THE ROLE OF RENEWABLE ENERGY TO ADDRESS THE CLIMATE CHANGE PHENOMENA: THE SOUTH AFRICAN CONTEXT

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ABSTRACT

The climate change phenomenahave in recent years made countries to rise together with concerted efforts to deal with its impact on the ecosystem, economy, public health and the socio-economic conditions. The South African energy sector much as globally, is the highest contributor to climate change because of its high emission levels of Green House Gasses that are mostly contributed by the electricity supply industry. As the country's energy generation is dominated by coal burning, it became evident that this problem must be addressed not as an option but a priority. The country embarked on a number of initiatives which among others include solar energy programmes. As part of the research methodology, the study utilised semi-structured interviews with households and officials distributed between different institutions. The study established that renewable energy can positively contribute to the climate change adaptation and mitigation programmes.

KEYWORDS

Renewable energy, climate change, ecological governance, sustainability, greenhouse gas emissions

1. INTRODUCTION

Climate change is a global phenomenon, which is causing a hype on how nations can address this giant of a problem. Nations have in recent years come together to fight the scourge of different challenges that they face as a result of climate change, whose causes are comparable across the world. Climate change has severe effects on the ecosystem, inclusive of the environment and also the economic wellbeing of countries, both developed, developing and underdeveloped [1], [2]. Evidence of the effects of climate change presents itself through ecological and environmental impacts such as floods and drought, which South Africa has also become a victim of in recent years. If climate change is not mitigated, the consequences can be dire, as many researchers have made assumptions that climate change has the potential to threaten an average of approximately one-quarter of species on land by the year 2050 amongst other ecological effects [1], [3].

South Africa is rated the 14th largest Green House Gasses (GHG) emitter globally and the most carbon-intensive developing economy in the world [1], [2], [4].The country, in its National Development Plan and the Climate Change Response Strategy claims that it is committed to addressing climate change through a just transition towards an inclusive, environmentally sustainable and climate-resilient economy. In order to address the climate change problem, South Africa also signed international agreements, which include the United Nations Framework Convention on Climate Change (UNFCCC) that was signed in 1998, the Kyoto Protocol signed in 2002 and the Paris Agreement signed in 2015 [4]. These commitments should provide a motive

and appetite for the country to ensure that climate change concerns are addressed, considering the magnitude of the problem and ecological impacts.

The country's vision on climate change is well articulated in the National Climate Change Response Strategy which is to ensure a "*transition to a climate resilient and lower-carbon economy and society*". The objectives in the strategy are to manage the impacts of climate change through interventions that build and sustain the country's social, economic and environmental resilience and to make a fair contribution to the global efforts of stabilising GHG concentrations [4]. It is also clear that South Africa is committed to dealing with the problem, as climate change mitigation and adaptation form part of national priorities as articulated in national level plans such as the National Development Plan: Vision 2030 and the Medium-Term Strategic Framework. In addition, each province has a climate change response strategy, which identifies measures that are needed to mitigate and adapt to climate change.

Public attention on the human contribution to ecological degradation seems to have gained momentum over the years. With the increase in demand of fuel-based energy, which consequently increase the greenhouse gas accumulation, the negative impact to climate change becomes a reality and something unavoidable. The generation of electricity using conventional methods such as the burning of fossil fuels has many negative externalities which affect both the ecology and the economy. The effects include climate change, increase in energy costs/ prices and ill-health among humans. The main argument of ecological economists and climate change researchers is that emissions of GHGs are caused by both natural and human activities. Anthropogenic causes of GHG emissions refer to the emissions which are caused by human activities such as the burning of fossil fuels to generate electricity.

Anthropogenic causes can, however, be addressed, unlike the natural causes, as these are dependent on the decisions that are taken. Ecological governance, therefore, becomes key in ensuring that proper systems are put in place to internalise the externalities that are caused by these human activities. Changes to the ecosystem are usually a combination of effects resulting from natural causes and economic decisions. Any development initiatives must take into consideration ecological sustainability, which provides for the promotion of more use of renewable resources [5]. Thus, ecological economics remains crucial in understanding the relationship between the economic and ecological systems. Electricity generation through the burning of fossil fuels has been proven to be the major culprit for environmental degradation, which unfortunately dominates South Africa's electricity generation industry. The main aim of this study is to provide an insight on what role can be played by renewable energy to address the effects of climate change through mitigation and adaptation programmes, which is in line with the theory of ecological economics.

2. LITERATURE REVIEW AND THEORETICAL FRAMING

Researchers in ecological economics and climate change have argued that climate change presents long term impacts that might not be reversible in the long run if not corrected now[1], [2], [6], [7]. This includes a fundamental threat to natural resources and biodiversity, people's livelihoods, clean water availability and food production, which is contrary to the main provisions of ecological economics which call for long term solutions to the problems of the ecosystem. The long term effects of climate change would, unfortunately, affect the future generation if not addressed now, and this will create a phenomenon of "***dealing with the injustices of the past***" by the future generation.

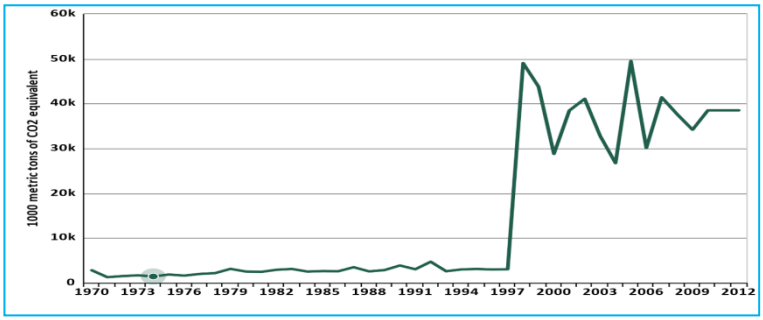
The energy sector has been identified as the most contributor to climate change, through the GHG emissions that result from burning fossil fuels to generate energy. There have been debates on

how nations can use other sources of energy, which are clean and renewable in order to avoid carbon emissions that result from generating energy through coal burning. Climate change is definedas a significant and lasting change in the statistical distribution of weather patterns over a period. It is argued that climate change is caused by factors that are observed over a period, including oceanic processes, variations in solar radiation that is received by earth, plate tectonics and natural disasters such as volcanic eruptions which can also be attributable to human activities that change the composition of the global atmosphere [7]. The determinants of climate change are linked to the increasing absorption of carbon dioxide in the atmosphere [6].

A study conducted by Parr, Swilling and Henry on the Paris Agreement and South Africa's just transition, found that one of the key policy areas in South Africa is electricity generation mix that is dominated by coal-fired electricity generation, which contradicts the just transition to a lower carbon economy. This is on the basis that electricity generated through the burning of fossil fuels accounts for the highest level of GHG emissions [2]. In the 2017/18 financial year, 86 percent of electricity generated in South Africa was contributed by coal-fired stations, which confirms that the country's electricity generation is dominated by coal despite its negative ecological and environmental impact [8].

On a positive note, regardless of the very high contribution of coal-based electricity generation as shown in the current energy mix, there is some evidence of its reduction as well as plans to reduce the generation of electricity through coal burning. The 2018 draft Integrated Resource Plan of the country indicates that the actual net electricity sent-out declined at an average of 0,6 percent between 2010 and 2016, against the expected average growth rate of 3 percent as included in the promulgated IRP 2010–2030. The decline is attributable to reduced electricity demand resulting from economic conditions that negatively impact energy-intensive sectors, improved energy efficiency, increasing embedded electricity generation as well as fuel switching from electricity to Liquefied Petroleum (LP) Gas for cooking and space heating [9].

In terms of carbon emissions levels, the South African national GHG emissions in 1990 were estimated at 347Mt, which increased by 44 percent to 518Mt in 2012. The Paris agreement indicates that the country's GHG emissions would peak between 398Mt and 614Mt by 2025, then plateau for a decade, and thereafter decline [10]. To achieve the targeted decline of emissions, the countrywould, however, need to put in a lot of efforts and measures that would reduce or completely displace major sources of GHGs. The figure below shows South Africa's overall GHG emissions from the 1970's to 2012. According to the figure, a very high peak in emission levels was experienced in 1998. The high peak coincided with the period when South Africa was two years into implementing its democratic Constitution of 1996, where commitments were made to improve the livelihoods of the people, including through access to energy.



Source: [11]

Figure 1: South Africa's GHG emission trends

Electricity externalities, are a cost or benefit that results from an economic transaction borne by individuals who are not directly involved in the transaction. Externalities may be positive or

negative, and the effects of climate change, in this case, are harmful as they adversely affect society, including those who are not involved in economic activities. Thus, even those who do not have access to coal based-electricity still suffer from the effects of climate change as ecological and environmental effects are borne by all. The poor, however, experience more effects compared to the elite who are able to get means to temporarily avoid the effects. The externalities associated with the generation of electricity through the burning of coal affect the society and the ecosystem negatively, with severe and damaging effects. The effects make internalisation of these externalities key for all nations [12].

The use of renewable energy can avoid the adverse effects of coal energy generation to planetary life support, thereby avoiding the depletion of natural capital and harmful effects such as climate change, biodiversity loss, ocean acidification, change in land use, chemical pollution and atmospheric aerosol loading. It is argued that the planetary effects that are caused by the use of non-renewable resources could lead to an unsustainable path for the growth of human population and economic activities that cross critical planetary or natural capital thresholds, thereby de-stabilising the global environment. There is, however, a need for the renewable energy initiatives to be managed in line with ecological governance if they have to contribute to the displacement of energy generation using the finite and dirty resources such as coal. It is not debatable that universal access to energy is still a priority, as access to clean energy is a constitutional right. However, meeting universal access by upscaling coal energy generation capacity undermines the perseveration of natural capital and the planetary life support [13], [14].

It is contended that ecological economics aims to address the interdependence and co-evolution of human economies and natural ecosystems over time and space. What is important about ecological economics is that it recognises that practical solutions to pressing social and environmental problems require new interdisciplinary approaches that have a focus on the links between economic, social and ecological systems [15]. Renewable energy addresses these social and environmental problems without harmful effects on ecological systems. The importance of using renewable energy in ensuring universal access to electricity and improving the quality of life is the fact that it is free and renewable or infinite, which provides more significant social and economic benefits. Ecological economics emphasises on sustainability, which requires minimising the negative anthropogenic impacts on the biosphere while fulfilling important goals of improving the lives of the people. Renewable energy can offer these benefits, which are more beneficial in countries that are well endowed with excellent tools for renewable resources such as solar radiation.

The challenge of ecological economics requires a rethinking of the major problems of the past that were temporarily solved by economic growth. Owing to the fact that the price of electricity has been increasing, there could be a greater motive to shift to renewable energy which has been applauded to be affordable. The perspective of ecological economics is that measuring natural capital reliability in monetary value is misleading as an increase in the monetary value of a resource can be as a result of the physical depletion of the resource. Ecological footprint and appropriated carrying capacity of land provide clear direction for action. The main aim of embracing renewable energy sources is to move nations away from harmful modes of production and consumption towards sustainable practices that would reduce environmental injustices of the past and the negative impacts on the environment and ecological scarcities, while improving the well-being of the people and social equity [16].

A study conductedby Katye, Altieri, Trollip, Caetano, Hughes, Merven and Winkler on achieving development and mitigation objectives through a decarbonisation development pathway in South Africa, found that there is a need for the country to maintain a feasible supply system for energy if it has to meet the rising energy needs, while at the same time meeting energy emissions reduction targets. If the country has to reach climate change mitigation targets, significant

decarbonisation of the electricity sector is fundamental.The increased use of renewable energy is a way to go as the country has good solar radiation suitable for the deployment of renewable energy. In addition, renewable energy technologies are reported to have the capacity that can make a significant contribution to the decarbonisation of electricity supply in South Africa, given its technical feasibility, commitment in stated policy and tariffs which are highly competitive [17].

The increased use of renewable energy in the energy mix would lead to less demand for non-renewable sources, thereby reducing the emission of greenhouse gases and their impacts [18]. The report on the "*rethinking energy: renewable energy and climate change*" compiled by the International Renewable Energy Agency (IRENA) reported that renewable energy, which accounts for more than 22 percent of total global electricity generation has contributed to emission reductions in the power sector (i.e. 3.1 Gt CO2 equivalent of emissions was avoided through renewable energy use in 2012). Furthermore, the IRENA's renewable energy roadmap for 2030 provides that doubling the share of renewable energy sources in the energy consumption from 18 percent in 2010 to 36 percent by 2030, combined with significant improvements in end-use energy efficiency, would limit global temperature increases to under 2°C [19].

3. METHODOLOGY

The study draws from the findings of the interviews that were conducted with households from communities in Limpopo and Gautengprovinces, officials from the Department of Energy (DoE), provincial departments of Economic Development for both Limpopo and Gauteng Provinces, the National Energy Regulator of South Africa (NERSA), Eskom and municipalities (i.e. Thulamela Local Municipality, Polokwane Local Municipality, City Power on behalf of the City of Johannesburg and the City of Tshwane). The findings from the fieldwork/ interviews are also complemented by information from available published reports and literature on climate change, renewable energy and electricity generation from different sources. This study basically answers the question "*how does renewable energy initiatives, if managed in line with appropriate ecological governance systems, reduce the ecological influence resulting from coal-generated electricity or the burning of fossil fuels (i.e. how do they internalise the externalities associated with the use of coal/ fossil fuel generated electricity?)*.

The study utilised a critical theory paradigm whose aim was to challenge the status quo in the energy sector regarding the use of alternative energy and how the initiatives are designed, planned and implemented. The critical theory explains what is wrong with the current social reality, identifies the actors to change it and provides clear norms for criticism and achievable, practical goals for social transformation [20]. The study aimed to contribute to an academic discussion about the role that renewable energy can play in bringing change on the current status of the effects of current dominating electricity generation sources in South Africa. The critical theory assisted with identifying the challenges with the planning, design and implementation of the climate change adaptation and mitigation programmes in South Africa and also provided an understanding the status quo on the initiatives by combining theory and practice. This study, therefore, contributes to both the social, economic and ecological change that would benefit and contribute to theoretical and policy development.

3.1. POPULATION AND SAMPLE

The criterion sampling method was utilised in selecting the population and sample for households. In each of the four case study areas, 20 households were selected according to the criteria that they use renewable energy sources, which focused on solar home systems in the Limpopo Province and solar water heaters in the Gauteng Province. This was on the basis that

those who use these technologies are the ones who were able to provide rich information regarding their experiences and perceptions with regards to renewable energy. Criterion sampling is a type of purposive sampling that allows for the selection of cases which are information-rich, which becomes effective when those who are interviewed understand the processes and weaknesses of the systems [21]. As part of the criteria set, interviews were conducted with one adult per household regardless of gender. In addition to the households' interviews, six (11) officials were selected using criterion purposive sampling and were interviewed: four officials from each province and three from responsible national Institutions. The purposive criterion sampling, in this case, allowed the researcher to identify individuals who are knowledgeable and experienced about renewable energy initiatives and the roles of different institutions.

A qualitative research approach was utilised to collect data with key informants (households) and major government and private institutions involved in renewable energy programmes, either at a policy or implementation level. A qualitative research approach is used to answer questions that relate to the experience, the meaning and perspective of the participants on a certain subject, most often from the standpoint of the participant[22]. Qualitative methods were used to reveal, for example, potential problems in implementing renewable energy programmes, where individual respondents were able to explain their views on the implementation. Interviews were conducted face to face with all the identified respondents. The interviews were recorded with the consent of the respondents, together with the use of a field diary for writing notes from the interview.

The establishment of rigor was ensured through triangulation by interviewing a wide range of informants, and also reviewing supporting documents and reports. This ensured that findings were more dependable when they were confirmed from several independent sources, thereby enhancing rigor. Reflexivity was applied to achieve trustworthiness by using a field diary and materials to reflect on how the research was being conducted as well as reflecting on own actions, feelings and conflicts experienced during the study. Reflexivity is a continuous process of the researcher reflecting on the values, pre-conceptions and behaviour of respondents which may have an effect on the interpretation of responses. Reflexivity, which is basically a way of making the interview process open and transparent is important because qualitative studies have some level of subjectivity as the interpretation of the respondents' behaviour and the collected data is influenced by the values, beliefs, experience and the researcher's interest [23].

3.2. DATA ANALYSIS

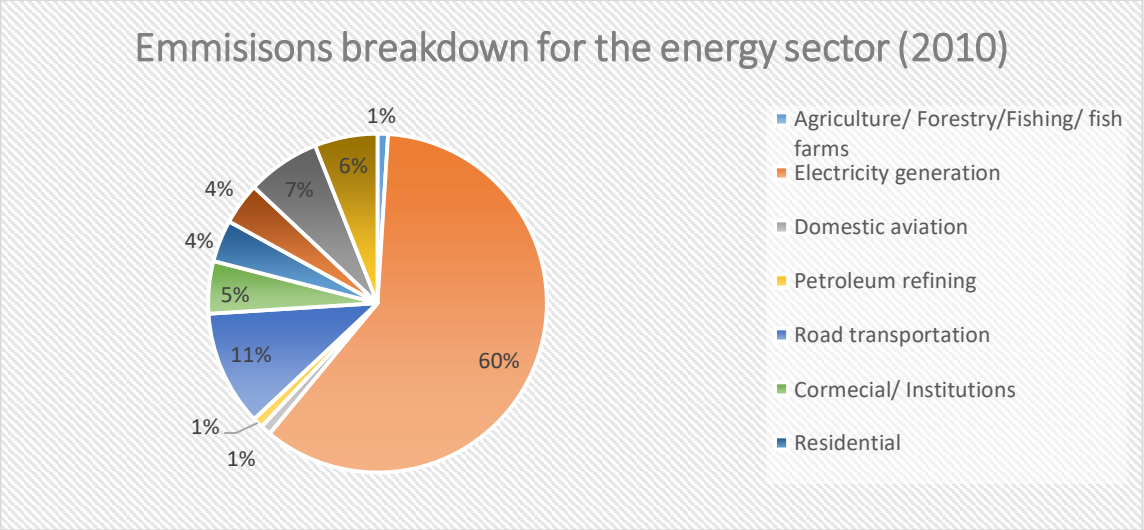
The approach to analyse data was inductive, which required reading of field material based on the interviews conducted and listening to the recorded tapes of the interviews and transcribing them. The inductive data analysis method is aimed at allowing the research findings to occur from the frequent and dominant themes that are inherent in the collected raw data. The inductive data analysis, therefore, ensures that extensive and different raw data can be summarised into a brief format as well as establishing the clear links between the research objectives and the summary of findings that were derived from raw data [24].

In analysing data, the raw data from the interviews was reorganised through re-checking the interview guide as well as identifying and differentiating between the questions that the study seeks to answer and those that were simply included in the interview guide as important, but not essential. The ideas and concepts were organised from the data by finding meaning in the language that was used by respondents. This ensured an understanding of perceptions, attitudes and feelings of respondents about renewable energy initiatives. The way in which informants express themselves through words can reflect their attitudes or behaviours [25]. This was crucial, as household perceptions about renewable energy were one of the themes of the study, which made it important to reflect on the attitudes and behaviours of interviewed households. After

finding meaning from the language, all the ideas and concepts were organised into different categories. The categories used focused on experience, feelings, opinions, knowledge and inputs. It was ensured that each of the response categories has one or more associated themes that offered a deeper meaning to the data in order to build overarching themes in the data. Different categories were then collapsed under main overarching themes. Possible and plausible explanations for findings were then found by providing a summary of findings in line with the themes. This included the review of whether the findings are related to expectations of the study based on the literature reviewed. In addition, major surprises in the findings were checkedthrough assessing whether there were any differences or similarities regarding what was stated in the literature. This required reading of the field diary and listening to the recorded interviews several times, to avoid eliminating important aspects of the responses. Lastly, the information was organised into a final report by summarising the research findings including the implications of the findings, strategies and areas of future research that were identified.

4. DISCUSSION OF FINDINGS

The study found that renewable energy, if managed in line with ecological governance can contribute to the mitigation and adaptation of the effects of climate change as majority of the GHG emissions are produced through the coal electricity generation, which are regarded as anthropogenic. The study findings are in agreement with the arguments of climate change researchers and ecological economists, who posits that emissions of GHGs are caused by both human and natural factors [26], [27]. It is evident in the South African GHG inventory data that the majority of the GHG emissions in the country can be avoided as they are caused by human factors (i.e. the burning of fossil fuels in generating energy). As shown in figure 2 below, 60% of the GHGs that were emitted in the energy sector in 2010 were from electricity generation.



Source: [28]

Figure 2: Energy sector emissions breakdown

Government officials also agreed during the interviews that coal generated electricity is a problem, as it creates GHG emissions which are harmful to the environment. Mark, an official who was interviewed from the Gauteng Department of Economic Development indicated that the generation of electricity through the burning of fossil fuels has a negative impact on the environment. He said:"*The current ways of generating electricity in South Africa are not*

sustainable to the environment. This motivates for a greater need to move away from this method of generating electricity for the benefit of the environment. Climate change is a reality and needs to be addressed with all seriousness".

Another official, John from the Polokwane Local Municipality reiterated that the economic activities must take into consideration the impact on climate change. He said:"*The way in which South Africa is generating electricity produces unnecessary emissions which negatively impact the ecosystem, including the underground water system. These are activities that can be avoided by using alternatives such as renewable energy*".

The above is in line with available literature and clarifies the objections and resistance by trade unions and opponents of renewable energy. Even though the provision of jobs is an important development area, climate change mitigation must not be compromised. A study conducted by Arif concluded that there is an urgent need for countries to make renewable energy technologies more accessible for the sake of reducing greenhouse gas emissions.Arif also submitted that residential solar energy systems have the potential to reduce carbon emissions at significant levels, which requires that the initiatives are designed in an ecological manner. Careful consideration should however be taken when deciding on which technologies can be used to internalise the externalities associated with coal-generated electricity[14], [29]. Ecological economists and researchers recommend the use of renewable energy to internalise these externalities. This is on the basis that renewable energy is clean (i.e. it does not emit GHGs), replenishes itself and is sustainable and affordable (no external costs such as carbon tax and its prices does not depend on economic status).

Displacing coal-generated electricity with renewable energy displaces the amount of GHG emissions resulting from burning fuels to generate electricity, which implies that renewable energy internalises the externalities that are associated with coal-generated electricity [30]. This is supported by available statistics on the electricity generated and emissions level as shown in the figure below. As shown in the figure below, coal-based electricity declined from 248 914 GWh in 2010/11 to 235 486 GWh in 2017/18, while renewables increased from 6 945 to 15 103 in the same period. As the renewables contribution to the energy mix increases, GHG emission levels showed a decline from 5 865(MtonCO2)[3] in 2010/11 to 5 644(MtonCO2)[3]in 2017/18; thus, renewable energy positively contributes to the reduction of GHG emissions.

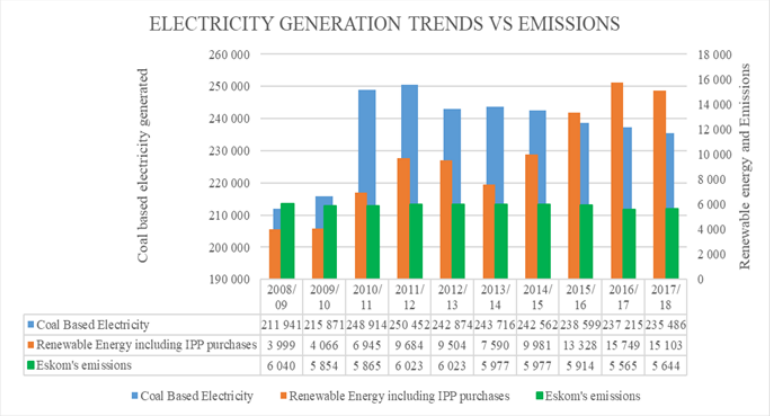


Figure 3: Electricity generation trend versus emissions

Source: Author's construct using information from Eskom's integrated reports

The figure above provides information which could support decision makers when making decisions on which energy sources to prioritise when taking into consideration the impact on climate change. One of the important aspects of climate change mitigation, is the availability of relevant data. Data, in this case, refers to emission levels and electricity generated through different sources. There is a need for developing countries to understand the dynamics of local climate so that they can make necessary forecasts to respond to climate variability and change, and this can be possible if there is available data [31].

To provide data on the savings in GHG emission levels resulting from increased deployment of renewable energy, the South African Independent Power Producers (IPPs) office has also reported in its annual report that, during the 2017/18 financial year, emissions of 9.4 million tonnes of CO2 (MtonCO2)[3] were avoided through the use of renewable energy. This was based on the 9 255 GWh[3] energy from IPPs that was generated and supplied to the grid during the financial year. From the inception of the IPP project to date, a total of 25MtonCO2[3] reduction was realised. This shows the positive impact that renewable energy has in reducing greenhouse gas emissions, thereby contributing positively to the mitigation of climate change [32].

Renewable energy plays a crucial role in providing for future increases in energy demand, and to replace capacity that is currently provided by burning fossil fuels. The overall benefits of renewable energy are the reduction of environmental pollution, reducing the impact on public health and reducing the impact on climate change [14], [33]. It is also worth noting that as the costs of renewable energy technology decline, making them more affordable and accessible, nations could take advantage of their benefits and ensure large scale deployment. The indirect benefits would also include removing the monopoly in the energy generation industry.

In agreement with the above, Mark from the Gauteng Department of Economic Development (GDED) indicated the following when asked what the importance of renewable energy is in contributing to the climate change agenda.

"*Renewable energy plays an important role in correcting the wrongs of the past. This is on the basis that renewable energy is cheaper, clean and sustainable. The promotion of renewable energy has many benefits in reducing the effects of coal-generated electricity*".

Contrary to the ecological economics beliefs, the state utility, Eskom, postulates that enhanced technology for coal-fired stations can eliminate the greenhouse gas emissions [8]. The main argument by ecological economists such as Costanza, Cumberland, Daly, Goodland and Norgaard is that technology may reduce but not eliminate the GHG emissions in energy generation. Furthermore, using technology to reduce the emissions of GHG in coal electricity generation can result in the increase of electricity cost which undermines the universal access of affordable electricity goals [34]. Ecological economics is also about equitable distribution of ecological goods and efficiency, therefore, high prices of electricity are in contrast with the sustainability goals.

The transition to renewable energy such as biomass, solar and hydroelectric power can contribute to increased clean energy access, thereby addressing the effects of coal-generated electricity to the climate [30], [34]. A just transition to a renewable energy intensive environment, which is a transition that joins the sustainable use of natural resources with a universal pledge to sufficiency could possibly address the problems associated with the increased use of coal-based electricity [2]. According to Zhai, Larsen, Millstein, Menon, Masanet, renewable energy sources have the potential to increase future energy generation through renewable energy that will ensure a reduction of dependence on fossil fuels based electricity [35].

Perceptions also form part of the human factor, as some households still believe that renewable energy is inferior in comparison to grid-based electricity generated through coal. Patrick, the solar home systems concessionaire in the Limpopo Province said: "*The challenge is, households believe that non-grid electricity such as solar home systems is inferior; hence they prefer moving to the grid. This has an effect on the roll-out of renewable energy programmes, as support and commitment by communities are crucial for the programmes to be viable, and for them to bear fruits*". He suggested that *"improving the non-grid technologies for them to provide more energy capacity would resolve the sustainability issue, thereby contributing to increased deployment and support from communities".*

The human factor to climate change causes also relates to decision-making processes, which Lundqvist refers to as ecologically rationale decision making [36]. While South Africa indicates its commitment to reducing the levels of GHG emissions, through the use of renewable energy among others, the country, through Eskom commenced with the construction of two coal-fired power stations, Kusile and Medupi. The main question in this regard is whether or not the decision to construct Kusile and Medupi coal-fired stations, whose total operational capacity is estimated at 9 600 MW combined, during an era where everyone is talking about addressing climate change is ecologically rationale. These two stations could each consume 17 million ton of coal annually while contributing an additional 30 million tons of CO2 load per station, leading to an increase of the already very high CO2 emissions by 60 million tons or 34 percent of the 2017 Eskom's CO2 emissions [37].

The findings from the interview with the Department of Energy are consistent with the analysed reports. During the interview, when Peter from the DoE was asked about his view on the role that renewable energy can play in contributing to climate change mitigation and adaptation, he said: "*Renewable energy plays an important role in both climate change mitigation and adaptation*". He added that*: "renewable energy reduces greenhouse gas emissions as the technologies are GHG emission free, which contributes to the climate change mitigation agenda of the country as set in the NDP and the country's commitments to the international agenda*".

Even though the DoE indicated the positive benefits of renewable energy to climate change mitigation and adaptation through the reduction of greenhouse gas emissions, the systems for collection of data on the emissions is still not widely utilised. This might suggest that that it would be difficult to measure if the increased use of renewable energy is bearing fruits with regard to reducing GHG emissions. The responsibility for climate change data inventory is with the Department of Environmental Affairs (DEA). In this regard, Peter said:

"*There are no tools which are used to monitor and measure the level of greenhouse gasses emissions avoided as a result of using renewable energy technologies. The estimations made are based on the amount of renewable energy generated against what would have been the norm in terms of coal-based electricity generation*".

Contrary to Eskom's view on different reports about renewable energy, during the interviews, the official from Eskom also aligned with the view that renewable energy can contribute to reducing the effect of climate change. In responding to the question of whether solar energy can contribute to the reduction of the negative impact of climate change, Mathews said:
"*Yes, solar energy generation does not have GHG emissions unlike the fossil fuel energy that has a direct impact on climate change*".

Mathews further said, "*All renewable energy generation initiatives are implemented with the ideology to limit environmental impacts. However, if there is no environmental governance during the construction and implementation of such technology, the environmental benefit of these technologies would diminish*".

The above response by Mathews indicates that renewable energy can work in climate change mitigation initiatives, which focus on reducing the amount of greenhouse gases emitted into the atmosphere. Patricia from GDED also said that renewable energy plays an important role in climate change mitigation and adaptation. She said:

"*The fact that South Africa has good resources that can be used for renewable energy such as the good solar radiation means that the country can take advantage to reduce the greenhouse gas emissions by deploying renewable energy technologies at a larger scale".*

The important findings regarding the role of renewable energy on climate change programmes were that of the households, which shows that households also understand their roles and contribution to the climate change agenda.

Mary, a resident from Hlatlaganya said: "*I support the use of a solar home system as it provides me with clean energy that does not emit carbon or dirty substances into the air*". She further said: "*The system would make more impact on reducing carbon emissions if the capacity of electricity provided by the system is increased for us to use more appliances such as stoves. This is because we still continue to use dirty energy such as firewood to cook and heat water*".

This was also confirmed by Tim from Soshanguve who said "*solar water heaters contribute to the reduction of greenhouse gas emissions. This is because we no longer have to use the coal-based electricity to heat water, which reduces electricity demand, and, therefore, reduces carbon emissions*".

It is of crucial need for municipalities to support government initiatives on climate change mitigation and adaptation. All the four interviewed municipalities indicated that they fully support the climate change programmes of the government, including promoting the increased use of renewable energy. John from the PLM said, "*The importance of renewable energy goes beyond ensuring universal access to electricity, to include reducing the increased use of coal-based electricity in support of the climate change mitigation initiatives*".

Moreover, John further said that "*the generation of energy through solar has both ecological and environmental benefits as there are no carbon emissions that are produced from solar*".

Takalani alluded to the fact that solar energy plays an important role in internalising the externalities of coal-based electricity. He said:"*I think the migration to wiser use of energy has to do with more than just renewables and policy design. We have to change our attitude to consumption at all levels. Unfortunately, after 15 years of advocating on environmental and specifically climate change matters, I think that only major disasters, such as the fires which are now happening in the Western Cape, will make people notice that patterns are changing*".

In addition, Takalani said: "*Currently, if we take away the subsidies for fossil fuels, renewables would be more affordable as they provide cheaper per unit of energy. There are also the additional benefits of higher employment potential in the production, installation and maintenance of renewable infrastructure. Further benefits are energy security, less dependence on the grid, flexibility, and so on*".

The Energy Information Administration (EIA) also postulates that emissions can be reduced through increased promotion of energy conservation and demand management. It further says that increased use of alternative renewable energy in the energy mix would lead to less demand for non-renewable sources, thereby reducing greenhouse gases and their impacts [18].

5. CONCLUSIONS

The deployment of renewable energy technologies has both ecological and environmental benefits, including positive contribution to climate change mitigation and adaptation initiatives. Ecological governance remains an important factor in ensuring that renewable energy initiatives are successful and can be sustainable in order to realise their intended benefits. It was noted that not all renewable energy initiatives are implemented with ecological sustainability in mind. This was obvious with the implementation of some of the renewable energy initiatives such as the Solar Home Systems programme which was just meant to address energy poverty in the short term without considering their contribution to the global climate change agenda. In summary, as informed by the findings, the study concludes the following in relation to the role of renewable energy in addressing climate change problems:

- Renewable energy sources provide **uninterrupted power** as they replenish naturally. Goulder and Pizer suggests that renewable energy supply can easily be predictable and consistent with fewer risks such as commodity price volatility, climate change impact and electricity blackouts [38].

- Renewable energy **displaces** fossil fuel-based electricity, which reduces the amount of GHG emissions that result from burning fossil fuels to generate electricity. Ecological economists' advocates for the use of clean and renewable energy.

The study found that displacing coal-generated electricity with renewable energy displaces the amount of GHG emissions resulting from burning fuels to generate electricity, which implies that renewable energy internalises the externalities associated with coal-generated electricity.The demand for electricity in South Africa increased due to the government's policy of ensuring universal access to electricity and as the need for economic activities increased due to other economic and social factors. The challenge is still with the perceptions that renewable energy is not sustainable on its own, which leads to continuous dependency on coal-generated electricity.
This study confirms the positive contribution of renewable energy projects in reducing the level of GHG emissions resulting from coal-based electricity generation, thereby contributing to climate change mitigation. The study also shows that a high level of GHG emissions in South Africa is anthropogenic, which could easily be avoided, thereby addressing the climate change problem. The study found that another element that is a barrier to the successful and sustainable implementation of solar energy initiatives is the fear of the unknown. How do people move towards implementing new ecological and environmentally friendly initiatives if they do not know the benefits and what will happen next? This is the question that one must askwhen understanding how perceptions influences the support of sustainability initiatives. Fortunately, responses by interviewees for this study overall agreed that there is fear that the full-blown roll-out of renewable energy initiatives would de-monopolise Eskom as its main business is coal-based energy generation while upscaling the roll-out of renewable energy would impact on the municipalities revenue generation as their primary source of revenue is electricity distribution. The spill-overs of the upscaling of renewable energy initiatives are viewed to be linked to job losses and the decline of revenue of the mining industry.

Because the renewable energy industry is still developing, not much has been done to provide education and awareness on its benefits, its successes and its positive contributions to the country's main priorities. As indicated in the recent debates about the deployment of renewable energy through IPP programmes in South Africa, there seems to be fear on what would happen to coal mines, Eskom and other institutions involved in coal activities once a just transition or the shift to a renewable energy intensive environment occurs [39]. The fear must be addressed through ecological governance, through public awareness programmes that will ensure that the benefits of renewable energy to the ecosystem, public health, economic growth and socio-

economic conditions are understood by all.

There are also gaps in the current GHG inventory reporting as the country is still working on the best system through the DEA. The contribution of renewable energy or its success in ensuring a just transition depends on the availability of relevant data which shows how the current projects have performed. Businesses and individuals find it difficult to invest in something that has not been proven, and this is evidence that data availability plays a critical role. South Africa is still establishing a reporting system (i.e. the climate change inventory) to ensure that the savings can be calculated.

One of the concerns regarding the displacement of coal-generated electricity with renewable energy is the fear of what would happen to the coal mining industry. According to Langenhoven, coal makes up the largest share of mining in South Africa. He indicates that the coal mining industry provides for 81 000 direct jobs, and an estimated 170 000 indirect jobs. It is crucial that the proponents of coal mining and its use look beyond job creation, and consider ecological and environmental impacts of the industry. The issues raised are on the basis of lack of knowledge on how renewable energy can create jobs [40].

The above provides evidence that there is fear of what could happen if renewable energy is used as the only source of energy to meet the country's demand for electricity. The IPP office has proved that the renewable energy sector also has the potential to create jobs, and this has been provided in the IPP office performance reports. For instance, in 2017/18, a total of 30 763 jobs were created during the construction of the 62 IPP projects. These jobs are expected to increase as more projects are added to the IPP portfolio [31].

The above achievements are proof that the jobs that would have been lost due to the displacement of coal-generated electricity can be recovered through the implementation of renewable energy projects. Those who do not support the increased deployment of renewable energy have also raised a concern regarding the prices of renewable energy technologies which are argued to be very high and unaffordable.

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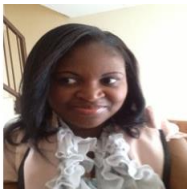

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