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Review Article

Energy Transition Agenda in Tanzania Within the Auspice of Sub-Saharan Africa: A Review of the Power Sector

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Abstract

The energy transition is on the high agenda in the global space to allow the international communities to meet the global objectives of lowering anthropogenic emissions that cause global warming. The international community is guided by the scientific evidence of increasing climate change impacts and is working under the auspice of the Paris Agreement, which aims to limit GHG emissions. As one of the significant contributors to GHG emissions, energy will play a critical role by shifting from dependence on fossil-based sources to renewables and using technologies to decarbonize the sources. Energy transition in the power sector is primarily associated with shifting towards directing investments in renewable energy. Sub-Saharan Africa (SSA) is still a niche market in the power sector with substantial suppressed demand, and where only about half of its population still does not have access to electricity. The region also strives to power its economic activities to support economic growth. The region is endowed with renewables and fossil fuels to support its economic transformation. Investment in renewable energy entails high capital costs, which makes it hard for the countries in the region with financial constraints to afford it. Renewables also have some limitations in supplying baseloads and are inherent to issues of dispatchability. Countries in SSA have been approaching the energy transition agenda with care to address local needs while supporting international climate change concerns. The energy transition agenda in countries like Tanzania considers multidimensional factors when investing in the power sector, primarily fostering universal access to electricity for its population, attaining security of supply, and accelerating industrial development. This paper reviews what the transition entails in the context of sources and technologies that will support the sustainable transition; it discusses renewable energy and energy efficiency. It also touches upon the role of fossil fuels in the energy transition agenda. The paper also reviews the policies and politics around the energy transition landscape, looking at the global context and its effects in the developing world, notably the sub-Saharan Africa region. The review concludes by analyzing different potential factors that contribute to decision-making on energy transition policies using the system thinking theory, looking at how various factors are interlinked.

Keywords

Energy Transition, Power Sector, Sustainability, Climate Change, Energy Financing, Sub-Saharan Africa, Tanzania

1. Introduction

Energy transition connotes the transformation of the current practices that depend primarily on finite and polluting energy sources towards cleaner energy sources, mainly renewables [1]. It is often argued that achieving a net-zero future does not

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necessarily mean completely phasing out the role of fossil fuels in the energy mix; reaching net zero in the near future is challenging due to the investments required to transform the dependence on fossil fuels into cleaner energy sources. Compared to 2022, the net zero scenario and other solutions require a substantial increase in solar and wind investment – eight times and five times for solar and wind installed capacity [2]. There are several arguments put forward by scholars on energy transition and climate change; the main drivers for global energy transition are mentioned to be "addressing climate change; meeting domestic energy demand; tackling energy access challenges; the realization that oil and gas resources across the region are not infinite and could be depleted within the next few decades; and the fall in oil prices. Some of these drivers are briefly discussed below as far as their impact on the future of fossil fuels in Africa [3]." This is in line with other technological support, such as energy efficiency measures and the cleaning of fossil technologies. Oftentimes, the cleaning of fossil technologies is not given much attention as it entails substantial investments. Technology such as carbon capture and storage would be ideal for embracing the use of fossil fuels that have thus far the most advantage in terms of having necessary attributes for energy for socio-economic flourishing. This brings another argument to the question of whether the urgency of energy transition does justice to the global south [1]. With reference to historical trends, the energy transition is not to be viewed as a one-time event but a long and protracted affair. It is also further argued that the speed and scale of energy transition do not matter but the timing for which it occurs [4]. However, some scholars argue that energy transition refers to energy transformation. While Africans argue that they should be allowed to undergo the pollution trajectory that will enable them to progress before embracing the transition to cleaner energy sources, [5] this contradicts the argument that climate change is global and must be tackled jointly. This is where the energy trilemma emerges: balancing energy security, affordability, and the whole concept of sustainability [6]. The argument that Africa should be central in embracing energy transition holds water as it is projected that in the next decades, the continent's energy needs will increase substantially and achieving universal access for all will need to triple by 2033 [7] due to rapid economic population growth. However, the concept of just transition also adds another dimension to the equation. The international community will need to find appropriate and just approaches to undergo energy transition such that they do not deny human basic needs and do not jeopardize the planet and future generations.

2. Methodology

The study employs systematic literature reviews on the energy transition and its link to climate change impacts and policies. The literature reviewed the global energy transition agenda, contextualizing it in the regional dynamics of sub-Saharan Africa. In-depth reviews of Tanzania's power sector have highlighted a just and rational transition pathway.

3. Energy and Sustainability

There are many ways of defining sustainability; in the energy sector, sustainability is centered on the three dimensions: economy, environment, and society. For energy services to uphold sustainability dimensions, they must be aligned with principles that do not jeopardize the existence and development of future generations. The energy intervention must be designed to be people-centered and planet-centered. Energy investments must be able to provide essential input for economic growth, looking at essential attributes of energy that include affordability, reliability, versatility, and scalability [8].

Energy should be available when needed to perform a function required at a certain time and should also be affordable and available when needed. Oftentimes, it has been argued that low-cost energy sources are essential for the energy service to accelerate socio-economic development [9]. On the other hand, energy sources should be able to support the concept of planet resilience in such a way that they do not harm planet Earth in terms of adverse climate impacts.

The concept of sustainability and energy is often viewed as aligned with phasing out the carbon-intensive sources, namely fossil fuels, and promoting more use of renewable energy sources. Little is being advocated for cleaning fossil fuels. The energy transition policies are less considerate of public opinion, which, if considered, will better shape the transformational changes required for a just transition [10], which might be the appropriate option for achieving the three sustainability attributes. Fossil fuels are undeniably essential for the economic growth of the African continent as they support many features related to the continent's flourishment [3]. It can be argued that the way the concept of sustainability is perceived jeopardizes the economic growth pathways for the SSA, thus making it hard to achieve financial independence and, therefore, remain under the economic slavery of the Western world. The energy transition agenda performs well if approached on a region-by-region basis since different regions will have differing priorities tied to resources and needs [11].

4. The State of Energy in the SSA and the Global Landscape

The use of unsustainable biomass dominates the final energy consumption in the SSA; this, in turn, affects the three dimensions of sustainability: economy, environment, and social. It is also projected that by 2050, Africa will remain the largest consumer of biomass energy, maintaining a share of 27 percent worldwide [6]. Energy is an engine for economic growth and essential for the social flourishing of the country. It is evident that strong economies have large per capita en-

ergy consumption. It can also be argued that the energy source capable of revolutionizing the economy is fossil fuels in nature. Heavy industries such as steel, cement, and mineral extraction depend primarily on fossil fuels due to the unique characteristics of high energy content, the most needed ingredient to industrial processes [12]. There has been a growing call for the world to shift from dependence on fossil fuels towards using cleaner energy sources, especially renewables.

Despite the persistence of the international campaign on this shift, little has been achieved today because the world has yet to find an alternative for energy options that fit with all the essential attributes. The International Energy Agency (IEA) and others report that renewable energy penetration in the global energy mix is only 17.7 percent [13]. Under the same auspices, globally, most energy investments are directed to funding fossil fuels. To add to the complexity, even renewable energy investment is largely directed to developed nations, leaving Africa with only a small share, about two percent, in global renewable energy investments [14]. This is primarily due to the fact that the international investment space has yet to factor in the *externality* costs of energy investments; as such, clean energy sources become unjustifiably expensive compared to fossil fuels.

There has been growing resistance to Africa concentrating on renewables and abandoning fossil fuel sources, arguing that Africa needs to pollute first, just like the West did before concentrating on clean energy investments. While this is fallacious, it holds some water as the continent lacks the necessary financing for such an energy transition due to inherent competing priorities of scarce financial resources to address the acute poverty situation. The statistics show that Africa utilizes only four percent of global oil and gas demand [7]. It can also be argued that the push for such a transition comes from the global north, whose readiness to support it is questionable. There is an unprecedented regional discrepancy in global renewable energy investment; between 2010 and 2020, sub-Saharan Africa had only 1.5 percent of the global share of such investment [6].

4.1. The Resources and Technologies

Understanding the energy resources available on the continent is essential, as it will inform the decision to make appropriate and sustainable investments. Africa is endowed with both fossil fuels and renewable energy sources. Both fossil fuel and renewable energy resources are yet to be fully extracted. There is also a potential for utilizing other technologies suitable for the supply of clean energy services.

4.1.1. Fossil Fuels

Fossil fuel resources available in Africa include oil, gas, and coal. Africa is home to 13 percent of the world's natural gas and seven percent of the oil resources [7]. Only a fraction of these resources, oil, natural gas, and coal, are being utilized. SSA has a relatively minor role in global fossil fuel production, with respective shares of four percent for coal, five percent for crude oil, and two percent for natural gas. A significant percentage of the resources is concentrated in a few countries, such as coal in South Africa [6].

More than 5,000 billion cubic meters (bcm) of natural gas resources have been discovered in Africa, but these have not yet been approved for development. These resources could provide an additional 90 bcm of gas a year by 2030, which may well be vital for the fertilizer, steel and cement industries, and water desalination [7]. Sub-Saharan Africa has undiscovered but technically recoverable energy resources estimated at 115.34 billion barrels of oil and 21.05 trillion cubic meters of gas [15]. Tanzania is estimated to have natural gas reserves close to 50 trillion cubic feet (Tcf); however, the contingent resources are at 29 trillion cubic feet (Tcf) [16]. Table 1 depicts the onshore and offshore natural gas resources in Tanzania.

Table 1. *Natural gas discoveries and developments in Tanzania, 1974–2016.*

Field	Discovery date	GIIP (Tcf)*	Proven (Tcf)
Songo Songo	1974	2.5	0.880
Mnazi Bay	1982	3–5	0.262
Mkuranga	2007	0.2	0.2
Kiliwani	2008	0.07	0.027
Mtwara-Ntorya	2012	0.178	–
Deep Sea	2010-14	35.10 (2013) 49.30 (2016)	–
Total		57.25 Tcf (assuming 5 Tcf Mnazi Bay)	Unknown

Note: *. GIIP = gas initially in place, not proven reserves; Tcf = trillion cubic feet.; – = not available

Source: Eberhard et al. (2018)

4.1.2. Renewables

Africa is endowed with the most renewable energy sources found in the SSA region, including solar, hydropower, wind, geothermal, and biomass. It holds 60 percent of the global solar energy potential [7]. The average irradiation in SSA is the highest in the global landscape. The region experiences high solar radiation intensity ranging from 4.0 to 7.0 kWh per square meter [17]. It is estimated that the continent has a potential of up to 10 TeraWatts (TW) of solar power; some argue that solar potential is unlimited and can power the entire world. Wind potential is estimated at 110 GW [15] but remains underdeveloped due to several challenges, including political and financial [18]. The geothermal potential is about 15 GW, which can only be found in the Rift Valley areas. Hydropower, the most mature technology in the region, has mainly been the single most dependent on source and has the potential of 350 GW [15]. This is primarily a theoretical potential that is subject to dispute because it might not be economical or include restricted areas, such as those nurturing wild and protected aquatic life. The use of biomass to generate energy is also one of the options that can be found in the region; biomass contributes half of Africa's total primary energy supply [15].

Other potential renewable energy sources, such as tidal waves, are occurring relatively on small scales, and the technology is yet to demonstrate maturity in the region.

4.1.3. Other Technologies

The continent also has other potential technological sources to drive energy transition, such as the use of nuclear energy. With the typical unit capacity of a 1,000 MW power plant, this technology can address the energy challenge Africa is facing today [19]. While this technology could serve a greater deal in addressing the acute shortage of power on the continent, it is faced with issues that will need to be addressed: high investment, long lead-time, power network infrastructure to accommodate large capacity and political acceptability [20]. Nuclear power plant takes a long time to be realized, as much as ten years of construction; the region is also faced with a weak regulatory framework that is not suited for accommodating nuclear power development; the infrastructure to accommodate such sizeable power sizes is not readily available in most of the countries, the power infrastructure is either dilapidated or not capable of accommodating large capacities; another aspect is the lack of maintenance culture in the region, which contradicts with the strict requirements for operating nuclear power infrastructure; safety is one of the significant issues of concern as the continent is yet to be perceived to be able to uphold all the safety feature required by the nuclear technology [19].

4.2. Investment and Cost Implications

4.2.1. Transition in Energy Applications

Energy application is the most crucial factor affecting the transformational change in the energy transition agenda. The world is undergoing a transformational shift in various domains that relate to the application of energy in such areas as heating, cooling, cooking, industrial processes, and transportation; in some cases, these are dependent on geographic locations; for instance, heating is prevalent in the global north while cooking in the global south.

Economic growth and increased civilization affect energy use, which translates to an increased or decreased per capita energy consumption; it also relates to what energy is mainly used. In sub-Saharan Africa, the total primary energy consumption is dominated by unsustainable biomass, especially for cooking. East African countries have high levels of dependence on traditional biomass, well above the African average of 67 percent: Uganda at 97 percent, Tanzania at 96, and Kenya at 84 percent, which is the lowest level [21]. This contributes to deforestation, which causes increased global warming and affects climate change. In Tanzania, the deforestation rate is estimated to be about 469,420 hectares per year, primarily caused by the massive use of charcoal [22]. According to Global Forest Watch, Kenya experienced a net change of -285 kilo-hector (-6 percent) in tree cover in the period of 2000 to 2020; further, the country lost 357 kilo-hectors of tree cover, equivalent to 11 percent of the tree cover since 2000. This amounted to 184 megatons of GHG emissions [23]. Other countries in the region and globally have experienced substantial loss of forest cover [24].

Industrial processes, primarily in high energy intensity activities such as cement and steel, contribute substantially to countries' pollution stock. Tanzania's per capita cement consumption is estimated at only 2370 kg over the period of 1970-2018. This is relatively small compared to the developed world. It is, however, argued that developing countries like Tanzania are experiencing rapid population and economic growth that demands extensive use of energy for a better quality of life through increasing demand for housing and infrastructure, which leads to increased demand for cement production [25]. Fuel switching in the cement industry has significantly changed the course; most of the cement industries in Tanzania are connected to natural gas. Conversely, Kenya has a better chance of using process heat from renewable sources, such as geothermal [26]. Kenya is the only country in the East African region that has developed geothermal energy; Tanzania is still in the exploration phase.

Transportation is also one of the major contributors to GHG emissions. In 2021, Tanzania registered a total of 3,228,612 vehicles in all categories [27], primarily running on fossil fuels: gasoline and diesel, accounting for 49.93% of its total GHG emissions [28]. It is anticipated that the increased cost

of energy in the global market will trigger policy changes toward switching to clean fuels and technologies for transportation. Tanzania has a policy of changing the rapid transit bus fleet in Dar es salaam to use the natural gas product: Compressed Natural Gas (CNG). It is also promoting the use of CNG for other vehicles; in this effort, 3,000 vehicles have been fitted with CNG technology; in line with this, there are five CNG Filling Stations established (3- in Dar es Salaam, 1- Mkuranga and 1- Mtwara), and the ten more are planned to be established in Dar es salaam in the next 12 months [29]. There is an increasing sentiment of electric vehicles in the East African region. Kenya and Rwanda are ahead, whereby Rwanda has introduced electric buses and electric motorbikes in the capital city of Kigali. Kenya has also introduced electric vehicles in buses and motorbikes. Tanzania is lagging in the electric vehicle space but ahead of others in using CNG.

There is another dimension that is energy intensive: the mining sector. This sector has proved to be challenging because it is characterized by the use of equipment that needs high energy intensity, which is missing in renewable energy technology. The sector's emissions come from three major streams: burning diesel, electricity generation, supply chain, and transport. These are attributed to mining activities that include mineral extraction and processing. This sector is projected to remain dependent on fossil fuels for decades until an appropriate option is found through increased technological innovations and development. Some of these measures include improving operational efficiencies, using sustainable fuels, going fully green (sustainable drivetrain), embracing green electricity, and deploying sustainable sourcing measures [30]. The agriculture and agro-processing industry is also one of the sectors that require energy sources with high energy intensity. However, the current situation is that cultivation is done in a subsistence fashion, primarily depending on human and animal energy. The situation is likely to change with increased needs for agricultural yields that will require modern machinery.

The East Africa region is one of the regions that have rapidly growing cities. Dar es salaam, for instance, with an estimated population of 5.38 million in 2022 [31], is projected to be one of the megacities [32] with a population of about 16 million by 2050 [33]. Nairobi, Kenya, Kigali, Rwanda, and Kampala, Uganda, are the densely populated cities. With increased population, the countries will see increased needs for energy services.

4.2.2. Power Sector Investment Landscape

Looking at the energy generation landscape, Africa is dependent, by three-quarters, on fossil fuels (oil, gas, and coal) to generate its electricity [7], mainly from burning natural gas [34]. Hydropower also has a notable share of the power sector; the projects are still on the high agenda for sub-Saharan Africa power sector investments. The largest hydropower stations in the SSA are built in Ethiopia and Tanzania. Ethiopia's Grand Ethiopian Renaissance Dam (GERD) is a USD 5 billion project with an installed capacity of 5.15 Gigawatts [35, 36]. Tanzania is investing in the largest hydropower station in East Africa, a USD 2.9 billion, 2,115 MW Julius Nyerere Hydropower Project (JNHPP) [37].

Trends to invest in renewables, especially solar energy, and a few wind power stations have shown positive trends, with many countries in the SSA developing enabling frameworks to attract such investments. The prepared framework of competitive tendering has resulted in reduced energy costs to utilities while increasing investment appetite in the renewable energy sector. Kenya has progressed well in investing in renewable energy sources, especially geothermal, wind, and some solar energy [38]. Tanzania also has positive trends in the renewable energy sector, with investment commitments to several solar and wind projects [39], with the first 50MW solar part underway [40].

Coal investment has proved challenging in South Africa, which remains the primary source of electricity generation by 96 percent [41]. Despite the commitment to decarbonize its electricity sector, the efforts are fading due to the new challenges that the country is facing with regard to meeting its growing needs, making it resort to burning more coal [42]. Natural gas investment in SSA is considered appropriate for addressing energy shortage and security issues.

The level of investment in power infrastructure and electricity coverage in SSA is lower compared to the global landscape. By 2022, the total installed capacity was 143 GW, which is comparable to France, which had 144 GW [6]. This makes it hard for the subcontinent to leapfrog in economic prosperity as access to this most critical energy carrier is marginalized. The sustainable future scenarios for power generation in the SSA will likely embrace the mix of various sources, considering available fossil fuels and renewable energy resources. Arguably, fossil fuels will be critical in supporting economic growth and poverty alleviation in the SSA region [43]. By 2030, solar and wind will likely need to provide 27 percent of power generation, with electricity demand increasing by 75 percent [34]. The percentage is projected to be much higher by 2050 when the two renewable energy sources are projected to make up to 70 percent of the electricity mix [6].

4.2.3. Challenges to Alternative Energy Sources

Despite the vast renewable resources in SSA, the region has seen little progress in realizing such investments. The major challenge the sub-continent faces is low access to electricity; in the global landscape, about one million people lack access to electricity, most of them – 600,000 being in sub-Saharan Africa. The continent is faced with a low per capita electricity consumption, which in turn affects economic growth. This means that any move towards alternative sources should be able to address basic electricity access alongside supporting economic growth.it is argued that Africa needs energy sources that are reliable, versatile, and of low cost in nature. These attributes are mainly found in fossil fuels, notably natural gas. Renewable

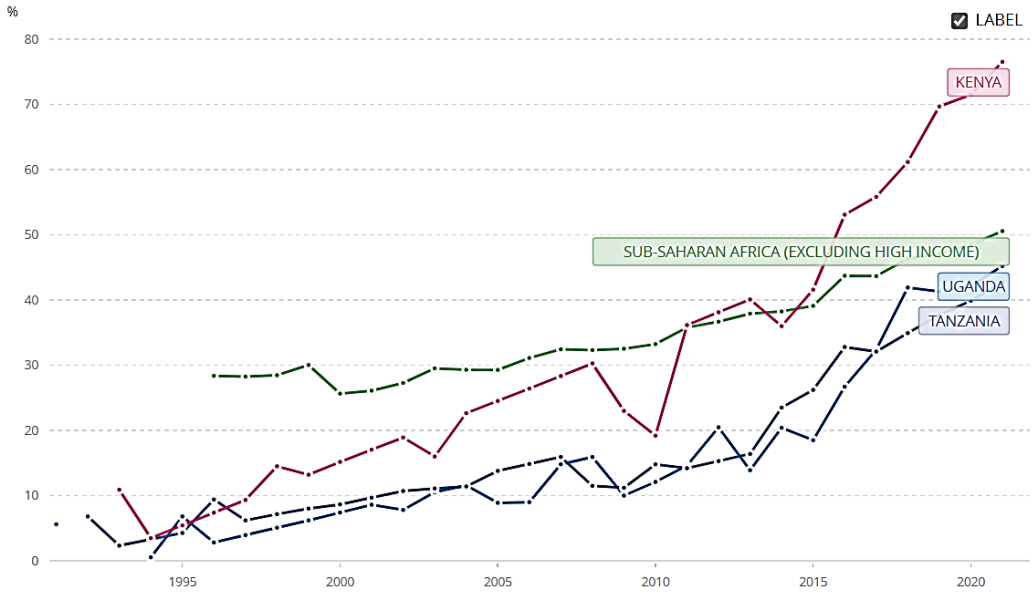
energy sources such as solar and wind lack the necessary characteristics of adequacy, flexibility, and reliability [2]. However, there is a counterargument that fossil fuels are finite and subject to price volatility [44] and thus cannot be counted as sustainable in terms of providing long-term solutions for energy-suppressed demand in SSA. Alternative sources will also require substantial financing, which is largely missing in the continent due to the economic stretch faced with competing priorities to address basic needs and the need to create the necessary infrastructure to support economic growth.

4.2.4. The Cost of Energy Transition and SSA Perspectives

The costs inherent to energy transition are unprecedented, both in monetary terms and social aspects. The social aspects are mainly focused on the effects of shifting from the use of fossil fuels to clean energy options; this is mainly related to the loss of jobs necessary for the majority of the marginal population to live. In monetary terms, that means countries should resort to investing more in clean energy in place of fossil fuel sources. In the power sector, for instance, investing in renewable energy entails high investment costs compared to the fossil counterparts; the discrete capital cost of investing in natural gas is about USD 917/kW (90% capacity factor) compared to offshore wind, USD 6,230/kW (35% capacity factor) and Solar PV USD 3,873/kW (20% capacity factor). Take into account the capacity factor and equate the same amount of energy generated. The cost will be even more astonishing: natural gas, USD 1,019/kW; offshore wind, USD 17,800; and solar PV, USD 19,365 [45]. These numbers demonstrate that it takes a substantial investment to achieve sector decarbonization. McKinsey & Company analysis estimates the "Capital spending on physical assets for energy and land-use systems in the net-zero transition between 2021 and 2050 would amount to about $275 trillion, or $9.2 trillion per year on average, an annual increase of as much as $3.5 trillion from today [46]," this is substantial spending which is about nine percent of the global GDP which stands at USD 101.23 trillion [47]. This investment is primarily triggered by the substantial requirements for a transformational change in the electricity sector to be able to meet the demand in a reliable manner. The IEA argues that electricity will need to reach net zero by 2040, where it will be required to supply half of the energy required; in this case, reliability of supply will be critical, and the use of storage systems, hydrogen fuels, hydropower, and demand response will be essential [48].

The cost of energy transition in Sub-Saharan Africa is not well established as the continent is still struggling to achieve universal energy access for all. The continent still struggles to invest even in fossil-based sources such as natural gas due to the lack of financing. The World Bank estimates that SSA requires an estimated investment of USD 20 billion to be able to achieve SDG 7 [49]. Although this seems low, equivalent to about one percent of its GDP, which stands at USD 2.06 trillion [50], it still presents a notable challenge, looking at other issues for which SSA is struggling to achieve in the courses of socio-economic development. In this case, the discussion for Africa differs from that of the developed world, where sector decarbonization is the least priority.

Looking at the East Africa region, countries will need to strengthen their policies and strategies to be able to go at par with international goals of achieving SDG7 by 2030 and the next-zero economy by 2050. Figure 1 depicts the trend of the three selected East African countries, namely Tanzania, Kenya and Uganda, looking at energy access space compared to the rest of the sub-Saharan region [13].



Source: World Bank. Data compiled from Tracking SDG 7: The Energy Progress Report 2023.

Figure 1. *Electricity Access Trends for Selected East African Countries, 1991-2021.*

5. Financing Energy Transition in SSA

5.1. Financing Power Generation

Energy transition in the power sector would require cleaning the existing fossil-based systems and investing in renewable energy technologies. It is often argued that the cost of capital for renewable energy is diminishing compared to fossil fuels. However, this is only true if the cost of externalities is considered, which is not a selling point for the African continent, which usually argues that it is in need of reliable and versatile energy sources. Further, it is claimed that despite enormous potential in the SSA region, natural gas makes up only five percent of its energy mix, compared to 20-25 percent of the global average [51]. Although economic analysis comparing renewable technologies' levelized cost of electricity (LCOE) shows that they can compete with conventional technologies [52], this is deceiving as these variable sources miss the critical attributes of energy sources: reliability and dispatchability. It is argued that low-cost energy is essential for economic growth [8], and this is a central argument for the SSA countries to invest in such sources as natural gas, which are said to help the continent progress economically [53].

5.2. Financing Power Infrastructure

SSA has substantially suppressed demand to be able to supply electricity to all of its population; currently, 43 percent of its people do not have access to electricity. Even those with access to electricity face substantial reliability challenges due to dilapidated infrastructure. Power rationing is a norm; this includes South Africa, which is typically excluded. It is common to find that a country has surplus installed capacity compared to internal demand, but the power is not available. For instance, Tanzania has an installed capacity of around 1.9GW and a peak demand of 1,432 MW (on May 15, 2023) [29]; from the figures, the power should be sufficient with a surplus. However, there has been consistent power rationing for the several months of the last quarter of 2023 and the first quarter of 2024. This is argued to be caused by several factors, including the aging of power plants, which causes reduced firm capacity and draught, hampering hydropower resources [54]. In this case, as depicted in the former subsections, financing is said to be a critical factor in addressing these challenges. Concurrently, financing new and advanced technical solutions for renewable energy investments would be challenging before addressing the existing power infrastructure problems.

Energy transition, primarily focused on increased penetration of renewable variable sources, notably wind and solar, would require necessary investment in the transmission and distribution infrastructure that can take up those variable sources without jeopardizing the reliability and quality of the power supply. This will mean digitizing the power infrastructure, among other things.

5.3. Financing Corporate and End-User Transition

Transition in the power sector will need to go together with changing the demand landscape in order to have sufficient power supply and potentially avoid sudden peak power that costs the utilities. Heavy power-consuming industries such as still and cement will need to transform their processes to become efficient by retrofitting their equipment or participating in the transition by investing in clean energy solutions. Financing these corporates will be key. However, the value proposition for them to participate in clean energy generation and use is not yet clear as they are focused on profitability, which is subject to market volatility [55].

The end user is a crucial stakeholder group that must be involved in the energy transition agenda. This is also falling under the demand-side management category. End-user efficiency is essential in low-cost investment in the energy sector. It will take capacity-building efforts and a supply of efficient equipment to achieve this objective. Countries will need to set aside financing for this. However, this is not entirely a priority for SSA due to regional financial constraints.

European Investment Bank (EIB) argues that unlike in European countries where energy efficiency is primarily looking at retrofitting the buildings and similar infrastructure, SSA takes a different approach, focusing on the promotion of greenfield, energy-efficient infrastructure, industrial processes, and equipment, as well as consumer products and appliances [56].

5.4. General Issues in Financing Energy Transition in SSA

The availability of affordable financing will be key in attaining energy transition objectives. Renewable energy and fossil fuels do compete in the weighted average cost of capital (WACC), which has sustainable impacts on energy costs. GDP is also an important indicator of affordability in the energy transition agenda. Africa is characterized by high WACC and low GDP per capita, which affect the affordability of the energy transition pathway. WACC is essential in investment since it is a measure to express the average financing cost of a project. Due to perceived risks, renewable energies are more sensitive to financing variables than fossil fuel investment. In this case, it will be necessary for the continent to have access to financing de-risking mechanisms [57]. It is then paramount for Africa to be supported financially in both the public and private domain to be able to undergo a just and manageable energy transition [58]. Investment capital for a just transition can be mobilized from diverse sources, including Governments, Development Financing Institutions (DFIs), Multilateral Development Banks (MDBs), impact

investors, corporations, and philanthropic foundations [59].

6. Human Rights and Energy Transition

The energy transition agenda is often argued to have a human rights element. It also connotes the issue of energy justice: "achieving equity in both the social and economic participation in the energy system while also remediating social, economic, and health burdens on marginalized communities [60]." This is impacting both negatively and positively. Human rights principles require that people's dignity be restored, including the right to live in a better environment and access to jobs. The agenda is conflicting; on the other hand, energy transition benefits society by giving them access to a better working environment and living conditions, free from pollution; it is also jeopardizing them by threatening their jobs related to fossil-based sources. Globally, most of the energy-related workforce is employed in the fossil fuel industry and its related value chain. In 2017, the Fossil fuels industry supported about 30 million jobs, while renewables supported about 10.7 million [61]. Recent data show that there has been a slight increase in the number of jobs created by the renewable energy industry. In 2019, around 65 million people worked in energy and energy-related sectors; renewable energy employment totaled an estimated 12.7 million in 2022 [62]. However, most of these jobs in renewable energy are found in the developed world; of the 12.7 million jobs, southern Africa recorded only 48,000 jobs. Energy transitioning is expected to result in substantial job loss. It is estimated that the coal sector alone is projected to lose around 2 million jobs, mostly in Asia, while the oil and gas industries may see a further 600,000 jobs lost by 2030 [62].

One might see that there is a gap between the jobs that are anticipated to be generated by renewable energy versus those that are employed in the sectors dependent on fossil fuels. There is also an argument that fossil fuels cannot compensate for jobs lost from the use of fossil fuels; this is primarily because the nature of jobs and the skill sets required are different. While transitioning to renewables can result in increased jobs in the energy sector, the nature of the jobs requires specialized skills, resulting in narrow job opportunities. In this case, those who will lose their jobs from abandoning fossil fuels will likely become jobless.

Conversely, there are counterarguments that continuation of the use of fossil fuels has many negative impacts on the life of the population, ranging from health impacts, in some cases, forcing them to relocate from their Indigenous villages and forego their fertile lands necessary for their living, thus causing hunger and hardship. This kind of argument is seen in the ongoing construction of an East African crude oil pipe running 1,443 km from the coast of Tanzania to Uganda [3]. A similar argument can be put forward on renewables, especially utility-scale renewables, which also require large pieces of land to generate just a megawatt of power. It is then argued that it is likely that utility-scale renewable projects will face reputational and litigation risks [63]. Further, on the contrary, the benefits of shifting to clean energy may lead to sustainable economies should the right policies be employed [64]. Affective sustainable energy policies are said to support delivering adequate and affordable energy supplies, encouraging energy efficiency, Accelerating the use of new renewables, and widening the diffusion and use of other advanced energy technologies [64].

The issue of energy transition and human rights is a double sword, and the pros and cons have to be addressed well; however, in any case, it remains a substantial challenge that attracts political interventions so that to make fair and just energy transition decisions without infringing human rights and civil liberties.

7. The Role of the Public and Private Sector in Energy Transition

7.1. Private and Public Sector Engagement in Energy Transition

Transition to investing in clean power generation will require both public and private sector involvement. With countries that are usually running on debts as high as 80 percent of the global GDP, the private sector will have a more significant role to play in investing in energy transition [65]. Governments will be required to create conducive environments to attract private-sector investments in the energy sector. Private sectors, being primarily tied to profitability and security of their investments, will look at country policies, political stability, and regulations. McKinsey's study estimates that, in 2016, the global private sector investment was USD 120 trillion. However, only one percent went to sustainable infrastructure such as clean energy technologies [66].

7.2. Enabling Frameworks Landscape

SSA is lagging behind other regions in terms of energy investments and progression due to inherent frameworks that exist or are lacking. The policies are poorly structured to absorb the need for economic growth and address international sustainability concerns. Most SSA policies find themselves to be retroactive following the global climate policies, which do not necessarily support sustainable investments in the energy sector. In the early 2000s, the promotion of biofuels was booming following Brazil's success stories. Most countries were caught in situations that forced them to think of investing in the biofuel sector without much knowledge of the dynamics of the sources and technologies; this way, countries found themselves in a food-energy dilemma. During this time, governments tried to come up with such policies as biofuel policies, which were primarily financed by the investors – the situation that can be argued that policies have investors' interests that do not necessarily reflect the country's situation.

Three issues are identified to be necessary for accelerating Africa's energy transition: policy support, financing support, and technology and innovation [34]. Policies need to be developed and aligned to support clean energy investments, and funds need to be made available to support the investment in new technologies and resources. The region also needs to embrace targeted research, innovation, and development.

Policies and Regulations guiding the energy sector, particularly electricity, have not been consistent, thus creating a state of uncertainty for investors. To a large extent, the regulations that have been developed are not well operationalized, therefore lacking the necessary integrity to attract foreign investments. Most African countries are embedding the electricity sub-sector with the countries' internal politics.

Financing is the singlemost important factor that affects progression in the energy sector in the SSA. Most of the power infrastructure in the region is dilapidated due to less attention being paid to maintenance and technology upgrading [43]. Access to foreign investment is also challenging due to the competing policies of international financing institutions and the African governments. For instance, Africa prioritizes investing in natural gas, while the World Bank's policy is not to finance fossil fuels infrastructure [67]. This makes it difficult for the countries to realize their strategic energy investments.

7.3. The Governance Structures: Systems, Tools, and The Politics

The energy sector in Africa is faced with substantial governance issues. Most power utilities are state-owned and have vertically integrated structures such that one parastatal organization is responsible for the entire power supply chain: generation, transmission, and distribution. This makes them overwhelmed and thus inefficient. For instance, Tanzania's power utility, the Tanzania Electric Supply Company (TANESCO), faces challenges across all three power system parameters: Generation, Transmission, and Distribution. The generation, which is mainly dependent on hydropower, is usually faced with challenges of power shortage due to the increased draught and competing uses of water for other purposes [54]. The transmission system, designed during colonial times, does not meet the current needs; only recently, the government embarked on an investment of 400kV power lines, which are currently undergoing implementation, while most of it is 132kV and 66kV. This is far below the industrialized world's power systems, such as China, which is transmitting 1,000kV levels. The distribution system is dilapidated with frequent power outages when subjected to little shocks due to weather conditions such as rain. The power utility has been adding customers with little attention to upgrading its infrastructure, such as transformer sizes.

This scenario reflects most of the power systems in the sub-Saharan Africa region. The power systems are also affected by politics and political instability. Grid extension does not necessarily reflect the economic and financial benefits of the utility and the country but rather is geared towards gaining political mileage for some politicians. The political economy discourse on energy access interventions and politics are inseparable parameters [68]. Political instability in most countries within the SSA region makes investing in such energy infrastructure difficult due to struggling economies or insecurity. For instance, with one of the lowest electricity coverages and per capita consumption, Chad barely has electricity coverage across the country. It depends on one 150 MW diesel-powered plant that supplies the capita N'Djamena and its neighborhood, leaving the rest of the country with no grid network [69].

The power systems in SSA find it challenging to integrate with variable renewable energy sources such as solar and wind due to the grid weakness that cannot absorb regular power intermittency. To embrace energy transition in these countries means investing in the systems, such as embracing digitalization and tools to transform the governance structures.

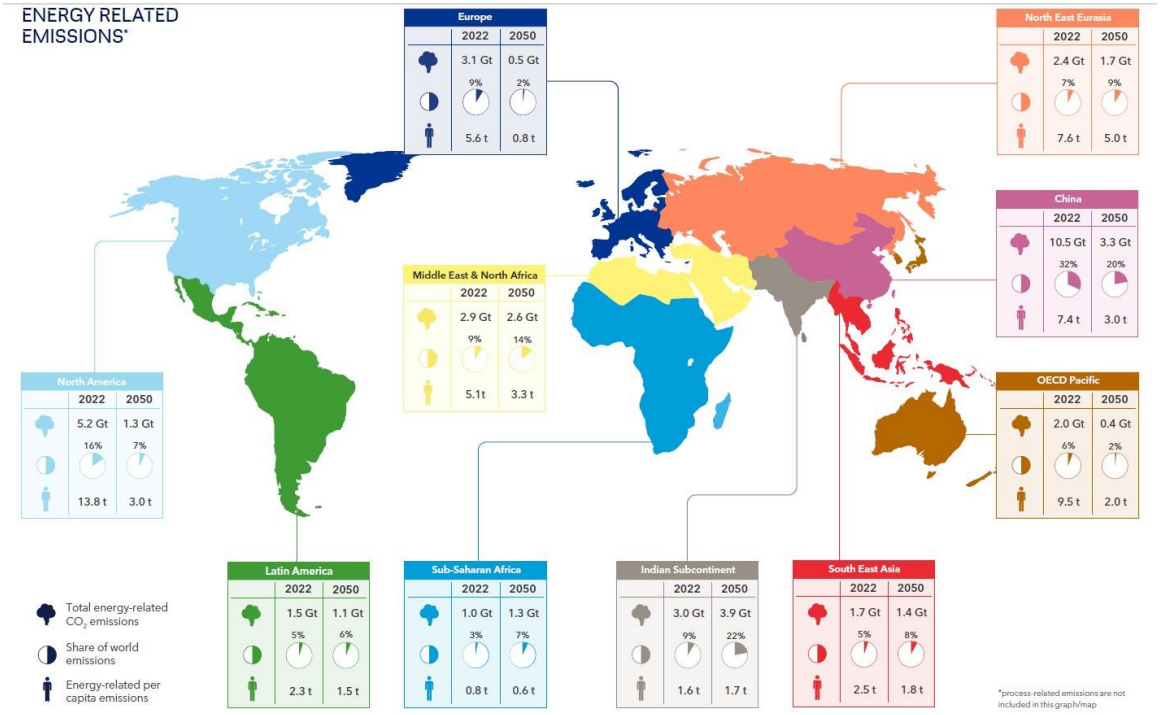
8. Energy-Socioeconomic Growth Nexus

There is a strong linkage between energy and socio-economic prosperity. As seen previously, the countries that are well in the economy are also the largest per capita energy consumers. These are also heavy in consuming modern energy such as electricity; to the contrary, the global south is heavy in unsustainable biomass as the main primary energy source [70]. Achieving the Sustainable Development Goals (SDGs) will depend on the shift to utilizing more modern energy sources and technologies. Achieving the United Nations' articulated SDGs can mean contradicting international climate policies, such as achieving the Paris Climate goal of limiting pollution to 1.5 to 2 degrees Celsius above pre-industrial levels [71]. There is a strong argument that the African continent should be waived when it comes to putting more emphasis on Paris goals instead of achieving SDGs, especially SDG number seven, which calls for achieving universal energy access for all by 2030. SDG7 has been a center point for achieving climate goals; thus, mechanisms to track its progress have been put in place [13].

8.1. Examining the One-Fits-All Approach

It is argued that the energy transition narrative mainly favors the Western world and disfavors the global south. The narrative that climate change is global and thus is to be tackled by all has raised some contradictions. This kind of one-fits-all approach proved to fail at the time of the Kyoto Protocol when it was evident that countries had varied priorities, and thus, the approach needed to consider the global perspective but with a local approach [72]. The new approach that was articulated during the fifteenth International Conference of Parties on Climate Change (COP15) in Paris, France, that resulted in the

Paris Agreement tried to address this discrepancy and came up with the so-called Nationally Determined Contributions (NDCs) that are meant for each country to articulate their priorities in line with the transition towards cleaner and sustainable future. However, it is also possible to argue that this approach is yet to receive the necessary international support to address local needs; for instance, Africa would need to invest in natural gas to help the continent progress economically, while there is a potential to invest in clean fossil fuels, the continent itself is not positioned to make the necessary investments and to add to the complexity, the West is making it hard to access such finances. For instance, the European Investment Bank (EIB) has decided not to fund gas projects despite a persistent call by the African nations [73]; the same token applies to the World Bank, which instituted a policy not to finance fossil fuels-based projects since 2019 [67]. It is further claimed that stopping financing fossil-fuel-based projects in Africa is not the sustainable climate solution due to several indicators, including the fact that the continent is far less emitter of GHG emissions in the global space, far less marginalized in the access to modern energy and as such this results to significant development loss with a fraction of climate gains. [74] In the global landscape, sub-Saharan Africa contributed only 3 percent of the global GHG emissions, which is projected to increase slightly to 7 percent by 2050. The region has the least energy-related per capita emissions, estimated at 0.8 tons of carbon emissions-equivalent [75]. The global GHG emissions outlook is shown in Figure 2.



Source: DNV 2024

Figure 2. *Global Energy-Related Emissions Landscape.*

The ideal approach to curbing GHG emissions would be to act locally and think globally with a notion of shared responsibility. The future pathways for African countries' clean energy are centered on getting the necessary financing to enhance their power infrastructure to accommodate varied sources. Developing necessary systems that support such investments will also be paramount. The Wärtsilä Energy Report (2022) argues, "Despite the diversity of the African countries, the ingredients of the energy transition are similar for every nation. Renewable energy, supported by flexible balancing capacity, is the most effective way to replace coal and diesel generation, reduce energy costs, increase energy access, and improve reliability while laying the foundations for net zero energy systems [76]."

8.2. Systems Thinking and in Context of Sustainable Energy Transition in Sub-Saharan Africa

Energy transition needs to be approached by looking at these three factors: the transition does not harm the environment, embraces social equity, and supports economic growth. Balancing the three is always a challenge, as some policies are viewed to be aligned on one or two aspects and leave others aside. For instance, international policies on climate change are primarily based on environmental protection and are less considerate of the developing world's economic growth. Ar-

guably, With the current level of human civilization and the pace of economic development, the world will need an energy supply source with the necessary cost-effective attributes: low-cost energy, abundance, versatility, and reliability [8]. The future of energy investment pathways needs to consider these attributes alongside protecting the environment.

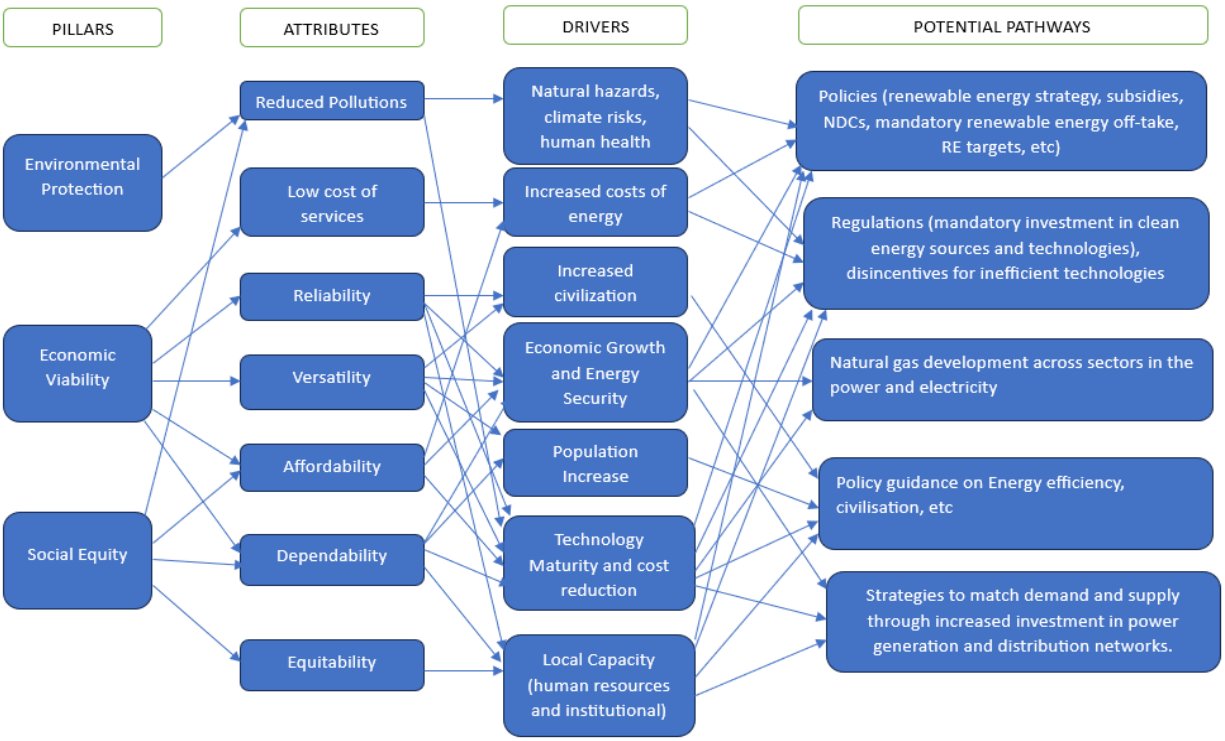
Oftentimes, energy investments do not consider the social aspect: social equity. This entails how the investment in energy affects the social lives of the target population, affecting such issues as employment, recreational activities, and health.

The research will examine factors that contribute to a rational decision-making process in choosing the policy direction that Tanzania may adopt to invest in power systems to foster economic development, considering social and environmental well-being. Sustainability pillars will be examined together with potential attributes and drivers for the energy transition agenda to determine the possible pathway for sustainable energy investment in Tanzania.

The underlying theory in the research is a system thinking theory used to analyze factors contributing to devising appropriate policies for a sustainable energy transition looking at the power sector. System thinking has been used to understand technical, social, economic, environmental, and institutional factors linked to the sustainable energy transition agenda. By understanding the connections among variables, it might be easy to deduce the plausible policy direction in the form of multicriteria analysis in a systemic manner. This way, it is easy to deal with the organization of logic and integration of disciplines to understand patterns and relations of complex issues [77].

Energy transition in practice consists of several discrete transitions that span industries such as power generation, transportation, and agriculture. Young et al. (2024) argue that these various pathways to a net zero economy are often tightly connected, with overlapping value chains, technology innovations, adoption rates, and feedback effects [78]. Rational energy policies often consider sound technologies, yet the reality in the world is a lot more than technological soundness. In this case, policies may be confronted by social and institutional forces; furthermore, it is essential to consider and undertake a multidisciplinary analysis while devising the appropriate pathways for energy transition [79].

Figure 3 depicts the way in which the sustainable energy transition pathways can be determined, looking at the systems thinking approach - how different factors co-relate and contribute to shaping the policy direction of a sustainable energy transition agenda. These are grouped into pillars, drivers, and attributes contributing to the potential energy transition pathway.



Source: Author's Analysis

Figure 3. *Sustainable Energy Transition Pathway Mapping.*

8.3. Power Sector Transformation and Transition in Tanzania

8.3.1. Power Sector and Climate Impacts in Tanzania

In 2021, the share of the power sector in the total GHG emissions in Tanzania was about 17 percent. Most of this (about 97.4 percent) comes from natural gas [80], which accounts for 62 percent of the total installed capacity [81]. The share of oil in power generation has been reduced drastically, contributing only 2.6 percent of the country's emissions from power generation [80]. Recently, the power mix has changed substantially due to the progressive commissioning of the Julius Nyerere Hydropower Project (JNHPP); by March 2024, natural gas contributed 56 percent of the power generation, followed by hydropower, contributing 39 percent of the grid capacity [82]. The power generation mix is projected to drastically shift in 2024 when the JNHPP is fully commissioned, contributing an additional 2,115 MW. This will give hydropower more contribution to the electricity mix, followed by natural gas. Most electricity is still used in industry (21.5%) and commercial and public services (31.1%). Residential use accounts for 44.4% [83]. With the switch to the natural gas trajectory in electricity generation and industrial processes, the power sector will achieve notable decarbonization and contribute substantially to achieving the country's NDC commitments.

8.3.2. Power Generation: The Future Outlook

The future outlook for Tanzania's power sector investment landscape is featured by a mix of technologies and sources: Renewable energy, natural gas, and potential technology support. Tanzania is committed to achieving 5,000MW installed capacity by 2025, of which 20% will come from renewable sources [29]. Tanzania has notable potential for renewable energy sources, primarily solar, wind, geothermal, and biomass. Currently, Tanzania is planning to develop its renewable energy sources into diverse energy sources as a means to address the issue of energy security and meet its global obligations to support the fight against increased climate change impacts. Solar and wind power is gaining traction. The first 50MW solar project has attained financial close and is under implementation [40]. Some strategic projects in the pipeline include geothermal, which is yet to be exploited.

The policy direction of Tanzania is to embark on projects that are strategic to the country's economy; these include hydropower projects. Tanzania is embarking on developing its hydro resources within and cross-border in collaboration with neighboring countries. The JNPP, a 2,115GW project, is expected to fully come online in 2024. There are other hydropower projects which are under implementation [84-88].

Gas to power is one of the strategic interventions to unlock the country's economic growth potential. When its exploitation started, the gas was used entirely for power generation, starting with the Gas-to-Power project, which oversaw the installation of a couple of megawatts of electricity in the country [89]. The gas-to-power initiative proved successful through the Private-Public Partnership that resulted in TANESCO off-taking power at 0.06 cents per kWh, making it a low-cost and reliable source of electricity [90]. It is argued that natural gas will support the country's progress toward economic prosperity while addressing the global concern of increasing GHG emissions from the energy sector [91]. The natural gas discovery in Tanzania is estimated to be 57.54 Tcf: 10.41 Tcf onshore and 47.13 Tcf offshore. The exploitation is only about 72.53 billion cubic feet, a small fraction of the potential [29].

Tanzania aims to achieve 20.2 GW installed capacity by 2044; the sources that will dominate this and provide more than 87 percent are natural gas, coal, and hydropower. Solar, wind, and geothermal are projected to contribute around 13 percent of this [92]. This is depicted in Figure 4. The power master plan projects these generation capacity levels would satisfy the forecasted peak demand requirements and leave adequate reserve capacity and export potential. The government, through the power master plan, targets to reduce system losses to 12 percent by 2026 from the current 15.43 percent in 2022 [93]; it also aims at raising electricity per capita consumption levels to 490 kWh in 2025, about four times the current levels. The government also targets to achieve 75 percent electricity access by 2025 and 100 percent by 2030.

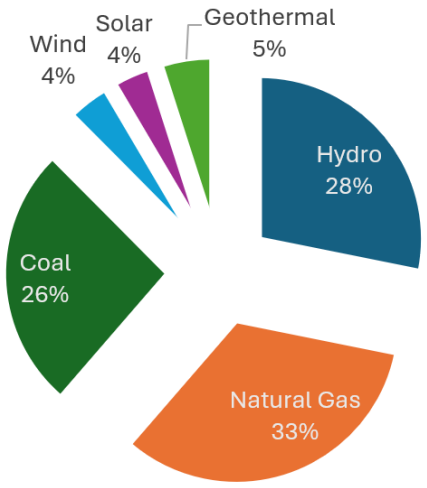


Figure 4. *Tanzania's Power Generation Mix Target by 2044.*

Source: Tanzania Power Systems Master Plan 2020-2044, 2020 Update

8.3.3. The Policy Landscape

Tanzania's energy policy has been strategically positioning the country to address the two common challenges inherent in the sector, namely achieving universal access to affordable, reliable, sustainable, and modern energy services and in-

creasing the supply of electricity for social and economic development while being mindful of climate impacts caused by fossil fuels [94]. Tanzania has taken some initiatives to support the energy transition that aligns with policy reforms. It works on renewable energy strategies that provide a strategic direction for exploiting and using renewable energy sources to support energy security and achieve global climate obligations to reduce GHG emissions. This strategy will shape the investment landscape in the power sector to include renewable energy and other potential opportunities in the energy transition agenda [95]. The energy efficiency strategy and implementation plan are also part of the country's efforts to undergo policy reform in line with sustainable energy transition. The policies must include economic growth and focus on the human-centered dimension: social justice. Furthermore, policy reforms need to continue consultations with key stakeholders, including the users of the power sector's electricity products.

9. Conclusions

The literature consulted is rich in information related to the energy sector in general, particularly on the power sector and how it is interlinked with the impacts of climate change. This information is particularly found in many books and reports from renowned sources such as the International Energy Agency (IEA) and the International Renewable Energy Association (IRENA). However, the information does not cover much of the specific issues of the sustainable power sector transition in the context of sub-Saharan Africa. It is possible to argue that sponsors of these sources have particular interests that are not necessarily suited for the transformational change supporting the sustainable pathways for the Global South. Similarly, the journals visited during the study lack a specific focus on the subject matter; above all, there is no specific study that articulates international aspects of the power sector investments and the ongoing global call to invest in the sources that are supporting the international agenda of fighting climate change impacts through reducing temperature rise.

Together with this, countries have been in the midst of striking a balance between economic growth and climate change issues. There are few scientifically-backed studies that provide clear theoretical frameworks on how to deal with the multidimensional issue of supporting the global south's economic growth with less climate change impacts.

It is also possible to argue that there is substantial progress made in the SSA in the area of energy transition that is not necessarily documented nor available in the public domain. Countries like Tanzania have embarked into investing in power systems that are geared towards providing affordable energy services, provide access to majority of the population and guarantee of supply. Fossil fuels have proved to be key in the energy transition agenda, where they are invested back-to-back with the renewable energy sources so that to leverage the shortcomings of renewable sources. The fact that emissions by SSA countries is so small provides them with the leeway to approach the energy transition agenda in a net zero Lense rather than zero emission trajectory.

Abbreviations

BCM	Billion Cubic Meters
COP	Conference of Parties
CNG	Compressed Natural Gas
DFIs	Development Financing Institutions
EIB	European Investment Bank
GDP	Gross Domestic Product
GERD	Grand Rennaisance Dam (Ethiopia)
GHG	Greenhouse Gas Emissions
IEA	International Energy Agency
IRENA	International Renewable Energy Network
JNHPP	Julius Nyerere Hydropower Project (Tanzania)
LCOE	Levelised Cost of Electricity
MDBs	Multilateral Development Banks
NDC	Nationally Determined Contributions
SDG	Sustainable Development Goals
SSA	Sub-Saharan Africa
TANESCO	Tanzania Electric Supply Company
TCF	Trillion Cubic Feet
WACC	Weighted Average Cost of Capital

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Conflicts of Interest

The author declares no conflict of interest.

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Biography

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