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Identification of obstacles to in/11/ation and success factors

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Summary

The objective of task 14.9 which is reported in this deliverable was to identify factors that contribute to the market success of innovation, as well as to examine the barriers that hinder innovations regarding establishing Energy Villages in Africa. The project partners had several meetings with stakeholders and villagers in Botswana, Namibia, Kenya and Uganda. Based on questionnaire surveys, all partner countries collected information on the energy potential and the energy vectors in the energy villages. The meetings also reveal major obstacles to innovations. As a result, across the partner countries, a major obstacle to social innovation is the fear of changing from traditional cooking using firewood to renewable energy solutions. To overcome this obstacle, it is important to provide training and offer short courses about renewable energy. So knowledge sharing and training is a key success factor that was identified to close the knowledge gap of villagers, especially in rural energy villages. In contrast to the situation in European countries, across all partner countries, poverty through high unemployment rates and the lack of jobs with high income in rural energy villages is a major obstacle that hamper the implementation of self-sustaining renewable energy systems. The meetings with villagers have revealed that villagers have no equity capital and the banking sector has no financial products, such as microcredits, in place to support villagers with low income to purchase renewable energy systems. A success factor in social innovation is the availability of microcredit products for villagers with low incomes to overcome the low purchase power for renewable energy solutions in Africa. In addition, the lack of insurance is another obstacle to innovation. Thus, a further key factor to innovation is the availability of insurance products to reduce the risk when it comes to low-income households purchasing renewable energy solutions. In particular, security reasons in Ethiopia are reported as a further obstacle to innovation, because a regional conflict does not allow it to reach the energy village.

Approval

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September 2023

Identification of obstacles to innovation and success factors

as a deliverable for WP 14

Version Final

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Abbreviations and Acronyms

Acronym	Description
WP	Work Package
RE	Renewable Energy
RES	Renewable Energy Sources
EV	Energy Village
SDG	Sustainable Development Goals
DESCO	Distributed Energy Services Company
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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So knowledge sharing and training is a key success factor that was identified to close the knowledge gap of villagers, especially in rural energy villages. In contrast to the situation in European countries, across all partner countries, poverty through high unemployment rates and the lack of jobs with high income in rural energy villages is a major obstacle that hamper the implementation of self-sustaining renewable energy systems. The meetings with villagers have revealed that villagers have no equity capital and the banking sector has no financial products, such as microcredits, in place to support villagers with low income to purchase renewable energy systems. A success factor in social innovation is the availability of microcredit products for villagers with low incomes to overcome the low purchase power for renewable energy solutions in Africa. In addition, the lack of insurance is another obstacle to innovation. Thus, a further key factor to innovation is the availability of insurance products to reduce the risk when it comes to low-income households purchasing renewable energy solutions. In particular, security reasons in Ethiopia are reported as a further obstacle to innovation, because a regional conflict does not allow it to reach the energy village.

Keywords

Energy village; Renewable energy; Renewable energy resources; Energy consumption and potential; Stakeholders; High Investment costs; Low equity capital; Distributed Energy Services Company

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1. Introduction

Africa is expected to become an increasingly energy-demanding continent now more than ever. As it stands now, with 1/5th of the world's population, Africa accounts for only 6% of global energy demand and little more than 3% of electricity demand. About 11% of the global population lacks access to modern electricity of which more than 80% are in Sub-Saharan Africa, developing Asia and South America predominantly located in rural areas. Moreover, the average energy consumption per capita in most African countries is well below the world average and traditional use of bioenergy is still the largest source of energy in Africa, meeting 45% of primary energy demand and over half of final energy consumption, with serious consequences on health and pressure on the environment (deforestation, biodiversity loss). As is well-known the African Union is determined and committed to the full implementation of the Paris Agreement. Ever since many initiatives here at home and from international organisations have been underway to investigate renewable energy resources and energy-efficient mechanisms in alignment with Sustainable Development Goals (SDGs). Even so, Africa has a long way to go before this comes true and is awaiting more initiatives to play a key role. Accelerating the use and adoption of renewable energy (RE) in society is critical to achieving Sustainable Development Goals.

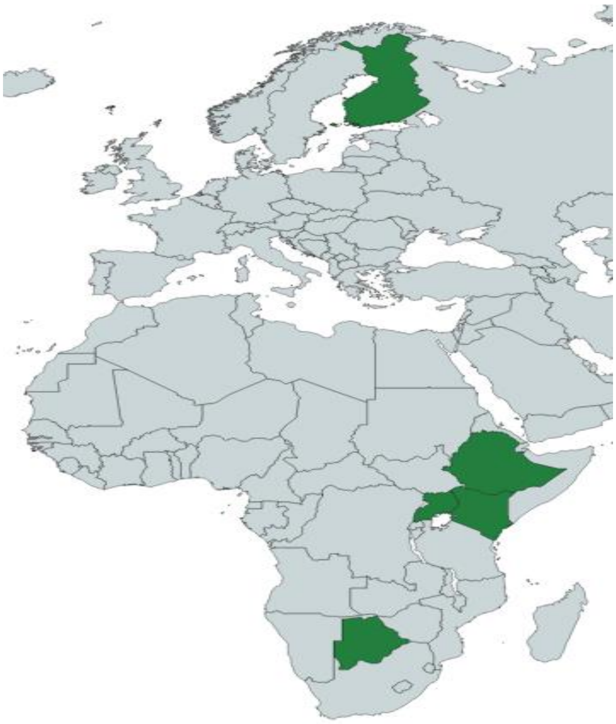

Figure 1: Visualization of the partner countries in Sub-Saharan Africa together with the WP leader from Finland in WP14 of the LEAP-RE project.

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A promising initiative is the LEAP-RE (Long-term Europe-Africa Partnership on Renewable Energy) project which focuses on specific objectives, such as accelerating the usage of reliable, sustainable and affordable renewable energy to name a few. The LEAP-RE project has a constituting consortium of 96 partners; 21 from African countries and 13 from European Union countries. Under its work package 14, four organisations in Africa namely AASTU in Ethiopia, MU in Kenya, MaK in Uganda, BIUST in Botswana and one in Europe namely UVA (the leader) in Finland are establishing energy villages (see Figure 1).

The energy villages and the respective countries in Africa are shown in Table 1. The focus is to create in Ethiopia, Kenya, Uganda and Botswana energy self-sufficient villages, i.e., generation of own energy from local renewable energy sources and to identify the possibility of developing local businesses that can sell renewable energy.

Table 1: List of potential energy villages in Africa

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

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Thus, renewable energy village projects have gained prominence as models for achieving energy security, environmental sustainability, and community empowerment. These projects exemplify the successful integration of renewable energy technologies into the fabric of daily life, resulting in reduced carbon emissions and enhanced quality of life for residents. To be specific, access to affordable, clean, and sustainable energy drives economic growth by improving living standards and industrial productivity enabling social and economic development.

In each energy village, establishment of energy village community, several meetings with stakeholders have been organized. The energy village concept starts from an analysis of the energy potential in the village and the estimation of all energy vectors (electricity, heating, and transport) used by the villagers in rural areas. In each partner country of WP14, the project partners developed questionaries to address all energy vectors. Based on the questionnaires, the data collection has been made through several visits to the demonstration villages. After that, the surveys were analysed. As a result, the type and amount of energy consumption of each village were identified and quantified. Better yet, the potential the individual villages are endowed with renewable energy resources was pinpointed.

All project partners have observed that the community of the rural energy villages use firewood in large proportion the reason is that in rural area demonstration villages, the majority of villagers use the traditional way of cooking based on firewood. The firewood was collected in the neighbourhood of the villages through the villagers. For example, in addition to that the villagers in Botswana's rural areas (Jamataka, Majawanaadipitse and Matsaudi) use the selling of collected firewood along the road through the village as a source to create income. Yet, renewable energy resources such as solar, wind and other biomass are untapped resources that have the potential to radically change the energy usage of the energy villages. With no procrastination, the utilisation of these renewable energy resources in the energy villages seems the way forward. In this context, the Energy Village Concept is a promising approach that evaluates the currently used sources of energy together with the potential renewable energy sources that provide the development of smart standalone solutions for rural areas (the overall process is displayed in Figure 2). In Figure 2 stages already starting from stages 2 – 4 can be achieved by future projects and investments, according to the previous plans of Energy Village concepts that were implemented in Finland and EU nations. Similar steps can also be taken during practising and implementing the Energy Village concept in Africa.

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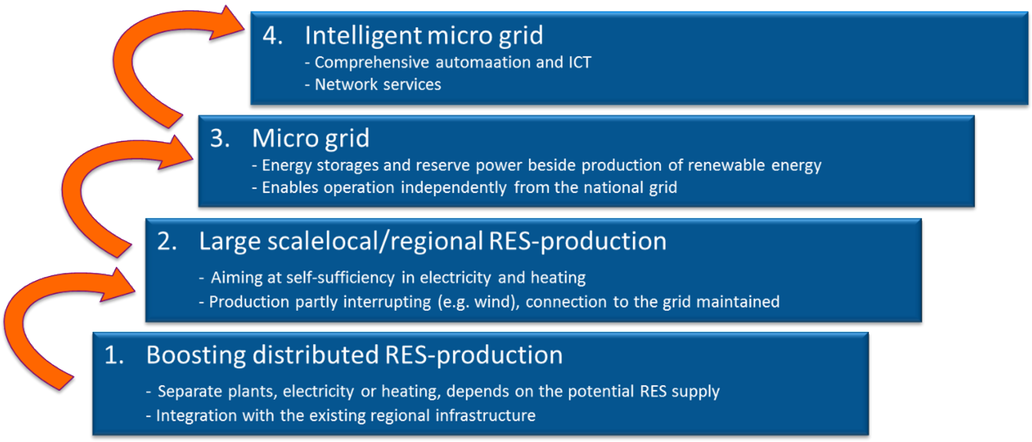

Figure 2: Multi-annual Roadmap through the Energy Village concept to achieve energy security, environmental sustainability, and community empowerment through smart stand-alone systems.

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2. Analysis of Obstacles to Innovation

Innovation is a way to implement ideas that lead to new or improved products, and services. The overall aim is turning ideas into sustainable tangible values which often happens through the business models reflecting the ability to innovate. We can classify different types of innovations. Two main categories are economic innovations and non-economic innovations, respectively. Technical innovations belong to economic innovations, while non-economic innovations are, for example, social innovations or green innovations.

Our focus in WP 14 is the development of an energy village concept that aims to provide, for example, in rural villages with a resilient and durable energy solution including local value creation, rural entrepreneurship, and fair employment. In addition, this also implies a way for the decarbonisation of rural regions targeting long-term carbon neutrality, with a strong replication potential. The interplay between social, economic, environmental and innovation aspects for the development of a successful sustainable, resilient and durable energy supply in rural areas can be represented by a four-node network topology (see Figure 3). Searching for an affordable renewable energy solution can be linked to that network.

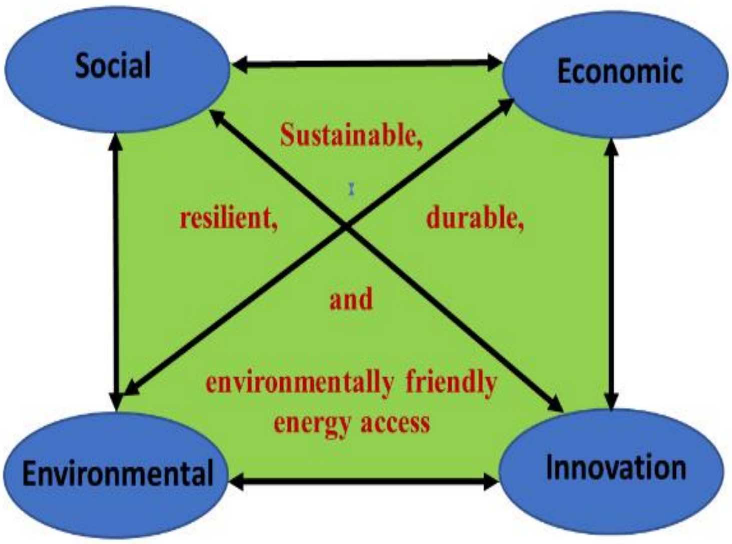

Figure 3: Four-node network representation scheme visualizing the interplay between social, economic, environmental and innovation aspects for the development of a successful sustainable, resilient and durable energy supply in rural areas.

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Identifying obstacles/barriers to an innovation strategy before setting it out helps to turn ideas into tangible value or to establish sustainable business models.

This empowerment of consumers into active players is currently one of the main social innovation challenges for the electrification of rural areas and can be seen as one of the obstacles to innovation. While in most projects technological innovations are the main focus, social innovation and the incorporation of wider societal aspects are regularly overlooked in the design phase of innovation processes. For example, social innovation is to define new roles in an energy village community compared to the existing or traditional roles.

- Traditional roles are
- working on cattle posts,
- do farming (ploughing, growing crops),
- produce traditional bricks,
- work as peace jobbers to build traditional houses
- collecting and selling firewood.

Rural villages in Sub-Saharan Africa have a high unemployment rate and villagers have a low income. The fear of changing traditional roles is another obstacle to innovation to implement renewable energy solutions, such as moving from traditional cooking with firewood to solar cooking. A third obstacle is the limited eigen-capital due to low income and the associated poverty in rural energy villages in Africa. For low-income regions, there is also a lack of innovative investment strategies offered by the banking sector. Another obstacle is short-term thinking because a limited eigen-capital and the poverty trap in rural areas lead to long cashback cycles for renewable energy solutions in energy villages. Also, the lack of innovative business models like the establishment of community DESCO companies is an obstacle to innovation. This goes ahead with the lack of leadership to establish sustainable renewable energy solutions. Moreover, geographical constraints and education level are significant obstacles to achieving green innovations. Finally, security reasons in serval countries in Sub-Saharan Africa can be seen as an obstacle to innovation. Differently speaking, local and regional conflicts make it often impossible to reach energy villages.

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2.1 Obstacles Identified in Botswana

Major barriers are the non-availability of resilient and affordable technological solutions and socio-economic factors that hamper the implementation of self-sustaining renewable energy systems in rural areas of Botswana. The poverty trap, generated by low income and high unemployment, in rural areas, is a further key reason for long cashback cycles in villages (Kumur, Prasad, Samikannu, 2018). Also, the lack of innovative investment strategies offered by the banking sector the access to investment is a major obstacle in Botswana. Loan products like microcredits and crowdfunding opportunities are of crucial importance (see Chapter 3) to purchase RES for villages with no equity capital. Based on several visits with stakeholders, another obstacle to social innovation in Botswana is the fear of changing from traditional cooking using firewood to renewable energy solutions.

Figure 4: Observed energy waste and the energy data for the aircon used at Regent Hill School.

Looking at Village 1 - Regent Hill International School in Gaborone - the school has pre-primary, primary and secondary school classrooms, facility buildings, a sports ground, a garden and a swimming pool. For the school, we performed an energy audit. The school in Gaborone is grid-connected and has operated since 2021 a small grid-tied 39kWp solar system (no storage) for both self-consumption and selling electricity to the grid. We also have access to the energy data showing the load, the energy used from the grid, and the renewable energy production. We monitor the energy used from the grid, the own consumption of the electricity produced by the solar system as well as the overproduction that is sent to the grid. The base load is 15kW. During the week 100% of the production is consumed by the school. Only at the weekend, energy is exported to the grid. The school

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is part of the rooftop program and gets paid for the overproduction sent to the grid. The energy audit shows that the school has high demand peaks in their load profile when starting the school business from 7 a.m. to 4 p.m. Especially during the wintertime the load peak jumps in the morning from a base load of 15 kW to 150 kW. A major objective of innovation is the high peak demand. The reason is the electrical heating through the aircon in each classroom and that fluorescent lamps are running at night and during the day (Figure 4). At night and during the weekend, the energy consumption is the base load. The school bought a gas heater to reduce the load in the wintertime to avoid load peaks leading to enormous costs and associated penalties from Botswana Power Cooperation (BPC), the energy supplier. As a consequence, the school buys energy from the national grid at the maximum price.

Figure 5: Solar systems in households and generators used by households in Jamataka.

Jamataka – Village 2 – consists of private households, the Kgotla, a cultural/community meeting point; the primary school; the clinic and village administration facilities The residents bank drinking water on a single water point and despite insufficient rainfall the community relies on agriculture as their primary source of income. Due to the widespread nature of Jamataka and the associated high costs for connecting low-income households to a local grid, the SolaNetwork project brought to life the idea of wireless grids and introduced a 10.8 kW PV plant with a battery rental system (10 kWh). The obstacle to the success of the battery rental system is the lack of adequate payment systems, such as mobile payment systems (Bardouille, Muench, 2014). In 2021, the national power grid extended its reach and erected a grid connection point on the outskirts of Jamataka. However, the issue of expensive grid connection to households remains the limiting factor and therefore is an obstacle to innovation for energy access in Jamataka. Only a few villagers can pay the costs to connect their households to the grid on the last mile. Figure 5 shows the common energy technologies used by households and businesses in Jamataka

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(Samikannu, Oladiran, Gamariel, Makepe, Keisang, Ladu,2022). A major obstacle is that these technologies have drawbacks such as being unreliable and emitting CO_2, for example, the generators. In addition, the available technologies are costly to maintain and operate. The majority of households use traditionally firewood for cooking. Meetings in the village reveal the fear of the villagers to change to solar cooking.

Figure 6: Traditional cooking with firewood, and solar systems in households in Majwanaadipidse.

In Majwanaadipitse – village 3- the meetings and the interviews with villagers revealed that the villagers doing a lot of farming. The situation is that most villagers have a low income and the unemployment rate is high. Most of the villagers only use firewood for cooking and low-quality solar lamps as light at night (Figure 6). A major obstacle to innovation is the fear of change, for example, how to cook. We found these fears during the IRES project (2018-2021) on research on combining a thermoelectric device with photovoltaic cells to enhance efficiency from waste heat collected from cooking as well and we still see neo-change in the mindset of the villagers in the energy village project. Another obstacle to innovation is the low purchasing power due to low income and lack of employment. Higher-income allows the next step to improve living conditions by purchasing, for example, electricity (off-grid PV solutions). We also had several meetings with the staff of the primary school in the village. The primary school is powered by an off-grid 50kWp micro-grid solar system with battery storage (four 40kWh Lithium Iron Phosphate battery backs) which is connected via transmission lines to the school buildings and staff houses. We have access to the PV production data and monitor the behaviour of

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the microgrid. Two aspects are observed, first of all, the batteries are fully charged at 11 a.m., i.e., the micro-grid is underutilized through the consumption. Based on the meetings and discussions with the staff, we observed difficulties in running the microgrid. The staff is not trained to analyze and solve errors and failures in the microgrid system. A major obstacle to innovation is the knowledge gap on how to maintain the microgrid and how to run the microgrid smoothly.

Finally, the meetings and the interviews in Matsaudi – village 4- have shown that the majority of the villagers are cooking with firewood. The villagers are very sceptical about replacing traditional cooking with firewood through solar cooking. The fear of change is one major obstacle to innovation here and is common for all rural energy villages (Jamataka, Majwanaadipitse, and Matsaudi) in Botswana. We identify as a barrier high initial investment cost. As a consequence, a second major obstacle to innovation in Botswana is low purchasing power due to low income and lack of employment.

2.2 Obstacles Identified in Ethiopia

Villages in Ethiopia have little or no access to clean energy supply, and villagers stick to tradition and culture. As was observed during field visits in different villages, traditions and specific cultures are one form of obstacles to change. The ways of energy usage these days remain as it was in the days of inception. Lack of awareness of efficient energy utilization adds another layer of obstacles and inclination to renewable energy resources is way less beyond what should be. Infrastructure has a negative impact across many villages in the event of establishing and spreading energy villages. Another major issue that comes into play when envisioning to electrify remote villages is the so-called security. A conducive environment to assess, quantify and implement renewable energy resources demands peace and order in the villages. However, some villages are inaccessible due to security matters. Amibera, the then-energy village, is one such village that has alarming security issues. Shortly after its inception, its establishment as a full-energy village was interrupted and then totally cancelled to a point of no return. Security, as is so often the case, is a barrier to development, against socio-economic changes and puts a wedge between a society. To determine the potential and the actual consumption of any form of energy in a certain village, the art-of-state equipment and instruments are required to make in-situ and ex-situ characterization and to collect/generate reliable data. The scarcity of such portable devices is an obstacle in some cases.

Be that as it may, renewable natural resources are abundant in the village. However, investment in renewable energy utilization be it from solar, wind, biomass or others is less common both from the government and the private sector. It seems that enforcing the

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implementation of energy policies and strategies that the country drafted with strong commitment is the way forward to overcome the challenges. Another obstacle that is encountered more often is red tape. As such, it was and is difficult to get enough and on-time data from the concerned body. All told, the obstacles befallen many during the assessment of renewable energy in each village namely the AASTU campus, Tulefa, Wonji and Langano. Yet, the opportunities and strengths are way more conducive to innovation and implementation.

2.3 Obstacles Identified in Kenya

The following villages were studied in Kenya: (i) Chebaiwo in Uasin Gishu County, (ii) Langas, Eldoret in Uasin Gishu County, (iii) Lelan in Elgeyo Marakwet County, (iv) Nandi Hills in Nandi County, and (v) Kerio valley in Kerio. The following were identified as obstacles to innovation and major challenges to the energy village concept and its implementation:

1. Difficulty in establishing contact with potential villages: It was challenging to establish contact with the prospective villages. Identifying the key persons of contact and influence is a challenge that was faced in all villages.
2. Difficulty in bringing people together and discussing the project: rallying the community to attend the community meetings to present and discuss the energy village concept was another challenge. Many people are busy trying to earn a living and it was not easy even finding a suitable and convenient time for the meetings.
3. Vested interests by various stakeholders: more often we encountered people with vested interests and who hoped to make individual gains through the project. Such people, often influential, could sway the communities to want to take control of the project.
4. Mistrust arising from previous failed projects in the communities: many of the communities had been involved in previous projects (not necessarily on the energy village concept or renewable energy) and some had previous bad experiences. Some even considered all projects to be avenues for a few people to amass wealth at the expense of the masses.
5. Difficulty in getting accurate data for modelling: in most of the villages the members could not provide accurate data on their energy consumption or even expenditure. This is because they are not used to keeping such records.
6. Translation of modelling tool to English: the application of the energy calculator which initially was not in English also proved problematic to the researchers and the communities.

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7. Lack of finances to support the transition from conventional energy sources to renewable energy sources. In most of the villages, there was an overwhelming willingness to embrace renewable energy sources but communities cited a lack of finances to make this a reality.

3. Identification of success factors to innovation

When looking at rural communities in Africa in a nutshell, apart from non-available resilient technological solutions, socio-economic factors, such as high levels of unemployment, hamper the implementation of self-sustaining renewable energy (RE) systems. Hence, the major challenges in supplying rural communities with RE are low purchasing power compared to high initial costs and lack of employment. In addition, within conventional solar photovoltaic energy installations, the bulk of value creation remains outside Africa. For the successful implementation of solar solutions in the rural SSA markets, the development of effective sustainable business models with employment potential is crucial. Key success factors for innovations are public acceptance of renewable energy solutions, the development of energy policies through policy-making authorities in the partner countries, access to the financial market, access to insurance, the knowledge of how to operate and maintain renewable energy installations successfully, and to well-designed business models to refinance investments (Figure 7).

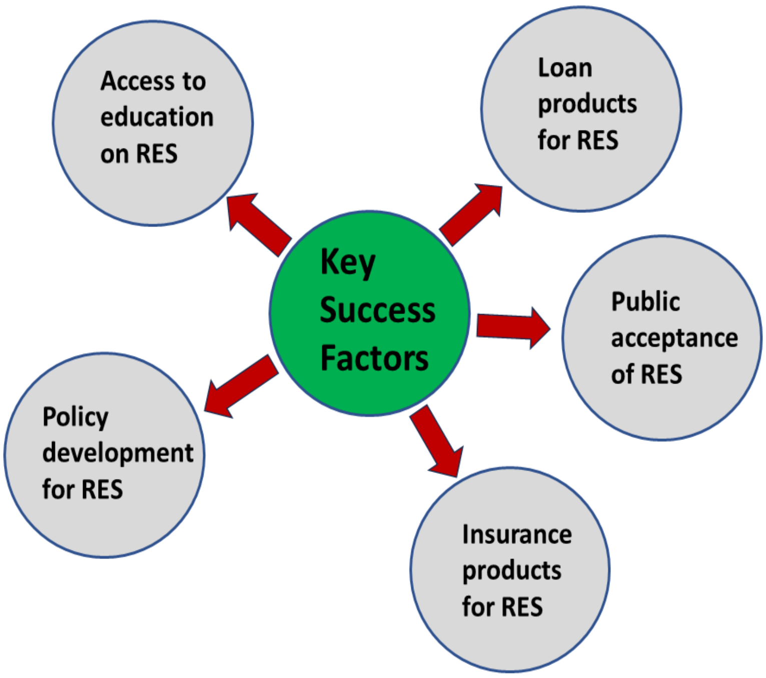

Figure 7: Key success factors to innovation for renewable energy solutions (RES) in energy villages.

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The public acceptance of sustainable renewable energy solutions can be achieved through education. In particular, through the development and offering of training and certified short courses. Training and certified short courses for operating and maintaining photovoltaic equipment are the key to the success of sustainable innovations in the energy village approach. As a first step, capacity building and educational training of villagers is crucial for the willingness to purchase renewable energy solutions. The purchase and successful operation of renewable energy solutions requires policy developments through governmental decision-making bodies, access to microcredits and crowdfunding opportunities. A crucial success factor is financing through microcredit concepts or crowdfunding together with risk reduction through insurance products to enable sustainable renewable energy solutions. Another key success factor for energy villages is the establishment of a DESCO as a community development company.

3.1 Success Factors Identified in Botswana

At Regent Hill School – village 1- we found that a success factor in innovation activities is to get access to Loan products from the banking sector. Thus, the introduction of innovative investment strategies would lead to the purchase and addition of battery storage as RES to the existing solar system at Regent Hill School and boost the full implementation of a self-sustaining renewable energy production system at Regent Hill School. Based on our energy audit, a second key success factor to innovation is the integration of a smart control system to reduce electrical energy waste at the Regent Hill School in Gaborone. A smart energy control system is key by reducing the operative time of items without any practical use at school during the opening time and therefore can reduce the electricity bill significantly. In combination with the added battery storage, this will reduce the peak load at the school significantly. A third success factor can be made by changing governmental policies by introducing an advanced tariff system with different tariffs over the day for selling overproduced electricity to BPC.

In our rural energy villages (Jamataka, Majwanaadipitse, and Matsaudi) we identified through several meetings, interviews and the questionnaire survey the following key factors that bring success in implementing innovation activities:

(i) Educational training through workshops and certified short courses is a key factor to have success that villagers in rural areas in Botswana will purchase and use renewable energy solutions for cooking and lighting houses. This is a key success factor for social innovation in Botswana to overcome fears of changing from traditional cooking using firewood to renewable energy solutions. Educational training requires two steps, first, it is necessary to provide a general introduction to renewable energy, because older villagers

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as well as the educational program at the primary school level give less attendance to the practical use and the underlying principles of renewable energy. In the second step, educational training needs to be conducted for villagers to run renewable energy systems correctly. In Figure 8, we see damaged inverters used in a household in Majwanaadipitse. The reason was an improper use of equipment. Another positive aspect is that educational training in Botswana will increase the public acceptance of RES, a prerequisite for purchasing RES.

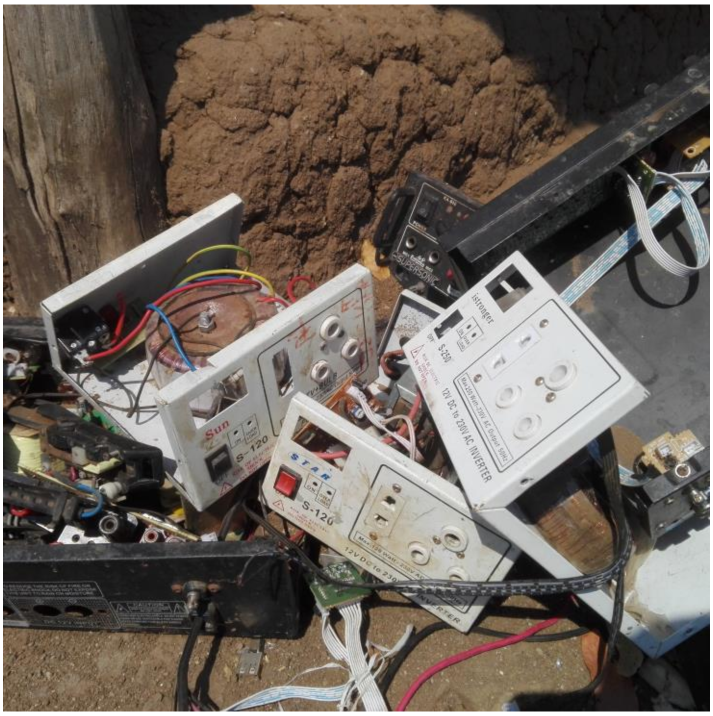

Figure 8: Damaged inverters used in a household in Majwanaadipitse.

(ii) The development of innovative investment strategies, such as microcredits, offered by the banking sector is a further key factor in implementing successful innovation activities in Botswana. Because of the low purchase power of the villagers (no with no equity capital) in Botswana (that is totally in contrast to the purchase power in Europe for RES) support through investments and loans is a key factor to drive innovation activities.

(iii) Insurance products are a third success factor in social innovations in Botswana. Insurance reduces significantly the risk for villagers and enables the acceleration of the green transition in Botswana.

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3.2 Success Factors Identified in Ethiopia

The progress made so far in the selected energy villages in Ethiopia is a milestone. In a nutshell, the way to implement the energy village concept is paved. Now that the energy consumption and potential of villages are quantified and pinpointed, drawing the attention of investors is an easy feat. Community engagement in the stated energy villages is one achievement in terms of awareness creation about the energy village concept. AASTU campus energy village is a typical example. The energy villages concept i.e. sufficient renewable energy supply within a village is the talk of the campus particularly at the top management level. Nor is that all, the concept is widespread to all, if not most, of the campuses in Ethiopia via the university leaders. The concept was presented to 45 university presidents and vices, and the AASTU campus energy village is considered to be a "seed" of replication to others.

Now the AASTU energy village team works closely with the management to radically change the traditional way of energy utilization. The team proposed a solar-biomass hybrid system solution based on the status quo and scenarios of AASTU to completely replace firewood consumption at the café and to obviate the power interruption. The proposed hybrid system consists of photovoltaic panels to cover the energy demand during peak Solar sun hour, flat plate collectors to provide hot water utilities and biodigester to produce biogas as an alternative for firewood consumption. Moreover, thermal energy storage is proposed in addition to batteries. The thermal energy storage mechanism involves PV to convert solar energy into electricity, and magnetite material to store the electrical energy in thermal energy at high temperatures. Thermal energy stored can be used in different appliances when the solar intensity is down.

Similarly, at Wonji Energy Village, an attempt was made to engage stakeholders and to have cooperation and collaboration with the top management of the factory. The options and the best ways to utilize renewable energy are pinpointed in collaboration with the experts in the village. As a sustainable energy supply solution, solar energy for the pumps used by out-grower farmers and a briquette made of cane top for the community are proposed.

The social factor that was achieved is another important step forward for innovative success. Orientations about renewable energy utilization to the residents of each village were delivered once again aiming to bring about behavioural and attitude changes. It is believed that it creates fertile ground for implementing the concept in practical terms. For full-scale implementation, the following key success factors are important:

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Community engagement and support: It is essential to have the support of the local community to establish an energy village. This means working with community leaders and members to develop a shared vision for the energy village and to ensure that it meets their needs and priorities.

Strong governance and policies: An energy village needs to have strong governance in place to ensure that it is managed effectively and sustainably. This includes having a clear governance structure, as well as policies and procedures in place for decision-making and financial management.

Renewable energy resources assessment: An energy village needs to have access to renewable energy resources to meet its energy needs. This could include solar, wind, hydro, or biomass energy.

Financial resources: Establishing and operating an energy village requires significant financial resources. This funding can come from a variety of sources, including government grants, private investment, and community fundraising.

Technical expertise: It is important to have the technical expertise necessary to design, install, and operate the energy system for an energy village. This includes having a team of engineers and other technical staff with the necessary skills and experience.

Partnership: Partnering with other organizations, such as government agencies, businesses, and non-profit organizations, can help to provide the resources and support needed to establish and operate an energy village.

Innovation: Innovation is important for developing and implementing new technologies and approaches that can help make energy villages more efficient, affordable, and sustainable.

Education and outreach: It is important to educate the community about the benefits of energy villages and how they can participate. This can help build support for energy villages and ensure that the community can reap the full benefits of these projects.

3.3 Success Factors Identified in Kenya

The following were identified as success factors in the energy villages in Kenya:

1. Overwhelming willingness by communities to embrace renewable energy sources such as solar and biogas for cooking and lighting. Given access to appropriate financial facilities and technical support, the energy villages can achieve energy sufficiency.

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2. Potential for replication: the success of the implementation of the energy village concept in these villages has the potential for cascading and replication in various parts of the country. During some of the community meetings, members inquired if we were planning to do this in other areas, hence demonstrating the potential for replication in other parts of the country.

3. The government of Kenya is keen on renewable energy sources and a way of addressing climate change concerns. Therefore, this can be the right moment to rally government support through the energy village concept to realize this.

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4. Conclusion

The partners provided an analysis of major obstacles to innovation in demo villages in their countries. In addition, key success factors are identified for establishing sustainable renewable energy solutions in Botswana, Ethiopia, Kenya, and Uganda. A summary of both the major obstacles and the key success factors in each energy village across the partner countries is presented in the Table 2.

Table 2: Summary of obstacles to innovation in energy villages.

Partner country	On-/Off-grid	Energy village	Obstacles
Ethiopia	On-grid	AASTU campus	Lack of long-term data about biomass
		Wonji	Lack of real-time data, specification of equipment, and red tape
	Off-grid	Langano	Not enough data on geothermal potential, and on-time data, Lack of awareness of efficient energy utilization, Lack of investment, security issues
		Amibera	Security issues to travel there. This village had been cancelled from the Energy village lists.
		Tulefa	Not enough and on-time data, Lack of awareness of efficient energy utilization, Lack of investment
Kenya	On-grid	Cheboiwo	Difficulty in establishing contact with potential villages, Difficulty in getting accurate data for modelling; Vested interests by various stakeholders
		Lagas	Difficulty in establishing contact with potential villages, Difficulty in getting accurate data for modelling; Vested interests by various stakeholders
		Nadi hills	Difficulty in establishing contact with potential villages, Difficulty in getting accurate data for modelling

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	Off-grid	Lelan	Difficulty in establishing contact with potential villages, Mistrust arising from previous failed projects
		Kerio Valley	Difficulty in establishing contact with potential villages, Mistrust arising from previous failed projects
Botswana	On-grid	Regent Hill School	Lack of access to financial products to finance and purchase battery storage
	Off-grid	Matsaudi	Fear of change, Knowledge gap in renewable energy, Lack of access to financial products to finance and purchase renewable energy solutions
		Majwanaadipitse	Fear of change, Knowledge gap in renewable energy, Lack of access to financial products to finance and purchase renewable energy solutions
		Jamataka	Fear of change, Knowledge gap in renewable energy, Lack of access to financial products to finance and purchase renewable energy solutions

Table 3: Summary of key success factors in energy villages.

Partner country	On-/Off-grid	Energy village	Key Success factors
Ethiopia	On-grid	AASTU campus	Community engagement and support, Strong governance and policies, Renewable energy resources assessment, Financial resources, Technical expertise, acceptance by the top management
		Wonji	Community engagement and support, Strong governance and policies, Renewable energy resources assessment, Financial resources, Technical expertise, acceptance by the top management
	Off-grid	Langano	Community engagement and support, Strong governance and policies, Renewable energy resources assessment,

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			Financial resources, Technical expertise
		Amibara	N/A
		Tulefa	Community engagement and support, Strong governance and policies, Renewable energy resources assessment, Financial resources, Technical expertise, and acceptance by the local administrators
Kenya	On-grid	Cheboiwo	Willingness by communities to embrace renewable energy sources, Cascading and replication of RES
		Lagas	Cascading and replication of RES, Government support
		Nadi hills	Cascading and replication of RES, Government support
	Off-grid	Lelan	A willingness by communities to embrace renewable energy sources, cascading and replication, Government support
		Kerio Valley	A willingness by communities to embrace renewable energy sources, cascading and replication, Government support
Uganda	On-grid	Nakasengere	N/A
		Wanale	N/A
	Off-grid	Kayanzi	N/A
		Refugee camp	N/A
		Maziba Murole	N/A
Botswana	On-grid	Regent Hill School	Loan products for purchasing RES
	Off-grid	Matsaudi	Educational training, Loan products for purchasing RES, Insurances to minimize the purchase risk of RES
		Majwanaadipitse	Educational training, Loan products for purchasing RES, Insurances to minimize purchase risk of RES
		Jamataka	Educational training, Loan products for purchasing RES, Insurances to minimize purchase risk of RES

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Bibliography

Kumur, S., Prasad, J., & Samikannu, R. (2018). Barriers to implementation of smart grids and virtual power plant in the sub-Saharan region—focus Botswana. *Energy Reports*, 4,119–128.

Bardouille, P., & Muench, D. (2014). *How a New Breed of Distributed Energy Services Companies Can Reach 500 mm Energy-poor Customers Within a Decade: A Commercial Solution to the Energy Access Challenge*. [WWW] UNFCCC Technology Mechanism. [WWW] Available from: www.ctc-n.org/resources/

Samikannu, R., Oladiran, M.T., Gamariel, G., Makepe, P., Keisang, K., & Ladu, N. S. D. (2022). An Assessment and Design of a Distributed Hybrid Energy System for Rural Electrification: The Case for Jamataka Village, Botswana, Hindawi International *Transactions on Electrical Energy Systems*, Volume 2022.

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