DE-RISKING RENEWABLE ENERGY INVESTMENT TOWARDS A LOW CARBON DEVELOPMENT PATHWAY: THE CASE OF SOUTH AFRICA

By

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DECLARATION

I declare that **"DE-RISKING RENEWABLE ENERGY INVESTMENT TOWARDS A LOW CARBON DEVELOPMENT PATHWAY: THE CASE OF SOUTH AFRICA"** is my own work. I have acknowledged with full references in the text and in the reference list all sources that I have cited, used and quoted. This work has not been previously submitted to any university or institution of higher learning for any qualification.

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ABSTRACT

South Africa is a country that depends heavily on coal to produce energy. With the global outcry to address climate change challenges, a shift to renewable energy sources is critical. The change from large carbon footprint power sources (e.g., coal power stations) to renewable energy sources, comes with its own issues such as cost of production, energy transmission, barriers to entry, availability of power, power quality issues, resource location, information barrier, politics and intermittent nature of renewable energy options (Dey *et al.*, 2022). The main dangers and obstacles to the growth of renewable energy are examined in this thesis. Focus was placed on de-risking elements that could be considered to encourage investment in renewable energy. Among these were financial, political, regulatory, and policy concerns are only a few of the hazards that have been highlighted. De-risking investments in renewable energy has been identified as one of the essential pillars for accelerating the adoption of renewable technology for many emerging nations. Using the De-risk Investment Framework and Financial Tool of 2013 from the United Nations Development Programme (United Nations Development Programme, 2015), this study examined the energy and policy landscape in South Africa. The study identified the financial risks and other barriers that discourage the deployment of renewable energy projects in Nkangala District of Mpumalanga, in South Africa. Furthermore, policy instruments that promote renewable energy investments in South Africa are evaluated. Finally, the study proposes sound and effective ways of de-risking renewable energy investment towards a low carbon development pathway in South Africa.

Key Words: Renewable Energy, risk, De-risking, investment, policy

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CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The first part of this chapter seeks to use relevant literature which gives an overview of the RE transition policy landscape at international, continental, regional, and country level. The landscape highlights policies implemented by South Africa in a bid to address the energy needs. It further broadens the understanding of de-risking instruments with specific reference to emerging economies. A summary is given on the country's RE potential, and an overview of the use of RE technology. Lessons are drawn from studies of other countries who have successfully transitioned to RE use. De-risking instruments are examined, thus broadening the understanding of such instruments.

2.2. Renewable Energy Transition Policy Landscape

The energy sector has witnessed a shift in policy direction which has tilted more towards a low carbon future. At the centre of the transition has been a significant number of policies and frameworks such as deployment, integrating, enabling, structural, and just transition. Holistic global policy frameworks are guiding and shaping the emerging trends (IRENA, 2021). The above policies are illustrated in Figure 2.1 and are explained in detail below.

2.2.1 Deployment Policies

Deployment policies can be divided into support operations, and investment and consumer facing policies. Investment based policies are those policies used by government to support private investors towards renewables. These include interventions such as capital grants, low interest loans, and tax exemptions. Subsidies are government interventions towards promoting RE investments; however, subsidies that promote fossil-based projects act as a barrier towards renewable project investments (Sarti, 2018). Support operations policies can be represented by quantity and price-based operations. Quantity based policies use the capping technique of the maximum gas emissions and make use of tradeable certificates to control firms that fail to meet the minimum emission levels. In promoting renewable technology, a tendering system can also be used to create a competitive environment to allow that technology to have a share of the market. Price based mechanisms in the form of feed in tariffs set a fixed price to be paid for renewable electricity. Such price-based mechanisms have been used globally (Sarti, 2018). De-monopolising distribution of electricity at retail level plays a great role in influencing consumer behaviour by giving consumers options on where to source electricity. Creating favourable conditions for renewable power prompts consumers to purchase their electricity from renewable sources, as well as sell back to the grid (Sarti, 2018).

2.2.2 Integrating Policies

To promote integration of reducing global warming and sustainable power, the following policies were recommended:

- a push to clean energy through Sustainable Development Goal 7 which advocates for clean energy through the 5 targets of energy services which are affordable and reliable.
- substantially diversify the worldwide energy mix with increase in RE.
- promote international cooperation to propel access to clean energy.
- foster broader regional and continental collaborations.
- tapping into international funding platforms that promote low carbon future technologies.
- intensive energy technologies and adopting a diversified energy portfolio.
- advance integrated RE and promote climate action through climate mitigation/adaption (UNECA, 2011).

2.2.3 Enabling Policies

Enabling policies that can lead to transition to RE include eradicating fossil fuel technologies by declaring a climate emergency and financial relieve opportunities, reigniting ambition, addressing COVID-19 challenges, redirecting SDGs and Paris Agreement policies to boost investors' confidence, reforming energy markets, and policy frameworks that consist of policy statements, plans and targets (Polack, 2021). Among these are conventions such as the United Nations Framework on Climate Change Convention (UNFCCC). The Kyoto Protocol (KP) was adopted in Kyoto Japan on 11 December 1997, and entered into force in 2005 (Waissbein *et al.*, 2013). The KP is linked to RE through its article 12 whose main objective was the clean development mechanism (CDM). Other policies include the GHG Protocol; the ISO 14064; Green Stimulus Packages ; Green Economy Initiative; Cancun Agreement; UN International Year of Sustainable Development; and the COP17/CMP7.

2.3. United Nations Framework on Climate Change Convention (UNFCCC)

The UNFCCC, formed in 1992, is a world commitment by countries in a bid to control the rise in global temperature. At present, 195 parties have signed the UNFCCC. Funds have been set aside in a bid to adapt to climate change, namely the Adaptation Fund and the Green Climate Fund. The Kyoto Protocol is linked to the UNFCCC which commits its parties by benchmarking emission reduction targets. It was adopted in Japan on 11 December 1997. The mechanisms of Kyoto are the International Emission Trading (IET), Clean Development Mechanism (CDM), and the Joint Implementation Plan (JM). These mechanisms help facilitate green investment, and for parties to achieve their emission target in a cost effective way (Town, 2015).

A significant milestone in the climate mitigation discourse has been the development of standards and methods for corporates' carbon footprint, key of which includes the GHG Protocol and ISO 14064 as explained in Figure 2.1.

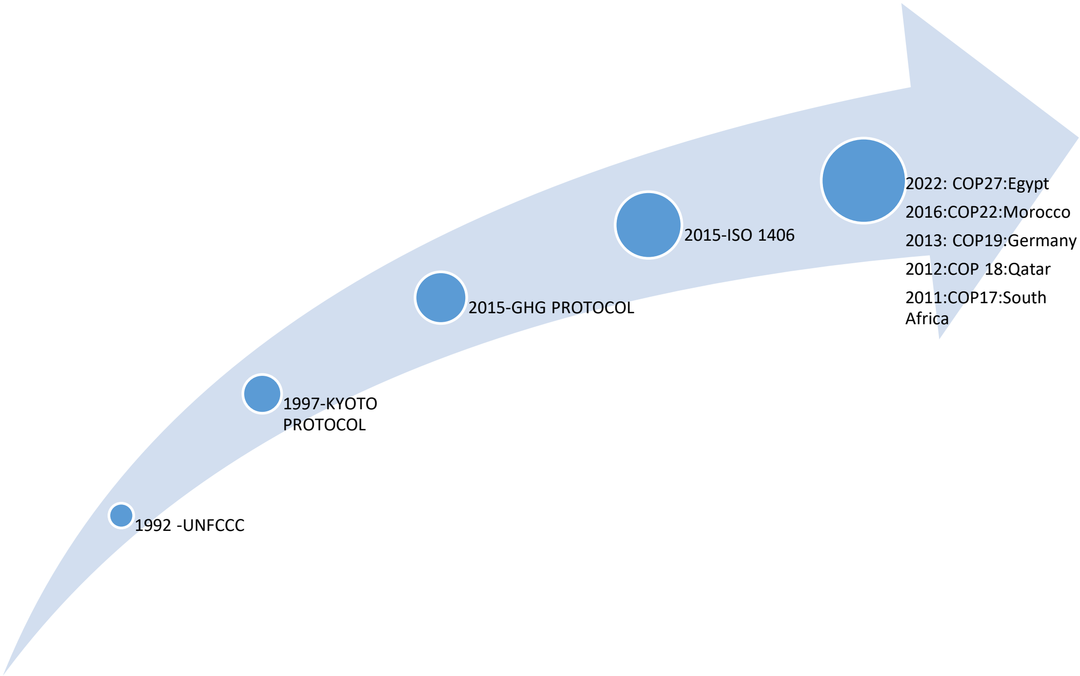

Figure 2.1. Standards and Methods of Carbon Footprint

(Source: Author)

2.3.1 GHG Protocol

The GHG Protocol creates a comprehensive global standardised framework that quantify the greenhouse gas (GHG) emission. Companies internationally benchmark themselves using the GHG Protocol. It was created as a plan of action to combat climate change, which included the requirement for standardized measurement of GHG emissions and the Paris Agreement that was adopted within the United Nations Framework Convention on Climate Change (UNFCC) in December 2015 (Polzin *et al.*, 2015). The GHG Protocol's main objectives are:

- To assist users in accurately, consistently, openly, fully, and pertinently evaluating the GHG effects of policies and actions.

- To improve understanding of the emissions effects of policies and activities to assist policymakers and other decision-makers in developing efficient strategies for managing and reducing GHG emissions.
- To support consistent and transparent public reporting of emissions impacts and policy effectiveness.
- To improve global uniformity and openness in the estimation of the consequences of GHG policies.

2.3.2 ISO 14064

It is the board which audits the quantification by GHG Protocol to ensure transparency, consistency, credibility, verification, reporting, and facilitating the certification and trade of GHG emission reductions (Wintergreen and Delaney, 2006). RE certificates are being used by companies to report reduction in emissions from purchased electricity in a bid to meet science-based targets. However, the disadvantage is the exaggerated approximation of mitigation efforts which has resulted in 42% of Committed Scope 2 emissions. A call to revisit the accounting guidelines has been made by scientists to require companies to report real emissions (Bjørn *et al.*, 2022). South Africa has training companies that offer certifications to companies and provide relevant material. Such training courses are offered on an annual basis due to the changing nature of calculation methodologies, and factor reporting requirements.

2.3.3 Cancun Agreement

These are long term decisions agreed by international communities in building a sustainable future with objectives such as promoting global cooperation in decreasing carbon emissions and promoting the creation and distribution of clean technology to combat climate change (Park, 1989). Some of its objectives include mobilising manufacturing and deployment of clean energy technology participation to the developing world (UNFCCC, 2020).

2.3.4 Conferences of Parties (COP*)*

These are conferences of the parties (COP) to the Kyoto Protocol that convene to make decisions with regards to climate control. Several parties have met, with the most recent being the COP 27 held in Egypt. Major achievements include the mobilisation of billions of dollars in funding. About 274 million British Pounds was pledged to support communities across Asia and the Pacific to improve conversation and deliver low carbon development in the previous COP 26 convention (UNFCCC, 2021).

2.4. Renewable energy transition institutional landscape

Some renowned international institutions such as the International Energy Agency (IEA), International Renewable Energy Organisation (IRENA), Organisation of the Petroleum Exporting Countries (OPEC), and International Network for Sustainable Energy (INFORSE) placed RE as one of their key priority goals in a bid to shape the energy landscape (UNFCCC, 2020). The next section below describes how some of the above notable international institutions have shaped the RE agenda.

2.4.1. International Energy Agency

The International Energy Agency (IEA) acts as an advisor on the drive to (RE) transition. The IEA offers thorough market analysis, policy advice, and technology intuitions to expedite a swift balance up in renewable distributions through the transport, electricity, and heat sectors (Wu, Xu and Yang, 2018). IEA works diligently with governments, industry partners, and technological partnership programmes. The organisation has conducted joint research and development projects on the use of RE. The agency makes contributions to global initiatives such as clean ministerial, G7, and G2. IEA has managed to be a universal reference for analysis of system integration of renewables, supporting policymakers and operators in acclimating power systems in various local contexts. The IEA works in collaboration with other organisations which share the same vision of use of RE, such as the IRENA and the Renewable Energy Policy Network for the 21st Century (REN21), which has published a report that identifies key barriers and highlights policy options to boost RE deployment (Polzin *et al.*, 2015).

2.4.2. United Nations Environmental Program (UNEP)

It is the spearheading body advocating for clean environment by encouraging nations to take responsibility in keeping a healthy environment. It works under the umbrella of the 2030 Agenda for Sustainable Development by identifying and addressing critical environmental issues (McCrone *et al.*, 2020). UNEP supports the Green Economy Initiatives programmes. The UNEP has been able to compile a report to give an overview of government 2030 RE targets. A mega 721GW of energy from diversified energy options such as geothermal, solar, biomass, and wind must be generated by end of 2030. A clear point from the report was the ambition of governments such as China, India, and Germany which have to generate 70GW, 68GW, and 48GW respectively to meet their targets (McCrone *et al.*, 2020).

Commendable efforts put towards investments in RE over the previous decade 2010-2019 have to be recognised. From Figure 2.2 below, a reflection of the top 20 markets is illustrated - with China taking the lead in investments of renewables with $818 billion (McCrone *et al.*, 2020).

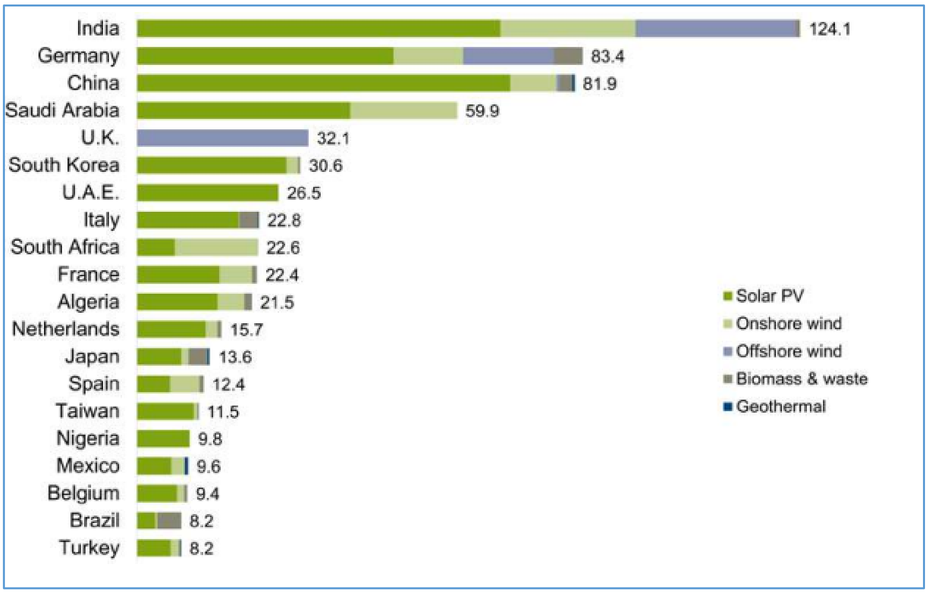

Figure 2.1. Top 20 Renewable Market for decade 2010-2019.

(Source: UNEP, Frankfurt School-UNEP Centre, Bloomberg NEF 2020:14)

An overall global new investment in RE by asset class between 2004 and 2019 in billion dollars was reported too by UNEP as indicated in Figure 2.3. The trend shows an increase by 2% to an amount of $301.7 billion. This increase exceeded the average of the last decade of $284 billion. Venture capital and private equity investment increased by 22%; this increase still falls short of the $3.4 billion for the previous decade (McCrone *et al.*, 2020).

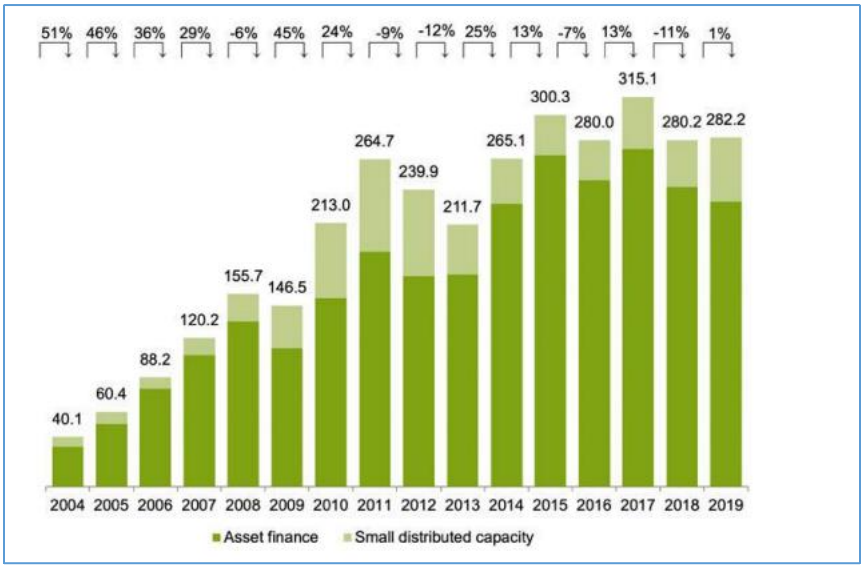

Figure 2.2. Global New Investment in Renewable Energy between 2004 and 2019

(Source: UNEP, Frankfurt School-UNEP Centre, Bloomberg NEF 2020:23)

Regional performance in the Middle East and Africa by country revealed that the United Arab Emirates' $15.6 billion in 2019 was a decrease from the $16.5 billion achieved in 2018. Sadly, new players in RE investments such as South Africa, Jordan, Egypt, Morocco, and Kenya reported a decline in renewable investment as shown in the Figure 2.4. South Africa decreased by 76%, Kenya by 45%, Morocco by 83%, Egypt by 56%, and Jordan 69%. Growth was reported by Saudi Arabia, and Zimbabwe, with 53% and 3754% respectively (McCrone *et al.*, 2020).

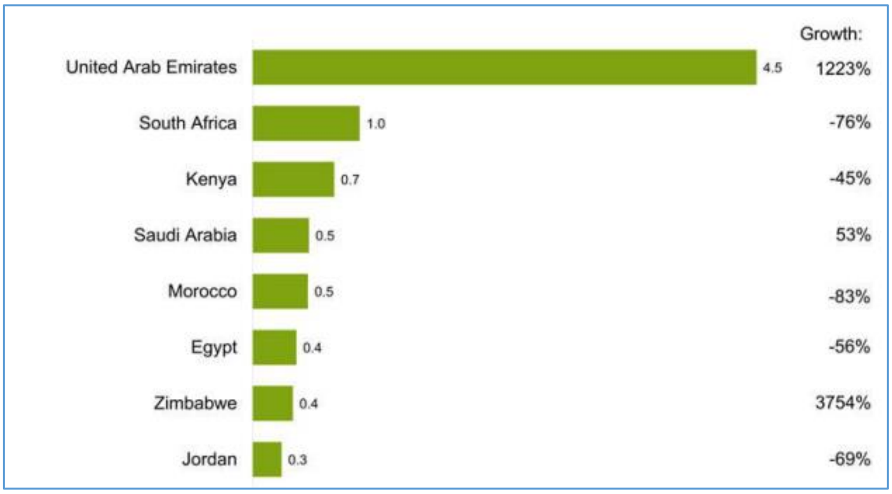

Figure 2.3. Regional Performance of Renewable Energy Investment

(Source: UNEP, Frankfurt School-UNEP Centre, Bloomberg NEF 2020:23)

The Latin America region shows growth in countries such as Brazil (74%), Chile (302%), and Mexico (4.3%); and a decline in RE investment in countries such Argentina (18%), Dominican

Republic (66%), and Panama (44%). Guadeloupe and Ecuador did not show any growth (McCrone *et al.*, 2020). This is shown in the Figure 2.5.

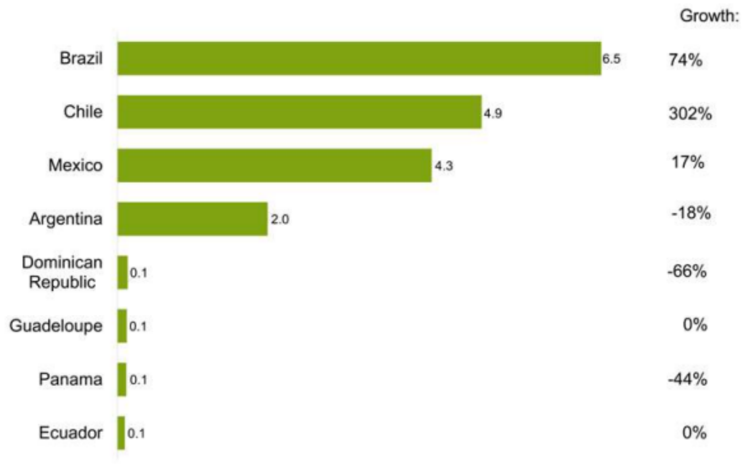

Figure 2.4. Growth of Renewable Energy Investments in Latin America

(Source: UNEP, 2020:49)

2.4.3 International Renewable Energy Agency

IRENA is an inter-governmental organisation which acts as a knowledge hub for energy transformation through knowledge and innovation. As seen in Figure 2.6, it aids nations as they make the transition to a future of sustainable energy.

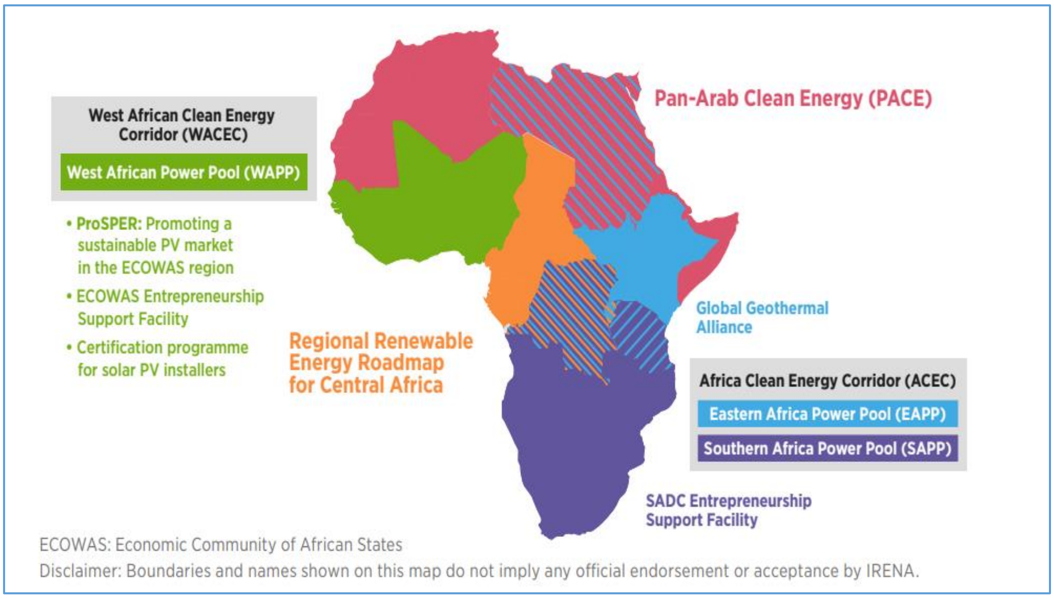

Figure 2.5. Transition to a Sustainable Future of Economic Community of Africa States

Source: IRENA (2020:10)

IRENA is in a joint initiative with the United Nations Development Programme (UNDP) and Sustainable Energy for All (SEforALL). In collaboration with the Green Climate Fund (GCF) they are a Climate Investment Platform (CIP) that has a mandate to raise the amount of capital mobilised and RE investing in developing countries (IRENA, 2018a). It gives a global voice for renewables, facilitates networking, and provides advice and support for countries who have a vision towards clean energy. Members who join the organization must be members of the United Nations and willing to conform to conditions specified by the organization (IRENA, 2018). Some of the efforts made by IRENA include providing RE capacity studies, RE cost studies, renewable readiness assessment, RE benefit studies, RE technology studies, facilitation of regional RE planning, and undertaking spatial mapping of energy resource potential across the globe (Hirschl, 2009).

2.4.2.1 Clean Energy Corridors

The IRENA Clean Energy Corridor's main goals are to encourage the development of regional markets for RE, and to enable the integration of affordable renewable power sources into national systems. The Clean Energy Corridors serve in four sub-regions which are: African Energy Corridor (ACEC) whose member countries are from the Eastern and Southern African pools; West Africa Clean Energy (WACEC) whose member countries are within the Economic Community of West African States; and the Clean Energy Corridor for Central America (CECCA) whose member countries are in the Central American Integration System (SICA) (Renewable Energy Agency, 2020).

2.4.2.2 Coalition for Action

IRENA Coalition for Action forms ‘a key international platform that facilitates a network to interrogate trends in the industry , develop action plans, and cross pollinate ideas and best practices within the vision of global transitions in line with the Sustainable Development Goal 7 on affordable and clean energy (Renewable Energy Agency, 2020). The Coalition has managed to have a pool of 130 leading RE players for different stakeholders that include private sector companies, industry associations, civil society, research institutes, and intergovernmental organisations.

2.4.2.3 Collaborative Framework

Collaborative Framework is another platform to bring cooperation and coordination among different stake holders to accelerate the global energy transformation, contributing to the on-going work of the Agency. Its main agenda is to strengthen energy markets and regulations, and create an environment that contributes to long term investment security, and promote cross country interconnections of trade of renewable electricity (IRENA, 2018). Challenges that have been met by a number of countries include the speed up development of RE, including the supply reliability, grid stability, and market design (IRENA, 2018).

2.4.2.4 Renewable Energy Roadmaps

Renewable Energy Roadmaps (Remap) facilitate programmes that bring potential for countries to speed up renewables (IRENA, 2020). Remap focuses on possible technology pathways and factors such as cost of systems, with the needed investment taking into account externalities such as air pollution (IRENA, 2020). South Africa has set ambitious targets for renewables, although it is still highly depended on fossil fuels. The target for new capacity procurement by year 2030 in renewables is 14,4 GW wind, and 6GW PV (Olatayo, Wichers and Stoker, 2020).

2.4.4 Renewable Energy Policy Network

Renewable Energy Policy Network (REN21) is a universal communal of RE actors from science, academia, government, and non-governmental organisations. REN 21 gives current facts, figures, and peer reviewed analysis of global development in technology, politics, and markets to decision makers. Its mandate is to encourage decision makers to move towards the use of RE (REN21, 2017). Some of the products produced by REN 21 include the Renewable Global Status Report, Renewable Interactive Map, Renewable Academy, Regional Reports, Global Future Reports, and International Renewable Energy Conferences (REN21, 2017).

2.4.4.1 Renewable Global Status Report

An overview of countries with Renewable Energy Regulatory policies, 2011 to 2021, is shown in Figure 2.7. About 156 countries have power regulatory incentives or mandates, while 70 countries have transport regulatory incentives and 26 countries have heating and cooling incentives which assist towards use of clean energy (McCrone *et al.*, 2020)

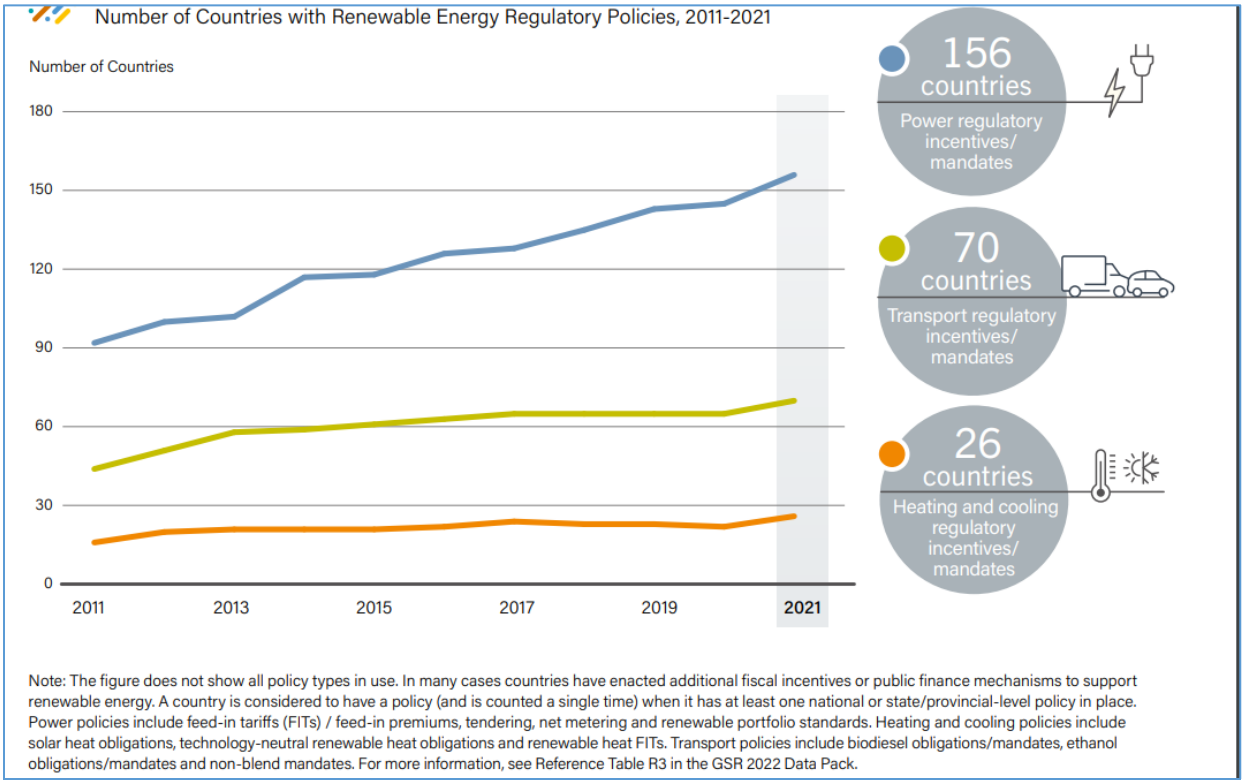

Figure 2.6. Countries with Renewable Energy Regulatory Policies,2011-2021

Source: REN21 Global Status Energy Report (2022:76)

2.4.4.2 African Union (AU) and Regional Economic Communities (RECs*)*

At the continental level, African Agenda 2063 provides a social-economic transformation strategy plan for the continent's socio-economic change, starting in 2013. This indeed has been the overarching pinnacle of the RE agenda spearheaded by the African Union. The African Agenda 2063 lays foundation on the execution of continental growth path initiatives. Among these has been the Lagos Plan of Action, the Abuja Treaty, the Millennium Integration Programme, the Regional Programme for Infrastructural Development in Africa (PIDA), and the Comprehensive Africa Agricultural Development Programme (CAADP). All of these added impetus to energy security although in some cases they did not explicitly speak to the transition to RE (African Union Commission, 2015).

One of Agenda 2063's aspirations are to have an inclusive, sustainable, and prosperous African continent based on inclusive growth and sustainable development. With RE designated as a priority area, its objective is to build ecologically sound and climate resilient economies and communities (AU, 2016). Initiatives include the African Renewable Energy Initiative (AREI), with the vision to have a large capacity of RE by 2020 for the whole continent. The African Union

Commission, the New Partnership for Africa’s Development (NEPAD) Agency, and African Group of Negotiators drive this initiative. The African Development Bank (AFDB), UNEP, and the IRENA are pushing the Agenda 2063 (African Union Commission, 2015).

The current policy for the RE landscape has also been shaped by regional economic groupings. Regional institutions such as the Southern African Development Countries (SADC), the Economic Community of West African States (ECOWAS), and the East African Community (ECAS) have formed policies such as the 2009 SADC Protocol on Energy (Nhamo and Ho, 2011). The SADC Protocol makes provision for the regional review of RE and energy efficiency developments, provides platforms for creation of policy landscapes, reviews market trends towards achievements in RE on and off-grid and the financing of these activities (Until and August, 2015). Projects done through regional integration for supply of RE energy include the Muela plant in Lesotho, the Cabora Bassa North in Mphanda Nkuwa in Mozambique, and a joint hydro power plant on the Batoka Gorge between Zambia and Zimbabwe. Even though the energy generated from the power plants above is still at minimal point, there is great potential (Klunne, 2013). ECOWAS, in partnership with the Energy Commission of Nigeria, has seen the successful distribution of a million compact florescent lamps (CFO) to replace the incandescent lamp and policy measures such as the National Renewable Energy and Energy Efficient (NREEEP) which set targets for enactment of all relevant legislation required for policy implementation by 2020 (Aliyu, Modu, and Tan, 2018).

2.5. Overview of the Energy Sector Policy Framework for South Africa

The Republic of South Africa's policy environment for RE has been extensively researched throughout the past 20 years (Nhamo, 2014; Kaggwa, Savious and Nhamo, 2013); Winkler, 2005; DME, 2003; Stafford and Facer, 2014). Some of the rules have been in place to control the amount of renewable electricity (for example, by establishing goals for RE) and to control pricing by regulating tariffs (Winkler, 2005). Among the key defining frameworks has been the 2003 white paper on RE, the industrial policy action plan (IPAP), the energy act of 2008, the National Integrated Energy Plan of 2008, and the Integrated Resource Plan (IRP) promulgated in 2011.

2.5.1. White Paper 2003

The white paper on RE goals (DME, 2003) was to guarantee that fair resources are allocated for the development of RE technology. The white paper, therefore, sought to drive the following:

- Investing in the use of RE technology with public funds.
- Setting up appropriate financial incentives for RE.
- Fostering an environment that will attract investment for the growth of the RE sector (DME, 2003).

The white paper has instruments which provide frameworks and support structures for the development and successful implementation of RE technologies. These include financial, legal, technology development, awareness raising, education and capacity building, market-based incentives, and regulatory instruments in a bid to raise awareness in RE. One of the key legislative instruments enacted by the government of the Republic of South Africa is the Energy Act of 2008.

2.5.2. Energy Act of 2008

The act focused its input on the diversification of energy to promote RE which fosters a low carbon future resource (Malhotra *et al.*, 2017). To ensure implementation of RE, strategic plans such as the National Integrated Energy Plan (IEP) have been developed. The IEP maps the actions to be taken by South Africa to meet its energy plans. These initiatives and plans have drawn traction with multinational organisations and increased foreign direct investment in renewables - a case in point being the World Bank and Africa Development Bank which have financed some of the successful RE projects in South Africa. These have been explained in Section 2.10. With the support of the Department of Energy, emerging innovative projects subsidised with an installed capacity of 23.9 Megawatt (MW) have been witnessed (DEA, 2013). These were managed by the Rural Energy Finance and Subsidy (REFSO), a government entity responsible for promoting and managing RE technology options. The South African government also promulgated the Integrated Resource Plan (IRP) 2010-2030 to drive the RE implementation.

2.5.3. Integrated Resource Plan 2019 (IRP)

The Integrated Resource Plan (IRP) was the backbone policy to the future of RE. The policy examined all possibilities for the types of electricity resources and technologies in which the country should invest in, in order to meet the national demand until 2030. The IRP 2010-2030 was gazetted on 21 March 2011. It called for the production of an additional 52.2GW, with the share of RE envisaged to rise to 9% (Scholtz et al., 2017). Ultimately, this saw the coming in of the Renewable Energy Independent Power Producers Programme (REIPPP).

2.5.4. Renewable Energy Independent Power Producers Programmes (REIPPP)

The Renewable Energy Independent Power Producers Programme (REIPPP) was established in 2011 with the vision to promote sustainable energy (Jain and Jain, 2017). The REIPPP paves way for Independent Power Producers (IPP) to operate large scale RE power plants across South Africa. REIPPP have managed to attract investors and brought in competition with impressive price reductions. A total of 64 New REIPPP were recorded successfully, with an investment of $14 billion and a successful 3922MW in wind and concentrated solar power connected to the grid (Eberhard, 2015). For the past 12 months, 9255GWh has been generated by RE (Power and Procurement, 2018). Figure 2.8 shows location of the 11 projects implemented in 4 of the 9 provinces of South Africa. In summary, Northern Cape has 5 projects, Eastern Cape 2 projects, Western Cape 2 projects, and KwaZulu-Natal 1.

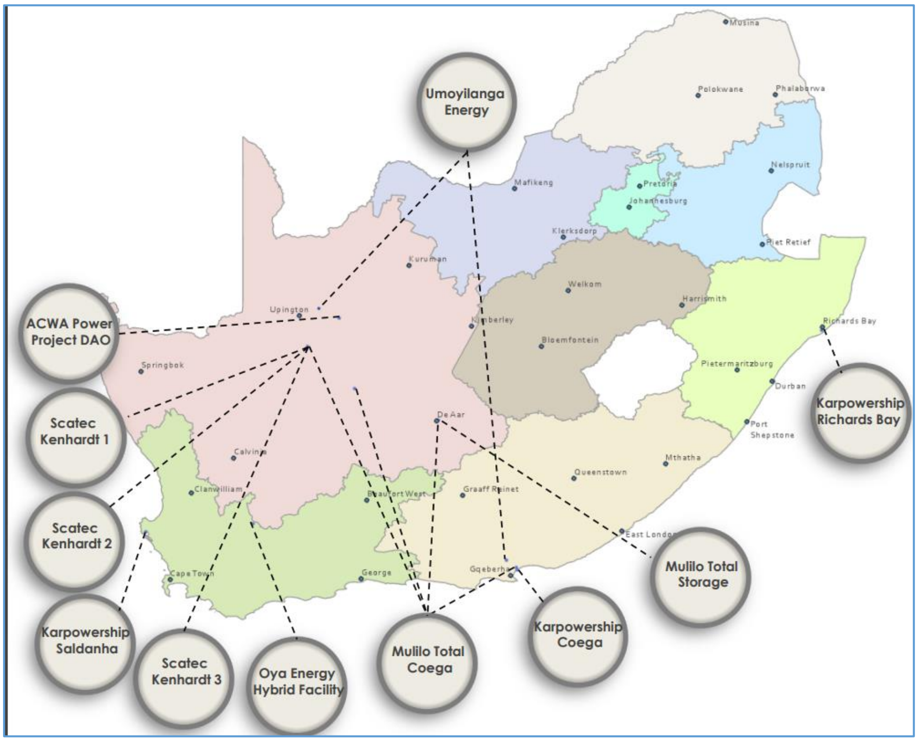

Figure 2.7. South Africa's REIPPP in 4 of the 9 provinces

Source: Independent Power Producer Procurement Programme (IPPPP), (2021:50)

2.5.5. Industrial Policy Action Plan 2018 (IPAP)

Within the broader framework of driving the green economy agenda which propels RE, the Industrial Policy Action Plan (IPAP) has been the driving pillar. IPAP has over the years promoted resource efficiency and diffusion of RE technology options. The policy drives the energy production capability, enhances production of high value-added productivity, and also enhances resource optimisation and efficiency (National Strategy for Sustainable Development (NSSD), 2009-2014)

2.5.6 The National Strategy for Sustainable Development (NSSD)

The NSSD was developed based on the founding principles of the World Summit on Sustainable Development held in Johannesburg in 2002 (Pearson Institute, 2012). There are many other initiatives championed by a myriad of sectors such as the business community, the civil society organisations, and the government - all with a common vision of addressing sustainability. This clearly shows the importance of sustainable development principles for the country. NSSD has been the strategic priority focus on the green economy which sought to propel transition towards a resource efficient, low carbon, and pro-employment growth path (Nhamo, 2013). The important players whose actions influence the adoption of RE in South Africa are listed in Table 2.1

Table 2 1: Role players of energy

Role Player	Mandate
Department of Mineral and Energy (DME)	It is responsible for policy drafting and planning for the energy sector. It pays attention to energy security through expanding the country's energy mix to include RE sources (DME, 2003).
National Energy Regulator of South Africa (NERSA)	It is responsible for licensing and regulation of energy infrastructure (DME, 2003).
National Treasury	It administers the fiscal and procurement policies.
Department of Trade and Industry (DTI)	The department cultivates local industries and trade, with interests in green industries and job creation in a bid to attract foreign investment.
Department of Public Enterprise (DPE)	Shareholder representative of the government with oversight responsibility for energy and resource in organisations such as Eskom.
Department of Economic Development	It sets and establishes economic policy, economic planning, and economic development - focuses on employment creation and the green economy.
Department of Environmental Affairs (DEA)	Promotes environmental management through National Environment Management Act (NEMA).

Provincial departments and municipalities	Regulates and provides an enabling environment for propagation of RE.
Eskom	In addition to redistributor, it generates, transmits, and distributes power to industrial, mining, commercial, agricultural, and residential users in all phases of the electrical supply chain.

2.6. Renewable Energy Potential in South Africa

Renewable Energy is energy that comes from an infinite source, in contrast to fossil fuel which comes from a finite source (Scholtz, Louise;Muluadzi, Khodhani;Kritzinger, Karin;Mabaso, Mbali;Forder, 2017). RE sources include solar energy, wind energy, hydro energy, and geothermal energy. Geographically, South Africa is endowed with a variety of RE potential sources, among which is solar energy and wind energy, biomass, small hydros, and waste energy. Some municipalities in South Africa are on a drive for 100% renewable electricity. eThekwini in 2021 passed its transition policy with targets of 40% electricity from low carbon technologies by 2030 and 100% by 2050. To implement this vision, the city launched a tender to procure 400MW of additional electricity supply from IPP in South Africa. This was a ground breaking decision granted to municipalities to procure new generation capacity from private producers (REN21, 2022).

2.6.1. South Africa’s Wind Energy Potential

According to research conducted by the Council for Scientific and Industrial Research (CSIR), South Africa can provide land which is able to produce 6700GW of power through wind. Figure 2.9 below represents the technical theoretical potential for wind power in the southern parts of the country.

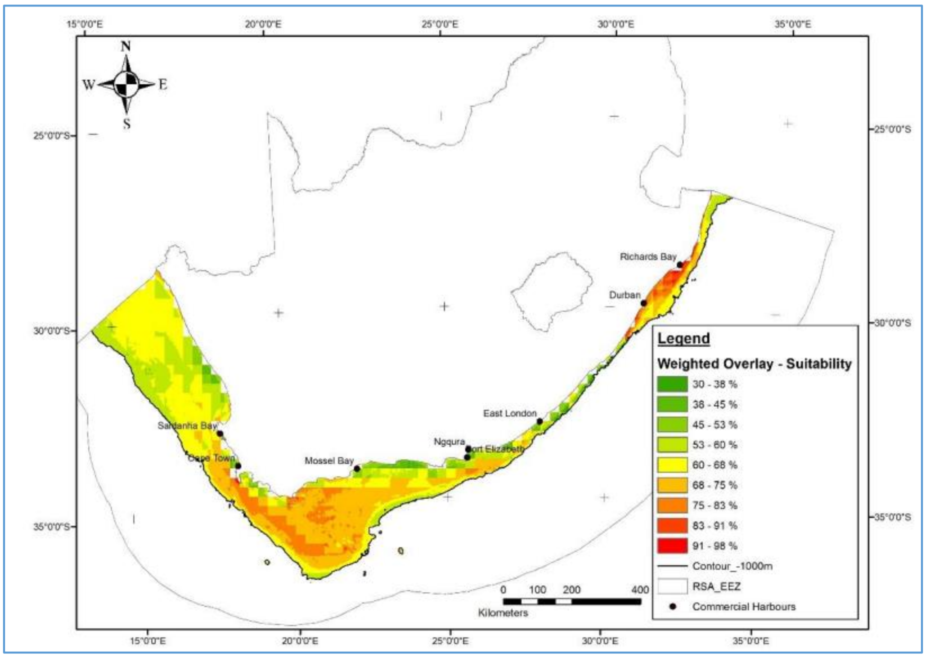

Figure 2.8. Southern parts of South Africa's wind potential

Source: Rae and Erfort (2020:39)

2.6.2. Solar Energy

South Africa also enjoys abundant sunshine which provides a good case for solar energy. South Africa's daily solar radiation stands between 4.5 and 6.5kWh/m²/day, which is fairly high compared to Europe and the United Kingdom which get 3.6kWh/m²/day and 2.5kWh/m²/day, respectively (Scholtz *et al* ., 2017).

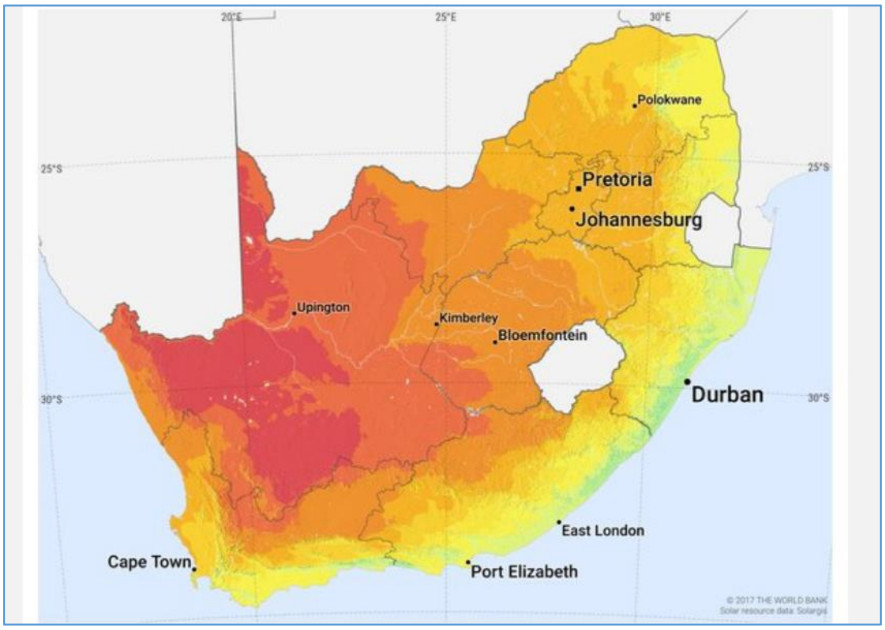

Figure 2.9. Direct Normal Irradiation of Republic of South Africa

Source: Solargis (2022)

2.6.3. Scaled down Hydro.

Scaled down Hydropower is technology drawn from water sources such as rivers and dams. In South Africa, this technology is being practised on a small scale with success stories hailing from projects such as the Friedenheim Hydro Plant on the Krokodil River in Nelspruit. It is privately owned and equipped with 1MW Francis turbines. Power produced there is used by the Friedeheim Irrigation Board; 93% of the other power is sold through the IPP to the Nelspruit district (Klunne, 2013). Other hydro energy generation potential from the inactive small scale such as Belvedere with potential for 2.1MW, Ceres (1MW), Hartbeespoort (5.7MW), and Teebus (7MW) (Klunne, 2012) hydro development. South Africa has an installed a capacity of 38MW from this technology (Klunne, 2013). Eskom even though it runs coal power stations also operates the following hydro-power stations: Colley Wobbles (42MW), Gariep (360MW), Second Falls (11MW), Vanderkloof stations (240MW), First Falls (11MW) (6MW), and Ncora (1.6MW).

2.6.4. Bioenergy

Bioenergy is produced from organic matter known as biomass. In South Africa, the primary energy is from solid biofuels (Pelkams, 2018) as shown in Figure 2.11.

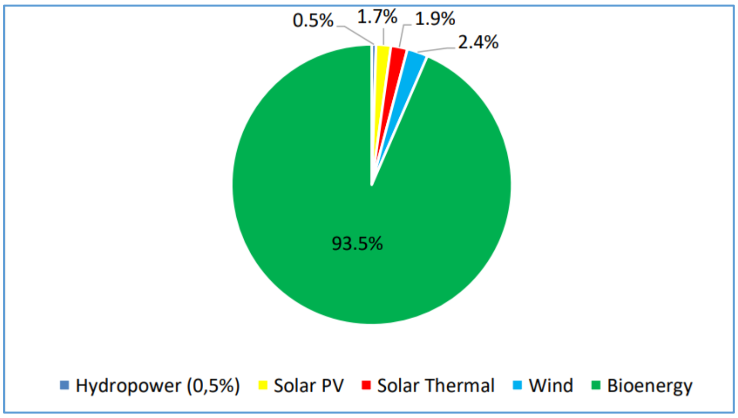

Figure 2.10. Total primary energy supply from bioenergy in South Africa in 2018

Source: Lundqvist (2020:36)

Projects on bio energy include the Wing feasibility project which started in January 2018 and saw it receiving financial support of 1.2 million pound from the European Union Switch Africa Green Programme. The project targets 25 SMMEs to make a contribution to the supply chain of an energy company (Pelkams, 2018). Other stakeholders such as the Biomass Action Plan for Electricity Production's (BAPEPSA) focus is to identify, promote, and facilitate the utilisation of biomass in South Africa.

2.7. Reflections on Renewable Energy Transition

Just like many other emerging economies, despite all the promising policy initiatives the deployment and diffusion of RE technology has remained very low or minimum in South Africa. Winkler (2013) notes that RE contributes far less than the anticipated off-grid targets. Essentially, while the white paper targeted 10000GwH by 2013, the progress has been very slow (Nel, 2015).

It is against this background that this study seeks to interrogate and de-risk investment in RE to propel the low carbon trajectory, together with meeting the dire demands of climate change.

When compared to the use of fossil fuels, switching to RE is expensive due to its high capital expenditure. Lebanon conducted a study on de-risking renewable energy investment. The study identified three policy instruments, namely; policy de-risking, financial de-risking, and direct financial incentives in a bid to minimise risk associated with investing in RE (UNDP, 2017). The study's findings led to the conclusion that investing in risk-reduction strategies is a practical way to improve wind and solar energy. Considering Lebanon is a moderately developed country, which relies on importation of fossil fuels could the same be applied within the South African context grappling with a huge inequality gap and endowed with huge fossil fuel deposits?
Other studies showing the promotion of RE include a study conducted in China. China started by endorsing the RE Law of the People's Republic of China (Wang and Li, 2013). The aim of the law is to encourage the use of RE, considering China's heavy reliance on fossil fuels (Wang and Li, 2013). The RE Law built the first national framework which is centred on national adequate generation, equitable distribution, and cost effective access mechanism, guided with sound policies (Wang and Li, 2013). The implementation of this law saw the significant growth of wind capacity. Further to its vision of RE, China made a commitment to a certain 2020 climate and clean energy goal (Wang and Li, 2013). The aim was to get 15% of all its energy from non-fossil energy. Some of the incentives that were made available were the on-grid electricity price for RE, to which a feed-in tariff system was put in place. Other incentives included a cost sharing mechanism as well as the RE development special fund which paved way for research and development, and piloting of projects (Wang and Li, 2013). China has promoted research and development focusing on the role of subsidies, fiscal and tax rebates, market development, grid connection and favourable tariffs incentives in promoting alternative energy options such as wind energy projects (Abdul *et al.*, 2021).In India, strategies used to promote investments in the renewable sector include provision of open, transparent, reliable conditions for foreign and domestic firms such as flexible labour markets and safeguard of intellectual property (Abhishek

and Kumar, 2017; Qadir *et al*., 2021). China, India and South Africa are all within the BRICS block of nations. Could similar patterns of de-risking in China be ascertained for South Africa? This study thus explores the extent to which similar trends and patterns can be ascertained within the South African context given its policy environment.

Other studies which show that a de-risking approach results in drive towards carbon use include the study by (Carafa, Frisari and Vidican, 2016) The authors realised that huge capital costs and investment risks act as a huge impediment to investment in low carbon infrastructure in the Middle East and North Africa. In order to promote investment, a research was conducted which involved a mixed methods approach involving both qualitative and quantitative methods; and the conclusion was reached that de-risking policy pays off as it gives favourable return on investment to financial investors (Carafa, Frisari and Vidican, 2016). The de-risking at project level shows that lowering of financial costs comes as a result of concessional finance provided by multi lenders, while policy de-risking lowered required return from private investments as well as competition driven from policy implementation (Carafa, Frisari and Vidican, 2016). In this study we sought to scan the conditions offered by lenders to RE investors and explore the pursuit of such if any have facilitated the diffusion of RE technologies.

Steckel and Jakob (2018) mentioned that de-risking financial investment transfers risks from private investors to the public sector. Mechanisms identified that transfer risk include provision of subsidies which has an effect of lowering interest rates on the borrower. Availability of public loans at preferential rates also attracts investments. This was successful in the case of the India solar program which had interest rate available at 5% lower than the normal market rate of 12% (Steckel and Jakob, 2018). The study did not articulate the barometer used to measure success. In this study we focus on the conditions offered by lenders if they filter to the end users by examining the user's perception.

Other mechanisms which de-risk financial investments include green bonds. China made available Green Bond Directives and a Green Bond Catalogue for RE investment which accounted for 10% of available loans in the market. China became one of the worldwide green bond markets with the quickest growth because to this policy (Steckel and Jakob, 2018). At international level, the Green Finance Study group is pursing the success of de-risking investment towards low carbon investment. Green bonds have been criticised particularly in under-developed financial markets with appropriate rating markets.

The European case is yet another striking example which demonstrates policy role in driving the RE agenda. Policies such as the feed-in tariffs, quotas, tenders, and tax incentives across EU countries and US states have promoted the use of RE. A study done in these countries showed that investors favour long term policies that guarantee return on investments in support for RE policy (Kilinc-Ata, 2016). Generous tariffs implemented by RE producers led to rapid development of the technology, and extremely high profits to RE. In 2015, 20 out of 68 countries implemented the Fit Scheme (Pyrgou, Kylili and Fokaides, 2016). The utility of tariffs within the first world countries could it have a similar effect on emerging countries such as South Africa? This study thus identified existing tariffs in South Africa.

2.8 Just Energy Transition Efforts in South Africa

In 2022, President Cyril Ramaphosa of South Africa established a commission to aid in the transition to low-carbon consumption and the use of clean energy from renewable sources. Financing this objective will require $250 Billion (PCC, 2022). Effort to move away from high carbon use has been evidenced by the conversion of the old coal power plant Komati Power Station which winded up its operations on 31 October 2022. Komati Power Station is set to power 220MW of solar and 70MW of wind. This was made possible by financing from the World Bank to the tune of $497 million (World Bank Group, 2022). Provision of such finances is a powerful way to move towards low carbon use in South Africa.

Risks still threatening the smooth just energy transition include: taking time to make decisions that solve disagreements, poor policies that do not promote RE investments and result in the country losing out in competition to manufacture technologies, and heavy reliance in fossil based fuel which results in increased export tariffs like the EU'S Carbon Border Adjustments Mechanism (CBAM) (PCC, 2022). The biggest project under the just energy transition is the Redstone Concentrated Solar Thermal Power (CSP) with a generation capacity of 100MW. The project was awarded under the REIPPPP to a consortium of Solar Reserve and ACWA (Businesswire, 2022).

2.9 Factors Determining Investment in Renewables

2.9.1 Game Theory

A game of strategy is any circumstance where participants make strategic decisions and outcomes depend on what each participant does (Maskin, 2016). Power system issues like loss allocation, optimal resource allocation in networks, allocation of transmission expansion costs, energy management frameworks for smart grids, system reliability performance, management and control of distributed systems, and scheduling of renewable energy sources have all been examined using cooperative game theory. Other applications of cooperative game theory include end-user coordination, control of micro-grid distribution networks in hybrid solar and wind systems, and the integration of renewable resources, particularly the aggregation of wind resources and profit sharing (María *et al.*, 2020). Utilizing cooperative games, regulations and incentives for distributed generation and micro-grids have also been investigated.

2.9.2 Project Finance

Projects can fail if risk management is deemed not to be strong (Geddes, Schmidt and Steffen, 2018). This has no relationship with presence or absence of finance. Project finance is preferred compared to corporate finance; this has seen a growth in offshore wind finance in Germany. New projects attract greater risks as compared to existing projects. This poses a threat to entrants to renewable technology investment compared to fossil-based projects which have existed for a long time(Geddes, Schmidt and Steffen, 2018). Financing projects through corporate finance basing on the balance sheet is a deterrent because if the balance sheet is heavily geared with debt, new projects may not be taken in(Cárdenas Rodríguez *et al.*, 2015)). German has successfully invested in renewable technologies using project finances, having managed to complete wind onshore (88%) and solar PV (96%) projects (Geddes, Schmidt and Steffen, 2018).

2.9.3 Social Acceptance

Public awareness on benefits of RE investment poses a risk in determining RE investments. In Kenya 0.4%, even though significantly low, was a determining factor in the locals to invest in renewable energy (Malhotra *et al.*, 2017). The Fukushima nuclear accident that occurred in 2011 has had a great influence on social acceptance of not only nuclear energy but RE adoption (Lucas *et al.*, 2021). In South Korea before the tragic Fukushima accident, Park and Ohm (2016) conducted a study on the main reasons behind use of renewable technologies; however, after the tragic accident it was noted that perceptions became notable determinants towards desire to adopt the technologies (Park and Ohm, 2014). Trust in developers of RE investments and sufficient knowledge shared will boost people’s confidence. This includes involving community members in deciding where the windmill or solar panels, as an example, will be put (Segreto *et al.*, 2020). Equal justice from the project may decide if a RE investment will be accepted in the community. If community members see the project bringing in employment opportunities, then they are likely to welcome the investment (Segreto *et al.*, 2020).

2.9.4 Demography

According to Kusumawati (2013), important investment decisions are related to demographic factors such as age, education, and income. This is supported by a study in Medan City, North Sumatra, Indonesia, which showed that the higher the level of education, the more investment decisions are made. Return on investment is a key factor by high income earners in making investment decisions (Fachrudin, 2016).

2.10 De-risking instruments for emerging economies

2.10.1 Broadening the understanding of Renewable Energy De-Risking Instruments

1) Risk is described as 'future uncertainty about divergence from expected earnings or expected outcome' by the Economics Times. It gauges the level of risk that an investor is prepared to take in exchange for a potential return on their investment. Risk can be divided into three categories: financial, business, and no business.

   Business Risk

   Business risk is inherited by the business institutions to make profits. For example, the company can roll out a massive marketing campaign to have its brand recognised and in turn capture a large market share which in turn increase returns.

   Non-Business Risk

   These risks are affected by exogenous factors beyond the control of the business. Such factors can be emanating from political and economic forces.

   Financial Risk

   Risks due to market movements which are further classified into: market risks, credit risks, liquidity risks, operational risks, and legal risks.

2.10.2 Type of Risks

The following have been identified as Financial Risks: market risks, credit risks, and liquidity risks.

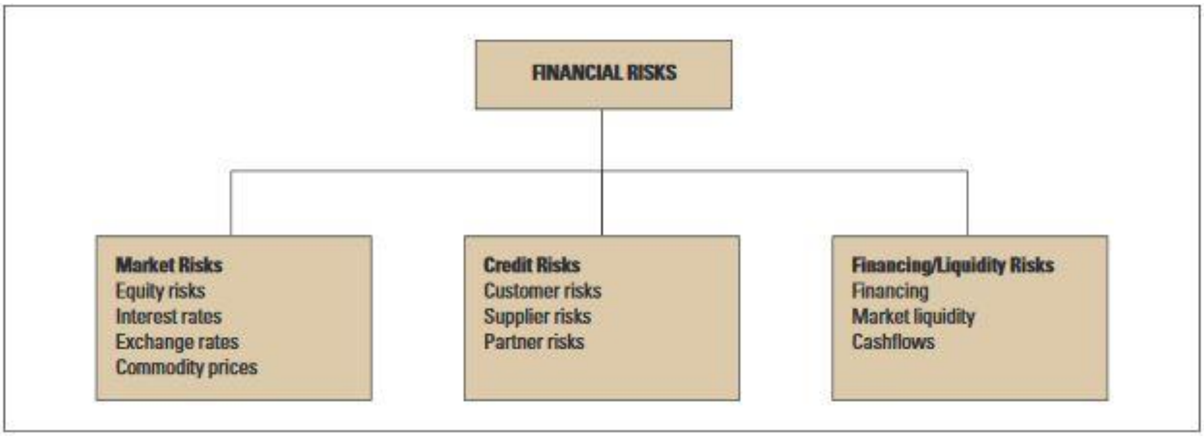

Figure 2.11. Risks Types.

Source: Woods and Dowd (2008)

- *Market Risk*

Uncertainties affecting overall performance of financial markets from forces like recessions, natural disasters, political instabilities, changes in interests' rates, and terrorist attacks. They can be broken down to absolute risk, relative risk, basis risk, and volatility risk (Woods and Dowd, 2008).

- *Credit Risk*

Losses due to failure by borrower to meet debt contractual obligations. Such losses could be sovereign risk, where a nation fails to meet its debt repayments, or settlement risk. Settlement risk could also be experienced when one party fails to owner the terms of credit by the end of contract due to default in between (Woods and Dowd, 2008).

- *Liquidity Risk*

  Ability of firms to fund their liabilities, which is funding liquidity and measured by current ratio.

2.11 **De-risking**

De-risking is absorbing risks that other financiers are unable or unwilling to carry (African Development Bank, 2017). De-risking is described as 'the phenomena of financial institutions terminating or reducing business connections with clients or groups of clients to avoid, rather than manage, risk' by the Financial ACTION Task Force (FATF). Derisking act as a powerful policy tool that will interest both domestic and international investors in attracting investments in RE (Ouedraogo, 2019).Some of the chosen main de-risking tools are described in the section that follows.

2.11.1 Partial Risk Guarantee

Partial Risk Guarantee (PRG) is a risk mitigation instrument that hedges the private lenders against risk of a government's failure to fulfil contractual obligations in line with a private project. PRG gives guarantee to pay back the loan in case the government failed to honour its payment obligation (Gatzert and Kosub, 2016). This is offered by the World Bank; it includes projects that involve government decisions such as build-operate-transfer, and risks that are covered include changes in law, lack of following contractual payments, expropriation, and nationalisation. The African Development Bank president, Dr Adesina, in his meeting with Minister of Energy, Gwede Mantashe, on 25 March 2022 cited the importance of financial support in the journey to energy transition. He encouraged South Africa to leverage on the available energy transition grant of $8.5 billion.

Advantages of PRG include better risk sharing. The PRG connected the Ugandan government directly with the funder in form of an indemnity agreement. These favourable conditions saw a significant reduction of cost of production to 105-110 million USD/MWH, which is half the average cost of 260 USD million/MWH (Frisari and Micale, 2015). In the Philippines, the Leyte-Luzon geothermal power plant was financed through 15-year bonds issued on international markets. They managed to raise $100 million. The risk was minimised by the condition that the bond owners have an option to sell their bonds to the World Bank on maturity, in return for repayment of the principal loan (The World Bank and Climate Investment Funds, 2013).

2.11.2 Political Risk Guarantee

Political Risk Insurance (PRI) is insurance taken against political conditions which may result in a loss as a result of political instabilities like wars and violence that may result in financial losses of investments made in a country (Frisari and Micale, 2015). This instrument has given investors who have invested in mega projects assurance. The project in Uganda is no exception as it saw investors successfully implementing the hydro power project as it offered a breach of contract coverage for 90% of the equity investments made to the value of $120 million and maturity of 20 years (Frisari and Micale, 2015). In Lao, a country in Asia neighbouring to Thailand, the Nan Theun 2 Power Project which is worth $1.25 billion was financed through debt and equity financing. The World Bank mitigated the risk by providing $42 million, a debt guarantee of $91 million, and gave an additional $150 million equity guarantee (The World Bank and Climate Investment Funds, 2013). Political Risk Insurance yielded positive results in the case of the Indonesian Ministry of Finance who provided a guarantee letter for power-off taker.

2.11.3 Feed-in Tariff

Feed-in tariff (FiT) is one of the instruments promoting investments in RE. It allows power producers to sell RE electricity at a gazetted price for a given period (Pyrgou, Kylili and Fokaides, 2016). The FiTs are extensively used globally, with over 80 countries having used them by year 2016 (Polzin *et al.*, 2019) among them Tanzania, Kenya, Ghana, and Algeria. For the FiT to be attractive to the investor, it must cover the cost of technology and ensure return on investment. Some of the criteria for FiT include inflation indexing of the tariff. The tariff is provided for a number of years sufficient to recover the cost incurred, and access to the transmission grid is essential (MEYER-Renschhausen, 2013). The FiT saw the successful generation of wind power in Denmark, with a 20% consumption of energy coming from wind power. The success of the wind power was because it was given an important role in the official Danish electricity plans (Haas *et al.*, 2004).

2.11.4 Tax Incentive

The Tax Incentive on RE projects are another instrument which de-risks investment in RE as it minimises costs by rewarding companies which invest in renewable energy. It acts as an incentive to those investors who get involved in the RE projects. For example, in South Africa, the South African Revenue Services (SARS) under Section 12b of the Income Tax has seen the depreciation allowance on RE increased to 1.00. Its main aim is to promote and incentivise the development of solar power at lower costs (SARS, 2017). Germany's implementation of carbon tax saw RE projects increasing. The United Kingdom has become a leading country to see strict and ambitious carbon reduction targets to 80%. The Carbon Price Floor (CPL) implemented in the United Kingdom is applicable to the fossil fuel based projects and hence poses an advantage to renewable generators who are exempted from the CPL tax (Morisset, 2014). In the United States, a production tax credit (PTC) is applicable to RE projects with USD cents of 2.3/kwh exempted on wind, biomass, and geothermal projects; while USD cent 1.1/kwh is for the rest of other renewable projects (Morisset, 2014).

2.11.5 Equity Tax

Equity is capital contribution by sponsors who do not expect any repayment but instead want ownership of the project (Lindenberg, 2014). It shares risk with the other investors as it assures full commitment. It has its own disadvantages, for example shareholders are last to be remunerated in the project. Different types of equity such as Venture Capital Fund, Private Equity Fund, and Infrastructure Funds are available (Lindenberg, 2014). For example, venture capital funds focus on projects that are in their infant stage. Capital is raised from insurance, pension funds, mutual funds, and high net individuals. Projects that are in their infant stages are considered high risk and, hence, their expected return on investment is 50% (Justice, 2009). Private Equity Funds focus on projects which have more mature technologies. Investment using Private Equity Funds is focusing on medium risk, and capital is raised from institutional investors, and high net individuals. Return on Investment is approximately 25% (Justice, 2009). Funds can be raised through Infrastructure Funds which is a medium investment of 7-10 years with a return on investment of 15% (Justice, 2009).

At international level, multilateral and bilateral banks pay a pivotal role in developing countries by making available financial and technical assistance in investments. The Development Finance Institutions (DFI) are a catalyst to the provision of huge amounts of capital on the international market (Sweerts, Longa and van der Zwaan, 2019). A fund such as the UNFCCC Green Climate Fund (GCF) had a budget of $100 billion to be used by year 2020 in investments on RE in a bid to reach the 2 degrees target of the Paris Agreement (Wuester, Jungmin Lee and Lumijarvi, 2016).

2.11.6 Resource Insurance

RI is an instrument which gives assurance to investors on the technology invested and the loss of revenue due to unexpected changes in weather patterns in cases of wind or sun energy as well as insurance against failed exploratory wells (The World Bank and Climate Investment Funds, 2013). Geothermal projects in Europe and Central Asia have made use of the resource insurance. This provided $8 million on direct investment and $7 million on technical assistance, and last but not least $10 million for geological risk insurance.

2.11.7 Small Scale Project Financing

These are investment instruments which encourage small-scale RE projects which supply energy off the main grid. The main aim of the instruments is to bring affordability to low-income persons wishing to invest in RE. The UNEP solar loan program in India’s states of Karnataka and Kerala have provided this facility. Instruments used include loan subsidy in the form of an interest rate subsidy for the borrower which is facilitated by local banks. For example, if the current interest rate is 12%, UNEP will subsidise half of it and the borrower only pays 6% upon successful repayment of the full loan. Since its inception the programme successfully issued 19 500 loans through 2 076 banks (The World Bank and Climate Investment Funds, 2013).

Benefits of project financing in reduction of total financing for project is shown by Agrawal (2012) in his study for REProject Financing. He highlighted several benefits which include reduction in agency costs. Agency costs could result because of opportunistic behaviour such as critical supply of inputs whose prices can skyrocket. The Project Finance will do away with the risk by facilitating a joint ownership and long-term contracts with the suppliers.

2.11.8 Levelized Cost of Electricity

Levelized Cost of Electricity (LCOE) is a model used to compare the cost of energy on projects that have minimised risks associated with investing in energy, versus those projects that have not considered the cost of investment (Schinko and Komendantova, 2016). To compare the cost structures and economic competitiveness of various energy production systems, investors utilize the energy cost metric as a tool for investment decision-making (U.S. Energy Information Administration, 2022). In the LCOE calculation, according to Visser and Held (Visser, Held, 2014) the following parameters are included as the minimum: capital costs, fixed operation and management costs, variable operations, and management costs and fuel costs.

By dividing the discounted monetary values of the initial investment and accumulated annual variable costs by the discounted monetary value of electricity sales over the course of the entire project lifetime, the net present value of electricity generation from any particular technology is determined (Schinko and Komendantova, 2016). The model can be applied in both RE projects and non-RE projects. The model has been applied in a study which was done in four North African countries, namely: Morocco, Egypt, Tunisia, and Algeria. The above countries have favourable geographical conditions for solar production than European countries. It was noted that if financing conditions could be the same as European countries the LCOE could be reduced from 0.236 USD/kWh to 0.145 USD/kWh, or by 39% (Schinko and Komendantova, 2016).

2.12. Relevant Authorities, Regulations Policies, Instruments, and Government role players

Table 2 gives a summary of relevant authorities, regulations, policies, instruments and government role players in South Africa addressing RE. This helps to clearly highlight policies and government efforts in place to address investment in RE.

Table 2.2. Relevant Authorities, Regulation Policies, Instruments and Government role players

Lead Authority	Relevant Focus
South Africa Constitution Act 108 of 1996	It makes provision of the law of protection of Human Rights such as access to energy.
National Planning Commission	Responsible for national planning, national priorities, and directing the course of national development.
National Development Plan (NDP)	Through the National Planning Commission NDP supports the call for energy security. Sets targets for energy generation for example old coal power stations like Kamoti power station that will contribute 150W Solar, 70W wind, and 150W storage batteries.
Department of Energy	as explained in table 2.1.
National Energy Act (Act No. 34 of 2008)	The entire planning for energy sector, sufficient generation capacity, price affordability, and consumption of RE is governed by the act.
Electricity Regulation Act (Act No. 4 of 2006), Second Amendment (2011)	The Act provides ministerial authority to grant approval of generation capacity i.e. provide an enabling environment for IPPs.
Amendment to the Electricity Regulations on new generation capacity (18 August 2015)	The amendment provides an extended definition of new generation facilities to include existing generation facilities not previously supplying electricity to the national grid and/or an extension or renewal of existing supply agreements from existing generation facilities for an additional period.
Biofuels Industrial Strategy, 2007	Propels bio-fuels sector in the energy space through provision of subsidies to prospective investors in the sector.
Biofuels Mandatory Blending Regulations, 2012	Propagates mandatory blends of bio-fuel with petrol and diesel as at 1 October 2015.
Petroleum Products Amendment Act (Act No. 58 of 2004	Authorises Minister to license petro-chemical wholesalers and producers to sell blended products from the bio-fuels sector.
National Energy Regulator of South Africa (NERSA)	Refer to Table 2.1.
Department of Environmental Affairs (DEA)	Refer to Table 2.1.
Environmental Impact Assessment (EIA) 2010, under the National Environmental Management Act (NEMA) (Act 107 of 1998) and amendment Act (Act 62 of 2008)	These are required for consideration for RE Projects for example 10MW require >1ha,>33kv transmission power, water management, biodiversity authorisation, land-use planning.

National Environmental Management: Air Quality Act 39 of 2004 Draft National Greenhouse Gas Emission Reporting Regulations ("the Draft GHG Regulations")	Carbon tax propels low carbon, GHG regulated, emissions levels and reporting. The current revised amendment reporting regulation is of 2016.
New Growth Path (NGP), Economic Development Department (EDD, 2011)	The NGP is Government's 'framework for economic policy and the driver of the country's jobs strategy'. Job creation is prioritised by outlining strategies to enable South Africa to develop in an equitable and inclusive manner. The NGP targets 5 million new jobs by 2020. It also aims for '300,000 additional direct jobs by 2020 to green the economy, with 80,000 in manufacturing and the rest in construction, operations and maintenance of new environmentally friendly infrastructure'.
Local Procurement Accord	Government, led by the EDD, and social partners signed a Local Procurement Accord on 31 October 2011, as an outcome of social dialogue on the New Growth Path. The accord was negotiated through the National Economic Development and Labour Council (NEDLAC) structures alongside the Green Economy Accord, showing the implicit and explicit aim that the Green Economy Accord and the resultant Green Economy should strengthen localisation efforts. The anticipation at the time was not that RE would be cheaper, but that it was worthwhile pursuing given the broader economic benefits that were available.
National Skills Accord (residing with the Department of Higher Education and Training, but a sister accord to the above)	The purpose of this Accord is to join the private sector, organised labour, communities and government in a strong partnership to expand skills in the country as a platform for creating five million new jobs by 2020. The Economic developments elements of the REIPPPP are examples of how the Accord is permeating successfully into REprocurement in the country.
Department of Trade and Industry (the dti)	Development of local industries and trade with particular focus on green industries and job creation; attracting foreign investment.
Industrial Policy Action Plan (IPAP) 6, Department of Trade and Industry (2014)	The DTI plays a critical role in supporting the local manufacturing base, which includes renewable technology development and deployment. The IPAP is an annually updated, three-year rolling plan for industrial policy implementation; since 2011 it has specifically identified the energy sector (Solar and Wind energy; solar water heating and energy efficiency) as a priority for the country's industrial policy.
National Treasury (NT)	Governing fiscal and procurement policies and incentives, inclusive of the mooted carbon tax.
Department of Water and Sanitation	Ensuring sustainable water use for present and future generations across the economy, including energy.

The National Water Act 36 of 1998 and its amendments, Act 45 of 1999 and Act 27 of 2014. Of the extensive regulations, GN R.1560 of 25 July 1986 and GN R 139 of 24 February 2012 might affect hydro power, GN R267 of 24 March 2017 might affect solar thermal power generation, while GN R810 could apply to both hydro and solar thermal power plants	Main act is to meet basic human water needs for all generations. It also regulates water use for energy development needs.

Source: State of Renewable Energy in South Africa Appendices A page 186-189

2.13. Effective ways of de-risking renewable energy

A benchmark exercise was conducted against developed nations with a focus on a multilateral guaranteed mechanism(Abhishek and Kumar, 2017). It has been established that a guaranteed system for payments for RE can lower the price of decarbonization in the electrical sector. The researchers employed two different categories of bidders, one of which was categorized as naive and established their valuation using net present cost (NPC), and the other of which decided their valuation using (Real) option-based cost (OBC). A risk neutral approach was used to determine project valuations for both bidders and the bidder with the real option-based cost (OBC) has minimal cost since they had access to the multilateral guarantee system. Below is a summary of effective ways of de-risking RE: Invest more in research and development, explore efficient waste management, increase subsidies for investors, government to step up on fines for pollution emissions by industries and create favourable environment in the energy?

2.14 Conclusion

Through a critical review of policy drivers at international, continental, and national level, this chapter identified factors relating to the drive of use of RE. As expected, the literature brings out the factors related to increases in RE production cross-nationally. Reducing risks in RE investments was sighted as a key factor towards low carbon use (Frondel *et al.*, 2010). This was confirmed by best practices, legislations, and mechanism policies (Abdmouleh, Alammari and Gastli, 2015). Lack of funding in most developed countries hampers the development of RE investment. Inconsistent policies and an environment that does not support investments derails such initiatives.

The UNFCCC and the Kyoto Protocol's existence has had a positive impact at national level. This is seen by countries participating at the conventions and making commitments towards the drive to mitigate climate change through initiatives of commitment in RE investments. Furthermore, participation at such international treaties draw interest in change in behaviour at domestic level. Though such international treaties have been signed, not a significant reduction in investments of carbon energy has been noted in countries who signed such treaties. Lack of continuous research and development programmes in educating on the benefits of renewables have hampered eagerness to invest (IRENA, 2020).

In conclusion the chapter gave an overview of RE, citing policy drivers at international, continental, and local levels. Notably it can be concluded that RE investments have increased in some parts of the world, while it has been in decline in some regions notably in Africa. Some European countries have successfully moved from a high carbon intensive to low carbon use adopting RE as a source of clean energy. South Africa has shown a commitment to drive towards RE - setting up policies that support clean energy. Geographical locations in parts of the country have been seen as a bonus to implementing RE technology. To achieve use of clean energy, creating a conducive environment that supports investment in renewable technology is key; and high investment costs were sighted as a hindering factor. Institutions that support the implementation of renewables were identified. Effort was made to highlight the RE technology potential in South Africa. Reflections on the RE transition with lessons learnt from other countries were made. The following chapter, which is on methodology, will give a detailed outline on how the research was conducted to fulfil the research objectives.

CHAPTER 1: INTRODUCTION

1.1 Background of Study

The current global energy crisis is not sparing any country. The combination of covid pandemic and the energy crisis has seen a pandemonium of 70 million people who had access to electricity now losing it due to affordability. In addition an estimated 100 million have opted to unclean fuels for cooking, resulting in a major setback of returning to unhealthy and unsafe alternatives use of energy (International Energy Agency , 2022).

The situation is dire on the African continent where more than 600 million people, or nearly twice the. population of the US, do not have access to electricity (Foundation, 2019). Africa's energy systems have been characterised by failure of utility companies to meet the energy demand, resulting in frequent blackouts (International Energy Agency, 2022) and increased rationing of the available energy (Lawrence, 2020). Africa, though rich in natural resources which could promote effective energy mix, remains the largest continent with a high-energy deficit (Sy and Copley, 2017). A number of factors have been noted, which include the high levels of poverty on the continent (Adenle, 2020). This is central to both the access and affordability of energy forms. Additional challenges include financial factors, technological factors, the skills gap (Campiglio *et al.*, 2018), corruption, and policy misalignment (Chirambo, 2018).. The convergent crises are affecting various facets of Africa's energy systems, including reversing positive trends that have been increasing access to contemporary energy (IRENA, 2020). In an era of accelerating change, the imperative to limit climate change and achieve sustainable growth is strengthening the momentum of the global energy transformation (Agency, 2018). Promotion of renewable energy (RE) has become a key ingredient to ensure energy security. The entire globe shares a common vision for sustainable energy use as reported by independent researchers (Kurbatova, T. and Perederii, T., 2020). The global call of Sustainable Development Goal Number 7 on clean energy has activated a sense of urgency among policy makers, industries, and development practitioners to find suitable and viable options of alternative energy sources (Chirambo, 2018). RE can also contribute towards the goal of ensuring healthy lives by reducing indoor air pollution (Mazzucato and Semieniuk, 2018). RE can unlock potential benefits such as "socio-economic and environmental benefits of renewable resources as a means for meeting increasing energy demand in a sustainable way" (Sweerts, Longa and van der Zwaan, 2019, p. 1). Low carbon sources in turn contribute towards achieving clean energy, which is one of the sustainable development goals.

Simultaneously, the study anchors the continental aspirations and initiatives that feed into the New Energy and Environmental Partnership (EEP) (Megan Van Wyngaardt, 2018).

1.2 Transition to Renewable Energy

In Africa, there will inevitably be a switch to RE. In addition to the intrinsic benefits of RE in the discourses on climate change (Town, 2015), health (Mazzucato and Semieniuk, 2018), and food security (Pradhan, 2019) mounting data supports these claims(Shi and Wang, 2023, Ali *et al.*, 2023, Hassan *et al.*, 2023). However, investing in RE has its own dangers and requirements. International investors in the electricity sector were surveyed, and the results showed that they are worried about things like the legal instruments used to define the rights and obligations of key parties (Lamech and Saeed, 2003). When evaluating whether to invest in RE, they analyse factors like consumer payment history and government and/or state agency subsidies. They recommended mitigations such as adequate and enforceable policies with strong political will in financial and subsidy incentives, compensation for land use and encouragement of community participation or ownership to mitigate security issues.

They look at factors such as the payment history of consumers, and subsidies from governments and/or state agencies when considering investing in RE. Tenure and stability of elected officials in the political process is also a determinant factor to investors. Reliance on a competitive bidding process to select project investors is a consideration in investment, just as the ability to integrate with other segments of the energy chain such as upstream generation or downstream distribution, gas supporters, power exports etc(Lamech and Saeed, 2003).These are some of the factors investors are interested in before they can commit their funding towards RE in a developing country. Evidence has shown that most developing countries still grapple with several challenges and barriers.

Technology costs are a hinderance transition to most developing countries. Meanwhile, analysts have observed a growing trend in the reduction of these costs over the last 10 years, solar photovoltaic (PV) had a cost reduction of nearly 98 per cent since 1979 (Creutzig *et al.*, 2017). It is still difficult for developing nations to get access to long-term, inexpensive financing that promotes investment in RE (Ondraczek et al., 2013). The need to minimise risks and barriers has prompted the development of frameworks and approaches that promote RE energy investments.

1.3 Public de-risking framework

The United Nations Development Programme (UNDP) developed a framework that supports policy makers in selecting public policy instruments that promote investment in RE (Waissbein *et al.,* 2013). This has provided a point of departure for this study. Some of the instruments include policy design, capacity building for institutions, assessment of resources, connection to the grid, as well as skills development for day-to-day operations. Financial instruments try to minimise the risks which key players such as development banks, individual investors, and public actors face. Typical such instruments are loan guarantees, political risk insurance (PRI), and public equity co-investments (Waissbein *et al.,* 2013). Adopting the same framework and testing it in the South African context becomes the key cornerstone of the study.

1.4 Problem Statement

The fossil fuel base as feedstock for both the power and fuel industry has largely dominated the energy industry in South Africa. Meanwhile, the country's energy sector has been characterised by an increasing demand for energy; plant failures - exacerbated by operational challenges – which have led to perpetual load shedding. Of late, there has been intense debates between the pro-coal and pro-clean energy proponents. The transition from coal to RE-based industries which drive towards a low carbon future, has proven to be a complex and insurmountable task. This cuts across financial, technological, institutional, environmental, and policy spheres along the value chain in the industry. As the world is calling for sustainable energy (Chirambo, 2018), South Africa is compelled to adapt accordingly. However, high capital costs and other investments risks when considering RE are a major deterrent factor - primarily because the traditional argument has always been that initial investments in fossil fuels come at lower costs and low risks as compared to investing in RE (Sweerts, Longa, and van der Zwaan, 2019). This is highly debatable given the far-reaching consequences and the cumulative costs, particularly when we look at the environmental and global challenges to climate change. Therefore, to encourage the use of RE it remains important to de-risk the investment in this sector.

1.5 Research Objective

The overall objective is to provide research evidence on how to de-risk renewable energy investment in low carbon energy sources using South Africa as the case study.

The specific research objectives are:

I. Identify the financial risks and other barriers that discourage the deployment of RE projects in Nkangala District, Mpumalanga Province in South Africa.

II. Identify and evaluate South Africa's policy instruments that promote RE investments.
III. Propose sound and effective ways of de-risking RE investment towards a low carbon development pathway in South Africa.

To assist in addressing the research objectives, the following questions were formulated:

I. What are the financial risks and other obstacles preventing the implementation of RE projects in Nkangala District in Mpumalanga Province, South Africa?
II. What are the policy instruments that promote RE in South Africa?
III. What are the effective ways of de-risking RE investment towards a low carbon development pathway in South Africa?

1.6 Study rationale and expected contribution.

This study contributes to the climate change crisis discourse and the energy security challenge through a detailed exploration of de-risking RE as part of transitioning to a low carbon economy (Pinto *et al.*, 2023), the energy security challenge (F, Ali and Sadiq, 2023) through an exploration of de-risk RE towards a low carbon future. The study acknowledges that climate change impacts are a clear sign that human activities are causing planetary-scale changes on land, in the ocean, and in the atmosphere, with dramatic and long-lasting ramifications (Zhang *et al.*, 2023). Hence the key to tackling this crisis is to end our reliance on energy generated from fossil fuels - the main cause of climate change. The need to transform our energy systems and speed up the shift to renewable energy is not just a necessity but a priority hence the quest to de-risk RE investments. The study argues that RE is a global public good which should be available to all and for all hence the quest to remove barriers which hinder the diffusion and deployment of these technologies for the common good. Nkangala district which has invested heavily in coal stations such as Kusile Power Station and Duvha Power Station thus provides a better case for South Africa given the huge interest by the South Africa government to propel the just energy transition (Field, 2021) where coal has been central source of energy for several decades.

1.7 Key terms and concepts

It is key to clearly define some of the key concepts and terms used throughout this thesis. Some of these include:

- Renewable Energy - it is 'energy derived from natural resources that are replenished at a higher rate than they are consumed such as solar energy, wind energy, geothermal energy, hydro power, ocean energy, and bio energy' (United Nations Development Programme, 2015,online). Available at www.undp.org [Accessed 14 April 2022].

- Barrier - in a policy concept - is that factor which prevents or hinders action and impedes progress or achievement in realising potential (IPCC, 2007).
- Risk - in the financial world refers to chances that an investment's actual return will differ from what is expected (Pyrkova *et al.*, 2018).
- De-risking Renewable Energy Investment – this is an innovative, quantitative framework to assist policymakers in developing countries to cost-effectively promote and scale up private sector investment in RE.
- .Independent Power Producers (IPP) refers to private players who generate power and are not part of the state-owned utility (Eberhard and Naude, 2016).
- De-risking means mitigating the risks of doing business in high-risk environments through concessionary finance or investment guarantees.

1.8 Thesis outline

This dissertation is structured as follows:

Chapter 1: Introduction: This chapter provides the background to de-risking renewable energy investment, the problem statement, the aims and objectives, and the study rationale. It concludes with a definition of terms and concepts applied in the study.

Chapter 2: Literature review: The chapter identifies global efforts in promoting RE with a specific focus on providing a broader understanding of the various de-risking instruments. It concludes with a discussion of the South African RE policy landscape.

Chapter 3: Methodological framework: The theoretical and empirical framework for this research is described. The research methods are discussed and ethical considerations that have been applied in the study are outlined.

Chapter 4: This chapter provides an analysis of data using the methods described in Chapter Three and, thus, provides the research findings of the study.

Chapter 5: This chapter provides an in-depth analytical discussion of the key findings of the study.

Chapter 6: Provides the conclusion, recommendations, and suggestions and gaps identified for future research.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The methodological approach used to accomplish the goals of the study is presented in this chapter. Each of the research objectives has specific questions that guide the research design and choice of the methods applied. The research design adopted is justified, accompanied by a motivation of the sampling techniques. The following section describes the adopted research design, and specific methods applied for data collection, instruments used, data analysis, results, and ethical considerations.

3.2. Study area

The study was undertaken in the district of Nkangala across three municipalities, namely: Emalahleni, Steve Tshwete, and Emakhazeni in Mpumalanga Province. The region is the largest producer of coal, with a total of 12 coal fired power stations. It shares borders with Limpopo Province to the north and Gauteng to the west. Gauteng's close proximity creates prospects for a broader market(COGTA, 2020) . In 2019, 1.49 million individuals made up the total population, or 2.5% of South Africa's total population. In Figure 3.1, the study area's map is displayed.

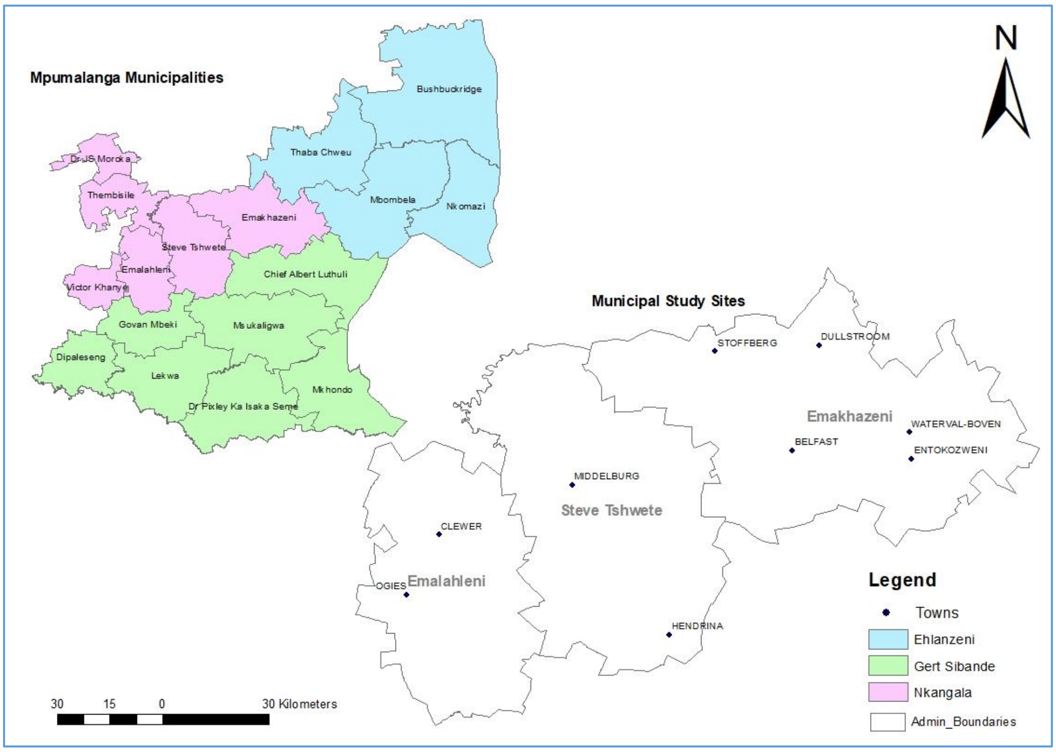

Figure 3.1. Location Nkangala District

Source: Author

3.3 Research paradigm

The study utilised a mixed method approach. The study follows a sequential approach, which defines the problem, articulates the objectives, the methods for data collection, processing, analysis, and discussion. In order to adequately respond to the research objectives, the study design follows a methodological framework that makes use of both qualitative and quantitative methods (Boman *et al.*, 2017).

The study adopts the UNDP DREI framework, which supports decision processes through various public instrument portfolios and their impacts. The framework facilitates organised processes, which is transparent with clearly defined inputs and assumptions. The process facilitates robust discussions and interrogates various scenarios for effective design market oriented and transformative RE initiatives (Waissbein *et al.*, 2013). Below is the summary of the framework as reported by the UNDP**:**

Stage 1: Risk Environment

Analyses how the existence of investment risks might drive up financing prices and identifies the set of investment barriers and associated hazards relevant to the RE technology costs. In the study, the financial risk is identified through a questionnaire and answer to the first objective of the study of identifying financial risk and other barriers that discourage the deployment of RE projects in South Africa.

Stage 2: Public Instruments

Select a composite of public de-risking instrument which addresses investors' risks and quantifies financial costs reduction potential. The step establishes the cost of selected instruments. In the study, a literature review is conducted to identify policies and other instruments in South Africa that promote RE investment. This stage addresses Research Objective 2 which seeks to identify and evaluate South Africa's policy instruments that promote investments.

Stage 3: Levelized Cost of Electricity

Ascertains the extent to which reduction in financial costs influence RE's levelized cost. A review of studies on the LCOE of different technologies was done in a bid to show sound and effective ways of de-risking renewable energy towards a low carbon development pathway in South Africa.

Stage 4: Evaluation

Four performance metrics are used together with assessment chosen. The four metrics are: (i) investment leverage ratio, (ii) savings leverage ratio, (iii) end-user affordability, and (iv) carbon abatement.

3.4 Research Methods

Table 3.1 provides an illustration of the data collecting and analysis research methodology used.

Table 3.1. Research Methods on data collection and analysis

Data Collection Method	Reasoning	Data Analysis Method
Quantitative Survey undertaken for data collection. Applied non-probability purposive sampling to identify the respondents. Survey monkey method that automatically allows electronic capturing of data was used. Relationship establishment between independent variable which is knowledge of RE against demographic characteristics of sample population.	Deductive	Analysis was done through descriptive analysis. Association Analysis through chi square testing.
Quantitative and Qualitative Consolidation of themes by using scientific sources.	Deductive	Themes were selected from responses by sample population and analysis done.
Qualitative	Inductive	Identification of themes Grouping of themes. Verification of themes.

Source: Author

Both qualitative and quantitative techniques were employed to collect and process data as illustrated in table 3.1 Combining qualitative research with quantitative instruments that have greater breadth of coverage and generalisability can result in better evaluations that make the most of their respective comparative advantage. Qualitative data was obtained through structured interviews across key stakeholders of the RE supply chain. The structured interviews included utility executives, independent RE project developers, alternative RE finance providers, public sector policy experts, institutional finance NGOs, institutional RE investment specialists, or fund managers. These enabled detailed investigation of investment issues. Quantitative data was collected through a survey to the households and institutions around Nkangala District

3.4.1 Inductive and Deductive Approach

Findings are triangulated with literature-based reviews. The results from the survey are used to identify themes of financial risks which allowed the researcher to evaluate instruments that promote RE. Data was collected systematically from the questionnaires, structured interviews, and literature reviews to address the research questions formulated for the study. A deductive approach was used to look for similarities and differences of responses on qualitative data and quantitative data obtained during the data collection phase The overview of the techniques and resources used in this investigation is shown in Figure 3.2.

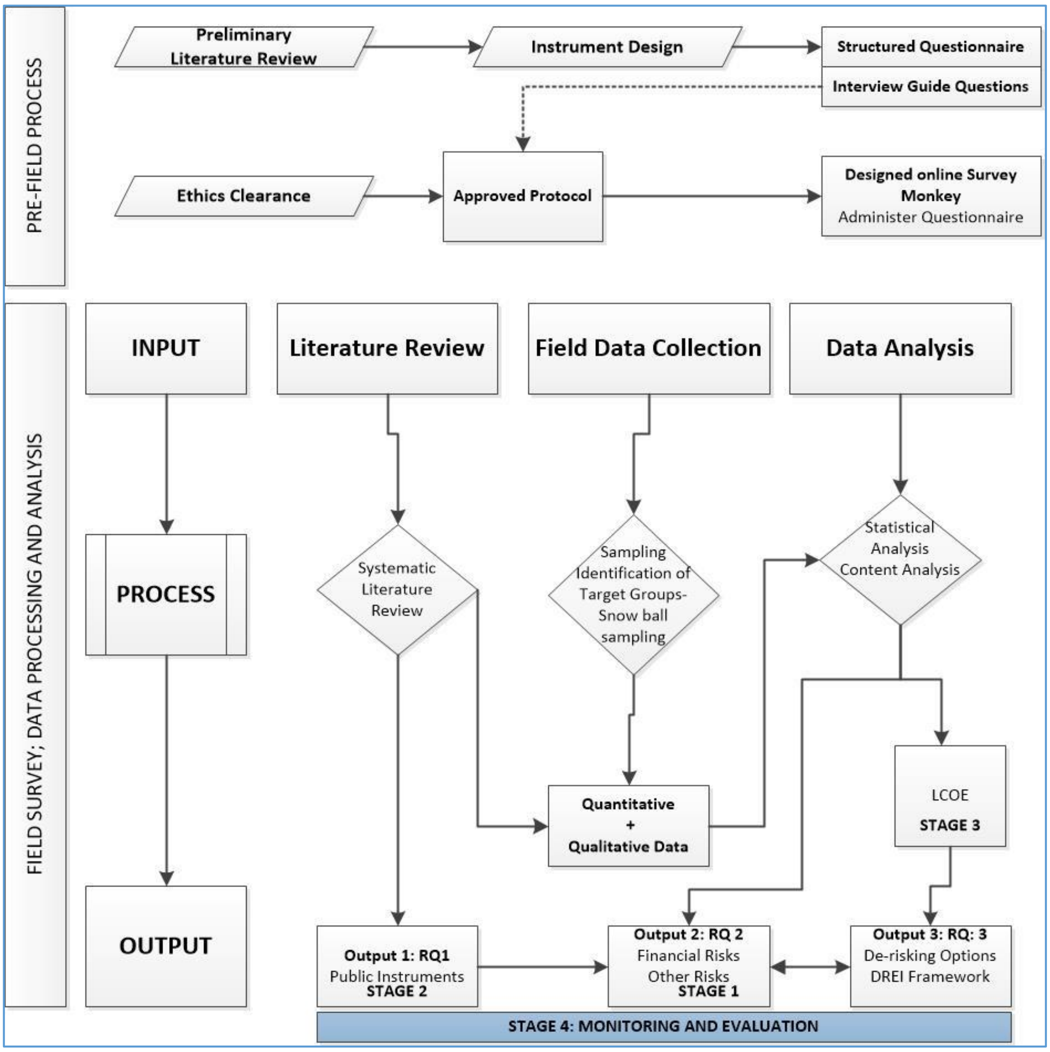

Figure 3.2. Overview of methodology

Source: Author

3.4.2 Pre-field Process

Preliminary literature review as indicated in Figure 3.2 was conducted during the proposal development phase which helped in the instrument design which was developed to allow data collection. The researcher developed a structured questionnaire and interview guided questions. The study adopted a similar research design applied by (Malhotra *et al.*, 2017) regarding the research project, concentrating on increasing financing for off-grid RE. The researcher used structured questionnaire surveys to get quantitative ratings of financial risks that discourage investment in RE. Similarly, Frisari & Stadelmann (2015) used a similar research design with a structured questionnaire to get investors preferences and behaviour.

3.4.3 Validity of Data Collected

Various indicators were used to take into consideration the validity of the data collected. Among these were credibility, dependability, conformability, transferability, and authenticity.

i. *Credibility*
   Ensures the interview respondents are the intended participants across the identified groupings in the study.
ii. *Dependability*
   A systematic approach and processes are followed in the study. This implies that other researchers may repeat the same processes and come close to similar findings using the same raw data.
iii. *Conformability*
   The objectivity and the data accurately represent the participants' response to the study.
iv. *Transferability*
   The findings should be transferable to similar contexts elsewhere.
v. *Authenticity*
   The data provided should be undisputable, authentic, ethical, and traceable using objective procedures and methods which enhance the quality of results.

3.4.4 Ethics

The researcher asked the University of South Africa's Ethical Council for permission to conduct the study. It is important to seek clearance to increase credibility of research findings as well as to protect intellectual honesty, fairness, accuracy, and the human subjects involved in the conduct of the research. This also eliminates legal risks in the collection of data. The ethical clearance certificate is shown in Annexure B. Since institutions are interviewed, gate keeper permission letters were sought and granted from the participating institution. Issues of confidentiality were considered, with respondents not asked to write their personal details on the questionnaires. Physical engagement was essentially prohibited as a result of the COVID-19 Pandemic's harsh lockdown in the country. The only way which could work was to design a survey monkey tool which was administered online. A snowball technique was used. Snowball technique is when referrals are made by subjects who are part of the population sample (Naderifar, Goli, and Ghaljaie, 2017).

3.4.5 Literature Review

Literature review was done to give output response to the first research objective of the policy instruments that promote RE in South Africa. This feeds into Stage 2 of De-risking Renewable Energy Investment (DREI) framework as illustrated in Figure 3.2. Essentially, the study adopts steps identified by Piper (2013) in undertaking a systematic literature review. The first step defines the objective of the review, which seeks to unpack the policy instruments promoting REin South Africa. The literature review exercise articulated the review methodology which outlined the eligibility criteria on literature found (i.e., study selection criteria that included academic published articles, policies as well as official gazetted publications from institutions and ministries that deal with RE). A literature search was conducted, priority was given to scholarly publications from recommended databases that contain reliable information such as google scholar, web of science, EconLIT, Scopus, and others. The study then synthesised the results by integrating the results of different studies and presenting them using a combination of narrative description, graphs, and tables.

3.4.6 Qualitative Research

A qualitative approach was used to collect data through interviews. Interviews were done with 5 key stakeholders from financial institutions to gather information regarding the conditions that investments institutions consider for RE Projects. The interviews sought to collect data on the organisations' perceived risks in granting funding for RE investments. The aim of the interview was to answer research question 1 and research question 2 which sought to identify the financial risks and other barriers that discourage the deployment of RE projects in Nkangala District. The interviews allowed the researcher to find out bankable projects, versus projects that do not attract funding, let alone the enabling environment for investors to secure funding for their projects.

3.4.7 Quantitative Research

A quantitative approach was used to collect data through a questionnaire. The questionnaires were distributed through survey monkey due to the COVID-19 restrictions which did not permit physical meetings. Data was then cleaned, and 113 responses were used to conduct a meaningful analysis. This survey answer Research Question 2, the financial risks, as well as other risks that discourage the deployment of RE projects in Nkangala District in South Africa. Stage 1, illustrates the risk environment of the DREI Framework as illustrated in Figure 3.2.

3.3.5.1 Sampling

Purposive sampling was utilised for the purpose of the study. It is a non-probability sample chosen in accordance with the study's goals and the characteristics of the population. It is also considered selective. Purposive sampling was chosen because the study is centred on RE, hence the sample was chosen selectively, since not everyone is interested in RE.

Due to limited time and resource constraints, the researcher chose five institutions to represent Group Two users. The identified RE investment funders are: banks, a national financial institution which is the Industrial Development Corporation (IDC) as it deals with many companies that provide funding for investment purposes, utility executives from energy entities, and one representative from the Department of Energy representing the policy makers.

3.3.5.2 Identification of the target Groups.

The researcher identified three groups to be used as population for the study:

- **Group 1** consisted of clean technology users and non-users. Users are the subjects who currently are making use of RE as a source of energy at their site. These include households using RE for domestic purpose and institutions. The targeted sample was identified from the housing developers who had made provision of use of clean technologies in some housing units. A sample of 148 households was used as population.
- **Group 2** users were represented by Fund Managers, Utility Executives, and Financial Institutions representatives from the Industrial Development Corporation.
- **Group 3** users were represented by Utility Executives of energy distributors. These are the distributers of solar energy technology.

3.3.5.3 Sample size estimation

Ability to conduct sensible statistical analysis requires sufficient data and this acts as a guideline in drawing the sample size (Fugard and Potts, 2015)The criteria that act as a guideline in determining sample size of the study population are level of risk the study can take, level of precision, and degree of variability in the attributes being measured. According to the Department of Energy 2017 report, the province has a total of 17 776 households with solar installations. The population is large, and, for practical reasons, purposive sampling has been chosen to suit this study for all the 3 groups. For Group 1 users the sample size was drawn from the two municipalities of Nkangala District in Mpumalanga Province. The total population is 17 776, therefore its approximately 5 925 per district. Mpumalanga Province has the following districts: Ehlanzeni District, Gert Sibande District, and Nkangala District. The Nkangala District of interest has six municipalities which can be equated to approximately 987 installations per municipality. The study adopted sample size estimation by as illustrated below (Suresh and Chandrashekara, 2012):

$$N = \frac{Z^2_{\propto/2} * P(1-p) * D}{E^2}$$

To determine the total population

$$N^1 = \frac{N}{1-q}$$

Where N is population and q is the non-response rate

Where N represents the total population

$Z_{\alpha/2}$ represent……deviation for two-tailed alternative hypothesis at a level of significance

P represent ……Prevalence or proportion of the target groups

D represent………...Design effect

E represent………Precision or margin of error

The calculated sample size was 150 at 95% confidence interval and 5% margin of error. The researcher used 148 households and 2 identified schools which are powered by solar energy in the chosen study area. The identified schools are the only schools in the Nkangala District with solar energy. The calculated sample size was deemed sufficient for the study amidst resources and time constraints. The researcher considered that total energy consumption used by institutions provided an indication of the reduced demand from the Eskom grid.

3.5 Data analysis

3.5.1 Content Analysis

Content analysis from literature review and structured interviews were done. The researcher, based on the Research Question 2 of identifying the policy instruments that promote renewable investment, chose the text to be analysed. The researcher went on to define the themes from the responses and draw conclusions from the analysis.

3.5.2 Statistical Analysis

Considerations of the sample size, and the number and type of variables were a determining factor on how data would be analysed statistically. The researcher opted for descriptive statistics and relationship testing of variables through Chi-square testing technique. Descriptive statistics was used to identify financial risks and other barriers that discourage the deployment of RE in Mpumalanga’s Nkangala District. The questionnaire probed the respondents on knowledge of renewables, ownerships of renewable technology, income, occupation, level of education, age, whose responsibility it is on climate change, and barriers they perceive on renewable technology investments. Such information helped the researcher to answer Research Question 1 which seeks to identify financial risks and other barriers that discourage deployment of RE. Chi-square test of association is used to establish if there is a relationship between the sample demographic and knowledge in renewables. For an association to be significant, the probability value must be greater than 5 % ($p<0.05$) (Rice, 1989). Cross tabulation was done to examine relationships within the data that is not automatically obvious. The study applied the deductive approach to look for similarities and differences of responses on qualitative data and quantitative data obtained during the data collection phase.

3.5.3 Levelized Cost of Electricity and Evaluation

Levelized Cost of Electricity (LCOE) is an analysis that was used to identify the benefit and disadvantages of energy investments in terms of total costs. It is an economic evaluation of an electricity unit's net present value. It is used to contrast various energy generating methods, both renewable and non-renewable, including solar, wind, biomass, geothermal, coal, natural gas, and nuclear on a consistent basis (Durakovi,2021). LCOE answered Research Question 3 which seeks to find the effective ways of de-risking renewable energy investment towards a low carbon development pathway in South Africa. A feed to the Output 3 of the DREI Framework, it also shows how costs can decrease in the presence of de-risking elements such as advancements in the technology, subsidies, tax breaks, other government programmes, and policy conditions. The equation of the LCOE is below:

$$LCOE = \frac{(C * CRF) + Fo\&m \qquad 8760\, xCf}{}$$

Where C =Overnight capital cost (R/MW)

CRF =(i(1+)^t/((1+i)^t-1)

i =interest or discount rate

t =time years

Fo&m	=Fixed O &M costs (R/Mwh)
Cf	=Capacity factor
8760	=number of hours in a year(h)
Vo&m	= Variable O&M costs (R/Mwh)
FP	=Fuel Price
HR	=Heat Rate (efficiency)

The study reviewed the LCOE already calculated on various technologies and came up with a deductive reasoning to be able to draw conclusions on the effective ways of de-risking renewable energy investment towards a low carbon development, which is Research Question 3 of the study.

The de-risking tool in the study acted as an investment tax credit. The higher the investment credit and the lower the operations and maintenance cost, the lower the LCOE.

3.6. Conclusion

The chapter provided an in-depth description of the research paradigm and methods applied. Careful consideration for estimating the sample size was done with due consideration of the cost and time constraints. By and large, the study hinges more on the adopted UNDP framework for de-risking renewable energy investment, especially in the least developed world. Chapter 4 provides the analysis of the data.

CHAPTER 4: RESULTS

4.1. Introduction

This chapter describes the main findings drawn from the Nkangala District in Witbank Mpumalanga, South Africa. The focus of the study was to establish de-risking measures and policy instruments of RE investment towards a low carbon development in South Africa. The first part of the chapter describes demographic characteristics of the respondents, particularly looking at livelihood, gender, and employment levels. The second component looks at the overarching policies that guide energy investments in South Africa. The results spell out the listed financial risks and other barriers discouraging the deployment of RE projects in the country. This is followed by a suggestion on the ways of de-risking renewable energy investment towards a low carbon development pathway in South Africa.

4.2. Socio-economic characteristics of the respondents

A total of 150 questionnaires were distributed via a Survey Monkey tool, and 121 responded. However, a total of 113 respondents participated fully in the study. Socio-demographic characteristics addressed in the study were gender, age, and educational level. The gender characteristics of the respondents who participated in the study were such that 64% were male and 36% were female, as shown in Figure 4.1. The age structure of the respondents revealed that only 4 were between the age of 18 and 30, while most of the respondents were between the age of 31 and 50, with a total of 90 respondents; only 19 were between the age of 51 and 60.

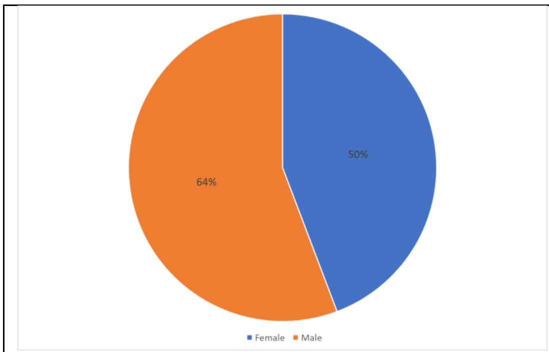

Figure 4.1. Gender distribution of respondents

Source: Author

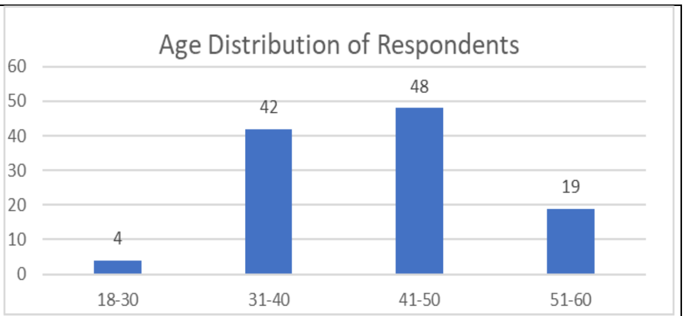

Figure 4.2. Age distribution of respondents

Source: Author

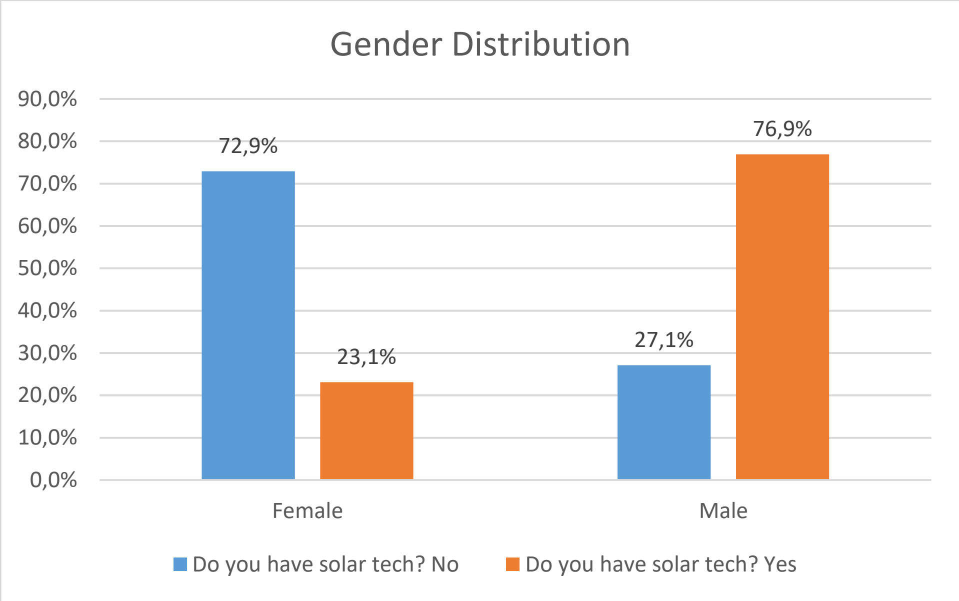

Figure 4.3. Gender distribution of respondents' solar ownership

Source: Author

Figure 4.3 shows that 72.9% of the female respondents do not have solar technology, and 76.9% of males who responded have solar technology. It can be concluded that more male respondents owned solar technology than their female respondents.

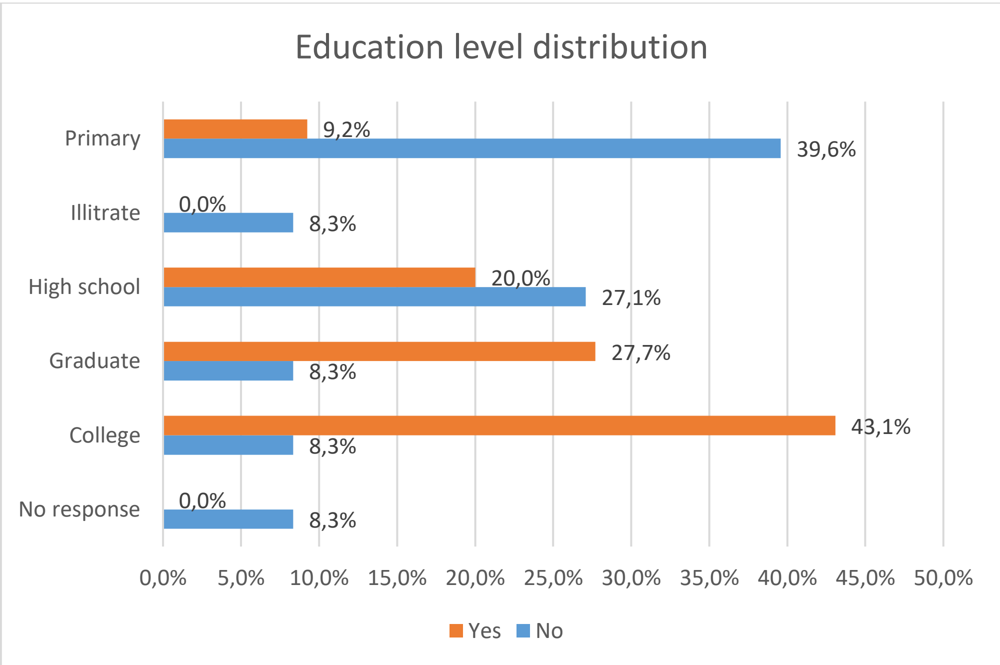

Figure 4.4. Education level distribution

Source: Author

Figure 4.4 shows the education level distribution of the respondents who own solar technology. The majority of respondents who own solar technology are those who went to college, with 43.1%, followed by those who are graduates, with 27.7%, and those with high school qualification were only 20%. The least category owning solar technology was 9.2% with primary education. A study done by Enel Foundation confirms that education is of paramount importance to empower changes, and promote investment. It has been confirmed that literacy levels in Africa are slightly above 20%, which is record low if compared to the global average of 38% (IRENA, 2019:121).

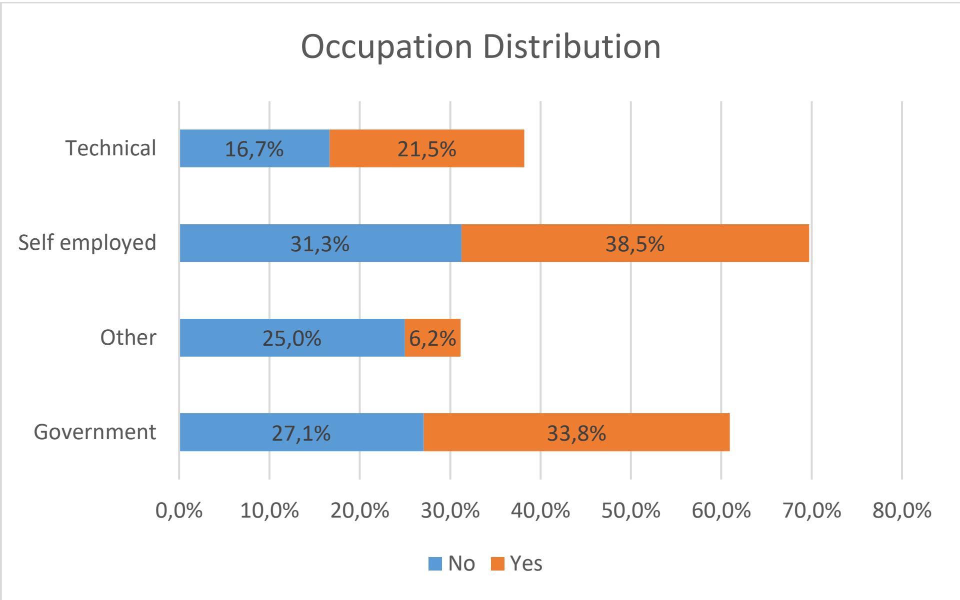

Figure 4.5. Occupation distribution

Source: Author

Figure 4.5 shows respondents' occupation distribution status of those with and without solar technology. About 38.5% of the respondents who are self-employed own solar technology. Those working in the technical field constitute 21.5%. The proportion of respondents from other occupations was only 6.2%. Government employees account for 33.8% of respondents. Of those without solar technology 16.7% are technical, 2 5% are from other occupations, whilst 31.3% and 27.1% come from self-employments and government sector, respectively. Respondents who are self-employed in a country affected by loadshedding take a lead in owning renewable technology, as most of them operate from their homes.

4.3 Knowledge of Renewable Energy

Knowledge of RE technologies was examined using selected variables, namely: gender, age group, income, education, and occupation. In addition, the study gauged the respondents' knowledge considering ownership of solar and familiarity with climate change management. Table 4.1 illustrates a cross tabulation with the proportions of the respondents' knowledge. About 58% of the male respondents and 42% of female respondents acknowledged that they have knowledge of renewables. The 41-50 years age group ranks highest with 42.5%, indicating that they are knowledgeable of RE, compared to the 18-30 years age group with 3.5% (and being the least). Looking at the income levels, those with income levels of above 50 000 monthly were more knowledgeable about solar, and these were 43.4%; while only 7.1% with income levels between 10 000 and 20 000 monthly have knowledge for RE. Those who went to college reported a high percentage of 28.3%, a sign that those in the affordability bracket for renewables are the high-income

earners with better paying jobs.

Table 4.1. Respondents' knowledge on difference between renewables and non-renewable energy

		Do you know the difference between Renewable and Non-Renewable Energy?							
		Don't Know		No		Yes		Total	
		Count	Column N %	Count	Column N %	Count	Column N %	Count	Column N %
Gender	Female	16	76.2%	20	33.9%	14	42.4%	50	44.2%
	Male	5	23.8%	39	66.1%	19	57.6%	63	55.8%
	Total	21	100.0%	59	100.0%	33	100.0%	113	100.0%
Age Group	18-30	4	19.0%	0	0.0%	0	0.0%	4	3.5%
	31-40	4	19.0%	34	57.6%	4	12.1%	42	37.2%
	41-50	8	38.1%	17	28.8%	23	69.7%	48	42.5%
	51-60	5	23.8%	8	13.6%	6	18.2%	19	16.8%
	Total	21	100.0%	59	100.0%	33	100.0%	113	100.0%
Income in Rends	10000-20000	0	0.0%	11	18.6%	0	0.0%	11	9.7%
	21000-30000	0	0.0%	22	37.3%	15	45.5%	37	32.7%
	31000-40000	0	0.0%	8	13.6%	0	0.0%	8	7.1%
	41000-50000	0	0.0%	0	0.0%	8	24.2%	8	7.1%
	Above 50000	21	100.0%	18	30.5%	10	30.3%	49	43.4%
	Total	21	100.0%	59	100.0%	33	100.0%	113	100.0%
Education		4	19.0%	0	0.0%	0	0.0%	4	3.5%

	College	4	19.0%	22	37.3%	6	18.2%	32	28.3%
	Graduate	0	0.0%	0	0.0%	22	66.7%	22	19.5%
	High school	4	19.0%	17	28.8%	5	15.2%	26	23.0%
	Illiterate	4	19.0%	0	0.0%	0	0.0%	4	3.5%
	Primary	5	23.8%	20	33.9%	0	0.0%	25	22.1%
	Total	21	100.0%	59	100.0%	33	100.0%	113	100.0%
Occupation	Government	4	19.0%	17	28.8%	14	42.4%	35	31.0%
	Other	8	38.1%	4	6.8%	4	12.1%	16	14.2%
	Self employed	5	23.8%	20	33.9%	15	45.5%	40	35.4%
	Technical	4	19.0%	18	30.5%	0	0.0%	22	19.5%
	Total	21	100.0%	59	100.0%	33	100.0%	113	100.0%

Source: Author

4.4 Perception on expectations of whose responsibility it is to manage climate change.

The respondents (84.4%) strongly feel it is the responsibility of the government to manage climate change, while 19% strongly feel it is the responsibility of the public to manage climate change as shown on Figure 4.6 Only 7.4% do not think it is the responsibility of government to manage climate change.

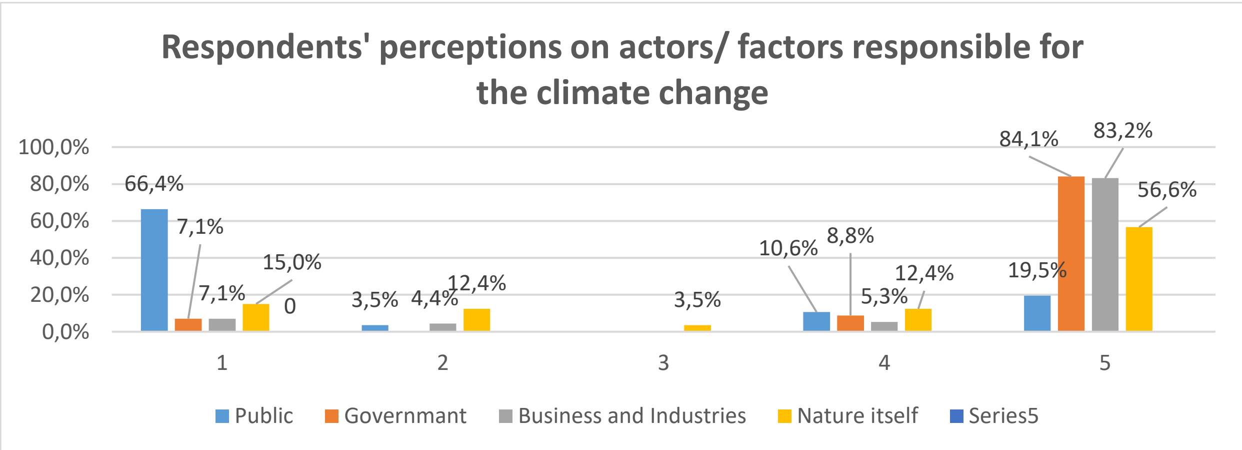

Figure 4.6. Respondents perception on subjects responsible for climate change

Source: Author

4.5 Institutional responses on their strategies/programme on RE

Of the 65 institutions that responded, 50.8% confirmed that there is no dedicated department running with RE projects, neither are there any programmes being run by the institutions. This is illustrated in Table 4.2 below. Respondents also agreed that they have a responsibility towards the drive to renewable energy, with 51% agreeing to this while 49% still are convinced it is not their responsibility. About 51% of the respondents could not confirm. Only 31% of respondents indicated there is no budget for renewable projects while only 19% confirmed there is budget for renewable technology. About 51% of the respondents were aware of existence of RE policies.

Table 4.2. Responses from institutions regarding renewable energy

		Do you have renewable technology			
		No		Yes	
		Count	Column N %	Count	Column N %
Does renewable energy have a dedicated division or unit?	No Response	28	58.3%	33	50.8%
	NO	16	33.3%	16	24.6%
	YES	4	8.3%	16	24.6%
	Total	48	100.0%	65	100.0%
Do you have any programs in your company that focus on renewable technology?	No Response	28	58.3%	33	50.8%
	NO	16	33.3%	28	43.1%
	YES	4	8.3%	4	6.2%
	Total	48	100.0%	65	100.0%
Is there any funding designated for enforcing the use of renewable energy?	No Response	28	58.3%	33	50.8%
	NO	16	33.3%	20	30.8%
	YES	4	8.3%	12	18.5%
	Total	48	100.0%	65	100.0%
Do you favour taking the lead in advancing innovation in renewable energy?	No Response	28	58.3%	33	50.8%
	YES	20	41.7%	32	49.2%
	Total	48	100.0%	65	100.0%
Do you believe that the private sector has a significant impact on the development of renewable energy?	No Response	28	58.3%	33	50.8%
	NO	5	10.4%	17	26.2%
	YES	15	31.3%	15	23.1%
	Total	48	100.0%	65	100.0%

Does South Africa have a policy on renewable energy?	No Response	28	58.3%	33	50.8%
	NO	5	10.4%	0	0.0%
	YES	15	31.3%	32	49.2%
	Total	48	100.0%	65	100.0%

Source: Author

4.6 Risks associated in investing in renewable energy.

The survey looked at the respondents' view about several of risks associated with de-risking renewable energy. Among these were financial constraints, knowledge, and resistance to change, and socio-technical perceptions such as durability efficiency, maintenance costs as illustrated in Table 4.3. About 96.5% strongly agree that both financial constraints and knowledge of RE are high risk factors for RE investments. Resistance to change has been identified as a key risk to investing in renewables, with 89% of the respondents strongly in support of this notion. Socio-technical perceptions such as durability of social technology was noted as high risk, with 83.5% strongly agreeing this could be a possible cause to not investing in RE.

Table 4.3. Response on risks associated with investing in renewable energy.

		Do you have solar technology					
		No		Yes		Total	
		Count	Column N %	Count	Column N %	Count	Column N %
Financial Constraints	Strongly disagree	0	0.0%	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%	0	0.0%
	Neutral	0	0.0%	0	0.0%	0	0.0%
	Agree	4	8.3%	0	0.0%	4	3.5%
	Strongly Agree	44	91.7%	65	100.0%	109	96.5%
	Total	48	100.0%	65	100.0%	113	100.0%
Knowledge on the use of Solar	Strongly disagree	0	0.0%	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%	0	0.0%
	Neutral	0	0.0%	4	6.2%	4	3.5%
	Agree	0	0.0%	0	0.0%	0	0.0%

	Strongly Agree	48	100.0%	61	93.8%	109	96.5%
	Total	48	100.0%	65	100.0%	113	100.0%
Resistance to Change	Strongly disagree	0	0.0%	0	0.0%	0	0.0%
	Disagree	0	0.0%	4	6.2%	4	3.7%
	Neutral	0	0.0%	0	0.0%	0	0.0%
	Agree	4	9.1%	4	6.2%	8	7.3%
	Strongly Agree	40	90.9%	57	87.7%	97	89.0%
	Total	44	100.0%	65	100.0%	109	100.0%
Sociotechnical Perceptions on durability and efficiency	Strongly disagree	0	0.0%	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%	0	0.0%
	Neutral	0	0.0%	6	9.8%	6	5.5%
	Agree	8	16.7%	4	6.6%	12	11.0%
	Strongly Agree	40	83.3%	51	83.6%	91	83.5%
	Total	48	100.0%	61	100.0%	109	100.0%
Maintenance costs	Strongly disagree	22	45.8%	34	52.3%	56	49.6%
	Disagree	1	2.1%	31	47.7%	32	28.3%
	Neutral	25	52.1%	0	0.0%	25	22.1%
	Agree	0	0.0%	0	0.0%	0	0.0%
	Strongly Agree	0	0.0%	0	0.0%	0	0.0%
	Total	48	100.0%	65	100.0%	113	100.0%

Source: Author

4.7 Financial risks

Respondents gave their opinions on the financial risks involved in making investments in RE. Among these financial risks were market risks, inflation risks, interest rate risks, liquidity risks, and other financial risks. About 41.7% of those who do not own solar technology confirmed that financial risks limited them in entering the market, hence decided not to invest in renewable technology. About 33.9% strongly agreed that all the financial risks were a deterrent to investments in solar technology**.**

Table 4.4. Financial Risks

		Do you have solar technology			
		No		Yes	
		Count	Column N %	Count	Column N %
Market Risk	No Response	28	58.3%	33	50.8%
	Strongly Disagree	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%
	Neutral	0	0.0%	4	6.2%
	Agree	0	0.0%	6	9.2%
	Strongly Agree	20	41.7%	22	33.8%
	Total	48	100.0%	65	100.0%
Inflation Risk	No Response	28	58.3%	33	50.8%
	Strongly Disagree	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%
	Neutral	0	0.0%	6	9.2%
	Agree	0	0.0%	4	6.2%
	Strongly Agree	20	41.7%	22	33.8%
	Total	48	100.0%	65	100.0%
Interest Risk	No Response	28	58.3%	33	50.8%
	Strongly Disagree	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%
	Neutral	0	0.0%	6	9.2%
	Agree	0	0.0%	4	6.2%
	Strongly Agree	20	41.7%	22	33.8%
	Total	48	100.0%	65	100.0%
Liquidity Risk	No Response	28	58.3%	33	50.8%
	Strongly Disagree	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%
	Neutral	0	0.0%	10	15.4%
	Agree	0	0.0%	0	0.0%
	Strongly Agree	20	41.7%	22	33.8%

	Total	48	100.0%	65	100.0%
Other l Risks (Regulatory risks, policy risks name	No Response	28	58.3%	33	50.8%
	Strongly Disagree	0	0.0%	0	0.0%
	Disagree	0	0.0%	0	0.0%
	Neutral	0	0.0%	10	15.4%
	Agree	0	0.0%	0	0.0%
	Strongly Agree	20	41.7%	22	33.8%
	Total	48	100.0%	65	100.0%

Source: Author

4.8 Maintenance Cost of Solar Technology and Investment

A total of 50.8% of the respondents indicated that they invested more in buying solar technology, compared to a low maintenance cost of 6.2% as illustrated in Figure 4.7 - a clear indication that it costs a lot of money to invest in solar technology as compared to maintenance of existing technology. A report by Nedbank on 24 August 2022 confirms it is expensive to invest in solar technology since most consumers do not have cash to buy the technology and are likely to opt for a loan. Loans will require repayment which may not be a saving to the consumer.

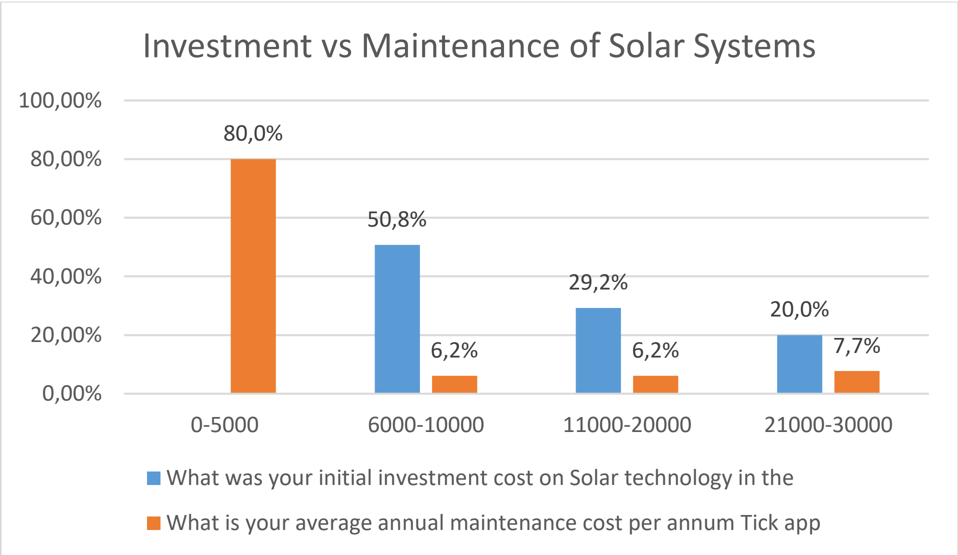

Figure 4.7. Maintenance vs Investment

Source: Author

4.9 Challenges of Renewable Technology

Table 4.5 highlighted the respondents' challenges to renewable technology. These include: inability to meet sudden demand of energy, poor weather conditions reducing efficiency, and component failures resulting in inability to generate energy. Inability to meet the sudden demand of energy was cited as a challenge to renewable technology, with all the respondents agreeing to this. Poor weather conditions reducing efficiency was unanimously agreed upon as a challenge to RE. About 78.5% of the respondents agreed that components failure is a challenge to RE, with only 6.2% not agreeing to component failure as a challenge.

Table 4.5. Challenges of renewable energy technology

		Do you have solar technology			
		No		Yes	
		Count	Column N %	Count	Column N %
Inability to meet sudden demand of energy		48	100.0%	0	0.0%
	YES	0	0.0%	65	100.0%
	Total	48	100.0%	65	100.0%
Poor weather conditions reduce efficiency		48	100.0%	0	0.0%
	YES	0	0.0%	65	100.0%
	Total	48	100.0%	65	100.0%
Component Failure results in inability to generate energy		48	100.0%	4	6.2%
	NO	0	0.0%	10	15.4%
	YES	0	0.0%	51	78.5%
	Total	48	100.0%	65	100.0%
Poor installation		48	100.0%	14	21.5%
	NO	0	0.0%	46	70.8%
	YES	0	0.0%	5	7.7%
	Total	48	100.0%	65	100.0%

Source: Author

4.10 Chi square (x2) test of association

Chi-square was performed to establish if there is a relationship between the sample demographics and knowledge of renewables.

4.10.1 Association between age and ownership renewable energy

The test statistics from the Chi-Square test results is 7.376, the corresponding p value of the test statistics is 0.061 and is higher than the chosen significance level alpha= 0.05. It can, therefore, be concluded that there is no association between age and knowledge of RE as shown in figure 4.8

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7,376[a]	3	,061
Likelihood Ratio	8,849	3	,031
N of Valid Cases	113		

a. 2 cells (25,0%) have expected count less than 5. The minimum expected count is 1,70.

Figure 4.8. Chi square test: Age and knowledge of renewable energy

Source: Author

4.10.2 Association between education and ownership renewable energy

The test statistics from the Chi-Square test results is 40.017, the corresponding p value of the test statistics is less than 0.001 and is lower than the chosen significance level alpha= 0.05. It can, therefore, be concluded that there is an association between age and knowledge of renewable energy as shown in figure 4.9 .

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	40,017[a]	5	<,001
Likelihood Ratio	45,511	5	<,001
N of Valid Cases	113		

a. 4 cells (33,3%) have expected count less than 5. The minimum expected count is 1,70.

Figure 4.9. Relationship between and ownership of renewable energy

Source: Author

4.10.3 Association between income and ownership renewable energy

The test statistics from the Chi-Square test results is 40.017, the corresponding p value of the test statistics is less than 0.001 is lower than the chosen significance level alpha= 0.05. It can, therefore, be concluded that there is strong association between income and knowledge of RE as shown in figure 4.10. This is a confirmation by several scholars who are still of the view that cost is a hindering factor if one is to consider RE investment (Malhotra *et al.*, 2017); Hirth and Steckel, 2016).

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	75,916[a]	4	<,001
Likelihood Ratio	99,531	4	<,001
N of Valid Cases	113		

a. 5 cells (50,0%) have expected count less than 5. The minimum expected count is 3,40.

Figure 4.10. Association between income and ownership of renewable energy

Source: Author

4.10.4 Association between occupation and ownership of renewable energy

The test statistics from the Chi-Square test results is 8.076, the corresponding p value of the test statistics is 0.044 and is lower than the chosen significance level alpha= 0.05. It can, therefore, be concluded that there is strong association between type of employment and knowledge of renewable energy as shown in the table below. One's profession or nature work can help improve one's knowledge of renewable energy let alone affordability of technologies as some professions have higher paying jobs.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8,076[a]	3	,044
Likelihood Ratio	8,143	3	,043
N of Valid Cases	113		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,80.

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	,267	,044
	Cramer's V	,267	,044
N of Valid Cases		113	

Figure 4.11. Association between occupation and ownership of renewable energy

Source: Author

4.11 Findings from interview data

The researcher conducted interviews with 5 institutions. Interview questions were given in advance to the institutions to prepare. Ethical considerations were observed. The following table represents the responses of the participants. To observe confidentiality, names of the institutions were withheld, and the institutions will be identified as Institution 1, 2, 3, 4, and 5. The responses are shown below the interview questions below.

1. What size of projects do you normally fund (small, medium or mega)?

Institution 1 response: small

Institution 2 response: small and medium

Institution 3response: all of them

Institution 4 response: small

Institution 5 response: small and medium

2. In your investment portfolio which project do your normal fun debt funded projects or Equity funded projects?

Institution 1: Debt funded projects.

Institution 2 response: Debt funded projects.

Institution 3response: Debt and Equity funded project

Institution 4 response: Debt funded projects.

Institution 5 response: Debt funded projects

3. What are your key considerations for funding RE Investment projects? In other words what are the salient elements you consider for a bankable project?

Institution 1 response:

- Collateral provided by the lender, such as real estate, rights under contracts and permits, bank accounts, and stock in the project firm.
- Power Purchase Agreements (PPA)
- Construction Contract
- Warranties

Institution 2 response:

- Energy take off agreements
- Energy performance contract
- Regulatory and Environmental Doc and Approvals
- Construction Contract
- O&M Agreement

Institution 3 response:

- Market economics as in electricity shortages, base load opportunity
- Project economics, comprising the technology to be used, the performance history, the efficiency, and the cost per MW Utilising carbon credits and support program subsidies.
- Contract structure like that of a turnkey contractor with a set price, date-specific agreement
- Security Package as in product warranties, comprehensive risk coverage
- Sponsor support as in level of contingent equity available for completion

Institution 4 response:

- Project revenue sources should be sufficient to support a highly leveraged loan financing.
- Physical collateral sufficient to cover lender repayment in case of unforeseen closure
- Significance level of technology risk
- Turnkey relationships with reputable companies for services key to the success of the project

Institution 5 response:

- Receivables of revenue streams must be enforceable against a creditworthy entity under contractual rights.
- Technology risk Expected return of project invested.
- Payback period

4. In some cases investors consider sovereign guarantees or partial credit guarantees. What are some of these which you would consider?

Institution 1 response:

- None

Institution 2 response:

- None

Institution 3 response:

- Both sovereign guarantees and partial credit guarantees

Institution 4 response:

- Partial credit guarantees

Institution 5 response:

- Sovereign guarantees

5. May you comment on liquidity, local currency loans, interest rate and other facilities? To what extend do these influence your decision on considering RE investments

Institution 1 response:

- On liquidity it is important to assess the risk of incurring losses from the inability to meet payment obligations timeously
- Local Currency loans assessment on how strong the currency is against international currencies.
- Interest rate know as internal rate of return (IRR) is key to considering RE investments, the higher the IRR compared to cost of capital the more the attractive the project.
- Net Present Value (NPV) is key to monitor the inflationary environment as it measures the present value of money without taking inflation. The higher the NPV the lucrative the investment option.

Institution response 2:

- They also agreed the internal rate of return should be greater than capital costs.
- Net present value (NPV) has to be higher than capital costs.
- Construction and development risk are looked at through a feasibility study
- Market risk is a consideration, likely competition or access to market

Institution response 3:

- Political risk is key determinant of investments as it tends to influence other factors such as interest rates, which can be affected by imposition of new taxes, export restrictions, devaluation of the currency.

Institution 4 response:

- Environmental risk is key to the institution as they attract fines which in turn will affect the return on investment of project.

Institution 5 response:

- Projected cash flow is key and as the institution focus more on cost benefit analysis (CBA)that take into account benefit-cost ratio, net present value, and internal rate of return, lease cost planning and sensitivity analysis.

5. What are the political risks that you may consider if any?

Institution 1 response:

- High chances of a war
- Country being given sanctions by other countries.

Institution 2 response:

- War
- Sanctions
- Nationalisation of project assets

Institution 3 response:

- War
- Sanctions

Institution 4 response

- War
- Nationalisation of assets
- Radical changes of constitution of country

Institution 5 response:

- War
- Sanctions

What other factors do you consider when considering investment in RE?

Institution 1,2,4,5 response was none.

Institution 3 response:

- Reliable relationships with local authorities are key.
- Regulatory system in the country is key during feasibility assessment.

4.11.1Thematic analysis of results

Common themes identified in the interview were: size of projects, type of funding, conditions for granting funding, and liquidity risks. Small sized projects were favoured compared to large projects. Debt financing was the preferred option of funding than equity, as the institutions found loans to be more favourable. Conditions of granting loans were in line the National Credit Act of South Africa which guides financial institutions on lending to public and other stakeholders. Some of the conditions identified include ability to pay back the loan, warranty agreements of projects, and collateral measures in the invent that they fail to pay back. Most financial institutions indicated they do not make use of partial credit guarantees, these are usually offered by the government itself. Liquidity risks identified included projected cash flow from project (as it determined ability to pay back the loan), and internal rate of return of the project. Political risks identified by the institutions were wars, sanctions, and market environment as it influences the performance of the local currency against the main international currencies.

4.12 Levelized Cost of Electricity of new utility scale renewable power generation technologies

Figure 4.14 shows the levelized of electricity of new utility scale power generation technologies between the period of 2010-2021 at global level. Wind technology LCOE reduced from USD 0.188/kWh to USD 0.075/kWh. CSP LCOE increased from USD 0.039/kWh to USD 0.048/kWh. Biomass LCOE decreased from USD 0.078/kWh to USD 0.078/kWh. Geothermal LCOE increased from USD 0.054/kWh to USD 0.071/kWh (IRENA, 2020).

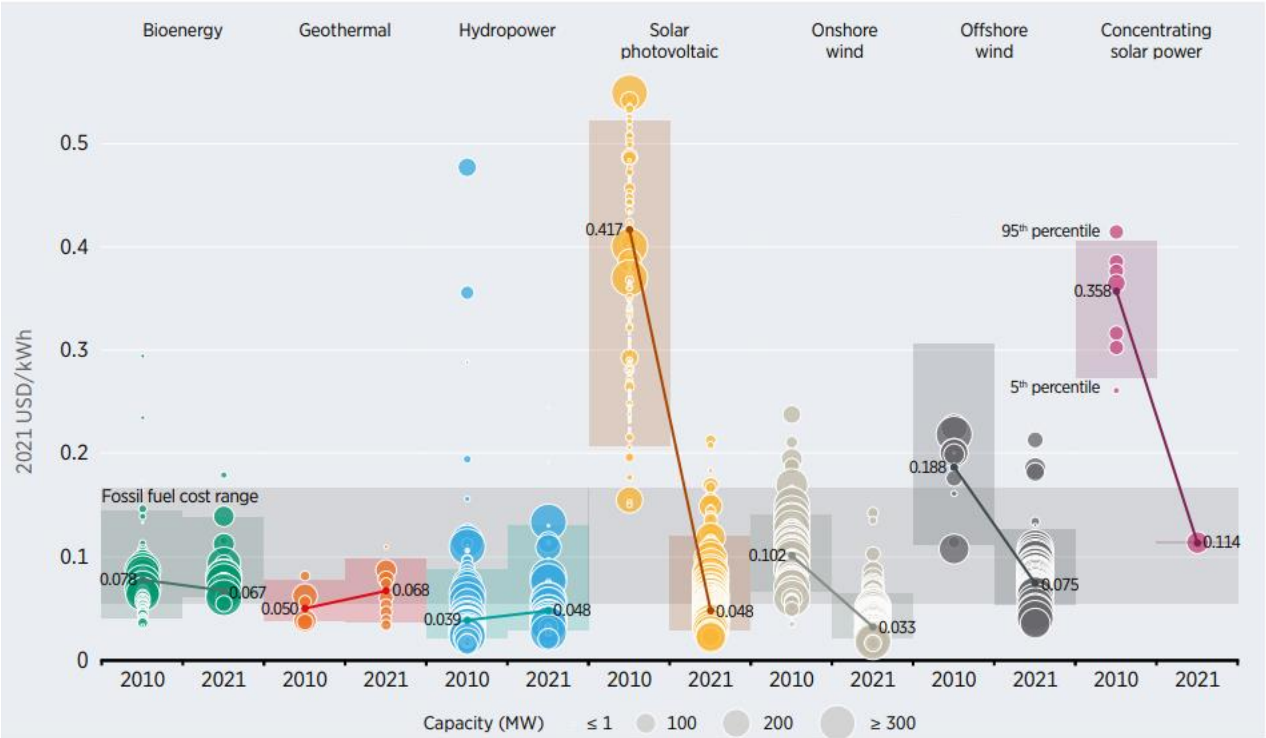

Figure 4.6. Newly installed utility-scale renewable energy production technologies' global weighted average LCOE,2010-2021.

Source: Renewable Power Generations (2021:32)

LCOE for wind technology can also be presented per country for small markets from the period of 2010-2021. Countries with increase in LCOE include Argentina, Chile, Costa Rica, Croatia, Norway, Pakistan, South Africa, and Uruguay as shown in Fig 4.11 (IRENA, 2021).

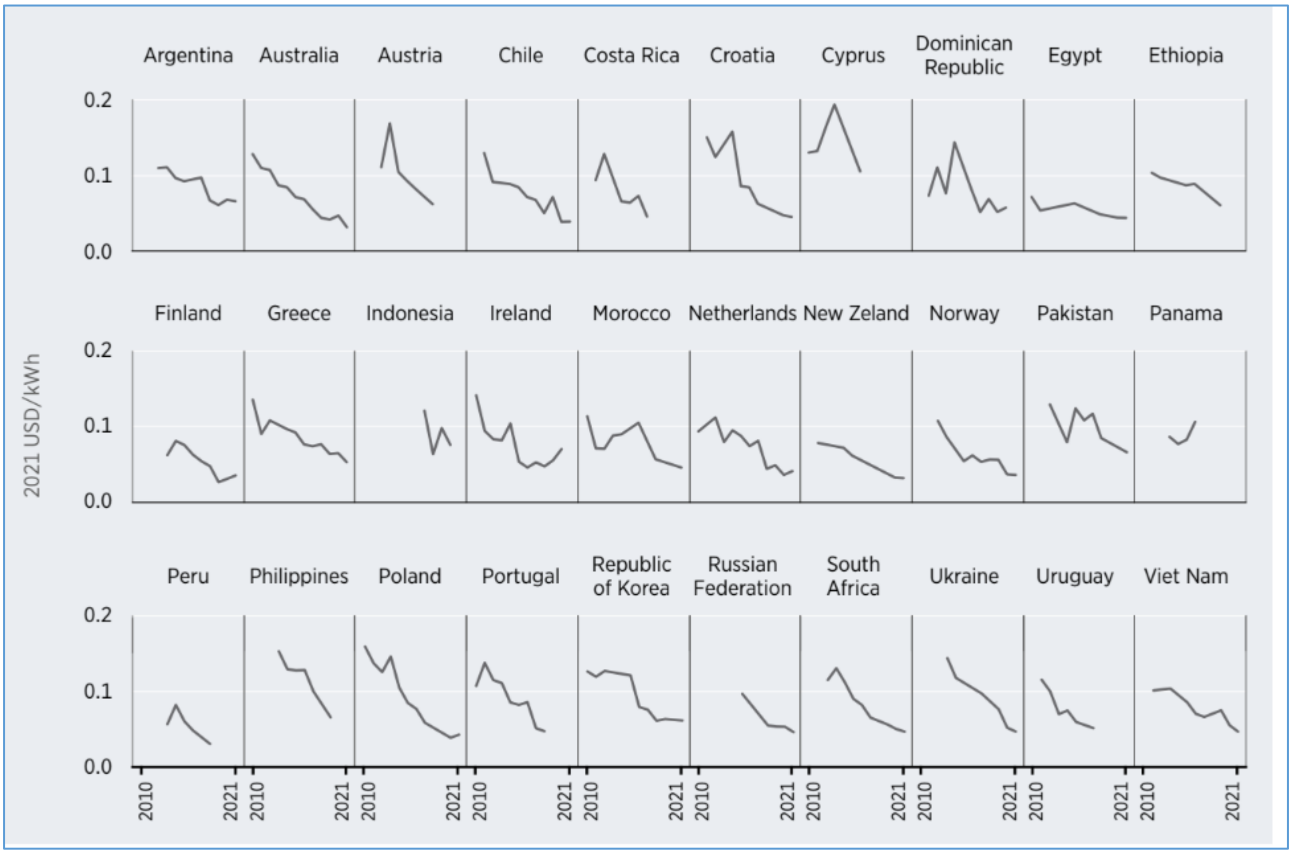

Figure 4.7. Onshore wind weighted average capacity factors for news projects in smaller markets by country and year 2020-2021

Source: Renewable Power Generations (2021:70)

4.13. Conclusion

This chapter presented the results mainly from the survey undertaken in Nkangala District in Mpumalanga, South Africa. Financial risks and other risks were proven to be a deterrent to investing in RE - with more than half of the respondents in agreement to this. Findings have shown that levels of education which in turn determine levels of income for the respondents was an additional factor determining ownership of renewable technology. Closely linked to this is lack of knowledge on renewables, which was identified to be a risk in investing in renewable technology. The Energy Act, for example, aims to strengthen energy planning in order 'to ensure that diverse energy resources are available, in sustainable quantities, and at affordable prices, to the South African economy', and more specifically to 'provide for energy planning, increased generation, and consumption of RE' as South Africa moves towards a low-carbon environment. Chapter 5 discusses if these policies are effective.

CHAPTER 5: DISCUSSION

5.1. Introduction

The chapter provides a discussion drawing insights from key findings, articulated in the previous chapters. The chapter engages and interrogates the financial risks, policy instruments, together with an array of identified ways of de-risking renewable energy investments and how these relate to other comparable research findings.

5.2 Obstacles to the use of renewable energy in South Africa

Several barriers have been interrogated. These include financial risks, market related risks, profitability risks, the level of education, the policy environment, technical barriers, public acceptance, and environmental barriers policies as well as technology efficiency.

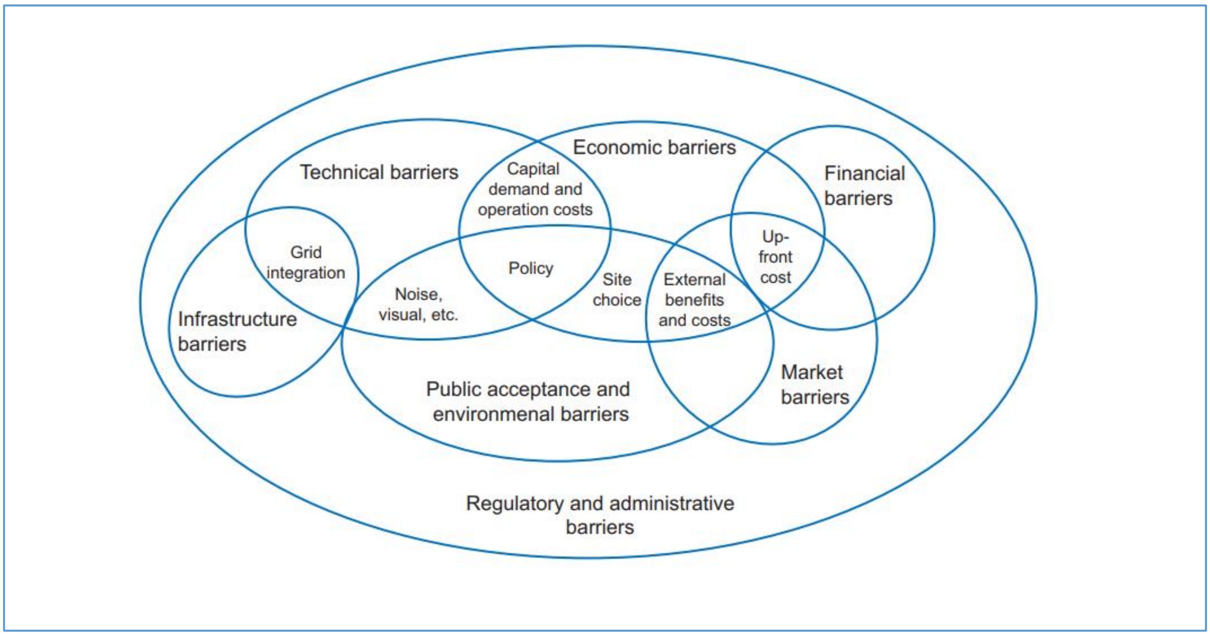

Figure 5.1. Barriers to renewable energy are interlinked.

Source: International Energy (2011:86)

5.2.1 Financial risks

This study revealed that the main financial risks in the South African context are market risks, inflation risks, interest rate risks, and liquidity risks. About 41.7% of the respondents who do not own solar technology believed that all the financial risks limited them from entering the market hence they decided not to invest in renewable energy technologies. About 33.9% strongly agreed that all the financial risks, together with market risks, were a deterrent to investments in solar technology**.** These findings resonate with the economic theory which predicts a positive link between risk and return

(Egli, 2020). Similarly, studies by Waissbein *et al.*, (2013) corroborate these as their assertion is centred on the economic theory. Egli (2020) identified barriers to RE investments which include curtailment risk, policy risk, price risk, resource risk, and technology risk. Egli elaborates that these listed risks outweigh the financial risks, and more focus should be on de-risking these mentioned risks. An interesting dimension was brought by UNFCCC (2018) which provides an additional dimension suggesting that exposing climate-related risks to the world will influence investors to: shift away from carbon-intensive assets and drive into low carbon opportunities, and value low carbon investments.. The latter emerges as one of the key driving pinnacles shaping the global agenda on climate mitigation (Sweerts, Longa, and van der Zwaan, 2019); in particular climate finance and its bearing on the energy sector. The last decade has witnessed a surge in the drive towards renewables in South Africa revolving around the Green Economy (Department of Environment Forestry and Fishery, 2020). Thereafter, the just energy transition (Bridle, Schmidt and Geddes, 2022) has followed, witnessing some of the topical issues which include re-purposing of coal-fired power stations (Scholtz *et al.*, 2017).

5.2.2 Market Risks

Market risks were confirmed by 58.8% of the respondents as a factor in determining investments in RETs. Within the South African context, Eskom is the national utility or state-owned energy entity with the mandate to produce, distribute, and supply energy to the nation. The state-owned entity has a monopoly over the electricity sector. If the entity has no political will and incentives to support RE, this poses a major barrier to the proliferation of RE. South Africa's existing and potential coal supply chain's disruptions has an inherent net effect on Eskom's coal-fired power stations (Hanto *et al.*, 2021). The reluctance by Eskom to sign PPAs is a red flag to adoption of RE investments (Lawrence, 2020).

Eskom's failure to meet the energy demand and its continued bail out from the national fiscus reflects the dire financial situation, which partly explains its reluctance to sign PPAs thus constraining the prospects of RE investment. The market for REin South Africa is underdeveloped due to high dependence on fossil energy. This environment presents high volatility and poses a great risk (Nel, 2015). Other respondents flagged the concern that investments in RETs may result in higher energy prices and pose a threat to economic growth and poverty reduction goals in South Africa. This is a confirmation of the Kuznets Curve which supports the relationship between economic development and environmental quality (Dasgupta *et al.*, 2002). Another market risk posed by the respondents was the structure of the markets in South Africa. Service delivery was a concern due to municipalities not performing, because markets are divided according to municipalities in terms of distribution.

5.2.3 Return on Investment

The profitability risk was a determining factor in investment in RETs. About 41.7% of the respondents acknowledged that the reason for not investing in RETs is that they do not see how they will generate profit from it. The main driving factor being financial viability, with factors such as high capital costs, price of products, tax benefits, grants, subsidies, and foreign currency risk. In South Africa, lack of fossil fuel energy investments to pay externalities make the RETs investments less competitive, and hence low returns on investment. Default risk poses a huge risk in return on investment, as the off takers are free riders as they do not make monthly payments required.

Respondents mentioned currency risk as one of the factors affecting return on investment. This came as a result of the costing of the systems specification done months before the system is purchased or installed. Because the technology is imported, the exchange rate affects the cost of the system over time. Contrary to this perception, farmers in West Midlands in the UK see RETs as a diversification for income streams (Bergek and Mignon, 2017). A substantial number of farmers in this region embraced RETs to diversify farm income from the general agricultural business. Macro-economic indicators such as inflation have also been explored. Inflation risk was a determining factor in investment in Renewable Energy Technologies' (RETs). About 41.7% of the respondents agreed that general increase in price affect return on investment.

5.2.4 Level of education and Income

Knowledge of renewables together with income levels was deemed to be a determining factor for residents to invest in renewable technologies. A total of 58% of males and 42% females had knowledge on the renewable technologies. Equally, the level of education was proportional to general income levels. The results also showed that lack of knowledge and low-income levels pose a risk to RE investments in South Africa. This has been echoed by Ting and Byrne (2020). Other studies by Charles (1979) and Bergek and Mignon (2017) support this finding that lack of knowledge is a risk to Rets Income. Status, age, and policies also pose as a risk to investment in RETs, this is supported by literature (Parkinson *et al.*, 2022; Ongan *et al.*, 2009; Vasseur and Kemp, 2015). This assertion shows that only 9.2% of the respondents with primary qualification owned RETs, compared to 43.1% with college qualifications and better income.

Closely linked to these, other studies have shown that lack of information and expertise in low-carbon assets impacts heavily on renewable investments (Nelson and Pierpont 2013; Kaminker and Steward

2012; Della Croce, Kaminker and Stewart, 2011). Other scholars further argue that there is need to develop liquid financial instruments to match investors preferences (Granoff, Hogarth and Miller, 2016); Nelson and Pierpont, 2013; Kaminker and Steward, 2012).

5.2.5 Policy environment

Findings of this study posit that a good policy environment is critical for successful REtransition. A plethora of literature strongly agree that lack of a supportive policy framework, incentives, and market-based instruments have a heavy bearing in attracting private capital for low-carbon transition (Polzin 2017; Granoff, Hogarth and Miller, 2016; Fabian, 2015; Jones, 2015; Nelson and Pierpont, 2013; Kaminker and Stewart, 2012; Della Croce, Kaminker and Stewart, 2011). Essentially, the pertinent investment policy framework and incentives are of paramount importance in convincing investors, with expected returns and profitability (Polzin *et al.*, 2019). Investment portfolios such as pension funds pose a significant barrier since they have a minimal figure of not less than €100 million, in the case of Europe (Nelson and Pierpont, 2013; OECD, 2016). Such barriers are in line with second domain Efficient Market Hypothesis (EMH) logic. The Efficiency Market Hypothesis 'is a theory in which investors have perfect information and act rationally in acting on that information' (John L, 2017-4)

Inconsistent policies have posed a risk to the development of RE investments. About 50.8% of the respondents do acknowledge that there are policies set by government which encourage REinvestments. However, 48.2% feel these policies are not consistent. As an example 'the Department of Mineral Resources and Energy in South Africa is driving new coal venture investments, including clean coal technologies, underground coal gasification, and carbon capture and storage, demonstrating a continuing commitment to coal as a source of primary energy' (Bridle, Schmidt and Geddes, 2022). Additionally, the edge to further investment in gas by the government may indeed be viewed as inconsistent with a low-carbon transition agenda. Some of the investments in gas in fields span beyond the borders to Mozambique and Namibia (Yelland, 2020). Though the aim is to address load shedding challenges currently faced by the country, this will see renewable technologies making more expensive bids in such auctions and making them uncompetitive on the market. Another school of thought is the drive towards building an effective energy mix for the country(Kaggwa, Savious and Nhamo, 2013) , which inherently promotes all forms of energy supply in order to meet the national energy demand. This school of thought has been supported by the Minister of Mineral Resources and Energy who said at the National Energy Dialogue that 'the lion share of new energy generation capacity being developed by IPP between now and 2030 includes 14

400MW to wind; 6 000MW to solar, 2 088MW to battery storage and 2 500MW to hydropower projects and a commitment to procure more energy through additional RE under bid Window 7, on a six months interval'.

5.2.6 Subsidies

The South African government has controversial energy subsidies. Currently the government of South Africa has spent ZAR56 billion bailout on production of fossil fuel energy through Eskom (Bridle, Schmidt and Geddes, 2022).The free basic electricity subsidy has increased significantly, costing the tax payers ZAR11.65 billion. The country energy subsidies are heavily biased towards fossil energy. A lion's share on fossil fuel subsidies tends to have a ripple effect on the consumption of fossil fuels, which in turn increases high carbon emissions. Such drives derail the diffusion of RE technologies in the country. The reporting linked the emissions and the carbon disclosure with an implication on targets of the Sustainable Development Goals. By eliminating fossil fuel subsidies, South Africa's carbon emissions might drop by over 3% by 2030, according to modelling by the International Institute for Sustainable Development (United Nations, 2021).

5.2.7 Government responsibility

Perception on responsibility of the government to manage climate change poses as risk to investment in RETs. From the study, 84.4% of the respondents strongly feel that it is the responsibility of the government to manage climate change, while 19% strongly feel it is the responsibility of the public to manage climate change. There is an element of truth from the respondents because the situation on the ground shows that the government of South Africa relies on Fossil fuels as an important source of revenue. It raises its revenue by imposing taxes on fossil fuel consumption. Total revenue generated in the fiscal year of 2019-2020 was ZAR100.5 billion (Bridle, Schmidt and Geddes, 2022). Comparing with other members of the BRICS, South Africa's revenue proportion is at par with Brazil, and is even higher than China (Bridle, Schmidt and Geddes, 2022).

It is a risk, too, if people do not take ownership to participate in climate mitigation through renewables. Behavioural economics (Earl, 1990) has shown that individuals tend to imitate fellow human beings' behaviour. If at that point, like respondents in this study feel, it is not their call to participate in renewables investments, which then tends to have a ripple effect on other individuals too.

Once a certain method is established as a rule, it remains in effect because we prefer to follow the rule given the assumption that others will follow it (Kelman, 1958, p. 53). With Mpumalanga being a coal producing province, it is a possibility that local residents do not see the need to take ownership on opting for renewables. This confirms Young's school of thought on norms. A view of treating risks from renewable investment like other financial risks, rather than viewing them simply as a corporate social responsibility issue, would not satisfy financial risk standards (Campiglio et al., 2018). This has been evidenced in the UK banking system, where an oversight of the financial risks from RE investment and overarching responsibility for paving strategy, and risk appetite is beginning to be considered at board level (Khamis, 2022).

5.2.8 Technology efficiency

Perception on durability of RETs poses a risk to RE investment. Findings from the study show that 83.5% of respondents strongly agree that the technology is durable and efficient. In the climate of the current loadshedding in South Africa, such findings promote renewable technologies. However, high initial costs in investments of RETs has been sighted as a risk. This is shown by 50.8% of the respondents who indicated that they invested more in buying the solar technology compared to a low maintenance cost of 6.2%. Such findings confirm studies done by Sen and Ganguly (2017) who cited market failures as risks towards investment in RETs. Market failures are caused by human activities, they can bring external benefits or external costs. The external costs cited by Sen and Ganguly (2017) included high initial investment costs which make it unaffordable to aspiring customers, especially in developing countries. Such findings support the Force Majeure theory as well as man-made damages, as this is easily compromised by external factors like extreme bad weather conditions. Acts of crime can act as a deterrent to efficiency of technology. However, this could be avoided by making use of third-party insurance to mitigate such risks.

Reduction in efficiency was cited as a risk in investing in RETs by the respondents. Of those who own the RETs ,65% of them cited a sudden increase in demand for use of the technology, poor installation of RETs, weather conditions, and component failure reducing operation efficiency as most of these have a maximum capacity. Such findings confirm studies by Sen and Ganguly (2017) who also reiterated the reduction in efficiency due to the same conditions.

5.2.9 Private sector drive

Of the 65 institutions that answered, 50.8% acknowledged that neither the institutions nor any specialized departments are managing any programs related to RE initiatives. The tax benefits of Section 12B, which allows for an expedited write-off of the asset of 100% in the first year for solar PV energy of less than 1MW and promotes investment in distributed RE installations, are acknowledged by institutions. However, some responses criticized the absence of legal incentives to encourage the private sector's purchase of RE. The lack of an electricity wholesale market and clear laws, the respondents continued, prevents businesses from obtaining external debt financing from regional commercial banks, because only debt will be provided by external debt funders. Proposals suggested by the researcher to improve this situation include:

- Financing options that fill the upfront infrastructure financing gap and enlist creditworthy third parties as infrastructure owners or operators who then enter into long-term agreements with end customers.
- Transfer of risk through use of guarantees as this improves the risk return profile of private sector investment.
- Provide incentives such as outcome-based grants, highly concessional loans to financial institutions to innovate and scale funding for projects such as Energy Efficiency, and Climate Smart Agriculture.

5.3 Reflection on South Africa's renewable energy policy landscape

5.3.1 South Africa's renewable energy policy landscape as a response to Global Agenda

As part of the country's contribution to the Paris Agreement, the government of South Africa is aiming to have low carbon use by 2050 (Climate Action Tracker, 2020). A commendable action was the signing of the Round 4 of the REIPPP Scheme (Todd *et al.*, 2019). Further efforts have been shown through the draft 2018 IRP, which incorporated the NDC objectives setting out clear targets of renewable capacity. Such efforts are indeed a response to the global agenda towards clean energy (Averchenkova, Gannon and Curran, 2019). In line with the Paris Agreement, the NDC has made efforts to reduce emissions to below BAU levels (Climate Action Tracker, 2020).

5.3.2 The renewable energy policy environment in South Africa changes over time

Findings of this study have showed that the energy policy landscape for South Africa has evolved over the last two decades, as illustrated on Figure 5.2. The policy landscape has witnessed a huge transformation in the energy sector, even though coal remains the dominant feedstock for the energy sector.

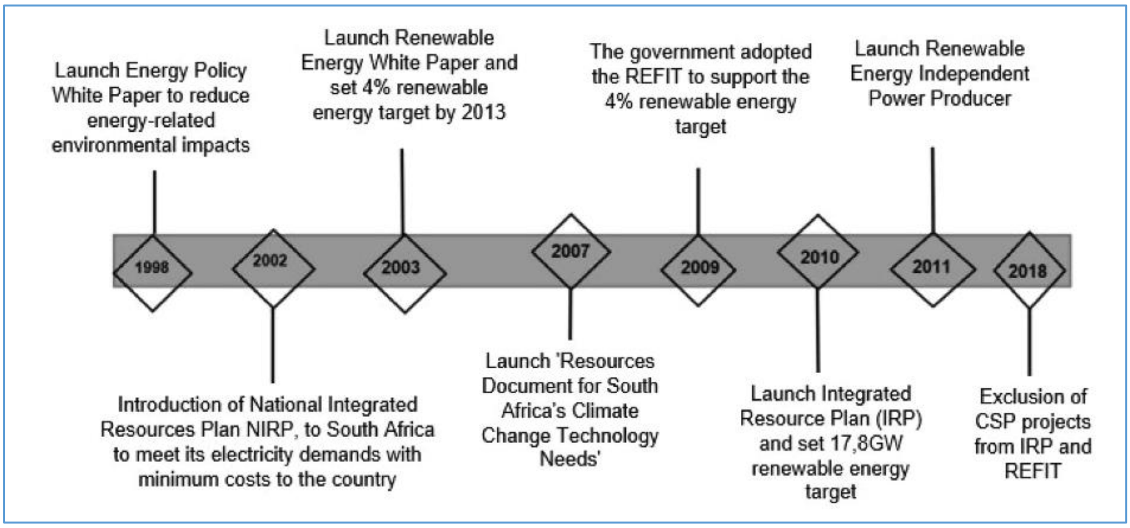

Figure 5.2. Historical overview of key support schemes for renewable energy niches in South Africa

Source: Mirzania, Balta-Ozkan and Marais (2020:8):

Figure 5.2 shows the historical overview of key support schemes for RE niches in South Africa, starting with the launch of the White Paper 2018. Not much progress was made in renewables, high capital costs were a major deterrent (Winkler, 2005). Another policy, the National Integrated Resources Plan (NIRP), was launched in 2002 with the aim to meet increased demand in energy (Nakumuryango and Inglesi-Lotz, 2016); However, this policy did not focus specifically on the renewables and as a result the NIRP did not contribute positively to renewables. In 2003, a White Paper on RE was launched with a target of contributing 4% towards energy by the year 2013 (Cuma and Koroglu, 2015). This later saw the launching of the Integrated Resource Plan with a set target of 17.8GW being generated from renewables. Though this proved to be a promising and noble idea, the enthusiasm was not backed up by policies or resources. The bold step of replacing the REFIT scheme with the REIPPP paved way for independent power producers (IPPs) to actively contribute in the operation of large scale renewable production (Peters, Marcol Lotz, 2014). Evidence of the seven CSP projects is attached in Annexure B and can be hailed as a success of the REIPPP policy in the country.

More groundwork was done to improve the REIPPP policy and this saw the improved revised version in 2018 (Larmuth and Cuellar, 2019). The shortfall to this policy was the incorporation of Eskom when it back-tracked from the CSP project as previously planned, resulting in the impediment of CSP projects (Craig *et al.*, 2019).

The Just Energy Transition (2020) asserts that South Africa is in the right direction in establishing policies and programmes that promote RE. Re-purposing ageing coal power stations towards RE is a sign of a drive to lower carbon use in South Africa.

5.3.3 Challenges facing the renewable energy policy landscape in South Africa

Lack of strategic and consistent funding schemes can be cited as a challenge to development of renewables in South Africa. Essentially, most implementation models have been backed by revenue payments only. This has failed to lure sufficient local financial institutions and local companies to invest in RE options. In countries such as the United States of America, schemes included both loan guarantees and revenue payments (Mirzania, Balta-Ozkan, and Marais, 2020). Heavy reliance on coal in South Africa's energy landscape remains a huge threat to renewables (Lawrence, 2020). This is reinforced by strong organised labour unions and political power in the mining industry which views the shift from coal as a threat to the labour market. Unions, such as the National Union of Mineworkers (NUM), are the largest affiliates to Congress of South Africa Trade unions (COSATU) (Todd and McCauley, 2021). In countries such as Australia and Germany, organised unions in mining industries had the similar predicament (Crowley, 2017); however, they eventually gave up when they were obliged to phase out coal mining (Renn and Marshall, 2016).

Social unrest during high unemployment is a threat to investment of renewables in South Africa. This is evidenced by the effects felt when the Glencore Coal Mine in Mpumalanga was closed in 2015. A massive loss of 1 000 jobs plus 500 contractor posts resulted from this closure of the coal mine (Renn and Marshall, 2016).

CHAPTER 6: RECOMMENDATIONS AND CONCLUSION

6.1. Recommendations

The study has presented critical and detailed information about the policies and instruments that de-risk renewable energy investments towards a low carbon use. The success of promotion of renewable energy will be made possible by fixing the current environmental factors that are deterring RE investment as discussed in great detail below.

i. Legal separation of Eskom helps better the governance and financial position of some of the restructured entities. This will allow RE procurement and significantly lower institutional incentives that promote existing coal-based generation over new RE. Eskom as a monopoly player to energy in South Africa poses a risk to development of RE , as cited in the study. The separation and distribution were expected to be completed by December 2022 (Parliamentary Monitoring Group, 2021).

ii. Another factor is the transformational program, allowing the rebirth of Eskom to participate in RE investment and reduce its high dependence on high-carbon energy(Bridle, Schmidt and Geddes, 2022). This de-risks the over-dependence on coal as main source of energy. A step in the right direction is Eskom seeking finance for a major clean energy investment program (Sguzazzin, 2021) with plans to invest over ZAR106 billion in a bid to transition away from coal. The plan sought to apportion ZAR61,75 billion investment towards wind energy and ZAR44,25 billion in solar energy. This study thus recommends the need to support and amplify such initiatives.

iii. Bailouts should be tied to the energy transition. This move will give RE investments a chance in an environment that is heavily fuelled by coal. A negotiating deal of $8.5 billion in climate grants as announced in 2021 during the COP26 Climate Summit in Glasgow will bring dawn to RE investments. More details to this deal and other developments were being discusses during COP27 in Egypt towards the end of 2022 when this write up was in progress. A deal was to be negotiated between South Africa and a group consisting of United Kingdom, United State of America, France, Germany, and the European Union.

iv. The status quo shows that the government has heavily bailed out the current energy utility, Eskom. There is clear evidence that the government is locked in fossil fuel production and indirectly subsidising untargeted consumers’ electricity subsidies. Even though bail-outs have good intentions, they fail to show the true price of electricity from fossil fuel, which may give the impression that fossil fuel energy is cheaper than RE (Bridle, Schmidt and Geddes, 2022). Adding bailouts to utilities in production of renewables can see a transition to low carbon use.

v. Carbon Tax mechanism: Effective carbon tax implementation across the economy will bring a revenue stream to the government, which in turn can be channelled to renewable energy investments. The proposed review of carbon tax due to start in 2023 will eliminate the fossil fuel subsidies and be in line with the ERP principles (Golden, 2022).

vi. Right Policy Settings

A fine tune to investments targets by the government can see the country being able to generate cheaper electricity from RE on a levelized cost basis. This has not been possible with South Africa. Government has the authority to share resources, decide national strategy, and pass legislation (Gumede, 2008). To improve policy delivery, Sy and Copley (2017) argue that regulatory practices are multipliers to policy delivery.

6.2. Study limitations

The study identified the following gaps: role played by trade unions in protecting a heavily fossil-fuel based country, liberating free trade of renewable technology in the country, more studies on knowledge of renewables in different sectors including curriculum offered in tertiary institutions and even high schools, more studies on adoption on renewables by investors without financial risks being the main determinant factor, and more reviews on countries that heavily subsidised renewable in an environment which is currently dominated by fossils.

The researcher would like to acknowledge that tackling such a broad topic using a district to collect evidence could be a great limitation and would highly appeal for future studies if funding and time permits to cover a large portion of the country to enhance outcomes of the studies.

6.3. Conclusion

The study has interrogated a plethora of barriers to RE in a bid to de-risk these towards a low carbon investment within the context of an emerging economy such as South Africa. The analysis depicted that the current reliance on fossil fuel, in particular coal, has overshadowed the focus on development of renewables. As fossil favoured policies outweigh those of renewables policies, lack of incentives to promote individuals to meet the high cost of investing in renewables has affected the promotion of renewables. De-risking such barriers will go a long way in moving the country to a low carbon use. Several recommendations have been proffered to de-risk renewable energy investment towards a low carbon development pathway in South Africa.

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ANNEXURES A

Please answer the relevant questions
There are no right or wrong answers.

SECTION A: GROUP A HOUSEHOLDS AND INSTITUTIONS THAT USE RENEWABLE TECHNOLOGY
RESPONDED BACKGROUND INFORMATION: Tick relevant box

GENDER:

GENDER	**YES**	**NO**
MALE		
FEMALE		

AGE GROUP:

AGE GROUP	18-30	
	31-40	
	41-50	
	51-60	
	60+	

INCOME:

INCOME IN RANDS	Less than 10000	
	10000-20000	
	21000-30000	
	31000-40000	
	Above 40000	

EDUCATION:

EDUCATION	ILLITERATE	
	PRIMARY	
	HIGH SCHOOL	
	COLLEGE	
	GRADUATE	

OCCUPATION:

OCCUPATION	GOVERNMENT	
	SELF EMPLOYED	
	TECHNICAL	
	FARMER	
	OTHER	

Renewable Energy Awareness

1. **Do you know the difference between Renewable and Non-Renewable? Tick appropriate box**

Yes	
No	
Do not know	

2. **Please rate how strongly you feel each one of the following is responsible for the climate change and its effects today on a scale of 1 to 5**
   a) **Public**

Not at all Responsible	**1**
	2
	3
	4
Highly Responsible	**5**

   b) **Government**

Not all Responsible	**1**
	2
	3
	4
Highly Responsible	**5**

   c) **Business and Industries**

Not at all responsible	**1**
	2
	3
	4
Highly responsible	**5**

   d) **Nature itself**

Not at responsible	**1**
	2
	3
	4
Highly responsible	**5**

3. Please answer "YES" or "NO" to the following questions.

	Do you have solar technology?	YES	NO
If YES to the above. What is it for?			
	Lighting	YES	NO
	Water Heating	YES	NO
	Cooking	YES	NO
	All		
	Any Other		

4. For how long have you been using the technology?

At least one year	**1**
2 – 3 Years	**2**
4 – 5 Years	**3**
6 – 7 Years	**4**
8 Years and Above	**5**

5. Is cost a factor when considering buying solar technology?

Very Unlikely	**1**
Unlikely	**2**
Low Likely	**3**
Medium Likely	**4**
Highly Likely	**5**

6. Financial Assistance

Did you receive any government subsidy when you purchased your Solar Technology?	YES	NO
Did you receive any Grant or support from any Institution to install solar technology?	YES	NO
If YES to receiving any form of support on b) Please specify……………………………………………………………………………………….		

7. How likely will you use solar technology compared to power from fossil technology?

Very Unlikely	**1**
Unlikely	**2**
Low Likely	**3**
Medium Likely	**4**
Highly Likely	**5**

8. **Considering your complete knowledge of renewable energy specifically solar and its benefits, how likely would you recommend your friend or stakeholders to start using solar technology**?

Very Unlikely	1
Unlikely	2
Low Likely	3
Medium Likely	4
Highly Likely	5

Barriers and Opportunities

9. **In your opinion what are the key barriers to the use of solar technology?**
Please rate the following on a scale of 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree

Financial Constraints	1	2	3	4	5
Knowledge on the use of Solar	1	2	3	4	5
Resistance to Change	1	2	3	4	5
Socio technical Perceptions such as durability, efficiency and safety	1	2	3	4	5
Maintenance costs	1	2	3	4	5

10. **What was your initial investment cost on Solar technology in the house? Tick appropriate box**

0-5000	
6000-10000	
11000-20000	
21000 to 30000	
+30000	

11. **What is your average annual maintenance cost per annum? Tick appropriate box**

0-5000	
6000-10000	
11000-20000	
+21000	

12. **What challenges if any may you have faced since the adoption of Solar Technologies. Tick appropriate box**

Inability to meet sudden demand of energy	YES	NO
Poor weather conditions reduce efficiency		
Component Failure results in inability to generate energy		
Any other specify		

SECTION B: GROUP B FINANCIAL/UTILITY/DISTRIBUTING INSTITUTIONS

Please rate the following on a scale of 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree

13. Please answer "YES" or "NO" to the following questions.

12.1	Does renewable energy have a dedicated division or unit?	YES	NO
12.2	Do you have any programs in your company that focus on renewable technology?	YES	NO
12.3	Is there any funding designated for enforcing the use of renewable energy?	YES	NO
12.4	Do you favour taking the lead in advancing innovation in renewable energy?	YES	NO
12.5	Do you believe that the private sector has a significant impact on the development of renewable energy?	YES	NO
12.6	Is there a policy for renewable energy in South Africa?	YES	NO

Please rate the following on a scale of 1=strongly disagree, 2=disagree, 3=neutral, 4=agree and 5=strongly agree

14. The most likely reason to adopt renewable technologies

13.1	Providing access to energy	1	2	3	4	5
13.2	Creating employment opportunities	1	2	3	4	5
13.3	Reducing the cost of energy imports	1	2	3	4	5
13.4	Prolonging the lifetime of coal base	1	2	3	4	5
13.5	Reducing carbon emission to mitigate climate change	1	2	3	4	5

15. Barriers of the implementation of renewable energy:

15.1	Do you believe there are obstacles preventing the use of renewable energy?	1	2	3	4	5
15.2	Do these obstacles result from laws or regulations?	1	2	3	4	5
15.3	Are these obstacles a result of a lack of funds?	1	2	3	4	5
15.4	Do you believe these obstacles can be lessened and the deployment of renewable energy can be accomplished if the government works in collaboration with the private sector?	1	2	3	4	5

15.5	Do any statutory requirements conflict with your institution's ability to implement renewable energy?	1	2	3	4	5

16. To what extent do you rate the following as financial barriers for renewable energy?

16.1	Market Risk	1	2	3	4	5
16.2	Inflation Risk	1	2	3	4	5
16.3	Interest Rate Risk	1	2	3	4	5
16.4	Liquidity Risk	1	2	3	4	5
16.5	Other Financial Risk (name)	1	2	3	4	5

17. To what extent do you rate the following as renewable energy investment incentives?

17.1	Tax Rebates	1	2	3	4	5
17.2	Subsidies	1	2	3	4	5
17.3	Resource Insurance	1	2	3	4	5
17.4	Other Incentives(name)	1	2	3	4	5

18. Renewable Energy Market Opportunities

18.1	Do the laws, rules, and policies make it easier to enter the market for renewable energy sources??	1	2	3	4	5
18.2	Are the price structures for renewable energy favourable?	1	2	3	4	5
18.3	What technological tools are available to support energy storage before it is utilized or sold?	1	2	3	4	5
18.4	Are there any programs in place to enhance capacity for market opportunities?	1	2	3	4	5

19. Technology Development: Do you import, manufacture or source locally your energy technologies?

Import ☐ Manufacture Local ☐ Local ☐

20. Do you think the Country have adequate knowledge and expertise to manage the available resources?

YES	
NO	
I DO NOT KNOW	

21. . Do you think labour movements have a bearing on the spread or diffusion of renewable technologies? Select appropriate box

YES	
NO	
DO NOT KNOW	

22. What advice can you propose that will help reduce renewable energy barriers?

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23. Any Additional Comments

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Thank you very much for your time!