Renewable Energy Consumption and Gender Development in Southern Africa, 2002-2020

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Abstract
The need for energy increases drastically as economies develop and become more industrialized. Fossil fuels are finite and can only be generated over geological time, hence people will ultimately need to adopt renewable energy sources. On the other hand, previous research has also shown that gender inequalities are still persistent and need immediate attention, particularly in developing nations. Therefore, most developing countries have been trying to reduce gender inequalities to attain sustainable development. Technological advancement such as the switch to renewable energy sources can have an impact on inequality. However, if certain groups (women) are unable to access these new technologies, the advantages of technological progress may increase inequality. This paper analyzed the impact of renewable energy consumption on gender inequality using the fixed effects panel methodology for the period 2002-2020. The results revealed that an increase renewable energy consumption worsened gender inequalities in the selected Southern African countries. A scenario which needed to be avoided by these countries to ensure a just transition to renewables from the onset. However increased Access to Electricity reduced gender inequalities showing that current electricity shortages in the region have negative implications for gender inequality in these nations. However, there is still a window of opportunity to reduce gender inequality through genderising the access to electricity while ensuring that the electricity is from clean energy sources.

Key words: Gender Inequality, Renewable Energy, Sustainability, Access to electricity

Introduction

As countries grow and become more industrialized, so does the demand for energy. According to the Renewables Global Status Report (2022), the rebound increase in economic activity after COVID 19 resulted in a rise in demand for global energy of around 4%. While most of the developing countries are already dependent on imports of energy, the energy shortages worsened worldwide due to the Russia-Ukraine war (IEA 2022, p21). Thus, examining renewable energy usage to address the region's escalating electricity issue is crucial given that the mining sector is one of Southern Africa's biggest users of electricity and that mining businesses incur enormous losses during power outages (Musingwini and Simatele, 2017).

Since fossil fuels are finite and only produced over geological time, society will eventually have to embrace renewable energy (IPCC, 2014). There are two main ways that renewable energy benefits the economy; firstly, the transformation and distribution of energy items and services generates jobs and value within the sector. Secondly, its value chains may have an

impact on the production and acquisition of all goods and services, promoting economic activity throughout the entire economy (WEF 2012). Therefore, without access to the services from the use of modern energy, no economy in the world has been able to advance from a subsistence economy (Wolde-Rufael, 2006; Opoku et al. 2021).

In light of this, the energy sector has undergone significant paradigm shifts in recent decades. A global shift toward renewable energy sources has been triggered by the rising understanding of the urgent need to combat climate change. On the other hand, previous research has also shown that gender inequalities are still persistent and need immediate attention, particularly in developing nations (Nguyen and Su, 2021; Odaga, 2020; Ramas et al. 2020; Sarkodie and Adams 2020). Therefore, it has been increasingly acknowledged that Sustainable Development Goals (SDGs) on access to modern clean and sustainable energy (SDG 7), gender equality and empowerment (SDG 5) are interconnected (IRENA 2019, p19).

Even though gender disparities are noticeable in many important economic sectors, industry specific data indicates that the energy sector may be where they are most pronounced (Pearl Martinez and Stephens, 2016). Consequently, there is a window of opportunity to bridge the gender gap in a variety of fields especially the energy sector through the transition to renewable energy. Although lack of access to energy affects everyone, women are believed to bear a disproportionate share of the burden due to the additional barriers that gender inequality places on their ability to receive energy services and benefits, particularly in developing nations (Opoku et al. 2021; Danielsen, 2012).

Women and girls living in the rural Africa are responsible for obtaining energy for their families and most of this energy is from traditional biomass such as agricultural waste and wood charcoal (Carr and Hartl, 2010; Karlsson, 2007). This is very time-consuming since they must travel great distances to obtain it (Danielsen, 2012; Dutta et al. 2017). This qualifies women, especially those living in impoverished and rural areas to be crucial to the production, distribution, and consumption of energy. Hence, making it important to acknowledge the tremendous effect that the switch to sustainable energy could have on transforming gender inequalities in Southern Africa.

Therefore, if deliberate consideration of gender diversity is not prioritised, the shift to renewable energy could potentially worsen existing gender inequality in developing nations. Thus, numerous earlier studies recommended considering gender in all areas of energy policy (Martinez and Stephens, 2016). Further, Tabrizian (2018) underscored that the slow uptake of clean modern energy in developing countries is usually due to failure at the introductory stage which explains the importance of genderizing the transition to renewables at the initial stages. Nawaz and Rahman (2023) also cited that the results of past studies have been inconclusive with regard to factors influencing the consumption of renewable energy such as gender (Asongu and Odhiambo, 2021; Wang et al., 2016; Zhang and Lin, 2012). Thus, additional research is necessary to fully understand the factors influencing the consumption of renewable energy.

The Concept of Renewable Energy

Renewable energy generally represents energy produced from a natural resource such as wind or solar energy, hydroelectric, biomass, nuclear or geothermal energy that is inexhaustible when used (UNCTAD, 2023). Underground thermal energy is known as geothermal energy, hydro energy is from water whilst biomass is energy from plants and animals. Nuclear energy is generated from the nucleus of atoms and the long-term availability of all these types of energy is one aspect of sustainable energy which has recently gained acceptance because it does not harm the environment.

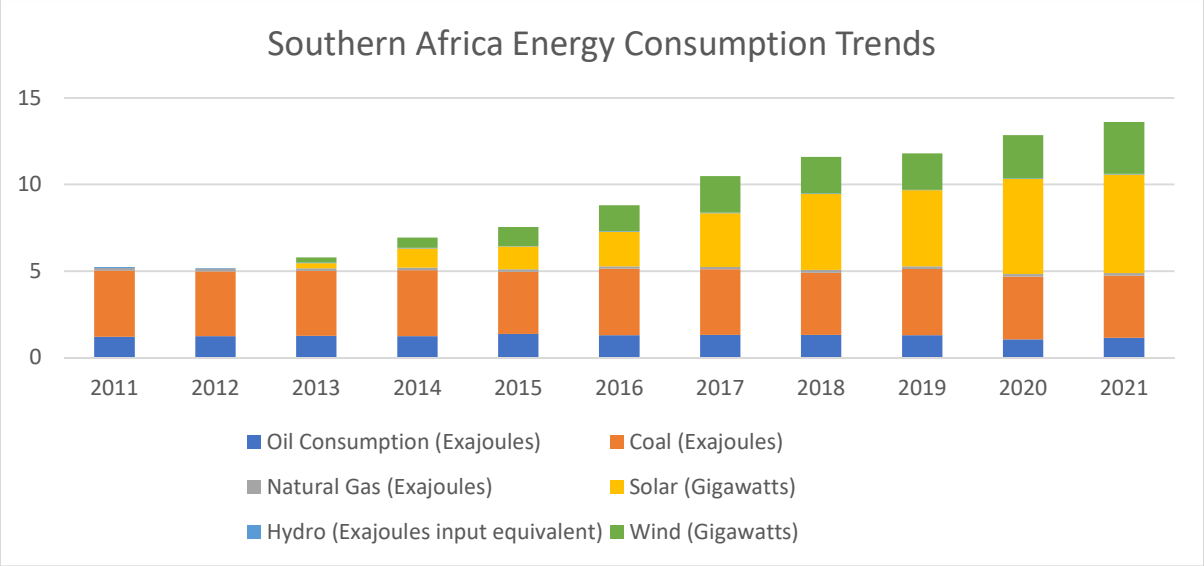
Even though renewable energy is environmentally benign, it has some downsides to it as well such as unreliable supply as it depends on some strategic minerals found in specific countries. For instance, solar energy cannot be harnessed in the night whilst wind energy can only be harnessed at certain speed levels (UNCTAD 2023, p21). Moreover, there is a lot of infrastructure such as batteries that need to be put in place for renewable energy to be stored and used when needed. Notwithstanding the drawbacks of clean energy sources, fossil fuels still have the biggest disadvantage of harming the environment and this leaves policy makers settling for the best attainable energy mix including both renewable and non-renewable energy.

Renewable Energy Consumption Status in Southern Africa

The SADC Renewable Energy and Energy Efficiency Status Report (2018) highlighted that since 2015 Southern African countries significantly increased their dedication to the use of renewable energy sources yet access to electricity remains a major challenge for the region. There are several reasons why renewable energy has become more popular in Southern Africa including the need for energy security due to the high volatility and rising costs of fossil fuels, particularly oil. In addition, under the current circumstances, the rising cost of fossil fuels and grid extension drives down the cost of certain renewable energy solutions especially solar energy.

Also given that rural electrification is still a priority area for the region, renewable energy provides affordable solutions to supply off-grid energy supplies such as household solar systems and small-scale hydro plants to the rural areas, where there is an ever-increasing need for energy in Southern Africa (SADC 2018, p58). Chart 1 below shows the Energy consumption trends of Southern African region for the period (2011-2021).

Chart 1: Southern Africa Energy Consumption Trends



Source: BP Statistical Review of World Energy;2022

The energy consumption trends depicted in chart 1 above show that the Southern African Region mainly consumes fossil fuel energy from coal. However, there has been a growing trend in the use of solar energy and wind energy consumption since 2017. South Africa has been ahead of the rest of the countries in terms of renewable energy consumption. Moreover, it is the only country representing installed capacity for wind energy in Energy consumption trends above.

Even though South Africa is the only country with significant wind energy installed capacity, SADC (2018) also highlighted that eight nations were found to have present or future wind energy capacity given the region's estimated 800 TWh of annual wind energy potential. However, the high initial capital expenses associated with wind energy has deterred nations from building wind farms to increase the availability of reliable electricity for consumers (UNCTAD 2023, p37). Most importantly, the lack of wind also causes supply variations, which makes wind energy unreliable as a main source of electricity for the region.

Southern Africa also has a huge potential for solar energy, and it is available in all the countries. Chart 1 above shows the growth of solar energy consumption in the region which grew by 7.8% in 2021 (BP, 2022). IRENA (2014) also concurred that the most likely option for expanding renewable energy access in Africa is solar power generation due to its low cost and ease of installation. On the other hand, Southern Africa's hydropower also remains one of the main sources of renewable energy in the region and is largely untapped due to the extremely high costs of constructing new hydropower stations. Nonetheless, as the financing of large-scale hydropower plants becomes progressively hard, countries such as Zambia are now focusing on small-scale hydro plants.

In terms of other renewable energy sources some Southern African countries, including Democratic Republic of Congo and Zambia, have undertaken preliminary exploration for geothermal potential and have confirmed resources. However, setting up of geothermal plants

is very expensive and tapping into these resources would require a lot of investment and setting up of the appropriate regulatory framework. Further, the only country with an operational nuclear power facility in the region is South Africa. Greenpeace (2011) highlighted that Koeberg, a state-owned nuclear power facility in South Africa comprised of two 922 MW reactors that were built in 1984 and 1985, respectively and supplied up to 6% of the nation's electricity.[1] However, nuclear energy still faces resistance, regulatory and safety risk issues in terms of the disposal of the highly radioactive waste to be pursued in the country at a larger scale.

As a result, despite the huge potential for more renewable energy consumption in the Southern African Region the resources remain largely untapped resulting in the worsening electricity shortages. Moreover, Southern African Development Community (SADC) countries had access to electricity of 48% overall and only 32% in rural areas which indicates the existence of quite severe energy poverty in the region especially in the rural areas (SADC, 2018). This can also be partially attributed to the fact that it is challenging to switch to cleaner energy sources for mineral resource rich countries such as South Africa because coal-fired power stations are the predominant source of energy.

Therefore, the transition to clean energy sources comes at a huge cost as it poses a serious threat in terms of loss of jobs in the coal mining sector since a new green economy requires retraining of workers and their integration into new energy systems (Borchadt 2023, p112). The cost of switching to the use renewable energy is not just economic but is also a social cost, clearly showing the need for a just transition to modern clean energy in the region.

The Concept of Gender Inequality

Women's involvement and interests in the generation and utilization of energy have long been recognized (Agarwal 1986; Cecelski 1992). More than three decades ago, Boserup (1970), documented the role of women in development. However, the concept of gender was established in the 1980s after the realization that concentrating solely on women would not successfully eradicate gender inequalities given that women's circumstances and status are intimately linked to their interactions with males. Therefore, according to UN-Women (2022) "Gender refers to the roles, behaviors, activities, and attributes that a given society at a given time considers appropriate for men and women"[2].

Nearly all major developments since the Beijing Women's Conference in 1995, The African Union's Gender equity and Women's Empowerment Strategy (GEWE) [3]and the SADC Protocol on Gender and Development (2008) [4]have sought to integrate gender issues into

[1] Also see government website: https://www.energy.gov.za/files/esources/nuclear/nuclear_back.html
[2] For detailed definition see: https://www.unwomen.org/sites/default/files/2022-02/Handbook-on-gender-mainstreaming-for-gender-equality-results-en.pdf
[3] African Union, AU Strategy for Gender Equality and Women's Empowerment (GEWE). AU, Ethiopia. 2018.
[4] Southern African Development Community (SADC). Protocol on Gender and Development. SADC, South Africa. 2008.

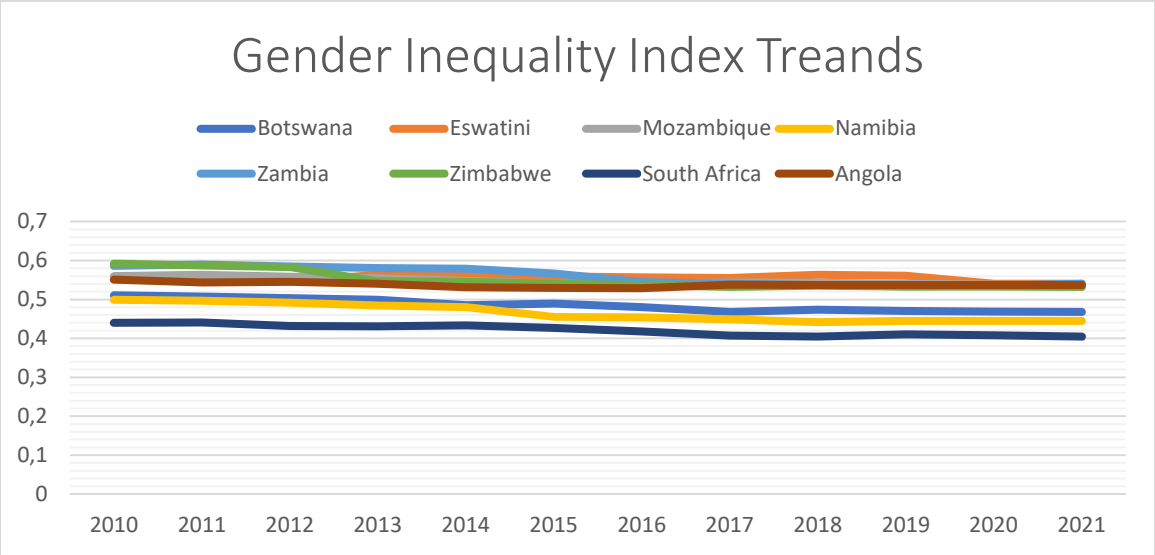
economic processes to some degree. However, Barnes (2017) pointed out that, the traditional role of women still influences many cultures today especially in the developing nations, and the world has not yet fully realized that women are an important part of the economic development process.

Gender Inequality Status in Southern Africa

Even though the Southern African nations are committed to reducing gender inequality and are signatory to various regional gender development agreements, they are still experiencing the challenge of gender inequalities. Previous studies on gender inequality used various gender inequality measures which vary according to components and methodology. For instance, "the Gender Development Index (GDI) is a composite index that provides a gender-sensitive adaptation of the human development index (HDI) by adjusting the Human Development Index (HDI) for gender inequality in life expectancy, education attainment gross enrollment rate and literacy rate, and income to show the level of gender development in different countries" (UNDP, 2017).

However, in contrast, "the Gender Inequality Index (GII) was developed as a result of many improvements to the Gender Development Index making it a more comprehensive measure of gender disparity developed by the UNDP in 2010" (Gonzales 2015, p14). This index considers disparities in economic opportunity (labor force participation rates by sex), reproductive health (maternal mortality ratios and adolescent fertility rates), empowerment (share of parliamentary seats) and secondary education attainment for both sexes. The GII demonstrates more comprehensively, the lost opportunity for development brought on by the disparity between male and female accomplishments in these fields.

Chart 2: Southern Africa Gender Inequality Trends



Source: UNDP Data; 2023

Chart 2 above shows the Gender Inequality Index trends for Southern African countries under study according to the UNDP for the period (2010-2021). The scale goes from 0, where men and women are at par, to 1 at which one gender performs the worst possible across all measured dimensions. Thus, countries with higher scores typically have more gender inequality across the three dimensions. The Gender Inequality Index rankings ranged from 0.44 to 0.58 in 2010 and between 0.41 to 0.54 in 2021 As shown above.

This demonstrates the complexity of reducing gender inequality because, despite significant advancements in women's participation in the area covered by the index- in Southern African countries given the patriarchal nature of African culture, much work remains to be done to achieve zero or, at the very least, lower inequality levels of below 0.50. South Africa, Namibia and Botswana were leading in terms of lowering gender inequalities having Gender Inequality Index scores below 0.50 in 2021. Nonetheless, the rest of the countries were lagging and still had a very long way to go in terms of reducing gender inequalities especially Eswatini, Mozambique, Zambia and Zimbabwe which attained higher scores above 0.50, clearly showing the prevalence of gender inequalities in the region.

Implications for Women from the Transition to Renewable Energy

IRENA (2019) also highlighted that energy policy and practice has moved away from focusing purely on technical supply concerns over the past two decades to embracing a wide variety of new issues including the demand side, equality, development issues, privatization and globalization, and a growing interest in the relationships between energy and the environment. This has led to a greater focus on the role of energy consumers including women, social and economic factors in technology adoption, and impacts on humans.

Access to reliable, affordable healthcare made possible by sustainable modern energy has a well-known and well-documented transforming impact on women. Access to energy also saves time for women who might have otherwise spent an average of 100 hours a year collecting firewood, giving them more flexibility because lighting allows them to do more at night (IRENA 2019, p14). This also affords girls more time to study and in turn stand a higher chance to do well in school and get better income generating jobs after completing their studies and reduce the gender wage gap. This clearly shows that renewable energy initiatives and projects can help women in poor countries overcome some of their most immediate problems.

However, Bazilian (2013) pointed out that the effects of increased usage of renewable energy alternatives on women still have not been studied much. Most of the research on renewable energy consumption has been on its impact on economic growth, the income gender gap and the employment of women in the energy sector. Further, IRENA (2019) highlighted that a Gender perspective of Energy policies is neglected at macro-level and has been considered mostly at micro-level (community level) through introduction of cook stoves and solar cookers, and yet mainstreaming gender into energy policies could increase the uptake rate of renewable energy. Large-scale (macro-level) renewable energy projects have had less attention from a

gender viewpoint compared to these small-scale community level and off-grid renewable energy projects showing that there is still a clear knowledge gap in this area (Nelson and Kuriakose 2017, p2).

Even though the gender-based disaggregation of renewable energy consumption is important because renewable energy consumption may evolve differently between groups (men and women). There is no clear evidence on the relationship between gender inequality and the transition to renewable energy consumption. Therefore, this paper seeks to thoroughly analyse the gender perspective on renewable energy use in eight developing countries selected from the South African region on the basis of the availability of data (Zambia, Zimbabwe, Namibia, Mozambique, Angola, Botswana, South Africa and Eswatini). The research used panel data for the period (2000-2019). The hypothesis to be tested is whether there is a relationship between renewable energy consumption and gender inequality.

Main Approaches Linking Gender inequality and Energy Consumption

Energy Poverty is the main approach linking gender and energy consumption especially in developing countries where it has often been found to be a serious challenge with severe consequences (Nguyen and Su, 2021). According to Petrova and Bouzarovski (2015), studies on energy poverty in developing countries provides a more sophisticated understanding of the connection between energy services and family needs, and the significance of going beyond electrification to include home heating and cooking services. Further Clancy et al (2003) highlighted that due to the inter-connection between energy poverty with other forms of poverty, it is critical to investigate this connection, particularly the issues pertaining to gender.

Naryan (1999) also supported this notion that there is a clear gender component to the processes that lead to poverty. Therefore, it has long been known that the majority of the world's poor use biomass as a source of energy, and that there is a growing shortage of energy especially in Southern Africa, which makes it more difficult for the women who are responsible for gathering it to complete their chores (Clancy et al 2013, p6). Therefore, this paper builds on the literature on renewable energy and gender that incorporates energy poverty as the main concept linking gender and renewable energy consumption.

Gender and Energy Poverty

Energy is clearly a vital component in maintaining people's livelihoods as it is fundamentally needed for the most basic needs such as heating, boiling, and preparing meals. According to the UNDP, energy poverty is specifically defined as “the inability to cook using contemporary clean cooking fuels and the absence of even the most basic electric lights for reading or other productive activities around the house after dusk” (Gaye 2007, p4). On the other hand, Reddy (2000) defined it as “the lack of sufficient options for obtaining adequate, reasonably priced, dependable, high-quality, safe, and environmentally friendly energy services to promote human and economic growth”.

The slow adoption of modern energy services in certain regions, especially in the developing world, may be partially attributed to a failure to address the gender aspects of energy poverty (Pachauri and Rao, 2013). Also, Pachauri and Rao (2013) highlighted that another important factor influencing the uptake and advantages of modern energy consumption are the power dynamics and roles that exist within the developing region's families and societies, which are the most energy impoverished. Past studies have also shown that even though women are usually allocated the kitchen work according to gender roles in the home especially in developing nations, when it comes to choosing a new stove, men frequently decided on the technology (Tucker, 1999).

Ngarava et al. (2022) in their study using the 2016 General Household Survey (GHS) emphasised that due to a lack of assets related to property ownership, homes headed by women were found to be particularly vulnerable to energy poverty and male-headed households were more adapted to energy vulnerability because of various revenue sources available to them. The study concluded that besides being pro-poor, energy policies, needed to prioritise gender and ethnic diversity. Further, Ding et al (2019) using Fieldwork, literature reviews, and data processing research techniques in the Tibetan region in China found a strong correlation between gender and energy poverty in this region. Women's health improved because of clean and efficient energy technologies. Devices that use clean, efficient energy including solar energy, improved energy efficiency and reduced energy poverty in this region.

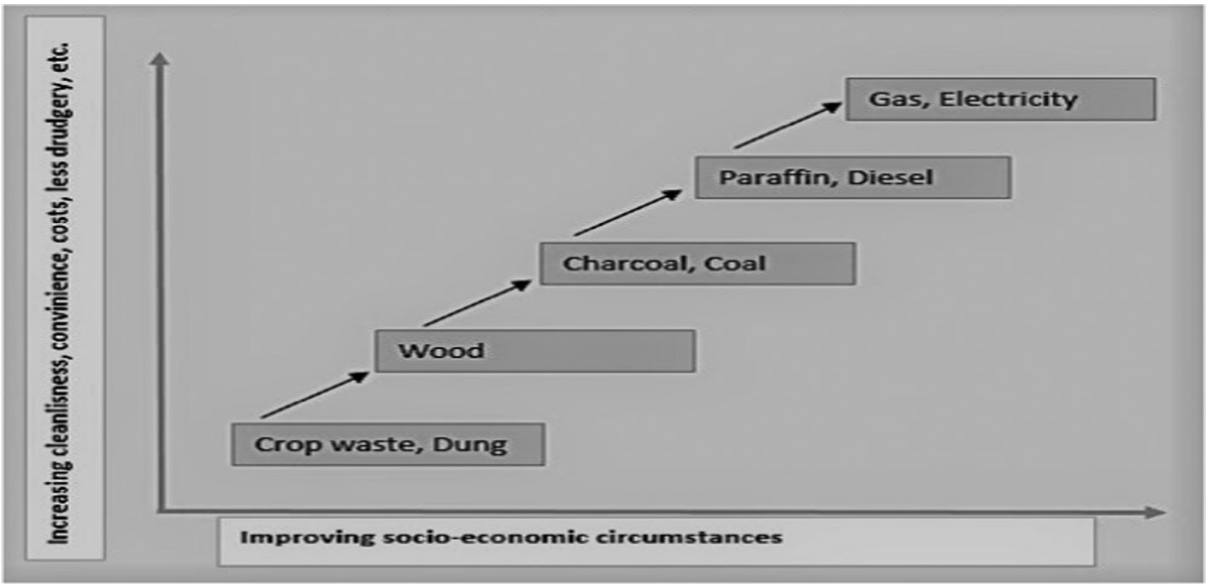
Additionally, women are thought to experience energy poverty at a higher rate than males because of the gender wage disparity, as well as the demographic fact that women are more than men and tend to live longer (Petrova and Bouzarovski 2015; Dutta et al. 2017). Borchdat (2023) also confirmed that in Kareeville, South Africa, women struggled more than males with energy poverty especially in terms of making the difficult and limited choices regarding accessing energy and supplies, managing household finances, and sometimes relied exclusively on social state assistance. Further, women and girls frequently suffered the worst health effects because of their 'choices' since they are frequently left with no other choice but to cook over an open fire and fetch firewood due to energy poverty.

This clearly shows that richer people tend to have more options when it comes to energy sources, and many choose the contemporary and cleaner forms of gas or electricity, such as biogas or LPG. On the other hand, the impoverished frequently lack the resources to make these kinds of investments and instead choose less expensive choices such as wood. The most widely used illustration of energy poverty for cooking and heating uses "energy ladders". The energy ladder, according to Holdren and Smith (2000), is " the proportion of people utilizing fuels ranging from basic biomass (wood, charcoal, dung, and agricultural leftovers) to liquid and gaseous fossil fuels (kerosene, liquefied petroleum gas, and natural gas), and finally to electricity".

The concept as shown in chart 3 below, suggests that the main energy sources utilized in rural parts of developing nations can be put on a "ladder," with the "simplest" or most "traditional"

fuels and sources, including crop waste, animal dung and wood, at the bottom and refined electricity or gas at the top. The efficiency of the fuels or sources is frequently used to characterize the ladder, with the more efficient ones being placed higher on the ladder. For instance, liquefied petroleum or diesel is more efficient than crop residues and dung, while charcoal is more efficient than wood for cooking (Barnes and Floor, 1996). Several academic studies have discussed the energy ladder (IEA, 2008, Cook et al., 2005; IEA, 2006).

Chart 3: Energy Ladder



Source: Mohlakoana et al; Development Southern Africa; 2018

On the Contrary, Sovacool (2012) suggested that although frequently used in the literature on energy poverty, the ideas of energy ladders and energy equity have drawn criticism for not accurately representing the nuances of how households utilize energy. The model's fundamental assumptions are that customers would constantly try to climb the ladder, that dung, agricultural waste, and wood are the "energy of the poor," and that price disparities have minimal bearing on the energy fuels and technologies that households choose. According to a survey carried out in Botswana, firewood was chosen by households of all income levels even rich ones because it is easily accessible and reasonably priced (Hiemstravander and Hovorka, 2008).

Also, some households used many fuels at once, effectively gripping several rungs of the ladder. For example, higher-income families in Mozambique use both charcoal and liquefied petroleum gas while middle- and upper-class homes in South Africa and Zimbabwe continue to use wood (Savacool, 2012). Therefore, wood use in some countries was not substantially correlated with income. However, Bhide (2011) argued that households with lower incomes tend to use biomass for heating and cooking and as income rises modern fuels and electricity are needed lighting, appliances, and communication, but they do not take the place of cooking and heating. Therefore, the full replacement of household biomass consumption occurs only at higher income levels.

Thus, it can be concluded that past research on the severity of energy poverty especially in developing countries indicated that energy poverty negatively affects the health of women and girls (Nguyen and Su 2021; Sadath and Archarya 2017). Moreover, Access to essential everyday life necessities such as clean water, clean cooking and health care is especially hampered for women who live in energy poverty. Clearly showing that, men may not be as affected by energy poverty as women, and energy poverty has significant consequences for gender inequality (Robinson, 2019; Pueyo and Maestre, 2019).

Feminist Theories

Feminism is another school of thought advocating for gender equality analysis over the years. "The fundamental tenet of feminism is to promote women's equality and fairness in all areas of life and to give them equal access to the resources that are often available to men without restriction" (Raina, 2017). This study broadly defined feminism as a philosophy that encompasses "a broad range of ideas as well as movements for social and political change". Therefore, implying that, the aim of "feminism" is to identify, develop, and attain political, economic, cultural, individual, and societal parity of sexes (Raina 2017, p1). Feminist theory is very important in the gender perspective analysis of the transition to renewables because it focuses on the often-ignored issues of irrational process such as the structural power within the sexes which would require different strategies than rational bureaucracy to be resolved (Woodward 200l, p14).

According to Lorber (2010), modern feminism first emerged as a formalized movement in the nineteenth century in Europe, America, and Japan as a reaction to the stark differences in citizens' legal statuses between men and women. The nineteenth and early twentieth century first-wave feminists campaigned for freedoms that are now taken for granted, such as the ability to vote, possess property, become a licensed physician, present evidence in court, and to serve on a jury (Lorber 2010, p1). In summary, the aim of first-wave feminism was to secure equal legal rights for women, particularly the ability to vote.

Also, Lorber (2010) pointed out that it was not until the late 1960s, when young people began openly questioning numerous aspects of western society, the second wave of feminism began but it did not come as an organized political force. Since then, the feminist movement has had a significant impact on social change by drawing attention to the fact that women continue to face social disadvantages that men do not, examining the sexual oppressions that women experience, and advocating for both interpersonal and societal reforms. In contrast to first-wave feminism, there are now many different feminist approaches to addressing gender inequality. As a result, the feminist perspective on what really causes women and men to be unequal is less consistent today (Lorber 2010, p2).

A younger generation of feminists who experienced feminism as children formed the third-wave feminism movement in the 1990s. They rejected the notion that women are oppressed by men since they grew up in a world with women's studies curricula in schools and a less

segregated social, economic, and political environment. Instead, they included male activists for feminism. The third wave provides a more diverse, intersectional and multiperspectival interpretation of feminism that includes women's various societal circumstances and the distinct set of difficulties they encounter (Snyder 2008, p5). Also, in line with the third feminist wave, women were further classified according to their race, ethnicity, religion, and socioeconomic status and the primary focus has been on a broader movement for social, economic, and environmental justice.

The key point that all the waves of modern feminism has emphasized regarding gender inequality is that it is not an individual issue but instead, is rooted in the social structures of society. Also, marriage, family structures, employment, the economy, politics, religions, the arts and other forms of cultural output are all structured in ways that promote gender inequality (Lorber 2010, p7). Therefore, social, rather than individual, solutions are required to achieve gender equality. Besides the above-mentioned three waves, Feminism theory can further be classified into many different classes according to the methodology such as Liberal, Marxist, Socialist, Radical and Ecofeminism. Nevertheless, the main tenets of all these classes of feminism remain the development of a gender-neutral society without class distinctions and the protection of freedom and liberty in a just society (Haradhan 2022, p24).

However, it is important to note the importance of the contribution made by the Marxism theory which has been widely applied to the understanding of feminism as well as gender analysis and historical dialectical materialism of the emergence of a class society, and the emergence of class conflict (Hartmann, 2015). Federici (2018) highlighted that Marx's approach has provided the important basis and tools that allow us to consider feminist ideology, the anti-capitalist movement, and the intersection of class and gender together. Thus, the focus of Marxist-feminists has been on domestic labor and how it relates to capital, with most past research contending that domestic labor carried out by women generates surplus value (Hartmann 2015, p3).

Ecofeminism

Ecofeminism was birthed due to the improved industrialization and contemporary society, which is driving up demand for resources and energy for social production and daily living, causing humanity and nature to be unbalanced (Ling 2014, p2). Therefore, ecofeminism promotes the consideration of social gender issues while analyzing and resolving ecological and environmental issues. Ecofeminism is dedicated to challenging the current industrial civilization and works to restore societal cultural values to free both women and the environment. Most importantly, ecofeminism integrates environmental issues with women's issues by incorporating female principles into the ecological movement, to address environmental issues from a female point of view (Ling 2014, p5).

Francoise d'Eaubonne, a French author, first used the word "ecofeminism" in 1974 and in 1976, Ynestra King continued to develop it, until it became a movement in 1980 [5]. It revealed the fact that the greater fight to protect the environment and life on Earth is inextricably linked to the freedom of women (Rao 2012, p2). Ferguson (2017) concurred that eco-feminism, dates back to Merchant and Griffin in the 1980s as a movement and that it is the source of feminist theories of environmental change. These authors foresaw the widespread impact of our species' planetary degradation bringing ecological philosophy and discussions of gender and identity.

Also, the analysis of sustainability and economic growth is fundamentally supported by feminist work on services, particularly care giving services by women (Chodorow 1978, 2000). Hence, ecofeminists believe that human diversity is valuable because of biological diversity and the impoverished including women should all be valued for their worth, according to this principle (Howell 1997, p5). The linkages between the marginalization of women and the degradation of nature are emphasized to comprehend the reasons "why environmental issues are feminist issues" and "why feminist issues can be approached through the lens of environmental concerns" (Gaard 1993, p. 4).

According to Lorentzen and Eaton (2002), empirical, conceptual, and the epistemological connection are the fundamental connections between woman and nature according to ecofeminist theory, even though a variety of woman/nature links are being investigated. The Empirical connection points to the fact that according to actual data (empirical evidence), women have been found to be disproportionately affected by environmental issues in most regions of the world. Also, in most countries especially developing countries, there is a sexual division of labor that views women's work as providing for the family rather than environmental degradation or unpaid work per se, which is the cause of the greater burdens women bear (Lorentzen and Eaton 2002, p1).

In terms of conceptual connections, men are associated with masculinity and power, while women are associated with femininity and the earth. Further, the epistemological connection championed by ecofeminist Vandana Shiva, postulates that women are more negatively impacted by environmental issues than men and they are better qualified to be experts on these issues and are thus in a position of epistemic privilege. This suggests that women know more about earth systems than men (Lorentzen and Eaton 2002, p1). This epistemological connection is very important in linking gender issues and the environment because it implies that women are uniquely positioned to contribute to the development of novel ecological theories. This idea places women at the forefront as advocates for environmental issues such as the just transition to renewable energy consumption to combat carbon emissions.

Bell et al (2020) also underscored that the Feminist energy approach, according to Fraser[6], starts by giving visibility and significance to the "hidden abodes" that enable capitalism. Thus,

[5] Françoise d' Eaubonne, Le Féminisme ou la Mort. P.Horay : Paris. 1974.
[6] Fraser, Nancy. Behind Marx's Hidden Abode: For an Expanded Conception of Capitalism. New Left Review, 86: p55–72. 2014a.

introducing a feminist perspective into the energy sector, seeks to shift political power away from the quest for individual gain and toward the creation of shared prosperity. Therefore, feminism in energy policies entails more than merely expanding the use of renewable energy sources but seeks to establish a collectively created, owned, and supervised system in place of existing energy system (Bell et al 2020, p5). Thus, the feminist viewpoint on energy system prioritises well-being of people and biodiversity above profit.

Gender Mainstreaming

Theoretically, gender mainstreaming is based on feminist analysis of gender inequality and seeks to update and broaden the fundamental feminist ideas and methodologies. "It is a strategy for ensuring that the interests and experiences of both men and women are taken into account in the design, execution, oversight, and assessment of all policies and programs in all domains political, economic, and social so that the gains are distributed equally between the sexes".[7] Since its inception, gender mainstreaming has long been a recognized method for advancing gender equality in social and economic development policies at the national and international levels, including those of the European Union, the UN, and other national governments (True and Mintrom, 2001).

However, the mainstream must be understood to comprehend gender mainstreaming because it varies greatly depending on the policy areas into which gender equality problems are to be accommodated such as the Renewable Energy Sector (UN-Women, 2022). According to Martin (1998), gender insensitivity does not emanate from structures alone but from the bases and understandings behind those structures. In addition to being a technical process, gender mainstreaming is a political one. It entails novel techniques to formulating and implementing policies, with the hope that these approaches will result in a change in organizational or institutional culture, which should eventually lead to modifications in societal structures (Guzura 2017, p3).

Earlier methods to decrease disparities between genders frequently centered on women targeted programs for instance giving them greater education and resources. Countries including Netherlands and Canada were part of the pioneers of policies promoting gender equality in the mid-70s. Unfortunately, these early efforts to attain gender equality faced some challenges such as lack of political will, lack of clear understanding of the concept itself and buy in from the bureaucrats amongst others (MacKay and Bilton 2000, p14). This earlier approach utilized the vertical approach where the government addressed gender issues through some specially created women's offices (Woodward 2001, p19). Contrary to this, gender mainstreaming now emphasizes the need for a horizontal approach where gender issues are included in the entire policy spectrum.

[7] See formal United Nations Definition here: https://www.unwomen.org/sites/default/files/2022-02/Handbook-on-gender-mainstreaming-for-gender-equality-results-en.pdf

Over the years, countries have been trying to implement gender mainstreaming. However, Kumari (2013) highlighted that, the work of mainstreaming has proven to be highly challenging because the term "mainstreaming" itself is frequently misunderstood and confusing, according to (MacKay and Bilton 2000, p2). "Mainstreaming is sometimes referred to as a tool, sometimes a process or method, and sometimes a strategy". Implementers reported that gender mainstreaming is confusing and that it does not offer specific guidelines for how to use it in practice (Carney, 2004). Lombardo (2003) also makes the point that the lack of a blueprint on how to implement gender mainstreaming makes the strategy difficult to implement and many governments have experienced issues while putting together collaborative programs with other stakeholders.

Also, Clancy (2014), highlighted that the unavailability of gender disaggregated data poses a challenge to mainstreaming gender into energy policies especially in developing countries resulting in the gender blindness of energy policies. Further, financial resources were found to be a crucial component of gender mainstreaming, according to AfDB (2012), and are required to ensure enough funding for consultants and staff members who specialize in gender issues, as well as for resources that help create capacity such as tools and training to eliminate the confusion surrounding the gender mainstreaming concept especially in specialised sectors such as the renewable energy sector in developing countries (AfDB 2012, p25).

Furthermore, Daly (2012) emphasised that the gender mainstreaming theory has not paid enough attention to the interaction between the state and society. Even if actors create legislation that is enlightened, gender disparity may be lessened but will not be eradicated by public policy alone because it is a social phenomenon. Thus, countries still have a long way to go in implementing and continuously improving national gender mainstreaming frameworks and ensuring that they are transformative to achieve gender equality in all sectors of the economy.

Other Gender Transformative Opportunities Through Renewable Energy

The goal of gender-transformative techniques is to alter the power structures and processes that underpin exclusion, discrimination, and gender-based inequality in important development issues such as livelihoods/entrepreneurship, employment, and technology adoption. The power dynamics at all levels perpetuating gender inequalities in these important areas have been examined throughout literature on Renewable Energy and gender to enhance policy focus to mainstream gender in these sectors which are very crucial for the livelihoods of women especially rural women (Pearl-Martinez 2014; Barron et al 2020; Rifkin 2011; Shatilova et al 2021; Baruah 2016; Wajcaman 2010; Mohideen 2018).

Opportunities for Sustainable Livelihoods for Women

As a result of the transition to renewable energy female entrepreneurs have attained a productive role in a typically male-dominated industry. With this accomplishment, women now have access to new roles and opportunities in the sector and can create a good social impact in

their communities. However, Langevang et al. (2015) highlighted that Subsistence entrepreneurship, which is mostly motivated by necessity and need for survival because of the lack of official employment is increasingly common in Sub-Saharan Africa (SSA).

Past studies including (Fajardo, 2020) have shown that energy entrepreneurship enables women to sustain their families, achieve financial independence, and meet their fundamental needs. For women across the whole energy value chain, employment and entrepreneurship in decentralized or off-grid energy offers the potential to become a significant source of income (Pearl-Martinez, 2014). This can be attributed to the distinctive relationship they have with other female energy users and the growth of renewable energy consumption particularly in rural areas.

Moreover, women's home decisions on energy issues give them a detailed awareness of their customer base and supply chain, which translates into a low business cost for finding and securing clients as renewable energy entrepreneurs (Pearl-Martinez 2020, p17). Since female business owners are more inclined to invest their profits in their children's education, their success would also lead to reinvestment in communities and families and health compared to their male counterparts. Some developing countries such as Rwanda have already implemented women empowerment projects and programmes in the renewable energy sector for rural women. For instance, Barron et al. (2020) utilizing observational data from more than 1,000 rural businesses discovered that on average, women sold much more units of solar lights than men in Rwanda.

Also, women led group businesses consistently outsold male-led businesses indicating that women performed even better than males while working in groups. Overall, these findings imply that Rwanda's solar energy industry benefited greatly from the sales expertise of women entrepreneurs and that social enterprises such as Nuru Energy can increase sales and market penetration for renewable energy products by strategically hiring women entrepreneurs in the rural areas (Barron et al 2020, p64). Similarly, Barefoot College in India implemented a program where indigenous women from rural parts of Latin America, Africa, and India were trained to become solar engineers who offer solar solutions to their communities (Mishra et al 2023, p2).

Also, in line with capacity building Joshi et al. (2019) emphasized the significance of expanding energy access in rural communities through capacity building and entrepreneurial development. Gains in technical skill, financial independence, and other social advantages for the locally trained women were among the positives highlighted in this study. Mishra et al. (2023) also concluded that the success of local business owners especially women has the potential to increase community access to renewable energy. Despite these advantages, evidence from previous studies suggests that women still encounter more barriers to starting enterprises especially in the renewable energy sector than males in most developing nations.

Barriers for Women's Livelihoods Through Renewable Energy

Available evidence highlights the numerous and significant obstacles that prevent women from owning their own renewable energy businesses, including a lack of capital, regulatory restrictions, exclusion from business networks and intermediaries, inability to obtain market data and information, discriminatory cultural and gender norms, a lack of role models and mentors who are women, and the conflicting demands of home and family duties (Pearl-Martinez, 2020). Past Studies also demonstrated that encouragement through addressing issues outside the business sector such as gender-based violence, childcare, land and property rights is necessary to increase women's entrepreneurship (Buvinic and O'Donnell, 2016).

According to Shankar et al (2020), female entrepreneurs require five different types of capital namely economic, time, social, cultural and symbolic (status) capital but the cultural and symbolic capital are frequently the hardest to address, measure, and are far too frequently entirely ignored. For instance, improving economic capital through financial access is essential, but without also enhancing financial literacy and business education (cultural capital), these financial services may go unused (Shankar et al 2020, p42). The mental patterns that result in the display of bias against women in business are crucial to understanding cultural capital (Shankar et al, 2020).

Also, Cecelski (2000) concurred that capital costs are one of the major factors preventing women from using modern clean energy systems in their small businesses. In light of this, governments have devised creative financing channels to offer loans to consumers, with help from donor grants and loans. “Nevertheless, there have been concerns, that most women could still be unable to get loans for the contemporary clean energy home systems because they lack collateral” (Gupta and Shukla, 2018, p16). Therefore, there are other important factors such as lack of collateral to be considered in the process of ensuring access to renewable energy for households and businesses owned by women. Hence the need for green Micro-Finance Institutions (MFIs) and women's emancipation in the renewable energy sector especially in rural areas.

Past studies showed that gendered family responsibilities play a significant part in why women entrepreneurs frequently have less effective business networks than men entrepreneurs (Renzulli, Aldrich, and Moody 2000; Brush et al. 2002). Further, a study by Matinga et al (2018) using a literature review methodology on renewable energy in the informal food processing sector, concluded that there is a scarcity of literature on gender and the use of modern energy within the informal sector.

The study found that even though women dominated the informal food sector in Sub-Saharan Africa, patterns of usage of various forms of energy, particularly traditional and modern forms, were gendered. Additionally, because they are cleaner and save time, improved cookstoves were found to boost informal food processing businesses. The use of clean energy enhanced working conditions and the profitability of women-owned small firms in the sector. However, the study emphasized that enterprises continued to use traditional fuels because modern clean energy alternatives were hindered by erratic supply (Matinga et al 2018, p7).

Despite all these barriers, women in SSA consistently pursue business possibilities, according to data from the Global Entrepreneurship Monitor (GEM) (Bosma et al. 2020). However, it is clear that government plays a crucial role in creating a supportive environment for female energy entrepreneurs in the renewable energy sector to overcome these barriers, including ensuring a sound legislative framework and public attitudes. Also, creation of a supportive institutional and regulatory environment for the growth of women's entrepreneurship was found to be critical for progression toward the formalization of women-owned businesses (Fajardo 2020, p39).

Employment of Women in the Renewable Energy Sector

Women's employment in the renewable energy sector has the potential to encourage more community engagement during the transition since women participate more in community-based activities than men (Pearl Martinez and Stephens 2016, p4). However, IRENA (2013) cited that developing and emerging economies had insufficient expertise in the field of renewable energy particularly among women. Moreover, learning these skills might be particularly difficult for impoverished and rural women and girls due to low literacy rates and restricted access to basic education (Baruah, 2010). Therefore, there is growing concern that women, who are already disproportionately underrepresented in the sector, will further be marginalized (Baruah, 2016).

Pearl-Martinez (2015) highlighted that according OECD data nations such as Canada, the United States, Spain, Germany, and Italy had a mere 20–25% of jobs in the Renewable Energy Sector held by women. Moreover, most of these jobs were lower-paying, non-technical, administrative, and public relations positions. Further, Baruah (2016) found that a combination of social norms, cultural views, societal values, and economic need have shaped how many women participate in the formal job market. Past academic literature has repeatedly noted that a barrier to women's full participation in Renewable Energy and, more broadly, in STEM areas, is a combination of women's self-perception and social judgments about women's inadequacy in technical talents. This coupled with misconceptions about the nature of the work done in these professions dissuades women from pursuing careers in Renewable Energy and, more broadly, engineering and technology (Baruah 2016, p4).

Further, Atif et al (2021) found that among all employees working for energy generation firms, women made up 38% of the STEM field, 54% of the non-STEM field, and 55% of the non-qualified field. They also discovered that gender-diverse boards in companies were advantageous in terms of increased renewable energy consumption and that the interaction between board gender diversity and renewable energy consumption enhanced firm financial performance. Therefore, they suggested that companies with less than two female directors on their boards ought to think about hiring more female directors. In support of this, Vangchuay and Niklaus (2021) also emphasised the importance diversity and equality for the just transition to the use of renewable energy particularly through diverse workforces in the renewable energy sector.

In terms of managerial positions, Arias et al (2023) highlighted that there were significant gender discrepancies in executive and management positions; for renewable energy producing firms, the percentage of female executives and in management positions was 24% and 22%, respectively. In addition, 68% of the companies that were surveyed lacked a gender policy (Arias et al 2023, p10). This study concluded that, the renewable energy labor market will not change as a result of a gender perspective of advances in technology alone without the relevant supporting government, sectoral and individual company gender policies being produced and implemented.

Gender Inequality in Renewable Energy Technology Adoption

Wajcman (2010) highlighted that the level of adoption of new technologies for energy production and consumption determines the key aspects of the energy transition which entails altering the way energy is created and used. Further, this study asserted that the distinctive insight of feminists in Science and Technology or what is referred to as "technofeminism" is the degree to which socio-technical processes are ingrained in gender culture. The materiality of technology is therefore influenced by gender power relations, and vice versa. Therefore, increasing women involvement during the conception and construction of technological products is not only a problem of equal job opportunities but also a matter of renegotiating gender power relations in the home (Wajcman, 2010).

As a result, given the historical growth of science as a clearly and largely masculine discipline, feminist views in the 1980s changed the conversation from asking how women might be treated fairly by science and technology to asking how science can be altered to empower women (Mohideen 2018, p31). Women's access to technology was no longer the focus of feminist studies of technology; instead, they began to focus on how the development and use of technology itself has altered and worsened established gender power relations. These studies provide a convincing argument against technological determinism, claiming that social relations of production have a significant impact on technology (Mohideen, 2018).

Mohideen (2018) also emphasised that technology is a socially useful product, developed and produced by a socio-technical process that combines men and women, organizations, culture, and knowledge. This socio-technical process is fundamentally influenced by gender and at every level, gender shapes technology, and vice versa; the two are historically dependent on one another and context dependent. This study concluded that the social pillar should be considered while designing and modelling energy systems because they are crucial to the system's functionality. Therefore, integrated solutions are required to prioritize the time of women and economic empowerment criteria. This comprises comprehensive approach, that connects energy to water and sanitation, low-carbon transportation, and communication, among others.

Studies conducted in several nations, including Mexico, the United Kingdom, South Africa, and India, have highlighted the possibility that transitions to modern clean energy could end up escalating racial and economic disparities (Ring et al 2022, p3). This is regardless of how a

variety of labor and energy-saving technologies may have a significant potential to decrease the significant time burden placed on women and increase labor productivity in general. Additionally, empirical studies revealed that rural women's use and adoption of these technologies has not always been high and is typically much lower than men's (Ragasa 2012, p10). However, Aryal et al. (2020), found that homes where women participated in decision-making had a higher likelihood of embracing new technologies according to their study.

This implies that the user's attributes influence how people accept and use technology hence gender and age are significant contextual elements in technology adoption. Also, the adoption of technology by rural women may be influenced by their income (Dwivedi et al 2022, p2). Economides and Terzis (2011) added that perception of usefulness affects how men use technology, but perception of usability affects how women utilize technology. In support of this notion, Venkatesh et al. (2000) highlighted that females tend to place more emphasis on the amount of work required, and enabling circumstances influence whether they want to use technology. Thus, inequalities between men and women on the significance of factors influencing technology adoption become increasingly conspicuous (Morris et al., 2005; Venkatesh et al 2003).

Also, geographical location within and between countries significantly affects gender inequalities in technology adoption, demonstrating the significance of institutional and socioeconomic context in determining opportunities and limits. Many studies point out that barriers to a much improved and quicker adoption of new technologies for rural women includes an inability to obtain information about the technology or a lack of the necessary supplementary knowledge and skills to use it (Ragasa 2012, p14). Some studies blamed the insufficient response to the requirements and limits of rural men and women, societal acceptance, and cultural norms on the lack of participation of important players such as women in priority-setting and innovation processes (Meinzen-Dick et al. 2010; FAO 2010).

Further, a cross-country study conducted in Ghana and Zambia discovered that households led by women were more likely to embrace manual technologies than male-headed households, and they adopt small-scale technologies at a rate that is two-thirds that of households headed by men (Theis et al 2017, p9). Attempts have been made to ensure that women in rural areas also have access to new technologies and to change the power dynamic in homes through the organization of women into groups and focusing on them with resources and training. However, these efforts have yielded very little results because though women understand the new technology, these initiatives fail if they do not first win the support of the males who live in those households (Theis et al 2017, p35). This is because men largely govern women's participation in these group opportunities in the first place (Theis et al 2017, p22).

Further, Singh and Kotwaliwale (2011) found that women frequently relied on less mechanized and more labor-intensive processing technologies which can be explained by affordability and access to financing. The availability of credit for both men and women was also found to be strongly correlated with uptake of new technology such as renewables (Ragasa 2012, p16). Therefore, microfinance continues to be a key component of financial services accessibility for

women living in rural parts. Even for the same activities, loans are typically given to women in smaller amounts than to males, and they are significantly underrepresented in the programs that support larger loans (Ragasa 2012, p17). Therefore, women in agriculture may have less access to more advanced agro-processing equipment than men in Sub-Saharan Africa.

Also, Ring et al (2022) highlighted there are millions of non-property owners, particularly women, were left out of the solar panel adoption market in Germany since adopters are required to possess property to mount solar panels. While class is a major factor in who owns property, other factors include age, gender, citizenship, ethnicity, and race. Therefore, it is clear how clean energy might increase inequality if solar panels are only available to the wealthy (Ring et al 2022, p2). Thus, the recurring theme in the literature is the general underrepresentation of women in policy, legislative, and public investment processes and in the research and innovation systems.

Access to water, electricity, internet, and mobile phones were evaluated by Jacobsen (2011) in the context of several technological avenues for transforming gender equity. She concluded that the provision of electricity was "more promising" for gender development because it replaces physical work and enhances a variety of productive activities. Also, the all-encompassing nature of the energy transition, makes it necessary to address gender inequality in technology adoption using the whole set of technologies.

Political Economy of Renewable Energy Consumption and Gender Inequality

Since fossil energy reliant systems are supported by institutions, alliances, norms, and capacities, breaking the carbon lock-in is fundamentally a political effort (Bernstein and Hoffman, 2018). A change may be stymied or delayed by stakeholders who have directly benefited from the institutions, practices, and policies that have contributed to climate change. Therefore, it is crucial to grasp a nation's institutions, players, and interest groups to comprehend how policy innovations take place (Mildenberger, 2020).

According to Opoku et al (2021), the interaction between political participation by women and energy-related issues illuminates the fundamentals of government. Governments are typically in the forefront of the provision, distribution, and price of power in African nations. Additionally, governments typically take the lead on issues related to sustainable energy consumption. Beer (2009) discovered that there was a correlation between government spending as a percentage of GDP and gender equality suggesting that political parties and the government play an important role in promoting gender equality. Therefore, politics plays a significant role in securing access to power because energy issues are mostly related to policy and governance.

Renewable energy systems are not always sustainable, nor can they guarantee fairness making it improbable that modern energy technologies alone, without a corresponding modern energy politics, will stop the impending global environmental catastrophe (Bell et al 2020, p4). Renewable energy sources cannot provide democracy and equality since they can still be

manipulated by autocratic and exploitationist governments. Howe (2019) in her study of a planned wind park project in Mexico discovered that it adhered to the conventional model of extraction, demonstrating how renewable energy initiatives "risk repeating old conventions that are unequally distributed."

To decipher the link between the degree of democracy and gender inequality, Richards and Gelleny (2007) applied the Gender Related Development Index (GDI) and Gender Empowerment Index (GEM) of the United Nations as well as three indicators from the Cingranelli-Richards Human Rights dataset to assess the circumstances of women. Most of their measures of women's status were found to be positively correlated with democracy.

According to Beer (2009), greater gender equality was also substantially correlated with long-term democracy and the participation of women in democracy. The results clearly showed that long-term democracy and women's participation have a substantial impact on raising the status of women in comparison to men, even after taking development and modernization into account. The study concluded that, even in developing nations with low levels of public spending, women's participation and democracy improved the lives of women (Beer 2009, p15).

Büscher (2009), through the implementation of a critical political economy of energy in South Africa which examined and challenged the political and economic power structures that affect how local and global actors make decisions about energy, and the deeper structures underlying energy production and consumption among different actors on different scales. They concluded that the factors influencing the "the energy debate" were energy inequality and energy sustainability, and it required a critical political economics approach to provide a more solid analytical foundation. The findings emphasized on the need for a more thorough transformation that will ultimately be essential to cope with the social and environmental injustices of the MEC (Mineral-Energy Complex) in South Africa, since the country relies heavily on the coal sector (McDonald 2009c, p450).

On the other hand, Fine (2008) highlighted that despite the emergence of new players and changing institutional and technological configurations in South Africa's energy sector, the MEC continues to be a significant influence on policy choices regarding electricity and still symbolizes a vital connection between public and private capital as well as a "core set of activities around mining and energy" (Fine 2008, p1). Also, Geels (2011) concluded that the 'niche' improvements in renewable electricity generation cannot be viewed as 'radical' because they are off-grid and the centralized grid infrastructure to which they will link remains largely unaltered. Moreover, IEA (2023) highlighted that at least 3 000 gigawatts (GW) of renewable power projects, of which 1, 500 GW were in advanced stages were still waiting to connect to the grid. This clearly indicates that grids are increasingly becoming a barrier to the transition to clean energy and transforming them into smart grids will take a very long time.

Kim and Standal (2019) found that the political economy of energy, cultural beliefs regarding energy sources, and the economic viability of electricity use all contribute to the development

of local practices in Kyrgyz rural households that have the potential to ease tensions brought on by transitional uncertainties but also present significant challenges for women's empowerment. However, the state, men and markets mediated women's interactions with energy sources first. The results suggested that the presumption that having access to electricity precludes the use of conventional labor-intensive energy sources must be reconsidered. This is because families relied on firewood, dung, and coal in addition to the fact that electricity was either unaffordable or unreliable and that energy consumption is linked to gendered identities and cultural practices such as cooking methods that are not easily changeable.

Further, IRENA estimated that private investment in renewable energy accounted for over 90% of total investment in 2016 (Bell et al 2020, p4). Public policy and regulation were cited as significant "enablers" for investment. As a result, political authority is portrayed as a supportive factor of financial interests. However, private investors may be able to increase the amount of solar and wind energy that is delivered to the grid, but because their business models depend on ever-increasing energy demand for profit, they cannot be relied upon to pave the way for the development of decarbonized and just energy systems (Bell et al 2020, p5). Even though achieving the ideal fuel mix is vital, but so are the methods of energy production, transmission, and consumption. Therefore, political will and government regulation is crucial for the just renewable energy transition.

Methodology

Sources of data

The panel data utilized in this paper is secondary data. The data includes Renewable Energy Consumption (REN), Access to Electricity (AE), Gross Domestic Product per capita (GDPpc), Official Development Aid percentage of GDP (ODA), Trade Openness (TO), Regulatory Quality (RE), Foreign Direct Investment (FDI) for the period 2002-2020 obtained from World Bank open data country indicators. This data is supplemented by the and the Gender Inequality Index (GII) data obtained from United Nations Development Program (UNDP).

Model

To analyze the long-term relationship between the Gender Inequality (the dependent variable) and the independent variables, panel regression method was used to estimate the relationship using annual data for the period (2002-2020) as shown in the equation below:

$$GII_t = \beta_0 + \beta_1 REN + \beta_2 ODA + \beta_3 lnGDPpc + \beta_4 lnTO + \beta_5 lnAE + \beta_6 lnRE + \beta_7 FDI + u_{it}$$

Null Hypothesis

H_0: There is no relationship between renewable energy consumption and gender inequality.
H_0: $\beta o = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$

Alternative Hypothesis

H_1: There is a relationship between renewable energy consumption and gender inequality.
H_1: $\beta o \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$

Diagnostic Tests
Cross-sectional Dependence

According to Torres (2007), before performing serious diagnostic tests it is important to check for cross-sectional dependence, which may result from common shocks, spatial dependence, and unobserved components. Given that these countries are in the same region and have very close cultures and economic characteristics it is highly probable that cross sectional dependence will exist. The commonly used tests for cross-sectional dependence are Frees' test, Friedman's test and Pesaran's CD test.

Pesarans CD test, Frees and Friedmans test were performed, and they gave the same conclusion of the presence of cross-sectional dependence as shown in table 3 below. The null hypothesis of the absence of cross-sectional dependence is rejected by Friedman's and Pesaran's CD tests at 5% and 10% significance level respectively. The test statistic was greater than the critical value for Frees test, also showing that the data has cross-sectional dependence.

Table 1: Tests for Cross-sectional dependence

Test	Test Statistic	Critical Value
Friedman	26.866	0.0004***
Frees	0.707	0.1782
Pesarans CD	1.735	0.0828**

*** $p<.01$, ** $p<.05$, * $p<.1$

Heteroskedasticity and Autocorrelation Test

Panel data models are built under the assumption that there is no presence of heteroskedasticity or autocorrelation within the error terms. If this assumption is violated the model becomes inefficient and the results are biased. Therefore, the Groupwise heteroskedasticity test using the modified Wald test and the Baltigi-Wu's LBI test for autocorrelation were used to test for heteroskedasticity and autocorrelation respectively and the results showed the presence of both heteroskedasticity and autocorrelation, as shown in table 3 below.

Table 2: Heteroskedasticity and Autocorrelation Test Results

Test	Test Statistic	P-Value	Conclusion
Heteroskedasticity	368.89	0.0000	Heteroskedasticity present

Autocorrelation	0.61385942 0.85665949	0.7051	Autocorrelation present (Tests statistic<2)

Robustness

Given the presence of cross-sectional dependence, heteroskedasticity and autocorrelation in the data, robust estimation methods were applied. The Driscoll Kraay (1998) Standard Errors were used to deal with this problem (Hoechle, 2007; Beylik et al, 2022). In line with reliable covariance matrix estimation methods such as those employed by Newey and West (1987) or Andrews (1991), the Driscoll Kraay covariance matrix estimator is also reliable and addresses heteroskedasticity, cross sectional dependence and autocorrelation concerns.

Estimation of the model

Before the application of the Panel Regression Model, the Hausman test was carried out to determine whether the fixed effects or the random effects model would be more appropriate to use. According to the Hausman test results the fixed effects estimation model was found to be more consistent. Lastly, the The Driscoll Kraay (1998) Standard Errors were used to resolve the problems of heteroskedasticity, cross sectional dependence and autocorrelation and the results are shown in table 3 below.

Table 3: Results

Variables	**GII**
lnTO	0.0344*** (0.010)
lnODA	0.0085*** (0.005)
lnGDPpc	-0.0160** (0.037)
lnREN	0.0879** (0.044)
lnAE	-0.0416*** (0.000)
lnRE	-0.0118** (0.016)
FDI	0.0002 (0.343)
Observations	152
R^2	73%

**** p<.01, ** p<.05, * p<.1*

Discussion of Results

When the robust fixed effects panel estimation was employed the findings showed that an increase in Renewable Energy Consumption (REN) increased Gender Inequality (GII) as shown in the above table of results. This Result is in line with the results found by (Ding et al. 2019, Parikh, 1995). A possible explanation of this is that Gender inequality reduction takes a long time to be achieved because it is a complex social issue and also most countries' renewable energy policies are still considered to be gender blind in terms of implementation especially in developing nations. However, Access to electricity (AE) had an inverse relationship with gender inequality and reduced gender inequality as was found by Nguyen and Su (2021). Also, Regulatory Quality (RE) was negatively associated with gender inequality meaning that an improvement in Regulatory Quality led to a decrease in gender inequalities in these countries in line with (Bell et al. 2020).

According to Hakura et al (2016), GDP per capita and Official Development Assistance (ODA) when targeted at women's programmes are also expected to have a positive impact on gender inequality as they can lead to more opportunities for women to be productive. In this study, GDP per capita (GDPpc) had a negative relationship with gender inequality and an increase in GDP per capita resulted in a decrease in gender inequality. However, Official Development Assistance (ODA) had a positive association with Gender Inequality. Implying that increases in ODA worsened gender inequalities and that the ODA rolled out in these countries was not necessarily prioritising or targeting gender development.

Trade openness and FDI can have a positive impact on gender inequality since trade liberalisation could improve the employment opportunities and wages for women and lead to the reduction of gender gaps in the labor market for instance if FDI flows into sectors where few women are employed including the energy sector (Arora, 2012; Enersto, 2011). Contrary to this, the results showed that increases in trade openness worsened gender inequalities meaning that trade liberalisation and employment opportunities in these countries may not be targeting gender development. Moreover, Foreign Direct Investment was insignificant implying that Global corporations do not encourage the use of renewable energy and the transfer of green technology through FDI inflows into these developing nations (Elheddad et al. 2022; Nawaz and Rahman, 2023).

Conclusion

The results revealed that an increase renewable energy consumption worsened gender inequalities in the selected Southern African countries. This scenario where the transition to renewable energy consumption worsens existing gender inequalities shows that these countries are not on-track in terms of ensuring a just transition to renewables. Therefore, policy makers need to put more effort in ensuring the gender perspective in the adoption of renewable energy

before it is too late. Also, national gender mainstreaming strategies in the renewables sector should be improved through provision of more funding for training implementation, monitoring and data collection for gender mainstreaming into energy policies to ensure that gender mainstreaming is transformative.

According to Husnain et al, (2021) Access to Electricity has been used in literature as a good proxy for energy poverty for developing countries. Past studies including (Jacobsen, 2011, Nguyen and Su, 2021), recommended that developing countries should focus on reducing energy poverty first which is also implied by the results of this study because increased access to electricity reduced gender inequalities. Since rural electrification is a priority in Southern Africa, policy makers in these developing nations still have a window of opportunity to reduce gender inequality through genderising the access to electricity while ensuring that the electricity is from clean energy sources especially for rural women.

Across literature the recurring conclusion was that the just transition to renewables which leaves no one behind requires quality regulation to ensure that the vulnerable groups also gain access (Fajardo, 2020, Pearl-Martinez, 2020, Arias et al, 2023). African nations are aware of their weak institutions and regulation quality. Also, the results of this study showed that increase in Regulatory Quality reduces Gender Inequalities in the nations under study. These results concur with Adams et al. (2016) who also concluded that Energy policy is enhanced by robust democratic governance in Africa.

In light of these findings, policy makers need to ensure the improvement of regulatory quality and institutions especially those dealing with gender issues so that they reduce gender inequalities especially in the renewable energy sector which was found to be gender blind. Creation of a supportive institutional and regulatory environment for the growth of women's sustainable livelihoods in renewable energy and also for renewable energy resources in general are significant enablers for the much-needed investment into the renewables sector.

Appendix

List of Countries

Angola
Botswana
Eswatini
Mozambique
Namibia
South Africa
Zambia
Zimbabwe

Table 4: Normality and Hausman Tests

Test	Test Statistic	P-Value

JB Test for Normality	2.064	0.3564
Hausman	14.84	0.0380

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