

Through your participation I hope to understand the economic value of meteorological services to the users, the users' willingness to pay for these services and benefits of improved meteorological services to the Energy (Power Generation) Sector. The results are intended to contribute to building a strong case on the necessity to government to increase the funding of the infrastructure and technology required by the National Meteorological Services.

Your participation is this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequences. There would be no monetary gain emanating from participating in this research. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, University of KwaZulu-Natal.

If you have any questions or concerns about completing the questionnaire or about participating in this study, you may contact me or my supervisor, the details of which are listed above.

The survey should take about 10 – 15 minutes to complete. I hope you will take some of your precious time to complete.

Sincerely

Student/Researcher Signatur [redacted] Date: ……………………………

This page is to be retained by the participant.

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI
Graduate School of Business and Leadership

Dear Respondent,

MBA Research Project
Researcher: Nomalungelo Natacia Simelane (083 974 5357)
Email Address: nomalungelo.simelane@nersa.org.zaa
Supervisor: Dr. Elias Munapo (0027 31 260 8943)
Email Address: munapoe@ukzn.ac.za
Research Office: Ms Mariette Snyman (0027 31 260 8350)
Email Address: Snymanm@ukzn.ac.za

Research Project Title:

"Socio-economic Benefits of Meteorological Services in the South African Energy (Power Generation) Sector".

CONSENT

I ……………………………………………………………………………………………… (Full names of participant)

Working for ……………………………………………………………………………………… (Full company name)

Hereby confirm that I fully understand the contents of this document and the nature of the research project and I consent fully to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT: ……………………………………

DATE : …………………………………..

Benefits of Weather and Climate Services Survey

Please make a mark (X) on the an appropriate statement

1. Gender	
Male	
Female	
2. Age Group	
18 - 25 years	
26 - 35 years	
36 - 45 years	
46 - 55 years	
56+ years	
3. Please indicate your highest completed education level	
Did not Complete High School	
Completed High School	
Some College or Technical School Certificate	
Bachelors Degree	
Masters Degree	
Professional degree or Doctorate (e.g. DBA, PhD, MD, DDS, EdD)	
4. What is your primary use of information provided by the Weather and Climate Services?	
PV solar power generation	
Hydro power generation	
Wind power generation	
Other (Please specify)	
5. (Only if Q2 = 1) For what type of energy generation do you use the information provided by the Weather and Climate Services?	
Own power generation	
Commercial power generation	
Other (Please specify)	
6. The meteorological information provided by the SAWS is categories into two broad groups: basic meteorological services and special meteorological service. Please specify a category of meteorological services you use.	
Basic meteorological services only	

Special meteorological service only	
Both categories of meteorological services	
7. How do you receive the information provided by the Weather and Climate Services?	
South African Weather Services (SAWS) Web Sources	
Non-SAWS Web Sources	
Mobile Service	
TV	
Radio	
Newspaper	
Other (Please specify)	
8. How frequent do you typically access the information provided by the Weather and Climate Services?	
Daily	
Weekly	
Monthly	
Several times a month	
Annually	
Several times a year	
Don't know	
9. Which of the following weather and climate forecasts have you used recently (less than a year)?	
Temperature (Max/Min) Forecasts	
Chance (Probability) of Precipitation Forecasts	
Wind (Direction, speed) Forecasts	
Cloud Cover Forecasts	
Dew Point Forecasts	
Wave Height Forecasts	
River Height Forecasts	
1 – 4 Week Outlook for Temperature and Precipitation	
3 – Month Drought Outlook	
3 – Month Local Temperature Outlook	
10. Value is defined as economically beneficial or an improvement to quality of life. Using a scale of 110, where 1 is Not Valuable and 10 Very Valuable, please rate the value of each of the following products and service?	
SAWS Climate products and services	
SAWS hydrological products and services	
Hazardous weather products and services	

11. Does the information provided by the Weather and Climate Services assist in planning decisions?	
Yes	
No	
12. Considering you interaction with a SAWS office, using a scale of 1 – 10, where 1 is Unsatisfactory and 10 is Very Satisfactory, please rate the staff on each of the following:	
Accessibility	
Responsiveness	
Knowledge	
Professionalism	
13. Updating technology is essential to ensure that Weather and Climate information meets the needs of its customers. Using a scale of 1 – 10, where 1 is Poor and 10 is Excellent, Please rate	
The quality of radar data available through the SAWS website.	
The quality of data available through the SAWS website	
14. In your opinion do you see the need for SAWS to update its technology and infrastructure to better serve its customers?	
Yes	
No	
15. As technology evolves, what sources will you most likely use to get the SAWS information (Select all	
that apply)	
Desktop/laptop computer	
Mobile Device	
Social Media (e.g. Facebook, Twitter)	
Direct interaction with SAWS staff (e.g. in-person, telephone, web chat)	
Other (Please specify)	
16. How useful is SAWS awareness and safety information in helping you prepare for or respond to the hazardous weather-related threats? Use a scale of 1 – 10, where 1 is Not Useful and 10 is Very Useful	
17. Would you take an action based on the information you received from the SAWS? Use a scale of 1 – 10, where 1 is Not Probable and 10 is Very Probable	
18. How probable are you to use the SAWS as a source of weather and climate information? Use a scale of 1 – 10, where 1 is Not Probable and 10 is Very Probable.	
19. Do you consider yourself to have saved a lot from as a result of the information provided by the SAWS?	
Yes	

No	
20. How much are you currently paying for the meteorological information provided by the SAWS?	
21. What amount will you be willing to pay for improved meteorological information provided by the SAWS?	
22. How much saving you have achieved from using the meteorological information provided by the SAWS?	

APPENDIX 2 – Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

16 March 2017

Mrs Nomalungelo Natacia Simelane (213572236)
Graduate School of Business & Leadership
Westville Campus

Dear Mrs Simelane,

Protocol reference number: HSS/0435/015M
Project title: Socio-economic benefits of Meteorological Services in the South African Energy (Power Generation) Sector

Approval Notification – Amendment Application

This letter serves to notify you that your application and request for an amendment received on 16 March 2017 has now been approved as follows:

- Inclusion of Co-Supervisor (Mr Alec Bozas)

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for period of 3 years from the date of original issue. Thereafter Recertification must be applied for on an annual basis.

Best wishes for the successful completion of your research protocol.

Yours faithfully

pp .....[redacted]...
Dr [redacted]
/ms

Cc Supervisor: Dr Elias Munapo and Mr Alec Bozas
Cc Academic Leader Research: Dr Muhammod Hoque
Cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
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APPENDIX 3 – TURITIN SUMMARY

Turnitin Originality Report

Socio-economic Benefits of Meteorological Services in the South African Energy (Electricity Generation) Sector by Nomalungelo Simelane

From Final Chapter (Dissertation)

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