LEAP-RE

Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

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Mapping of policies and initiatives supporting the Energy Village Concept

as a deliverable for WP14

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Abbreviations and Acronyms

Acronym	Description
WP	Work Package
RE	Renewable Energy
RES	Renewable Energy Sources
RERS	Renewable Energy Resources
SDG	Sustainable Development Goal
CRGE	Climate Resilient Green Economy
GoE	Government of Ethiopia
GHG	Greenhouse Gases
AASTU	Addis Ababa Science and Technology University
BIUST	Botswana International University of Science and Technology
MU	Moi University
MaK	Makerere University
UVA	University of Vaasa

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Summary

This report offers a mapping and analysis of local, national, regional, and international policies and initiatives that support the establishment of self-sufficient renewable energy villages established in LEAP-RE project work package 14 in Africa. There are four African countries represented by the Universities in this work package and the main emphasis of the analyses is on those countries. They are Moi University (MU) from Kenya, Botswana International University of Science and Technology (BIUST) from Botswana, Makerere University (MaK) from Uganda and Addis Ababa Science and Technology University (AASTU) from Ethiopia. The report aims to provide a holistic view of the policy landscape, identify synergies across different levels of governance, and promote the advancement of affordable, sustainable and energy-independent communities across the continent.

In addition, the report presents a literature review of Africa's renewable energy development and it shows what kind of renewable energy development has been progressing in Ethiopia, Botswana, Uganda and Kenya as a case study representative of the African content. There has already been a lot of renewable energy development going on in Africa, which is very promising for the possibility of future energy security and economic development in Africa but there is still a lot of work to be done. Having such a method or concept as the 'Energy Village Concept' can help the whole of Africa and/or the developing nations to speed up and promote renewable energy in their energy mix. Therefore, they benefit from the readily available natural energy resources in the local area not only to help the local economy or reduce climate change pollution but also to ensure the energy security of their nation.

Keywords

Mapping of policies; Policies; Initiatives; Energy village; Renewable energy; Renewable energy resources; Energy consumption and potential; Stakeholders

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1. Introduction

The energy consumption in Africa is predominantly based on biomass energy resources; mainly fuel wood, charcoal, branches, animal manure and agricultural residues (Dasappa, 2011). Besides these traditional energy resources, modern energy resources namely petroleum and electricity top up the balance that accounts for the small proposition (Yalew, 2022). According to previous reports of Energy Village projects in Finland, transportation takes the highest amount of fossil energy, energy cost and economy. In the African context, the most important issue in the energy sector is the supply of household fuels, which is associated with massive deforestation and the resultant land degradation (Ibrahim et al., 2021). Moreover, challenges to accessing traditional energy resources are inevitable as the population increases, and yet the effects of such energy consumption trends have now appeared on the surface and are already experienced. As is well-known energy is the backbone of socio-economic development and is a power for states.

To that end, the governments set out different policies and initiatives with the intention to radically change the current energy landscape in Africa. With its bigger scope for renewable energy resources, ambitious electrification targets and numerous incentives, the legislations and regulations are made for an increasingly appealing choice for private investors. Priority for modern and sustainable energy usage is the core and the basic element of the government's policies. To improve energy access by increasing renewable energy production, identification of policies that support the Energy Village (EV) concept, implementation strategies for EVs including identification of integrated policies, and initiatives to support EVs are presented in this report as per the context in Ethiopia, Botswana, Uganda and Kenya.

Thus, this report is prepared to show an assessment of a brief literature review, relevant policies and initiatives related to EVs for selected energy villages in each African partner nation as per their contexts and based on the LEAP-RE reports of the representative institutions (the Universities). The studying Universities are AASTU in Ethiopia, BIUST in Botswana, Makerere in Uganda and Moi University in Kenya. The potential energy villages for which extensive energy potential, consumption and demand have been studied are listed in Table 1. There are four Energy Villages in Ethiopia and Botswana, and five Energy Villages in Uganda and Kenya that policies and initiatives are mapped for.

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Table 1: List of potential energy villages explored in the project

S/N	Energy village	Country
1	AASTU campus	Ethiopia
2	Langano	
3	Wonji	
4	Tulefa	
5	Regent Hill	Botswana
6	Matsaudi	
7	Jamataka	
8	Majwanaadipitse	
9	Kayanzi	Uganda
10	Refugee camp	
11	Nakasengere	
12	Maiba Murole	
13	Wanale	
14	Cheboiwo	Kenya
15	Lelan	
16	Langas	
17	Kerio valley	
18	Nandi hills	

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2. Literature Review of African Nations' Renewable Energy Directions and Developments

This section gives a brief literature review presenting what kind of renewable energy development has been progressing in Ethiopia, Botswana, Uganda and Kenya as a case study representative of the African content. There has already been a lot of development going on in Africa, which is very promising for the possibility of future energy security and economic development in Africa.

2.1 Ethiopia

The barriers and recommendations to scaling up renewable energy (solar mainly) in some Sub-Saharan African countries including Ethiopia are mainly classified and are related to four groups: 1) energy policy implementation 2) lack of technical capability and information 3) investment and financing and 4) connection of solar energy infrastructure to the national grid (Mas'ud et al. 2016). Ethiopia has an annual exploitable electric energy potential of 7.5 PWh from solar energy, 4 PWh from wind and 0.2 PWh from hydroelectric energy (Tucho et al. 2014). Hydro, Wind and Solar are promising options among renewable energy resources for the energy and environmental challenges the world facing today (Tucho et al. 2014). Like most of the sub-Saharan African countries, most Ethiopians use biomass as a dominant energy source for cooking (Tucho et al. 2014).

In addition, they concluded in the Tucho et al. publication that, existing Western solutions concerning renewable energy supply systems do not solve energy problems in developing countries. Because renewable energy electricity production is expensive for cooking purposes. Usually, they are suitable in rural areas only for lightning and powering of electronic devices (Tucho et al. 2014). There are also more studies on renewable energy optimization in Ethiopia by Boke et al. (2022). Boke et al. (2022) and Tesfaye et al. (2021) concluded that Ethiopia's national target plan can make increasing grid connections to 96% by 2030. This is because the country has enough renewable energy potential. This is also true for the majority of African nations. In addition, Ethiopia is planning to commence a nuclear program for a peaceful application of nuclear science and technology this is a part of the strategies of both targets in the energy mix and sustainable development goals (Kibatu et al. 2021).

Although Ethiopia is considered to be a growing leader in the energy sector in the Sub-Saharan region, it is also facing numerous problems as other African nations (Khan Singh 2017). The presence of renewable energy resource potentials must be utilized to overcome

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these numerous problems in energy sectors. According to Tesfaye et al. (2021), the plan for Ethiopia's future is to address energy, water and food helix problems to become a middle-income country status by developing its untapped resources e.g., water and land resources. The model used by Tesfay et al. (2021) indicates that "Ethiopia has adequate physical water supply potential and renewable energy resources to develop and satisfy the growing demand until 2050''. Ethiopia and Kenya are among the African nations that have the huge resource potential of solar PV and concentrating solar power; wind; hydropower big and small; and geothermal, according to Allington et al. (2022).

The implementation of an energy mix is a way forward for the future, especially for nations such as Ethiopia, which are affected by severe droughts and whose main energy source is hydropower (Mekonnen et al. 2022). They also mentioned that by 2065 there will be a significant decline in energy production from hydropower. This can be compensated to some level by using renewable energy mix resources (Mekonnen et al. 2022). According to Mekonnen et al. (2022), the effect of climate change in terms of drought on hydroelectric resources is already experienced in Ethiopia. It is important to notice here also climate change can also create an advantage for some renewable energy technologies. For example, a solar intensity increase can benefit solar energy production and an air temperature increase can benefit geo-energy resources e.g., a water temperature increase can benefit sediment heat energy production at least in summer [Girgibo et al. (2022); Girgibo (2021) and Girgibo (2022a)]. The advantages of climate change effects must also be utilised in African nations.

2.2 Botswana

On another hand, in the Sub-Sahara African nation (Botswana), wood has been the "energy of the poor'', which has been considered a threat to environmental and development goals (der Horst and Hovorka 2008). In terms of renewable energy sustainability, a higher population growth rate inhibits the prospects of achieving energy sustainability across selected Sub-Saharan African nations, according to the results of Mushed et al. (2022). "For the entire panel, the regression findings reveal that a 1% rise in the energy efficiency level increases the energy sustainability index by around 11% in the long run'' (Mushed et al. 2022). Therefore, this statement is a crucial notice that in ensuring the sustainability of renewable energy it is very important to consider energy efficiency. In Botswana as in most developing nations, biofuel development is driven by rural development, employment, greenhouse emissions and increasing energy security (Kashe et al. 2021). As Kashe et al. (2021) described, biofuel plants can be invasive depending on the plantation locations.

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Invasive species were one of the risks of renewable energy use and production to the environment analysed by Girgibo (2022b).

Botswana has no hydropower resources and no petroleum resources; the main resources available are coal, solar energy (huge resource potential) and biomass energy (Katende 2021). Wind energy is not an option because there is less wind speed (about 3.5 m/s), which is insufficient for energy production (Katende 2021). To compete and grow for developing nations such as Botswana in 21st-century waste management and west to energy are important (Charis et al. 2019). On the other hand, Botswana has a massive potential energy source: solar irradiation (Mutoko and Mutoko 2019). This solar energy potential should be harnessed with various projects to overcome Botswana's electricity power shortage which has been faced in recent years (Mutoko and Mutoko 2019). The solar energy solution suggested by Tlhalerwa and Mulalu (2019) is concentrating solar power (CSP) systems, which Botswana has a very high potential for this technology.

2.3 Kenya

Based on Ngusale et al. (2014), in a study made in Kenya, briquettes made from biomass residues could contribute to ensuring the sustainable supply of biomass energy. This is a very nice way of using biomass energy in compacted form suiting the current energy utilization (fire for cooking) in most developing nations. One of their conclusions Ngusale et al. (2014) was that making opportunities of briquettes from biomass (from wastes/residues) are immense and could help curb deforestation thereby reducing environmental degradation. The innovative way of producing briquettes from biomass wastes/residues can be essential in helping in replacing firewood. Based on Ngusale et al. (2014) descriptions, Briquette produces minimal greenhouse gases, especially when used in well-ventilated spaces compared to other local fuels. As well, they mentioned that briquette emissions characteristics might be better than those of firewood. This means that replacing firewood fully or to some percentage can contribute to declining greenhouse gas emissions. Among the challenges noticed in Kenya, one of the financial challenges is that wind, solar, hydropower and biomass electricity find it difficult to access financing (Ngusal et al. 2014).

Ulsrud et al. (2015) presented a very good example of implementing, managing and supplying solar energy in a rural village in Kenya. They have even presented a conceptual framework that can be adapted by other villages. On the other hand, the use of energy for cooking has been affected by COVID-19 based on the study conducted in Nairobi, Kenya (Shupler et al. 2021). Therefore, there are changes due to COVID-19 in the type of cooking

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fuel and amount used, which now coming to the previous normal patterns after the COVID-19 lockdown is over in most nations. Most have started using wood or kerosene instead of LPG (liquified petroleum gas) during the lockdown period (Shupler et al. 2021).

On the other hand, IEA (2020) found that on a global scale, the number of greenhouse gas emissions decreased during the COVID-19 period, due to the decrease in commuting (transportation). Based on Shupler et al. (2021) descriptions, household energy access is a multifactorial issue influenced by fuel availability, price, proximity, family composition, cultural preferences and convenience and now COVID-19 (differences may present in rural and urban households). In the gender socio-demographic, the female respondents were less likely to have a positive attitude toward both geothermal and wind technologies (Oluoch et al. 2020). Kenya has been progressing very well in setting policies for emission reductions (Koasidis et al. 2022). In Kenya, the national production of the energy mix includes 52.1% of hydro, 32.5% of fossil fuels, 13.2% of geothermal energy, 1.8% of biogas cogeneration, and 0.4% of wind (Takase et al. 2021).

2.4 Uganda

The number of people who have access to electricity increased significantly in Uganda by 2020 compared to 2001 (Wabukala et al. 2021). This increase includes off-grid clients. In expansions of mini-grids and renewable energy in Africa, one of the shortages noticed by foreign companies is a lack of understanding of local communities, which can lead to a fall in diffusion attempts (Eder et al. 2015). Based on the same article, the whole step of entering a developing country with innovation is a process rather than a product breakthrough. Even though the locals mentioned other reasons for not adopting electricity, it was found that the main reason for locals not to adopt it in Uganda's villages was financial problems (they cannot afford the electricity price) (Eder et al. 2015).

The dimensions related to adoption can be technological, economic and social. To promote innovative technology in villages, the energy service company must promote technologically reliable service, a sustainable energy generation method, technological awareness and functionality as benefits, and productive usage (Eder et al. 2015). There are economic factors that affect the adoption of electricity in villages. For example, according to Eder et al. (2015) in Uganda, Tiribogo village had four factors that affected the adoption: affordability, payment systems (i.e., how to pay), investment costs, and appropriate tariffs. In addition, they noticed that it is important to understand the preferences of the locals if they want monthly payments or usage-based tariffs if the electricity is going to be sold to them. In terms of the social dimension, foreign firms need

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to collaborate with local actors, especially when emerging new social systems with disruptive innovation (Eder et al. 2015). They found the social dimension factors: partnering with local experts, incorporating local inhabitants, utilizing proper communication channels, and managing users' expectations properly. On the other hand, Bogomin and Nziu (2022) and Mohamad et al. (2021) summarized most renewable energy development and current stage in Uganda and about solar chimneys, respectively.

Bioenergy use and development have also been going on in Uganda (Okello et al. 2012). Among the bioenergy (biomass) types firewood has been the biggest contributor to energy production mainly for household uses (Okello et al. 2012). They have concluded that attributes of high capital costs, and lack of technical expertise, among others, are the reasons why the rate of adoption of improved bioenergy technology remains very low in Uganda (Okello et al. 2012). The use of the west for generating energy (west to energy) in Kampala, Uganda is visible, according to a simulation analysis by Amulen et al. (2022). Bioenergy from biomass is important in Uganda because the residue is readily available and therefore it is a great energy source for most people staying in the rural areas and a new income source (Xiavar and Perry xxx). Coffee husk gasification can be a sustainable energy source in Uganda (Miito and Banadda 2022). Based on Wabukala et al. (2021), the renewable energy policy in Uganda mainly focuses on power generation from hydro, solar, biomass and geothermal resources, but no plan for wind energy. In wind energy, there is a lot of potential for research in Uganda (e.g., Wabukala et al. 2021) thus it can be included in Uganda's renewable energy policy in future.

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3. Local / National Policies and Initiatives

Understanding policies and initiatives supporting Self-Sufficient Renewable Energy Villages in Africa under the LEAP-RE Programme is a crucial pre-requisite for implementing the energy village concept by utilizing clean and secured sources of renewable energy such as biomass, small hydropower, solar, and wind for the rural African people based on the preliminary LEAP-RE reports. Development of an implementation plan and feasible business model with high replication potential to show how to realize and operate energy villages requires mapping of policies and initiatives based on each region's renewable energy source (RES) potential and total energy consumption report. On top of this, Energy Villages' Strategic Plans allow stakeholders to consider the best use of the locally available renewable energy resources and reduce the impact of climate change on the community.

In line with the objectives of the energy village establishment of the LEAP-RE project, the governments of Ethiopia, Botswana, Uganda and Kenya have issued different documents that set out energy policies. In Ethiopia, for instance, energy policies started to take effect in 1994 (NEPE 1994). The energy policy document showed the government of Ethiopia's (GoE) intentions in each of the sub-sectors. Thus, it aims to address household energy problems by promoting agro-forestry, increasing the efficiency with which biomass fuels are utilized, and facilitating the shift to greater use of modern fuels. Furthermore, the policy paper states that the country will rely mainly on hydropower to increase its electricity supply but it also mentions taking advantage of Ethiopia's geothermal, solar, wind and other renewable energy resources where appropriate. In addition, it aims to further explore and develop oil and gas reserves. It also refers to the need to encourage energy conservation in industry, transport and other major energy-consuming sectors, to ensure that energy development is economically and environmentally sustainable. Providing appropriate incentives to the private sector is the other area the policy statements emphasize. The energy policy document is further elaborated by different sectoral policies and strategies like industrial, agricultural, etc. The main energy policies in Ethiopia are:

- Policy on Energy Resource Development
- Policy on energy supply
- Policy on energy conservation and efficiency
- Policy on comprehensive measures

The general objectives of the energy policy are:

- To ensure a reliable supply of energy at the right time and affordable prices, particularly to support the country's agricultural and industrial development strategies adopted by the GoE.

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- To ensure and encourage a gradual shift from the use of traditional energy sources to modern energy sources.

- To streamline and remove bottlenecks encountered in the development and utilization of energy resources and to give priority to the development of indigenous energy resources to attain self-sufficiency.

- To set general guidelines and strategies for the development and supply of energy resources;

- To increase energy utilization efficiency and reduce energy wastage; and,

- To ensure that the development and utilization of energy is benign to the environment

These kinds of policy initiatives were started and even have been developed in most Sub-Sahara African nations and/or the whole of Africa. To promote and realize the country's Green Development Strategy, ongoing initiatives to generate electricity from hydropower and the development of other renewable energy sources like biofuels, solar and wind will remain the strategic direction, as described in the energy policy documents. In addition, new technological innovations will be utilized to ensure that the energy sector does not emit additional carbon dioxide. To promote and sustain rural alternative energy development activities, the policy says efforts will be made to enhance the capacity and knowledge of regions, producers and consumers in this regard. The distribution of fuel wood-saving materials and technologies throughout the country will be continued. The GoE has also initiated the Climate Resilient Green Economy (CRGE) initiative to protect the country against the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle-income status. In general, four initiatives for fast-track implementation have been selected under the CRGE:

(i) exploiting Ethiopia's vast hydropower potential;

(ii) large-scale promotion of advanced rural cooking technologies;

(iii) efficiency improvements to the livestock value chain; and

(iv) reducing Emissions from Deforestation and forest Degradation (REDD).

These initiatives will have the best chances of promoting growth immediately capturing large GHG emission abatement potentials, strengthening Ethiopia's leading role in sustainable growth, and attracting climate finance for their implementation. To ensure a comprehensive program, initiatives from all other sectors will also be developed over time into concrete proposals. These policies and initiatives appear to be the fertile ground for the implementation of the energy village concept of the LEAP-RE project.

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Shaping a country's renewable energy future strongly depends on the governance and mechanism of the respective valid legal situation in terms of energy policies and regulations. In Botswana, energy-related legislation is administrated by the Department of Energy (DoE) of the Ministry of Mineral Resources, Green Technology and Energy Security (MMGE) and the Botswana Energy Regulatory Authority (BERA). BERA, as a regulatory authority, handles all energy regulation matters in Botswana. Thus, BERA is responsible for providing an efficient energy regulatory framework for Electricity, Gas, Coal, Petroleum products, Solar and all forms of renewable energy. It was established by the Botswana Energy Regulatory Act 2016 and started its operations on the 1st of September, 2017.

Since 1985, Botswana's energy sector developments have been guided by the Botswana Energy Master Plan (BEMP), which was last reviewed in 2002. The BEMP was recently replaced by the National Energy Policy (NEP), which was approved by the Parliament of Botswana in 2021 showing Botswana's commitment to transform the energy sector from fossil sources to renewable energy sources. The NEP is founded on three guiding principles (i) economic development, (ii) equity and (iii) environmental protection (Government of Botswana, 2020a). The NPD is closely aligned with the goals of the eleventh national development plan (NDP 11). The eleventh National Development Plan (NDP), for the period 2017-2023, flagged climate change as a challenge faced during NDP 10 and explicitly recognized the imperative of addressing climate change (Government of Botswana 2017). Under the NDP's core priority area of "Sustainable Use of Natural Resources," the NDP highlighted the role that climate change mitigation and adaptation can play in employment creation and economic growth and emphasized the need to mainstream climate change into development planning. The NDP also called for gender-responsive adaptation and mitigation processes and smart agriculture. Moreover, the NPD is also closely aligned with Botswana's Vision 2036 (Vision 2036 Presidential Task Team, 2016). The transformational Vision 2036 gives the frame and defines the national objectives for Botswana's future development and includes a holistic sustainable energy perspective, being defined by the attribute's availability, accessibility, safety, affordability, reliability and environment-friendliness.

In August 2020, the first Integrated Resource Plan (Government of Botswana, 2020b) of Botswana was approved which provides the national framework for energy planning, that identifies priority renewable and thermal energy projects to meet growing energy demand. Moreover, in 2020, the government of Botswana launched the Rooftop Solar Programme (Botswana Energy Regulatory Authority, 2020) which allows domestic and commercial/industrial consumers to install solar systems to generate electricity for self-consumption and to feed the produced excess electricity to the grid, i.e., to sell the produced excess electricity to Botswana Power Cooperation (BPC).

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As a further initiative, Botswana aims to reduce carbon emissions by 15% by 2030 compared to the base year 2010 (by using 8307 Gigagrams of Carbon Dioxide equivalent or CO2e) as a baseline). Therefore, Botswana developed the UNDP National Climate Change Strategy and Action Plan in 2018 (UNDP, 2018). In a quite similar way, the Governments in Uganda and Kenya introduced different energy policies and initiatives to tackle climate change based on international agreements and yet to transform the traditional ways of energy utilization.

The Government of the Republic of Kenya has long noted the significant potential for power generation from renewable energy sources in the country. The Government has therefore sought the expansion of renewable energy generation in its overall power development plan for the period 2017 to 2037. The projection is that by the year 2037, renewable energy sources will provide just over 60% of the installed power capacity in the country.

Kenya adopted the Energy Act No. 1 of 2019 (the Energy Act) to, among other objectives, promote the generation of renewable energy in Kenya. The Energy Act mandates the Cabinet Secretary for the Ministry of Energy and Petroleum to develop, publish and review energy plans concerning renewable energy to ensure the delivery of reliable energy services and to, at a minimum, cost and develop a conducive environment for the promotion of investments in energy infrastructure development. To promote energy investments, national and county governments are required to facilitate the acquisition of land for energy infrastructure development (CMS 2023).

The Energy Act establishes the Energy and Petroleum Regulatory Authority (EPRA) to, among other functions: regulate the production, conversion, distribution, supply, marketing and use of renewable energy; collect and maintain energy data; ensure, in collaboration with the Kenya Bureau of Standards, that only energy-efficient and cost-effective appliances and equipment are imported into the country; and coordinate the development and implementation of a national energy efficiency and conservation action plan.

The powers of the Authority include, but are not limited to, the power to issue and renew licenses and permits for all undertakings and activities in the energy sector; manage electric power tariffs and tariff structures; investigate tariff charges; formulate, set, enforce and review environmental, health, safety and quality standards for the energy sector; approve electric power purchase and network service contracts for all persons engaging in electric power undertakings; investigate and determine complaints or disputes between parties over any matter relating to licenses and license conditions under the Energy Act; and impose such sanctions and fines as may be appropriate for violation.

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The Energy Act establishes the Tribunal to hear and determine civil disputes and appeals from the EPRA and any other licensing authority relating to the energy and petroleum sector. The Tribunal has powers to grant equitable reliefs including, but not limited to injunctions, penalties, damages, specific performance and the power to, on its motion or upon application by an aggrieved party, review its judgments and orders.

The main purposes of the RERC are to spearhead the development of renewable energy resources in Kenya and to accelerate the pace of rural electrification in the country. The RERC is mandated under the Energy Act to undertake feasibility studies and maintain data to avail the same to developers of renewable energy resources and provide an enabling framework for the efficient and sustainable production, conversion, distribution, marketing and utilisation of renewable sources in Kenya (CMS 2023).

Kenya's renewable electricity grid is at 90 per cent. According to the African Development Bank, Africa's energy financing gap as of May 2022 is $24.5 billion (Sh2.96 trillion) annually. The Electricity Sector Association of Kenya (ESAK) has unveiled key measures to enable Kenya to achieve 100 per cent renewable energy (RE) by 2030. This is even as it reaffirms its commitment to the global climate agenda. Recent Energy statistics report by the Energy and Petroleum Regulatory Authority (EPRA) shows that Kenya has promising potential for power generation from renewable energy sources. Following a least-cost approach, the government has prioritized the development of geothermal and wind energy plants as well as solar-fed mini-grids for rural electrification.

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4. Regional Collaborative Efforts

Ethiopian envisions energy integration across the East African nations and initiatives are underway which is grounded by a long-term vision of an integrated, prosperous and resilient East Africa (Späth et al., 2022). There are several policies and initiatives in place to support collaboration and cooperation on renewable energy in East Africa. One of the most important is the East African Community (EAC) Energy Strategy, which was adopted in 2012. The strategy calls for the EAC member states to develop a common energy market, promote the use of renewable energy, and improve energy efficiency. In addition to the EAC Energy Strategy, several other regional initiatives support renewable energy cooperation. For example, the Eastern Africa Power Pool (EAPP) is a regional power pool that allows member states to buy and sell electricity from each other. The EAPP has played an important role in facilitating the trade of renewable energy in the region. The SE4All initiative has several regional initiatives in place, including the East Africa SE4All Hub. The East Africa SE4All Hub is a platform for governments, donors, and the private sector to collaborate on the implementation of SE4All goals in the region. Here are some specific examples of collaboration and cooperation on renewable energy in East Africa (Mugisha et al., 2021):

- In 2019, Kenya and Ethiopia signed a power purchase agreement to allow Kenya to import 200 MW of electricity from Ethiopia's geothermal power plants. This agreement will help to reduce Kenya's reliance on fossil fuels and increase its access to clean, renewable energy.
- In 2020, the EAC member states signed a memorandum of understanding to develop a regional renewable energy market. The memorandum of understanding calls for the member states to harmonize their renewable energy policies and regulations, and to promote the cross-border trade of renewable energy.
- In 2021, the East Africa SE4All Hub launched the East Africa Renewable Energy Investment Program. The program aims to mobilize $1 billion in investment for renewable energy projects in the region.

Collaboration and cooperation on renewable energy in East Africa is still in its early stages, but there is growing momentum for regional cooperation. The policies and initiatives that are in place are helping to create a more favourable environment for renewable energy investment and development. As the region continues to invest in renewable energy, it is important to ensure that the benefits are shared equitably. This means ensuring that renewable energy projects are developed sustainably and inclusively and that they create jobs and opportunities for local communities.

In conclusion, collaboration and cooperation between states in East Africa and other sections of Africa are essential to accelerate the deployment of renewable energy and

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achieve its full potential. The policies and initiatives that are in place are helping to create a more favourable environment for renewable energy investment and development. As the region continues to invest in renewable energy, it is important to ensure that the benefits are shared equitably.

In 2020, the government of Botswana launched the Rooftop Solar Programme (IRENA, (2021). This initiative allows that allows residential and commercial clients to install grid-tied and hybrid solar systems and feed power back into the national grid. The produced excess electricity, which is feed-in the grid, will be paid out by Botswana Power Cooperation through the energy bill (Botswana Energy Regulatory Authority, 2020).

The Mega Solar initiative was launched (based on the signing of a memorandum of intent between all partners in 2021) as a commitment to large-scale solar development collaborations between Power Africa, the Governments of the Republic of Botswana and Namibia, the International Finance Corporation, the International Bank for Reconstruction and Development (World Bank), and the African Development Bank to support the development of Southern Africa's largest solar-generation project (2-5 GW solar power). The Mega Solar initiative will also strengthen the legal and regulatory frameworks for renewable energies in both Botswana and Namibia, the focal countries.

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5. International Support and Initiatives

There is a lot that can be learned in both directions from the EU to Africa or vice versa. In terms of different developments, in the development of renewable energy, methods used in the development, cultural and religious laws and practices.

International collaboration and cooperation on renewable energy is essential to address the global challenge of climate change and achieve a sustainable energy future. Renewable energy technologies have the potential to provide clean, affordable, and reliable energy for all, but their deployment requires significant investment and coordination. There are several benefits to international collaboration and cooperation on renewable energy. First, it can help to reduce the cost of renewable energy technologies and infrastructure. By working together, countries can pool their resources and negotiate better deals with suppliers. Second, international cooperation can help to accelerate the development and deployment of new renewable energy technologies. By sharing research and expertise, countries can bring new technologies to market more quickly. Third, international cooperation can help to promote the transfer of renewable energy technologies to developing countries. This can help to reduce global greenhouse gas emissions and support sustainable development.

There are several international policies and initiatives in place to support collaboration and cooperation on renewable energy. One of the most important is the Paris Agreement, which was adopted in 2015. The Paris Agreement is a legally binding international treaty that sets out a global framework to avoid dangerous climate change. Another important international initiative is the Sustainable Energy for All (SE4All) initiative, which is a global effort to achieve universal access to affordable, reliable, and sustainable energy services by 2030. The SE4All initiative has several global and regional goals, including increasing the share of renewable energy in the global energy mix to 30% by 2030. There has been promising progress in how much renewable energy can reduce carbon emissions in the EU (IEA 2020). Among EU nations Nordic nations were among the best who have been using renewable energy in their national energy mix.

In addition to the Paris Agreement and SE4All, several other international organizations and initiatives support collaboration and cooperation on renewable energy. These include the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), and the UN Climate Change Conference of the Parties (COP). Moreover, the International Solar Alliance (ISA) and the Global Geothermal Alliance (GGA) are intergovernmental organizations founded to promote solar geothermal energy development. The Global Green Growth Institute (GGGI) is also an intergovernmental

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organization that works with governments to develop and implement green growth strategies. GGGI has several programs that support renewable energy development, such as the Renewable Energy Integration Program, which helps countries integrate renewable energy into their power grids.

There are several benefits from international collaboration and cooperation on renewable energy. First, it can help to reduce the cost of renewable energy technologies and infrastructure. By working together, countries can pool their resources and negotiate better deals with suppliers. Second, international cooperation can help to accelerate the development and deployment of new renewable energy technologies. By sharing research, methods (such as the Energy Village Concept) and expertise, countries can bring new technologies to market more quickly. Third, international cooperation can help to promote the transfer of renewable energy technologies to developing countries. This can help to reduce global greenhouse gas emissions, local energy security, new job creation, local regional or national economic development, support sustainable development and much more.

The International Renewable Energy Agency (IRENA), in collaboration with Kenya, Denmark, Germany, and the United Arab Emirates founded a new partnership on 4 September 2023, pledging to boost renewable energy in Africa called the Accelerated Partnership for Renewables in Africa (APRA) at the first Africa Climate Summit in Nairobi. In addition to Kenya, APRA includes Ethiopia, Namibia, Rwanda, Sierra Leone, and Zimbabwe. The partnership focuses on three key areas: mobilizing finance, providing technical assistance and capacity building, and engaging the private sector. Partners are inviting other countries as well as public and private sector organizations to join APRA to amplify efforts, lead ambitious climate action, and implement effective green energy strategies.

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6. Regulatory Frameworks and Incentives

International organizations play a vital role in supporting African countries to develop and implement regulatory frameworks and incentives for renewable energy access. Some of the key organizations and their activities include:

International Renewable Energy Agency (IRENA): IRENA is the global intergovernmental organization that supports countries in their transition to a sustainable energy future. It provides technical assistance and capacity building to African countries on a range of issues, including renewable energy policy and regulation, resource assessment, and project development. IRENA also leads the Renewable Energy Roadmaps (REmap) initiative, which has developed country-specific roadmaps to scale up renewable energy deployment in Africa.

Africa Renewable Energy Initiative (AREI): AREI is a continent-wide initiative to accelerate the deployment of renewable energy in Africa. It is supported by several international partners, including the African Union, the European Union, and the United States. AREI provides financial and technical assistance to African countries to develop and implement renewable energy policies and programs.

World Bank: The World Bank provides a range of financial and technical assistance to African countries to support the development of renewable energy. It also works to promote regional integration and cooperation on renewable energy.

Global Environment Facility (GEF): The GEF is a global multilateral fund that supports developing countries to address global environmental challenges. It provides funding for a range of renewable energy projects in Africa, including small-scale renewable energy systems for rural communities.

United Nations Development Programme (UNDP): UNDP works with African countries to develop and implement sustainable energy policies and programs. It also provides support for the development of renewable energy projects, including mini-grids and solar irrigation systems.

In addition to these organizations, several other international development partners are also supporting African countries to develop and implement regulatory frameworks and incentives for renewable energy access. These include the European Union, the United States, Germany, and the United Kingdom. Some of the key regulatory frameworks and incentives that international organizations are supporting African countries to develop and implement include:

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Feed-in tariffs (FITs): FITs are a policy mechanism that sets a guaranteed price for renewable energy electricity. This can help reduce the risk of investment in renewable energy projects and make them more attractive to investors. One article that shows the benefit of FITs is Probst et al. (2021).

Net metering: Net metering is a system that allows renewable energy generators to sell any excess electricity they generate back to the grid. This can help to reduce electricity bills for consumers and encourage the installation of renewable energy systems.

Auction mechanisms: Auction mechanisms can be used to allocate renewable energy capacity to developers competitively and transparently. This can help to reduce the cost of renewable energy and attract investment.

One-stop shops: One-stop shops can be used to streamline the process of obtaining permits and licenses for renewable energy projects. This can help to reduce the time and cost of developing renewable energy projects.

Local content requirements: Local content requirements can be used to ensure that a certain percentage of the goods and services used in renewable energy projects are sourced locally. This can help to boost local economies and create jobs.

International organizations are also supporting African countries to develop and implement regulatory frameworks and incentives for the development of mini-grids and off-grid renewable energy systems. These frameworks and incentives are essential for attracting investment and scaling up the deployment of renewable energy in Africa.

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6. Showcasing an Exemplary Case of Energy Village

Energy villages are communities that aim to produce their renewable energy and become self-sufficient in terms of their energy needs. They can be implemented in a variety of ways, but typically involve a combination of renewable energy generation, energy efficiency measures, and smart grid technologies. Finland is one of the leading countries in the world in the implementation of energy villages. In 2010, the University of Vaasa started the EnergiBy project, which aimed to create 10-15 energy villages in Finland by 2020. Afterwards, there have been at least three large projects related to the Energy Village concept at the University of Vaasa (Energy Village project, Energy Village 500 project and ASPIRE project). These projects and others were very successful, and there are now over 20 energy villages in Finland. Some of the key features of energy villages in Finland include:

Community ownership and engagement: Energy villages are typically owned and operated by the community. This helps to ensure that the benefits of the energy village are shared by all members of the community.

A mix of renewable energy sources: Energy villages typically use a mix of renewable energy sources, such as solar, wind, and biomass. This helps to reduce the risk of energy supply disruptions.

Energy efficiency measures: Energy villages typically implement a variety of energy efficiency measures, such as insulation, energy-efficient appliances, and smart energy management systems. This helps to reduce the overall energy demand of the community.

Smart grid technologies: Smart grid technologies can be used to optimize the use of renewable energy and improve the efficiency of the energy system. For example, smart meters can be used to collect real-time data on energy consumption and generation. This data can then be used to manage the energy system more effectively.

One example of an energy village in Finland is the village of Komossa. Komossa is a small village in western Finland with a population of around 200 people. The village has a mix of renewable energy sources, including solar, wind, and biomass. It also has several energy efficiency measures in place, such as insulation and energy-efficient appliances. Komossa became an energy village in 2015. The village's residents decided to develop an energy village plan after they became concerned about the rising cost of energy. The plan set out several goals for the village, including increasing the share of renewable energy in the village's energy mix, reducing energy consumption, and creating jobs in the renewable

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energy sector. The village has made significant progress towards achieving its goals. The share of renewable energy in the village's energy mix has increased from 20% in 2015 to 60% in 2023. The village has also reduced its energy consumption by 15% over the same period. The development of Komossa into an energy village has had several benefits for the community. The village is now more energy-self-sufficient and less reliant on imported energy. This has helped to reduce the village's energy costs. The development of the energy village has also created jobs in the renewable energy sector. The implementation of energy villages in Finland is a good example of how communities can transition to a more sustainable energy future. Energy villages offer several benefits, including reduced energy costs, increased energy security, and job creation.

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7. Conclusion

Renewable energy has the potential to play a major role in addressing Africa's energy challenges and supporting its sustainable development goals. Renewable energy resources are abundant in Africa, and the cost of renewable energy technologies has fallen dramatically in recent years. Governments across Africa are increasingly recognizing the potential of renewable energy and are putting in place policies and initiatives to support its development and deployment. In addition to these policies and initiatives, African governments are also working to create a more enabling environment for renewable energy development. This includes reforming the energy sector, improving access to finance, and developing the capacity of the renewable energy sector workforce.

At the international level, there is a growing recognition of the importance of renewable energy access in Africa. Several international organizations and development partners are providing financial and technical assistance to support renewable energy development in Africa. The policies and initiatives at both the national and international levels are helping to accelerate the deployment of renewable energy in Africa. However, there are still several challenges that need to be addressed, such as the high upfront cost of renewable energy projects and the need to develop the capacity of the renewable energy sector workforce. Despite these challenges, the outlook for renewable energy in Africa is positive. The cost of renewable energy technologies is continuing to fall, and there is a growing commitment from African governments and the international community to support the development of renewable energy. As a result, renewable energy is expected to play an increasingly important role in meeting Africa's energy needs and supporting its sustainable development goals.

The literature review of Africa's renewable energy development and direction presents what kind of renewable energy development has been progressing in Ethiopia, Botswana, Uganda and Kenya as a case study representative of the African content. There has already been a lot of renewable energy development going on in Africa, which is very promising for the possibility of future energy security and economic development in Africa.

Having such a method or concept as the 'Energy Village Concept' can help the whole of Africa and/or the developing nations to speed up and promote renewable energy in their energy mix. Therefore, they benefit from the readily available natural energy resources in the local area not only to help the local economy or reduce climate change pollution but also to ensure the energy security of their nation.

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