The role of off-grid energy systems for sustainable energy transition in Ethiopia

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The Role of Off-Grid Energy Systems for Sustainable Energy Transition in Ethiopia

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Abstract*— The lack of energy in rural areas of Ethiopia, the second-most populous country in Africa, impedes development, and economic growth. Nonetheless, the nation has been working hard to create a green legacy and use renewable energy. Due to restricted access to national energy supplies, traditional fuels like fuel wood, dung cakes, and agricultural residues are primarily used for cooking and lighting in Ethiopia. Solar, hydro, wind, and geothermal energy are among the many renewable energy sources that exist but are not yet used. Grid and off-grid energy systems can be combined to accomplish this transition. The renewable energy-based off-grid system lowers greenhouse gas emissions, lessens the use of conventional fuels, enhances indoor air quality, and protects the ecosystem. To better understand how off-grid energy systems can support Ethiopia's energy transition, this paper analyzes the country's current energy situation, highlights the role of off-grid solutions, and suggests strategies to increase their adoption and spread. To achieve this, it examines the obligations, advantages, and difficulties associated with putting off-grid energy solutions into practice during Ethiopia's energy transition.

The paper addresses the following questions: How can off-grid energy systems contribute to Ethiopia's energy transition? What are the benefits of off-grid solutions? What are the responsibilities, opportunities, and challenges associated with implementing off-grid energy systems in Ethiopia? What is the implication of the national energy policy and regulatory frameworks? How can the adoption and expansion of off-grid energy systems be boosted?

The results showed that off-grid energy systems, particularly those far from the national grid, are promising solutions to Ethiopia's energy issues. These systems can facilitate the nation's overall energy transition, enhance access to energy, and promote sustainability. Off-grid energy systems can help achieve several SDGs ((SDG 5, SDG 1, SDG 7, SDGs 3 and 4, and SDG 13). However, because of insufficient funding, ineffective laws and regulations, and low stakeholder commitment, the development of off-grid energy systems is moving more slowly than anticipated.

To promote investments in off-grid energy, the government, business community, and international organisations must collaborate to develop off-grid energy systems in Ethiopia. Addressing major obstacles and putting laws, rules, and incentives that benefit the whole off-grid ecosystem from importers to consumers will help hasten the energy transition. To do this rules that enable and guarantee the use of all available implementing agent's public, private, public-private partnerships, and cooperatives must be established and enforced.

Index Terms— ***Energy transition, Ethiopia, Off-grid energy systems, Renewable energy***

I. INTRODUCTION

Energy is essential for economic growth in developing countries, as it can help eradicate poverty and improve quality of life [1]. Ethiopia's unreliable electricity obstructs progress in key areas like the economy, education, healthcare, and overall development. Utilizing the existing local energy resources is crucial in determining a sustainable development path for an economy, especially in countries that heavily rely on traditional fuel sources like charcoal, fuel wood, agricultural and tree residues, and dung cakes [2],[3] for people in rural areas who lack access to energy and rely on them for lighting and cooking. Research documents indicate that Ethiopia has the lowest per capita consumption and supply of energy [4],[5], with approximately 56% of the population lacking access to any form of energy [7]. In Ethiopia specifically, the lack of energy access is a major problem, with 59 million households lacking access in 2018. This makes Ethiopia the third-highest country in Sub-Saharan Africa with a per-capita energy deficit [6].

To address this, Ethiopia is investing heavily in the construction of large hydroelectric power plants, with around 95% of current energy coming from hydropower [8],[7]. However, around 90% of households in rural and peri-urban areas still rely on solid biomass fuels [9] which means there is a huge energy discrepancy in rural and urban areas [10],[11]. The country needs modern, affordable, and reliable energy, taking into account that the energy mix, is important for societal development to meet the growing demand caused by population growth, urbanization, and industrialization.

Given the energy deficiency and use of traditional energy sources challenges, it is crucial to transition to alternative forms of energy that increase supply and diversify the energy portfolio. Ethiopia's energy transition is important at various levels (local, national, regional, and global) and particularly relevant locally because providing energy to rural households [12] necessitates the use of off-grid systems [13]. Modern energy supply is crucial for Ethiopia's anticipated growth to become a middle-income country by 2025 [14],[15]. The country exports energy to neighbouring nations [8] with the focus of earning FOREX and parallelly promoting regional economic integration [16],[17]. Therefore, the move towards transitioning the energy sector based on renewable energy can be considered both a national and regional concern. As mentioned earlier, Ethiopia's energy production mostly

comes from hydropower plants built on rivers that cross borders, which means that working together with neighbouring countries on water management is crucial [18] for regional integration.

The Ethiopian government has implemented two Growth and Transformation Plans (GTP-I and GTP-II) with a focus on industrialization, urbanization, and export promotion to reach middle-income status by 2025 [15],[19].

Likewise, the energy sector is at the heart of the current Pathway to Prosperity (2021-2030) [5] plan to create a green economy that's resilient to climate change. The plan focuses on key points of ensuring equal access to energy, improving energy quality, using alternative energy sources, reliable energy infrastructure, investing in the energy subsector, and increasing income [14].

Ethiopia has shown support for off-grid energy systems through policy and regulation development in line with the national Growth and Transformation Plan [14],[5]. To implement off-grid energy systems, national energy policies, rural electrification programs, national electrification programs, renewable energy feed-in tariffs, regulatory frameworks, and tax exemptions are in place as a written document. The development of these systems can be a game-changer, promoting access to energy, reducing indoor air pollution and environmental degradation, and generating income while enhancing environmental sustainability and the national and regional development agenda [20]. To tackle the challenges, the government has implemented strategies such as universal access to electricity, enhancing energy efficiency, creating decentralized off-grid power generators, and exporting electricity to neighbouring countries [21],[22]. However, Off-grid energy use was previously limited to donor-funded projects [22],[23]. This implies that to deploy off-grid energy systems in Ethiopia, a comprehensive approach is necessary, linking government, private sectors, and international organizations [7],[24].

This paper explores how off-grid energy systems can assist Ethiopia's energy transition by efficiently addressing its energy challenges. It examines Ethiopia's current energy situation, policies, regulations, opportunities, and barriers related to implementing off-grid energy systems. It also highlights the benefits of off-grid solutions and suggests ways to accelerate their adoption and expansion. The findings offer insights into challenges and actions needed by policymakers, the private sector, and the research community.

The paper is structured in five sections. Section 2 provides an overview of the methodologies employed while section 3 offers an insight into the energy landscape in Ethiopia. Section 4 discusses the progress made so far in the implementation of off-grid energy systems and the related challenges with section 5 recommending key actions to facilitate the implementation of off-grid energy systems.

2. Methodology

The research involves the review of national and international publications, technical reports, energy policies, and regulations to gain a comprehensive understanding.

3. Ethiopian Energy Landscape

3.1. The Legal and Regulatory Framework

The deployment of renewable energy is one indicator of energy transition and therefore Ethiopia has made significant progress in its energy transition efforts. Understanding the energy policy gaps and obstacles to sustainable energy transition is crucial. The 1994 national energy policy prioritizes securing reliable and affordable energy, modernizing energy services, utilizing indigenous resources, promoting efficiency, and incorporating environmental protection [25],[26]. To accomplish the vision of the policy, focus was given to prioritizing hydropower, transitioning from traditional to modern energy, enforcing energy efficiency standards, developing human resources and institutions, incentivizing private sector involvement in energy development, and paying close attention to progress [25],[26]. From the policy, regulatory frameworks for the development of renewable energy were designed. In Ethiopia, investment laws and regulations led to the partial liberalization of the energy sector, resulting in the division of duties into three entities given that Ethiopian Electric Power (EEP) is responsible for generating and transmission energy, while EEU became responsible for power distribution, sales, and customer service, and the Ethiopian Energy Authority (EEA) is mandated to issue energy generation licenses and energy generation authorization.

Parallel to the unbundling of the Ethiopian Electric Power the Energy Proclamation was enacted to establish a legal framework enabling Independent Power Producers (IPPs) to generate electricity through power purchasing agreements (PPAs) [7]. Private investors can produce electricity in Ethiopia under Amended Investment Proclamation 373/2003. While private actors can generate and supply electricity outside of the national grid, state-owned enterprises still control transmission, distribution, and supply through the integrated national grid system, as stated in Investment Proclamation No. 280/2002 [27]. The energy law and regulation comply with the Investment Proclamation 769/2012 and investment incentives for domestic Investors Council of Ministers regulation no. 270/2012 as amended [28]. The Ethiopian Energy Authority Establishment Council of Ministers Regulation No. 308/2014, is another framework that can govern energy development.

The government or a government joint venture have sole investment rights in electrical transmission and distribution through the national grid system, while the private sector is only involved in Engineering, procumbent, and construction (EPC) projects. The energy sector's regulations are outlined in various directives, including the Energy Proclamation 810/2013. [29], and the Energy Regulation 447/2019 [30].

3.2.Energy Strategies and Plans

The Ethiopian government has implemented various policies and strategies to achieve its objectives, such as Energy Conservation, the Climate Resilient Green Economy Strategy (CRGE), Environmental Policy, National Electrification, Energy Development and Transformation, and the Ministry of Water and Energy Strategic Plan. The CRGE strategy aims to achieve economic growth while improving climate

resilience and reducing GHG emissions. It involves implementing various strategies such as enhancing agriculture, conserving forests, utilizing renewable energy, and adopting energy-efficient technologies to address climate change. Current energy policies lack coherence and long-term vision due to limited resources in terms of human, technical, and institutional capabilities to effectively adapt to the rapidly changing energy landscape both nationally and globally [16], [30] [31].

Ethiopia's energy sector lacks institutional capacity aggravated by the frequent changes in the relevant ministries and agencies, leading to missing records due to reshuffling and reorganizing [32]. In essence, this means that the country must work hard to improve its institutions, human resources, and technology to tackle current and future energy challenges and take advantage of opportunities in the energy sector as issued by [16], [30]. It should prioritize preserving sustainable planning and fulfilling energy needs while considering the environment.

There is an urgent need for a clear roadmap to achieve energy transition, as emphasized in sources [16],[33]. Despite efforts to expand renewable energy generation, more action is required to encourage the transition to clean energy and improve living standards, as discussed in sources [16],[13]. The country needs to make practical efforts to maximize its non-hydropower renewable energy sources to establish a sustainable and adaptive power system for widespread energy access, climate change vulnerabilities, and geopolitical concerns. Developing a power generation strategy requires conducting extended studies on the energy mix pathway, involving both supply and demand projections. We need to create a flexible energy transition plan that takes into account current and anticipated changes at a national and global level. Energy authorities and institutions should keep up with global trends and adjust energy supply and demand projections accordingly to meet the needs of all sectors and minimize environmental impact.

3.3. Status of Power Generation and Access

Ethiopia has a total electricity generation capacity of 5,273.77 MW by 2022 [34], with most of it coming from hydropower. Despite this, there are significant differences in electricity access between urban and rural areas [11], with over 90% of the rural population lacking access. As per the International Energy Agency [35] the final energy consumption of Ethiopia is estimated at 40,000 GWh, whereof domestic appliances consumed around 92%, 4% by transport sector and 3% by industry. Ethiopia has abundant sources of renewable energy such as hydro, solar, wind, and geothermal power. Though it has not fully exploited its potential, Ethiopia is among the few countries in sub-Saharan Africa, that generates over 90% of its electricity through renewable sources. Concerning the economic growth of the country, the energy demand is also rising enormously and is expected to increase at a rate of 10-14% per year up to 2037 [36]. As depicted in Figure 1, as of 2012 the peak demand forecast has grown from 1237MW to 21731MW by 2037 in the base load case, whereas in the high case, it has grown to 32486 MW.

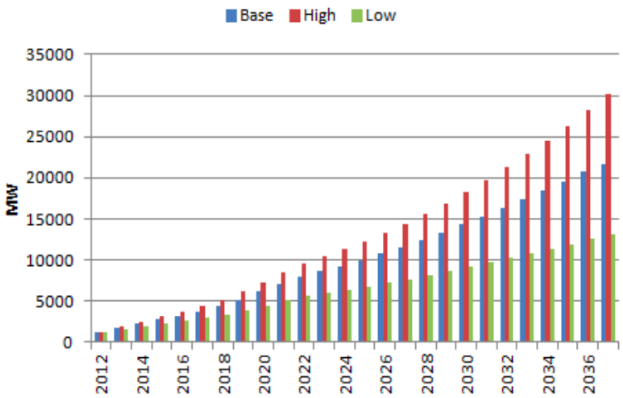

Figure 1: Ethiopia Electricity Demand Forecast [36] (own elaboration)

Besides, Ethiopia's energy system is not very diverse compared to other African countries [37], [4]. Despite having access to various energy resources, over 95% of Ethiopia's energy is generated solely from hydropower [7],[8], unlike the other African countries [4].

3.4. Electrification achievements

The Ethiopian Government has been striving to achieve universal access to electricity as a primary goal. Various programs and initiatives have been implemented by the government starting from 1999. The first electrification project initially started by extending the electricity network to district-level towns that are near existing distribution lines. In its first phase of electrification from 1999 to 2004 around 164 towns were electrified. In 2017 & 2019, the Ethiopian government initiated the National Electrification Plans (NEP & NEP 2.0) for universal electrification by 2025 with a focus on using both on-grid and off-grid approaches [7]. The National Electrification Program explained that by 2025, 65% of households have to be electrified through the main grid, whereas 35% have to be electrified off-grid.

4. Progress and Challenges of the Deployment of Off-Grid Energy Systems

4.1. Progress of the Deployment of Off-Grid Energy Systems

The energy strategic plan outlines the goals from the Growth and Transformation Plan and National Electrification Plan (NEP II), with specific targets for both grid and off-grid electricity. The NEP identifies solar energy as the top choice for off-grid electrification [38],[7]. In 2018, the country's overall access rate was 44%, with 33% access through grid connections and 11% access through off-grid solutions [7]. Ethiopia's government has launched the National Electrification Program II (NEP II) to achieve universal electrification by 2025 [7] using both on-grid and off-grid energy solutions, alongside poverty reduction goals. The government has set initiatives to achieve its goals, which include expanding and diversifying domestic power supply by 15-20% through non-hydropower renewable energy sources by 2020, initiating energy exports, providing universal network coverage to priority towns and villages, and achieving universal energy access [7].

An analysis by the NEP II showed that 90% of households in

Ethiopia are within 10 km of the national grid, indicating their proximity to the existing grid [7]. The NEP II aims to connect 65% of the population to the centralised grid by 2025 [7], starting with those closest to the existing network. The remaining 35% will receive electricity from off-grid technologies in the same year. By 2030, the grid will expand to connect 96% of the population, with 4% still relying on off-grid technologies [7]. The NEP 2.0 is to improve connectivity through densification (less than 1 km), intensification (1-2.5 km), and extension (2.5-25 km) from the current grid up to the grid line [7]. Off-grid solutions will serve 35% of the population to achieve this goal.

The National Electrification Plan consists of short-term pre-electrification (within 2.5 km from the grid) mid-term pre-electrification (between 2.5-5 km from the grid) and long-term off-grid/deep rural (>25 km from off-grid).

Short-term pre-electrification: it is considered that the grid connectivity will take years to materialize, and households will therefore remain unelectrified. The NEP 2.0 therefore is estimated to connect 3.3 million households within 2.5 km from existing lines by 2025.

Mid-term pre-electrification: This approach focuses on target beneficiaries living between 2.5 and 25 km from the grid. Though connectivity is the least cost option, households may have to wait numerous years to connect to the existing grid network. It is estimated that the number of households who are beneficiaries of off-grid is expected about 8.1 million by 2025. However, due to their proximity to the grid, these beneficiaries are expected to be connected to the national grid by 20230.

Long-term off-grid/deep rural: in this category, it considers residents that are beyond 25 km from the national grid network, and homes that are not far from the grid connectivity but are so dispersed to settlers. In this category, it encompasses around 1 million households (about 4% of the population by 2030). In this regard, as their distance is within 100 km (within the mandate of the Ethiopian Electric Utility) in the long term some of them may eventually be connected to the grid beyond 2030.

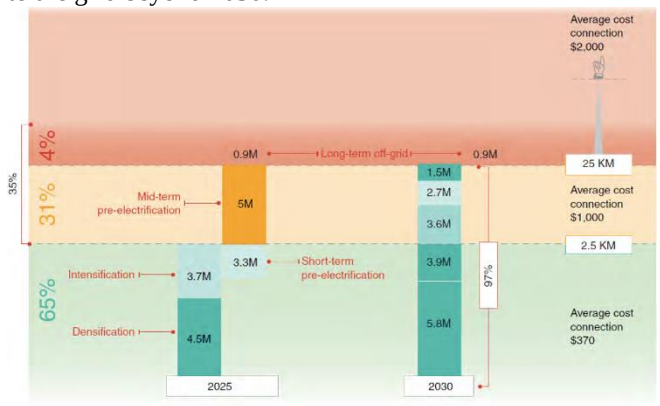

Figure 2: The national electrification program integrated on- and off-grid components [7].

The NEP's off-grid implementation framework considers to use of solar off-grid solutions, isolated mini-grids, and hybrid solutions to provide services to beneficiaries. The program has already given over 2.2 million people access to electricity through public and private sector efforts. To help with off-grid connections, though it is not cohesive, regulatory initiatives were created to support the necessary off-grid energy ecosystem. These initiatives include harmonizing national quality standards with global lighting standards and providing exemption from duty and excise for importing solar products under 15Wp capacity. Normally, the Revenues and Customs Authority (ERCA) charges up to 35% duty and up to 100% excise tax on imported products, bigger solar PV home systems with quality certificates are also exempted, but they still need to pay 15 per cent VAT and 3 per cent withholding tax. They only need Pre-Verification of Conformity instead of testing [7].

Microfinance institutions (MFIs) and Private Sector Enterprise (PSEs) have played a vital role in providing solar lighting and charging products and home systems through a credit line from the World Bank's funding at the Development Bank of Ethiopia. The credit line covers solar lanterns, solar home systems, solar water pumps, mini-grid development, improved cook stoves, domestic biogas, and waste-to-energy products, domestic biogas, and ethanol stoves.

By the end of 2018, approximately 2.2 million off-grid services in the country had access to solar lighting and stand-alone systems, which accounts for 11% of the overall access [7]. According to the NEP II, the majority of off-grid access utilized by the Ethiopian population is through off-grid solar lanterns that are typically used for one lightbulb and mobile charging purposes only.

Micro financial institutions (MFIs) and private sector enterprises (PSEs) have deployed around 72,370 solar home systems and 4,059,024 million Lighting Global-certified solar lanterns to the communities [39]. As per the NEP II document [7] the Rural Electrification Fund has been mandated to oversee off-grid electrification since its establishment in 2003, and its efforts resulted in the deployment of around 206,553 solar home systems to communities through rural electric service cooperatives, about 4,484 institutional solar PV systems provided with 300Wp solar PV off-grid solutions to light up to 3 rooms, in collaboration with the Ministry of Health, above 200 micro-technicians trained in operation and maintenance of solar home systems, and solar PV testing facility handed over to the Ethiopian Conformity Assessment Enterprise for quality assurance of products.

The program has shown progress on service standards through the years, for example, before the Tigray conflict in November 2020, health posts and clinics were equipped with 600 Wp solar PV systems, allowing for six light bulbs, refrigeration, radio, and TV use for a maximum of six hours per day, and schools were served with 300 Wp solar systems for the illumination of 2-3 classrooms.

4.2. Challenges Related to Off-grid Energy Systems

Lack of modern energy significantly limits access to essential social services such as water, healthcare, and education. However, deploying off-grid technologies is hindered by barriers such as complicated licensing, low tariffs, and limited lending support [40]. Moreover, the COVID-19 pandemic, increased costs of energy technologies, and disruptions in global supply chains are negatively affecting the progress of electrification [11],[41].

The conflicts in northern Ethiopia and Ukraine are leading to socio-economic challenges that are increasing fuel prices

[42], food prices, and transportation costs in Ethiopia. These challenges have the potential to impede the achievement of Ethiopia's NEP II targets, causing a decrease in the national utility's capacity, affordability, and electricity demand. Furthermore, Ethiopia has encountered various challenges when it comes to implementing and improving off-grid renewable energy sources.

4.2.1. The Policy and Regulatory Framework

Although Ethiopia's policies and regulations are generally in favour of renewables, the absence of effective implementation strategies has hindered progress. The absence of clear regulations and policies is a barrier for off-grid energy systems. A supportive regulatory framework is crucial to encourage private sector investment and innovation. Strategies and guidelines for non-public activities related to off-grid services are not well-defined. The Strategic Plan of the Ministry of Water and Energy has general plans for solar home systems but lacks specific strategies and investment plans for their implementation. Foreign investors considering setting up PV module assembly plants in Ethiopia find the current regulations unappealing for investment in energy technology manufacturing. Investors avoid the sector due to legal and financial uncertainty. Domestic manufacturing regulations are adverse, as taxes are waived for imports of certain PV products. Still, Ethiopian companies producing these products must pay taxes on the components used to make them [43],[39].

4.2.2. Sector Development Support

Ethiopia's market for distributed renewables is lacking in knowledge, information, finance, and other necessary inputs. The institutional structures for sector development have existed for years but have not been effective. Local suppliers also lack financial capacity, and resources are diverted when large procurements are tendered through foreign suppliers. There are no technical standards or monitoring for PV products and services, limiting market development and quality assurance efforts. Local testing and approval systems are lacking, causing delays and expenses for external testing and approval. Additionally, there is a lack of clarity around the diffusion or dissemination model for PV in off-grid areas, and little research and development is focused on off-grid energy systems in universities.

4.2.3. Financial and Economic Limitation

Off-grid power services receive less financial support compared to grid-connected options, which makes it challenging for renewable energy entrepreneurs to obtain funding. Limited financial support and foreign currency availability impede the development and implementation of off-grid solutions. The participation of private sector energy providers including solar products, can be difficult due to challenges accessing foreign exchange. Additionally, high interest rates from the finance industry have resulted in decreased demand and made these products too expensive for many buyers [39],[44].

4.2.4. Technical Capacity Barriers

As to the document of the (NEP II) of Ethiopia [7], the government of Ethiopia prioritizes on-grid electrification over off-grid rural electrification, resulting in capacity barriers. Private investors are reluctant to invest in micro-grid infrastructure in rural areas because the Government of Ethiopia lacks long-term grid expansion plans. Even though there is an increasing demand for off-grid lanterns and solar household systems, there is a lack of technical service infrastructure, including the ability to design, manufacture, assemble, install, and provide service for solar products has not kept up with the surge of lower-quality products available.

4.2.5. Investment Barriers

Barriers to investment in off-grid technologies include a cumbersome process for obtaining business licenses, verifying quality, and paying taxes involving multiple organizations that lead to delays and increased transaction costs. The involvement of inefficient actors such as ministries, banks, and agencies further aggravate these issues. Tariffs have caused a decline in off-grid solar technology adoption and made high-wattage equipment unaffordable for most consumers. There are also communication challenges for solar product suppliers due to the import process involving multiple agencies, and a lack of clarity regarding agency responsibility for quality certificate verification and approval. Multiple organisations, including the Ministry of Water, Irrigation and Electricity, the Ethiopian Energy Authority, the Ethiopian Revenues and Customs Authority, the Ministry of Trade, and the Ethiopian Conformity Assessment Enterprise, are assumed to be responsible for different factors involved in importing. Solar equipment is currently tested for 47 days without unloading from the truck, causing delays, and resulting in costly demurrage expenses for the importer.

Underdeveloped Rural Energy Infrastructures and Markets

Rural areas lack energy infrastructure and markets, making it difficult for private sector involvement due to high start-up costs. This is due to inexperience with commercial operations and weak delivery systems in the country.

Low Information and Understanding

Rural residents in Ethiopia lack knowledge about clean off-grid energy options and technical requirements. The population needs education on the benefits of these options. Furthermore, there is insufficient and outdated information and maps for renewable energy development in Ethiopia [44].

4.2.6. Political Barriers

Political conflicts in Ethiopia, including the war in Tigray, Amhara, and Oromia, may impede the development of off-grid energy systems. Limited resources, political instability, and diversion of funds may further slow progress [44].

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5. Recommendations for Scaling-up of Off-grid Energy Systems

To facilitate and ensure a sustainable energy transition in Ethiopia various recommendations ought to be considered. Establishing a comprehensive regulatory framework that incentivizes renewable energy investment, and investing in research and development to enhance the cost-effectiveness of renewable energy are among the key issues to consider. Furthermore, to speed up the expansion of off-grid energy systems, the government must take strategic actions such as involving both foreign and local companies in the distribution and servicing of PV systems. Here are some of the necessary actions required to facilitate off-grid energy system deployment.

5.1. Capacitating Local Manufacturing Capability of Off-rid Energy Technologies

Ethiopia has an abundance of renewable resources and is experiencing growing revenues, implementing a green economy strategy, and having a skilled workforce. By improving the local manufacturing capability of off-grid energy technologies, Ethiopia can harness these opportunities further. The country has an opportunity to establish a domestic off-grid energy industry due to the increasing demand. Both large and small companies are investing in assembly, installation, and service to fill the market need. This will result in the creation of a sustainable supply chain for products and services. To encourage the manufacture of off-grid energy equipment locally, policy measures like tax exemptions, industry awareness campaigns, and resources for investors should be adopted. This strategy has succeeded in other East African countries and would result in job opportunities and reduced reliance on imports [13].

5.2. Regulations and Sector Development Support

Regulations and sector development are essential for promoting competitiveness in the market and off-grid energy development. Support for sector development is necessary along with regulations to promote the domestic market for renewables. Continual support is required to improve the off-grid energy system, which includes technical capacity building, research and development, and funding for end-users. Regulations need to be clearly defined, easy to implement, and enforced accurately. They should also be updated regularly to reflect changes. Ongoing reviews of regulations and sector development support are necessary to adjust to changes. China provides tax incentives, R&D, and investment subsidies to its renewable energy industry to support development. Regulatory support and financial aid from the Chinese government have fostered growth in renewable energy technology in the country [13]. To ensure local involvement in the industry, the government mandates that a certain percentage of the renewable system's cost must come from local sources, prompting external developers to establish manufacturing facilities in China or partner with Chinese companies [45],[45]. To improve importation, simplify and organize institutions and regulations. Use third-party Verification Conformity to prevent customs delays, reduce losses from non-compliant imports, and lower prices for consumers. This process has been successful in Tanzania, Kenya, and Uganda [13].

5.3. Ensure Strategic Alignment and Inter-Ministerial Coordination in The Renewable Energy Ecosystem

It is important to have strategic collaboration between ministries and authorities to grow the energy sector, particularly the off-grid energy sector and find national solutions. This involves working with the Ministries of Water and Energy and Lowlands, and Agriculture, along with development partners [46]. Together, they can achieve results and expand Ethiopia's off-grid energy market.

5.4. Leverage Remittances and Attract International Investors in The Energy Market

The government can increase off-grid energy by seeking solar investments from overseas diaspora groups and attracting foreign investors in renewable energy. This will address the issue of the country's lack of foreign currency and support the sustainable growth of the renewable energy sector.

5.5. Foster Collaboration Between Researchers and Industry

Create networks that facilitate collaboration between researchers and industry to showcase energy transition

possibilities, create off-grid energy solutions, establish inventive business strategies and funding mechanisms, and enhance socio-economic advantages.

Provide Education and Outreach Programs for Specific Audiences

Provide educational and outreach programs to specific groups, using methods like workshops, seminars, technical training, and conferences. These initiatives aim to enhance knowledge of off-grid energy technology. Customize the information about renewable energy technology for important audience groups, including financial institutions, policymakers, customs employees, private firms, diaspora communities and influential end users.

ACKNOWLEDGEMENT

The authors acknowledge the UK Research and Innovation and the Global Challenges Research Fund for providing funding to conduct this research work under the grant reference number: ES/T006358/1.

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