THESIS

Thabiso Maphalala

2023

Hungarian University of Agriculture and Life Sciences

Károly Róbert Campus

Institute of Agronomy

Bachelor's education in Agricultural Engineering

UTILIZATION OF RENEWABLE ENERGY SOURCES IN SOUTH AFRICA

Insider consultant:	**Dr. Gábor Koncz**
	associate professor
Insider consultant's Institute:	**Institute of Rural Development and Sustainable Economy**
Created by:	**Thabiso Maphalala**

Gyöngyös

2023

Table of Contents

1. Introduction

The southernmost country on the African continent is South Africa. has coastlines on both the Indian Ocean to the east and the South Atlantic Ocean to the west. Platinum, diamonds, and gold are just a few of the many mineral resources that are found in the nation. Its economy has benefited from these riches for quite some time.

Coal is an important mineral resource for South Africa. The International Energy Agency (IEA) lists South Africa as either the seventh or eighth largest coal producer in the world. Coal mining has been a cornerstone of the country's economic growth, providing a key source of energy for numerous sectors, including power generation and heavy industries.

South Africa, a developing nation, is experiencing growth and the need for power in this country has been rising over the past few years. However, South Africa's energy infrastructure is extremely reliant on a single fuel — coal — which provides more than 80% of the country's electricity. Because of its reliance on fossil fuels, South Africa is among the world's leading emitters of glasshouse gases, contributing to the acceleration of global warming. To mitigate climate change and lower its emissions of glasshouse gases, South Africa has to adopt alternative energy sources (ALIYU ET Al., 2018).

Slow economic expansion in South Africa may be traced back in large part to the country's inadequate energy policy and infrastructure. Africa's emerging nations continue to struggle because of their inadequate or non-existent energy infrastructure. Energy is the lifeblood of progress (WORLD BANK, 2019). Energy has a part, in powering enterprises, manufacturing processes, transportation of commodities and the delivery of services throughout the nation. It's fundamental to our basic survival and affects every sphere of our existence. Therefore, energy serves as a catalyst, encouraging growth and guaranteeing steadiness.

It is vital that countries with growing economies, like South Africa, achieve sustainable development goals and live up to international obligations regarding climate change migration. It is crucial that South Africa follows suit and makes the switch to a low-carbon energy system.

The frequent power outages in South Africa are evidence of the country's heavy reliance on fossil fuel and its many antiquated power facilities. This is another evidence that South Africa should prioritise developing renewable energy sources.

Since South Africa has a high energy demand and needs to decrease carbon emissions, renewable energy has become a critical problem in the country. By enacting laws and programmes that support investment in renewable energy technology, the government has made major efforts to promote the use of renewable resources. The purpose of this thesis is to assess the existing status of renewable energy in South Africa and its potential for expansion.

1.1 Purpose

To explore the use of renewable resources, in South Africa, it is evident that with the growing demand for electricity in the country there is a need, for renewable and sustainable energy infrastructure and technology. The South African government acknowledges that significant possibilities exist for energy and power technology through the improvement and use of renewable power structures.

1.2 Statement problem

The energy sector of South Africa relies heavily on coal, which is an environmentally harmful resource. This over-reliance causes immense harm to the environment and is not a reliable source of energy in today's world.

1.3 Aims of the Study

The primary objective of this study is to identify the challenges and opportunities associated with the adoption of renewable energy sources in South Africa. The study has the following objectives in mind:

1. To assess the current state of renewable energy utilization in South Africa.
2. To identify the challenges facing the adoption of renewable energy sources in South Africa.
3. To explore the opportunities that exist for increasing renewable energy utilization in South Africa.

1.4 Research Questions

The following will be the key research questions:

1. What is the status of renewable energy resource availability in South Africa?

2. What are the most promising renewable energy technologies for South Africa's specific climate and geography?

3. What are the main barriers hindering the widespread adoption of renewable energy in South Africa?

2. Literature Review

2.1 Use of renewable energies in the past and their possible role in the future

Energy is a vital resource for developing a stronger economy and expanding the industrial sector. The delivery of worldwide electrical demand relies heavily on fossil fuels, which are the primary assets. However, there are only so many fossil fuels left, and burning them has a negative effect on the planet. Keeping the world's ecosystems healthy and free from pollution is a top concern for governments everywhere. A country's economic, industrial, educational, and social progress may be gauged by looking at its population and energy consumption rates (URRY, 2014).

Any national power policy must take into account concerns of both electricity security and environmental sustainability. Managing these crucial aspects is an ongoing challenge in Africa and around the globe. High energy consumption growth, global expanding fossil fuel prices, significant environmental pressure closer to lowering glasshouse gas impacts, and promotion of renewable energy generation (BRUNET ET AL., 2022).

Renewable energy is power generated from non-depleting, naturally occurring sources that can be reliably replenished indefinitely. Solar, wind, hydro, geothermal, and biomass are all examples of such resources. The sun, the motion of the planets, and the slow decay of radioactive elements are the only sources of energy. This holds true for the power generated by the sun, the wind, rivers, dams, plant materials, waves, and sea currents. Instead of using fossil fuels, which contribute to global warming and air pollution, switching to renewable energy sources is a good idea (VERBRUGGEN ET AL., 2010).

Almost all energy was renewable before the advent of coal in the mid-nineteenth century. More than a million years ago, the earliest known use of renewable energy, the use of traditional biomass for fuel, was discovered. Many hundreds of thousands of years later, the utilization of biomass for fire became commonplace. Harnessing the wind to propel ships across the sea is perhaps the second-oldest application of renewable energy. This technique dates back 7000 years to ships in the Persian Gulf and the Nile. Since Palaeolithic times, geothermal energy has been used for bathing in hot springs and space heating since ancient Rome (HIRST, 2023).

Renewable energy is preferable to the use of fossil fuels, which are used up at a far quicker pace than they can be replaced. Renewable energy resources and significant opportunities for energy efficiency exist throughout a wide geographical region, in contrast to traditional energy sources, which are concentrated in a limited number of countries. Increased energy security and economic growth might result from the swift implementation of energy efficiency, renewable energy, and technical diversity in energy sources (HAELG, 2020).

Many countries are investing in the research, development, and implementation of renewable energy technologies because of their rising popularity and decreasing costs. For instance, in many regions of the world, solar and wind power have surpassed coal in terms of cost, while developments in battery storage technology have made it feasible to store renewable energy more effectively for later use (DIVYA – ØSTERGAARD, 2009).

Clean energy, also known as renewable energy, is power that is produced without polluting the environment and can be renewed on a constant basis. It's worth remembering that utilising nature's energy sources for heating, transportation, lighting, and other uses has been in practice for a long time. Although fossil fuels were formerly the dominant source of energy, renewable energy has become more important due to the development of contemporary and cost-effective ways of capturing and storing wind and solar energy. Massive offshore wind farms and rooftop solar panels on residences are only two examples of the fast-expanding use of renewable energy sources (DELL – RAND, 2004).

Switching to renewable energy sources can have numerous benefits:

- decreasing greenhouse gas releases,
- enhancing air quality,
- creating new job opportunities,
- increasing energy independence.
- Improved affordability, as many varieties of renewable energy are cost-competitive with traditional energy resources,
- providing greater access to clean energy for communities that are not connected to the main power grid, or those living in remote, coastal or isolated areas (SOEIRO – DIAS, 2020).

Although renewable resources come with many advantages the are some challenges currently faced when using renewable resources including:

- Intermittency and Variability: Renewable energy sources have a major drawback in that they are frequently inconsistent and variable, with their power output fluctuating due to weather conditions or other factors. This makes it difficult to rely on them as a consistent source of power.
- Energy Storage: To address the intermittent nature of renewable energy sources, energy storage tools such as batteries and pumped hydro storage are necessary. However, these technologies can be expensive and require significant investment.
- Land Use: Renewable energy sources have a problem in that they often require considerable land space. For instance, wind turbines and solar panels can occupy vast areas. Consequently, concerns may arise regarding their impact on wildlife habitats and ecosystems.
- Upfront Costs: renewable energy sources can be cost-effective over their lifetime; they often require significant upfront costs to install and set up. This can make them difficult to implement in certain areas or for certain populations (EGLI ET AL., 2018).

2.2 History of Energy in South Africa

Coal has been one of South Africa's most important energy sources for more than a century, and the country's long history of energy production and use is directly related to its abundance of natural resources.

The first people to use energy for things like cooking and heating in what is now South Africa relied on conventional fuels like firewood and charcoal. As the nation expanded and modernised in the late 19th century, so did the need for cleaner, more reliable electricity.

Coal was first found in South Africa in the middle of the nineteenth century. The country's coal production and exports had grown substantially by the turn of the century. Development of the nation's energy infrastructure, including the building of new power plants and the extension of the electrical grid, sped up in response to the rising demand for coal (LAWRENCE ET AL., 2020).

In 1923, Johannesburg was home to South Africa's first coal-fired power plant, the Witwatersrand Electric Power Station. As the need for energy grew in the 1930s and 1940s, more and more coal-fired power plants were built.

During the apartheid era, the government placed a high focus on energy security and self-sufficiency, which contributed to the growth of the country's nuclear power sector. In 1984, the Koeberg nuclear power station became operational in South Africa; in 1991, the Pelindaba facility went online. However, there were those who opposed nuclear power because of safety concerns and fears that it may be used to spread nuclear weapons (AKINBAMI, 2021).

In the early 1990s, with the end of apartheid and the installation of a democratic government, there was a growing realisation of the need to transition towards more sustainable and environmentally friendly kinds of energy. As a result, the government invested more heavily in the growth of its renewable energy industry, which includes wind and solar power.

To spur private investment in the renewable energy industry, the government launched the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in 1998. Several large-scale wind and solar generating facilities have been built around the country as a result of the program's success in drawing investment from both domestic and foreign sources (BAKER, 2017).

Coal now makes up over 70% of South Africa's energy mix and is the primary source from which the country generates power. The government, however, has set lofty goals to boost the proportion of renewable energy in the energy mix, including the procurement of 11,800 MW of renewable energy capacity by 2030. This is a piece of a larger plan to wean the nation off of its reliance on fossil fuels and move it towards a low-carbon energy system.

2.3 South Africa's Renewable Energy Policy History

South Africa began focusing on sustainable and environmentally friendly forms of energy in the early 1990s, leading to the development of several key renewable energy policies since then.

- **White Paper on Energy Policy (1998)**

1998, the South African government published the White Paper on Energy Policy, which provided a blueprint for the country's energy policy. The aim of the White Paper was to promote sustainable and environmentally friendly energy sources, such as renewable energy, domestic energy resources, and energy efficiency. The document identified some of the

major challenges facing South Africa's energy sector, including overreliance on fossil fuels and limited access to energy in rural areas. To address these challenges, the White Paper outlined policy objectives such as improving energy efficiency, diversifying the energy mix, enhancing energy security, and expanding access to energy. Overall, the White Paper was a significant milestone in South Africa's energy policy history, setting a clear vision for the country's energy policy in the future (MARQUARD, 2006).

- **Renewable Energy Development Programme (2003)**

The South African government launched the Renewable Energy Development Programme (REDP) in 2003 to promote the growth of renewable energy in the country. The aim of the program was to grow the portion of renewable energy in the country's energy mix and support the development of the renewable energy industry in South Africa. To encourage the development of renewable energy projects, the REDP provided a variety of economic incentives and support mechanisms, such as feed-in tariffs, tax incentives, and grants. The program also aimed to promote research and development in renewable energy technologies and to build capacity within the industry. The REDP was a vital step towards creating a more sustainable and diversified energy sector in South Africa (JAIN – JAIN, 2017).

- **Integrated Resource Plan (IRP) (2010)**

In 2010, the South African administration published the Integrated Resource Plan (IRP) which aimed to establish a long-term strategy for the country's energy sector. The primary goal of the plan was to provide a reliable, affordable, and sustainable energy supply to the country while reducing its carbon footprint. The IRP comprised a variety of energy sources such as coal, gas, nuclear, and renewable energy, and set specific targets for the share of renewable energy in the country's energy mix. The objective was to increase renewable energy to 42% of the new generation capacity by 2030. Additionally, the plan included specific targets for energy efficiency and demand-side management measures. The IRP underwent several updates, with the most recent version published in 2019. The IRP played a crucial role in promoting a sustainable and diversified energy sector in South Africa. (BAKER, 2017).

- **Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) (2011)**

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) was initiated by the South African government in 2011 to promote the development of renewable energy projects in the country. The primary objective of the program was to increase the proportion of renewable energy in the country's energy mix and to foster the growth of the renewable energy industry in South Africa. The government invited independent power producers to submit proposals for renewable energy projects such as wind, solar, biomass, and small hydropower. To encourage the development of these projects, the government provided several incentives, including long-term power purchase agreements, tax benefits, and access to financing (MARQUARD, 2006).

So far, the REIPPPP has been successful in attracting significant private sector investment in the renewable energy sector in South Africa. Over 100 renewable energy projects with a combined installed capacity of more than 6,000 MW have been procured under the program. The REIPPPP has played a vital role in promoting the growth of the renewable energy industry in South Africa and increasing the proportion of renewable energy in the country's energy mix.

- **IRP Update (2019)**

The Integrated Resource Plan (IRP) Update of 2019 is a crucial energy strategy plan published by the South African government. The plan outlines the country's energy needs and priorities for the period from 2019 to 2030. The primary objective of the plan is to ensure that South Africa has a reliable, sustainable, and efficient energy supply while reducing the country's carbon footprint (KENNY, 2019).

The IRP Update includes a wide range of energy sources, such as coal, gas, nuclear, and renewable energy. The plan sets specific targets for the share of renewable energy in the country's energy mix, aiming to increase the renewable energy capacity to 24.7 GW by 2030. The plan also emphasizes energy efficiency and demand-side management measures.

The IRP Update places a greater emphasis on renewable energy as it recognizes the declining cost of renewable energy technologies, which have become increasingly competitive with traditional fossil fuel sources. The plan also includes measures to promote the use of

distributed renewable energy systems, like rooftop solar panels, and to improve the integration of renewable energy into the grid (KENNY, 2019).

2.4 Sources of renewable energy

Renewable energy is the type of energy that is obtained from natural sources that are continuously replenished at a rate that is equal to or faster than the amount at which they are spent. These sources of energy are thought to be environmentally friendly and sustainable because they do not deplete natural resources or contribute significantly to greenhouse gas emissions. Some of the commonly used sources of renewable energy include:

2.4.1 Solar energy

Solar energy is a source of renewable energy that derives from the sun's beams. It's a cheap, renewable resource that may be utilised directly for things like lighting and heating or converted into other forms of electricity. Photovoltaic (PV) cells, solar thermal systems, and concentrated solar power (CSP) plants are only a few of the technologies utilised to collect sunlight for usage (NYABADZA, 2012).

Solar panels, sometimes called photovoltaic cells, are devices that use the photovoltaic effect to directly convert sunlight into energy. These displays are typically fabricated from silicon or other semiconductor materials. Direct current (DC) power is generated when photons from sunlight activate electrons in solar cell junctions. This electric current may be utilised to power houses, businesses, and other purposes. A household solar panel system using moderately efficient panels may provide roughly 10 to 12 kWh (kilowatt-hours) of energy per square metre of solar panels per year in places with excellent sun insolation (ARMAROLI – BALZANI, 2016).

Water heating, room heating, and powering industrial operations are just some of the many potential uses for the thermal energy generated by solar thermal systems. In these setups, fluids are heated using solar energy captured by collectors. Renewable energy is harnessed when this fluid is used to heat water or other fluids (ARMAROLI – BALZANI, 2016).

Mirrors or lenses focus sunlight onto a tiny area, allowing concentrated solar power (CSP) facilities to generate electricity. Because of the high temperatures created, steam may be utilised to power a turbine and create energy (PHILIBERT, 2011).

There are a lot of positives to using solar energy. It is a clean and renewable energy source that does not release any hazardous gases into the atmosphere. It's also plentiful since scientists believe the sun will keep shining for billions of years. To power outlying locations that may not have access to grid electricity, solar energy can be used in a decentralised fashion. In addition, it eventually lowers energy prices and helps lessen dependency on fossil fuels (UGLI, 2019).

However, solar power is not without its drawbacks. Although the cost to install solar panels or solar thermal systems has decreased over the past few years, it can still be a significant investment upfront. Location, shade, and climate all have a role in how effectively solar panel's function. Solar energy is only produced during the day, therefore there needs to be a way to store it until the evening, and effective and affordable energy storage options are currently being developed (UGLI, 2019).

2.4.2 Wind energy

People have traditionally used wind energy to generate electricity. Ancient Egyptians created wind-powered boats about 5,000 years ago. Windmills were used to grind grain and pump water in the Middle East and China in 200 B.C.E.

Wind energy is the power that is produced by turning the momentum of wind into either electrical or mechanical power. Wind is a renewable energy source because it is a plentiful and non-depleting resource that may be utilised indefinitely to provide electricity. Wind power, in contrast to fossil fuels, does not result in the release of glasshouse gases or other air pollutants when it is used to generate electricity (HERBERT, 2007).

Renewable wind energy is generated by using wind turbines to capture the wind's kinetic energy and transform it into useful mechanical work or electrical current. This renewable energy source is plentiful and does not diminish when utilised to generate electricity. Wind power generation does not result in the release of any glasshouse gases or air pollutants, in contrast to the combustion of fossil fuels. Therefore, wind energy is regarded as a potential

strategy for lowering our carbon footprint and moving to a more sustainable future (DOORGA ET Al., 2022).

Wind turbines are tall structures with huge blades that revolve as the wind blows, converting the kinetic energy of the wind into usable electricity. A generator is powered by the rotor's rotation, and the resulting electricity may be utilised to light and heat buildings. Onshore wind turbines can be placed on land, usually in windy locations like plains, coastal regions, or mountain ranges; offshore wind turbines can be placed in open water (HERBERT, 2007).

As a clean and sustainable energy option, wind power has several benefits. It contributes to cutting down on emissions of glasshouse gases, slowing the progression of climate change, broadening the range of available energy sources, and generating new jobs in the renewable energy industry. However, wind energy faces obstacles including the unpredictability of wind patterns, the possible destruction of animals and habitats, and the disruption of local residents through noise and visual pollution (WANG – WANG, 2015).

Wind power is a renewable energy source with great potential to help the world fight climate change and move towards a more environmentally friendly energy future. Its viability and influence are projected to grow in the next years as new technologies become available and more wind energy projects are put into action.

2.4.3 Hydroelectric power

In order to harness the energy of moving water, hydroelectric electricity, also known as hydropower, is generated. As early as the Stone Age, waterpower was used to turn waterwheels that ground grain and powered other mechanical devices.

Hydropower, a renewable energy source, is generated by redirecting the flow of water through a dam or other structure. The kinetic and potential energy of flowing water is transformed into electricity by utilising turbines and generators. The potential for power generation is proportional to the height of the water drop and the velocity of water flow through the system. Long-distance electric wires may bring power to people's homes and places of business (BALMER – SPRENG, 2008). In addition to being a renewable energy source thanks to snow and rain, hydropower also provides a lot of power and can be easily adjusted to meet fluctuating electricity needs by regulating the flow of water via turbines.

There are others who believe that hydropower's potential for environmental damage necessitates strict sustainability regulations for any new hydropower projects. Although there are many different kinds of hydropower plants, they are always driven by the kinetic energy of water in motion. Conventional hydroelectric plants generate electricity by rotating a turbine, which in turn turns a generator, using the kinetic energy of water flowing down a pipe (the penstock) (AKASHIE, 2022).

There are a number of benefits to using hydroelectric electricity, including the fact that it is a renewable resource. It's a sustainable and eco-friendly power option because it doesn't contribute to global warming or cause water shortages during its generation. Hydroelectric power is a sustainable alternative to fossil fuels since it doesn't deplete and may be used indefinitely.

The construction of dams and reservoirs can have negative effects on the environment, such as the relocation of people and animals, the disruption of natural river ecosystems, and the increase or decrease in sedimentation and water quality. Dams may be both costly to construct and operate, and their building may need extensive surrounding infrastructure improvements. In addition, there may be a scarcity of appropriate sites for hydropower facilities, and the availability of water is essential to their functioning (AKASHIE, 2022).

2.4.4 Geothermal energy

Geothermal energy, sometimes known as Earth's internal heat, may be used for things like powering turbines and warming buildings. The core of the planet is a hot, molten mass of rocks and metals, and this heat is continually being created by the decay of radioactive isotopes. This heat moves upwards through the Earth's crust and may be captured by geothermal power plants, which collect the heat from the Earth and turn it into usable electricity (DICKSON ET AL., 2013)

There are primarily three categories of geothermal power plants: dry steam, rapid steam, and binary cycle. Dry steam plants employ steam created by the Earth's natural geothermal sources to power turbines, ultimately resulting in electricity production. On the other hand, flash steam plants turn geothermal water into steam to power turbines. In binary cycle plants, the geothermal energy is transferred to another fluid via a heat exchanger and then used to power turbines (DICKSON ET AL., 2013).

Since the Earth's core generates heat constantly, geothermal energy is a renewable resource. In addition, it is a clean energy option because it does not contribute to the emission of glasshouse gases or other pollutants. However, its usage is restricted to areas with accessible geothermal resources, therefore it is not as extensively adopted as other renewable energy choices like solar and wind power (DICKSON ET AL., 2013).

2.4.5 Biomass energy

The term "biomass energy" refers to a type of renewable energy that is derived from natural matter, including wood, crops, agricultural residues, and animal waste. Biomass energy may be acquired from both plants and animals. The generation of heat, power, and fuels for vehicles are all possible uses for biomass.

The process of turning biomass into energy might look very different according to the type of biomass that is being used and the output that is being sought. For the production of heat, for example, wood can be burned directly, or it can be turned into charcoal, which burns hotter and for a longer period of time (HARVEY ET AL., 2018). In a similar vein, agricultural waste may be burned to create energy, or it can be fermented to make biogas, which is a combination of methane and carbon dioxide that may be utilised as fuel. Both of these processes are viable options.

In comparison to fossil fuels, biomass energy offers a number of significant benefits. The fact that it is a renewable source of energy that can be refilled relatively rapidly is one of its advantages. This is in contrast to the formation of fossil fuels, which may take millions of years. Another advantage of energy derived from biomass is that it may assist in the elimination of trash. Fuel that is produced from organic matter that would otherwise be dumped in landfills can be used instead, leading to a reduction in the overall quantity of trash and a better overall environment (HARVEY ET AL., 2018).

Utilising biomass as a source of energy is not without its share of difficulties. For instance, the generation of biomass can compete with the production of food for agricultural land, and the harvesting of biomass can have severe environmental implications if it is not done in a sustainable manner (HARVEY ET AL., 2018). In addition, the production of biomass can be used to create jobs. In addition, the burning of biomass can release pollutants like

particulates, nitrogen oxides, and carbon monoxide, all of which are known to have the potential to adversely affect a person's health.

2.4.6 Ocean energy

Waves, tides, and currents are all potential sources of ocean energy that might be used to create power. Several alternative technological approaches can be used to capture this energy:

• Wave energy: the method described here is able to tap into the energy contained within ocean waves and transform it into a form of electricity that can be utilised. It does this by converting the motion energy of the waves into electrical energy that may then be used.

• Tidal Energy: The natural rise and fall of the waves is a natural source of tidal energy, which may be harvested. Tidal power plants tap on the potential energy contained within the motion of the surrounding water in order to create electricity.

• Ocean Thermal Energy Conversion (OTEC): The OTEC technology generates energy by taking advantage of the temperature difference that exists between the warmer surface waters and the colder waters found deeper in the ocean (KHAN, 2017).

• Salinity Gradient Energy: This method generates power by taking advantage of the fact that saltwater and freshwater have significantly different levels of salt content.

It is possible that ocean energy might produce a sizable quantity of renewable energy in the future. However, the technologies that can generate energy from the water are still in their early phases of development, and the costs of creating this sort of energy are currently greater than those that are associated with producing other forms of renewable energy. Despite this, there is a tremendous amount of untapped potential in ocean energy, and researchers and experts are continually looking into and developing new ways to capture this renewable energy source (KHAN, 2017).

2.4.7 Waste-to-energy

The conversion of trash into usable forms of energy, such as electricity, heat, or fuel, is referred to as waste-to-energy, or WTE for short. Several different processes, including

incineration, gasification, pyrolysis, and anaerobic digestion, can turn the organic stuff that is found in trash into usable energy (RODSETH ET AL., 2020).

WTE can contribute to a reduction in the quantity of garbage that is sent to landfills, which in turn helps to lessen the harmful impact that landfilling has on the environment. In addition, the usage of WTE can contribute to offsetting the effects of the consumption of fossil fuels by lowering emissions of glasshouse gases and other pollutants (KOTHARI, 2010).

WTE is not an ideal solution and has been criticised because of fears regarding the potential negative impacts that the process might have on the environment and people's health. These issues include air pollution and poisonous ash (KOTHARI, 2010). It is essential to keep in mind that waste-to-energy conversion, despite the fact that it has the potential to serve as a source of renewable energy, cannot take the place of efforts to cut down on trash and boost recycling rates.

3. Material and method

3.1 Research design

This study will use a literature review research design to investigate the utilization of renewable energy in South Africa using secondary data and sampling design.

3.1.1 Secondary data

The study will gather information on the present situation of renewable energy utilisation in South Africa by conducting a literature assessment of previously published academic publications, government reports, and other relevant materials. Internal and external secondary research sources are the two categories that may be distinguished. Internal data is defined as in-house data that can be acquired from the researcher's organisation. When a researcher cites "external data," they mean information that was produced by a source other than the researcher's institution.

3.1.2 Sampling design

Simple random sampling was used to choose the representative population to partake in the study. This was done due to the size of the population which restricted the researcher from being in contact with all members of this community. The type of sampling procedure used also promoted fairness to avoid any bias or exclusion of any members of the area. The sampled population was given questionnaires as part of data collection, content and discourse analysis will thus be used as an important tool that analyses this data into charts and tables.

The study will also use a purposive sampling technique to select documents for review. Documents will be selected based on their relevance to the research question and their quality and credibility.

3.2 Data collection methods and analysis techniques

The information gathered was analysed using content analysis. *Cooper and Schindler (2006*) define content analysis as “a research technique for the objective, systematic, and quantitative description of the manifest content of communication.”

*According to Olive Mugenda and Abel Mugenda, Research Methods: Quantitative and Qualitative Approaches (African Centre for Technology Studies 2003**)*** defined content analysis as the methodical description of the study’s objects or materials. The examination

of content essentially encompasses the perception made. The technique condensed the responses into fewer subgroups and factors, resulting in a summary of the findings. This made it easier to condense and correlate relevant data, as well as conclude from the information gathered. It aids in ensuring that large amounts of data with interconnected relationships are sensible and highlights associations that were not obvious as well as any underlying relationships.

By applying content analysis, we were able to draw conclusions about the variables affecting the usage of renewable resources in South Africa by methodically and objectively identifying distinct themes within the data. Conducting pilot research to assess the suitability of the data collecting tools and, by extension, the validity and reliability of the data obtained, prevented biased content analysis and assured the rigors adherence of reliability and validity standards. Information content and data characteristics may be determined by a content analysis, which comprises both systematic study and observation.

4. Results and their evaluation

4.1 The results of the primary research

The data was collected and analysed for the next step which is to conclude by the researcher. This theme covers the results derived from the analysis of the collected data during the study. Due to the collection methods which included a questionnaire that was filled by the participants, the following results will consist of personal statements made by participants to give more substance to the arguments presented. As a part of all conducted studies, generalizations are to be made from the results and used to produce interpretations and recommendations.

The survey questionnaire was developed, comprising a combination of closed-ended and open-ended questions. It consisted of 15 questions, covering various aspects of renewable energy.

4.1.1 Demographic characteristics of the study sample

The survey was conducted with over 80 participants, and demographic information was collected, including age, gender, educational level and location in South Africa. Most of the population sampled were young adults. The majority of respondents were between the ages of 18 to 25, with 50% falling into this category (Figure 1). This is because they are prospects and they are more into social media, and they are much more open and easily into sharing information and giving opinions on what affects their day-to-day life.

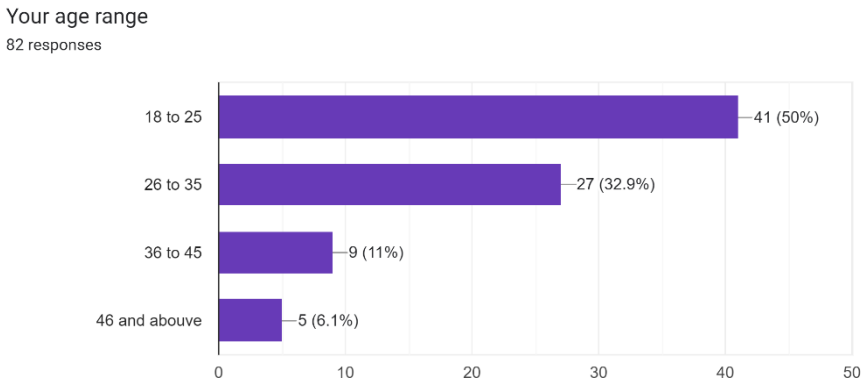


Figure 1 Distribution of respondents by age

Source: own editing based on a questionnaire survey, 2023.

The literacy level was important to the research as People of different academic backgrounds have diverse views and opinions on the use of energy, and how important it is to the environment. Most of the respondents had a bachelor's degree, with 45.1% falling in this group (Figure 2). This information in a survey provides crucial insights into the characteristics and diversity of the surveyed population, offering valuable information for decision-making in energy utilization.

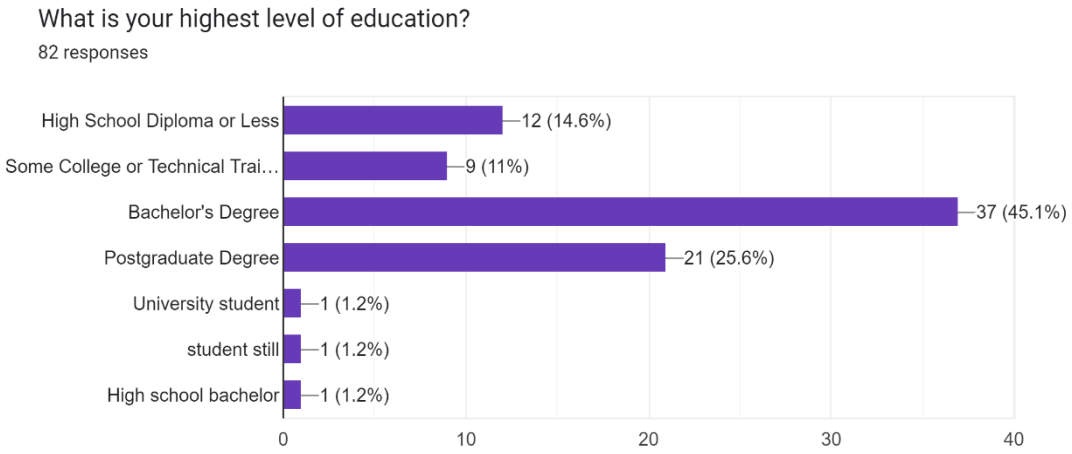


Figure 2 Distribution of respondents by highest level of education

Source: own editing based on a questionnaire survey, 2023.

South Africa's geography presents regional differences in renewable energy potential. Some areas might be more conducive to solar energy generation, while others might be better for wind power. Knowing the location of participants helps in understanding the feasibility and preferences for specific renewable resources in different regions and their uses. Each region might have its unique set of challenges and perspective factors influencing the adoption of renewable resources and the use of energy sources. Understanding the location-specific factors provided insights into local challenges, priorities, and needs related to renewable energy utilization. To the population that is considered rural, the energy sources are mainly just cooking, light, and heating. The distribution of the test sample among the regions of South Africa was as follows (Figure 3).

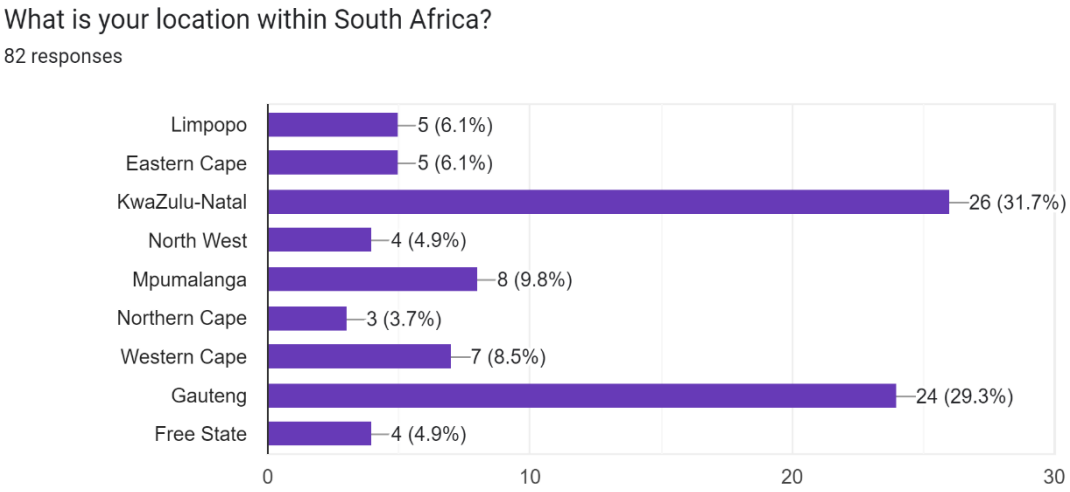


Figure 3 Distribution of respondents by location within the country

Source: own editing based on a questionnaire survey, 2023.

4.1.2 Participants' Perspective

The research sought to be able to understand how participant's knowledge of different types of energy, and their uses. How is beneficial to the country, and the current energy source if it is sufficiently safe and reliable? Also, its effects on the environment and how we can maximize the use of natural energy sources to the maximum extent possible.

The majority of respondents were aware of renewable energy sources, with 46.3% rating their awareness as 5 out of 5. This question helps establish a baseline level of awareness among survey participants regarding different types of renewable energy sources (Figure 4). It provides insight into their familiarity with solar, wind, hydroelectric power and other types of renewable energy resources. The question had a scale of 1 to 5, with 1 being a low awareness and 5 being the highest level of awareness.

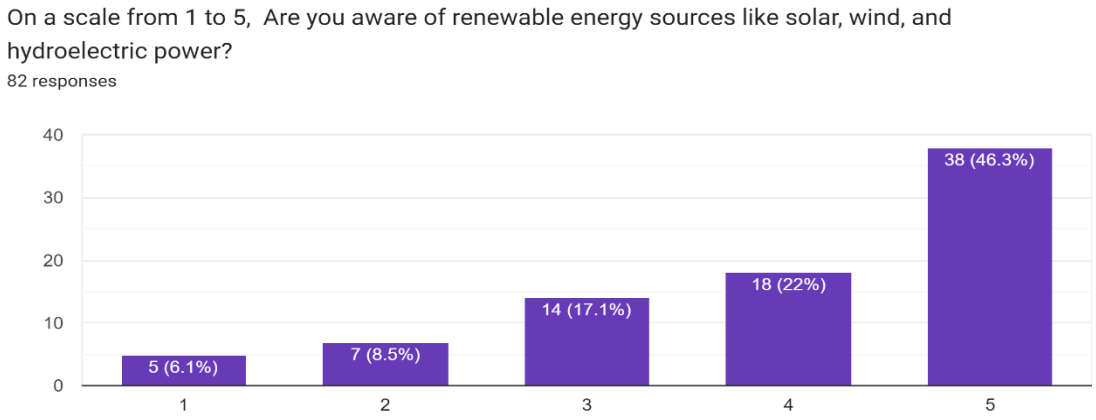


Figure 4 The level of knowledge about renewable energy sources

Source: own editing based on a questionnaire survey, 2023.

The below question helps researchers gauge the participants' perceptions regarding the environmental advantages of renewable energy (Figure 5). It provides insights into whether individuals understand the positive impact these energy sources can have on reducing greenhouse gas emissions and mitigating climate change. Including this question ensures a more comprehensive understanding of participants' knowledge, attitudes, and perceptions regarding renewable energy. It adds depth to the insights gained from the survey. The participants showed to be aware of the environmental benefits of renewable energy.

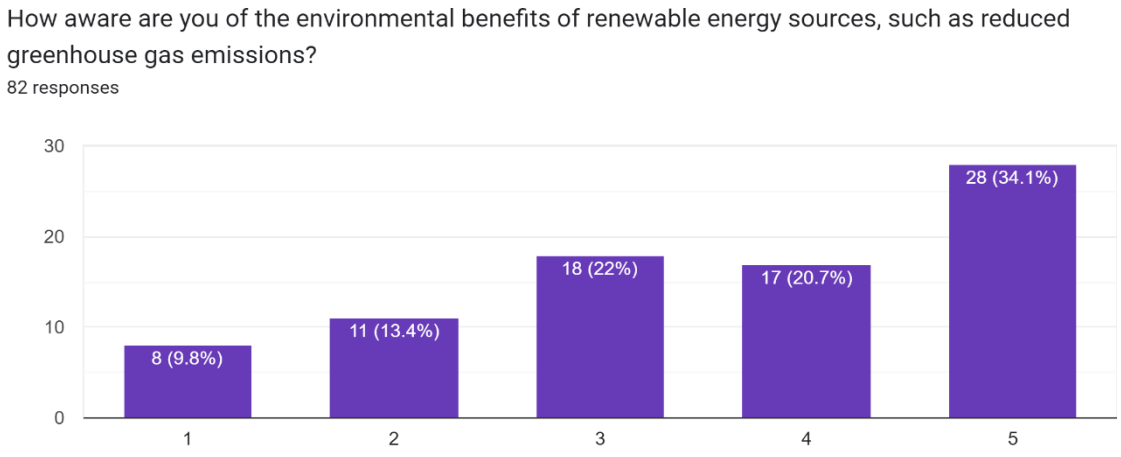


Figure 5 Knowledge of the environmental benefits of renewable energy sources

Source: own editing based on a questionnaire survey, 2023.

Assessing participants' familiarity with government initiatives provides insight into public awareness of policies and programs promoting renewable energy (Figure 6). Understanding this awareness helps gauge the public's knowledge of the existing measures supporting renewable energy utilization. Familiarity with government initiatives might correlate with an increased inclination to support or utilize renewable energy sources. Most of the participants to some extents were familiar with government initiatives in their area or around.

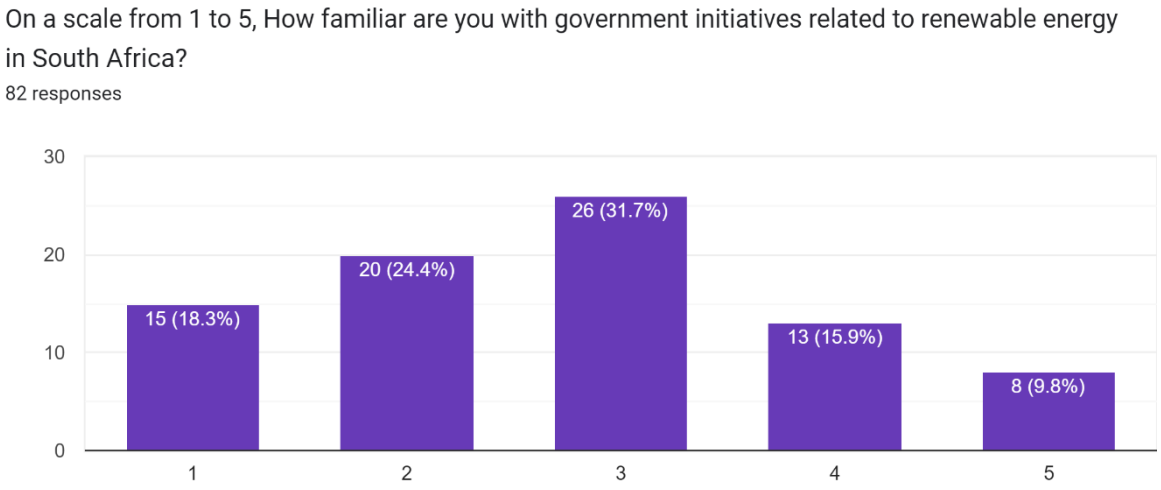


Figure 6 Knowledge of initiatives related to renewable energy sources

Source: own editing based on a questionnaire survey, 2023.

Recognizing public perceptions about the most promising renewable energy source for South Africa's energy needs is crucial for informed decision-making and aligning efforts towards the energy sources most favoured and deemed feasible by the population. Including this question in the survey provides a holistic view of public opinion. South Africa has diverse renewable resources like solar, wind, hydro, and biomass. Assessing public opinions can help align resource use with the perceived potential of different energy sources. Most of the participants were in favour of wind and solar power utilisation (Figure 7).

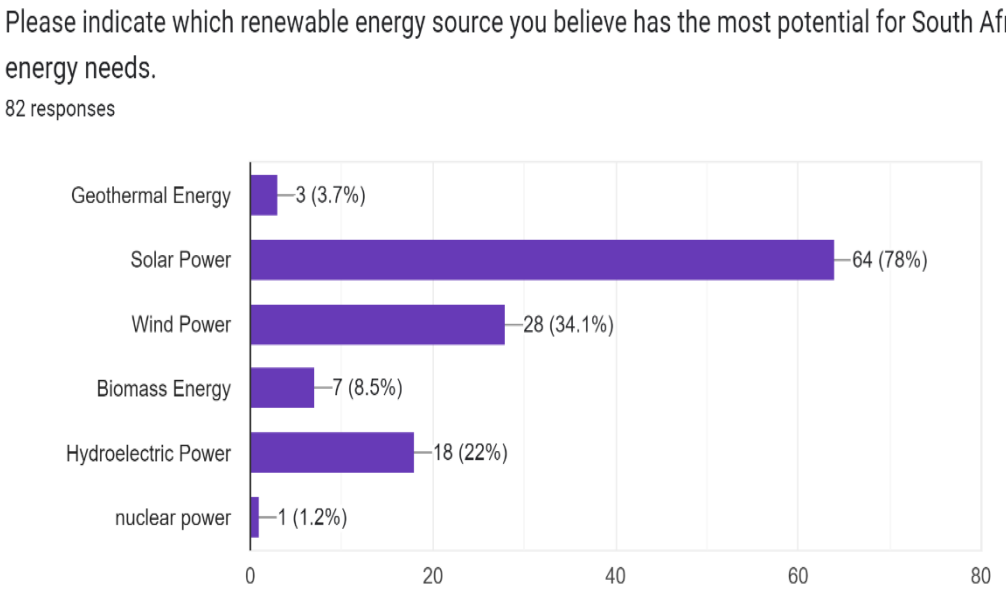


Figure 7 Opinion on the potential of individual renewable energy sources

Source: own editing based on a questionnaire survey, 2023.

Understanding public attitudes and feelings toward using renewable energy for heat production (such as heating, hot water, and cooking) informs insights into consumer preferences and behaviour. This information is vital for aligning future policies and initiatives with public sentiment. Most participants were in favour of the use of renewable energy resources for heat production (Figure 8).

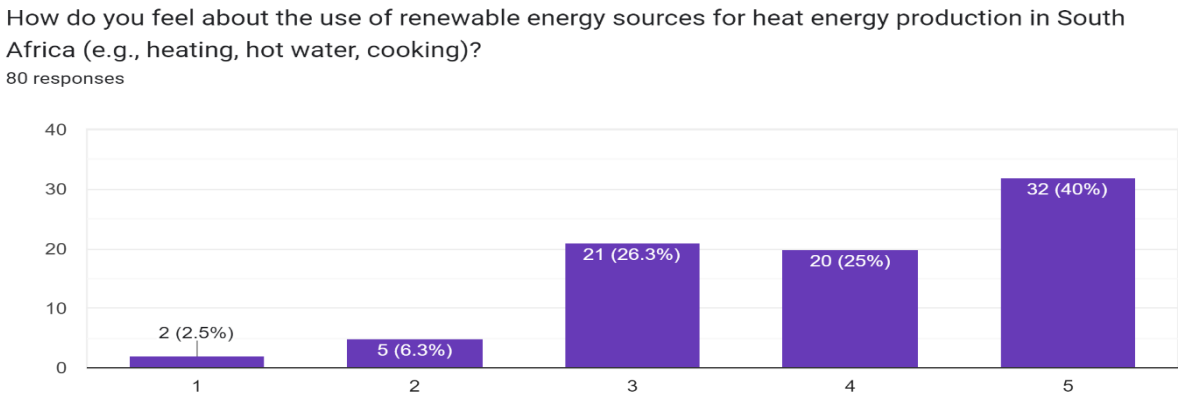


Figure 8 Use of renewable energy for heat energy production

Source: own editing based on a questionnaire survey, 2023.

Public opinions on renewable energy for transportation, particularly electric vehicles, provide insight into acceptance levels and preferences. Positive perceptions can encourage future adoption and utilization of these technologies. Positive perceptions can drive market trends and investments in the sector. More than half of the participants were in favour of the use of renewable energy sources for transportation (Figure 9).

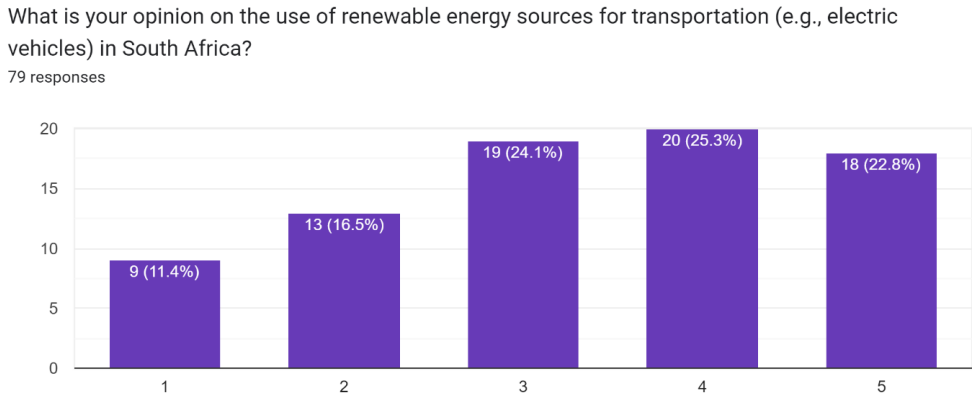


Figure 9 Use of renewable energy for heat energy production

Source: own editing based on a questionnaire survey, 2023.

More than 70% of the participants were in favour of the government prioritising and investing in renewable energy initiatives and infrastructure development. About 48 of the participants were in full support of the idea. With only just two who were not in favour of the initiative (Figure 10).

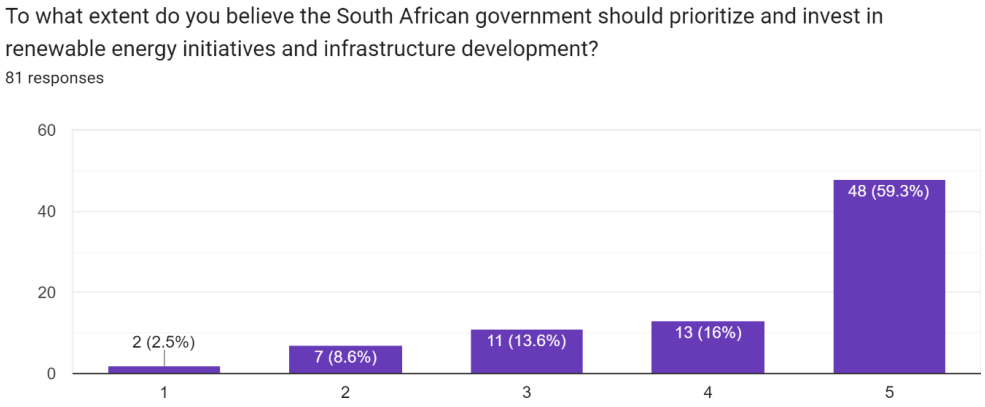


Figure 10 Assessment of government support for renewable energies

Source: own editing based on a questionnaire survey, 2023.

The below table chart clearly shows how the participants were convinced of the lack of utilisation of renewable energy resources in the country. Just 44 participants believe that the country isn't doing enough to push the renewable energy narrative (Figure 11).

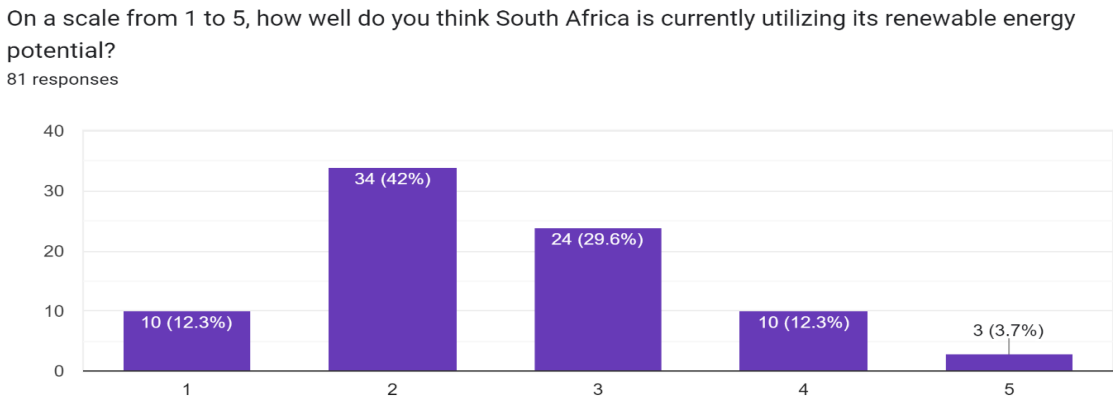


Figure 11 Evaluation of the utilization of the country's renewable energy potential at present

Source: own editing based on a questionnaire survey, 2023.

In the below question, it was important to understand what the participants believed was holding South Africa back in terms of the widespread adoption of renewable energy. The lack of government incentives was believed to be the main reason with 58.8% of the responses favouring it. The high initial costs were second. Additional responses highlighted that corruption could be another obstacle that the country is facing and not enough skilled workforce (Figure 12).

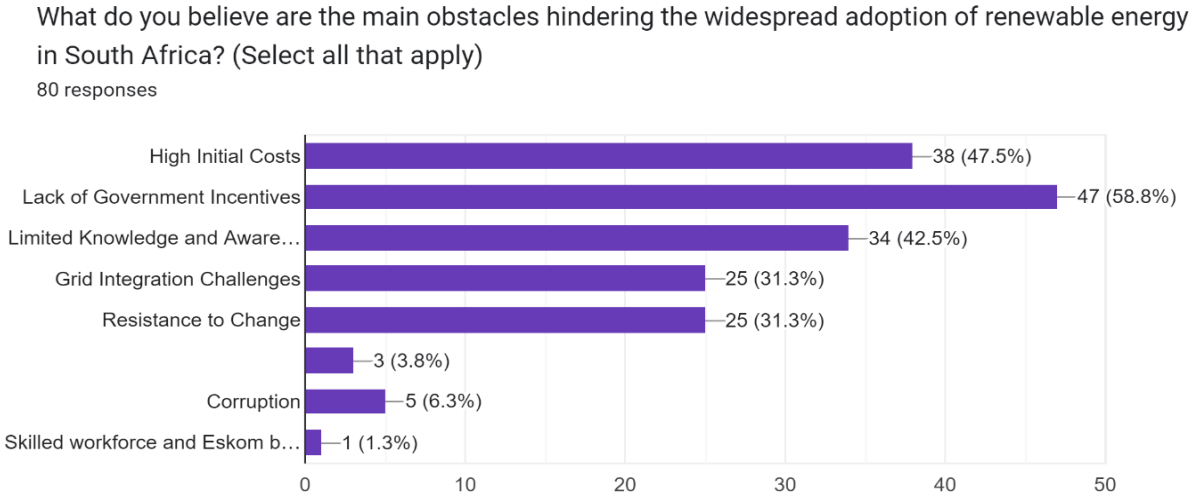


Figure 12 The main obstacles to the utilization of renewable energy

Source: own editing based on a questionnaire survey, 2023.

A majority of the participants were in favour of transitioning to a more sustainable and renewable energy future. This question helps to gauge the participants' supportive they are of South Africa's efforts to transition to a more sustainable and renewable energy future because this information can be used to inform policy decisions, gauge public support, and identify potential barriers to the transition. Only just three participants were against the use of renewable energy sources (Figure 13).

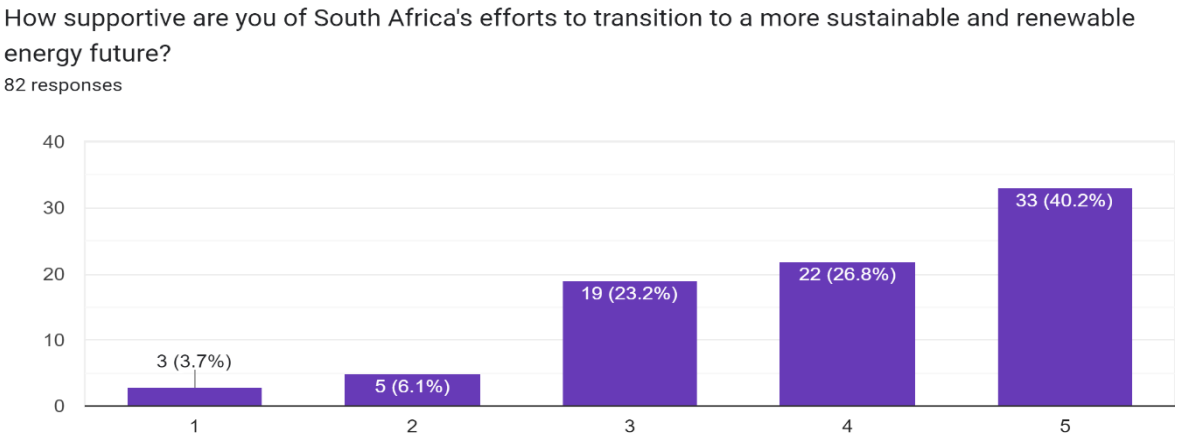


Figure 13 Support for a more sustainable future that utilizes more renewable energy

Source: own editing based on a questionnaire survey, 2023.

The research sought to find out the importance of the utilisation of renewable energy resources in South Africa. Below is some of the response of the participants:

"The South African government faces a challenge currently, that is between maintenance and construction of existing power sources. Therefore, for the utilisation of renewable energy sources, a government initiative should be launched that will create an impact that will move the electricity generation from monopoly to creating a competitive environment that will assist in the crisis. Also investing in infrastructure that will assist in this regard."

"Renewable energy is the future. It is about time that both the private sector and government intensify investment directed toward renewable energy resources. They are well aware of the benefits. The current failings of Eskom underscore the need for alternative energy sources."

"As South Africans, we need solar energy, and the government must provide for us because we are in an issue of load-shedding."

“I believe renewable energy should be practised because it is the future. Should we practice it in South Africa, load shedding would be a thing of history. Which is one of the biggest issues South Africa is facing at the moment.”

4.2 The results of the secondary research

4.2.1 Government initiatives and structures

ESKOM (Electricity Supply Commission**)** is the leading electricity generator and distributor in South Africa, utilizing diverse energy sources to power the country. The company was founded in 1923 and has since become the largest electricity provider in Africa, with an installed generating capacity of approximately 45,000 MW.

ESKOM, a government-owned company, generates electricity through a mix of 15 coal-fired power stations and a nuclear power plant located in the Mpumalanga and Western Cape regions respectively. They also operate a few hydroelectric power stations. Although ESKOM has been making progress in terms of utilizing renewable energies, they are unable to meet the country's electricity demand. Therefore, planned power outages, known as load shedding, have been implemented to help the country's power system cope with the overwhelming demand. Eskom can generate up to 45,000 megawatts per hour. Despite this, it failed to deliver 27,000 MWh, resulting in power outages or load shedding lasting several hours a day (ESKOM, 2021).

The chart below depicts the decline of electricity generation by Eskom (Figure 14), the company has faced several challenges in recent years, including financial difficulties, ageing infrastructure, and concerns about its environmental impact. Eskom is undertaking a range of initiatives, including upgrading its existing infrastructure, investing in new renewable energy projects, and implementing measures to improve the efficiency of its operations.

According to the International Energy Agency (IEA) on the energy mix in South Africa:

- As of 2022, South Africa's total renewable energy capacity is 10,445 MW.
- In 2021, South Africa's primary energy production reached a total of 5.3 quadrillion British thermal units. Coal dominated the production, accounting for 94% of the total share. The remaining share was divided between renewable and other sources at roughly 2.8%, and nuclear energy at 2.3%.

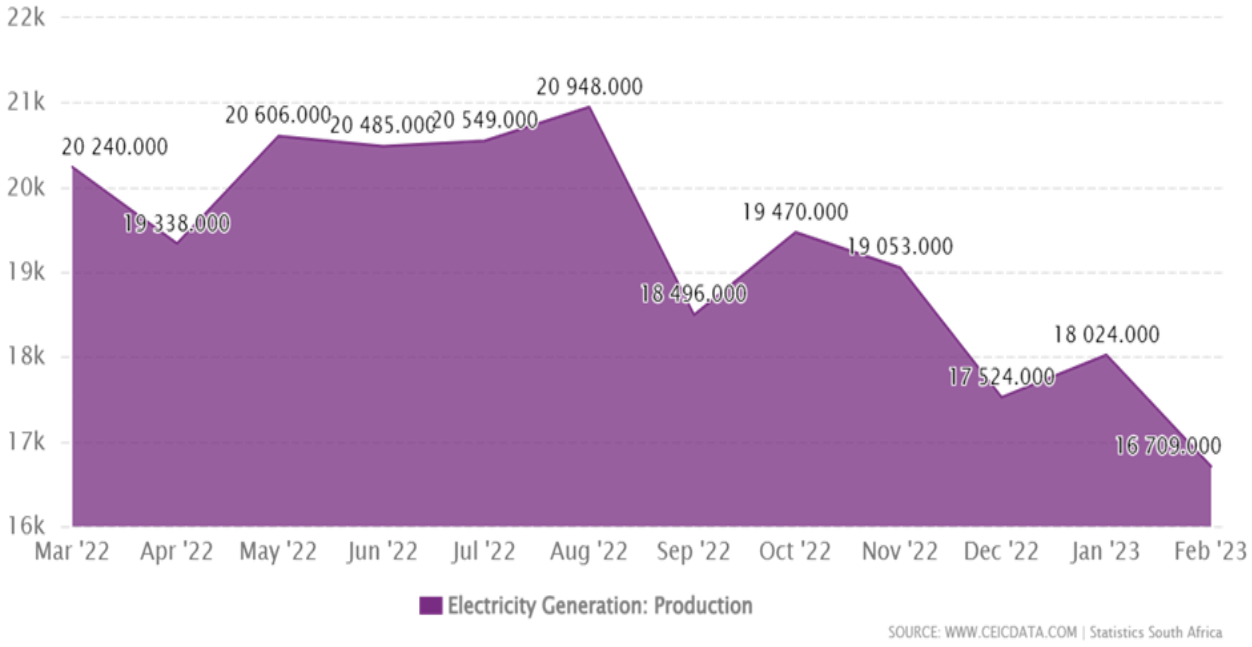


Figure 13 South Africa's electricity generation (March 2022 - February 2023)

Source: www.ceicdata.com, 2023.

According to the survey responses, the lack of government incentives is a major obstacle to the widespread adoption of renewable energy in South Africa. The South African Department of Energy has recently released the latest data on renewable energy usage in the country. The data shows that solar PV, wind, biomass, and concentrated solar power (CSP) are widely used in all provinces of South Africa. According to the histogram, the Northern Cape province has the highest deployment of renewable energy, including solar PV, CSP, wind, and biomass. The Eastern Cape Province comes in second, while the Western Cape Province has the lowest deployment. Renewable energy sources are highly valued by South Africa, just like many other countries, for their potential to supplement or replace the fossil fuel-based energy industry (AKINBAMI, 2021).

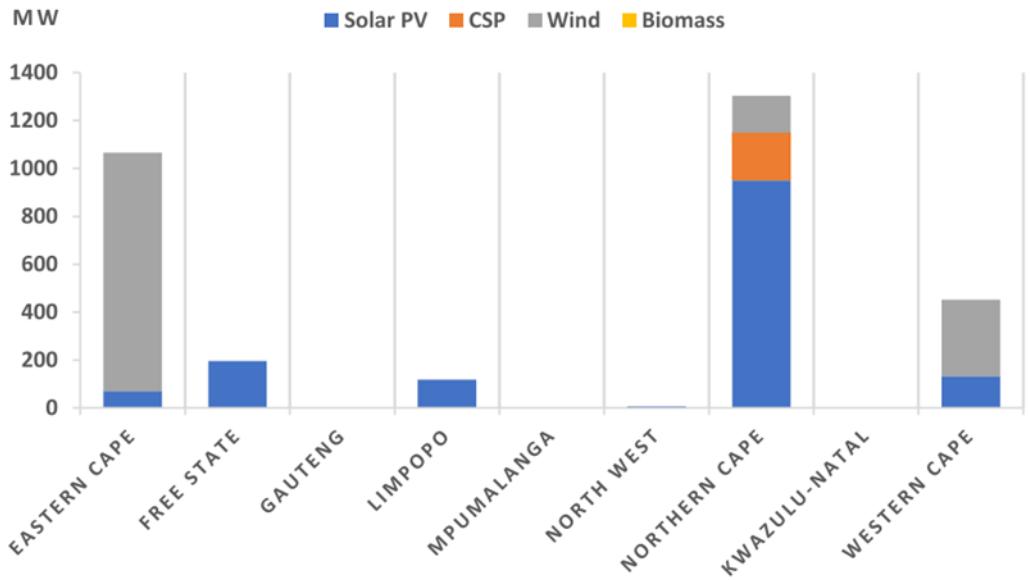


Figure 14 Installed capacities in different provinces

Source: (Trade and Investment KZN, 2021)

Currently, the installed renewable energy power plants around the country are:

4.2.2 Solar energy

One of the highest and fastest-growing renewable energy sources is solar energy. The survey responses also suggest that solar power is the most popular renewable energy source among respondents. The current installed solar capacities of renewable energy in South Africa:

1. Solar Photovoltaic (PV) Plants: South Africa has 29 solar PV plants, which are spread across the country. As of September 2022, the total installed capacity of solar PV plants in South Africa was 6,326 MW (AKINBAMI, 2021).

Some of the notable solar PV plants in South Africa include:

- Jasper Solar Energy Project This solar PV plant boasts an installed capacity of 96 MW. The plant comprises over 325,000 photovoltaic solar panels and covers an area of around 180 hectares. Situated near Kimberly in the Northern Cape commissioned in 2014.

Figure 15 The Jasper Solar Power Project in Northern Cape Province

Image source: Solar Reserve

- Solar Capital De Aar Project 1 and 2: The Solar Capital De Aar Project is located in the Northern Cape. The first project was finalized in 2014 with a capability of just over 85MW. The second project, which was added in 2016, has a capacity of 90 MW. Together, the two projects have a shared capacity of 175MW. The entire facility is about 500 hectares and is comprised of 700,000 solar panels.

2. Concentrated solar power: As of 2023, South Africa has 400 MW of Concentrated Solar Power (CSP) plants currently under construction and development. One of the largest plants is KaXu Solar One, situated near the town of Pofadder in the Northern Cape, with a capacity of 100 MW.

- The Bokpoort plant is a significant Concentrated Solar Power (CSP) project located in the Northern Cape province of South Africa. The plant has a capacity of 50 MW and is equipped with a molten salt energy storage system, which allows it to generate electricity even during periods when there is no sunlight available.

- The Kathu Solar Park is a 100 MW clean energy project situated in South Africa's Northern Cape Province, within the Kalahari Desert. The project comprises a parabolic trough plant, which incorporates a range of curved-mirror parabolic reflectors. In addition, it is equipped with an efficient molten salt storage system, that enables the plant to store thermal energy for 4.5 hours. This ensures that the plant continues to generate electricity during highest demand periods, even after sunset. The construction of the project began in 2016.

4.2.3 Wind energy

As the second most popular renewable energy, wind energy utilization has also made a significant increase over the years. The current installed wind capacities of renewable energy in South Africa:

1 Wind Farms: Currently, there are 34 wind farms in South Africa that are operational, with a combined capacity of over 3,400 MW added to the country's electricity grid, according to official Eskom data and the Department of Energy's IPP Projects data (AKINBAMI, 2021).

2 Some of the notable wind farms in South Africa include:

- The Roggeveld Wind is located in the Western Cape province and is the largest wind farm in South Africa by installed capacity, with a total of 147 MW. The facility consists of 65 turbines, and the concrete structures installed on-site reach a height of 100m.
- Kangnas Wind Farm: Located in the Northern Cape province, this is a 140 MW wind farm that was commissioned in 2020. Kangnas Wind Farm is able to generate almost 513,200 MWh/year of clean, renewable energy per year. The farm consists of sixty-one wind turbines that deliver 140 MW of clean, renewable power.

- Kouga Wind Farm: This is an 80.5 MW wind farm situated in the Eastern Cape province. It was established in 2015 and produces approximately 241 GWh of electricity annually. Although the farm spans 2,948 hectares in total, the 32 turbines and their infrastructure only occupy an actual area of 28 hectares.

Figure 16 The Roggeveld Wind Farm

Image source: roggeveldwindfarm.energy

3 Small-Scale Wind Energy: South Africa is not just producing large-scale wind farms, but also increasing its number of small-scale wind energy installations. These installations are commonly utilized to power singular homes, farms, and other buildings. As of September 2021, the collective installed capacity of small-scale wind energy in South Africa stood at 2 MW.

4.2.4. Hydro energy

South Africa's renewable energy mix does not heavily rely on hydroelectric power due to limited water resources and unsuitable sites for hydroelectric power plants. Hence, hydroelectric power is not feasible in the country, resulting in a low installed capacity of just 77 MW. This is a small fraction of the country's total renewable energy capacity. Hydroelectric power plants in South Africa are primarily used for peak load generation and to balance the grid during low-demand periods (BALLANCE, 2000).

Here are the hydroelectric power plants in South Africa:

- Gariep Hydroelectric Power Station: This power station is located on the Orange River in the Free State province. It has an installed capacity of 360 MW, making it the largest hydroelectric power plant in South Africa. Nonetheless, only a small part of its capacity is used for power generation, as most of the water is used for irrigation and drinking water.

- Palmiet Pumped Storage Scheme: This scheme is located near Cape Town in the Western Cape province. It has an installed capacity of 400 MW but only generates electricity during periods of high demand. The scheme works by pumping water from a lower reservoir to a higher reservoir during times of low demand and then releasing the water to generate electricity during times of high demand.

- Drakensberg Pumped Storage Scheme: This scheme is in the Drakensberg Mountains in the KwaZulu-Natal province. It has an installed capacity of 1,000 MW but only generates electricity during periods of high demand. Like the Palmiet Pumped Storage Scheme, it works by pumping water from a lower reservoir to a higher reservoir during times of low demand and then releasing the water to generate electricity during times of high demand.

4.2.5 Other renewable sources

- Biomass energy is produced from organic matter such as wood, agricultural waste, and municipal waste**.** The use of biomass is largely used in rural areas of the country. The use varies from heating, cooking and more. The total installed capacity of biomass energy in South Africa was 17 MW.

- Biogas is produced from the decomposition of organic matter such as animal waste and food waste. The total installed capacity of biogas energy in South Africa was 23 MW.
- Landfill gas is produced from the decomposition of organic matter in landfill sites. In South Africa, landfill gas is predominantly used for electricity

production. The total installed capacity of landfill gas energy in South Africa was 19 MW.

4.2.6. Renewable energy investments

'*South Africa's cabinet has approved an investment plan for an $8.5 billion package to accelerate the country's transition away from coal and towards clean energy*.'… By Chloé Farand.

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has attracted R53.2 billion in foreign investment and financing across all bid windows (DEPARTMENT OF ENERGY, 2015).

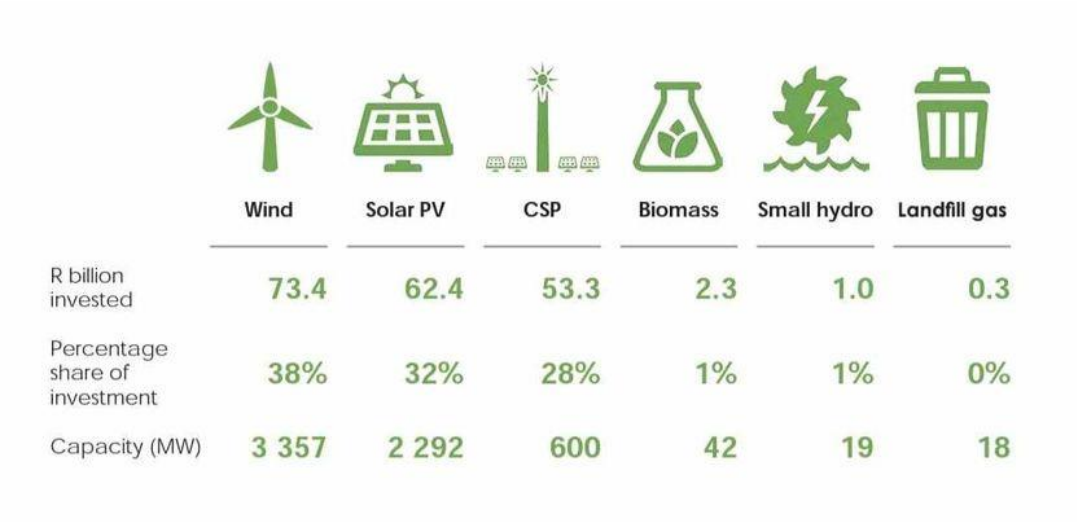


Figure 17 Investment by technology

Source: Department of Energy, 2015)

The majority of investment has been directed towards wind, solar PV, and CSP, while other forms of renewable energy receive less investment in technology.

Future or ongoing renewable energy projects:

- **Ubuntu Green Energy Hydrogen Project**: South Africa is prepared to become a major centre for green hydrogen production, spearheaded by the Ubuntu Green Energy Hydrogen Project. The project aims to build a 50 MW hydrogen electrolysis plant in Upington, situated in the Northern Cape province. According to Infrastructure South Africa (ISA), they have successfully raised a total of R300 billion to fund various green hydrogen projects across the country (AYODELE ET AL., 2019).
- **Eskom Just Energy Transition Project:** The Eskom Just Energy Transition Project (EJETP) is a $497 million initiative that was approved by the World Bank Group in November 2022, in response to a request from the Government of South Africa. The main objective of the project is to provide support to Eskom, the public energy utility, in the decommissioning of the Komati coal-fired power plant which has been in operation for 56 years. The project will also involve repurposing the area to accommodate renewable energy and batteries. Since 2021, the Komati power station has been functioning at a reduced capacity of 125 MW. However, this will soon change as the power station will be replaced with a combination of renewable energy solutions. This will comprise 150 MW of solar PV solar, 70 MW of wind energy, and 150 MW of batteries. This move is expected to not only improve power supply but also enhance grid stability (AKINBAMI, 2021).

4.3 Discussion of Data Findings

South Africa has made significant progress in the use of renewable energy sources in recent years due to high carbon emissions, energy security concerns, and growing electricity demands, as indicated by the data findings and survey. The majority of respondents were aware of renewable energy sources, with solar power and wind power being the most commonly known sources.

South Africa has taken several measures to diversify its energy mix, including the establishment of a Renewable Energy Independent Power Producer's Programme (REIPPP) in 2011 to encourage private participation in the country's energy transition. However, the

survey responses indicate that the lack of government incentives is one of the main obstacles hindering the widespread adoption of renewable energy in South Africa.

However, the majority of respondents believed that the South African government should prioritize and invest in renewable energy initiatives and infrastructure development. The government has already published the white paper policy in 2003 that outlines its plan to generate 10 TWh of electricity from renewable energy sources such as biomass, wind, solar, and small-scale hydro, and an integrated resource plan was released in 2011, setting a new target of adding 17,800 MW of renewable energy to the energy mix by 2030 (AKINBAMI, 2021).

Overall, these policies and programs demonstrate South Africa's commitment to a sustainable energy future and will help the country reduce its dependence on non-renewable sources of energy.

The Renewable Energy Independent Power Producer Procurement Program (REIPPPP) has played a crucial role in the growth and development of renewable energy projects in South Africa. As per the Department of Natural Resources and Energy in South Africa, the REIPPPP has so far procured 10,445 MW of renewable energy projects.

South Africa's solar energy sector has been experiencing significant growth in recent years. The country enjoys abundant solar radiation, especially in the Northern and Western regions, which makes it an ideal location for solar energy production. This has attracted both local and international investors, who have shown a growing interest in South Africa's solar energy market, increasing funding and project development. The survey responses also suggest that solar power is the most popular renewable energy source among respondents, and the government should prioritize investment in this area.

Today South Africa has over 20 installed concentrated solar power (CSP) and solar photovoltaic (PV) projects generating just over 3000MW in electric power. According to a publishment made by Natalie Cowling *'As of 2022, the solar energy capacity in South Africa amounted to 6,326 megawatts. This represented an increase of roughly 0.156 percent from the previous year. During the period under review, solar energy capacity grew dramatically from almost 260 to 6,326 megawatts*.' This refers to a study she did about the total solar energy capacity in South Africa from 2013-2022.

Based on the survey responses, wind energy was identified as one of the renewable energy sources with potential for South Africa's energy needs. As the second most prevalent renewable energy source, the nation has been unwavering in its efforts to foster growth and secure a more sustainable future. By harnessing the power of wind energy along the extensive coastlines in the Eastern and Western Cape regions

Established in 2008, the Darling Wind Farm is positioned on the west coast of South Africa, between the towns of Darling and Yzerfontein. It holds the distinction of being the first commercial wind farm to be established in the country. It was one of the first three wind farms to be built in South Africa and has a capacity of 5.2 MW with four turbines.

South Africa has made significant progress in utilizing renewable energy sources. For instance, wind farms like Roggeveld Wind can now generate ten times more electric energy using over 50 turbines. Currently, there are about 34 wind farms in the country that can produce over 3000MW, highlighting the remarkable milestones achieved in the adoption of sustainable and clean energy (APATA ET AL., 2020).

Based on the data analysis, hydro energy hasn’t been explored enough due to the water scarcity or lack of big rivers within the country. The majority of existing dams in the country have a primary use for agriculture or nature preservation.

Hydropower can still be used as a source of power generation. South Africa has a technical potential of producing approximately 14,000 GWh/year through hydropower, but around 90% of it has already been generated. The existing hydropower facilities have a capacity of 3,586 MW, including 2,832 MW of pumped storage, and generate around 4,750 GWh of electrical energy each year (BALANCE ET AL., 2000). This accounts for around 2% of the nation's power supply.

Large-scale biomass energy production in South Africa faces several obstacles, but it remains a viable solution to the country's energy concerns. Currently, the total installed capacity of biomass energy is only 17 MW. However, with increased investment and development, biomass has the potential to make a meaningful contribution to the country's energy grid. The survey also suggests that the utilisation of renewable energy sources for heat and transportation could be a viable option.

Landfill gas and biogas utilization in South Africa is still in the development stages. Currently, the total installed capacity of biomass energy in South Africa is 17 MW and for

landfill gas total installed capacity is about 19MW. The energy potential and environmental benefits of landfill gas and biogas are visible, but in South Africa, it's taking time to gain more recognition.

Most of the respondents on the survey saw that obstacle hindering the widespread adoption of renewable energy in South Africa, such as high initial costs, lack of government incentives, limited knowledge and awareness, grid integration challenges, resistance to change, and corruption, were also identified as obstacles to the adoption of renewable energy in the country.

Thanks to the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) a lot of effort in the investment in renewable energy sources has picked up in the country. Other institutions have also seen the potential of renewable energy and its being integrated into the country's electricity grid. Billions have been pledged by the government to invest in renewable energy utilization. These pledged commitments can help solve most of the above-mentioned obstacles to the adoption of renewable energy.

South Africa's commitment to renewable energy is evident in the $8.5 billion investment plan approved by the government bodies to speed up the country's shift from coal to clean energy. The investment plan will focus on wind, solar PV, and CSP technologies, as well as other renewable energy sources that are often overlooked or under-appreciated.

Looking at the country's future or ongoing renewable energy projects, most of these projects are mainly green hydrogen projects or technologies, with a total of R300 billion raised for the funding of green hydrogen projects in the country. Other projects include energy storage, such as the Eskom Just Energy Transition Project, which will see an old coal plant renovated into an energy storage plant (AYODELE 2019).

The survey responses indicate that the majority of respondents believe that the South African government should prioritize and invest in renewable energy initiatives and infrastructure development. On a scale from 1 to 5, the average response was 4.5, indicating strong support for government utilization and support in transitioning towards renewable energy.

With the continued support, and the right government policies and initiatives, South Africa can harness its renewable energy potential and transition to a more sustainable and prosperous future. South African government's commitment to renewable energy, as

evidenced by its investment plan and ongoing projects, is crucial in overcoming these obstacles. (ELLABBAN, 2014)

5. Conclusion and recommendations

5.1. Conclusion

South Africa has made remarkable strides in recent years towards the adoption of renewable energy sources. This shift towards cleaner and more sustainable energy has the potential to address many of the country's energy-related challenges while also contributing to economic growth, environmental sustainability, and energy security. The majority of respondents from a recent survey believed that the South African government should prioritize and invest in renewable energy initiatives and infrastructure development. Chapter 4 of the report further highlights the significant progress made in the utilization of renewable energy resources within the country.

The South African government has made a strong commitment to reduce its dependence on coal and other fossil fuels by 40% while increasing the use of renewable energy sources such as wind (21%) and PV (10%). This commitment to the energy mix was initially outlined in the government's white paper policy of 2003 and was reaffirmed by local entities in 2019 with a progressive target for 2030 (AKINBAMI, 2021). This commitment reflects the government's determination to promote a sustainable and clean energy future. With the guidance of the Renewable Energy Independent Power Producers Programme (REIPPP), a total of 6,422 MW of renewable energy has been obtained, with 3,876 MW already operational and available for use on the grid (ABDELRAZIK ET AL., 2022).

South Africa has been working towards increasing its use of renewable energy sources, but it has faced several obstacles. One significant challenge is the financial and operational difficulties that Eskom, the state-owned electricity utility, has been experiencing. These problems have affected the reliability of the power grid and have led to power outages. Furthermore, Eskom's financial instability has hindered the procurement of renewable energy on a large scale. A recent survey has highlighted some of the obstacles that are hindering the widespread adoption of renewable energy in South Africa, such as high initial costs, lack of government incentives, limited knowledge and awareness, grid integration challenges, resistance to change, and corruption.

South Africa is currently facing an infrastructure challenge that is impeding the integration of renewable energy. Most of the country's infrastructure was developed in the 90s, and the costs of transitioning to renewable energy sources and integrating them into the grid are

major obstacles. The electricity grid was originally designed for centralized power generation using coal and fossil fuels, which makes it difficult to incorporate variable renewable energy sources. As a result, there are challenges in maintaining grid stability, reliability, and upgrading infrastructure (VAIN, 2018).

South Africa is also facing a significant challenge regarding its energy storage infrastructure, to effectively address the intermittent and inadequate baseload challenges associated with renewable energy sources presents a challenge to South Africa's energy transition.

As per the survey, a few respondents have mentioned that corruption has a significant impact on South Africa's energy sector and its transition to renewable energy. Corruption has led to a lack of transparency in energy businesses and anti-corruption measures, which has undermined the country's clean energy plan. Also, corruption has resulted in the widespread mismanagement of Eskom, the state-owned energy provider that supplies almost 90% of the country's electricity (AMOAH ET AL., 2022). This has led to a lack of investment in new power plants and infrastructure, thus causing an energy crisis. In my opinion, corruption is a major problem in the country, not just in the energy sector but all sectors within the governing system and has hindered the development of the country tremendously.

One of the participants in the survey mentioned that the lack of a skilled workforce and Eskom's monopoly are significant obstacles to South Africa's transition to renewable energy. And I tend to agree with the participant. Eskom's monopoly has become an impediment to growth, including through rising electricity tariffs and frequent power outages (TING-BYRNE, 2020). The company has been relying on government support to continue with its outdated business model, which favours large-scale projects in coal and nuclear. Additionally, there is a lack of skilled workers in the renewable energy sector, which is hindering the country's transition to clean energy sources.

5.2. Recommendations

Addressing these challenges can help South Africa accelerate its transition to renewable energy sources, improve energy security, and reduce its carbon footprint. In my opinion, there are several steps that South Africa can take to improve on the transition to renewables.

One of the ways South Africa can improve or transition into renewable energy quicker is to invest in innovation and research. Invest in developing renewable energy technologies,

including emerging solutions such as wave and geothermal energy, and advanced solar and wind technologies. The country also needs to invest in updated infrastructure, especially in energy storage solutions. Research should be a priority in the country. South Africa has a 3,000 km long coastline, so offshore wind plants could be a viable option (MUROMBO, 2015).

With state-owned electricity utility currently facing operational difficulties, private-sector collaboration could be a way forward. Encouraging collaboration between the private sector and government to identify opportunities for renewable energy investments. This can lead to innovative financing solutions and accelerate project development. Jointly fund and develop renewable energy projects, sharing risks and rewards.

Investing in infrastructure for biogas and biomass is crucial for sustainable and decentralized energy solutions, especially in rural areas where access to the grid is limited. This includes the implementation of biogas digesters, gas distribution networks, and biomass processing facilities. Additionally, biomass cookstoves, small-scale biogas systems, and biomass-based mini-grids can be used for energy generation. Municipal wastewater treatment plants can produce sewage sludge, a valuable feedstock for biogas production. By treating sewage sludge through anaerobic digestion, biogas can be generated while reducing environmental pollution (ALAZRAQUE-CHERNI, 2008).

South Africa needs to improve its policies and incentives to support renewable energy development. According to the Department of Energy in South Africa, suitable fiscal incentives for renewable energy should be introduced, and an investment climate for the development of the renewable energy sector should be created. By implementing these solutions, South Africa can increase its renewable energy capacity and reduce its reliance on coal.

IRENA has provided several recommendations for South Africa to implement renewable energy. One of these recommendations was the realignment of the national energy sector structure: South Africa should optimize its energy sector structure by clarifying and simplifying the regulatory environment and undertaking research in key areas for energy transformation (IRENA,2017).

And finally, South Africa needs to reduce corruption in the renewable energy sector and increase investment in renewable energy. South Africa can solve the corruption problem in

the renewable energy sector by increasing transparency and corporate accountability. South Africa also needs to implement anti-corruption measures in public procurement and strengthen competitive procurement processes (AMOAH ET AL., 2022).

Policy development, strategic planning and formative actions to create awareness, participation, and enhance capacity building in benefits of renewable energy in the country.

6. Summary

The study attempts to investigate the challenges and opportunities connected to the implementation of renewable energy sources in South Africa. In doing so, it has three specific objectives: firstly, to assess the current state of renewable energy utilisation in the country; secondly, to identify the challenges that hinder the adoption of renewable energy sources; and thirdly, to explore the opportunities that exist for increasing the use of renewable energy in South Africa.

Renewable energy sources such as biomass, wind, and solar power have great promise in South Africa. Although coal is inexpensive, the country's heavy dependence on it creates serious environmental risks. As a result of the tremendous strain being placed on the nation's coal-fired power facilities, it is crucial that alternative energy sources be investigated and developed.

The interest in renewable energy is clearly on the rise in South Africa, as seen by the search data. This is because there is not enough electricity to go around because the country is dependent on fossil fuels. Therefore, a transition plan is essential for making the switch to renewable power. Load shedding, in which electricity is sometimes cut off, is a major hindrance to people's and businesses' ability to function normally.

The use of renewable energy is on the rise in South Africa. The country has made great strides in the use of these resources in recent years. According to the survey, several renewable energy sources, solar and wind were the most well-known. In reality, the most up-to-date information from South Africa's Energy Department demonstrates that all provinces make extensive use of solar PV, wind, and concentrated solar power (CSP). The biggest percentage of renewable energy in operation in South Africa is found in the Northern Cape province. After the Western Cape Province comes the Eastern Cape Province.

Currently, solar photovoltaic (PV) and wind power account for the vast majority of South Africa's renewable energy capacity of 10,445 MW. By 2030, the government aims to have 40% of the country's energy come from renewables. To a large extent, renewable energy projects in South Africa owe their success and expansion to the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). So far, approximately 100 renewable energy projects with a combined installed capacity of over 6,000 MW have been purchased under this programme (AKINBAMI, 2021).

The results of the study show that there are several barriers to the broad implementation of renewable energy sources in South Africa. It can be challenging to integrate renewable energy sources in some locations or among some people due to the high initial expenses involved, despite the fact that they can be cost-effective during their lifespan.

The intermittent and fluctuating nature of renewable energy sources presents a hurdle. Their power production might fluctuate according to weather conditions or other variables, making it difficult to rely on them as a steady source of electricity. Batteries and pumped hydro storage are two examples of energy storage technologies that might be used to solve this problem. However, these storage methods can be costly and time-consuming to implement.

Corruption has hampered anti-corruption measures and contributed to a severe lack of openness in the energy industry, both of which have had negative effects on the country's clean energy agenda (TING-BYRNE, 2020). As a result, Eskom, the state-owned energy supplier that provides about 90% of the country's electricity, has been completely mismanaged. An energy crisis has emerged as a direct result of poor management's failure to adequately fund the construction of new power plants and related infrastructure.

The constraints of integrating renewable energy into South Africa's power infrastructure are a major barrier to its widespread adoption. Incorporating intermittent renewable energy sources is difficult since the system was designed to support centralised coal and fossil fuel-based power generation. This raises concerns about the reliability of the grid and the difficulty of keeping the infrastructure up to date.

Nonetheless, the South African government has demonstrated a firm dedication to renewable energy through its investment strategy and existing projects, which will centre on wind, solar PV, and CSP technologies, among others.

Northern and western South Africa receive very high levels of solar radiation, making this country an excellent site for solar power plants. According to the results of the survey, solar power is the most popular renewable energy source, hence the government should put more money into solar energy projects. Batteries and pumped hydro storage are two examples of energy storage technology that can help smooth out the fluctuations in output from renewables. An existing coal plant, for instance, will be converted into an energy storage facility as part of the Eskom Just Energy Transition Project.

There are a number of initiatives in the works that will position South Africa to become a world leader in green hydrogen generation. A 50 MW hydrogen electrolysis plant is being built in the Northern Cape as part of the Ubuntu Green Energy Hydrogen Project. With the help of renewable energy sources including solar and wind, the Boegoebaai Green Hydrogen Development Programme hopes to create 28,000 tonnes of green hydrogen annually.

South Africa has established goals to increase the country's usage of renewable energy sources. The REIPPPP (Renewable Energy Independent Power Producer Procurement Programme) has been crucial in fostering the expansion and improvement of renewable energy initiatives around the country. The $8.5 billion investment plan agreed to speed up the transition from coal to renewable energy reflects the government's dedication to a sustainable energy future (AKINBAMI, 2021).

Bibliography

1. Abdelrazik, M. K., Abdelaziz, S. E., Hassan, M. F., & Hatem, T. M. (2022): Climate action: Prospects of solar energy in Africa. Energy Reports, 8, 11363-11377. https://doi.org/10.1016/j.egyr.2022.08.252

2. Akashie, E. U. (2022): Advantages and disadvantages of hydroelectric energy. Polytechnic University of Bucharest.

3. Akinbami, O. M., Oke, S. R., & Bodunrin, M. O. (2021): The state of renewable energy development in South Africa: An overview. Alexandria Engineering Journal 60(6), 5077-5093. https://doi.org/10.1016/j.aej.2021.03.065

4. Alazraque-Cherni, J. (2008). "Renewable Energy for Rural Sustainability in Developing Countries". Bulletin of Science, Technology & Society. 28 (2): 105– 114. doi:10.1177/0270467607313956. S2CID 67817602. Archived from the original on 19 March 2021. Retrieved 2 December 2020.

5. Aliyu, A.K., Modu, B. & Tan, C.W. (2018): A review of renewable energy development in Africa: A focus in South Africa, Egypt, and Nigeria. Renewable and Sustainable Energy Reviews, 81, 2502-2518.

6. Amoah, A., Asiama, R. K., Korle, K., & Kwablah, E. (2022): Corruption: Is it a bane to renewable energy consumption in Africa? Energy Policy, 163, 112854.

7. Apata, G. & Adebayo, A. & Awodele, K. (2020): Grid Integration of Wind Energy: The South African Challenge. 1-5. 10.1109/PowerAfrica49420.2020.9219813.

8. Armaroli, N. – Balzani, V. (2016): "Solar Electricity and Solar Fuels: Status and Perspectives in the Context of the Energy Transition". Chemistry – A European Journal. 22 (1): 32–57. doi:10.1002/chem.201503580. PMID 26584653.

9. Ayodele, T. R., & Munda, J. L. (2019). The potential role of green hydrogen production in the South Africa energy mix. Journal of Renewable and Sustainable Energy, 11(4).

10. Baker, L. (2017). Post-apartheid electricity policy and the emergence of South Africa's renewable energy sector. The Political Economy of Clean Energy Transitions, Oxford University Press, Oxford, 371-390.

11. Ballance, A., Stephenson, D., Chapman, R. A., & Muller, J. (2000). A geographic information systems analysis of hydro power potential in South Africa. Journal of Hydroinformatics, 2(4), 247-254.

12. Balmer, M., & Spreng, D. (2008). Hydroelectric power. In Future Energy (pp. 193-209). Elsevier.

13. Brunet, C. - Savadogo, O. - Baptiste, P. – Bouchard, M. A. – Cholez, C. – Rosei, F. - Gendron, C. -Sinclair-Desgagné, B. – Merveille, N. (2022): Does solar energy reduce poverty or increase energy security? A comparative analysis of sustainability impacts of on-grid power plants in Burkina Faso, Madagascar, Morocco, Rwanda, Senegal and South Africa. Energy Research and Social Science Vol. 87, 102212. https://doi.org/10.1016/j.erss.2021.102212

14. Dell, R. M. – Rand, D. A. J. (2004): Clean Energy. RSC Clean Technology Monographs, The Royal Society Chemistry, Cambridge.

15. Department of Energy, 2015 https://www.energy.gov.za/files/media/pub/state-of-renewable-energy-in-south-africa.pdf

16. Dickson, M. H. – Fanelli, M. (2013). Geothermal energy: utilization and technology.

17. Divya, K. C. – Østergaard, J. (2009): Battery energy storage technology for power systems—An overview. Electric Power Systems Research 79(4), 511-520. https://doi.org/10.1016/j.epsr.2008.09.017

18. Doorga, J. R., Hall, J. W., & Eyre, N. (2022): Geospatial multi-criteria analysis for identifying optimum wind and solar sites in Africa: Towards effective power sector decarbonization. Renewable and Sustainable Energy Reviews, 158, 112107.

19. Egli, F. – Steffen, B. – Schmidt, T. S. (2018): A dynamic analysis of financing conditions for renewable energy technologies. Nature Energy 3, 1084-1092.

20. Ellabban, O. - Abu-Rub, H. – Blaabjerg, F. (2014): Renewable energy resources: Current status, prospects and their enabling technology 21. Renewable and Sustainable Energy Reviews. 39: 748–764.

21. ESKOM, 2021 Electricity technologies [Online] Available at https://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Electricity_Technologies.aspx/html [Accessed: October 2021]

22. Haelg, L. (2020): Promoting technological diversity: How renewable energy auction designs influence policy outcomes. Energy Research & Social Science, Vol. 69, 101636. https://doi.org/10.1016/j.erss.2020.101636

23. Herbert, G. J., Iniyan, S., Sreevalsan, E., & Rajapandian, S. (2007). A review of wind energy technologies. Renewable and sustainable energy Reviews, 11(6), 1117-1145.

24. Hirst, K. K. (2013): "The Discovery of Fire". About.com. Archived from the original on 12 January 2013. Retrieved 15 January 2013.

25. International Energy Agency (2012)."Energy Technology Perspectives 2012". Archived from the original on 28 May 2020. Retrieved 2 December 2020.

26. IRENA (2017): https://www.irena.org//media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Africa/SouthAfrica_Africa_RE_SP.pdf?rev=9851ed405064418e94d8ddd8b24893e9

27. Jain, S., & Jain, P. K. (2017). The rise of renewable energy implementation in South Africa. Energy Procedia, 143, 721-726.

28. Kenny, F. (2019): Legal consideratios in developing and implementing the 2018 draft intergrated resources plan (IRP): a case study of the nuclear sector (Master's thesis, Faculty of Engineering and the Built Environment).

29. Khan, N. D., Kalair, A., Abas, N., & Haider, A. (2017). Review of ocean tidal, wave and thermal energy technologies. Renewable and Sustainable Energy Reviews, 72, 590-604.

30. Kothari, R., Tyagi, V. V., & Pathak, A. (2010). Waste-to-energy: A way from renewable energy sources to sustainable development. Renewable and Sustainable Energy Reviews, 14(9), 3164-3170.

31. Lawrence, A., Lawrence, A., & Ballard. (2020): South Africa's Energy Transition. Cham: Springer International Publishing.

32. Marquard, A. (2006). The Origins and Development of South African Energy Policy.

33. Mugenda, O.M. and Mugenda, A.G. (2003): Research Methods, Quantitative and Qualitative Approaches. ACT, Nairobi.

34. Murombo, T. (2015). Regulating energy in South Africa: Enabling sustainable energy by integrating energy and environmental regulation. Journal of Energy & Natural Resources Law. 33. 1-29. 10.1080/02646811.2015.1089113.

35. Nyabadza, M. C. (2012): Overcoming energy constraints on future development in Stellenbosch through energy efficiency: retrofitting of solar hot water heaters and gas stoves in middle- and high-income households in the residential sector [Thesis, Stellenbosch: Stellenbosch University]. http://hdl.handle.net/10019.1/20258

36. Philibert, C. (2011): Solar energy perspectives. International Energy Agency, Organisation for Economic Co-operation, and Development. Paris: OECD/IEA. ISBN 978-92-64-12458-5. OCLC 778434303.

37. Renewable Energy (2021) Energy sources [Online] Available at http://www.energy.gov.za/files/esources/renewables/r_hydro.html [Accessed: October 2021]

38. Rodseth, C. – Notten, P. - von Blottnitz, H. (2020): A revised approach for estimating informally disposed domestic waste in rural versus urban South Africa and implications for waste management, S. Afr. J. Sci. 116.

39. Soeiro, S. – Dias, M. F. (2020): Community renewable energy: Benefits and drivers. Energy Reports 6(8), 134-140.

40. Ugli, T. J. T. (2019). The importance of alternative solar energy sources and the advantages and disadvantages of using solar panels in this process.

41. Urry, J. (2014). The Problem of Energy. Theory, Culture & Society, 31(5), 3-20. https://doi.org/10.1177/0263276414536747

42. Ting, M. B., & Byrne, R. (2020): Eskom and the rise of renewables: Regime-resistance, crisis and the strategy of incumbency in South Africa's electricity system. Energy Research & Social Science, 60, 101333.

43. Vain D. B. (2018): Jarbandhan, Nadejda Komendantova, Romao Xavier, Elvis Nkoana. "Chapter 8 Transformation of the South African Energy System: Towards Participatory Governance", Springer Science and Business Media LLC.

44. Verbruggen, A. - Fischedick, M. - Moomaw, W. – Weir, T. Nadaï, A. - Nilsson, L. J. - Nyboer, J. – Sathaye, J. (2010): Renewable energy costs, potentials, barriers: Conceptual issues 38(2), 850-861. https://doi.org/10.1016/j.enpol.2009.10.036

45. Wang, S., & Wang, S. (2015). Impacts of wind energy on environment: A review. Renewable and Sustainable Energy Reviews, 49, 437-443.

46. World Bank (2019): Production from Renewable Sources: Excluding Hydroelectric 1971 - 2014 https://www.ceicdata.com/en/south-africa/energy-production-and-consumption/za-electricityproduction-from-renewable-sources-excluding-hydroelectri)

47. World Energy Assessment (2001): Renewable energy technologies Archived 9 June 2007 at the Wayback Machine, p. 221.

48.

Appendix

ANNEX 1

LIST OF FIGURES AND TABLES

- Fig 1 to 12…….. own editing based on a questionnaire survey, 2023
- Fig 13……. Electricity production by Eskom (image source: Ciec data, South Africa ZA: Electricity Production from Renewable Sources: Excluding Hydroelectric 1971 - 2014 | WORLD BANK,

https://www.ceicdata.com/en/south-africa/energy-production-and-consumption/za-electricity-

production-from-renewable-sources-excluding-hydroelectric)

- Fig 14……. capacities in different provinces (trade and investment KZN, 2021, file:///C:/Users/Admin/Downloads/Biomass%20Sector%20Report.pdf)
- Fig 15…… The Jasper Solar Power Project in Northern Cape Province. (Image source: Solar Reserve, https://www.renewable-technology.com/projects/jasper-solar-power-plant-northern-cape-kimberley)
- Fig 16…. The Roggeveld Wind Farm (image source: roggeveldwindfarm. Energy, https://g7energies.com/project/roggeveld)
- Fig 17……Investment by technology (image source: Department of Energy, 2015 https://www.energy.gov.za/files/media/pub/state-of-renewable-energy-in-south-africa.pdf)

ANNEX 2

Survey questions

To meet South Africa's increasing demand for electricity, it is crucial to explore renewable and sustainable energy sources utilization of renewable energy sources in South Africa

1. Your age range?

18 to 25

26 to 35

36 to 45

46 and above

2. What is your gender?

Male

Female

Prefer not to say.

3.

Other:

Check all that apply.

High School Diploma or Less

Some College or Technical Training

Bachelor's Degree

Postgraduate Degree

4. What is your location within South Africa?

Check all that apply.

Limpopo

Eastern Cape

KwaZulu-Natal

Northwest

Mpumalanga

Northern Cape

Western Cape

Gauteng

Free State

5. On a scale from 1 to 5, Are you aware of renewable energy sources like solar, wind, and hydroelectric power?

1 (not aware) – 2 – 3 – 4 – 5(very aware)

6 How aware are you of the environmental benefits of renewable energy sources, such as reduced greenhouse gas emissions?

1 (not aware) – 2 – 3 – 4 – 5 (very aware)

7. How familiar are you with government initiatives related to renewable energy in South Africa?

1 (not familiar) – 2 – 3 – 4 – 5 (very familiar)

8. Please indicate which renewable energy source you believe has the most potential for South Africa's energy needs

Other:

Geothermal Energy

Solar Power

Wind Power

Biomass Energy

Hydroelectric Power

9. To what extent do you believe the South African government should prioritize and invest in renewable energy initiatives and infrastructure development?

1 (Strongly Disapprove) – 2 – 3 – 4 – 5 (Strongly Approve)

10. On a scale from 1 to 5 How do you feel about the use of renewable energy sources for heat energy production in South Africa (e.g., heating, hot water, cooking)?

1 (Strongly Disapprove) – 2 – 3 – 4 – 5 (Strongly Approve)

11. What is your opinion on the use of renewable energy sources for transportation (e.g., electric vehicles) in South Africa?

1 (Strongly Disapprove) – 2 – 3 – 4 – 5 (Strongly Approve)

12. On a scale from 1 to 5, how well do you think South Africa is currently utilizing its renewable energy potential?

1 (not utilizing) – 2 – 3 – 4 – 5 (highly utilizing)

13. What do you believe are the main obstacles hindering the widespread adoption of renewable energy in South Africa? (Select all that apply)

Other:

High Initial Costs

Lack of Government Incentives

Limited Knowledge and Awareness

Grid Integration Challenges

Resistance to Change

14. How supportive are you of South Africa's efforts to transition to a more sustainable and renewable energy future?

1 (not supportive) – 2 - 3 – 4 – 5 (very supportive)

15. Please provide any additional comments or insights you have regarding the utilization of renewable energy resources in South Africa.

STATEMENT ON CONSULTATION PRACTICES

As a supervisor of **THABISO MAPHALALA** (NEPTUN ID: **TH7HXR**), I here declare that the thesis[1] has been reviewed by me, the student was informed about the requirements of literary sources management and its legal and ethical rules.

I recommend/don't recommend[2] the thesis to be defended in a final exam.

The document contains state secrets or professional secrets: yes **no***[3]

Place and date: Gyöngyös, 4 November 2023.

Internal supervisor

Dr. Gábor Koncz

[1] Please select applicable and delete non-applicable.
[2] Please underline applicable.
[3] Please underline applicable.

DECLARATION

on authenticity and public assess of final essay/thesis/mater's thesis/portfolio[1]

Student's name:	THABISO MELVIN MAPHALALA
Student's Neptun ID:	TH7HXR
Title of the document:	UTILIZATION OF RENEWABLE ENERGY SOURCES IN SOUTH AFRICA
Year of publication:	2023
Department:	Institute of Rural Development and Sustainable Economy

I declare that the submitted final essay/thesis/master's thesis/portfolio[2] is my own, original individual creation. Any parts taken from an another author's work are clearly marked, and listed in the table of contents.

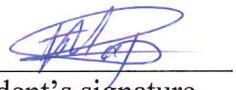
If the statements above are not true, I acknowledge that the Final examination board excludes me from participation in the final exam, and I am only allowed to take final exam if I submit another final essay/thesis/master's thesis/portfolio.

Viewing and printing my submitted work in a PDF format is permitted. However, the modification of my submitted work shall not be permitted.

I acknowledge that the rules on Intellectual Property Management of Hungarian University of Agriculture and Life Sciences shall apply to my work as an intellectulal property.

I acknowledge that the electric version of my work is uploaded to the repository sytem of the Hungarian University of Agriculture and Life Sciences.

Place and date: Budapest 2023 year 11 month 10 day



Student's signature

[1]Please select the one that applies, and delete the other types.
[2]Please select the one that applies, and delete the other types.