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RESEARCH REPORT

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Research Topic: Investigating Criteria and Indicators to Assess the Sustainability of Renewable Energy Supply in South Africa.

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1 INTRODUCTION

Historically, according to Gunnarsdottir, Davidsdottir, Worrell and Sigurgeirsdottir (2020), energy was perceived narrowly in terms of pollution and air quality. Things have progressed, and energy is now regarded as a critical enabler of social and economic growth and sustainable development. As a result of the more progressive understanding of energy, energy problems are no longer seen in isolation but rather in combination with other growth challenges. In their energy for sustainability guidelines and methodologies of 2007, International Energy Agency (IEA, 2007) describes energy as a means to an end, which highlights four areas; a) a clean and safe environment, b) sustainable economy, quality of life, and people's health.

IEA (2007) further indicates there is no good or bad energy source (renewable and non-renewable). Therefore, the benefit is derived from the energy source being able to deliver the end product. The wider interpretation of energy and its cross-cutting influence emphasises its significance and multidimensionality (Gunnarsdottir et al., 2020).

Depending on how energy from coal is processed, transported, and used, it could contribute to environmental degradation, climate change, and human health (IEA, 2007; Petinrin & Shaaban, 2015; Khan, 2020). Burning fossil fuels has been found to induce urban air emissions, regional acidification, and the possibility of climate change (IEA, 2007). According to Mathu (2014), the fossil fuels list includes "coal, natural gas, and fuel oil." Coal emits the most emissions (Mathu, 2014). A sustainable energy sector allows the country and the entire world to participate in economic and social activities by balancing production and energy use with no or negligible effects on the environment (Wang, Jing, Zhang & Zhao, 2009; Oke, Ibrahim & Bokana, 2021).

Many countries worldwide have embraced Renewable Energy as an alternative to fossil fuels (Armin Razmjoo, Sumper, and Davarpanah, 2020). Holt and Pengelly (2008) define Renewable Energy as "energy sources that are continually replenished by nature like the sun, the wind, water, the earth's heat, and plants. Renewable Energy technologies turn these fuels into usable forms of energy, most often electricity, but also heat, chemicals, or mechanical power." Renewable Energy options such as solar, wind, geothermal, hydroelectric, and ocean energy are sustainable options because they are available, non-replenishable, and proper for use (Armin Razmjoo et al., 2020). Renewable Energy is also considered clean and essential for sustainable development (Manso & Behmiri, 2013; Vanegas Cantarero 2020).

The energy structure is complex to understand because of its dynamic relationships with the dimensions of sustainable development (Narula & Reddy, 2015). It is because of the role energy plays in the social, economic, and environmental activities of sustainable development (Owusu and Asumadu-Sarkodie, 2016; Cîrstea, Moldovan-Teselios, Cîrstea, Turcu & Darab, 2018; Muniz et al., 2020; Oke et al., 2021).

1.1 Sustainability Assessments

Sustainability attempts to create dynamic and overlapping equilibrium between ecological, social, and economic subsystems (Wang et al., 2009; Lui, 2014; Gan et al., 2017; Cîrstea et al., 2018; Khan, 2020; Muniz et al., 2020). Measuring sustainability is not a simple task. Sustainability evaluations demand the use of several Criteria and Indicators to shape composite indexes to capture the scope of sustainability (Gan et al., 2017). They serve as a framework for learning about society, the economy, the environment, institutions, technology, and how these areas interact (Liu, 2014). According to Wang et al. (2009), assessing sustainability is a prerequisite for selecting the best or healthy alternatives and detecting a non-sustainable energy supply system's integrated performance by monitoring social impacts. Mendoza and Prabhu (2003) define Criteria and Indicators as "tools used to collect and organise information in a manner that is useful in conceptualising, evaluating, implementing, and communicating sustainability."

Criteria and Indicators provide information in a politically neutral way and contribute to joint discussions between government and people on the meaning of sustainability and establishing common policy goals (Muzin et al. 2020). Criteria and Indicators must be consistent with sustainability principles to track progress and assess and report the pervasive impact on policymaking (Liu, 2014). They also offer a view of the system, including interconnections and trade-offs between different aspects of sustainability and the longer-term effects of choices and decisions (Iddrisu & Bhattacharyya, 2015; Muzin et al., 2020). They could also measure or indicate desirable or undesirable results or define or provide helpful information on energy usage (IEA, 2007). Other benefits include explaining energy issues to decision-makers and the public. It also transforms simple statistical information to understand better the problem or dimension (Iddrisu & Bhattacharyya 2015). Lastly, Criteria and Indicators highlight the strengths and weaknesses of energy supply (Cîrstea et al., 2018). It is, therefore, appropriate that the indicators identified are appropriate for the intended assessment (Armin Razmjoo et al., 2020).

1.2 Problem Statement

Criteria and Indicators used to assess the sustainability of Renewable Energy, and its technologies differ from study to study. Many studies use the social, economic, environmental, and technical dimensions of sustainability in their assessments. Some scholars include institutional dimension (Cîrstea et al., 2018; Muzin et al., 2020), or political (Naicker & Thopil, 2019), or resources (Ghenai, Albawa & Bettayeb, 2020). Indicators on the various dimension of sustainability differ vastly.

South Africa's energy mix is dominated by low-cost domestic coal usage in the electricity generation sector. The use of coal for electricity generation results in 45 percent contribution to South Africa's greenhouse gas emissions (Ndlovu & Inglesi-Lotz, 2020). SA's heavy dependence on coal as a primary energy source for consumption and development renders it one of the world's most significant contributors to net greenhouse gas emissions. According to Strambo, Burton and Atteridge (2019), South Africa has enough coal for the next 50 years. Coal produces 92 percent of the country's energy and nearly 20 percent of liquid fuels. It is unlikely to change drastically in the next two decades due to a shortage of viable coal alternatives (Strumbo el al., 2019).

South Africa (SA) and many other countries committed to global initiatives to mitigate adverse environmental impacts of coal usage by introducing Renewable Energy to the energy mix. South Africa committed to a target of 70 to 85 percent of its electricity supply from Renewable Energy by 2050, thus the driving force for Renewable Energy's growth (Oke et al., 2021; Nkoana, 2018). South Africa's Integrated Resource Plan (IRP), published in 2019, placed a target of 24 379 Megawatt (MW) of Renewable Energy installed and in operation by 2030.

Sanderink (2020) found the deployment of Renewable Energy slow because of potentially conflicting energy access goals linked to socio-economic needs being the focus and not climate change. According to Owusu and Asumadu-Sarkodie (2016), factors like costs of technology, price of energy supply, politics, and market dynamics become obstacles discouraging developing countries from using Renewable Energy. In South Africa, Pegels (2010) says diffusion of Renewable Energy highlighted that the gap between policy and implementation is wide. The focus is not on environmental concerns but on financial. As a result, Renewable Energy will fail to reduce greenhouse gas emissions and meet South Africa's social needs. Kruba & Burch (2011) also found that concerns over the economy overpowered any benefits of Renewable Energy rollout. The cost of Renewable Energy and its environmental impact dominates the debate, and little focus is given to Renewable Energy's impact on welfare.

Moyo, Dingela, Kolisi, Khobai and Anyikwa (2017) studied the relationship between Renewable Energy consumption and employment in SA from 1990 to 2014. The results are that Renewable Energy technologies are more labour intensive compared to non-renewable and increased consumption of Renewable Energy could assist in reducing unemployment. The findings differ from that of Kruba & Burch in 2011, which found that Renewable Energy failed to address socio-economic factors as fewer jobs were created.

Several international agencies have jointly developed energy indicators for sustainable development as an initial basket of indicators to refine and ensure national policy relevance (Suganthi, 2020). National indicators help to assess and monitor sustainability or lack of at a national level (IEA, 2007). According to Cîrstea et al. (2018), indicators become sustainable (or unsustainable) when associated with boundaries, size, or time goals. Mangla et al. (2020) indicated a lack of research on energy sustainability in developing countries, making India an example. Winkler et al. (2017), on integrated assessment of renewable energy potential in rural South Africa, recommended Renewable Energy realization that is based on the dynamic relationship between societal, institutional, environmental, technical, and economic aspects. According to the study, technology must suit the local socio-cultural context.

There are currently no context specific indicators for South Africa to assess the sustainability of the Renewable Energy supply. This study investigates the Criteria and Indicators considering the socio-economic, environmental, and even technical needs and expectations for Renewable Energy supply in South Africa.

1.3 Research Question

The study seeks to answer the following questions:

a) What Criteria and Indicators can be used in South Africa to assess the sustainability of Renewable Energy supply?

b) What are the linkages and interdependencies among sustainability indicators of Renewable Energy supply?

1.4 Research Purpose

The study aims to propose evidence-informed Criteria and Indicators. The Criteria and Indicators will contribute to new knowledge on issues of concern for sustainable energy. In addition, they will assist future academic studies to assess the sustainability of Renewable Energy in South Africa. The linkages and interdependencies may also provide helpful information on the broader impact the indicators might have on sustainability.

1.5 Research Objectives

The objectives of the study are to:

a) Investigate and propose Criteria and Indicators to assess the RE supply's sustainability in South Africa using academic literature.

b) Investigate and present linkages and interdependencies between the various indicators of Renewable Energy sustainability to add to the body of knowledge.

2 LITERATURE REVIEW

The world faces two immediate problems; reducing global warming and enabling inclusive and equitable socio-economic growth (Petinrin & Shaaban, 2015; Vanegas Cantarero 2020). Energy is regarded as a vital factor for fulfilling everyday human needs. Countries that are still developing need more energy infrastructure than those developed as energy is key to sustainable development and poverty reduction. It affects sustainability facets, including livelihoods, access to water, agricultural production, health, population levels, schooling, and gender issues (Manso & Behmiri, 2013; Cîrstea et al., 2018). The United Nations Development Plan calls for all countries to strive for everyone to access affordable, reliable, sustainable, and modern energy (Sanderink, 2020).

Globally, clean energy options are pursued as outstanding alternatives and, by some, as a panacea for a balanced energy future (Oke et al., 2021). A transition to sustainable Renewable Energy systems is considered a possible solution because it is clean, essential for sustainable development, and preserves resources for decades to come (Manso & Behmiri, 2013; Vanegas Cantarero 2020). Renewable Energy plays a crucial role in reducing greenhouse gas emissions but must be technically practical and economically viable to reduce electricity costs (Manso & Behmiri, 2013; Oke et al., 2021).

According to Mangla et al. (2020), emerging economies such as India, Brazil, South Africa, China aims to pursue an energy supply that is secure and inexpensive to achieve economic development. In developed countries, sustainability aims to resolve environmental challenges. In developing countries, socioeconomic problems such as wealth and poverty need discussion while determining the viability of energy sustainability (Mangla et al., 2020). Changes in the energy mix should be achieved in a methodical and structured way, considering future political, socio-economic, and energy grid implications (Bohlmann, Horridge, Inglesi-Lotz, Roos & Stander, 2019).

2.1 Theoretical Framework

Evaluation of Renewable Energy demands the use of several Criteria and Indicators to shape the framework or composite index that captures the scope of sustainability (Gan et al., 2017). Several national and international organisations have developed collections of indicators to assess and analyse one or more sustainable development dimensions since the published Brundtland Study in 1987 (Cavalcanti & Cândido, 2017). Troldborg, Heslop and Hough (2014) indicated that selecting the most effective Renewable Energy technologies for a particular region or location is subject to several overlapping environmental, socioeconomic, and technological requirements. For example, greenhouse gas emissions reduction and non-renewable electricity dependency reduction may come with drawbacks of high cost or a detrimental effect on landscapes or biodiversity. The study suggests that these disagreements and trade-offs are necessary when determining the most sustainable and suitable renewable energy technologies in a given area. Cîrstea et al. (2018) suggest that selecting indicators to provide a complete picture is a problem because of many possible indicators, each merely an abstraction representing a partial story (Cîrstea et al., 2018). Scholars use different methods to develop Criteria and Indicators. Economic, social and environmental is the standard criteria. However, other studies include institutional and technical criteria.

Singh, Murty, Gupta and Dikshit (2009) suggest two primary approaches to sustainability framework and indicator development. They are top-down approach and bottom-up approach. The top-down method begins with a previously generated collection of Criteria and Indicators, adapted and modified by a team of experts or government officials based on the local situation. In the bottom-up approach, local communities participate in the process by suggesting Criteria and Indicators based on their perceptions (Khadka & Vacik, 2012). (Khadka & Vacik, 2012) criticise generic sets of indicators used in the bottom up approach for not considering context and development issues.

According to Dawodu, Cheshmehzangi and Williams (2019), the top-down approach fails to address social aspects of sustainability and considers a bottom-up approach as time-consuming. Dawodu, Cheshmehzangi and Williams (2019) further says that there might be difficulties connecting and interpreting a vast volume of raw data from multiple actors when following the bottom-up approach. This study followed a combined approach taking some aspects of the bottom up and top-down approaches of sustainability framework and indicator development. The experts who participated in this study were not provided with a previously generated list that the bottom-up approach follows. The experts suggested Criteria and Indicators based on their understanding of the context and sustainability. According to the bottom-up approach, the local communities suggest criteria and indicators based on local situation. Literature from various studies is used to evaluate the proposed Criteria and Indicators.

Ghenai et al. (2020) used five sustainability criteria and fourteen sub-criteria (indicators) to assess sustainability, including the ranking of renewable energy technologies. The indicators were obtained from literature and ranked by energy experts.

Ali, Chiu, Aghaloo, Nahian, and Ma (2020) developed a framework to assess energy generation technologies to decide on the best energy mix for Bangladesh taking into account the social, economic, and environmental complexities. The study consulted literature, reports, and energy experts to identify Criteria and Indicators. Ten experts from the energy sector and academia participated in the study.

Suganthi (2020) used a multi-criteria decision model to measure the efficiency of sustainable energy development. The study used natural resources, energy resources, water, land, capital, and national income and considered these as vital inputs for energy sustainability. The output criteria are economic, social, environmental, technical, and institutional dimensions of sustainability. They revealed that indicators continue to change over time, requiring adaptation to the needs of a nation based on the quality of the resources that a country has. The indicators proposed by Iddrisu & Bhattacharyya (2015) were found appropriate for the study and used as output criteria.

Cîrstea et al. (2018) created a composite index to measure the sustainability of Renewable Energy at national level. The proposed index highlights the strengths and limitations of the state in terms of renewable energy. The research proposed twenty-three indicators. The study consulted literature for indicator development, and criteria were considered equally important.

Iddrisu and Bhattacharyya (2015) explored the current energy sustainability monitoring and tracking metrics comprehensively. They found that existing multidimensional indicators do not sufficiently represent the sustainability dimensions. The research suggested a sustainable energy production composite index that focuses on determining the sustainability standard of both intra-and inter-generational needs at the national level. Research added the institutional and technical dimensions to economic, social, and environmental dimensions of sustainability. According to the researchers, the five dimensions provide an excellent description of the sustainability of energy multi-dimensionality and provides a solid starting point for identifying renewable energy access. Eleven indicators were identified through literature and used in this study.

Troldborg et al. (2014) developed and applied a national-scale sustainability assessment of Renewable Energy technologies in Scotland using multi-criteria analysis. The analysis used three criteria and nine indicators with social and economic combined into one dimension. The study used Wang et al. (2009) to formulate Criteria and Indicators. Criteria and Indicators were considered equally important. Contribution to the economy covers the social and economic impacts linked to new employment, new supply chain businesses, new energy industry at Cetera.

Wang et al. (2009) used the Delphi method to develop sustainable energy indicators. The method is structured and involves identifying and engaging a group of carefully selected experts to answer a questionnaire. Experts are advised of the responses from other participants and were allowed to revise their answers, reducing final selection indicators. Scholars used this method for economic, environmental, and social indicators.

Gunnarsdottir, Davidsdottir, Worrell and Sigurgeirsdottir (2020) conducted a review of sustainable energy indicators checking the comprehensiveness and robustness of indicators. Shortcomings identified by the researchers in indicator development include ambiguity in defining sustainable energy development and lack of understanding of specific domestic situations. According to the study, ambiguities in the definitions of sustainable energy development and, by extension, sustainable development, especially in the local context, have hampered efforts to establish appropriate sustainability indicators. The study concluded that although the ultimate objective of sustainable energy development remains the same, the path to it and the obstacles along the way will differ, emphasizing the importance of context-specific indicators. Energy systems differ significantly in size, availability of natural resources, and industrialization, hence the importance of context.

There is no universal set of indicators to assess the sustainability of Renewable Energy supply, both at the project and national level. Even though various studies engage experts, the basis of their criteria and indicator choice and prioritisation of indicators is their experience and knowledge.

Table 1 below reflects some of the Criteria and Indicators available in the literature to assess the sustainability of Renewable Energy. As indicated, the table reflects a vast number of indicators available. A top-up approach, had it been chosen, would have required a template with most of the indicators provided to experts to choose what they consider appropriate. As indicated by Dawodu et al. (2019), context-specific matters might be neglected. The scope of this project covered large-scale projects connected to the National grid. Since these projects do not supply directly to communities, a bottom-up approach would pose some challenges, hence a hybrid approach to indicator development.

Table 1: Authors Summary of Criteria And Indicators From Literature To Assess The Sustainability Of Renewable Energy Supply

Economic	Environmental	Institutional / Resource	Technical	Social
• Total gross electricity generation (Cîrstea et al., 2018) • Primary production of renewable energy (Cîrstea et al., 2018) • Greenhouse gas emissions from energy sector (Cîrstea et al., 2018) • Electrical capacity - Combustible fuels (Cîrstea et al., 2018) • Electrical capacity - Hydro, Wind, Solar (Cîrstea et al., 2018) • Inflation rate (Cîrstea et al., 2018) • Economic growth rate (Cîrstea et al., 2018)	• Stringency of environmental regulation (Cîrstea et al., 2018) • Enforcement of environmental regulation (Cîrstea et al., 2018) • Quality of the natural environment (Cîrstea et al., 2018) • Renewable energy consumption (Cîrstea et al., 2018) • Share of renewable energy in gross final energy consumption (Cîrstea et al., 2018) • Share of renewable in power production (Cîrstea et al., 2018)	• Transparency of government policymaking (Cîrstea et al., 2018) • Government Effectiveness (Cîrstea et al., 2018) • Regulatory Quality (Cîrstea et al., 2018) • Political Stability and Absence of Violence/Terrorism (Cîrstea et al., 2018) • GDP per capita (Cîrstea et al., 2018) • Area intensity (Ghenai et al., 2020 • Material intensity (Ghenai et al., 2020	• Capacity factor (Ghenai et al., 2020) • System efficiency (Ghenai et al., 2020) • Lifetime (Ghenai et al., 2020) • Technology maturity (Ali et al., 2020) • Reliability (Ali et al., 2020) • Efficiency (Ali et al., 2020) • Share of depletable energies (Iddrisu & Bhattacharyya, 2015) • Depletion coefficient of local energy resources (Iddrisu & Bhattacharyya, 2015)	• Availability of latest technologies (Cîrstea et al., 2018) • Affordability of financial services (Cîrstea et al., 2018) • Capacity for innovation (Cîrstea et al., 2018) • Job creation (Wang et al., 2009; • Current installed capacity (Ghenai et al., 2020) • Growth rate (Ghenai et al., 2020) • Company spending on R&D (Cîrstea et al., 2018) • University-industry collaboration in R&D (Cîrstea et al., 2018)

• Capital intensity - construction (Ghenai et al., 2020) • Capital intensity - fuel (Ghenai et al., 2020) • Delivered cost (Ghenai et al., 2020) • Investment cost (Wang et al., 2009; Ali et al., 2020) • Operating cost (Ali et al., 2020) • Cost of energy (Ali et al., 2020) • Net profit cost (Ali et al., 2020) • Per capita consumption of commercial energies (Iddrisu & Bhattacharyya, 2015) • Final energy intensity (Iddrisu & Bhattacharyya, 2015)	• CO2 intensity - construction (Ghenai et al., 2020) • CO2 intensity - fuel (Ghenai et al., 2020) • Noise (Wang et al., 2009; Ali et al., 2020) • Effect on ecosystems (Ali et al., 2020) • Force majeure risk (Ali et al., 2020) • Share of "dirty fuels" in residential energy consumption (Iddrisu & Bhattacharyya, 2015) • Carbon intensity (Iddrisu & Bhattacharyya, 2015) • NOx emission (Wang et al., 2009) • CO2 emission (Wang et al., 2009) • CO emission (Wang et al., 2009)	• Energy intensity (Construction) (Ghenai et al., 2020) • Overall Self Sufficiency (Iddrisu & Bhattacharyya, 2015)	• Overall system conversion efficiency (Iddrisu & Bhattacharyya, 2015) • Potential power generation (Troldborg et al., 2014) • Technology maturing (Troldborg et al., 2014) • Reliability of energy (Troldborg et al., 2014)	• Social benefit (Wang et al., 2009; Ali et al., 2020) • Social acceptance (Wang et al., 2009; Ali et al., 2020) • Political and legal (regulatory) risk (Ali et al., 2020) • Per capita consumption of clean ((Iddrisu & Bhattacharyya, 2015) • Renergies in the residential sector (Iddrisu & Bhattacharyya, 2015) • Income inequality (Iddrisu & Bhattacharyya, 2015)

• Share of productive use of energy (Iddrisu & Bhattacharyya, 2015) • Operation and maintenance cost (Wang et al., 2009) • Fuel cost (Wang et al., 2009) • Electricity cost (Wang et al., 2009) • Net present value (Wang et al., 2009) • Payback period (Wang et al., 2009) • Service life (Wang et al., 2009) • Equivalent annual cost (Wang et al., 2009) • Levelised cost of electricity (Troldborg et al., 2014)	• SO2 emission (Wang et al., 2009) • Particles emission (Wang et al., 2009) • Non-methane volatile organic compounds (NMVOCs) (Wang et al., 2009) • Greenhouse gas emissions (Troldborg et al., 2014) • Impacts on amenity (Troldborg et al., 2014) • Area requirement (Troldborg et al., 2014)			

• Contribution to the economy (Troldborg et al., 2014) • Social acceptability ((Troldborg et al., 2014)				

2.2 South Africa Context

2.2.1 Coal Energy Supply

Coal is a fossil fuel and has long been the backbone of South Africa's electricity supply (Mathu, 2014; Gauché, Von Backström & Brent, 2013). Coal is a non-renewable energy source due to its sluggish forming phase that takes millions of years. South Africa has about 30 408 million tons of coal reserves, ranking sixth in the world. Mpumalanga, the Free State, Limpopo, and the Kwa-Zulu Natal coalfields all have coal deposits (Mathu, 2014). Roya and Schaffartzik (2021) describe the coal complex as consisting: "of land, people, water and air, coal, mines, roads and rails, power plants, transmission lines, and electricity. It also spans institutions and organizations, movements and alliances, values and beliefs."

Coal is the cornerstone of South Africa's electricity grid, responsible for nearly 70 percent of total installed power generating capability. South Africa's energy market has been and continues to be at the forefront of its economic and social development. The sector has a strong effect on the economy because it uses labour and resources to generate electricity. This position is especially critical when economic development and job creation are top priorities in the world (Ratshomo & Ramaano, 2019).

The coal industry is the highest contributor to Gross Domestic Product and the third-largest employer than other domestic mining operations. The industry earnings are approximately R22 billion, with about 92 000 direct employees 70 000 indirect jobs created by the sector. Lastly, the industry created R129 billion in sales, which is 28percent of countries total minerals. The use of coal to generate electricity put South Africa on top of greenhouse gas (CO_2) emitters in the world (Bohlmann et al., 2019; Ndlovu & Inglesi-Lotz, 2020). Due to international commitments to reducing CO_2 emissions, the government plans to reduce coal-fired plants' electricity generation share. The integrated Resource Plan (IRP) is projecting to phase out 11 000MW of coal power generation by 2030 (Bohlmann et al., 2019).

2.2.2 Renewable Energy Independent Power Producers Purchasers Programme (REIPPPP)

The Integrated Energy Resource Plan (IRP) carries out South Africa's long-term electricity generation plan. As outlined in IRP, 2019, the plan aims to: a) maintain the reliability of energy supply, b) minimise the cost of electricity, c) reduce water consumption, d) reducing greenhouse gas (GHG) emissions, while at the same time facilitating policy changes in favour of broader socioeconomic developmental imperatives.
The plan placed a heavy emphasis on economic growth, with goals including achieving a low energy price to promote an internationally competitive market, a more sustainable and efficient economy, local job creation, and meeting climate goals. Also, the IRP outlined proposals for RE deployment and private sector investment in power generation, historically dominated by coal and Eskom (Matsuo & Schmidt, 2019).

In 2011 Department of Energy (DoE) led a procurement process for a variety of Renewable Energy technologies, including Solar Photovoltaic (PV), onshore wind, Concentrated Solar Power (CSP), mini-hydro, landfill-gas, biomass, and biogas, in the framework of an open auction known as the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) (Wright, Bischof-Niemzb, Calitza, Mushwanaa and van Heerden, 2019). The REIPPPP is a competitive bidding process that auctions a pre-determined amount of a variety of Renewable Energy technologies with a pre-determined maximum price limit per technology (Wright et al., 2019). The REIPPPP is developed to secure the needed energy (renewable and non-renewable) in South Africa from the private sector as determined. The minister of energy determines each bid window. Price is the most critical criterion in the adjudication of REIPPPP, accounting for 70 percent (Wright et al., 2019; Bazilian, Cuming and Kenyon, 2020). Successful bidders get a 20-year Power Purchase Agreement (PPA) indexed to Consumer Price Inflation (CPI) (Wright et al., 2019).

Hydroelectricity, solar, wind, biofuel, and geothermal are the major source of renewable energy. While nuclear power is not renewable, it is included in this group due to its low carbon emissions into the atmosphere (Mathu, 2014). According to Aliyu, Modu and Tan (2018), South Africa Renewable Energy targets are “18.2 Gigawatt (GW) of electricity using renewable resources by 2030. It includes 8.4 GW of solar electricity, 8.4 GW of wind electricity, 1 GW of concentrated solar energy, and 0.4 GW from other renewable sources.”

Hydropower is a kind of solar energy obtained indirectly. The sun vapor cycle produces rain, which gradually transforms into rivers to create hydroelectricity. The energy derived from hydro supplies is determined by the topography from which rivers flow (Aliyu et al., 2018). Hydropower is an outstanding energy source capable of providing base-load power (Gauché, Backström and Brent, 2013). It may also generate electricity on a small or large scale (Troldborg et al., 2014; Mangla et al., 2020). Small hydropower is one of the most cost-effective and environmentally sustainable ways to produce electricity (Mangla et al., 2020). The technology is effective and predictable, with the latter being particularly true for conventional and pumped storage hydroelectric schemes (Troldborg et al., 2014). Hydropower projects are critical to renewable energy resources' long-term production (Mangla et al., 2020).

Wind energy is indirectly related to solar energy since the sun's energy drives the temperature pattern and cyclical flow of water vapor and air (Aliyu et al., 2018). South Africa is one of the countries in Sub-Saharan Africa with the best wind prospects, with wind speeds ranging from 7.29 to 9.70 m/s reported in Cape Alguhas via Cape point (Aliyu et al., 2018). South Africa has the potential to become the continent's leading wind power producer, with a wind power production potential projected at 80.54 Terawatt-hour (TWh) with an installed capacity of approximately 30.6 GW (Olatayo, Wichers & Stoker, 2018). The total capacity of wind farms built in South Africa is 2078 MW, with a further 840.9 MW under construction with the largest wind farm in South Africa with 148 MW at Nxuba. South Africa's installed wind power is around 40 percent higher than its solar energy potential (Mostafaeipour et al., 2020).

Photovoltaic (PV) and Concentrated Solar Power (CSP), also called solar thermal energy, are the most common technologies for producing electric power from solar radiation. Silicon is used to direct solar radiation into electricity in photovoltaic panels. CSP plants use mirrors to focus the sun's energy to power conventional steam turbines or electricity-generating generators. Steam is then used by heat energy in the traditional turbine to generate energy (Aliyu et al., 2018). South Africa has the third-largest solar resource in the world (Gauché et al., 2013; Aliyu et al., 2018; Semelane, Nwulu, Kambule, & Tazvinga, 2021). It covers a cumulative area of nearly 194,000 km², including the Northern Cape (Aliyu et al., 2018). Water and transmission lines are the main CSP restrictions at suitable sites (Gauché et al., 2013).

Independent Power Producers Procurement Programme report for quarter one of 2021Financial Year indicates a procured 6422MW of RE energy, of which 4277MW is in operation and connected to the national grid. Impacts highlighted in the report includes; 52603 direct job years created, 50.2 (Metric ton) Mton of reduced emissions, and 59.4 million kilolitres of water saved since its inception in the programme in 2011. The report also reveals an R56.7 billion spent on local content since inception, 50 percent of project value that has been procured locally (IPP Report, 2021).

2.2.3 Sustainable Development

Sustainable development is fundamentally about enhancing the standard of living in a manner that can be maintained, economically and ecologically, assisted in the long term by the country's structural system (Cîrstea et al., 2018). In 2008, South Africa (SA) published the A National Framework on Sustainable Development (NFSD) that expressed sustainable development vision. According to the plan, "South Africa adopted a systems approach to sustainability. The economic, socio-political, and ecosystem are embedded within each other and integrated through the governance system, holdings all the other systems together in a legitimate regulatory framework. Sustainability implies the continuous and mutually compatible integration of these systems over time. Sustainable development means ensuring that systems remain mutually compatible, meeting key development challenges through specific actions and interventions to eradicate poverty and severe inequalities. The South Africa National Strategy for Sustainable Development monitors greenhouse gas emissions and the percentage of renewable power generation indicators in response to climate change." (A National Frame Work For Sustainable Development, 2008).

South Africa Sustainable Development Goals report for 2019 reported progress made towards achieving sustainable development goals. Indicators for goal 7 are; a) Proportion of population with access to electricity, b) Percentage of the population that uses solar energy as their primary source of energy, c) RE share in the total final energy consumption, d) Amount of RE at annual operating capacity, e) Annual amount of RE electricity produced from RE sources and, f) Energy intensity measured in terms of primary energy and GDP (energy supplied to the economy per unit value of economic output (South Africa Sustainable Development Goals Report, 2019).

2.3 Renewable Energy Sustainability Criteria and Indicators

2.3.1 Economic Sustainability

Energy resources are needed in all economic sectors to support economic and social development, income generation, and boost production (Cavalcanti & Cândido, 2017; IEA, 2007). According to (Owusu & Asumadu-Sarkodie, 2016), there is a positive relationship between economic growth and energy consumption. Moyo et al. (2017) also found a positive relationship between Renewable Energy consumption and economic growth.

Economic sustainability is concerned with the profitability and affordability of energy sources (Liu, 2014). The indicators assess whether the supply of RE is cost-effective and profitable, facilitate reinvestment, and whether they are affordable to society (Iddrisu & Bhattacharyya, 2015; Cantareoro, 2018; Muniz et al., 2020). The related costs are significant when analysing various renewable energy technology or proposals. They are considered primary criteria in many published multi-criteria analysis reports (Iddrisu & Bhattacharyya, 2015).

2.3.1.1 Indicator: Local Content

Local Content Requirements (LCR) is one of the requirements of REIPPPP. It is closely related to the case for job creation. The renewable energy initiative allows developers to prepare for the procurement of locally generated components. It is expected of original equipment manufacturers to prepare for investing, manufacturing, or constructing these products locally for local industries (Rennkamp, Haunss, Wongsa, Ortega & Casamadrid, 2017).

Hansen, Nygaard, Morris, and Robbins (2020), reviewed the literature on the role and effects of LCR in auction schemes to promote local industrial development for developing countries. The study examined (i) the size of the market; (ii) the design of policy; (iii) the flexibility or strictness of the LCRs; and (iv) the domestic factors that demonstrate the success of LCRs. It concentrated its efforts on four of the BRICS countries, Brazil, Russia, India, China, and South Africa, on developing local manufacturing of onshore wind power and solar PV components. The study results revealed that LCRs might have been most effective in developing China's wind turbine manufacturing industry.

Many of the deciding factors that allowed LCRs to have this impact seem to have been in place in China. These include a sizable and stable market, a pre-existing manufacturing base, and numerous complementary policies. The study found that in South Africa, wind turbine production locations were mostly limited to components with a low value-add like the towers. Higher value-add products, like nacell components, were included in the production of domestic components in China and Brazil. Also, solar PV has been identified as successful in all four BRICS countries studied, but primarily in module assembly rather than wafer and cell processing.

Bazilian et al. (2020) also conducted a review to analyse whether LCR rules help create local manufacturing and benefit local companies. The focus of the study was Brazil, India, and South Africa. All three implemented those laws when the renewables industry was still in its infancy. Brazil and India have aimed to encourage the growth of local players and, in particular, domestic manufacturing capability. On the other hand, South Africa's auction scheme intended to build jobs and foster socio-economic equality for the historically disadvantaged.
Renewables investment and the auction program in South Africa came to a halt after Eskom declined not to sign PPAs with the renewables auction winners in 2015. The study found that the nearly three years of political wrangling between government, Eskom and the renewable energy industry impacted the LCR progress made from previous bidding rounds.

Bazilian et al. (2020) highlighted that the blade manufacturing company had to close down due to few orders received per year. Two other companies closed down in 2015 but managed to pick up in 2019 when Power Purchase Agreements were signed again. As a result, according to Bazilian et al. (2020), businesses considering joining the South African market had to question whether the government's funding for the renewables auction program was large enough and long enough to justify setting up local capacity. Also, heavy competition from Chinese imports has hampered South Africa's manufacturing industry. Compared to Brazil and India, the South African market has a smaller average domestic share, which has decreased from Round 1(39 percent) to Round 4 (18 percent). South Africa's weak value chain for Wind and Solar resulted in companies using local requirements to purchase services like catering and logistics and import components from abroad.

Whereas, Semelena et al. (2021) conducted a feasibility assessment of manufacturing a solar plant in Steve Tshwete Local Municipality. Steve Tshwete municipality hosts a majority of coal generation power stations. The job opportunities generated by a socially owned solar panel manufacturing plant will help offset the future economic losses resulting from the phasing out of coal power plants. The economic feasibility analysis performed in this case study found that manufacturing solar panels in South Africa without any subsidies is not economically viable. The government would need to subsidize capital requirements for the local production of solar panels to complement the South African solar panels' minimum sustainable price.

2.3.1.2 Indicator: Levelised Cost of Electricity (LCOE)

LCOE calculates the cost of an energy-generating system and considers life cycle costs. The life cycle includes initial investment, operation, and maintenance costs, fuel costs, and capital costs. It is also affected by the technology's traditional characteristics, such as performance, annual production, service life, the quality of the energy source used, and the financial cost. It is the cost of generating electricity from a given source to break even (Olatayo et al., 2018; Lui, 2014; Troldborg et al., 2014).

Naicker and Thopil (2019) assessed RET in South Africa and highlighted feasible technology options. The study found LCOE a suitable indicator to show the advantages of Renewable Energy. The study suggests the inclusion of transmission grid expansion cost to accommodate the new load in determining LCOE. According to Ali et al. (2020), the cost of electricity is also relevant from an economic viewpoint. People cannot afford to use electricity if the cost of generation is very high. Cavalcanti and Cândido (2017) suggest that the price of electricity for end-users requires a necessary consideration for sustainability and does not affect national and international energy demand.

Price impacts affordability. Lui (2014) suggests that it is more critical for developing countries to make energy affordable to low-income groups to boost social and economic growth (Lui, 2014). Rennkamp et al. (2017) found that one of the most contentious topics in the conversation on renewable energies in South Africa is the cost of renewables. The opposition coalition claims that renewable energy is expensive and comes with high infrastructure costs. Further reasons against renewable energy are plentiful and cheap coal resources and concerns over energy stability.

However, Walwyn and Brent (2015) found that the cost of Renewable Energy has dropped significantly in the last decade. The study estimated that this decreasing production cost of renewable energy would continue until at least 2030. As the nation's economic output is not sufficient to measure poverty, Kemmler and Spreng (2007) propose that the affordability of fuels and electricity be used as a measure of energy poverty.

2.3.1.3 Indicator: Job Creation

The economic contribution measures the overall social and economic effects of the renewable energy projects, such as developing new jobs and businesses. For many governments and decision-makers, job creation is a significant reason to implement renewable energy technology. Job creation is related to direct, indirect, and induced jobs (Troldborg et al., 2014). The project creates direct employment, the input providers of the project provide indirect employment. Induced jobs apply to jobs created when project capital stimulates demand in other industries (Troldborg et al., 2014; Bohlman et al., 2019). Studies on the production of jobs resulting from clean energy projects generally look at the direct results. Some reports show that, for an energy project, the combined amount of indirect and induced employment is likely to be as high as or greater than that of direct employment itself (Troldborg et al., 2014; Bohlman et al., 2019). Countries that manufacture and export renewable energy technology are expected to create the most jobs; countries without local and export industries will also benefit from job growth. Large shares of renewable energy jobs occur at the project production and construction and in-service maintenance (Troldborg et al., 2014). Troldborg et al., 2014 indicate that the economic benefits of a green energy policy and overall jobs created are not easily quantifiable because of the uncertainties on methods to use to arrive at jobs created (Troldborg et al., 2014; Bohlman et al., 2019).

Cavalcanti and Cândido (2017) adds that indicators assess jobs created in the RE system's whole life cycle. Jobs created in the construction, installation, and manufacturing (CIM) of a new plant are separate from jobs created for its operations and maintenance (O&M) when assessing employment. CIM jobs are short-term or temporary, while the O&M jobs will last the plant's entire life. Cavalcanti and Cândido (2017) recommend building a knowledge centre where energy projects exist to build the technical skills required. In addition to the economic benefits of jobs created, Lui (2014) suggests that one of the positive impacts is that job creation directly affects people's quality of living in local communities.

Job creation and socioeconomic empowerment are at the core of SA's RE auction programme. (Bazilian et al., 2020). The programme imposes several legislative criteria to promote specific socio-economic development outcomes (Matsuo and Schmidt, 2019). According to Walwyn and Brent (2015); Matsuo and Schmidtd (2019); Hansen et al. (2020), socio-economic development targets were set in the following areas; "job creation, local content aimed at increasing local manufacturing, rural development especially the inclusion of previously disadvantaged regions in the economy, local community participation and socioeconomic development, skills development and education, enterprise development through the promotion of new entrants to the renewable energy industry, and participation of previously disadvantaged citizens in the industrial economy." Thirty percent of bid adjudication covers the socio-economic targets (Wright et al., 2019; Bazilian et al., 2020).

Job creation is a crucial argument in South Africa because of the high unemployment rate (Rennkamp et al., 2017). The unemployment rate in South Africa is incredibly high, making jobs and job losses a sensitive matter politically and socially (Strambo et al., 2019). (Rennkamp et al., 2017) indicated that the emphasis on jobs means not only efforts to generate new employment in the renewable energy sector but also preserving existing jobs in the mining industry. Research added that trade unions are firmly engaged in the debate and encourage the renewable power industries but not at the cost of coal jobs.

Strambo et al. (2019), at the end of the coal report, indicated that changes in the energy systems in South Africa would have a social and economic impact, particularly in mining regions. Impact includes losing jobs in coal power stations, coal mines, and the coal transportation business.
The coal mining business hires 80 000 employees while Eskom employs 50 000 employees. The unions call for a just transition, allowing coal employees and coal societies to face the possible accelerated reduction in jobs for the coal industry and emphasize creating decent alternatives in the regions affected. It further states that the transition should not worsen the existing poverty and inequality in mining areas. Nkoana (2018) adds to the debate that the move from polluting fossil fuels to sustainable RE sources needs to address social injustice, poverty, and unemployment.

2.3.2 Environmental Sustainability

CO_2 emissions in the atmosphere emitted by fossil fuel combustion cause climate change. In contrast, solid fuels used in homes are responsible for illness and death from indoor air pollution and forestry (Iddrisu & Bhattacharyya, 2015). Climate change is possibly the world's biggest environmental concern, owing to anthropogenic greenhouse gas emissions (Kemmler & Spreng 2007). The early 1990s saw the rise of climate change and the global warming phenomenon. Elevated greenhouse gas levels caused the unusual change in global weather patterns in the atmosphere, emitted by coal-burning in coal-fired power plants and factories (Mathu, 2014). The United Nations Convention on Climate Change (UNCCC) was established to lead the global movement for cleaner energy production, producing less carbon emissions. It emphasised the importance of turning away from coal as a primary energy source to reach the agreed-upon climate goals (Bohlmann et al., 2019). It also emphasised the need to increase renewable energy sources, producing cleaner energy to slow climate change (Mathu, 2014). Because of the high level of carbon emissions, the widespread use of non-renewable energy sources such as coal was a threat to the atmosphere. Unlike other fossil fuels, such as crude oil and natural gas, coal emits the most emissions (Mathu, 2014).

All three aspects of the Sustainable Development Goals (SDGs), social, economic, and environmental, are of equal significance and interlinked. However, the concept of sustainable development acknowledges the central position of the environment. Climate is the main subject of the SDGs, with around half of the goals and targets connected to the environment (Omisore, 2018). Power generation requires more environmentally sustainable (green) energy supplies and technology to mitigate nature's adverse effects (Moslehia & Arababadia, 2016). The generation, distribution, and use of energy causes environmental impact at home, in the office, in the community, nationally, regionally, and globally (Cavalcanti & Cândido, 2017). Environmental sustainability focuses on efficiencies in electricity production and distribution to reduce carbon emissions and improve air quality (Cavalcanti & Cândido, 2017). Long term impact of clean energy systems enhances environmental sustainability (Sarkodie & Adams, 2018).

According to Cavalcanti and Cândido (2017), there is no risk or waste-free energy generation or conversion process. It is crucial to consider and analyse the entire environmental footprint and the trade-offs between the benefits and drawbacks of renewable energy technologies to achieve renewable energy and carbon emissions objectives (Manso & Behmiri, 2013; Troldborg et al., 2014; Cavalcanti & Cândido, 2017. Competing environmental, socioeconomic, and technological requirements usually challenge selecting the most appropriate renewable energy technology for deployment in a particular region or location (Troldborg et al., 2014).

The benefits can include lowering emissions from greenhouse gas and reducing dependence on non-renewable energy sources. The drawbacks may be that renewable power is expensive or has a detrimental effect on landscapes or biodiversity (Troldborg et al., 2014). Approaches to these contradictions and trade-offs are needed to determine the most sustainable and suitable clean energy technologies at a given location (Troldborg et al., 2014).

Life Cycle Analysis (LCA) has been commonly used to investigate, evaluate and compare the total environmental impact of various electricity generation schemes, including renewables. LCA seeks to determine the environmental effects of all product life levels, from the extraction and manufacturing of raw materials to the manufacturing, delivery, use, repair and maintenance, and disposal or recycling of a specific commodity (Troldborg et al., 2014; Cavalcanti & Cândido, 2017). LCA usually considers quantifiable environmental effects leaving out, for example, the product's socio-economic impact. Recent advances have sought to supplement the more conservative environmental LCA with social dimensions (Troldborg et al., 2014). LCA works to minimize polluting gas pollution in the atmosphere, heavy use of water, vast land supplies, and waste production (Cavalcanti & Cândido, 2017)

The effect of RE on emissions is negative (Manso & Behmiri, 2013; Vanegas Cantarero 2020). It supports the pollution prevention strategies of deploying RE to promote a quality environment (Manso & Behmiri, 2013; Vanegas Cantarero 2020). One of the main driving factors behind the increasing need for RE technology is reducing GHG (CO2) emissions intending to combat climate change (Manso & Behmiri, 2013; Vanegas Cantarero 2020). The power system design also incorporates characteristics linked to low emissions of SO2, CO2, and NOx per generated electricity unit (Liu, 2014).

Eskom and Sasol are the biggest consumers of domestic coal, consuming 85 percent and top emitters in the country, contributing 50 percent of greenhouse gas emissions. Coal is also one of the major exports by volume in South Africa (Strambo et al., 2019). South Africa is Africa's economic powerhouse and the second most carbon-intensive region in the world because of its abundant fossil fuel reserves (Sarkodie & Adams, 2018).

2.3.2.1 Indicator: Greenhouse Gas Emissions

During production and conversion, the risk of harm to people and the environment from the toxins generated, released, or disposed of is eminent (IEA, 2007). Furthermore, due to increased emissions into the atmosphere, health problems associated with air pollution are rising (Mangla et al., 2020). Climate change is an issue that most sub-Saharan African countries have yet to resolve entirely (Omisore, 2018). Climate change strategies must be executed nationally, regionally, and globally and include green energy that is less carbon-dependent (Omisore, 2018). Perception is Renewable Energy is a cure for alleviating the energy shortage, climate change, and environmental pollution (Liu, 2014). One of the main driving factors behind RE technology's rising need is eliminating GHG emissions to combat climate change (Manso & Behmiri, 2013).

Carbon dioxide (CO_2) is primarily emitted by burning coal, oil, and natural gas in energy systems. Renewable Energy CO_2 emissions are crucial in assessing system sustainability as a significant measure. Overall greenhouse gas (GHG) emissions from a renewable energy system are among the most commonly used metrics for measuring renewables' viability (Troldborg et al., 2014). According to Troldborg et al. (2014), other studies consider GHG emissions avoided using renewable energy technologies relative to non-renewable energy technologies. The other indicator is life-cycle projections of GHG emissions from various renewable technologies estimated in equivalent According to Liu, 2014; Troldborg et al., 2014 the life-cycle assessment (LCA) considers all or part of the following life cycles of energy processing processes: (i) production and delivery of fuel to the plant; (ii) installation of the facility; (iii) operation and maintenance of the facility; and (iv) dismantling

Rennkamp et al. (2017), in their study, revealed that even though there is high support for carbon emissions reduction in South Africa, economic principles dominate. The environmental arguments often refer to the planned elimination of emissions due to Renewable Energy diffusion, making the initiative an explicit climate change strategy (Rennkamp et al., 2017

2.3.2.2 Indicator: Air Pollutant Emissions

The indicator assesses national policies' environmental performance. It describes the environmental controls associated with reducing air pollution in energy-related activities, including power generation and transport (IEA, 2007). The indicator includes Nox emissions from the combustion of biomass fuel and conventional fuels such as petroleum and coal. The pollutants (Nox) contain gasses that lead to local air pollution, acid deposition, and global climate change (Liu, 2014).

2.3.2.3 Indicator: Ambient Air Pollutants in Urban Areas

The indicator helps measure the number of people exposed to harmful levels of air pollution. It also assists in monitoring compliance with air quality requirements. Lastly, it measures the impact of regulatory documents by tracking and analysing trends. The highest risk for human exposure to environmental air pollutants and related health issues exists in urban areas (IEA, 2007).

2.3.2.4 Indicator: Land Use and Area Requirements

The land is a valuable natural resource in itself, consisting of soil and water, necessary for food cultivation and shelter for diverse populations of plants and animals. Energy practices can contribute to land degradation and acidification, affecting water quality and productivity in the agricultural sector. The use of timber (non-commercial) fuel could contribute to deforestation, leading to erosion and soil degradation in some countries. Water quality is compromised when liquid effluents from energy sources discharge into the environment (IEA, 2007; Suganthi, 2020).

The indicator assesses the amount of land used to generate electricity (Naicker & Thopil, 2019; Ghenai et al., 2020). REIPPPP allows bidders to acquire land for construction sites. According to Naicker and Thopil (2019), concerns over land grab instituted political unrest. It is a result of historical and contemporary land injustices. The government had to balance attracting foreign investment by restricting foreign land ownership. It also reopened legal avenues for land restitution, potentially complicating the REIPPPP process by encouraging certain displaced peoples to demand compensation or share landowner dividends.

According to Naicker and Thopil (2019), land area requirements are crucial because Renewable Energy Technologies compete for land with agricultural production and conservation in South Africa. Also, the study established access to suitable sites as a barrier. Although technologies such as large hydro and biomass can add to the energy mix and reach government goals. Hydro, in particular, is viewed as a mature technology; the unique obstacles identified hinder the adoption process. Large hydro projects may result in river diversion and population relocation, limiting the number of sites where the particular technology can be introduced.

2.3.2.5 Indicator: Water Usage

Energy and water are critical resources for developing nations (Suganthi, 2020). The use of water and the provision of energy are inextricably related. Water is required to produce energy, and energy is often required to pump, process, or transport water. Water is used extensively in the production of electricity, whether in the processing of raw materials or electricity generation. Given that South Africa is a water-scarce country, it is critical to consider water usage by various energy technologies. Climate change is expected to place increased pressure on water supplies due to predicted changes in seasonal and regional temperature and precipitation patterns (Sparks et al., 2014).

Water use is extensive in the coal mining processes, including dust suppression, washing and processing the coal as fuel, and rehabilitating the site after the mine is closed. Washing coal pollutes water with sulphur compounds and dissolved iron, resulting in sludge (Sparks et al., 2014). There is an expectation that RETs will reduce the reliance on water for energy production (Ali et al., 2020). The production of wind energy does not necessitate the use of water. The use of water during the turbine construction process is marginal. There is an expectation of minimal water usage in the cleaning of the turbine blades on occasion. The use of water in the development of rare earth elements such as neomycin in wind turbines has little effect on water use in South Africa. However, it does impact the global water footprint (Sparks et al., 2014). South Africa's energy sector draws 2 percent of the total national water allocation. Fossil fuels draw a significant amount compared to Solar and Wind (Sparks et al., 2014).

Suganthi (2020) conducted a study to assess Renewable Energy efficiency. The country's natural resources were input criteria, and the indices were output criteria. Experts concluded that the most significant input resources were water supply and energy reserves. At the same time, the most crucial output indicators were environmental and social indices.

However, out of the four input parameters, water was assigned the highest priority, followed by energy, showing that these two resources are critical for long-term growth. According to the study, the two resources could help achieve higher indices for sustainable growth when used effectively. Sparks et al. (2014) recommended water usage as an environmental indicator.

2.3.3 Social Sustainability

This dimension is concerned about minimising or eradicating harmful impacts (IEA, 2007; Liu, 2014). IEA (2007) has divided social indicators into two themes, equity and health. Social equity is one of the critical principles behind sustainable development and is linked to goal number 7. Energy should be accessible and affordable for all (IEA, 2007). Energy production and conversion should not be harmful to human health due to the release of emissions or cause injury and fatalities (IEA, 2007).

Each country's social, economic, and cultural conditions are different, making it difficult to define social sustainability (Hák, Sanousková & Moldan 2014). Iddrisu and Bhattacharyya (2015) define social sustainability as the local involvement in energy system operation and control and encompasses local ownership and participation, local skills base, local legislation, and investor and customer protection. Cavalcanti and Cândido (2017) define energy sustainability as integrating the social component determining whether the creation and consumption process impacts individuals' health and well-being and produces employment and income. According to Iddrisu and Bhattacharyya (2015) and Haseeb, Abidin, Hye, and Hartani (2019), social sustainability tests the distributional impact of energy on society, whether the energy supply is acceptable and accessible. Iddrisu and Bhattacharyya (2015) further indicate that society embraces what it sees as equitable and offers everyone equal chances.

Liu (2014) considers the social impact of renewable energy to include employment that the system can create. According to Manso and Behmiri (2013), enhanced job creation is an indirect macro-economic advantage theoretically correlated with Renewable Energy.

According to Mangla et al., 2020; Kemmler and Spreng (2007), and Narula and Reddy (2015), sustainability aims to resolve environmental challenges for developed nations. However, for developing nations, problems relevant to society, such as equity and poverty, must be tackled in determining the sustainability of energy systems. Rennkamp et al. (2017), poverty is not specifically an issue raised to oppose Renewable Energy in South Africa. However, it does come within the context of broader growth issues and arguments for job creation and general welfare.

Oke et al. (2021) found that Renewable Energy supports economic and environmental sustainability but negatively impacts social aspects. The high price deprives an average African person of Renewable Energy benefits. They rely on the cheaper and more accessible non-renewable energy supply (Oke et al., 2021). The African case is that most people who subscribe to green energies are middle-and upper-class income classes.

2.3.3.1 Indicator: Social Acceptance

Antwi and Ley (2021) define acceptability as a favorable or positive response (including attitude, intention, behaviour, and where appropriate use) relating to proposed or in situ technology or social-technical system by members of a given social unit (country or region, community or town and household, organisation). The indicator assesses the general acceptance evaluation of various clean energy projects and plans (Troldborg et al., 2014; Naicker & Thopil, 2019). Social acceptance varies from place to place, and attitudes shift over time. It is not easy to quantify social acceptance (Troldborg et al., 2014; Naicker & Thopil, 2019).

Rennkamp et al. (2017) reported that the reasons for the green energy strategy of South Africa constituted a loosely related cluster dominated by economic principles. Economic incentives, job creation, industrial development, emissions reductions, international investment are the arguments supporting RE diffusion in South Africa. They reflect socio-economic growth concerns. The study's political discourses are job creation and high unemployment level being the central argument. According to Ali et al. (2020), it also means acceptance to reduce emissions and greenhouse gases, which means accepting higher tariffs.

Antwi and Ley (2021) suggest a bottom-up approach that requires residents to be critical players from project implementation to monitoring and evaluation. It is a requirement that cannot be overlooked to cope with the ramifications of acceptance succinctly. The benefit is increased acceptability and longevity and a deep sense of ownership, both essential for project progress (Antwi & Ley, 2021).

Acceptance of renewable energy may also be influenced by perception (Antwi & Ley, 2021). In African contexts, understanding psychological influences interconnecting with and affecting adoption can boost project planning and execution, such as understanding the functioning and consequences of technology, influencing the consumer's cost-benefit perception (Antwi & Ley, 2021).

Personal, psychological, and contextual factors may all influence people's overall attitudes toward adopting renewable energy. Influencing acceptability is also one's knowledge, fears, and expectations (Antwi & Ley, 2021). In order to meet the energy needs of the people, the principle of social acceptability is essential (Antwi & Ley, 2021).

2.3.3.2 Indicator: Just Energy Transition

The concept of a Just Energy Transition helps to shield jobs and families from transitioning in a way that leads to detrimental effects. It also supports the preservation of jobs, social programs for affected workers, enhancing the labour force, rehabilitation of the environment, and small business development. Other advantages are reducing climate impacts, sustaining economic development, better air quality, and improved public health (Mutezo & Mulopo, 2021). According to Semelane, Nwulu, Kambule and Tazvinga (2021), clean energy solutions do not have the same large value chain as coal. That should be the reason for support of a just energy transition. For example, the coal industry hires many low-skilled workers in coal mining and skilled workers who operate coal power stations. Also, the transportation industry supports coal power plants by transporting coal from mines to power plants over a power plant's lifespan. According to Kaggwa and Sithole (2019), Just Energy Transition's fundamental assumption is that renewable energy jobs would most likely be smaller than coal industry jobs. Employees working in the coal industry might not be able to fill the Renewable Energy jobs due to the geographical location of the new energy plants.

Renewable Energy projects have been deployed mainly in the Northern, Eastern, and Western Cape. However, the power stations are based in Mpumalanga. The challenge with continue building Renewable Energy in the mentioned provinces is that the grid infrastructure in Mpumalanga could be left stranded. Twelve of the Sixteen coal generation power stations are located in Mpumalanga, and grid infrastructure is mostly near these power stations (Bohlman et al., 2019).

Also, the power plants have been sustaining the communities for years in providing jobs and income (Bohlman et al., 2019). According to (Bohlman et al., 2019), decommissioning them due to age or transitioning decisions would inevitably have a negative short-term effect on the province if no interventions are in place. Provinces with high renewable energy resources will experience positive socio-economic impact from the new plants, becoming employers and sources of income. There will be fewer jobs in the Mpumalanga area.

The study suggests regional planning is necessary, especially in terms of the labour migration implications of a long-term transition to low-coal electricity generation. The study highlighted that coal industry plant operators and trade workers would be impacted most. This group might benefit from the new renewable energy jobs. However, it might come at a cost if the transition is improperly handled.

2.3.4 Institutional Sustainability

Muzin et al. (2020) define institutional sustainability as dealing with the impact and effects of institutions on social relations, including influencing the behavior of various social actors and from an economic point of view as an organization's capacity to produce valuable results so that it acquires sufficient inputs to maintain production at a constant or increasing rate. Institutional indicators evaluate the availability of the institutional framework and sufficiency required to support an effective and efficient energy system (Gunnarsdottir et al., 2020). According to Spangenberg (2002), the goal of social, economic, and environmental sustainability is reached, effective, and complied with when complemented by institutional objectives that promote justice and participation.

According to Vera et al. (2001); IEA (2007), the institutional indicators perform many functions; a) measure the institutional structure's existence and adequacy required to sustain an effective and reliable energy system, b) help assess policy initiatives aimed at shaping social, economic, and environmental patterns, c) track the effectiveness of legislative, regulatory, and enforcement measures encouraging efficient energy systems, and d) help assess the presence and the efficacy of a national sustainable energy strategy. Muniz et al. (2020) recommend that future research extend the qualitative study of some of the core concepts in energy sustainability evaluation processes to include institutional dimension.

2.3.4.1 Indicator: Education and Training

Lucas, Pinnington, and Cabeza (2018) analysed the renewable energy education offered globally using the International Renewable Energy Agency (IRENA) Renewable Energy Learning Partnership database. The researchers further looked at the demand in renewable energy education based on queries received. The study's finding indicates that 40.9 percent of courses are available in Europe and only 6 percent in Africa. The United States is leading in terms of the number of courses currently offered. India, the leading developing country, ranks fifth overall, with 104 courses currently identified. The percentages reflect that leading knowledge hubs are the United States, United Kingdom, and Germany.

The highest share (32.4 percent) of RE courses are taught in educational institutions at the master's level. Short-term professional development training follows closely in second place. There are fewer courses that have hands-on training; 15.8 percent is classified as vocational training. The rest of the percentage is undergraduate and doctoral studies. Financial constraints, shortage of qualified teachers and trainers, and lack of know-how in developing Renewable Energy curricula are cited for lack of education and training in developing countries.

Naicker and Thopil (2019) indicated that South Africa is dependent on international technology providers for skills development. The study added that the higher education system has recently started catering for learning in renewables and created a capacity for skills and knowledge development in all technologies. However, there is a need for a policy proposal for educational and training programmes related to artisan-based skills that can support and maintain RE projects. Another urgent need highlighted in the study training focused on Concentrated Solar Power (CSP) due to the emphasis and support given to the technology. CSP reveals shortcomings regarding the availability of local champions and the ease of information and skills transfer.

Sen and Ganguly (2017) indicated that lack of highly trained resources in Renewable Energy is a significant impediment to renewable energy production in developing countries. The ability to operate and manage Renewable Energy hardware is critical to the success of a Renewable Energy project.

2.3.5 Technical Criteria

Modern economies rely on a stable and sufficient supply of energy, and interruptions result in significant financial and economic losses (IEA, 2007). Technical criteria are designed to aid decision-making in determining better ways to produce and use energy. The decline in fossil fuel inventories necessitates a transition that incorporates energy policies toward clean energy with reduced environmental effects (Cavalcanti & Cândido, 2017).

2.3.5.1 Indicator: Energy Efficiency

Energy efficiency is replacing electrical equipment with less energy-consuming equipment of equivalent output magnitude. It is essential to recognise obsolete energy equipment and develop solutions to increase energy sector performance. Energy performance enhancement is the most cost-effective, time-efficient, and environmentally friendly way to satisfy a large portion of the energy demand in the world. Energy production has technological and financial hurdles subordinate to other barriers, such as funding, public knowledge, benefits, and proper education. The benefits of energy efficiencies are reducing harmful emissions and delivering environmentally sustainable electricity facilities at a fair cost (Aliyu et al., 2018). Efficient energy supply is considered one of the primary conditions for economic development (Cavalcanti & Cândido, 2017).

Naicker and Thopil (2019) indicated that Renewable Energy technologies still face diffusion challenges even though they have gained more political support. The technologies will not be adequate on their own to satisfy the baseload requirements, which will need to be supplemented with fossil fuel technologies. Naicker and Thopil (2019) further indicated that existing grid infrastructure might not accommodate the expansion of these technologies, limiting their diffusion. According to Gauché, Von Backström and Brent (2013), while coal capacity will decline to a lower proportion of the mix, it will still provide a significant portion of the electricity until 2030. This viewpoint is also supported by Naicker and Thopil (2019).

2.3.5.2 Indicator: Energy Reliability

Reliability represents whether the energy supply is subject to interruptions, such as solar panels, which do not work at night. Wind turbines cannot operate when there is no wind or when wind speeds are too high. Energy source reliability has often been an issue, and interruptions affect the stability of energy supply and continuity (Troldborg et al., 2014).

2.3.5.3 Indicator: Security of Supply

Security of supply translates to robustness against energy source disruptions. The expression of energy security relies on the context, time, geography, and energy security changes. It is concerned with both current and preparing for future Renewable Energy systems. The two concerns are important because they deal with the availability of services and efficiency of energy supply.

The implementation of renewable energies raises new concerns about energy security, disruption of supplies, and the susceptibility of energy supply to random and natural uncertainties and extreme events such as drought. However, RE will improve the efficiency of energy supply, especially in remote and rural areas that do not access the grid. An energy mix, good management and system design can boost security levels. Ensuring energy security involves diversification of energy sources which assist in meeting demands and improve on efficiencies. (Manso and Behmiri, 2013).

3 METHODOLOGY

This chapter explains the research execution, starting from the philosophical approach to research methodology, design, data collection methods, and the techniques used to analyse data. The main question that this research seeks to answer is, what are the Criteria and Indicators that can be used in South Africa to assess the sustainability of Renewable Energy supply? Merriam (2009); Wagner, Kawulich, and Garner (2016) suggest that there should be coherence in the research design; that the question, methodology, and methods fit within the same framework. Before developing Criteria and Indicators, scholars have used qualitative and quantitative studies to illustrate this alignment, leaning more on the qualitative side. Various stakeholders and experts are engaged, especially at the initial stages of the initial development of sustainability or energy indicators basket. The question is best using a qualitative case study design. The subheading below details the choices made to execute this study.

3.1 Research Philosophy

The research approach starts with an understanding of the assumptions and perceptions of reality and what is truth. Leading primary research approaches are positivism, interpretivism, and critical theory (Rehman & Alharthi, 2016). Other scholars include postmodernism and pragmatism. This research follows the interpretive assumption that truth lies within human experience and that reality is context dependant and cannot be generalized (Ponelis, 2015). According to Merriam (2009), interpretive analysis means there is no single, tangible reality but multiple realities or interpretations exist.

Interpretivism opposes the positivism philosophical idea that a single, verifiable truth exists independently of our senses. Interpretive epistemology is subjective. Individuals communicate with other individuals and allocate meaning and names to various social phenomena. Researchers are inextricably involved in investigating social phenomena. The interpretative approach calls for the interpretation of social phenomena through the participants' eyes instead of the investigator.

The researcher attempts to find trends in the data using themes to explain the phenomena and create the hypothesis, making it an inductive approach (Rehman & Alharthi, 2016). The characteristics of positivism and critical theory mentioned below do not fit the objectives of this study.

Positivism believes that reality is autonomous of human beings and context-free. Since truth is context-free, various researchers working at different times and locations can come to the same conclusions regarding a given phenomenon (Rehman & Alharthi, 2016). Also, this philosophy depends strongly on experimentation. The approach to study is deductive in that it seeks to evaluate the current hypothesis (Rehman & Alharthi, 2016).

Critical theorists believe that reality exists but is influenced by cultural, political, racial, gender, and religious forces that interfere with each other to construct a social system. The philosophy claims that no object is studied without being influenced by the researcher and thus subjective. The study seeks to transform society and shed light on the values and acts that limit human rights (Rehman & Alharthi, 2016).

This study seeks to create a new, rich understanding and interpretation of the social world and its context. By following the interpretivism approach, experts express their views on sustainable energy based on their experience and understanding of the South African context. They also suggested indicators to assess the sustainability of Renewable Energy. The reach data is categorised into themes to propose Criteria and Indicators.

3.2 Research Approach

Qualitative research is about understanding phenomena from the viewpoint of participants. The researcher collects and analyses data to construct ideas, theories, and descriptive analysis of phenomenon (Merriam, 2009). Under the umbrella of Qualitative study are various designs with common attributes but different focus resulting in a difference in how the researcher samples, collects and analyse data and writes the final report (Merriam, 2009).

This study recognises the phenomenon in its own right rather than from an external perspective. It uses open and exploratory questions compared to the quantitative study on closed-ended hypothesis, allowing explanation to seek more meaning instead of fixed choices. Lastly, something new could be discovered instead of confirming a hypothesis, making it an interpretive study (Elliot & Timulak, 2005).

3.3 Research Design

The interpretive philosophy has various research designs of qualitative studies (Saunders, Lewis & Thornhill, 2016). According to Saunders et al. (2016), the interpretive research designs are; phenomenology, grounded theory, ethnography, and case study. They focus on non-numeric evidence and meaning rather than the mathematical form of data analysis (Elliot & Timulak, 2005). The phenomenology research approach seeks to learn about how people perceive the world around them. The philosopher should express preconceptions about his or her perception of the universe (Bryman, 2012). Ethnography means a written history of individuals or ethnic groups. The ethnography research approach seeks to describe and interpret cultural behaviours, beliefs, values, and practices of a group of people (Saunders et al. 2016).

In comparison, Grounded Theory seeks to develop a theory for social experiences and mechanisms in various settings, including business and management. The goal is to discover or generate a theory based on evidence collected from social actors. This study does not align with ethnography and grounded theory (Saunders et al., 2016).

The design that answers the question best is the case study. According to Merriam (2009), the definition of a case study is an in-depth description and analysis of a bounded system. It is an intensive and holistic explanation and examination of a restricted phenomenon, such as a program, an organization, an individual, a mechanism, or a social unit (Merriam, 2009; Saunders et al., 2016). The case study also helps to explore and describe the phenomenon in its setting using various data sources (Wagner et al., 2012).

Saunders et al. (2016) state that both positivist and interpretivist researchers use case studies for descriptive, exploratory, or explanatory purposes. A researcher uses qualitative case studies when interested in perspective, discovery, and understanding rather than theory testing. The case study approach can elicit perspectives from extensive and in-depth interviews leading to detailed, empiric descriptions and theoretical advances (Saunders et al. 2016). Case study studies benefit from a mixture of archival records and documents, diverse types of observation, ethnography, interviews, and focus groups, questionnaires, reflection, and use of research journals and other research aids (Saunders et al. 2016). According to Saunders et al. (2016), there are single or multiple cases and holistic or embedded cases. This study follows a single case study.

An exploratory case study analyses circumstances in which there is no simple, single set of consequences for the intervention studied (Baxter and Jack, 2008). For this study, Renewable Energy includes large-scale solar, wind, and small hydro generation plants connected to Eskom networks for transmission and distribution within South Africa and beyond. The research excludes self-generation, whereby households and businesses generate their electricity using either coal or RE. Participants propose Criteria and Indicators based on their understanding of Renewable Energy supply and the South African context. In the exploratory case study, the difference in understanding and views of participants results in different responses.

Within the case study design, this research best fits the exploratory single holistic case. According to Saunders et al. (2016), choosing the unit of analysis, setting and parameters are crucial in deciding on the case study. South Africa is the unit of analysis. What makes South Africa a unit of analysis is that South Africa is already transitioning to Renewable Energy supply. According to the plans, 50 percent of the energy supply will be Renewable by 2030 also, 11 000MW of coal generation units on the plan for decommissioning. It is a massive step for South Africa, a country dominated by coal supply for years. Also, South Africa is facing high unemployment rates and other socio-economic needs. Energy plays a vital role in facilitating socio-economic growth. A framework fitting South Africa context is needed to assess the sustainability of the Renewable Energy supply deployed.

3.4 Research Tools and Applications

Research tools are the instruments used to collect data (Wagner et al., 2012). The suitable tool for this study is semi-structured interviews. An interview guide with open-ended questions assists during interviews to extract data. Interpretive analysts use approaches that produce qualitative data. While numerical data can be involved, they do not rely on them (Rehman & Alharthi, 2016). Examples of qualitative data collection approaches include open-ended interviews, observations, reports, and documents (Rehman & Alharthi, 2016).

The study asked the following research question:

a) What is your understanding of sustainable energy or sustainability?
b) What is unique to South Africa concerning the RE supply?
c) What are the Criteria and Indicators included in the framework to assess the sustainability of RE in South Africa? Why do you think each indicator suggested is essential for the South African context?
d) What are your views about prioritizing some Criteria and Indicators over the others?

Participants firstly responded to a context question of whether there is anything unique to South Africa about Renewable Energy. Also, they provided their understanding of sustainable energy or sustainability, taking into consideration the South African context. The main focus of this research is Criteria and Indicators to assess the sustainability of Renewable Energy supply in South Africa. Participants suggested these with the reason why such criteria and indicator is vital for South Africa context. The follow-up question to the provided Criteria and Indicators is the prioritisation, whether one should be prioritised over the other with reasons.

The population is the entire group of people studied (Wagner et al., 2012). Most energy-related studies use quantitative methods and frameworks to investigate relationships and interlinkages between Renewable Energy and sustainability. However, they lack the views, input, and knowledge of participants like RE industry experts. For this study, industry experts (executives of participating institutions) became the population. They play a significant role in policymaking, energy planning in the country, electricity infrastructure designs, research, installations, development, and influence the Renewable Energy path in South Africa.

Non-probability sampling methods support the study, and a purposive sampling technique was used to find participants. Purposive sampling is when the researcher uses innovative ways to find suitable respondents (Wagner et al., 2012). For this study, respondents are experts in the energy fraternity. Research targeted and managed to interview fifteen experts. Fifteen participants were interviewed. The participants' industry breakdown is as follows; three were from civil organisations, three from academic institutions, four from independent power producers, three from the state-owned power utility, one from a power engineering company, and one from financing institutions and academic institutions. All participants hold senior positions in their organisations and are familiar with the transition to Renewable Energy supply in South Africa.

3.5 Process of Analysis

In this study, inductive nature and subjective and socially constructed views in the form of text influenced the approach to data analysis. In qualitative research, the collection, analysis, and verification of proposals are interrelated and collaborative (Wagner et al., 2012). The process started with transcribing the audio recorded interviews into a word document. The data was then sorted into themes and later analysed using the thematic analysis approach. Thematic analysis is a technique that searches for themes and patterns in data for analysis resulting in description and explanations (Wagner et al., 2012). The themes identified were sorted into the proposed Criteria and Indicators.

3.6 Limitations, Feasibility, and Positionality

Finding participants was a challenge. The COVID-19 pandemic and lockdown presented limitations such as access to sites and respondents. Some organisations did not list their employees' e-mail addresses, making it challenging to send e-mails to potential respondents. Some organisations disconnected the telephone lines due to employees working from home. One could not call to request an e-mail address or follow up on e-mails. There was a general lack of response to e-mails, whether sent using student or private e-mail addresses. It took longer than anticipated to conduct fieldwork due to these challenges. Follow-up e-mails were sent while continuously searching for new respondents until the target of fifteen respondents was reached. It was also not feasible to do fieldwork from mid-December to January due to the year-end closing, creating a month of fieldwork delay. The second limitation is budget. The study had not budgeted for services like transcription and editing. Also, extending the study by a few months would require registration and fees for another year.

To address positionality, three executives from the organisation were interviewed with no prior working relations. The rest of the respondents were unknown and found through an internet search of respective companies and LinkedIn was used to confirm profiles before request emails were sent. Interviews were conducted online using Zoom and Microsoft Teams. These tools made it feasible to conduct interviews during the pandemic and lockdown.

3.7 Ethics

The purpose of the research is to fulfil the requirements of a Master of Management degree qualification. Wits School of Governance Human Research Ethics Committee issued an ethics clearance certificate for this research. The employer gave permission to conduct this study research. Ethical concerns were addressed in the research introduction letter, which was sent with every request for participation. Those who acknowledged the interview invitation had to sign the consent form before the interview. Both documents guaranteed the respondents security, anonymity, and the use of pseudonyms.

I also adhered to the panel outcomes to only use purposive sampling. My proposal had included snowball, which I think would have made data collection quicker. However, I might not have reached the level of diversity required for this research had I followed snowball.

I am the only person who conducted the interviews and accessed the recording, transcripts and analysed data. Data storage is a password-protected laptop. Documents were retrieved electronically, and the research did not produce any hard copies with personal information.

3.8 Research Report Trustworthiness

The criteria used to assess the qualitative study are trustworthiness and authenticity, each with its criterion (Bryman, 2008; Rehman & Alharthi, 2016). Bryman (2009), criteria for trustworthiness are credibility, transferability, dependability, and confirmability. Credibility relates to the degree to which the researcher's representation of the subjects suits the individual's interpretation. Transferability relates to the degree to which research findings are applicable in a similar situation. Objectivity was maintained during data collection and processing. Consistency in data collection and interpretations helps achieve dependability and confirms that the research objectives did not change. I used the interview guide to assist me with the questions and ensuring that the data needed is collected. Participants gave their permission to record and keep data for not more than five years. The interview records and data are in their original format and stored in a secure environment for audit trail purposes.

To achieve triangulation, two sources of data were used, literature and interviews. Facts from data validate the conclusions of this report. Data collected from the various documents (academic research articles, energy reports, programmes, plans, policies, institutions mandates, and governance documents) is verified against the interviews' data to ensure triangulation in the research. Triangulation ensures that findings are valid and the report is credible (Bryman, 2008). The findings of this research will not be generalised as a wide range of experts has not been sampled. Also, Ponelis (2015) suggests that interpretive studies cannot be generalised because the findings are based on human experience and change with context.

3.9 Conclusion

It is therefore concluded that the research design meets the features of the interpretive study. Secondly, the philosophical approach chosen answered the research question. Finally, the methodology, design, and methods fit within the same framework.

4 ANALYSIS AND DISCUSSION

In this section-, the analysed data is presented under themes and subthemes. The first theme is the Renewable Energy context of South Africa, where the participants have given their views pertaining to the context of Renewable Energy in South Africa. Context is vital in the deployment and sustainability of energy supply; it determines the type of supply needed for the country or energy resources. Context also presents a picture of the social, economic, and environmental aspects that the country faces and also aspire to achieve. The participants have provided Criteria and Indicators that need to be assessed based on their understanding of Renewable Energy's sustainability. Sungathi (2020) alluded to this that experts suggest Criteria and Indicators and even weigh them based on their views of the national context and what they consider essential.

The second theme focuses on Sustainable Energy. Sustainable Energy is defined by the role energy plays in achieving development. A such, the sustainability indicators need to cover all dimensions of sustainability in order to reflect a balanced view. This second theme also presents the views and understanding of the participants on what sustainable energy is. According to White (2013), sustainability is a complex term to grasp because it has multiple definitions for different individuals and is difficult to describe.

The third and final theme answers the central question of this study. It represents Criteria and Indicators as suggested by participants to assess the sustainability of Renewable Energy supply. The indicators are the lenses to view the Renewable Energy supply in South Africa. They consider how the participants understand the context and consider it necessary to have a sustainable Renewable Energy supply. The subthemes are presented as indicators. Fifteen subthemes have been identified and presented under the five identified criteria.

4.1 Renewable Energy Context

The participants are of the view that South Africa has coal in abundance for domestic use and exports. They also acknowledge the heavy reliance on coal to generate electricity and believe that South Africa should continue to use coal while it is still available. The environmental impact of coal is acknowledged by most as a downfall of generating electricity by using coal. However, participants believe that the coal supply does not have to end due to environmental impact. One participant indicated that the use of coal could buy South Africa time for the transition. This participant suggests that there could be solutions to handle emissions while transitioning to Renewable Energy. Another participant also saw the high emissions in a positive light.

The view from this participant is that South Africa can participate in the global governance structures to shape international policies on climate change because of its high contribution to global emissions. Mathu (2014) and Gauché, Von Backström and Brent (2013) confirmed that South Africa has abundant coal to generate electricity supply. In 2016, the energy report indicated that the country had about 50 years of coal reserves. Below is the extract from participant H's interview.

> *Participant H: We are a coal-rich country. The natural resource that we have is something that should be utilised to a very large degree before we transition full force into renewables, as imposed right now.*

The view of participant H is that South Africa should continue to use coal while transitioning to Renewable Energy supply. Reasons given are that Renewable Energy supply comes with challenges like employment, local content, reliability, cost, lack of skills that need attention before fully transitioning. In addition to the view by participant H, there is also a view amongst other participants that Renewable Energy is imposed on South Africa. The view from the participants is that South Africa is not ready to implement the recommendations from United Nations Framework Convention on Climate Change.

The second aspect highlighted about South Africa's context is that Renewable Energy resources are also in abundance throughout the country, especially wind and solar energy. However, some participants are of the opinion that it is not enough, mainly because solar and wind projects come in small sizes, therefore not viable for South Africa. In light of this, hydro is viewed as a better alternative when it comes to Renewable Energy resources. Generating energy through hydro also has its challenges because South Africa does not have huge rivers, one participant indicated this. The extract below from Participant E indicates the abundance of Solar and Wind resources in South Africa, a view shared by many.

> *Participant E: We have got exceptional solar resources throughout the country. Some of the worst areas of solar resources within the country are still better than many areas of Europe.*

Studies by Gauché et al. (2013) and Olatayo et al. (2018) and Aliyuet al. (2018) confirm the Renewable Energy prospects in South Africa. Olatayo et al. (2018) added that South Africa could lead the continent in generating wind power.

At the same time, Gauché et al. (2013) suggested that South Africa has the world's best solar opportunities. Gauché et al. (2013) (2013) and Troldborg et al. (2014) supports participants statement that hydro can offer large-scale projects, equivalent to a coal plant.

In addition to coal and renewable energy resources, participants indicated that the REIPPPP is unique to South Africa. Firstly, it is a joint programme between the National Treasury and the Department of Minerals and Energy, including the office of the Independent Power Producer (IPP). According to the participants, South Africa struggled to introduce Renewable Energy before this program. Secondly, the auction model or competitive bidding is unique because of the socio-economic requirements unique to South Africa. Lastly, the participants think the model is suitable for the South African environment and its history. The extract below is from participant N's interview, highlighting the context to which the socio-economic aspects of the programme were necessary, for example, the social differences and need for transformation.

> *Participant N: The intricacies of South Africa's renewable energy markets are due to historical socio-economic and political factors rather than something unique to renewable energy supply. Our governance, social differences specifically poverty issues, and requirements for transformation across the sector. Those kinds of policy inputs change how our market might work compared to some others. For example, the BBEEE rules are not something you find in procurements elsewhere in the world. So those are the type of things unique specific to South Africa.*

Participants appraised the programme but believed that the uncertainties and political interferences failed to achieve the socio-economic goals. Matsuo and Schmidt (2019) and Bazilian et al. (2020) confirm that the cornerstone of REIPPPP in South Africa is jobs and socio-economic empowerment.

Lastly, the participants indicated that South Africa is a third-world country. Their views are that South Africa should not be held to the same standards as first-world countries regarding emissions management and roll-out of Renewable Energy. The concern from participants is that South Africa cannot afford a fast-paced rollout; therefore, they suggest the continuation of coal and slowly transition into Renewable Energy. The extract below from Participant C highlights the economic conditions of South Africa, which, according to the participant, are not suitable for the quick roll out of Renewable Energy. This view is linked to the statement made above by participant H to continue to use coal and that Renewable Energy is imposed on developing countries.

Participant B: Maybe the last one I am going to add is that, unfortunately, we are not a very rich country. A lot of the countries have done a transition, the fast transition, in the early part of the cost curve while these renewables were going at a lower cost have paid for it. Because they are very rich countries, your Germany, Denmark, Norway, US, UK and so on, we are not in that league. We are not that rich, and unfortunately, we cannot just say do it, and we will pay.

In support of their views on why South Africa should continue with coal generation, the participants indicated that South Africa has no money to subsidise Renewable Energy to keep electricity prices as low as possible. Secondly, the participants emphasised the need to keep electricity costs low for a developing country to attract foreign investments. Thirdly, South Africa does not have the skill set required for this new technology. Lastly, a secure and reliable supply that comes with coal helps developing countries to build the economy through industry and manufacturing development. Signing the Paris Agreement is seen positively by some but maintains that it should not mean fast-tracking of Renewable Energy.

Participants acknowledged that South Africa has both coal and Renewable Energy resources in abundance. Participants are also concerned about the socio-economic and technical aspects of Renewable Energy which entail the cost of supply, reliability of plant, and skills required to build and operate the plants.

4.2 Sustainable Energy

In this theme, the responses from the participants in defining sustainable energy are detailed. There are similarities within the group of respondents. The main aspects covered to define sustainable energy are; long-term planning and use of Renewable Energy, availability of resources, environment protection, affordable and reliable supply that meets demand, and just energy transition.

The first group of participants views sustainable energy from an institutional perspective. According to the participants, a sustainable energy industry has a long-term plan that is executed without interruptions. Participants indicated that South Africa paused the Renewable Energy programme in 2015 and created uncertainties in the industry and delays in achieving Integrated Resource Plan targets. According to the participants, this pause meant a short-term focus. Lastly, the participants expressed a lack of planning.

This lack of planning means that there is no indication whether the bids will go as far as ten bid windows, implying unsustainable programs due to short-term focus. The following extract is from participant E's descriptions of sustainability energy.

Participant E: Sustainability, not just energy, implies a long-term view. It is not something you do with the short-term focus. From an energy perspective, the sustainable energy solution allows for the continued use of this particular technology or option beyond the short-term horizon.

The overall view of the participants is that for Renewable Energy to be sustainable, it requires consistency and time. The programme needs to run for an extended period to build the technical expertise required. This statement is supported by Participant J; see extract below. Participant believes that the benefits of continued implementations are reduced cost, improved performance, and building the required skills and capabilities.

Participant J: When you talk about sustainability in the energy industry, you have to have a long-term vision of 20 to 30 years to ensure maturity of scale and benefits.

In addition to extended use and long-term focus, the second group of participants added the environmental perspective of sustainability. According to the participants, sustainable energy does not harm the environment. The participants compared Renewable Energy to coal energy that causes environmental damages, especially emissions. The extract below is from Participant G. The participant details that sustainable energy does not harm the environment during the generation of electricity process. Moreover, participants indicated that the resources should not deplete. If they deplete, then the energy supply is not sustainable. The use of resources also relates to the use of coal that will deplete and renewable energy resources that do not deplete.

Participant G: Sustainable energy means providing energy that does not harm the country's natural resources as part of generating electricity. Do not have emissions or emitting very limited, almost zero emissions in the renewable plant.

Participants acknowledged that sometimes Renewable Energy plants use fossil fuel energy as backup, especially when sun and wind are not available, therefore generating emissions. The environmental issues raised are not limited to emissions but water and land. Participants believe that Renewable Energy requires land that is not available.

Also, Renewable Energy plants are mainly in the Northern Cape, a water-scarce province. Participant I on the extract below indicated that there needs to be the sustainability of livelihoods and that water and land resources are kept for future generations.

> *Participant I: Specifically, in South Africa, sustainability is the sustainability of livelihoods. We need not gobble up all our water resources and our land availability. So, when you say sustainability, it means something that can endure for a long time. You know, something that's not going to displace people and not pollute our water supplies. Yeah, so you know, sustainability means that we are better off; let us say 100 years from now that we have the resources, we need to do what we need to do. It also means understanding how we use energy*

Participant I expanded input resources to include land, water, and the need to preserve resources for future generations. In addition, participants indicated that Renewable Energy supply should be delivered with an understanding of community needs in mind. The other characteristic added is meeting the energy demands in South Africa.

Participants in the third group expressed concerns about the availability of supply. There are two aspects of the availability of supply that are expressed. The first one is the availability of Renewable Energy resources compared to coal. The group suggests that for energy to be sustainable, especially Renewable Energy, it has to be available for use and not be depleted. The basis is that coal will not always be available. It has an end date. This view from the participants aligns with (Armin Razmjoo et al. (2020) that Renewable Energy's availability and non-replenishable nature is a sustainable option. Extract from participant N indicates the need for the resource to continue to exist. Coal or Renewable energy sources are inputs into electricity generation. However, participants H on the extract below add reliability which is different from being available.

> *Participant N: Sustainability would be the ability of anything to continue to exist and develop without depleting natural resources.*

Participant D shares the view that Renewable energy is sustainable energy because it is replenished by nature.

Participant D: Now, much of the energy is produced by Eskom. However, in the long future, we will have sustainable energy: solar and all other energy forms from Independent Power Producers.

Participant H adds the need to determine the needs for future and long-term focus. In addition, the participant indicates the availability of energy sources and reliability, and the ability to meet the demand.

Participant H: in terms of sustainability, you are looking at repeatable and reliable energy sources according to demand, whether it be a forecast or a requirement.

Participant F rules out Renewable Energy as sustainable energy because of its technical capabilities or lack of. This aspect talks to the reliability aspect mentioned by participant H, being available when needed, able to forecast it. Participants also indicated that Renewable Energy sources (wind or solar are not always available, hence the need for battery storage or backup generators.

Participant F: Firstly, renewable energy is not dispatchable. For renewable energy to be sustainable and replace coal, you need to have some means of backing renewables. There are two options. One is the pumped storage, and the second is gas turbines. So renewable energy on its own with nothing else to back it up cannot be sustainable. It is renewable energy and some other technology to back it up for it to be sustainable.

The second aspect implies the reliability of supply that sustainable energy is available when needed. The argument is that with Renewable Energy, the sun is not always shining, and the wind is not constantly blowing and therefore not sustainable. To be sustainable, participants suggest that it needs fossil fuel as a backup supply. Cavalcanti & Cândido (2017) have a similar view of energy sustainability. Their study highlighted that energy sustainability is determined by how demand is met when adhering to environmental sustainability, social equity, and economic viability principles. That is why Participant A, as per the extract below, highlights meeting demand without compromising the environment. Participants also highlight dependencies in the system, that a reliable and efficient supply is dependent on the availability of resources.

Participant A: Sustainable energy or sustainable renewable, in general, is making sure that energy supply meets the energy demand in an efficient, improved, and environmentally friendly manner. Moreover, these depend on the availability of the resources of all our suite of technologies.

The last group encompassed everything mentioned above. They coupled energy demand with affordability and reliability. According to the participants, to ensure availability when needed, the energy systems need to be affordable by keeping the price low and reliable. Troldborg et al. (2014) confirm that reliability has been an issue with Renewable Energy as it affects supply and reliability. The extract below from Participant C introduces affordability, which is linked to the cost of supply and just energy transition that has to do with coal industry jobs. Participants' view is that price has to be kept low so that the lower-income groups can afford it and access it. The participants address sustainable energy from the South African context by including income levels, which is different from other countries as indicated during the context discussion.

> *Participant C: You have to look at all the different aspects of energy use. It is getting to a state of zero greenhouse gas emissions and minimizing air, soil, water pollution, and waste production. You also have to consider the economic aspects, especially in a country like South Africa with a high Gini coefficient in the world. So we have to keep the price of electricity affordable. Moreover, we have to look at social aspects of energy, such as the energy transition. The unions are very concerned about losing coal-related jobs. So we have to manage the technical aspects of renewable energy somehow so that we still have a reliable, secure electricity supply and political sustainability.*

Gunnarsdottir et al. (2020) suggest that the importance of energy in promoting social and economic growth is now widely acknowledged. Also, governments worldwide are debating issues such as accessibility, affordability, energy transition to renewables, and energy efficiency. As a result, Sustainable Energy Development has increasingly gained a more systematic meaning and increased significance. According to the study, transitioning to Renewable Energy supply includes affordability, reliability, education, and training.

Participants C and B suggest that a sustainable energy supply should consider the impact on the Coal industry, especially jobs lost. The extract below from participant B suggests that South Africa needs to consider the just energy transition and ensuring that coal employees are not compromised. The statement from the participant implies that the climate change and price to consumers should not justify the loss of jobs in the coal industry.

Participant B: When you use the word sustainability, it takes me to three areas. The first one is the environment because we sell renewables from the perspective of the reduced damage to mother earth. We will be more sustainable rather than burning coal forever because we have reduced emissions. That is sustainability from the perspective of climate change. Then the second one is the affordability of the product. One can do excellent modelling around protecting the earth, but there is a problem if the solution is not affordable. The third angle is just energy transition. Never mind the climate and the price to the end consumer, but you have got to be fair to the industry supporting what you are replacing as well. If you miss the balance between these three, then the use of the word sustainable may be in doubt.

Even though the participants' views differ on defining sustainable energy, their definitions of sustainability show the role which energy plays in the various aspects of sustainable development. They also confirm the multi-dimensionality of sustainable energy covering sustainability's social, economic, environmental, institutional, and economic dimensions.

Gunnarsdottir et al. (2020) also support this statement and further indicate that sustainable energy development can vary significantly across countries and energy systems. The energy-related issues confronting developing countries differ considerably from those facing developed countries, owing to differences in energy requirements. Furthermore, the availability of energy resources in a country may be a deciding factor for sustainable energy development. Gunnarsdottir et al. (2020) add that regardless of the various circumstances and energy-related obstacles, the ultimate aim of sustainable energy development is to foster sustainability at all levels. The research concludes that sustainable energy systems aim to enhance the well-being of the people by delivering services that foster economic and social progress while reducing environmental and health impacts.

4.3 Proposed Criteria and Indicators

The participants are the ones that proposed Criteria and Indicators to assess the sustainability of Renewable Energy supply. The subthemes are presented as indicators under the five proposed criteria.

4.3.1 Economic Indicators

4.3.1.1 Indicator: Local Manufacturing

Various participants suggested local manufacturing as an indicator. The participants indicated that for the Renewable Energy supply to be sustainable, components should be manufactured locally. Their primary motivation for local manufacturing is to boost industrial development. They also believe local manufacturing will compensate for the few permanent jobs available in the Renewable Energy plants and short-term jobs available during construction. The following extract highlights the need for a long-term strategy that supports local manufacturing and job creation.

> *Participant E: Whatever solution you put on the table, it needs to have that long-term view, from localization and a job creation perspective. The jobs you create in terms of this renewable industry and the transition from coal to cleaner energy have to be a long-term focus.*

Participant E draws back to the definition of sustainable energy, that of having a long-term strategy that looks at the entire value change. Participant I highlights the opportunities in the Renewable Energy industry, one being able to create jobs in local manufacturing. Participants suggest that such opportunities are not available in the coal industry. Lastly, participant I's extract below considers opportunities in the small-scale projects, private installations like buildings and homes generating their electricity. Within that, there is an opportunity to manufacture locally and create jobs, according to the participant.

> *Participant I: Whereas in the renewable energy sector, you can have sustainable jobs of assembly of components, manufacturer of components, maintenance, repairing, and having that go hand in hand with things like energy efficiency, and building buildings with energy built for energy efficiency as well.*

The participant further says that procuring an already manufactured plant or products from other countries is not sustainable. The following extract suggests the need to use local resources as input material in the manufacturing of components. The participant believes that South Africa exports raw materials to China and then imports the parts produced by our raw materials. This participant suggests that South Africa should be mining their raw materials, manufacturing, and exporting to other countries to boost the country's economy and create jobs.

Participant E: We also have a number of mineral resources that we could mine to beneficiate the Renewable Energy industry and create long-term and sustainable jobs by exporting the beneficiated products and our expertise.

Other participants who suggested the need for local manufacturing are D and J. Troldborg et al. (2014) indicated that countries with local and expert industries benefit more from job growth. Participant F also suggested that local manufacturing could assist with the possible loss of employment in the coal industry. The following extract from participant F suggests that local manufacturers could employ coal sector employees.

Participant F: We need to manufacture something related to that (Renewable Energy) plant in South Africa. People employed in the energy sector can find alternative employment in the manufacturing sector, manufacturing components, or items linked to renewables to substitute jobs and employment losses.

The participant is further concerned about the towns that host the coal mines and power stations, suggesting that manufacturing should take place in those towns to minimise the impact.

Participant F: When you transition to renewables, you will need to consider upping the manufacturing sector. You have a town built around a power station. That power station is predominantly coal; half the town could be unemployed. So half the town needs to be catered for, so if you are building a renewables plant, then manufacturing the solar panels or manufacturing components, etc. needs to take place in the decommissioned power station.

Semelane et al. (2021) support the statement that local manufacturing is crucial for creating jobs and supporting a just energy transition. Regarding solar panel manufacturing near coal mines and power stations, Semelane et al. (2021) conducted the feasibility study to manufacture solar panels in towns near power stations because of the potential job loss. The results of the study revealed that it is not financially feasible to manufacture without a government subsidy.

There are concerns from other participants, posing a question that needs to be addressed. The question is, at what costs does South Africa pursue local manufacturing to achieve job creation? Local content is a requirement during the bidding process accounting for 7 percent. Compared to other countries like India, China, Brazil, and South Africa is less successful in achieving local content (Matsuo & Schmidt, 2019; Hansen et al., 2020). The main reasons are the size of the market, policy certainty, and prior existence of capabilities.

Participant N did not suggest this indicator. However, highlighted that political stability and consistency are needed to achieve local content.

> *Participant N*: *Without consistency in the market, you will not harness all of the social aspects required from building renewable energies, for example, creating jobs and industry.*

Participant O also did not suggest this indicator. The participant supports local manufacturing, however, not in the renewable energy industry. The view of the participant is that pursuing local content could result in high electricity costs. The participant believes that the country should pursue a low electricity tariff, attract investment, and use taxes to manufacture and export other things. Participant O asked these questions to highlight the conflicting policy objectives in South Africa. The participant also reflects on the government's short-term views pursuing jobs to gain vote over the long-term effect like the cost of electricity supply.

> *Participant O: Is it a good idea to build a solar PV manufacturing plant in South Africa when massive factories in China and everywhere else manufacture these at a much lower cost than we can ever try and do? Is it better to have expensive energy or electricity because you add many policy objectives into your procurement process?*

South Africa's local content is characterised by uncertainty, small market size (Hensel et al., 2020). Bazilian et al. (2020) found that the market size is why LCR has not been successful in South Africa. The concern for the participants is beyond just the Renewable Energy industry. The view is that manufacturing components and parts locally will address unemployment and grow the economy. According to participant D, economic sustainability means creating small-scale industries that can start manufacturing equipment. In line with Participant F saying that for RE to be sustainable, manufacturing must be done locally. They associate local manufacturing with sustainability.

The other benefits are the drop in electricity prices in the long run and export opportunities (Participants D, E, and F). Participant F emphasised the matter by saying, definitely renewables will have a massive impact on unemployment, so you will need to look at escalating the manufacturing sector. However, the views from other participants are that local manufacturing could lead to high tariffs. They suggest that the country deals with employment in different ways outside the Renewable Energy industry.

4.3.1.2 Indicator: Jobs created/lost

The terms quality, sustainable and long-term jobs came up a few times. Participants suggest that the indicator should not be the number of jobs created but the type of jobs created. Participants G and E emphasise the need to measure the quality of employment, meaning the types of positions provided to include scientists and engineers as an example. The participants also suggest that the indicator provides a breakdown of jobs to reflect management positions, skilled labour focusing on engineering and not just artisans.

Participants A, B, C, and E share the same view that RE does not offer as many jobs as the coal industry. Also, the jobs are primarily construction-related and, therefore, short-term. Fewer jobs are required to run the operations and maintenance of the plant. These are some of the concerns shared by participants. Their view is that the coal industry offers more permanent jobs in mining operations, transportation of coal, and operating power stations. The extracts below from participant A suggest that a Renewable Energy plant requires few resources to operate and maintain.

> *Participant A: There are many temporary employees you will need from construction to hand over and less on operations because these things (RE plants) are self-sustainable.*
>
> and
>
> *Participant A: South Africa, with the challenges we have, we cannot have a purely renewable energy source for the baseload and sustain the economy. Because we are a developing country, you will lose many things in the process. One is jobs and job opportunities. You cannot reach equivalent jobs (with renewables).*

Participant E indicates that the energy mix still needs to consider coal to keep the unemployment rate low and boost the economy. Moreover, a developing country like South Africa cannot afford to lose many jobs, referring to the South African context of a developing country. Also, the statement by participant E goes back to the definition of sustainable energy by participant F that Renewable Energy alone is not sustainable.

Participants B and C supports the statement by participant A. The extract below from Participant B suggests that the indicator reflects sustainable jobs lost because Renewable Energy will not absorb coal industry employees because the technologies are different as participant A has indicated, there are no equivalent jobs.

Participant B: If somebody has a permanent job in a mine, how do you replace that job with a renewable dispensation because renewables are very different. Once you put it in there, you probably need ten people for a 500 MW plant to clean those solar panels or to service those wind turbines. So, what do you do where the mine was employing hundreds of people?

The extract below from Participant C is confirmed by Cavalcanti and Cândido (2017) that most Renewable Energy jobs are construction-related. The participant adds to the statement by participant A that few jobs are required to operate and maintain the plant.

Participant C: I think we are looking at jobs again. You will have to be quite clever because there is a construction phase and an operational phase. In coal, most of your jobs in the operational phase, but with renewables, it seems most of your jobs are in the construction phase, and they are short-term roaming jobs.

Participant N's view is that the Renewable Energy programme needs to continue as planned to deal with short-term jobs. The participant suggests that if a Renewable Energy plant is built every year, it will change a coal-based energy system concept for the next twenty years. The concept of temporary jobs will end as the Renewable Energy industry will become a cyclic industry. The participant further addresses the coal jobs issue by saying Renewable Energy is not destroying coal jobs as these jobs would end with coal. Literature confirmed that Renewable Energy attracts more construction jobs. The anticipated developments include introducing Renewable Energy technologies such as solar, wind, biomass, and hydropower (Semelane et al., 2021).

Participant N: I think this is where a lot of the renewable energy discussion gets muddied with all of these other views. Coming in is when you start saying, what do you lose by building renewable energy. It starts by jumping into this concept of people thinking that you are now destroying coal jobs by building renewable energy. Understanding coal was never available indefinitely. It has never been. It has always been a limited resource that would run out at some point. Renewable energy is not taking away any coal jobs.

It is simply making sure we still have electricity when coal stops being the mechanism to generate power.

The extracts above show a comparison between the coal and renewable energy jobs and participants. There is an understanding among participants that Renewable Energy does not offer the same jobs as coal. Troldborg et al. (2014) and Cavalcanti and Cândido (2017) confirm this. Moyo et al. (2017) study confirm that jobs will increase with the consumption of Renewable Energy supply in the long term.

Troldborg et al. (2014) suggest a separation of jobs when assessing employment. The study separated Construction, Installation, and Manufacturing (CIM) jobs from Operations and Maintenance (O&M). The study confirms that CIM jobs are short-term.

4.3.1.3 Indicator: Affordable supply

Participants suggested price of electricity or tariff be an indicator for economic sustainability. Some used the term affordability and levelized the cost of electricity. There are different views on the current price of RE, and one group believes coal supply is expensive and will continue to be expensive. The other group remains with the view that coal is still very cheap, and RE's introduction makes the electricity price expensive. Both groups agreed that the electricity price must be affordable. They share the same view that affordable electricity prices promote industrialisation, economic development, job opportunities, and access to supply.

The below extract from Participant F anticipates an initial increase in electricity prices and a reduction in price when more RE projects will be included in the mix. However, the initial increase needs to be accepted for the environment's sake for this to happen.

> *Participant F: I would say the key metric would be the emissions and global acceptance to reduce greenhouse gas emissions. The second one would be naturally following from the first one that you accept that the tariffs need to be higher if you accept the first one. As you roll out more and more renewable plants, the tariffs should decrease because of the economies of scale.*

The participant's view of sustainability lean towards environmental protection and believes that challenges with climate changes need attention. Participants suggest that a national acceptance of Renewable Energy will accept higher tariffs for a short period. Participant B believes that electricity is expensive now and that Renewable Energy is expensive. According to the participant, South Africa is not a wealthy county and cannot afford to subsidise electricity tariffs. Therefore, the customer has to pay. The increase in tariffs will create problems for the country. According to the participant B extract below, people who cannot afford electricity will disconnect themselves or steal electricity.

> *Participant B: So, the aspect of the price you have to measure. You can also measure drop-off in terms of people's disconnect and say sorry. I cannot afford this. You can measure things like theft of electricity and a few other things resulting from the electricity that is no longer affordable.*

Participant B suggests electricity price indicator should be measuring the number of people who disconnect due to the unaffordability of supply. Participants I share the same view and believe that expensive electricity will result in energy poverty and energy sovereignty. Participant I extract below suggests that installing their supply will drop from the national grid, leaving it to the poor who cannot afford it.

> *Participant I: So, is the energy affordable and accessible to everyone? Will it create sustainable livelihoods? Does it also enable energy sovereignty? We have seen the trends around the world, and people are already producing their energy. They can afford to do it. Thus, where does that leave poorer communities? How do we protect them? How do we supply energy in a way that's not going to compromise communities again in the future?*

Participants B, C, and I deal with the issue of access to electricity and affordability. The view from the participants is that if people cannot afford electricity, they will have no access to it, the reason for the price to be kept low. Because of inequality and poverty, participant J also calls for the accessibility of electricity at affordable rates to the consumer. Ali et al. (2020) suggest that electricity cost is relevant to access to electricity and affordability. Kemmler and Spreng (2007) proposed that the price of electricity be used to measure poverty. The researcher considers access to electricity a basic need. Participant C on the extract below refers back to the South African context and the need to keep electricity prices down for a country with people living below poverty lines.

Participant C: In a country like South Africa, we have a high Gini coefficient in the world. We still have a fairly large proportion of our society who either do not have access to the National Grid or have but cannot afford to use it. So, we have to keep the price of electricity affordable.

Participant M added that Renewable Energy supply requires new infrastructure. It comes at a cost to the consumer. For example, the transmission lines needed to carry the electricity to the rest of the country. This infrastructure is currently not available, and the customer will have to pay for it. Concerned about the price of electricity, a participant says a decision is needed on whether the Renewable Energy plants are built in areas where there are more or lesser resources. The less wind and solar resources could result in lower efficiency but cheaper electricity. Participants J, L, and O shared the same view. The extract below from participant J highlights that the prices need to be affordable to the customer, and linking to inequalities, the lowest income earners must afford it.

Participant J: And the third level is the accessibility of electricity at affordable rates to the consumer.

To keep the tariffs low, South Africa needs to choose the cheapest energy options. Participant M suggested that the basis for our new build programme should be the cheapest energy path with no subsidy or incentives. The aspect of not subsidy or incentives was shared by the participants that South Africa is a developing country that cannot afford subsidies. Participant M argues that the basis for future energy plans is on the modeling with proper data inputs. Participant further argues that correctly done, alternatives are eliminated, and one suitable path is provided. The exercise would have considered future demand, weather, and resource availability, amongst other things. Most importantly, the model will tell us the best technology for our system, assisting in proper decision making. The response from the participant as to why they consider this to be essential is mentioned below:

Participant M: Because if that is not the case, you start looking into all of these other aspects around whether or not we should be doing this. Does climate change matter? Are there social implications? Are the economic implications? Why are we doing this? Right?

According to the participant, the implication caused by short-term focus is continued load shedding, insufficient power supply, expensive power ships, and costly electricity. The participant believes that a model will provide the best energy solutions required for the country. For example, if it means including coal, then coal should be included and not be debating climate change. According to participants, affordable and reliable supply is critical.

It is evident from the discussions above that participants want South Africa to strive for a low-cost energy supply. Also, the cost of electricity is essential for a developing country with income disparities. Cavalcanti and Cândido (2017) suggested consideration of electricity price for energy sustainability. The study indicated that the electricity should be affordable to accommodate domestic users and attract international demand. Liu (2014) also indicated that price impacts affordability.

4.3.2 Environmental Indicators

Three participants indicated that they are not too concerned about the environment. Their first reason is that Renewable Energy has zero emissions and, therefore, a cleaner energy option. The second reason is that South Africa has good environmental management laws that ensure the environment is well looked after in all life cycle phases. The last reason is that coal pollutes the environment most, starting with the greenhouse gases causing climate change. Participant N, when asked about environmental indicators, said;

> *Participant N: South Africa is not in the luxury position of particularly caring about the environmental conditions of the technologies. That you have in place. To me, the environmental aspects are not important. I do not think there is any relevance to the environmental concerns around renewable energy. The impact on people's lives of environmental changes is not as significant as other indicators. South Africa does not have the luxury to say, okay, we will not have electricity because of environmental concerns.*

The participant brought load shedding and impact to the economy and considered those as burning issues than emissions. Participants believe that the environmental impact on the community is not significant. Participant O, extract below indicated that the environmental criteria of Renewable Energy supply could be easily achieved, emphasising that they are not an issue.

Participant O: I am not that concerned about it because South Africa has very good laws and processes in terms of environmental impact assessment etc. I would not say that is the biggest hurdle at the moment facing our future in terms of sustainability. However, it is just one of the criteria that hopefully can be ticked relatively easily with renewable energy. Hence, the more burning issues there need to be confronted, for example, economic.

Participant L shared the same view as Participant O on the environmental laws and regulations South Africa has and should be maintained during development. The participant suggests that Renewable energy zones be created and used first for development to avoid sporadic land use. See the land use indicator for details.

Participant L: I think we need to be cautious about where we develop and how we develop. Luckily, we have a very strong Environmental Management Act. Each project needs an Environmental Impact Assessment. The environmental regulations that we have are good. We should always live up to it, maintain it, and improve it as we develop.

Participant J indicated that the country's political economy defines the weight of emphasis on criteria. According to the participant, environmental matters are not that important to South African. The participant indicated that even within the developing countries, weightings of importance are not the same. Making an example with Nigeria that there might be similarities but not the same.

4.3.2.1 Indicator: Air Quality

Participants A, B, C E, H, M suggested the emission indicator. The extract below is the Participant's suggestion of life-cycle assessment for greenhouse gas emissions. The participant's view is that coal is used to generate components.

Participant A: From the environmental point of view will be the greenhouse emissions during the life cycle of the technologies.

Participant A's view is shared by participant H. The participant suggests a net effect of emissions. The idea is that construction and manufacturing produce emissions, and those need to be measured.

Participant H: So, looking at environmental is purely going to be elements around actual emissions. It is not only a contribution concerning direct emissions but also indirect. If we take a wind turbine as an example, people might think a wind turbine will replace a cubic meter of flue gas. It is going to replace it, but it is not a direct correlation. You have to ask yourself, when producing that wind turbine blade, did you use heat? Did you use fossil fuels? What did you use to produce that? So, I am talking about a net effect. There needs to be a net effect in terms of measuring environmental sustainability.

Participant C is concerned about the health implications of CO_2 and suggests monitoring emissions because the production of components uses fossil fuel, confirming Participants H and A's.

Participant C: CO_2 is a global issue. It is one of the biggest risks facing humans. South Africa has a very carbon-intensive economy, so we certainly need to reduce CO_2. It is documented that air pollution from coal-fired power stations kills a certain number a year.

Participant J takes a different turn which refers back to the context of the country. Participants suggest that emissions for a developing country are not that important compared to a developed country. The participant is of the view that South Africa has more burning issues than emissions.

Participant J: It fundamentally has to do with the nature of our economy, inequality, poverty. These sustainability criteria have to talk to the political economy of South Africa. So, everything is very different; for example, in Germany, the emphasis will be more on carbon emissions. Whereas here, the emphasis on carbon is 10 percent. Here the emphasis is on ownership and socio-economic issues, 90 percent. Our political economy defines the weight of emphasis you put on the sustainability criteria.

The participant in the study expressed that air quality would be a good indicator. The view is to measure both greenhouse gas emissions and particulate emissions. Most studies focus on greenhouse gases because of global climate change effects. Naicker and Thopil (2019) recommend life cycle assessment (LCA) for emissions. LCA takes into consideration fuel, transportation, construction, manufacturing, operating, and disposal emissions.

4.3.2.2 Indicator: Water requirements

Participants C and D suggested that water use should be one of the indicators. Participants C, D, and I say Northern Cape is a water-scarce region, and the resource needs guarding. Sparks et al. (2014) and Suganthi (2020) support this statement. Also very hot, hence the abundant solar resources. The heat causes the water to evaporate at a high rate during the solar energy production processes creating a risk of more water requirements than planned. Participant I added by saying water resources should be sustained for the future generation. Participant G suggests that Renewable Energy plants need to consider other users when using water resources for energy generation purposes.

> *Participant G: Northern Cape is a farming community as well. You need to be considerate of the farmers, and everyone, because this water is not only for you, energy production. Orange River is very constrained because many users are taking the water, so it is quite important to look after the resource.*

None of the studies mentioned above has a water use indicator. It is, however, one of the proposed indicators by IEA (2007). Experts in the Songata (2020) study considered water a significant input resource. Sparks et al. (2014) confirm that South Africa is a water-scarce country, and therefore essential to monitor how each technology uses water. According to their research, Renewable Energy production uses fewer water resources compared to coal. The inclusion of water use indicators is supported by Sparks et al. (2014).

4.3.2.3 Indicator: Land / Area Requirements

Land use or area requirement is one of the suggested indicators under the environmental criteria. Participant I calls for the better use of land. Participant suggests the use of existing structures to install solar generation technologies for the preservation of land. Also, the participant advocates for a decentralized energy system. The reason is that large-scale projects connected to the national grid require long-distance transmission lines and, therefore, land. The participants associate land use with the displacement of people and defined sustainability as not having to displace people. In the extract below from Participant I suggest that there could be some innovative ways of powering South Africa than using land and having large-scale projects. The Participant suggests that land be preserved for future generations.

> *Participant I: I do not necessarily believe that megaprojects of you know, like vast tracts of land allocated to solar, is the solution. We do have several urban areas, rooftop areas that can be used.*

Participant A presents a different view from participant I. The extract below from Participant I suggests that there is enough land in South Africa to accommodate the new renewable energy plants. According to the participant, the only concern is that land is in the hands of the few, and government needs to deal with the appropriation of land urgently.

> *Participant A: Now, on the land requirement, the key matter here is the land policy. As we know, in Africa specifically, the land is in the hands of the few. They monopolize access to land.*

Naicker and Thopil (2019) indicated that Renewable Energy technologies require large pieces of land. Research added that hydro projects might require the relocation of people, aligned with Participant I's view.

> *Participant I: We should also identify Renewable Energy Zones because these are very good pockets of areas for solar and wind. We almost use those first. The problem on the environmental side, if you spread out wind farms everywhere, I am not sure that would be the entire effect. Whatever the impact, it is in one place and can be managed. Important is that you need a backbone transmission infrastructure. You cannot start building power lines in every corner. It is not cost-effective to build lines.*

To minimize environmental impact, primarily land use, Participant L suggests the identification of Renewable Energy zones. New developments will be done within the zone to avoid having projects nationwide and building the many transmission lines to connect to the national grid. Also, any negative impact on the environment could be contained in the zone.

4.3.2.4 Indicator: Waste generated

Participants suggested waste that is generated to be one of the sustainability indicators. Participants believe that Renewable Energy generates waste in the various phases of plant life. The components used are either toxic or not recyclable, creating other environmental problems. IEA (2007) indicated that all energy generation or conversion technologies generate waste.

Also, a technology like Renewables may not emit toxic substances. The manufacturing or other aspects of the life cycle can be associated with pollution and waste. IEA (2007) confirms statements made by participants C and I below. The extract from Participant C below compares coal generation and renewable energy generation waste. It suggests that Renewable Energy generates toxic waste. Also, the lifespan of Renewable Energy is short, requiring decommissioning and breakdown that generates waste sooner than coal plants.

> *Participant C: Waste production, especially renewables, we do not just look at the waste generated from operations with which is like Eskom ashes which is a big issue, but with renewable plants have a shorter life cycle. You get to things like batteries, and they can be toxic, so you have to dispose of them carefully. We need an indicator of waste produced that incorporates both the construction, operation, and decommissioning phases.*

Participant I added that Renewable Energy components of Renewable Energy plants are not recyclable, creating waste and suggesting a design for recyclability. Participant added that

> *Participant I: So, if we produce many renewables like solar panels, that cannot be recycled. Currently, you can only recycle one part of the solar panel. If we consider the design for recyclability or the circular economy, that is another step toward sustainability. Because you are taking something out of the ground and not reusing it, it makes it a finite resource. Thus, unsustainable. Certain aspects of even renewable energy need to be looked at in designing for recyclability and sustainability. It is important.*

The study's finding is that life cycle analysis needs consideration in measuring environmental sustainability, whether from emissions, water, or waste-generated perspectives. Cavalcanti and Cândido (2017) pointed out that all energy generation processes generate waste. Therefore, the entire footprint must be analysed. The researcher further adds that environmental sustainability is concerned with system efficiencies. Participants in the study suggested efficiency in coal generation to deal with emissions to buy time while transitioning to Renewable Energy supply. Energy efficiencies reduce emissions while keeping prices low, according to Troldborg et al. (2014), Aliyu et al. (2018). As indicated by Troldborg et al. (2014), the opposite is true that pursue emissions reduction results in higher tariffs. This confirms the study's findings as participants indicated that South Africa would experience tariffs when replacing coal with renewables. Participants defined sustainable energy as an energy system that does not harm the environment.

Participants suggested efficiencies in coal plants to reduce emissions to protect jobs in the coal industry and allow time for transition. This is also a reflection of how interconnected the indicators are. Aliyu et al. (2018) indicated that environmental indicators, especially emissions, are dependent on energy efficiency, supporting the suggestion to fix emissions in coal power stations. This suggestion also indicates that participants want the environment protected but Renewable Energy is not the only solution. Pegels (2010) and Kruba and Burch (2011) also indicated that concerns about the economy overpowered debates on climate change.

4.3.3 Social Indicators

4.3.3.1 Indicator: Awareness and Acceptance

Participants D, F, and I suggested awareness and acceptance as a social indicator. These participants believe that by educating people and raising the awareness level, there is buy-in. Participant D says that there is a lack of general awareness on Renewable Energy, and awareness should start now and not at the end of coal life. The benefit, according to participant D, is acceptance of the new way of electricity generation. Also, those who afford, could generate their own electricity and not depend on the national supply. Lastly, awareness and acceptance afford communities to voice their concerns about the technology. The extract below from Participant D suggests that people need to be aware that coal will no longer be available to generate electricity. They need to start climatising to the idea of using Renewable Energy.

> *Participant D: There are few numbers of people in South Africa who are aware that renewable can, for the time being, overlap with non-renewable. After overlapping, there will be increasing use of renewable energy more and more so that it is sustainable to replace the coal utilised. Because sooner or later, I usually say within less than 50 years, there will be no coal. It will not be available in South Africa. It will be finished. What we do next is not to sit in the dark but to use the renewable. So one of the criteria obviously is awareness.*

Participants I and F add that, to get buy-in, a bottom-up approach is a better option. Participant F indicated that South Africa should have started twenty years ago before signing the Paris agreement committing South Africans to the need to reduce emissions. Extract from Participant F suggests a need for a national acceptance of a transition to Renewable Energy to address climate and the high cost of supply that comes with such a decision.

Participant F: The bottom line is that there needs to be a global acceptance that we need to clean up the earth and everybody needs to get onto that bandwagon. I would have imagined they should have started 20 years ago. It should have started by getting the community to buy in, then the provinces as a whole to buy in. then national acceptance.

Ali et al. (2020) support that acceptance of Renewable Energy also means accepting the drive to reduce greenhouse gas emissions. Participant I, however, refers to acceptance at a project level, which entails accepting land use, having a say in local development, including choosing the type of technology. The below extract from participants' interviews indicate the importance of awareness and acceptance.

Participant I: It is very important to have the views and engagement of people on the ground. It impacts the buy-in of projects. It shapes the project to serve the needs of people. The bottom-up approach is much better than the top-down approach.

Antwi and Ley (2021) confirm that the participants suggested having acceptance as an indicator, both from cost and understanding the technical requirements and how it also meets people's needs.

4.3.3.2 Indicator: Just Energy Transition

The first issue raised by participants on just energy transition is that Renewable Energy does not offer the same amount of jobs as coal. Participants are concerned about the temporary jobs created in the renewables versus the full-time employment offered in the coal sector. Participants also indicated that the coal sector is labour intensive, from the mining operation, transportation of coal, and operating and maintaining and coal-fired power station. Lastly, the technologies are also different, so the coal employees will need to be reskilled to work in the Renewable Energy sector. However, Bohlman et al. (2019) revealed that there would be a small impact on jobs. The extract below from participants indicates A the difference in jobs between the Renewable and Coal sector jobs;

Participant A: There are many temporary employees from construction to hand over. Less on operations because these things are self-sustainable plans, and they run without major maintenance.

Participant A suggests that Renewable Energy plants are not labour intensive and require few people to operate them once commissioned. This view is shared by Participant B, who adds that the maintenance and upkeep of the plan require few resources. The extract below from Participant further adds that besides the renewable energy plant, the coal plant also gets input from coal mines that also employ hundreds of people.

> *Participant B: How do you replace a permanent job in coal with a renewable dispensation because renewables are very different. Once you commission it, you probably need ten people for a 500 MW plant to clean those solar panels or to service those wind turbines. So, what do you do where the mine was employing hundreds of people you know.*

Participant O's view is that people are aware that coal is no longer an option. It pollutes the environment and is not cheap anymore. The participant says the transition to renewable energy will impact employees in coal power stations and further suggest that they are probably not concerned about climate change but providing for their families. According to the participant, both IPPs who seek profit or government seeking cheapest cost of electricity cannot ignore social impact issues. The participant asked the following questions;

> *Participant O: Where do we put our next wind and solar farms? Do we put it where we have the most wind and sun or where we have a lot of wind and sun, where it can also help the (coal) communities? Hopefully, bringing in the generator to those areas will generate money for the community or jobs.*

Asked for further clarity participant suggested that government has the choice to encourage where IPPs could build their plants. The example made is that, where there is high solar and wind concentration, the result could be cheaper electricity, which is an obvious option. The other option is where there is no grid infrastructure (transmission and distribution lines). Putting these might cost have time and cost to it, the cost of buying land and doing all the environmental authorisation. Participant further said;

> *Participant O: Going to Mpumalanga, it ticks the boxes of potential job creation or community ownership of plants or something like that, which is positive, but it generates much less electricity than in the Northern Cape. It is also closer to load centers, so there are less losses because of the distances between them.*

Participant O suggests that the programme should direct the development of the Renewable Energy plants to the Mpumalanga area to support the communities that the transition will impact.

Participants believe the impact is beyond unemployment. They are concerned about the negative impact on property markets near coal mines and coal power stations. Because of the closure of power stations and no potential influx of new jobs, property prices might drop, as one example given. Coal laborers, might suffer a significant loss when trying to sell their properties. The participants' views align with Bohlman et al. (2019) on transition coming at a high cost for specific communities if not done correctly. Bohlman et al. (2019) added that grid infrastructure would be left stranded in areas that hosted the twelve power stations. Building renewable in less concentrated areas as suggested by participants L, M and O could be the solution. Participant F suggested converting decommissioned coal plants to manufacture RE components to ensure activity in the towns near coal mines and power stations. Participant C also suggested a national plan to deal with the town that will be impacted. The extract below the participant suggests that the Just energy transition indicator should also focus on the impact on the communities.

> *Participant C: So once those power stations shut down, it is almost like whole towns are going to be shutting down. People's houses will have no value because no one is going to buy them. I am not sure of a metric that could take that into account. We need a national plan to deal with that specifically.*

The extract below from participant B shows how the industry supports the communities near coal mines and power stations and how the transition will impact them. The Participant joins in the call for the government plan to deal with the social impact in the towns near these coal mines and power stations.

> *Participant B: When you close mines, even the export market is depressed because everyone is going clean. Then the power stations have been shut. Will there be a Witbank? Will there be a Middleburg? We know this, Hendrina, Kriel is a clear case because they are 100 percent reliant on the mines and the power stations. They are small, and they are reliant on the mine and the power station. Maybe let me say 95 percent, but when there is no more mine and no more power station, are you going to have a Kriel and Hendrina? I doubt it. So those are the questions from the just energy transition. So those are the kinds of things that you would measure on just transition.*

There is optimism from other respondents that the coal industry will continue to operate. The towns supported by the industry will not shut down.

> *Participant G: I do not think the intention would be to move communities to where these renewable plants are. You will build a renewable plant where there and would empower the community around that plant. We can generate electricity with coal but in a cleaner way. Invest lots of money in making sure that you limit the emissions.*

The participants have expressed concerns for the people who have been part of the coal value chain. They suggest that this is one of the Renewable Energy sustainability measures.

4.3.4 Institutional Indicators

4.3.4.1 Indicator: Political stability

Participants considered the REIPPPP a success in bringing the price of renewable down, attracting foreign investment, and getting banks to buy into the programme. Also, participants consider it positive that the government provides the necessary surety, provides backup, and regulates the programme. According to the participants, the downfall was the delays experienced a few years back. The cause was government leadership changes, whereby the then minister was perceived to be pro-nuclear and stalled the REIPPPP. According to participant O's extract below, the investor might want surety on return on investment and be reluctant to invest or increase the price.

> *Participant O: That is the first thing that harmed the process. Many developers may be putting a little bit of a risk premium on the business in South Africa because there is no surety. People tell you there will be a bid window in the next two years, and for five years, you have nothing. So, spending all the money employing people, doing Environmental Impact Assessment, et cetera. Then what happens, you wait. There is no government response, so I think that highlights an important first aspect of sustainability: political alignment or political buy-in. It does not help to have an amazing technical program and financial program, but politicians want to do something different.*

Participant O highlights uncertainties experienced on the programme and the impact it created. The extract below adds that government should provide guarantees that will enable funding flow for the programme. According to the participant, investors want a guarantee of return on their investments. Also, this will assist in keeping the electricity prices down, something that South Africa needs.

> *Participant O: That is a very important aspect in all of this. You cannot expect cheap electricity, which we need with cheap energy in general, if there is no surety that makes investors comfortable.*

Another participant is concerned that there is no indication on whether the programme will continue beyond bid window 5, resulting in investor uncertainty, especially regarding opening manufacturing plants. The other impact is the potential job opportunities or job loss. Below extract from participants E and M on this matter. The participant narrates a story of a company that closed due to delays in the programme impacting jobs.

> *Participant E: We had a company that had established a wind turbine blade manufacturing facility locally, but because of the uncertainty in the Department of Mineral's IPP program, that facility was shut down because they are not getting enough orders to sustain the employment, and it impacted several households.*

Participant E adds that the company had to close down because they were not getting enough orders. Participant M added to highlight the missed opportunities of not continuing with the programme.

> *Participant M: A huge number of people would have benefited from a continuation of renewable energy rollouts had we continued with round 5 in 2015, year on year building new renewable energy.*

Participant J had a similar view that the REIPPPP's sudden stop held back the limited development happening in the country. Participants J extract below further adds that long-term planning and building investor confidence as the communication of plans is not just for the South African but also international players.

> *Participant J: When we talk about renewables, we talk about sustainability is long-term consistent policy coherence. So IPP Office signals to the world that we are definitely coming out with ten windows, and this is how it will be rolled out over the years.*

The participants highlighted the negative impact of not having stability in the programme: jobs lots and lost opportunities in manufacturing components. As indicated by the participant, the risk is a lack of interest from investors or a potential price increase. This might be considered a high-risk investment. Participant further says the programme can only be sustainable if it continues and has installed capacity in wind and solar over 20 to 30 years. This assertion supports participants' definition of sustainable energy.

4.3.4.2 Indicator: Industry collaboration

Participant O suggests a collaboration between industry, academia, CSIR, regulator, policymakers, politicians, regulators, and the development bank. The participant's view is that such collaboration will assist in aligning investment on what is best for the economy and society than just profitable solutions. Also, the research institutions will have focused research. Furthermore, the various bodies that need to decide or develop policies will be more informed. The decisions will focus on what is best for the economy or society than profit or political power. The extract below suggests a systems thinking will assist in building a sustainable energy environment.

> *Participant O: The role of CSIR and academia is to inform the politicians. It cannot be theoretical that you know money needs to flow. It is important to listen to the industry. So that is the whole idea of collaboration and inclusive system thinking-based planning. It is crucial, I think, for a sustainable energy environment.*
>
> *Interviewer: Do you think this is not happening currently in South Africa?*
>
> *Participant O: It is a human system. There are good and bad things about any human system. We will never have the perfect system. There always be some losses. You win, some, you lose others. So yes, we can definitely improve. I think South Africa has an amazing framework already with the REIPPPP. We definitely have quite a few things we can improve on.*

None of the studies reviewed has an industry collaboration as an indicator.

4.3.4.3 Indicator: Education and training

Education and training are some of the indicators suggested by experts in this study. Participant D suggests that the training should start at primary school and build to higher education.

> *Participant D: The next thing is to have renewable energy taught at the primary, secondary, and university levels.*

According to the participant, there is a need to build on knowledge from an early age. Renewable Energy is the future energy for electricity generation. Also, training at a higher education level will help develop local skills and ensure local skills in the construction, operations, and maintenance of Renewable Energy plants. The extract below from Participant E suggests that South Africa should delay Renewable Energy deployment and spend time and money building the required skills. Participant adds that community development should build the skills, teaching youth maths and science to work in the Renewable Energy plants.

> *Participant E: Instead of just pursuing renewables, you need to address the emissions at the existing power stations. You buy time for transitioning while focusing on localization, local job content, and socio-economic development. This gives us a great opportunity to establish sustainable growth from a science and maths perspective. By getting experts and resources into those areas (rural areas) to train and develop those individuals. Not to weave blankets or make something, but get a higher level of involvement, higher education level, and more long-term sustainability. Sustainable development promotes maths and science and promotes those individuals to become involved in the energy transition's overall life cycle. That is what gives you long-term sustainability, from my perspective.*

The other concern raised is that South Africa exports skills and work in Renewable Energy plants. Participant G highlighted Concentrated Power Plant (CSP), that South Africa does not have the skills for this technology. The skilled resources are therefore outsourced, bringing many international skills to South Africa. Participant H added that South Africa needs to see skills transfer to avoid external resources.

> *Participant G: We need to start building our skills. Remember, you cannot say that you would sustain these plants if you cannot sustain them with resources within the country.*

Naicker and Thopil (2019) indicated that higher education learning has started catering to learning in renewables. Naicker and Thopil (2019) research also confirm the statement by participant G on the dependence on international resources for Concentrated Solar Plant technology. Sen and Ganguly (2017) added that the ability to operate and manage a plant is critical to the success of a RE project. Cavalcanti and Cândido (2017) is the only study that included an indicator of human resources training in their menu of sustainability indicators.

4.3.4.4 Research and Development

Cîrstea et al. (2018) has company spending on research and development and university-industry collaboration in research and development indicator. The study suggests that innovation, research, and development provide the country a competitive edge in the industry. Also, that countries would have the latest technologies because of innovation that comes with research and development.

Participants O and J suggest that having different energy sources will present grid and technical challenges, and mistakes could be made in the process. Participants highlighted that the country is still learning the technical transitioning. Participants add that for the government to ensure sustainable energy transition, research, development, and innovation are critical aspects. Participants suggest research that focuses on integrating the various sources of supply and still keep grid stability. The research is to ensure that there is a continuous energy supply. Therefore, the government and other donors need to provide funding for the studies. Below is an extract from participant O suggesting that the increase in Renewable Energy increases through the years might present technical problems that cannot be overlooked.

> *Participant O: It is not simple to integrate a lot of variable renewable energy once you get to high penetrations. I think we are looking at 33 percent renewable by 2030, who knows, maybe 50 / 70 percent renewables. That is not something you do lightly and without a lot of research.*

Participant J suggested that the ability of the grid to manage different sources of energy in an excellent technical way and grid balance would be a good sustainability indicator. The participant anticipates a multidimensional energy future of utility, self, municipal, and independent power generations however, the ability for the grid to remain stable with all these sources.

4.3.5 Technical Indicators

4.3.5.1 Security and Reliability of supply

Participants are concerned about load shedding, load reduction, and continuous power failures, especially in the townships. The impact is both to the business, specifically small and medium enterprises, and communities that go without electricity almost every evening. The view from the participants is that a reliable and stable electricity supply contributes positively to economic growth by growing businesses and creating jobs. The extract from participants highlights the need to have a supply that meets the demand. The supply that needs the demand will result in employment. Lastly, the participant suggests that Renewable Energy supply will still need to mix with coal to provide security and meet demand. Manso and Behmiri (2013) also suggested that energy security requires diversification of energy sources that are context-based.

> *Participant J: I do not think, from a utility scale, you will get the kind of jobs you are looking for. You have to do it more from embedded generation. If you had an export market, you would have a healthy job. However, it is not going to solve your unemployment problem in the economy. But the indirect effects of more energy security may assist with it. The second part is the ability of our energy security to be met. So, energy securities are vital that are linked to and aligned to decarbonisation.*

The extract from participant J also shows the interconnections between the indicators the technical and economic indicators. That indicates that the achievement of economic indicators depends on the security of supply that meets demand. Other participants believe that this should be the focus of the country and the primary indicator of sustainability because it supports the economic and social indicators. This also takes us back to how the participants defined sustainable energy as meeting demand.

The other concern is the unreliability of Renewable Energy supply, characterized as intermittent supply. What concerns participant C is that Renewable Energy supply will not always be available, impacting South Africans negatively. According to the participant, the impact is that electricity will not be available on-demand, both for domestic and commercial use, impacting standards of living and economic development. When participants defined sustainable energy, some mentioned that it has to be reliable and meet the forecast or required demand. Failure to meet the demand makes the energy supply method unsustainable.

Participant C: I think an unaffordable electricity supply or an unreliable electricity supply has huge costs to be carried by the people of South Africa.

Troldborg et al. (2014) defined reliable supply as one free from interruptions. Troldborg et al. (2014) confirm participants' concerns by indicating that reliability is often an issue with Renewable Energy supply as the sun is not available at night. Wind turbines cannot operate when there is no wind. None of the studies analysed in the literature above prioritised the security and reliability of supply. According to Mangla et al. (2020), a developing country like South Africa must look for a reliable energy supply to support economic development.

4.4 Prioritising Criteria and Indicators

The participants interviewed in this study provided different answers when asked whether some Criteria and Indicators should be prioritised over others and why. One group of participants indicated that sustainable energy ensures that sustainability criteria are equally balanced. When asked the question, participants B, G, and I responded that none should be prioritised over the other. They should be pursued equally. Participants A and F prioritised emissions. However, Participant F suggested that emissions should be addressed at coal power stations to preserving jobs. Four Participants, D, E, K, and M, prioritised jobs. Participant F indicated that inequality and poverty should be a priority aligned to jobs.

Participant L indicated that the priority is the economic aspect that the REIPPPP progamme sets to create, including low cost of electricity, jobs, and local manufacturing. Participant O suggested low-cost electricity, which will produce indirect jobs. Participant N indicated that Technology with the least cost should be prioritised. Also suggested that the result would be achieving the social and economic benefits, which includes jobs. Furthermore, Participant C suggested a reliable supply. The last view is from participant 8, indicating that education and skilling should prioritize income difference and skills development. The extract below is from Participant H suggests that skills are developed to address unemployment and income differences.

Participant H: Is to upskill people to get them the opportunity to reduce unemployment. We have got the social problem of high unemployment rates, especially among the youth.

The extract below from Participant E, which is shared by a few, indicates that priority might change in the future. However, South Africa needs to prioritize jobs right now. Hence those choosing environmental, economic aspects or skills still have job creation or preservation in mind.

> *Participant E: It will be dependent on where you are in time. As I have indicated, we have indicated severe emissions constraints, and we also have job constraints. So, from an overall country perspective and this is just a view, and this view may change tomorrow, next week, or so. We need to be very wary of our job creation.*

Other participants have indicated this view by participant E. Participants suggested efficiencies in the coal power stations to reduce emissions. Participant O argues that indirect jobs should be a priority and not direct jobs. The way to achieve this, according to the participant, is to focus on getting cheap electricity that will attract foreign investment in manufacturing, and the result will be the indirect jobs needed. Participant further argues that the taxes could support the socio-economic aspects of building schools, hospitals, and develop industries that are not necessarily linked to the Renewable Energies. The extract below from Participant N suggests that the technology with the lowest cost should be prioritised and believes that social benefits might need to be reviewed. Making an example that perhaps BEEE in the renewable energy sector or even local manufacturing might not work, perhaps these things could be addressed differently.

> *Participant N: So, for example, if there are no jobs created out of the renewable industry? Will they be pushed back on? If there was not enough black empowerment in the renewable sector? Would it have any, would have continued the way it is? Right. So those are questions. Participant further says, is not about necessarily minimizing the technology cost that we choose. It is choosing the technology that has the lowest cost. Socially it is around making sure that we get the correct social benefit. There will be some trade-off at various points. Do we increase the cost of energy generation to increase localization and job creation?*

The central subtheme for this section is jobs. Participants wanted jobs created or preserved as a priority. Literature has revealed that Criteria and Indicators are not considered to be of equal importance all the time. Also, the studies reviewed indicated a difference in what is considered most important. Suganthi (2020) found that environmental and social indicators were significant for sustainable energy development among the performance parameters. Ghenai et al.'s (2020) study put more significant weight on the environmental indicators. CO_2 was the highest-ranked indicator.

Ali et al. (2020) study had a different view. The generation cost was considered the most important indicator. The different prioritisation shows how important the context is in prioritising the Criteria and Indicators. These themes are quotes from participants on the prioritisation of Criteria and Indicators.

5 FINDINGS AND INTERCONNECTIONS OF INDICATORS IN THIS STUDY

In this section, the findings of this study are documented. The data from the interviews is analysed and reviewed against literature to arrive at these findings.

The first finding is that participants are more concerned about the economic aspects of Renewable Energy supply. Participants want electricity prices kept low so that everyone could be able to afford and access it. They also want jobs created through local manufacturing, new renewable energy plants, and also preserve coal jobs. Some participants defined sustainable energy as an energy supply that is affordable and accessible to all. They also indicated that they would like to prioritise jobs followed by low-cost electricity. This finding is aligned with Pegels (2010), and Kruba and Burch (2011), that concern over economic growth overpower that of the environmental aspects of Renewable Energy Supply. The benefits of low energy prices, local manufacturing, and high employment are the main focus in the country to drive economic growth. Troldborg et al. (2014) combined the new jobs, supply chain, and industries as one economic indicator called contribution to the economy. The indicator covers direct, indirect, and the induced jobs created from the wealth generated from the RE industry, thereby stimulating demand in unrelated industries.

<u>Linkages to other indicators</u>

This indicator is linked to local manufacturing as an affordable electricity supply is required to promote industrialisation. The indicator is also linked to social acceptance. Participants indicated a need for national acceptance of Renewable Energy supply to support climate change initiatives.

The realization of economic indicators is dependent on the technical and institutional Criteria and Indicators. The supply has to be available and without interruptions to be able to achieve the economic indicators. Technical skills and capabilities are also required for the jobs in local industries and building and operating the new plants. Cavalcanti and Cândido (2017) and Aliyu et al. (2018) highlighted that energy efficiency promotes economic development by producing electricity at a fair cost. In addition, this study aligns with Rennkamp et al. (2017), where stakeholders showed support for Renewable Energy to reduce carbon emissions, but economic principles dominated the discussion.

The second finding is an indicator that will monitor the impact of Renewable Energy on the environment. The participants suggested a life cycle assessment for both emissions and water. Water usage and emissions are included in the Independent Power Producers and Sustainable Development Goals reports; however, these measures do not reflect life cycle assessment. The study found that the life-cycle is a more useful indicator as Renewable Energy plants do not emit many gases. Also, they do not use as much water during production as other phases of the life cycle. Life cycle assessment is supported by Liu (2014) and Troldborg et al. (2014) for emissions and Sparks et al. (2014) for water. Most studies have CO_2 emissions indicators. This shows the importance put on emissions to assess sustainability. In this study, as much as participants suggest emissions measured, most participants do not consider emissions a priority for South Africa. Ghenai et al. (2020) and Iddrisu and Bhattacharyya (2015) and Trolborg et al. (2014) included emissions in their set of energy sustainability indicators, confirming the findings of this study. Only Trolborg et al. (2014) assess life cycles greenhouse gas emissions. In contrast, Ghenai et al. (2020) assess only the construction and fuel during the generation process.

<u>Linkage with other indicators</u>

Linked to greenhouse gases is the issue of security of supply. The view is that the security of supply takes priority over greenhouse gases.

The third finding is that participants want the price of electricity monitored and suggested levelized cost of electricity as an indicator. Naicker and Thopil (2019) found LCOE a suitable indicator to show the advantages of Renewable Energy, supporting the findings of this study. Participants want electricity prices to be kept low. They want low-cost technology options for South Africa. One participant indicated that it is acceptable to have coal in the mix to keep electricity prices low. Low-cost electricity will afford South Africa opportunities for economic development, industrialisation, and job creation. Rennkamp et al. (2017) indicated that opposers of Renewable Energy in South Africa expressed concerns about the overall price of electricity. Also linked to the cost of energy is the issue of access. When the cost is high, the low-income communities will not afford it and therefore cannot access it. Kemmler and Spreng (2007) proposed that electricity affordability to measures energy poverty in South Africa. Troldborg et al. (2014), Ali et al. (2020), and Ghenai et al. (2020) included the cost of energy indicator in their assessments. Troldborg et al. (2014), Ali et al. (2020) both use Levelised Cost of Energy supporting the findings of this study. Iddrisu & Bhattacharyya (2015) has income inequality (Gini-coefficient) as one of the social criteria indicators. The participants did not suggest this as an indicator but have highlighted the income inequality to support the low cost of electricity.

The fourth finding is that participants want to monitor jobs in both renewable and coal sectors. The Renewable Energy sector will report new jobs, while the coal sector will report lost jobs due to transition. Troldborg et al. (2014) combined the jobs in industries and jobs in new relations plans as one indicator. The coming new industries and new jobs also show how interlinked and interdependent the two indicators are. Jobs created and employment are dealt with extensively in this study, in local manufacturing indicators and just energy transition indicators. A study by Rennkama et al. (2017) indicated that stakeholders support Renewable Energy because of possible new jobs and boosted employment. This study found that new direct and indirect jobs are few and short-term and will not cover the loss of jobs from the coal sector. Matsuo and Schmidt (2019), Bazilian et al. (2020), and Hansen et al. (2020) indicated that IRP, REIPPPP core objectives included job creation. In the South African context, job creation and job losses are political and social matters (Strumbo et al., 2019). The participants confirmed in this study that the government's focus is sometimes limited to short-term direct jobs to gain the votes. Troldborg et al. (2014) is the only study with jobs created linked to Renewable Energy, supporting the findings of this study. None of the studies assesses

<u>Linkages to other indicators</u>

This indicator is linked to the Just Energy Transition indicator. The majority of participants are concerned that Renewable Energy does not create as much as coal. The indicator is also linked to local manufacturing as Renewable Energy jobs are included. Finally, the indicator is linked to education and training as the jobs required in Renewable Energy are technical.

The fifth finding is an indicator that monitors Renewable Energy local skills development. Participants suggested that Renewable Energy studies need to be included in the education systems. The view from participants is that some of the technical skills required in construction and operations are not available locally and are outsourced. Participants view formal training as a vehicle for local manufacturing as it promotes innovation, participants indicated. Lucas et al. (2018) indicated that developing countries do not offer much formal training on Renewable Energy. Naicker and Thopil (2019) indicated that South Africa has recently introduced the training but still lacks skills in other technologies like Concentrated Solar Power (CSP). Their study proposed a government training programme for artisans. Lastly, not being able to train impends RE production in developing countries, according to Sena and Ganguly (2017). The study confirms the need to have the skills and capability to build a sustainable renewable energy supply. None of the studies assessed has an indicator monitoring skills development.

Linkage with other indicators

This indicator is linked to job creation; when the skills are sourced locally, employment levels improve.

The sixth finding is the monitoring of land use/area requirements. Participants expressed concerns about the use and availability of land. One of the concerns raised is that Renewable Energy requires land for new plants and transmission lines as there is no or limited infrastructure where they are developed. The other concern is that land is in the hands of the few and making it difficult for developers to access land. The last aspect, land requirements, should not result in the relocation of people. Naicker and Thopil (2019) indicated that in South Africa, Renewable Energy suppliers compete with Agriculture on land. The researcher also confirmed the availability of land to build new plants and future generations. This indicator will need access to land as well as preserving land for future generations. Ghenai et al. (2020) and Troldberg et al. (2014) had area intensity and area requirement indicators in their assessments, supporting the findings of this study.

The seventh is the monitoring of energy transition. The study's finding is that transition to Renewable Energy needs to be just to the coal industry. Participants want the social aspect of energy transition measured. Participants indicated that the closure of power stations would impact communities near coal mines and power stations. The social concerns raised are not limited to jobs. It includes the impact on towns that are near power stations and mines. This study found opportunities to divert some of the Renewable Energy plants to areas like Mpumalanga that do not have the same solar concentration as the Northern Cape. The Renewable Energy development in Mpumalanga could accommodate the communities where the closure of mines would continue to use the existing transmission infrastructure. None of the reviewed studies had a just energy transition indicator. However, Mutezo and Mulopo (2021) and Bohlmann et al. (2019) confirm that the possible social impact of energy transition could not be ignored and require consideration and planning.

Interlinkages with other indicators

This indicator is linked to job creation, local manufacturing, and training and development.

The eighth finding relates to having collaboration between industries to assist in Renewable Energy planning. The study found that when Purchase Power Agreements were not signed, the socio-economic aspects of REIPPPP were negatively impacted; this was also confirmed by Bazilian et al. (2020). None of the studies assess have industry collaboration indicator.

However, Cîrstea et al. (2018) have the following indicators under the institutional criteria; government effectiveness and transparency of government policymaking, which comes a little close to what industry collaboration seeks to achieve.

The ninth finding is the indicator that will track and monitor the security and reliability of Renewable Energy supply. This indicator will reveal whether the supply is continuously available and meeting the energy demands of South Africa. The other concern expressed is that currently, the energy supply is not reliable, affecting economic growth. The participants are concerned about the intermittent supply associate with Renewable Energy, confirmed by Trolborg et al. (2014). Ghenai, Albawa and Bettayeb (2020) and Aliyu et al. (2018) listed capacity factor and reliability of supply as an indicator. They want this indicator because they are concerned about the cost implications of not having a reliable supply. That is why participants suggested indicator number ten which is research and development. At the same time, Iddrisu and Bhattacharyya (2015) and Ali et al. (2020) monitor supply reliability. These studies confirm the findings of this study to monitor the reliability and security of supply.

<u>Linkages with other indicators</u>

This indicator is linked to economic indicators, local manufacturing, and job creation.

The participants also indicated the need for the government to invest in research and development. The tenth finding of this study is tracking expenditure in Research Energy technical research. Participants firmly believe that spending money on research will assist in ensuring efficient transitioning to renewable energy. The future benefit is ensuring a secure and stable supply. Cîrstea et al. (2018) indicated that training and development give a competitive advantage to the country. Participants indicated that South Africa needs time to transition to a total Renewable Energy supply.

<u>Linkages with other indicators</u>

This indicator is linked to the reliability of supply. The results of this proposed indicator are to ensure continuity and reliability of supply in the future.

The eleventh finding is the monitoring and management of waste. The study found that Renewable Energy produces waste and needs monitoring in all phases of the project. Cavalcanti and Cândido (2017) confirmed the findings of this study by pointing out that all energy generation processes generate waste. Therefore, the entire footprint must be analysed. Trolborg et al. (2014) impact amenity indicator, which includes visual, noise, adour, and damage to habitats that do not fully comprehend the full impact of waste

The twelfth finding is monitoring social acceptance of Renewable Energy supply. The participants suggest the need for general awareness, acceptance of Renewable Energy projects, and acceptance of Renewable Energy projects to address climate change. Ali et al. (2020) and Antwi and Ley (2021) confirm the findings of this study. Ali et al. (2020) suggest that acceptance of Renewable Energy also means accepting the drive to reduce greenhouse gas emissions. Antwi and Ley (2021) confirm that the participants also meant the cost and understanding the technical requirements of Renewable Energy and how it also meets people's needs. Of the studies analysed, Trolborg et al. (2014) and Ali et al. (2020) have acceptance indicators included to assess the sustainability of Renewable Energy.

<u>Linkages to other indicators</u>

This indicator is linked to environmental indicators. Acceptance of Renewable Energy will mean acceptance of climate change strategy. In addition, acceptance at the project level could assist with access to land.

The thirteenth and last finding is the monitoring of the political stability of the REIPPPP. Concerns from the participants are that the programme's success depends on a long-term view and consistent implication. Cîrstea et al. (2018) is the only study with a political stability indicator confirming the findings of this study.

<u>Linkage to other indicators</u>

This indicator is linked to jobs and local manufacturing. Political stability will create stability in the market which will result According to participants

The fourteenth and last finding is the monitoring of local manufacturing. Participants suggest that Renewable Energy components and parts be manufacture locally components and parts to promote economic development. Trolborg et al. (2014) monitor jobs from the Renewable Energy industry, confirming this study's findings.

Linkages to other indicators

This indicator is linked to job creation, just energy transition, price of electricity, and political stability. Participants want local manufacturing to boost employment and take care of coal industry employees and towns. They also want the price of electricity to be low. Low prices will attract investors to start manufacturing plants in South Africa is considered affordable. Lastly, political stability will create investor confidence to start building small industries in South Africa.

Table 2: Proposed Criteria and Indicators (constructed by the author)

Criteria	Indicators
Economic	Local manufacturing Cost of electricity Jobs created/lost
Environmental	Air quality Land requirements Water usage Waste generated
Social	Social acceptance Education and Training Research and Development
Institutional	Political stability Industry collaboration
Technical	Security and reliability of supply

6 CONCLUSION AND RECOMMENDATIONS

This research investigated Criteria and Indicators to assess the sustainability of Renewable Energy supply in South Africa. The suggested Criteria and Indicators are presented in Table 2. Job creation and the price of electricity were significant concerns. This confirms previous research on Renewable Energy which indicated that the economic aspect dominates the debates over other aspects, primarily environmental. The study also confirms the multiple dimensions of sustainable energy. None of the studies analysed in Chapter 2 have the same set of indicators; the participants in this study also ascertained this. It shows that indicators are context-dependent.

The study also reveals the linkages between the Criteria and Indicators. For example, a reliable and affordable supply promotes access to energy supply, industrialization, job creation, and improved living standards. An efficient supply supports the use of resources, especially water, and improves environmental performance. Furthermore, investing in training, research, and development is vital in achieving the technical aspects of sustainability like the security of supply and reliability of service. Lastly, the participants indicated that sustainable energy supply requires a long-term plan that considers all the social, economic, environmental, and technical aspects of Renewable Energy.

Studies that have developed sustainability indicators and assessed the sustainability of Renewable Energy supply take an initial list of Criteria and Indicators to experts to debate or give confirmation, including providing the weight of importance. In this study, the first recommendation is that taking the initial list to industry experts should continue to happen. It promotes debate and collaboration in the development of Criteria and Indicators. In addition, the suggested indicators are based on the current context. However, it should be considered that context changes, as the indicators might change as well with time. In light of this, the second recommendation is that further discussions and confirmations should be continuous. The third recommendation is that each indicator requires a data set as input to the framework or composite index for assessment. Some of these indicators are suggestions requiring the establishment of structures to exist before they can be measured, for example, industry collaboration.

It is evident in this study that the economic and social context of South Africa as well as participants' understanding of sustainability influenced the criteria and indicators proposed to assess the sustainability of Renewable Energy in South Africa. Literature supports this view to develop criteria and indicators. The risk is that there is a different and broader understanding of sustainability and therefore creating a wide variety of what the criteria and indicators should be. Therefore, the concept of Sustainability might needs to be critiqued and possibly defined for energy before the development of criteria and indicators in South Africa. That way, participants' perception criteria and indicators, will not be that much different, a challenge associated with the top-down approach criteria development framework.

The opening paragraph of this report indicated that energy is no longer viewed in terms of environmental impact but the role it plays in enabling social and economic growth and sustainable development. The participant's concerns are the social and economic impact of Renewable Energy deployment in South Africa. They view the South Africa economy as weak with a high rate of unemployment and closing coal mines and coal power stations will worsen the situation. They want the economic and social impact prioritised. It is almost as if Renewable should take its own space in the energy market, contribute to the economy without any impact on the coal market and industry. The question to be asked is whether that is possible considering that the Renewable Energy deployment is designed to replace coal and not to have both energies contributing to the economic and social growth in the long term. In addition, the reference to coal in measuring the sustainability of Renewable Energy suggests that Renewable Energy will always be measured as a direct comparison to coal and not independently. There is therefore a risk that Renewable Energy might be perceived as unsustainable because it fails to create the number of jobs that the labour-intensive coal industry offers. And perhaps the focus for South Africa should not be the assessment of Renewable Energy sustainability but whether South Africa is ready to accept Renewable Energy supply as the alternative taking into consideration the potential impact it might have on the cost of electricity, job, and impact on communities near coal mines and power stations.

7 REFERENCES

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