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

Business models which consolidate the achievements and allow managing the energy villages after the end of the project

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Summary

The aim of this deliverable 14.5 is to establish business models, which consolidate the achievements and allow managing the energy villages after the end of the project. This business model focuses on creating a vibrant community cantered around renewable energy, catering to both household (residential) and commercial needs. The deliverable of business models which consolidate the achievements and allow managing the energy villages after the end of the project gives business model for the LEAP-RE Energy Villages. By leveraging local resources, engaging the community and promoting sustainable practices, the renewable energy village can thrive while contributing to broader environmental, social and economic goals. The village may face challenges such as initial funding and technology adoption barriers. During these business model development and previous research there has been some main challenges noticed. 1) One of the key challenges in the project implementation of this EV is reliability. 2) Difficulty in getting accurate data for modelling. 3) Lack of financial loan products for purchasing renewable energy technologies and no insurances. 4) Educational training is needed to run and maintain renewable energy technologies. 5) Key challenges include securing the necessary financial resources. Moreover, 6) the need for specialized technical expertise and maintenance capabilities poses a challenge, particularly in a rural setting where skilled labor may be scarce. The business models can be considered strategic and conceptual tools that help firms understand, analyse, innovate and develop their businesses. Researchers have presented different perspectives on the business models in the academic literature. Nevertheless, these challenges present opportunities for innovation, collaboration and the development of scalable solutions that can be replicated in other communities. Technological integration will ensure that various renewable technologies are implemented, including solar panels and biomass systems. Smart grid technology will be utilized to optimize energy distribution and consumption, allowing for real-time monitoring and management.

Approval

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LEAP-RE

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

Research & Innovation Action

October 2025

D14.5 - Business models which consolidate the achievements and allow managing the energy villages

as a deliverable 14.5 for WP14

Version - Final

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Abbreviations and Acronyms

Acronym	Description
WP	Work Package
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
SDG	Sustainable Development Goals
DoE	Department of Energy
ECS	Energy Conversion Systems
UNHCR	United Nations High Commissioner for Refugees
EV	Energy Village

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Summary

The aim of this deliverable 14.5 is to establish business models, which consolidate the achievements and allow managing the energy villages after the end of the project. This business model focuses on creating a vibrant community cantered around renewable energy, catering to both household (residential) and commercial needs. The deliverable of business models which consolidate the achievements and allow managing the energy villages after the end of the project gives business model for the LEAP-RE Energy Villages. By leveraging local resources, engaging the community and promoting sustainable practices, the renewable energy village can thrive while contributing to broader environmental, social and economic goal. The village may face challenges such as initial funding and technology adoption barriers. During these business model development and previous research there has been some main challenges noticed: 1) One of the key challenges in the project implementation of this EV is reliability. 2) Difficulty in getting accurate data for modelling. 3) Lack of financial loan products for purchasing renewable energy technologies and no insurances. 4) Educational training is needed to run and maintain renewable energy technologies. 5) Key challenges include securing the necessary financial resources. Moreover, 6) the need for specialized technical expertise and maintenance capabilities poses a challenge, particularly in a rural setting where skilled labor may be scarce.

The business models can be considered strategic and conceptual tools that help firms understand, analyse, innovate and develop their businesses. Researchers have presented different perspectives on the business models in the academic literature. Nevertheless, these challenges present opportunities for innovation, collaboration and the development of scalable solutions that can be replicated in other communities. Technological integration will ensure that various renewable technologies are implemented, including solar panels and biomass systems. Smart grid technology will be utilized to optimize energy distribution and consumption, allowing for real-time monitoring and management. Regarding the economic model, the village adopts a cooperative model, where residents may share ownership of renewable energy assets, benefiting from lower energy costs and potential revenue from excess energy sales. By showcasing practical solutions to energy challenges, it not only serves its residents but also inspires broader societal change towards renewable energy adoption and sustainable practices. In conclusion, the energy village embodies the principles of sustainability, community engagement and innovation.

Keywords: Energy Village; Renewable Energy; Business Models Canvas; Sustainability; Energy Efficiency

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1. Introduction

Deliverable 14.5 – the Business models which consolidate the achievements and allow managing the energy villages after the end of the project, is the fourth deliverable of task 14.2. In this report we have developed business models for four energy villages located in Kenya, Ethiopia, Botswana and Uganda. Each of these business models describe how a chosen solution - renewable energy production - provides value for the energy village community. Moreover, it clarifies the roles of various stakeholders and what it takes to implement the solution in practise. The business cases will be highlighted, fostering the prosumer-like models, roles/impacts of stakeholders' local governments/energy distribution agencies, pricing as well as considering energy storages and/or advanced conversion to fuels. Again, the focus is both on separate technologies and the systemic level solutions. The studying Universities are AASTU in Ethiopia, BIUST in Botswana, Makerere in Uganda and Moi University in Kenya. The 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 to.

Table 1. List of energy villages in Africa chosen

S/N	Energy village	Country
1	Cheboiwo, Langas, Nandi Hills, Kerio Valley and Lelan	Kenya
2	AASTU, Tulefa, Wonji and Langano	Ethiopia
3	Regent Hill School, Regent Hill School, Jamataka, Majwannaadipitse and Matsaudi	Botswana
4	Nakasengere, Wanale, Refugee Camp, Maziba Murole and Kayanzi	Uganda

During these business model development and previous research there has been some main challenges noticed. 1) One of the key challenges in the project implementation of this EV is reliability. How reliable this project will supply power to the community as compared to the exiting energy options is a key area for consideration. 2) Difficulty in getting accurate data for modelling. In most of the villages located in remote areas, people do not have a record of the quantities and costs of their energy sources. 3) Lack of financial loan products for purchasing renewable energy technologies. No insurances products are in place to minimize purchase risks for renewable energy technologies. 4) Educational training is needed to run and maintain renewable energy technologies. Overcome fears when applying new renewable energy technologies, there is a strong need for a buy-in from the villagers into the energy village concept. 5) Key challenges include securing the necessary financial resources to cover the initial infrastructure setup, including the installation of wind turbines, solar panels, and biogas production facilities. Moreover, 6) the need for

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specialized technical expertise and maintenance capabilities poses a challenge, particularly in a rural setting where skilled labor may be scarce.

2. The Business Model Canvas

Business models can be considered strategic and conceptual tools that help firms understand, analyse, innovate, and develop their businesses. Researchers have presented different perspectives on the business models in the academic literature. Perhaps one of the most commonly applied tools is the Business Model Canvas by Ostwerwald and Pigneur (2005 and 2010). It describes how a business creates, delivers, and captures value through nine interrelated elements or business model blocks. In addition to the firm, Business Model Canvas has also been applied to the context of African villages [Mini-grid BM (2020) and World Report 15 (2016)]. In this deliverable, we use Business Model Canvas. Since the original Business Model Canvas primarily focuses on economic value, we extend the approach based on Bocken et al. (2014)'s and Joyce & Raymond (2016)'s idea to include social and environmental aspects. Next, we shortly describe the key idea of the Business model Canvas.

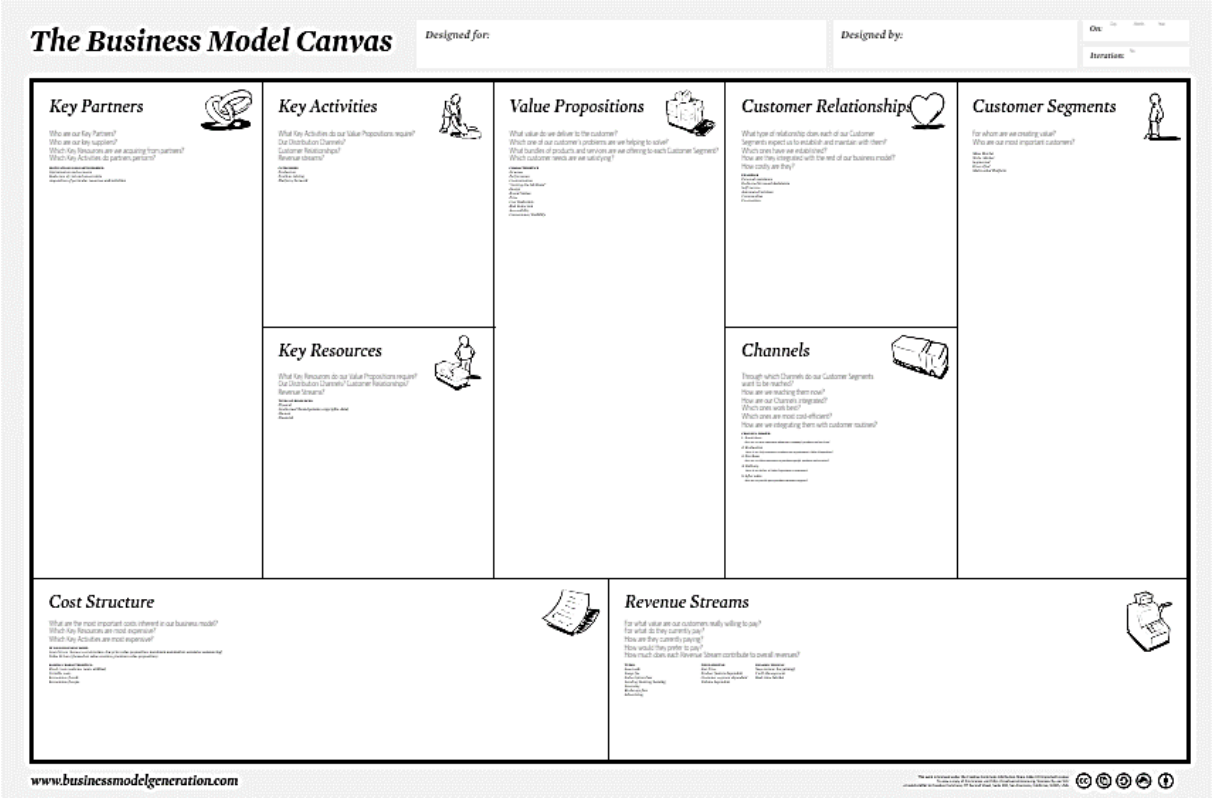

Figure 1 Business model Canvas comprises nine interrelated elements that jointly describe the business model and its logic

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The value proposition describes the value the products/services offer customers. This can be e.g. economic value (e.g., cost savings, new business opportunities), environmental value (less emissions), and social value (improved access to education, improved health). Customer segments describe the different types of customers (the local community) for which the service/product will be offered. Each customer segment may require a different value proposition since they target customers with different needs. Customer relationships describe how and by whom the relationship with each customer segment is managed and maintained, whereas Channels describe how product/service is marketed and delivered for the customers. Revenue streams describe the logic of revenue generation (e.g., streams and pricing models). Different customer segments might have different pricing models and ways to use products/services. Therefore, the business model may include several revenue streams and pricing methods.

The remaining business model elements describe what is needed to implement the business model and deliver customer value. Key partners comprise organizations with critical roles as enables or collaborators concerning the business model, providing key resources or activities needed to craft the value proposition. Key activities describe the most important activities needed for the business model implementation, whereas Key resources describe necessary resources (e.g., physical, human, or intellectual), skills, and competences. Therefore, key resources and key activities are highly interrelated. Finally, Cost structure describes the costs related to implementing the business model, mainly from key activities, resources, and partnerships, as well as from building and maintaining channels and customer relationships. In WP14, the partners from Uganda, Botswana, Ethiopia, and Kenya have chosen one energy village and built a business model for renewable energy production. Those business models are described in the following sub-sections: short context descriptions, holistic business model analysis, and short summaries.

2.1. The LEAP-RE Business Models

This chapter provides business model design and analysis for renewable energy production in four different villages in African.

2.2. Uganda

2.2.1. Description of the context (the demo village) and the solution

Uganda has established a number of Energy Villages namely Nakasengere, Maziba Murole, Refugee Camp. The Refugee Camp EV, located as shown in Figure 2 was chosen as a demo village in this context. This EV was designed for a humanitarian community specifically in

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the Northern Uganda district of Yumbe. Bidibidi was founded with the gazetting of 250 square kilometres of communal land by the host community, negotiated by the Office of the Prime Minister (OPM), through local officials and local community leaders.

Figure 2 Map showing the location of the chosen model village (Bidibidi refugee camp).

Selected population for the design of the EV was Refugee and host community in Zone Two in Bidibidi Refugee Settlement because it contained an average number of households per zone in the settlement. It also had most of the social amenities such as health centres, schools, women center, churches and mosques which were important in attaining the right energy demand picture for the zone. Zone two that lies on latitude 3.5222462 and longitude 31.3359669 was selected for this study purposely because it contained an average number of households per zone in the settlement. It also had most of the social amenities such as health centers, schools, women center, churches and mosques. It contains 8,343 households and 49,754 individuals comprising of both host and refugee community. The zone sits on a land size equivalent to 19.02 km2 with over 60% of the land space unoccupied or agricultural land UNHCR (2018). Survey questionnaires were administered to a sample of 380 households stratified random sampling technique comprising of 70% refugees. Table 2 shows the business canvas for Refugee Camp EV in Uganda.

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2.2.2. Business model design (business model canvas filled in + analytical description of each block)

Table 2. Business canvas for Refugee Camp EV in Uganda

<table>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Propositions</th>
<th>Customer Relationships</th>
<th>Customer Segments</th>
</tr>
<tr>
<td rowspan="2">

Ministry of Energy and mineral development
United Nations High Commissioner for Refugees (UNHCR)
The office of the Prime Minister
Energy consultants
Suppliers
Construction firms
Safety consultant
Electricity Regulatory Authority (ERA)
National environment regulatory authority

</td>
<td>

Social and environmental impact assessment
Power systems design, installation and commissioning
Power/energy distribution
Tariff and power sales
Finance mobilization
Community sensitization and dialogues

</td>
<td rowspan="2">

Increasing electricity reliability
Reduction in emission
Environmental protection
Improvement of livelihoods especially for the ladies
Reduced cost of energy
Improvement in literacy levels in the community
Job creation

</td>
<td>

Deployment of IT to streamline customer interactions
Setting up marketing strategies that are customer specific
Timely response to energy supply interruption
Ensuring the grid reliability

</td>
<td rowspan="2">

Host/rural communities in the village (households, and social amenities)
Refugees settled in the village (Households and social amenities)
Humanitarian agencies and organizations with offices in the zone
Small scale businesses in the village

</td>
</tr>
<tr>
<td>
Key Resources

Human resource
Equipment (Both for generation and distribution)
Finance

</td>
<td>
Channels

Marketing channels
Distribution channels
Revenue collection channel
Energy metering system

</td>
</tr>
<tr>
<td colspan="3">
Cost Structure

a) Fixed cost

Equipment cost (acquisition and installation)
Land acquisition
Project financing cost
Grid connection and distribution cost
Insurance cost

b) Variable costs

O&M cost
Labor cost
Utilities

</td>
<td colspan="2">
Revenue Streams

Usage
Subscription fee

</td>
</tr>
</table>

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2.2.2.1. Customer segment

Humanitarian agencies and organizations with offices in the zone. A number of offices in the zone will be targeted as a customer segment. The available staff accommodations will as well be considered. Small scale business in the village. Small scale businesses in the village. Small sized businesses like shops, welding workshops among others will use the power generated from the project to run their activities. Refuges settled in the village (Households and social amenities). The refugees make up the mobile population of the village. Host/rural communities in the village (households, and social amenities). One of the key customers for this project will be the refugee host communities. They will make up the rural communities.

2.2.2.2. Value propositions

Increasing electricity reliability: The project will result into supply of reliable energy for the community. Reduction in emission: The emission that resulted from the use of non-renewable sources will be reduced. Environmental protection: The level of encroachment on the available natural resources for energy need will be greatly reduced. Improvement of livelihoods especially for the ladies. Most times in this community: it is the ladies who are responsible for looking for firewood for cooking. This results into school drop outs and other negative implications. The project looks into averting that trend. Reduced cost of energy: The project looks into supply of low tariff electricity to the community. Improvement in literacy levels in the community. Schools and other learning centers will have reliable energy source hence improvement in the area academic performance. Job creation: Through the project, a number of job opportunities will be created both directly and indirectly. Improvement in health. The health issue resulted from use of inefficient ECSs will be minimized.

The listed value was broken down per customer segment as shown in **Erreur ! Source du renvoi introuvable.**.

Table 3. Segmentation of the value proposition per customer base

S/N	Customer segments	Proposed value
1	Refugee community	• Improved livelihood • Improvement in the literacy levels among the refugee's community • Reduced energy cost • Improvement in health of the refugees • Job creation
2	Rural or host community	• Improved livelihood

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		• Improvement in the literacy levels within the rural schools • Reduced energy cost • Relief of girls from the burden of fetching firewood • Job creation
3	Humanitarian agencies and organizations	• Attainment of environmental protection goals • Increasing electricity reliability for the community • Reduction in toxic gas emission levels
4	Small scale businesses	• Improvement in profit margins • Job creation • Availability of sustainable energy source

2.2.2.3. Customer relationships

Deployment of IT systems to streamline customer interactions. In order to have a seamless flow if information between the customer and the power supply organization (project), IT systems will be deployed to ensure timely delivery of important messages across all customers. Setting up marketing strategies that are customer specific. For the different market segments within the village, different marketing strategy will be deployed. For instance, the strategy used for refugees will not be the same as the one used for the host and humanitarian organizations in the village. Timely response to energy supply interruption. Technical support team will be set up for timely response in case of supply interruptions. This will help restore trust. Ensuring the grid reliability. Advanced Mini grid reliability technologies will be deployed to ensure that the power systems are entirely reliable.

2.2.2.4. Channels

Marketing channels: The key marketing channel that will be deployed for the services offered by the project will be the use of marketing agents. These will be tasked with a door-to-door execution of the marketing goals of the project. Distribution channels: The services of the project will reach the clients through the agents. For example, payments for the services will be done from authorized agents, among others. Revenue collection channel: A number of technologies will be used to ensure efficient collection of the tariff

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from the project. Energy metering system: Advanced metering system that is approved by ERA will be used in the project.

2.2.2.5. Key partners

There are a number of key partners that will play great roles in the successful implementation of the Energy Village model to this particular community. These roles are as described below. Ministry of Energy and mineral development. This is the energy ministry in charge of formulating energy policies for the country. They will be key partners in this case because the developed EV must work within the legal formulated energy policy and framework of the country. United Nations High Commissioner for Refugees (UNHCR): Since this designed EV is proposed to supply a sustainable energy to refugees and humanitarian communities, the refugee agencies like UNHCR will be key partners in many aspects which among others include provision of up to date about refugee population and funding of the project. The office of the Prime Minister: This is the government body or ministry that is responsible for the operation of the refugee camps in the country. This ministry will be responsible for the peaceful coexistence of the EV project with the refugee settlement community. Energy consultants: During the design and construction phase, a number of energy consultants will be used. These will have different inputs for a successful implementation and operationalization of the project. Suppliers: A number of suppliers both local and overseas will be used during the procurement and construction phase of the EV. Some of the items that will be procured from overseas is the energy conversion technologies. Construction firms: These will be engaged in the civil and construction works ad consultancies in the project. Safety consultant: Local HSE consultants will be used to ensure the EV project complies with the set national safety standards. Electricity Regulatory Authority (ERA): This will be the licensing and regulatory agency for the power generation from the EV project. They will ensure that the power generation is done as per the national standard and requirement.

2.2.2.6. Key activities

Social and environmental impact assessment: Impact of the project on the bigger picture of the community will be thoroughly analyzed. This will predict both short term and long-term impact of the EV project on the environment. Power systems design, installation and commissioning. One of the key activities here is the design of the power system to be used in this case. In this case, based on the demand, the generation capacity of the energy conversion systems will be estimated. The installation and commissioning aspects will equally be well captured in here. Power/energy distribution: This focuses on how the generated energy will reach the end user. It answers the question of which distribution channel will be used to achieve the target. Tariff and power sales: This activity will focus

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on establishing power sales strategy that will be used upon commencement of generation. Finance mobilization. The funding sources for the project will be detailed in this phase. This will help generate a clear financial road map for the project. Community sensitization and dialogues: Community will be sensitized about the project so as they attain the knowledge and understand the benefit of the project.

2.2.2.7. Key resources

The following are the key resources in the development of the Refugee Camp EV. Human resource. Human resource requirement for the project will range from the process managers, operators, designers and support staff. Equipment and machineries (Physical assets): A number of equipment and machineries will be used in the project. This includes the energy conversion systems, the transmission infrastructure among others. Finance: The financing option for the project will be from the key stakeholders like the government, NGOs and UNHCR: The estimated investment value for the project us as shown in **Erreur ! Source du renvoi introuvable.**4. This was based on the available resources in the area. Logistical resources: Transportation of the required resources in the village will require logistical resources such as vans, among others.

Table 4. The proposed financial requirement for the project

Power source	Capacity (kW)	Acquisition cost ($/kW)	O&M Cost ($/kW/ year)	Salvage ($/kW)	Cost Category	Total Cost ($)	Battery Replacement Cost ($) After 9 years
Solar (Panels & Battery bank)	341.40	2,058	566.10	11.25	Acquisition	1,221,451	351,301
Biogas generator	225.00	2,306	160.00	14.10	O&M	229,267	
					Salvage	7,013	
Annual Generation Capacity (kWh/year)							7,442,500

2.2.2.8. Cost structures

a) Fixed cost

Equipment cost (acquisition and installation): This is the cost hat will be incurred in acquiring and installing the energy conversion systems and other related power systems. Land acquisition. The project establishments will require land: A one-time cost will be incurred in that case. Project financing and consultancy cost. Quite consultancy activities

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will be required to ensure the project is a success. Grid connection and distribution cost: The distribution and grid infrastructure will be established to take the power to the end users. Insurance cost: To cater for any eventualities system will be insured at an estimated yearly premium.

b) Variable costs

O&M cost: The operations and maintenance cost for the project will vary from time to time. Labor cost: The man power hour cost will depend on the operations hour for the project.

2.2.2.9. Revenue streams

Usage: The main revenue stream for the project will be returns from the usage of generated power by the customers. Subscription fee: There are those customers that will subscribe for a periodical charge, this will add to the revenue stream for the project. **Erreur ! Source du renvoi introuvable.**5 shows the summary of the cost and revenue structure for the project with an estimated lifespan of 17 years.

Table 5. Summary of the revenue and cost structure for the project

Power Source	**Capacity (KW)**	**Investment Value ($)**	**O&M ($/Yr.)**	**Salvage ($)**
Solar	341.4	714,460	178,615	640
Biogas Generator	225	471,345	51,848	70,702
Total	566.4	1,185,805	230,463	71,342
	Operating Capacity			
Financial analysis (Project life time = 17 years)	100%	75%	50%	30%
Net Cash Flow	$585,128	$456,682	$328,235.09	$251,167

2.2.2.10. Challenges and problems that must be overcome

There are a number of challenges that ought to be overcome. The following are some of the challenges. Reliability: One of the key challenges in the project implementation of this EV is reliability. How reliable this project will supply power to the community as compared to the exiting energy options is a key area for consideration. Sustainability: This focuses on how long the project will supply a sustainable power for the projected project lifespan. Social relation: Looking at the community dynamics of the projected customer base, the social relation between the project and the community has to be carefully addressed and analyzed. Demand profiling and projections: This community have a lot of movements by the refugees and hosts. Accurate demand profile is a challenge that needs to be addressed ahead of time. Skilled man power: To ensure

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efficient delivery of the project mandate, presence of skilled manpower is important. Where necessary, further training and retooling of the workforce should be considered.

2.3. Botswana

2.3.1. Description of the context (the demo village) and the solution

Botswana has several villages that are not electrified from the national grid and Majwanaadipitse is one such village. It is located about 100 kilo metres north of Palapye. Majwaanadipitse (22°06'30''S, 26°52'59" E) consists of 700 villagers (Census 2022), approximately 200 households characterised by a low income and high unemployment rate. The village income is largely defined by a subsistence farming activity supported by remissions from a few family members who work in cities and support to their families in the village from time to time. Once a year, before the cropping season, the villagers remove invasive thorn bush from the agricultural lands, and they get paid for it by the government. The village has a shop, tuck shops, a clinic a primary school and a satellite police station.

Additionally, the main source of grid electricity in Botswana is a coal fired thermal power station, Morupule Power Station in Palapye, it must be supplemented by imports from the region as it does not provide all the required power. Most of the villagers use firewood for cooking and kerosene lamps and low-quality solar lamps as light at night. Only a few villagers use gas for cooking. A few households have portable solar systems for charging electronic gadgets. Alternative renewable energy sources mainly in the form a PV microgrid, but also biogas from biodigesters and solar cookers can be a feasible source for clean, sustainable, and affordable energy. Establishing a successful EV powered by renewable energy sources would provide a much-needed proof of concept that may demonstrate economic stimulation from clean energy in rural remote villages in sub-Saharan Africa. Business model design (business model canvas filled in + analytical description of each block). Table 6 shows the Business canvas for Majwanaadipitse village, Botswana.

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Table 6. Business canvas for Majwanaadipitse village, Botswana

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Propositions</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td rowspan="3">○ Ministry of Minerals and Energy.
○ Renewable Energy Companies.
○ IT Companies.
○ Funding agencies.</td><td>○ Project impact assessment.
○ Project design, and costing, compliance etc.
○ Finance mobilization.
○ Training of local workforce.
○ Monitoring and evaluation.</td><td rowspan="3">○ Job Creation and Entrepreneurial Ventures.
○ Enhanced Agricultural Practices.
○ Improved Living standards.
○ Reduced pollution.
○ Reduced deforestation.
○ Attainment of high-level skills.</td><td>○ Energy services company (DESCO)- to generate and distribute the energy and collect payments.</td><td rowspan="3">○ Households.
○ Village shop.
○ Agriculture / Farmers.
○ Police satelite station.</td></tr>
<tr><td>Key Resources</td><td>Channels</td></tr>
<tr><td>○ Finance
○ Expert Manpower</td><td>○ The Village Development Committee (VDC)
○ Social Media/Mobile Texts.
○ Prepaid metering.</td></tr>
<tr><td colspan="3">Costs
○ Planning and consultancy costs.
○ PV grid components (generation and distribution).
○ Digesters.
○ Installation/ construction.
○ Training.
○ Insurance cost.
○ Operation and Maintenance.</td><td colspan="2">Revenue Streams
❖ Energy sales</td></tr>
</table>

2.3.2. Key Partners

There are several key partners that will play key roles in the successful implementation of the Energy Village model to the community. These roles are as described below. Ministry of Minerals and Energy. On behalf of the government of Botswana, this ministry overseas and provides policy and regulations for the minerals and energy sectors of the economy of Botswana. Through the Botswana Regulatory Authority (BERA), the ministry licences and

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ensures service providers in the energy sector adhere to the set standards and generally oversees compliance. BERA will therefore license the power generation project according to their strict regulations and oversee any tariff and energy up-take issues that may crop up.

Environmental Assessment Practitioners: Any project that is to be implemented in Botswana requires a study to predict and evaluate the environmental consequences of the project, plans, programmes and products so that negative outcomes will be minimised. The impact assessment report will be a planning tool that promotes sustainable development by integrating environmental considerations into the proposed actions that constitute the project. It guides planners and developers on issues of location, design, size and helps provide alternative solutions. Through this stage interested and affected parties are consulted and have their opinions incorporated.

Funding Agencies: Possible sources of funding such as Non-Governmental Organisations (NGOs) and financial institutions, e.g. banks will be approached with a feasible/ sound project proposal for funding of the energy village. Renewable Energy companies: These are expert companies that will be engaged starting with a feasibility study that looks at the current energy scenario in terms of sources, current demand and future use predictions, the renewable energy resources available to the village and may extend to a skills audit of the villagers. The companies will then do the designs and cost the energy supply systems to be installed. Renewable energy companies will be responsible for installation of the power systems. IT Companies: The energy distribution, billing and service charge collection requires modern IT methods and so an IT company should be engaged.

2.3.3. Key Activities

Community Engagement: The villagers, through the Kgosi must be consulted and their permission, buy-in and participation secured. Impact assessment and feasibility studies: Experts in assessing the pros and cons of setting up the energy village, both on environmental and living standards (economic and social benefits) of the villagers should work out the impact of the project which will be used to pre-judge and decide if the advantages outweigh the disadvantages.

Power systems design and costing: Once the assessment and feasibility studies are concluded and with a positive outlook, expert renewable energy companies must be engaged to draw up the designs and cost the project. Energy uptake, uses, the tariff structure etc. will be included in consultation with government departments and related regulatory bodies. This process will complete the proposal. Finance mobilization. At this stage, there is a need to market the proposal to possible funding bodies and NGOs. It is

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important that the proposal shows that the project is financially beneficial, especially if the funding will come as a loan. Project construction and commissioning: Construction companies can be awarded contracts through a tender system and put up the project into place, followed by commissioning.

Training of local workforce: Local villagers must be trained and employed in the various roles as required in the energy village project. There will be operation and maintenance jobs, repair work, trouble shooting and other various jobs that can be stimulated by the availability of energy. The villagers should form the DESCO. Monitoring and evaluation: It is important to monitor the progress once the project is running. There is a need to periodically compare the actual performance and the perceived one so that the project does not go off track.

2.3.4. Key Recourses

These are the resources required in setting up the Majwanaadipitse EV. Finance: Several key activities will require financing. Environmental Impact Assessment, designs, costing, licensing, and construction will require financing. Expert Manpower: Training of villagers and setting up of a local company to run or manage the power plant will require experts. The monitoring and evaluation of the project will also require experts. Table 7 shows the Proposed project activities requiring financing.

Table 7. Proposed project activities requiring financing

Potential Resource	**Notes**
PV Microgrid	An additional PV system can be constructed
Biogas generator	Animal and plant waste can be used to produce biogas
Biomass Power Plant	Invasive bushes and crop residues can be used for thermal power generation
Solar cooking	Solar cookers can reduce wood use.

2.2.5. Value Propositions

Job Creation and Entrepreneurial Ventures: A Distributed Energy Services Company (DESCO) that provides renewable energy in the village can be formed. Examples are battery exchange services and services to run essential agricultural process in the agricultural value chain. The implementation and maintenance of renewable energy infrastructure creates employment opportunities within the community. The village shop and tuck shops will provide cold storage services where LPG gas refrigerators are swapped

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for cleaner renewable energy sources powered refrigerators. Enhanced Agricultural Practices: Renewable energy can be utilized to power irrigation systems (Agri solar farming) and crops can be grown under PV panels contributing to overall food security in the village. Villagers currently sell their farm products within a very short period due to the lack of cold storage facilities. Renewable energy can be used to increase income of farmers by extending the selling period of agricultural products through establishing cold storage facilities.

Improved Living standards: Battery exchange concepts can provide affordable electricity to households. Access to sustainable renewable energy is a foundation enabling villagers to enhance their educational pursuits. Furthermore, the availability of energy is a prerequisite for the integration of technology in education, providing villagers with access to electronic devices, online resources, and information. Electrical Lighting eliminates use of kerosene that is polluting. Solar cookers can reduce the use of firewood, reducing deforestation. Community Empowerment: The adoption of renewable energy technologies brings about skill development programs, empowering community members with valuable technical expertise as well as entrepreneurial skills. Villagers will undergo training through short courses and will be involved in active community engagement to make sure that the renewable energy initiatives align with the specific needs of the village.

2.2.6. Customer Relationships

A Distributed Energy Services Company (DESCO) that provides renewable energy services in the village to be formed and handle all energy issues to the satisfaction of the villagers. It will generate, distribute, and organise the billing of the PV microgrid energy.

2.2.7. Customers Segments

Households: The villagers live in family homes, they need energy for cooking, water heating, lighting, powering electronic gadgets, food storage etc. Village shop: There is a sole trader shop in the village, the shop sells groceries and has a small bar. Currently the shop uses gas for refrigeration and a generator for the sound system and lighting. The energy can be sourced from the PV microgrid. Agriculture/ Farmers: Villagers can form a farming company or can still grow crops at family level. The common denominator is the use of energy for crop irrigation, animal and domestic consumption. Botswana can be described as dry and rain water is not enough to satisfy water needs. Both agriculture and domestic water needs require energy, including for food processing and storage. Police satellite station: There is a police satellite station in the village and its energy needs should originate from the PV microgrid.

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2.2.8. Distribution/ Channels

The Village Development Committee (VDC): Information to and from the villagers is normally transmitted through the VDC, the project can use this protocol or liase with the VDC to see how best the flow of information can be handled. Social Media/ Texts Messages: Such platforms can be used for general communication and communicating bills. Prepaid metering: An IT company can set up system that automatically switches power on and off depending on whether the customer is paid up or owing.

2.2.9. Costs

Planning and consultancy costs: Planning of the EV involves various costs, including consultancy fees. PV grid components (generation and distribution): Equipment needs to be procured for setting up the PV microgrid in the village. Digesters, incinerator, solar dryer and cooker equipment: Such specialized equipment has to be procured at a cost. Installation/construction: specialized companies will be engaged to set up the infrastructure. Training: workshops and training sessions for the villagers will be held by qualified institutions and personnel who have to be paid. Insurance cost: Insurance of equipment and infrastructure is mandatory. Operation and Maintenance: The systems installed will need operators and maintenance, sometimes repairs.

2.2.10. Revenue Streams

Villagers, the village shop, tuck shops, police satellite station and any other users will pay for the energy they thereby raising revenue for the energy village.

2.2.11. Challenges

Difficulty in getting accurate data for modelling: In most of the villages located in remote areas, people do not have a record of the quantities and costs of their energy sources. Lack of financial loan products for purchasing renewable energy technologies. No insurances products are in place to minimize purchase risks for renewable energy technologies. Educational training is needed to run and maintain renewable energy technologies. Overcome fears when applying new renewable energy technologies, there is a strong need for a buy-in from the villagers into the energy village concept.

2.4. Ethiopia

2.4.1. Description of the context (the demo village) and the solution

Tulefa energy village is located approximately 65 kilometers from Addis Ababa, the capital of Ethiopia. The village is home to around 426 households with an average family size of seven members. It is spectacular landscape with so many lumps and bumps. It is endowed

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with enormous solar, wind & biomass untapped renewable energy resources. Located near the equator (9° 14'49" N, 39°14'59.9" E), solar energy is available for up 10 to 12 hours a day especially during clear and dry seasons. According to ten-year of data collected from National Meteorological Agency (NMA), the estimated solar intensity is 5.98 kWh/m2/day. In addition, wind is a 24/7 phenomenon with the most frequent wind speed of 7.2 m/sec at 50 m height and potential of 187 W/m2 power density. Biomass resources, primarily animal manure is also abundant with an estimated daily potential of 10 tons which holds promise for biogas production and/ or electricity generation. Figure 3 shows the Tulefa energy village.

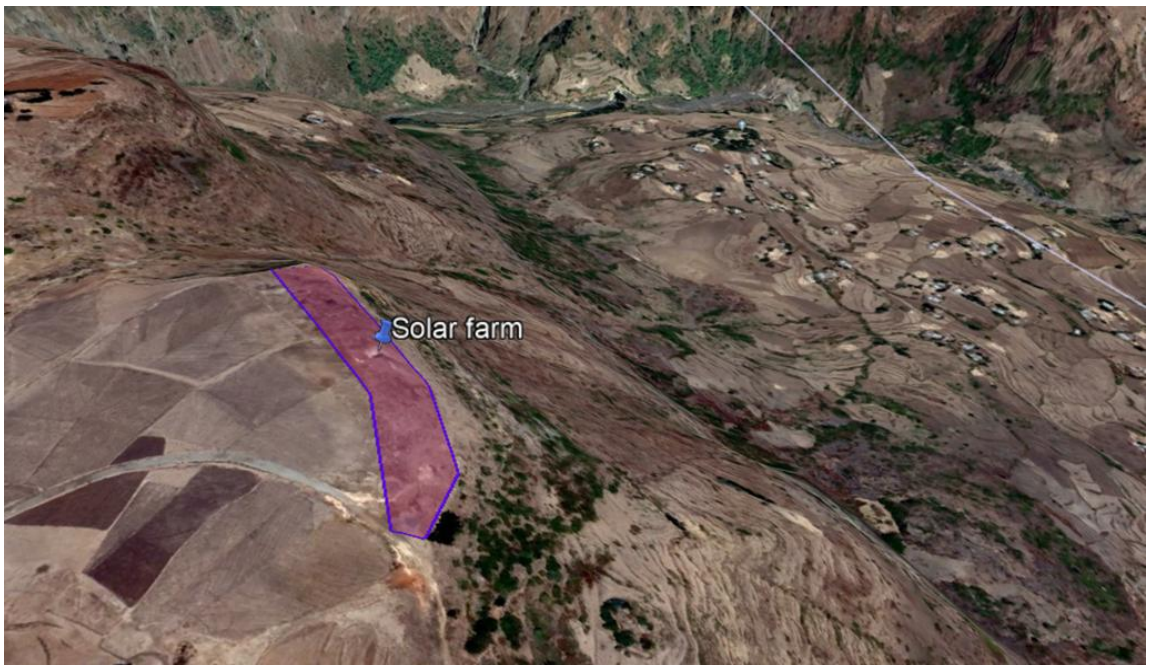

Figure 3 Tulefa energy village

On the other hand, however, Tulefa Energy Village (EV) consumes a substantial amount of wood, charcoal, and kerosene for cooking and lighting. The statistical analyses showed that each household on average consumes more traditional biomass (60%) mostly from firewood and charcoal as compared to renewable energy consumption which accounts for 40%. Based on the data survey made, it was found that the households in the energy village use firewood most frequently (53.5%) and cow dung (37.3) next to firewood. Others like charcoal (4.8%), crop residue (3.3%), kerosene (1%), electricity (0.02%), and solar (0.01%) account for only small portion (9.2%) of the total energy consumption in village. Figure 4 shows the Energy consumption of Tulefa EV.

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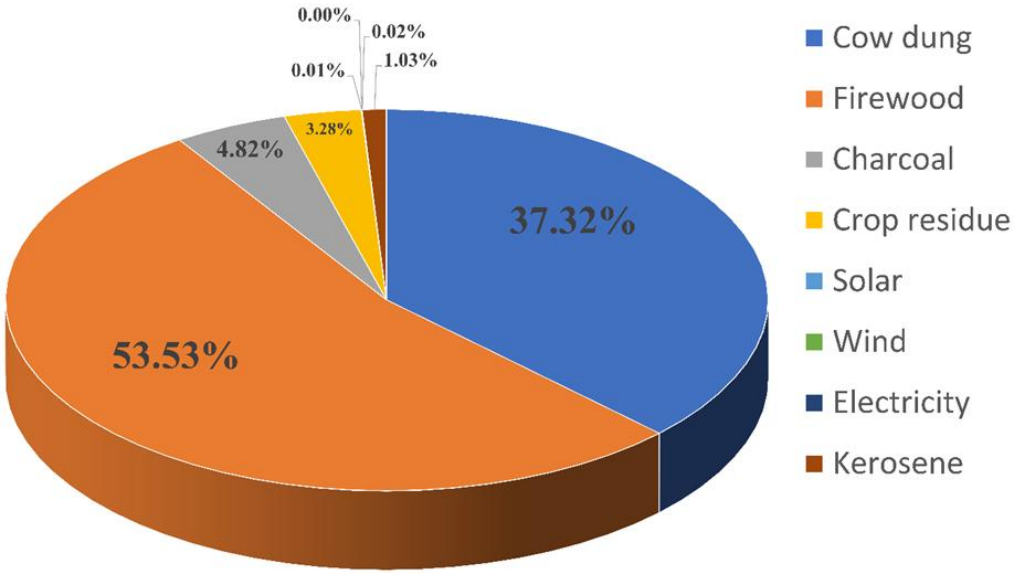

Figure 4 Energy consumption of Tulefa EV

To bridge the gap, the LEAP-RE project through its Energy Village Africa work package is exploring various possible ways in an effort to make Tulefa an energy self-sufficient village. The next Table 8 shows the Business model canvas of Tulefa EV.

2.4.2. Business model design (business model canvas filled in + analytical description of each block)

Table 8. Business model canvas of Tulefa EV

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
⊙ **Equipment Suppliers**: Vendors for wind turbines, solar panels, and biogas digesters (storage technologies). ⊙ **Government Agencies/NGOs**: For grants, regulatory support, and carbon credit facilitation. ⊙ **Local Community Leaders**: Partnerships with village leaders to facilitate engagement and trust.	○ **Energy Production**: Generate electricity through wind turbines and solar panels; produce biogas from biomass. ○ Develop energy storage systems for reliability and efficiency ○ **Maintenance & Operations**: Regular maintenance of energy systems and equipment to ensure reliability. ○ **Billing & Collection**: Manage billing systems, collection, and customer support.	➢ Provide sustainable, affordable, and reliable renewable energy to meet household needs, including electricity, heat, and biogas ➢ Reduce dependency on biomass, promoting environmental sustainability ➢ Improve quality of life through consistent energy access, health benefits (less indoor air pollution), and	❖ **Community Engagement**: Regular community meetings to gather feedback and educate on benefits ❖ Foster strong relationships with households through continuous dialogue and involvement in project planning ❖ **Support Service**: Provide 24/7 customer support for technical assistance. Offer regular maintenance services to ensure energy systems function effectively	✓ Primary: The 426 households in the village. ✓ Secondary: Small businesses or community facilities in the village (e.g., schools, healthcare centers).

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⊙ **Maintenance Contractors**: Local or regional providers for specialized repair and technical support	○ **Community Education**: Programs to educate residents on renewable energy use and benefits. **Key Resources** • **Natural Resources**: Wind, solar, and biomass resources available in the village. • **Technology**: Infrastructure for wind turbines, solar panels, and biogas production units. • **Human Resources**: Skilled staff for operations, maintenance, and community engagement. • **Financial Resources**: Initial funding or grants for setup, plus working capital for operations	economic opportunities	❖ **Billing Transparency**: Clear, affordable billing plans or pre-paid options to make costs predictable **Channels** ♦ On-site distribution system for electricity and heat. ♦ Biogas delivered via centralized biogas production facility with localized storage for cooking needs. ♦ Community awareness programs to promote renewable energy use and maintenance	
Cost Structure ❍ **Infrastructure Costs**: Installation and setup for wind turbines, solar panels, biogas facilities, and distribution network. ❍ **Maintenance & Operations**: Ongoing costs for regular system checks, repairs, and technical staff. ❍ **Community Outreach**: Costs for community meetings, awareness programs, and educational materials. ❍ **Administrative Expenses**: Billing, customer service, and administrative tasks.			**Revenue Streams** ✹ **Energy Usage Fees**: Monthly or pay-as-you-go fees for electricity, heat, or biogas usage. ✹ **Subsidies or Grants**: Seek government or NGO support to subsidize infrastructure and setup costs.	

Narrative of the business model canvas

Households in the EV (customer segment 1)

Households form the primary customer segment in the Tulefa Energy Village (EV), comprising 426 families with sizes ranging from five to ten members. Currently reliant on firewood and cow dung as their primary energy sources, these households face significant challenges, including health risks from traditional cooking methods and limited access to modern energy solutions. This renewable energy initiative seeks to transform energy utilization by leveraging abundant local resources such as solar, wind, and biomass to

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produce electricity, biogas, and thermal energy. The solution aims to provide sustainable, affordable, and reliable energy, improving living standards, empowering women by reducing health risks, and enabling students to study at night under proper lighting, fostering educational opportunities.

Building strong relationships with households will be a priority through personalized assistance and ongoing support. Local representatives will engage directly with families to offer tailored energy solutions that meet their specific needs. Community workshops and training sessions will foster trust, educate households about the benefits of renewable energy, and encourage proper system usage. To ensure long-term satisfaction, dedicated maintenance teams will provide continuous support and address any issues promptly, creating a reliable and lasting connection with the community. The renewable energy systems will be delivered through a comprehensive and accessible distribution network tailored to meet household needs.

An on-site distribution system will provide electricity and heat directly to homes, ensuring reliable energy access. For cooking purposes, biogas will be produced at a centralized facility and stored in localized storage units for convenient distribution to households. Community leaders and respected figures will actively promote the adoption of these solutions, helping build trust within the community. Additionally, community awareness programs will play a vital role in educating households about the benefits of renewable energy, proper system usage, and basic maintenance. Workshops and live demonstrations will further showcase the systems' functionality and encourage their effective use. To enhance convenience, mobile applications and hotlines will offer access to usage data, payment options, and customer service, strengthening the overall channel strategy.

The project will generate revenue through a combination of flexible and affordable payment models tailored to household needs. A pay-as-you-go system will allow families to pay based on their energy consumption, reducing upfront costs and ensuring accessibility. Monthly or annual subscription services will provide consistent access to electricity, biogas, or thermal energy. Small maintenance fees will cover system servicing and upgrades, ensuring reliability and longevity. To further support the energy production process, households may contribute biomass, such as cow dung and crop residues, creating a cost-sharing mechanism that fosters community collaboration. Additionally, subsidies or grants from government or NGO programs will be sought to help subsidize infrastructure and setup costs, reducing financial barriers for households and accelerating the project's implementation.

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Community service providers (customer segment 2)

The community service providers, including the school and health center, are critical customer segments that rely on reliable energy sources to function effectively. This renewable energy solution offers a dependable supply of electricity to power essential operations such as lighting, medical equipment, and educational tools, thereby enhancing service quality and community well-being. Relationships with these providers will be built through collaborative engagement, including consultations to assess specific energy needs and ongoing technical support to ensure uninterrupted service. The energy will be delivered via an on-site distribution system tailored for institutional use, ensuring reliability and scalability. Community awareness programs will also involve these providers, promoting the broader adoption of renewable energy within the village. Revenue will be generated through affordable service contracts with fixed monthly or annual fees based on energy consumption, supported by subsidies or grants from government and NGOs to offset installation and operational costs.

Key partners

Key partners for this renewable energy solution encompass a diverse range of stakeholders critical to its success and long-term sustainability. **Equipment suppliers**, including vendors of wind turbines, solar panels, and biogas digesters, are fundamental in providing high-quality infrastructure and technology required for energy generation. These partnerships ensure access to reliable and efficient systems tailored to the community's needs. **Government agencies and NGOs** are indispensable collaborators, offering grants and subsidies to reduce initial costs, providing regulatory support to streamline operations, and facilitating access to carbon credit programs, which can create additional revenue streams. **Local community leaders** play a crucial role in fostering trust and engagement by acting as liaisons between the project and the community, ensuring that implementation is smooth and culturally sensitive. Furthermore, partnerships with **maintenance contractors**, including local and regional providers, are vital for delivering specialized repair services and ongoing technical support. This ensures the systems remain operational and efficient over time, minimizing disruptions. Together, these partners form a robust network that supports the development, implementation, and maintenance of the renewable energy solution, driving its success and scalability.

Key activities

The key activities for this renewable energy solution focus on ensuring efficient **energy production**, **reliable operations**, **effective customer management**, and **community engagement**. Energy production involves generating electricity through wind turbines and

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solar panels, as well as producing biogas from biomass resources such as agricultural residues and cow dung, leveraging the community's natural resources. Maintenance and operations are crucial to ensure the reliability and longevity of the energy systems, requiring regular inspections, repairs, and system upgrades. Effective billing and collection systems will be implemented to manage payments, track energy consumption, and provide customer support, ensuring financial sustainability. Additionally, community education programs will be conducted to raise awareness about renewable energy usage, its benefits, and system maintenance practices, empowering residents to maximize the value of the solution. These activities collectively ensure the delivery of sustainable and reliable energy while fostering community involvement and satisfaction.

Key resources

The key resources for this renewable energy solution are integral to its functionality, sustainability, and scalability. Natural resources such as abundant wind, solar energy, and biomass available in the village form the foundation for energy generation, making the solution environmentally sustainable and locally driven. Technological resources, including wind turbines, solar panels, and biogas production units, are essential infrastructure components, requiring high-quality equipment to ensure efficiency and reliability. Human resources are equally critical, encompassing skilled staff for system operations, maintenance, and community engagement to build trust and ensure proper usage. Financial resources are vital for covering initial setup costs, sourced through grants, subsidies, or other funding mechanisms, as well as maintaining working capital for ongoing operations. Challenges in this area include ensuring consistent access to quality equipment, training local staff to develop technical expertise, and securing sufficient funding to cover initial investments. Development efforts should focus on establishing reliable supply chains for equipment, offering capacity-building programs for staff, and creating sustainable financial models to address long-term funding needs. These resources, along with strategic efforts to overcome challenges, are key to the success and growth of the project.

Cost structure

The cost structure of this renewable energy solution encompasses various essential components required for its implementation and ongoing operations. Infrastructure costs represent a significant portion, including the installation and setup of wind turbines, solar panels, biogas production facilities, and the distribution network to deliver energy to households and community service providers. Maintenance and operations costs cover regular system checks, repairs, and the salaries of technical staff to ensure reliability and efficiency over time. Community outreach expenses include organizing community

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meetings, conducting awareness programs, and developing educational materials to promote the adoption of renewable energy and proper usage practices. Additionally, administrative expenses are necessary for managing billing systems, providing customer service, and handling other operational tasks to maintain smooth and efficient service delivery. Balancing these costs while ensuring affordability for customers and long-term financial sustainability remains a key focus for the project.

2.4.4. Challenges and problems that must be overcome

The business model for Tulefa Energy Village offers several key advantages, notably its potential to provide sustainable, affordable, and reliable energy to a community that is currently dependent on traditional energy sources like firewood and cow dung. By harnessing abundant local renewable resources such as wind, solar, and biomass, the model aims to transform energy consumption patterns, reducing health risks associated with traditional cooking methods and providing electricity for improved education and community services. Furthermore, the integration of biogas production for cooking and heating can significantly improve the quality of life, particularly for women and children, while fostering environmental sustainability. The model also promotes local economic development by creating job opportunities in maintenance, operations, and community engagement.

However, there are challenges and development needs that must be addressed for the successful implementation of this business model. Key challenges include securing the necessary financial resources to cover the initial infrastructure setup, including the installation of wind turbines, solar panels, and biogas production facilities. In addition, the need for specialized technical expertise and maintenance capabilities poses a challenge, particularly in a rural setting where skilled labor may be scarce. To overcome these hurdles, there is a need for continued support from government agencies, NGOs, and financial institutions to provide grants and subsidies, as well as investments in capacity-building programs to train local staff. Furthermore, community outreach and education are critical to ensure proper adoption and maintenance of the energy systems, requiring sustained efforts to engage and empower residents. Addressing these challenges will be essential for ensuring the long-term success and scalability of Tulefa Energy Village's renewable energy solution.

2.5. Kenya

2.5.1. Description of the context (the demo village) and the solution

The Cheboiywo Village is in Tulwet ward, Kesses sub-county, Uasin Gishu county in Kenya. The population density of Tulwet ward is 241 persons/sq.km (Kimani, 2021). Information

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on the population of villages within the ward, however, has not been published. Most households in Chebaiwo depend on firewood and a few on charcoal for cooking. Majority of them use electricity for lighting and very few use kerosene and solar (Kimutai, Kiprop, & Snelder, 2019). Most rural residents in Uasin Gishu County have not adopted use of renewable sources of energy. The Cheboiwo energy village in Kenya is intended to create a sustainable community with adequate energy from renewable sources, with minimal environmental impact, and high economic impact. The study identified current sources of energy; determined the potential renewable energy sources within the community; and developed implementation plans for the adoption of renewable energy sources.

During the study, in Cheboiwo village, 100% of the respondents showed strong interests in renewable sources such as biogas and solar PV technologies. The community demonstrated readiness and willingness to embrace the use of these renewable energy sources. Given the strategic location of the village in an agricultural region with abundant sunlight and biomass; solar panels and biogas generation were the preferred renewable energy sources. The adoption and success of the Energy Village concept at Cheboiwo village is expected to inspire similar ventures in other areas in Uasin Gishu county and across the country.

The establishment of Cheboiwo Energy Village can be a model for different regions across the country. In quite similar fashion, all, if not, most rural areas in Kenya use firewood for cooking. The renewable energy resources in most rural areas in the country are like those in Cheboiwo village. As a result, the proposed application of biogas and solar based technologies can be adopted in various areas. The following are the success factors in the energy villages in Kenya: (i) overwhelming willingness by communities to embrace renewable energy sources such as solar and biogas for cooking and lighting. (ii) potential for replication: the success of implementation of the energy village concept in these villages has 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 potential for replication in other parts of the country. (iii) 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. Table 9 the Summary of the revenue and cost structure for the project.

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Table 9. Summary of the revenue and cost structure for the project

<table>
<tr><td colspan="2">Business Model Canvas</td><td colspan="3"></td></tr>
<tr><td>Key Partners</td><td>Key Activities</td><td>Value Propositions</td><td>Customer Relationships</td><td>Customer Segments</td></tr>
<tr><td rowspan="3">○ Renewable energy technology providers (solar, biogas)
○ County government and regulatory bodies
○ Environmental NGOs and sustainability organizations
○ Local businesses and cooperatives
○ Financial institutions for funding and investment</td><td>○ Development and installation of renewable energy systems (solar farms, biogas plants)
○ Energy management and distribution (smart grid implementation)
○ Community engagement and educational workshops
○ Maintenance and operation of energy infrastructure
○ Research and development for improving energy efficiency</td><td rowspan="2">○ Affordable and reliable renewable energy for households and businesses
○ Reduced carbon footprint and promotion of sustainability
○ Opportunities for local economic development and job creation
○ Enhanced energy security and independence from traditional energy sources
○ Educational resources and programs for energy conservation and efficiency</td><td>○ Personalized energy management services for households and businesses
○ Community forums and feedback sessions to address concerns and ideas
○ Transparent communication regarding energy production and costs
○ Support services for energy efficiency and sustainability practices</td><td rowspan="2">○ Households seeking affordable and sustainable energy solutions
○ Small to medium-sized enterprises looking to reduce energy costs</td></tr>
<tr><td>Key Resources
○ Land for energy generation (solar, biogas)
○ Renewable energy infrastructure and technology
○ Skilled workforce for installation and maintenance
○ Funding sources (grants, subsidies, investments)
○ Strong community network for outreach and participation</td><td>Channels
○ Workshops and community events for engagement and education
○ Online platforms (website, social media) for information sharing and updates
○ Partnerships with local schools and organizations for educational initiatives
○ Newsletters and community bulletins for ongoing communication</td></tr>
<tr><td colspan="2">Cost Structure</td><td colspan="3">Revenue Streams</td></tr>
</table>

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○ Initial capital investment for renewable energy infrastructure ○ Ongoing maintenance and operational costs of energy systems ○ Costs associated with community outreach and education ○ Salaries for staff and trainers ○ Research and development expenditures	○ Sale of energy to households and businesses (power purchase agreements) ○ Grants and subsidies from government and NGOs ○ Fees for energy management services and consultations ○ Revenue from educational workshops and training programs ○ Partnerships with local businesses for sustainability projects

2.5.2. Narrative of the business model canvas

2.5.2.1. Customer segment 1: Households

Households constitute a major customer segment in the Cheboiwo energy village. Most of these households currently rely on firewood for cooking. This results in environmental degradation and health challenges for the users. During the study, in Cheboiwo village, the community demonstrated readiness and willingness to embrace the use of these renewable energy sources. Given the strategic location of the village in an agricultural region with abundant sunlight and biomass; solar panels and biogas generation were the preferred renewable energy sources.

The project endeavors to build strong relationships with households by providing personalized assistance and ongoing support. Active community engagement with all stakeholders will ensure that the households receive tailored energy solutions. Capacity building through community workshops and training sessions will increase awareness and build trust and confidence in the benefits of renewable energy. To ensure long-term satisfaction, dedicated maintenance teams will provide continuous support and address any issues promptly, creating a reliable and lasting connection with the community. Community forums and feedback sessions will be employed to address concerns and ideas. Transparent communication regarding energy production and costs will be maintained as well as support services for energy efficiency and sustainability practices.

The provision of affordable and reliable renewable energy for households is a key mandate. Renewable energy solutions will be implemented through available distribution systems to provide electricity for lighting and heating. Biogas will be produced in a centralized location and then distributed to the households for cooking purposes. Key activities will include the development and installation of renewable energy systems (solar farms, biogas plants); energy management and distribution (smart grid implementation); community engagement and educational workshops; maintenance and operation of energy infrastructure as well as

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research and development for improving energy efficiency. To achieve these, community leaders and other people of influence will be involved to actively promote the adoption of these solutions and create ownership by the community. Revenue will be generated through the sale of energy to households and businesses (power purchase agreements). This will be achieved through a pay-as-you-use system that will allow families to pay based on their energy consumption. Grants and subsidies from government and NGOs will be sourced to reduce the economic burden on households. Fees for energy management services and consultations will be levied monthly or annually to cover system service and upgrades, ensuring reliability and longevity. Revenue from educational workshops and training programs as well as partnerships with local businesses for sustainability projects will create a cost-sharing mechanism that fosters community collaboration.

2.5.2.2. Customer segment 2: Small to medium-sized enterprises

The small to medium sized enterprises offering useful services such as schools and hospitals are important customers for renewable energy. Most of them utilize firewood for cooking and suffer when affected by power outages. The implementation of solar power and biogas offers a dependable supply of electricity to power essential for lighting, powering medical equipment, and cooking, thereby enhancing service quality and community well-being. Relationships with these enterprises will be fostered through collaborative engagement. Active community engagement with all stakeholders will ensure that the households receive tailored energy solutions. Capacity building through community workshops and training sessions will increase awareness and build trust and confidence in the benefits of renewable energy. To ensure long-term satisfaction, dedicated maintenance teams will provide continuous support and address any issues promptly, creating a reliable and lasting connection with the community. Revenue will be generated through the sale of energy to households and businesses (power purchase agreements). This will be achieved through a pay-as-you-use system that will allow families to pay based on their energy consumption. Grants and subsidies from government and NGOs will be sourced to reduce the economic burden on these enterprises. Fees for energy management services and consultations will be levied monthly or annually to cover system service and upgrades, ensuring reliability and longevity.

2.5.2.3. Key partners

Key partners for this project include a range of stakeholders necessary for effective implementation. They include: (i) renewable energy technology providers to supply solar panels and related equipment and, biogas digesters required to provide the required infrastructure. (ii) county government and regulatory bodies will play a key role in facilitating the establishment and implementation of the project to ensure operation within the stipulated regulations. (iii) Environmental NGOs and sustainability organizations are expected to offer

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grants and subsidies to reduce initial costs, providing regulatory support to streamline operations, and facilitating access to carbon credit programs, which can create additional revenue streams. (iv) Local businesses and cooperatives will play a crucial role in fostering trust and engagement by acting as liaisons between the project and the community, to form a robust network that supports the development, implementation, and maintenance of the renewable energy solution, driving its success and scalability.

2.5.2.4. Key activities

The key activities for this project include the following: (i) Development and installation of renewable energy systems (solar farms, biogas plants). This will be implemented in conjunction with the renewable energy technology providers. (ii) Establishment of energy management and distribution (smart grid implementation) structures to ensure the reliability and longevity of the energy systems. (iii) Community engagement and educational workshops to create awareness and foster trust and ownership. (iv) Maintenance and operation of energy infrastructure to ensure the reliability and longevity of the energy systems, requiring regular inspections, repairs, and system upgrades.

2.5.2.5. Key resources

The key resources for this project include the following: (i) Land for energy generation (solar, biogas). The area has abundant land mass and biomass resources for energy generation. (ii) Renewable energy infrastructure and technology such as solar panels, and biogas production units that will be sourced from the technology providers. (iii) Skilled workforce for installation and maintenance of the facilities to ensure longevity and efficiency of operation. (iv) Funding sources such as grants, subsidies, investments to provide capital for start-up and operation. (v) Strong community network for outreach and participation to foster collaborations and strengthen ownership.

2.5.2.6. Cost structure

The cost structure of this project includes the following: (i) Initial capital investment for renewable energy infrastructure for installation and set-up of solar panels, biogas digesters and the distribution network. (ii) Ongoing maintenance and operational costs of energy systems such as maintenance and repairs. (iii) Costs associated with community outreach and education to increase awareness and foster collaboration and ownership. (iv) Salaries for staff and trainers involved in providing administrative, customer service, billing and other services. (vi) Research and development expenditures to improve service delivery and capacity building.

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2.5.2.7. Challenges and problems that must be overcome

This business model focuses on creating a vibrant community centered around renewable energy, catering to both household (residential) and commercial needs. By leveraging local resources, engaging the community, and promoting sustainable practices, the renewable energy village can thrive while contributing to broader environmental, social and economic goals. The energy village serves as a living laboratory for sustainable energy practices, showcasing innovative technologies and community-driven solutions to energy challenges. It aims to reduce its carbon footprint, enhance energy resilience, and promote sustainable living. The village is situated in a region with abundant renewable resources (sunlight for solar energy and biomass for biogas). The village is located near Eldoret city; therefore, it can facilitate partnerships and supply chain.

The village engages residents in decision-making processes, fostering a sense of ownership and responsibility. The community members are actively involved in designing and implementing renewable energy projects, ensuring that solutions meet local needs. The village endeavors to become an educational hub, providing workshops and training programs on renewable energy technologies, sustainability practices, and energy efficiency. This will also enhance collaborations with schools and universities, promote research opportunities and hands-on learning for students. Technological integration will ensure that various renewable technologies are implemented, including solar panels and biomass systems. Smart grid technology will be utilized to optimize energy distribution and consumption, allowing for real-time monitoring and management.

Regarding the economic model, the village adopts a cooperative model, where residents may share ownership of renewable energy assets, benefiting from lower energy costs and potential revenue from excess energy sales. Economic diversification is encouraged, with opportunities for local businesses to thrive through sustainable practices. Furthermore, the village aims to be carbon-neutral or even carbon-negative, demonstrating the feasibility of sustainable living. Biodiversity conservation and local agriculture are promoted, integrating energy production with food systems. Support from local, regional, or national governments will provide funding, incentives, and regulatory frameworks that promote renewable energy adoption.

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3. Conclusions

Business models can be considered strategic and conceptual tools that help firms understand, analyse, innovate, and develop their businesses. Researchers have presented different perspectives on the business models in the academic literature. The value proposition describes the value the products/services offer customers (the local community). Customer segments describe the different types of customers for which the service/product will be offered. Each customer segment may require a different value proposition since they target customers with different needs. Customer relationships describe how and by whom the relationship with each customer segment is managed and maintained, whereas Channels describe how product/service is marketed and delivered for the customers. Revenue streams describe the logic of revenue generation (e.g., streams and pricing models). Different customer segments might have different pricing models and ways to use products/services. Therefore, the business model may include several revenue streams and pricing methods.

During these business model development and previous research there has been some main challenges noticed. 1) One of the key challenges in the project implementation of this EV is reliability. 2) Difficulty in getting accurate data for modelling. 3) Lack of financial loan products for purchasing renewable energy technologies and no insurances. 4) Educational training is needed to run and maintain renewable energy technologies. 5) Key challenges include securing the necessary financial resources to cover the initial infrastructure setup, including the installation of wind turbines, solar panels, and biogas production facilities. Moreover, 6) the need for specialized technical expertise and maintenance capabilities poses a challenge, particularly in a rural setting where skilled labor may be scarce. In addition, partnerships with NGOs and research institutions help in accessing expertise, resources, and best practices. However, the village may face challenges such as initial funding and technology adoption barriers. Nevertheless, these challenges present opportunities for innovation, collaboration, and the development of scalable solutions that can be replicated in other communities. By showcasing practical solutions to energy challenges, it not only serves its residents but also inspires broader societal change towards renewable energy adoption and sustainable practices. In conclusion, the energy village embodies the principles of sustainability, community engagement, and innovation.

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