



Deliverable 3.4

Report on Business Models

30-09-2025



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Summary Sheet

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Abstract	This document summarizes the activities of Work Package 3, Task 3.3 and outlines the approach and progress related to business model and business plan development across the five living labs in Kenya, Morocco, Ghana, Malawi, and South Africa. This document is the final project report and provide updates until August 2025.

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Abbreviations

AAMUSTED	Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development
AB	Aktiebolag
BAU	Business As Usual
BM	Business Model
BMC	Business Model Canvas
BoS	Balance of System
CAPEX	Capital Expenditures
DSCR	Debt Service Coverage Ratio
ENAM	School of Architecture in Marrakesh
EU	European Union
EV	Electric Vehicle
GEP	Green Energy Park
GG	Going Green
ICE	Internal Combustion Engine
ICT	Information and Communications Technology
IRESN	Institute for Research in Solar Energy and New Energies
IRR	Internal Rate of Return
ISO	International Organization for Standardization
KES	Kenyan Shilling
KWp	Kilo Watt peak
LED	Light Emitting Diode
LEITAT	Leitat Technological Center
LL	Living Lab
LPG	Liquefied Petroleum Gas
MIG	Make It Green
NGO	Non-Governmental Organization
NMU	Nelson Mandela University
NPV	Net Present Value
NTSA	National Transport and Safety Authority
OCP	Office Chérifien des Phosphates
OPEX	Operating Expenses
PAYG	Pay As You Go
PBP	Payback Period
PUE	Productive Use of Energy
PV	Photovoltaic
RE	Responsible Entity
REIPPP	Renewable Independent Power Producer Programme
RISE	Research Institutes of Sweden AB
ROI	Return On Investment
SA	South Africa
SESA	Smart Energy Solutions for Africa
SIN	Smart Innovation Norway
SME	Small and Medium-Sized Enterprise
SPCSS	Solar Powered Cold Storage System
TVET	Technical and Vocational Education and Training
UNA	User Needs Assessment

USB	Universal Serial Bus
USD	United States Dollars
WI	Wuppertal Institute for Climate, Environment and Energy
WP	Work Package

Glossary

Energy/transport-as-a-service (E/TaaS): the overall term for a model whereby consumers pay for an energy service without having to make any upfront capital investment. Responsibility for energy management as well as maintenance and repair lie with energy service company.

Individual purchase/direct sales: The consumer buys the product directly from the supplier.

Lease-to-own: end-user finance model where the consumer leases the product from the supplier and after a certain period takes over ownership on the product.

Pay-as-you-go: there are no upfront costs for the consumer; all the customer pays for is what they use right away, in some cases this is based on ICT-based remote consumption tracking and an online payment management system.

Pay-as-you-store (cold storage): Users pay a fixed rate for using the cold storage per weight and duration.

Pay-per-use: payment model where the consumer pays a fixed rate per use of a product or service (e.g. per taxi trip, per crate in cold room). This can include a pay-as-you-store business model and a pay-as-you-go business model.

Rental/leasing model: the consumer rents a product (e.g. e-motorbike) and pays a flat rental fee e.g. on a yearly, monthly or weekly basis. Can include a deposit.

Subscription model: The consumer pays a monthly fee for a specific service where the subscription price can vary based on different subscription packages (e.g. size/capacity of solar generator system). This can be cancelled at any time when the user has no longer any need for the services.

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Executive Summary

This deliverable summarizes the activities of Task 3.3 within Work Package 3 of the Smart Energy Solutions for Africa (SESA) project. The SESA project entails supporting demonstrations and validation sites across Kenya, Morocco, Ghana, Malawi and South Africa, and multiple replication sites.

Task 3.3 involves supporting the co-development and co-testing of nine business models as part of the demonstration actions and living labs. The key objective is to provide support to ventures¹ in developing viable and sustainable business models, to document learnings and reflections around successes and failures, to enable peer-to-peer knowledge exchanges among the partners, and to demonstrate the scalability possibility for some of the use cases. Some ventures are already a member of the SESA consortium while others were selected as part of the living lab stakeholders or through the SESA Call for Entrepreneurs, as follows:

- Kenya: WeTu (consortium member)
- Malawi: Going Green and Make it Green (consortium members) as well as Smart Energy Enterprise (SEE) selected through the first SESA Call for Entrepreneurs Validation Call, based on a rigorous process through Task 3.4.
- South Africa: uYilo (consortium member)
- Morocco: Green Energy Park (consortium member) in collaboration with local SMEs POGO
- Ghana: Nastech and Econexus - selected through the first SESA Call for Entrepreneurs, based on a rigorous process through Task 3.4.

This report is the fourth and final deliverable as part of Task 3.3. In the fourth year, the focus has been on expanding and reflecting on learnings across the use cases, updating operational and financial data for advanced pilots (e.g. e-mobility Kenya and Morocco), exploring the business dimensions and performance (e.g., cooling Kenya, EV in South Africa), testing and improving efficiency (e.g., EV in Kenya, briquetting Malawi) and scaling product and service rollouts to more users (e.g., EV in Morocco, cooling Kenya, briquetting Malawi).

The report also highlights cross-collaborations and coordination within and among WPs, in which Task 3.3 has played an active role in and that will better inform the work collectively in the project. In addition, the report briefly summarises the use cases in the 5 countries within the scope of the task and indicates the progress underway and the next steps. This deliverable has been updated every year in M12, M24, M36 and **M48**.

¹ We use the term Ventures in a broad sense as a business venture as our target entities comprise of small and medium enterprises (SMEs) as well as social enterprises, as well as part-research centres in some instances.

1 Introduction and scope

1.1 SESA project

Smart Energy Solutions for Africa (SESA) is a collaborative project between the European Union and nine African countries (Kenya, Ghana, South Africa, Malawi, Morocco, Namibia, Tanzania, Rwanda, and Nigeria) with the aim of providing energy access technologies and business models that are easily replicable and generate local opportunities for economic development, job creation, and social cohesion in Africa. Through several local living labs (LL), the project has facilitated the co-development of scalable and replicable energy access innovations, which were tested, validated, and replicated throughout the African continent.

These solutions include decentralised renewables (solar photovoltaics), innovative energy storage systems, including second-life electric vehicle batteries, smart microgrids, and waste-to-energy systems (biomass to biogas), climate-proofing, resilience strategies, and rural internet access. Running from October 2021 until September 2025, SESA is the result of a strong partnership between leading European and African universities, research centres, industry actors, local governments, knowledge and implementation organisations and networks. These are strengthened via peer-to-peer exchanges, policy dialogues, and regional and international events, among others.

The main objective of the SESA project is to “Provide innovative energy access technologies and business models that are easily replicable and generate local opportunities for economic development and social cohesion.” This is achieved by delivering 5 specific sub-objectives:

Inform: To Boost the accessibility of innovative, affordable, and efficient renewable energy solutions in the African continent,

Inspire: To facilitate exchange and partnership between Europe and Africa on sustainable energy innovations,

Initiate: To enable innovators in urban and rural communities in Africa to leapfrog to sustainable energy access,

Implement: To co-develop, validate, and replicate innovative energy solutions tailored to urban and rural contexts across Africa, and

Impact: To foster long-term partnerships and exchanges on innovative sustainable energy solutions

The SESA project is designed to combine innovative energy access solutions for a range of applications in both urban and rural contexts in Africa. The innovations are initially co-developed in one modular demonstration case (also known as the living lab) in Kenya addressing the three focus areas of innovation in energy transitions: access, productive use, and a circular economy. Figure 1 provides a snapshot of the interventions in the SESA project. The demonstration site in Kenya is followed by Validation LL in Morocco, South Africa, Malawi, and Ghana. See overview of Demo and Validation sites according to technology category in Table 1.

Figure 1: Interventions in the SESA Project

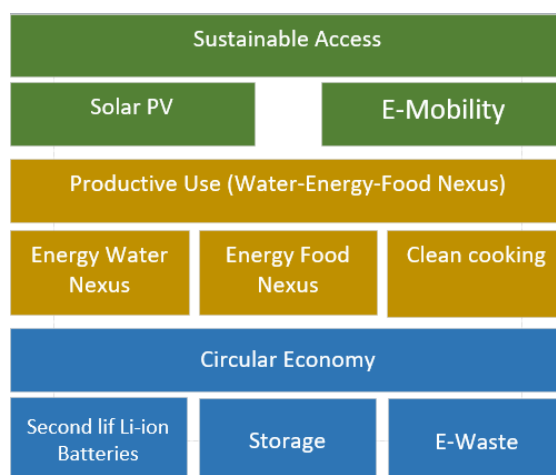


Table 1: Demonstration and Validation Pilots according to technology category

Technology Category	Specific use cases	Country/ Site	Pilot Type
Solar PV Hub for lighting, charging, and supporting services	1. Leasing fishing lanterns	Kenya	Demo
	2. Solar PV hub with panels, and battery banks	Kenya	Demo
	3. Solar off-grid containerised hub for productive use (particular focus on e-mobility)	South Africa	Validation
	4. Solar micro-grid for productive use and HHs	Morocco	Validation
	5. Solar micro-grid for rural communities	Ghana	Validation
	6. Info spots, Digital Inclusion	All	All
E-mobility	7. Leasing and battery swapping for EV two-wheelers	Kenya	Demo
	8. Charging infrastructure support to micro-utility EV	South Africa	Validation
	9. EV two wheelers tested and validated in urban areas	Morocco	Validation
Energy-water nexus	10. Solar-powered water pumping for irrigation	Kenya	Demo
	11. Solar-powered water pump irrigation	Malawi	Validation
	12. Solar-powered water pumping, filtration, and water collection services – for drinking	Kenya	Demo
Energy-food nexus	13. Solar-powered cooling (cold storage for agricultural and fruit produce)	Kenya	Demo
Clean Cooking	14. Small MIG Bio-cookers – local production and distribution, with USB port for charging, including focus on biomass fuel supply chain	Malawi	Validation
	15. Clean/efficient cookstoves for schools	Ghana	Validation
Second-life Li-ion batteries	16. Second-life EV batteries for stationary energy storage	South Africa	Validation
Storage	17. Lithium-ion battery banks for storage	Kenya	Demo

Source: SESA proposal

1.2 Objective and Scope of WP 3 and Task 3.3

Within the SESA project, Work Package (WP) 3 focuses on sub-objective 3: *Initiate _ Enabling innovators in African urban and rural communities to leapfrog to sustainable energy access.* WP3 activities include: i) providing a comprehensive catalogue of innovative sustainable energy measures and solution providers from Africa, Europe and other regions, to be made available through the online SESA toolbox (Task 3.1); ii) identifying the functional requirements, such as needs, technical constraints, environmental impact, cost limits, functionalities, etc. to guide the energy innovations deployed in demonstrations and linking these with the capacity-building activities for public and private sector professionals in WP 2 (Task 3.2); iii) co-developing and co-testing different business models as part of the demonstration actions in the living labs (Task 3.3); and iv) implementing a successful incubator program to foster partnerships and to establish models for job creation and growth (Task 3.4). The work in WP3 is closely linked with WP4, which focuses on innovation replication in the regions.

Tasks 3.3 co-develops and co-tests business models within the Kenya demonstration site (urban and rural) and four additional sites (Morocco, South Africa, Malawi, and Ghana). The key objective of task 3.3 is to provide support to living lab partners as well as the first SESA call for entrepreneurs' ventures² in developing viable and sustainable business models, and to document an entity's business plan supported with financial analysis. Some of the ventures are already part of the SESA consortium, others were selected either directly by the living lab facilitator (for example, Morocco) or through the first SESA Call for Entrepreneurs 2022, based on a rigorous process through Task 3.4.), as follows:

- Kenya: WeTu (consortium member)
- Malawi: Going Green and Make it Green (consortium members) as well as Smart Energy Enterprise (SEE) selected through the first SESA Call for Entrepreneurs Validation Call
- South Africa: uYilo (consortium member)
- Morocco: Green Energy Park (consortium member) in collaboration with local SMEs POGO
- Ghana: Nastech and Econexus - selected through the first SESA Call for Entrepreneurs Validation Call

Task 3.3 also provided support to Task 3.4 in the 1st SESA Call for Entrepreneurs. There is limited direct support from Task 3.3 on the 2nd Call for Entrepreneurs.

Among the 17 use cases highlighted in Table 1, Task 3.3 selected some use cases to develop in-depth business models. The aim is to cover a diverse mix of use cases, drawing on the strengths of the task partners. Each task partner works with the living lab demonstrator/business venture to co-develop and co-test the business model and business plans following the approach outlined in section 2. Task partners (within Task 3.3) synergise the business model support to use cases across sites, where possible, and exchange ideas and lessons (e.g. e-mobility use cases across Kenya, Morocco, and South Africa). Task 3.3 partners use the Business Model Canvas (BMC) (Osterwalder and Pigneur

² We use the term Ventures in a broad sense as a business venture as our target entities comprise of small and medium enterprises (SMEs) as well as social enterprises, as well as part-research centres in some instances.

2010)³ as a common framework to guide the work in Task 3.3 on business model development. See section 2 for details on approach.

The goal is that business models developed in Task 3.3 will be taken up by partnerships initiated by the consortium and beyond by other African innovators and ventures to widen the impact of the SESA project and contribute towards energy access for all (through task 3.4 and 5.1). WP3, through task 3.4, enable business-to-business partnerships to increase the uptake of innovations initiated by the project in various targeted African countries including an incubator program to foster partnerships and to establish models for replication. WP5, through task 5.1, develops concepts for projects aimed at scaling-up the demonstration and validation actions within the living labs. This includes developing pre-feasibility studies to seek for additional grant and/or non-grant funding.

1.2.1 Deliverables of Task 3.3.

Task 3.3 is responsible for the deliverable *D3.4: Report on business plans and models*. The initial target was six business models, but nine have been developed. Updates were provided at project months 12, 24, 36, and 48. Each task partner is responsible for leading at least one site and supporting at least one site as outlined in Table 5 and 6.

Two (2) report templates were developed, one for BM and one for BP (*see attached as Annex A*). These offer broad guidelines on what is expected to be delivered by task partners and included in the reports to be delivered to EU. The templates are subject to changes and modifications based on how the task evolves and the type of data and content available for each site. Also, due to the differences in the pace and progress of the different sites, reports from various tasks partners are completed at different stages and included in the annual updates of this deliverable to EU.

In summary, each task partner is meeting a joint deliverable:

- Comprising elements of a generic business model for the specific use case using the **business model** canvas and associated characteristics, and along with lighter elements of a **business plan** in line with the entity's goals including the aspects of costs and revenues, payback periods, competition and operational sustainability and viability in the long run, and a scalability roadmap.

In addition, a one-page summary of the business model containing information of relevance to other businesses that are interested in a similar market is extracted from the BM report. The one-page BM summaries protect the confidentiality of the SESA participating business entities but provide information about the implemented business models. They are disseminated widely via the toolbox website/toolbox (Task 1.1) to foster learning and replication. Task partners provide the content, and F6S supports the layout and design of these summaries.

³ Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. John Wiley en Sons Ltd. <https://doi.org/10.1523/jneurosci.0307-10.2010>.

1.3 Report Structure

The report structure is as follows, Section 1 introduces the project, its broad objectives, along with the scope and deliverables of Task 3.3. Section 2 provides an overview of the literature around business model canvas (BMC). It also describes the approach and methodology adopted by the Task, along with related activities carried out in coordination with other Work packages and Tasks. Sections 4 to 8 focus on the pilots including in Kenya, Morocco, South Africa, Malawi, and Ghana.

2 Business Models and Plans

2.1 Definition of business models

According to Osterwalder & Pigneur (2010)⁴, a business model “describes the rationale of how a social enterprise creates, delivers, and captures value.” The understanding of the business model of a venture can help us to understand, design, articulate, and discuss the ‘nuts and bolts’ of the business concept.

The Business Model Canvas (BMC), developed by Osterwalder and Pigneur, offers a simple, visual, one-page framework for designing, innovating, and discussing business models. Each BM is unique to the company and use case it describes. A typical business model addresses the desirability and value proposition of a company, product, or service. At a bare minimum, a business model needs to address revenue streams (e.g., a revenue model), a value proposition, and customer segments.

Beyond the classic BMC, this work also draws inspiration from the work on impact enterprises or social enterprises by the Yunus Centre⁵. The SESA project focuses on low and middle-income countries, emphasizing products/services that have strong social impact dimensions and have the potential to generate local employment and trigger income opportunities.

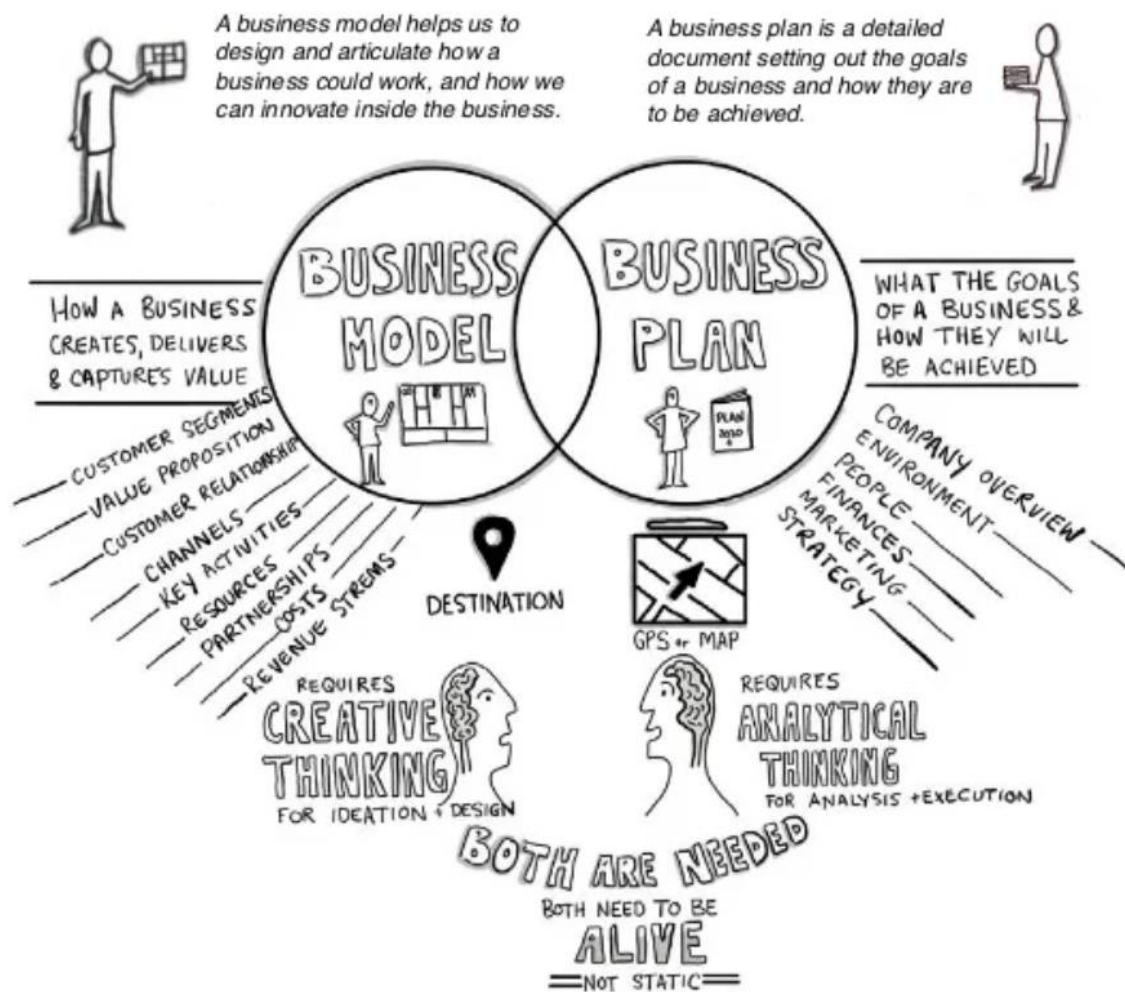
“The purpose of a BM is to help stakeholders understand and clearly articulate how a business is configured so that it creates, delivers, and captures value. In a brief way, it captures how an organisation does business, how that business generates revenue, what value a business offers to whom, who the customers are, and why customers would keep using this product or service.”

“BP goes into further detail to set out the goals of the business, how they will be attained, and what evidence there is that the business will attain those goals. BP outlines the vision, goals, strategy, financial assumptions, and projections, and marketing strategies. However, BP also needs to be constantly evolved with changing environments”.

⁴ Osterwalder, A., & Pigneur, Y. (2010). [Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers](#). John Wiley en Sons Ltd.

⁵ Ingrid Burkett (2020). [Using the BMC for Social Enterprise Design](#). The Yunus Centre, 2020 .

Figure 2: Distinction and Linkages between BM and BP in a diagrammatic way



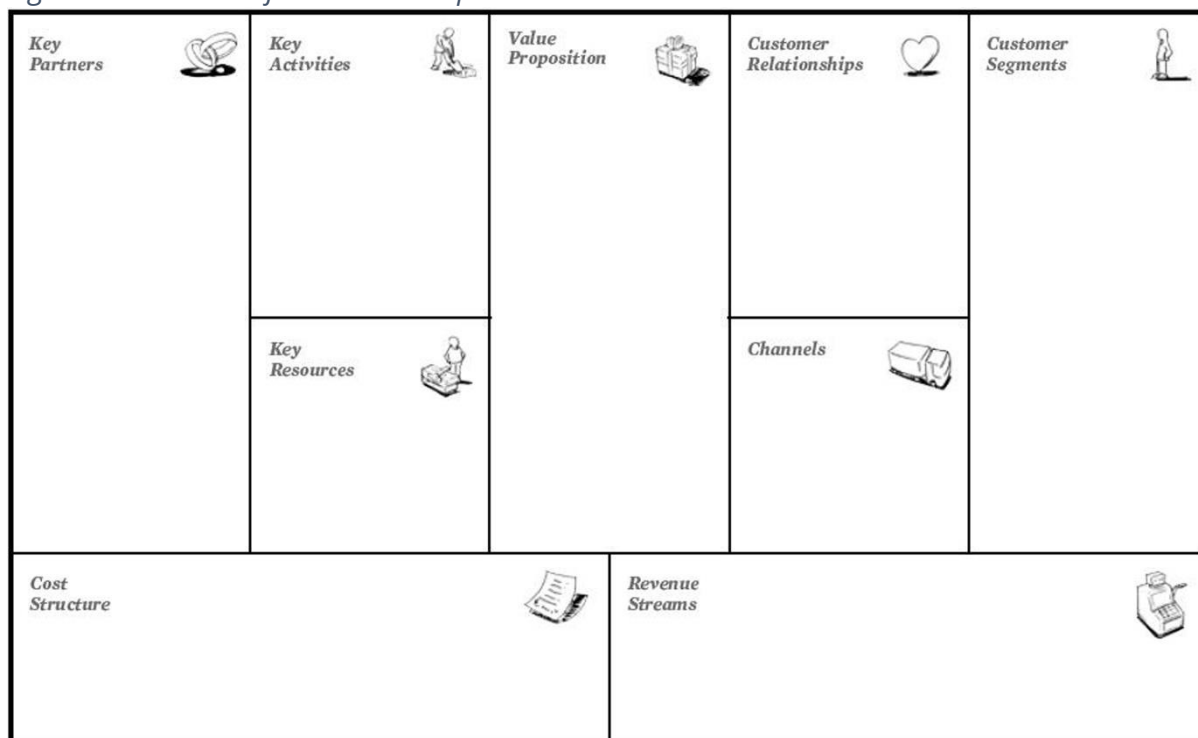
Source: Ingrid Burkett 2020: Using the BMC for Social Enterprise Design, The Yunus Centre

2.2 The Business Model Canvas

The Business Model Canvas is a single-page framework that outlines both what the social enterprise does (or wants to do) and how it operates. It enables structured conversations on management, strategy and business model innovation. The Business Model Canvas is applicable to all enterprises; however, this report focus on drawing on BMC references and examples in the context of social enterprises.

The BMC consist of s nine components, as highlighted in Figure 3.

Figure 3: Overview of the BMC Components



Source: Osterwalder and Pigneur 2010

There is a particular sequence and a logical priority order for these 9 elements, in which they have been described below:

1. **Customer Segments:** This refers to the different groups of people or organizations an enterprise aims to reach and serve. A customer segment is the part of the market targeted by the SME. In any business model, customers are at the centre of the business. There can be a need to classify or group these customers into distinct segments, identify their needs, common behaviours, and attributes, and satisfy them for the business to survive. Various customer segments have been illustrated in the Box 1 below.

Guiding Questions:

- Who are your customers? Please elaborate in detail.
- What needs do your customers have and how does your product / service fulfil them?
- What types of customers group will access, and use your products and services?

Box 1: Different customer and market segments a business model can target

- **Mass market:** A business model that focuses on mass markets doesn't group its customers into segments. Instead, it focuses on the general population or a large group of people with similar needs. For example, buyers of a product like a mobile phone.
- **Niche market:** Here the focus is on a specific group of people with unique needs and traits. Here the value propositions, distribution channels, and customer relationships should be customized to meet their specific requirements.
- **Segmented market:** Based on slightly different needs, there could be different groups within the main customer segment. Accordingly, different value propositions, distribution channels, etc. can be created to meet the different needs of these segments.
- **Diversified market:** A diversified market includes customers with very different needs.

Source: <https://www.strategyzer.com/business-model-canvas/customer-segments>

2. **Value Proposition:** these are the different products and services which the business offers, and which create value in various customer segments. This is the building block that is central to the business model canvas. Value proposition enables the customers to go for the product or service that is being offered as compared to alternative options available. It is the one that attracts the customers, and which makes the customers return. Some of the characteristics of value proposition include the newness, customization, uniqueness, and quality of the product or service. Price, design, brand, and accessibility are some of the key attributes of a value proposition.

Guiding Questions:

- What is unique about your product / service? How does your product stand out in the competition?
- Which one of the customer's problems are you helping to solve?
- What added value does your product or service offer to your customers?

3. **Channels:** These refer to mediums used by a company to deliver the goods and services to the customers, or how a company communicates with and reaches its customer segments to deliver the value proposition.

Guiding Questions:

- What channels (distribution and sales) are used to reach customers?
- What alternative channels are available to reach customers?
- Which channels that you plan to use are cost-efficient? How are you integrating them with customer routines?

4. **Customer Relationships:** This involves all the activities that are undertaken to retain, nurture, and grow customers. Different market segments have different relations which the business should identify and maintain.

Guiding Questions:

- How would you establish a relationship with each of your customer segments and how would maintain with them?
- What will be done to maintain effective communication with customers?
- How are customers able to provide you with feedback and how is feedback considered when adapting the product/service?

5. **Revenue Streams:** includes the sources that a business uses to secure income, see Box 2 below. There are different ways that an SME may use to earn revenues. Examples could be asset sale, subscription fees, and rent etc.

Guiding Questions:

- What are the main revenue sources for your business?
- What are the different pricing mechanisms for different customer segments?
- What is the business doing to secure more income?

Box 2: Additional details on revenue streams and sources

A revenue stream can belong to one of the following revenue models,

- **Transaction-based revenue** made from customers who make a one-time payment
- **Recurring revenue:** made from ongoing payments for continuing services or post-sale services

There are several ways you can generate revenue from

- **Asset sales:** by selling the rights of ownership for a product to a buyer
- **Usage fee:** by charging the customer for the use of its product or service
- **Subscription fee:** by charging the customer for using its product regularly and consistently
- **Lending/ leasing/ renting:** the customer pays to get exclusive rights to use an asset for a fixed period
- **Licensing:** customer pays to get permission to use the company's intellectual property
- **Brokerage fees:** revenue generated by acting as an intermediary between two or more parties

Source: <https://corporatefinanceinstitute.com/resources/knowledge/accounting/revenue-streams/> ; <https://www.strategyzer.com/business-model-canvas/revenue-streams>

6. **Key Resources:** Key resources are the main assets and resources that the business has and uses. The key resources can be physical, financial, intellectual, or human. It includes the equipment, assets, and other products that the business uses to reach markets, maintain relationships, earn revenues and to ensure that there is production and service delivery.

Guiding Questions:

- What are the key resources of your business?
- What is your strategy to grow these resources?
- What strategy do you have for staff development?

7. **Key Partnerships:** includes key stakeholders that the business requires to be able to perform its activities. Here is focus particularly on the strategic partnerships to develop and maintain the market (to keep your business running and to distribute your products).

Guiding Questions:

- Who are the key partners and partnerships?
- Which partners do you deem strategic and important for your business?
- How will you retain these partnerships?

8. **Key Activities:** The key activities of a business represent what the company must do to make the business model work. These are the activities that a business engages in to ensure its survival in the market.

Guiding Questions:

- What are the key activities of the business?
- What activities are needed to fulfil the value propositions?

9. **Cost Structure:** describes all costs incurred to operate a business. It includes the costs incurred during the creation and delivery of value (product or service), maintaining customer relations, and generating revenues. These include both fixed and variable costs. The costs structures can be value driven or cost drive- see the box below.

Guiding Questions:

- What are the important costs inherent to your business?
- Which key resources and activities are most expensive?

Box 3: Types of cost structure

- **Value-driven cost structure** - the focus is to create more value in the product itself, not necessarily producing the product at the lowest possible cost.
- **Cost-driven cost structure** - the focus is on minimizing the costs of the product or service as much as possible

Source: <https://www.strategyzer.com/business-model-canvas/cost-structure>

2.3 Approach and Methodology

This section captures some broader steps that are followed while carrying out activities under Task 3.3. A key aspect of many of these activities is constant engagement, support, and co-development along with WP4 Living Lab leads, hence this hasn't been explicitly highlighted in the method below but is implicit.

The methodology and the steps in *Figure 4* and *Figure 5* below was being put to test first in the Kenya Living Lab, and modified by T3.3 partners based on the practical experiences gained.

Figure 4 Steps for carrying out Task 3.3 work by all partners

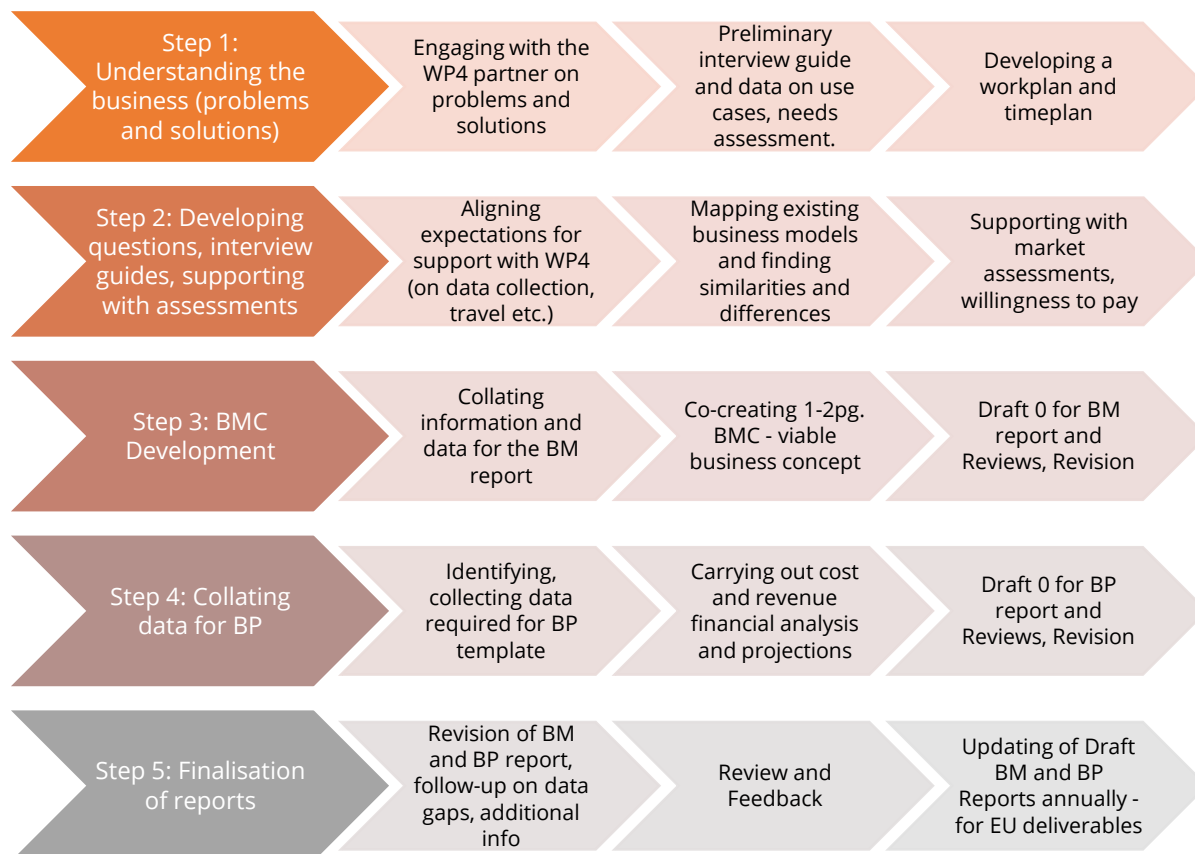
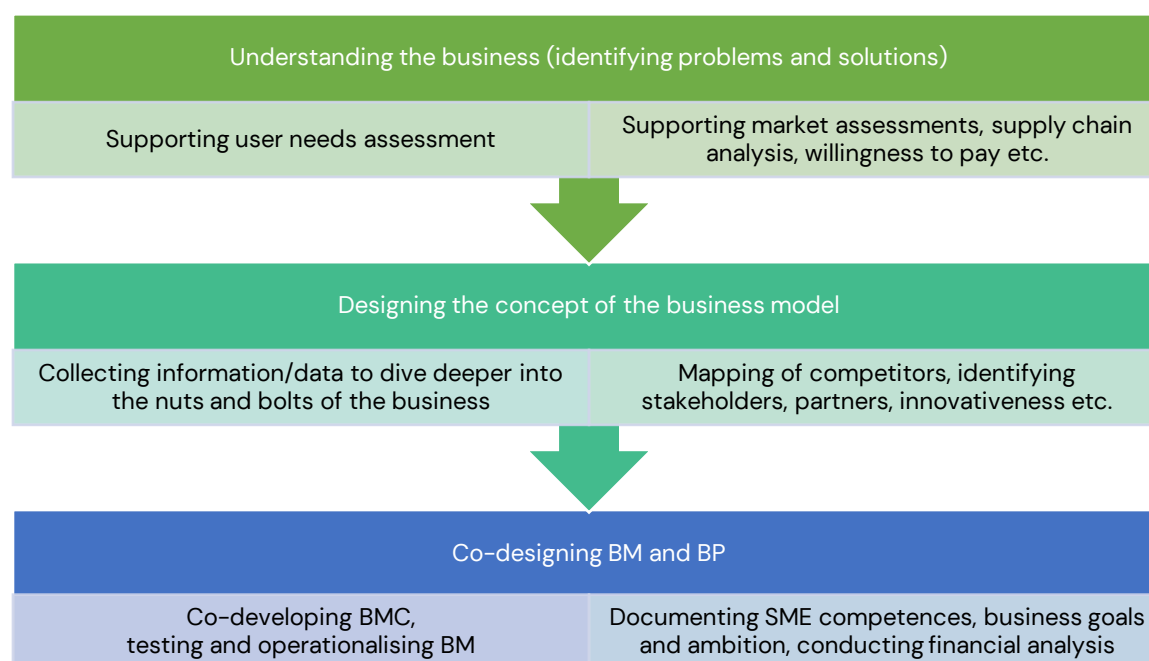


Figure 5: Unpacking the process for approaching the work



Note:

⇒ BM and BP reports is co-developed by the Work Package 4 Living Lab lead and Task 3.3 partner. See overview of partners and leads in *Table 2*.

Table 2: Mapping Responsible Lead Entities for BM and BP Coordination

Living Labs	Facilitating partners (Research institutions and private sector)	LL Leads relevant for Task 3.3 work
Kenya - Urban & Rural	WeTu	WeTu
Morocco	Cadi Ayyad University, Morocco	Green Energy Park + partner SME Pogo
South Africa	Nelson Mandela University - uYilo Mobility Program	uYilo
Malawi	RISE Sweden, Make It Green-Sweden	Going Green, MIG
Ghana	AAMUSTED, LEITAT and Technalia	Partners SME (SEE) for solar irrigation Partner SME (Econexus) for waste-to-energy Partner SME (Nastech) Micro-grid and second life batteries

2.4 Site-specific approach to business models and plans

The needs and requirements for specific support on business models and plans differ depending on factors such as the type of set-up, responsible partners, focus entities, and business ambitions. It is important to clarify and align the purpose upfront for Task 3.3 with the lead responsible entities for each site.

In *Table 3*, the use cases considered under the SESA for different living labs are listed.

Table 3: Demo and Validation Sites country-wise

	Use Cases (Services or products)
Kenya Rural – Kisegi, Homabay county	Solar PV Hub with panels and battery packs, to support the following services: –Solar PV lanterns (lights) –Solar Powered Irrigation
Kenya Urban – Katito, Kisumu County	Solar PV Hub with panels and battery packs, to support the following services: –Solar PV lanterns –Leasing e-bikes with swappable batteries –Solar powered Cooling
Morocco	–Leasing e-motorbikes in Marrakech
	Micro-grid: solar PV electrification for rural villages
South Africa	Operation of micro EVs – three-wheelers for passengers and cargo. (in combination with containerised off-grid solar PV network with solar PV panels and second-life EV batteries under T3.4)
Malawi	Sunflower Briquetting – local production and distribution, including focus on biomass fuel supply chain
	Solar water pumps for irrigation *
Ghana	–Biomass-to-energy solutions; Waste-to-energy and cookstove solutions to public secondary schools.*
	Solar micro-grid for rural communities *

*Implementation led by SME partners contracted under Task 3.4 by Siemens Foundation.

2.5 Responsible Partners and Division of Work

Table 4: Overview of Country Responsible Partners from WP4 and T3.3

Living Labs	Facilitating partners (Research and Industry Partners)	Living Lab Responsible Entity (RE)	Relevant Responsible Country Task 3.3 Partner
Kenya - Rural	WeTu	WeTu	Smart Innovation Norway (SIN) + UNEP
Kenya - Urban	WeTu	WeTu	UNEP + SIN
Morocco	Cadi Ayyad University, and Green Energy Park	GEP + SME for Solar GEP + Emob + Allianz	Siemens Stiftung (SS) + SIN
South Africa	Nelson Mandela University - uYilo eMobility Program	uYilo	Wuppertal Institute (WI)
Malawi	RISE Sweden, Make It Green- Sweden	Going Green (support from MIG + RISE)	F6S + Siemens
Ghana	AAMUSTED, LEITAT and Technalia	SME partner to be sourced (technical and business aspects co- developed by LEITAT and AAMUSTED)	LEITAT + AAMUSTED & Siemens / SIN

Table 5: Overview of Effort and Division of Work for Task 3.3 (subject to changes)

T3.3 Partners	Months	Roles
UNEP-CCC	8.5	Task coordination, Coordination across T3.3, T3.4, WP1, WP4, WP5, Overall Quality Control, Reporting Requirements, Lead for 1 Site (Kenya Urban) and Cross-cutting support
SIN	5	Lead for 1 site (Kenya Rural) and Support for 1 site (Kenya Urban); Coordination across T3.3 and T3.4, and other Work Packages (UNA), and Cross-cutting support.
SIEMENS STIFTUNG	16	Lead for 2 sites (Morocco and Ghana); Cross-cutting support for sites. Coordination across T3.3, T3.4 and link with WP5.1
WI	5	Lead for 1 site (South Africa) + Support for 1 site (Kenya Rural); Sharing of learnings and knowledge from SOLUTIONSplus.
F6S	6	Lead for 1 site (Malawi) + support for 1 site (SA); Coordination on toolkit and communications content.
LEITAT	3	Lead for 1 site (Ghana); Close coordination with local demonstrator
AAMUSTED	2	Support for 1 site (Ghana); Close coordination with local demonstrator

Note: the work division and responsibility could be modified further depending on the information received on the focus of T3.3 in each site, the effort entailed and linked also to the business ambition of sites.

2.6 Practical starting points for all T3.3 Task Partners

- Review Task 3.3. Guidance Note for Approach, implementation plans of WP4, and value mapping document by Task 3.4 for background information on LL.
- Participate in recurring country calls for specific updates and questions, and coordination with other WPs representatives.
- Support WP 1 and jointly guide the user needs assessments process.
- Set up bilateral interactions and engagement with the WP4 Responsible entity for the Living Labs (for data collection, co-creation of ideas and co-development of business models)
- Support selection of SMEs for Validation Call
- Work directly with ventures and selected SMEs on co-developing BMs & BPs

2.7 Coordination and Linkages with other WPs within SESA

The work under Task 3.3 entails close coordination and linkages with work across other Work packages.

WP1 – User Needs Assessment (UNA) - The Task 3.3 partners have represented and supported the UNA Task Force Methodology Development along with the development of Question Bank during the months of April-June 2022, by participating in the weekly UNA Taskforce calls. This includes a focus on the end-users of the services/solutions identified along with tailored questions for the solution providers. This will providing valuable information that will be incorporated while co-developing and innovating business models.

WP3 Task 3.4 – Validation Calls and Incubator Programs – The Task 3.3 partners have supported the process of identifying themes for the validation calls, by participating in the calls and brainstorming the purpose and fit of the SMEs which led to identification of SME partners.

WP5 – Elevation of business concepts/pre-feasibility studies – The work of Task 3.3 will feed into the work of WP5, particularly in scaling up business concepts and conducting pre-feasibility analysis.

2.8 Drawing on linkages with other EU Horizon projects

Task 3.3. has had a peer-to-peer knowledge exchange call with SolutionsPlus team to understand their approach to business model innovation in the EU project, and to gather some of their preliminary experiences, lessons, and challenges. The SolutionsPlus project is focused on innovating and diffusing electric mobility solutions across Asia, Africa, and Europe. The exchange explored: i) enabling peer-to-peer knowledge sharing and lessons learnt on urban e-mobility with ventures in SESA (esp. Kenya, Morocco and South Africa that are also piloting and innovating e-mobility solutions); ii) challenges, and lessons around business model innovation in general.

Table 6: Task 3.3. Time plan/Gantt chart

Project Activities	2021	Year 2 - 2022				Year 3 - 2023				Year 3 - 2024				Year 4 - 2025		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Scope clarifications on BM and BP																
Developing report templates																
Identifying sub-tasks, roles for the Task 3.3																
Coordination across other Tasks and WPs																
Preparing Guidance Note for T3.3. on Scope and Approach																
Contributing to the UNA Task Force																
Bilateral Sessions with Kenya WeTu on BM																
Deliverable 1 - M 12 (Kenya)																
Support the UNA process																
Bilateral Sessions with LL leads on BMC																
Support with interviews, questions, and map existing BMs																
Co-development of BMC and Collating data for BP																
BM and BP Report Reviews																
Deliverable 2 - M 24 (Kenya, Morocco, SA)																
Support the UNA process																
Bilateral Sessions with LL leads on BMC																
Support with interviews, questions, and map existing BMs																
Co-development of BMC and Collating data for BP																
BMC and BP Report Work																
BM and BP Report Reviews																
Deliverable 3 - M 36 (Kenya, Morocco, SA, Malawi)																
Bilateral Sessions with LL leads on BMC																
Support with interviews, questions, and map existing BMs																
Co-development of BMC and Collating data for BP																
BMC and BP Report Work																
BM and BP Report Reviews																
Deliverable 4 - M 48 (Kenya, Morocco, SA, Malawi, Ghana)																

3 Summary of business models and the status of use cases as of September 2024

Table 7 provides a snapshot of the contents as well as use case status included in this 2025 report (in green) as compared to the contents and status included in the 2023 and 2024 versions of the report (in black and blue respectively).

Table 7 - Summary of use case status as well as level of detail included in deliverable

Country	Use Case	Use case status as of September 2023 (in black), Status as of September 2024 (in blue), Status as of June 2025 (in green)	Level of detail included in the deliverables in 2023 (in black), 2024 (blue), and 2025 (green)
Kenya	E-mobility / E-bikes	- Procurement of bikes from a technical partner in Kenya, and a few bikes were retrofitted from ICE bikes to e-bikes. - Various testing of retrofitted bikes with the boda-boda riders in Homabay. - The retrofitted bikes experienced challenges with the frame of the bike along with battery performance in the slopy and rough terrain in Kisumu County. - The technical partner recalled the bikes and upgraded the bike + battery infrastructure. - Based on experience from initial testing a second version of the e-bikes that are fit for the terrain, gear-coupled and with improved battery performance have been developed. 7 second version e-bikes are now in operation. - Pricing model has been adjusted to cater for user group affordability - Increase in user interest and demand - Lack of insurance solution remain a hinderance to upscaling in the market - Focus on operation and increasing uptake - Increase in distance covered and number of battery swaps - Consultative user co creation sessions test prototypes and improvements (e.g. pricing model and technical aspects) - Further revised the pricing strategy: refundable deposit fee of 3000 KES (23 USD), Monthly rental fee of 2000 (15 USD) and a battery swap fee of 300 KES (2.32 USD)	- Info on the use case, data from the user and secondary data on e-bikes and challenges - Rider feedback during test phase - Info on battery performance - Next steps - Info on bikes currently in operation with operational data. - Info on pricing and feedback from riders on price, technical performance, maintenance, repair - Financial analysis, capex, opex, revenue projections. - Updated financial modelling and Operational Insights along with Lessons Learned (incl. challenges, etc.).
	Solar PV Cold Room	- Location for cold room met with various bureaucratic and procedural delays. The location had to be changed from Katito to Mbita. - Technology partner, Self-Chill, providing the cold room with cooling units. - End-user baseline and market assessment (surveys, discussions and FGD) was conducted in Mbita market to assess the need, type of usage, willingness to pay, extent of food waste and income loss problem.	- Info on the use case, technology set-up and partners - Secondary data on off-grid cold room and business models - Data findings from baseline / market assessment conducted - Next steps

		- Location paperwork is finalised, and construction of the cold room is soon underway - Construction completed and commenced operation May 2024. This was preceded by months of planning, sensitization with vendors, technical trainings and preparation for operators and staff. - Initial findings and data from the operational phase are being gathered. Digital app for tracking and monitoring produce stored in cold room is being finalized. - Pricing revised to make it more affordable for certain user groups (e.g., vendors selling leafy vegetables). Segmented pricing for different produce types introduced. - Focus on operations and increasing uptake from an average of 10 crates per day to 20+ crates per day - Additional user awareness and sensitization sessions conducted pertaining to handling and storage of produce - User evaluation feedback gathered	- Description of the business model - Initial findings and insights from the operational phase - Financial viability analysis - Challenges and lessons learnt - Update operational insight and uptake - Update financial model - Update on user feedback
	Solar irrigation	- Mapping – secondary data - Context/Baseline info from Kiseji – type of irrigation, diesel vs solar cost, need for irrigation etc. - Technology experiments (Kiseji) - Type of user segments, farmers land agri size/scope. - Pricing info tried so far - Piloting May to July 2025 - Irrigation as a service / community approach - Testing pumps robustness, local conditions - New pump from new provider	Field level piloting lessons (New inclusion in deliverable 2025)
Morocco	E-mobility / E-scooters	- E-scooters were procured for use by the female university students in Marrakesh. - End-user assessment was conducted with the students, along with mapping of the university buildings, routes, and the behavioural aspects i.e., usage patterns etc.	- Info on the use case - User needs assessment data - E-scooter testing feedback - Capex and Opex data - Secondary data on EVs in Morocco

		- Subsidised pricing was identified as the student-segment has low affordability along with a higher-paying end user (i.e., tourist segment) to cross subsidise the costs. - A phase of e-scooter testing was conducted, and feedback received. - Based on low user uptake of e-scooters in Marrakesh, some of the scooters were transferred to second tier cities Agadir and Fes. - The customer segment has been broadened to include tourists and all users in the age range 18-40. This has led to higher uptake of the scooters. - The app and digital monitoring of the scooters have been smooth. Live data is being gathered. - Focus on operations and increasing revenues - Increased profit margins from 12.9% (July 2024) to 40.3 % (June 2025) - Service expanded to new city (Casablanca)	- Updates from the operational phase of E-bikes including change in location, customer segment etc. - Financial analysis based on updated price/fee rate and projections on viability - Challenges and lessons learnt. - Update operational insight and financial model
Malawi	BioCooker and fuel briquetting	- The first prototype of the MIG BioCooker failed to meet the SESA requirements. - A second prototype of the MIG BioCooker was manufactured (in Sweden) under the SESA grant. with a few added features e.g., USB charging port etc. - The MIGBioCooker was tested among the farmers (end-users) in the Central Malawi region and general positive feedback was received. - Meanwhile, various types of biomass fuel in various shapes and sizes (in the form of briquettes and pellets) were also tested in the laboratory at RISE and the stove was fine tuned. - RISE carried out studies and explored the potential to turn sunflower stalk into briquettes. - Two briquetting technologies was tested. One from Poland and one from Czech Republic. - The Malawi living lab assembled 19 MIG BioCooker stoves and distributed them to 18 households for long term testing and validation. - The MIG BioCooker developed by the consortium partner is not at a stage where it is commercially ready to be taken up by a commercial partner	- Info on the use case - UNA data - Secondary data on cookstoves in Malawi market - Local context and challenges - Shift from focus on the BioCooker to the business model of briquetting - Updates from the use and uptake of the briquetting machine and production of briquets. - Exploring re-use or re-application of agricultural waste - Challenges, lessons and next steps

		due to the high pricing for advanced cooking stoves and low ability to pay by end users. • Briquetting technology from Czech Republic was delivered to Malawi living lab. • The production and selling of briquettes from sunflower stalks were started. • Sunflower stalks were bought from 90 farmer clubs. 1600 kg of briquettes have been produced until September 2024 and 60 bags of briquettes were sold to households by 10 selling agents. • Production of briquettes continued in season May-August 2025. • Production processes were improved which led to increase in production. • 3000 kgs of briquettes produced and sold • Increasing supply of stalks from farmer groups • Exploring different user segments, rural HH, low to middle income families/semi-urban HH and local businesses and restaurants	• New data and user information on briquetting • Cost information on existing pilot (unit) • Materials, equipment, transport, maintenance etc. • Distribution, Agents • Financial Projections, Volumes and Scale
	Solar Irrigation (SEE)	• SEE procured and distributed 25 solar-powered irrigation systems to 46 smallholder farmers in the Karonga district. • Lease to own model with after-sale services and market linkages to support farmers including extension services • Partnerships with financial institutions at the district level, facilitating connections between farmers and banks to obtain soft loans for purchasing solar pump irrigation systems. • SEE has achieved a 65% annual revenue growth and maintained a 96% loan recovery rate.	• Business model aspects tested and validated • Lessons learnt • Financial analyses, revenue model and projections. (Final submission in deliverable 2024. Contract ended.)
South Africa	EV for community and CARE	• The transportation needs of the CARE and the local communities was clearly identified in the Alicedale context in Eastern Cape, along with the most frequented transport routes and affordability challenges. • In near future, one EV will be operated in Alicedale at a highly subsidised fee in the community and data will be collected on the technical aspects, vehicle performance, battery efficiency of the secondary Lithium-ion, and transport usage uptake. The potential for the need and feasibility of the EV in Alicedale will be inquired.	• Info on the use case, local context, and the next steps • UNA data, findings from EV survey conducted • Spatial mapping of amenities in and around Alicedale • Initial info from the operations of the micro-EV and potential use and demand • Business model features using the canvas table • Cost calculations

		- Two micro EVs (one for passengers and one for cargo) have now been introduced and are operating in Alicedale. - Technical performance and testing is being carried out along with assessment of demand. - Surveys have been conducted with end users for initial feedback - Focus on operations and increasing uptake of the passenger and cargo vehicles	- Update Data on user uptake, demand, km, financial model based on data. - Updated Financial Scenarios on viability based on commercial operations and based on subsidy.
Ghana	Cookstove in Schools (Econexus)	- Analysis of the needs and gaps was conducted across various schools for cooking and also the usage of firewood accounted for, with longer-term impacts on deforestation. - A new ethanol based cookstove along with non-pressurized bio-based ethanol is being jointly introduced as a substitute to using firewood for cooking at schools and also for HHs in local communities. - Continuous testing and feedback by end-users has shown several challenges regarding costs of biofuels (yeast prices have increased by 150% due to inflation in Ghana), high evaporation rates of biofuel at high heat, a lack of demand in rural areas, leading to an overall decline in revenue sales and a total decline in production of biofuel by end of 2023. - This has led to the conclusion that the business model for clean cooking and biofuels will not be taken forward as planned due to a missing product-market-fit.	- Info on the use case, local context, the implementing partners. - Business model aspects tested and validated - Challenges and lessons learnt - Calculations on viability, financial analysis (Final submission in deliverable 2024. Contract ended.)
	Microgrid and battery recycling (Nastech)	- Three microgrids have been installed in communities in a pay per use model. - The customer based has been enhanced from 100 to 400 - Quantity of batteries has increased.	- Business model aspects tested and validated - Challenges and lessons learnt - Financial analyses, revenue model and projections. (Final submission in deliverable 2024. Contract ended.)

Table 8 provides a summary of the different business models that have been tested and validated in the project.

Table 8: Summary of business models by country and use case

Country	Use Case	Summary of model	Summary of key figures
Kenya	E-mobility / E-bikes	Rental. The user rents the E-bike on a contract with no end date with a monthly fee of 1000 KES (6.9 Euro) plus an additional 300 KES (2.1 Euro) per day for unlimited battery swapping on that day. Within the monthly fee, WeTu provides insurance for riders and are responsible for all maintenance and repair of the bikes. The user does not have any risk or responsibility for damage or loss of the e-bike. Customer segment: rural and peri urban boda boda riders and residents in Western Kenya.	7 ebikes in operation 92000 km covered - Weekly savings for end user (ICE vs Ebike): 2150 KES or 14 Eur
	Solar PV Cold Room	Pay per use (crate per day)/Pay-as-you-store: customers pay a fixed rate per day and per crate for using the cold room facility for a particular weight and time duration. E.g. leafy vegetables: 25KES(0.17Euro)/per crate/per day, tomatoes at 50KES (0.35 Euro)/per crate/per day, watermelons at 75KES (0.52 Euro)/per crate. Customer segments: market traders/vendors and retailers, wholesalers trading in bulk produce and Local businesses in the Mbita/Homabay region.	- One cold storage room 55 customers, mainly women - Preservation of 32 tons of fresh produce from May 2024 to July 2025
Morocco	E-mobility / E-scooters	Pay as you go model: Users unlock the e-scooters with an app and pay 0.99MAD (0.09 Euro)/min or 1.9 MAD (0.18 Euro)/Km. In addition, there is also another option whereby users can rent the e-scooter with a daily fee or even for an entire month with a monthly fee: one day, 10 euro; 7 days 55 euro and one month, 150 euro. This includes insurance and maintenance. Customer segments: Urban residents (18-40) who do not own a vehicle and tourists. E-Scooters are currently being implemented in Marrakech, Agadir, Fez, Benguerir and Casablanca.	40 ebikes in operation as per June 2025 650.000 Km covered 8000 active users 51 Tons CO2 saved
Malawi	MIG BioCooker and fuel briquettes	Direct sales of briquettes through agents. One bag of 20 kg briquettes is sold to agents at 7,000 kwacha (3.5 Euro) who resell to end users. Customer segment: the 18 MIG BioCooker users as well as users of other types of stoves in the market.	20 bio-cooker stoves in operation as per Sep 2024 5600 kg briquettes produced and sold by 12 sales agents, reaching nearly 5-

			10 customers per agent per day.
	Solar Irrigation (SEE)	Lease-to-own model. Total Price: 6,300,000 MWK (3,150 Euro). 20% down-payment for solar irrigation pump, followed by two installments (40% each) which are temporally aligned with the harvesting seasons. Customer segment: smallholders and commercial farmers. SEE has established partnership with financial institutions who provide loans to farmers to buy SEEs product based on a digital loan and pump management system, which allows SEE to shut down the irrigation system until payment is made. Direct sales. Price: 6,300,000 MWK (3,150 Euro). Customer segment: NGOs and commercial farmers.	As per Sep 2024 25 solar pumps sold 100% increase in yield for users of solar pump
South Africa	E-mobility / E-vehicles for residents and CARE	Taxi service: pay-per-trip. Customer segment: Alicedale community members and Care Community Centre: R10 (0.5 Euro) per trip (5-20km radius). Tourist excursions: R50 (2.5 Euro)/100 (5 Euro)/150 (7.6 Euro) per person for different tourist packages. Cargo service: pay-per-trip. Customer segment: Alicedale business owners and CARE Community Centre: Minimum cost of R50 (0.5 Euro), depending on the weight, distance and nature of the goods to be delivered.	- One cargo e-vehicle: 171 trips from July 2024 - Apr 2025, approx. 2 different goods transport requests per trip. Total: 966 km - One passenger e-vehicle: 175 trips from July 2024 - Apr 2025, approx. 6 people in a vehicle. Total 3991 km.
Ghana	Cookstoves in Schools (Econexus)	Direct sales of bio-fuel and cookstove with different price segments for bio-gel: \$2.0/L (1.8 Euro) and bio-fuel: \$1.20/L (1.1 Euro). Customer segments: Rural and peri-urban households, restaurants and secondary schools (tested as new customer segments as part of living lab validation).	As per Sep 2024 438 stoves sold 1,575 liters of ethanol fuels sold via 5 retail shops
	Micro-grid and battery recycling (Nastech)	Micro-grid solution: Subscription model: users pay connection fee: 700 GHS (40 Euro) plus a monthly fee: 100 GHS (5.8 Euro). Customer segment: rural residents in two communities. Individual solution: Pay-as-you-go and subscription model for solar generators. For generator with capacity of 1000 W, subscription fee: 1000 GHS (58 Euro) + monthly fee 100 (5.8 Euro) GHS) and for	As per Sep 2024 3 micro-grids installed with 54 microgrid HH subscriptions 64 Individual subscriptions for solar home systems

		capacity of 2000W, subscription fee of 1500 GHS (86 Euro) + monthly fee of 150 GHS (8.6). Customer segment: businesses and rural and urban residents. Direct sales of battery banks at 4000GHS (230 Euro) and solar generators: 1000 W at 2500 GHS (144 Euro) 2000 W at 4200 GHS (242 Euro) 5000 W at 23000 GHS (1325 Euro). Customer segment: businesses and urban residents.	5 retail outlets in 5 regions
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Exchange rates used

Exchange rates	Dollars	Euro
1 MAD (Morocco)	0.10	0.094
1 ZAR (South Africa)	0.058	0.050
1 MWK (Malawi)	0.00057	0.00049
1 KES (Kenya)	0.0077	0.0066
1 GHS (Ghana)	0.081	0.069

Table 9 provides an overview of key lessons learnt across the various business models. Lessons cutting across the use cases are reflected upon at the end of the report.

Table 9 Summary of key lessons learnt

Country	Use case	Key lessons learnt on business model aspects
Kenya	E-mobility / E-bikes	• User Economics is a Primary Driver of Adoption. WeTu has demonstrated a good user need/solution fit for rural/ peri-urban boda boda riders and e-bikes in Kisumu, Kenya. The reduction in daily operating costs, primarily fuel and maintenance expenses, emerged as a strong incentive for adoption among boda-boda riders. • Alignment of Service Models with Income Patterns. The transition from a combined daily lease-plus-swap fee to a pay-per-swap arrangement with a modest fixed monthly service charge better reflected the variable income streams of riders. This adaptation improved affordability and payment flexibility for the end users. • Initial uptake contingent upon visible endorsement from early adopters. Use of champion users and early adopters to increase confidence in the broader customer base has been effective. Peer-to-peer influence proved more effective in fostering confidence than technical documentation alone. Implication: Early project phases should prioritise demonstrable user success stories as a trust-building mechanism. • Localisation of Technical Solutions. The business model is heavily affected by the technology and conversion: substantial testing and bespoke adjustment needed for the bikes to be fit for purpose and substantial training of end users needed to increase uptake. Early drivetrain designs proved vulnerable to the region's terrain, vehicle overloading, and riding practices, necessitating recalls and modifications. • Building in-house conversion capacity. WeTu has built up skills and capacities to enter the market of converting existing petrol-bikes. This has reduced costs, shortened turnaround times, and enhanced local technical expertise. • The extensive need for staff in the early phases of implementation puts a strain on the viability of the business model. The model currently works as a social enterprise model where the goal is to reach break-even and not turn a profit. • Scaling the solution would be relevant for other areas with high density of users using bikes for income generating activities.
	Solar PV Cold Room	• Adoption Challenges with Cooling Technology - Vendors often rely on low-cost, informal storage methods—such as leaving produce on stalls or covering it with tarpaulins. Transitioning to cold

		room-based storage introduces not only a technological learning curve but also a new cost structure. Many vendors focus on the upfront fees, overlooking the potential for increased earnings through reduced spoilage and improved produce quality. • Limited Local Support Capacity - WeTu's ability to provide ongoing vendor support is constrained by limited local resources, making it difficult to maintain consistent engagement over time. • Need for Comprehensive Evaluation Before Deployment - Effective placement of cold rooms depends on a detailed analysis of food waste levels, seasonal variations in produce and pricing, farmer income impacts, and consumer willingness to pay. External factors like transportation infrastructure also play a critical role • Low Utilization Despite Affordable Pricing - Even with a flexible "price-per-crate-per-use" model tailored to vendor affordability, cold room usage remains below 40% of capacity. Operating margins are low, making the model commercially unsustainable without external financial support such as grants or concessional loans. • Segmented Pricing May Improve Viability - A tiered pricing strategy based on produce type and associated income margins could be more effective than a flat-rate model, potentially improving utilization and financial sustainability. Based on this reflection, the Mbita cold room pricing strategy was revised. • Gradual Uptake Indicates Latent Demand - Data shows a steady increase in crate usage over several months, suggesting that while demand exists, adoption is slow due to the time required for users to become familiar with the technology. • Secondary Markets Reduce Perceived Waste - Damaged produce is often repurposed by restaurants and hotels, serving as a cost-effective ingredient source. This existing coping mechanism reduces visible food waste and weakens the perceived need for cold storage solutions.
	Solar irrigation (new)	• Reliability Is the Foundation of Adoption. Farmers consistently compared solar pumps to the performance of 2.0HP petrol pumps. Early models failed due to low flow rates or technical fragility. Adoption only occurred when the technology proved reliable under real-world conditions, highlighting that uptime and consistent performance are non-negotiable. • Local Maintenance Capacity Is Essential. The lack of local spare parts and repair services for earlier pump models led to extended downtimes and loss of trust. The lesson: technical support must be locally available and responsive to ensure continuity and build farmer confidence. • Technology Must Align with Irrigation Practices. Most farmers use flood irrigation, which is water- and energy-intensive. Solar pumps optimized for moderate flows were perceived as weak. Success

		depends on bundling solar pumps with water-efficient methods like drip or sprinkler systems to match local practices. • User Co-Creation Drives Relevance and Uptake. The User Needs Assessment and focus group discussions shaped pump selection, pricing, and service design. Farmers are not passive recipients—they are active co-creators, and their involvement is critical for designing solutions that are adopted and sustained. • Integrated Systems Outperform Standalone Components. Farmers preferred complete, mobile solutions—not just pumps. The integrated trolley system combining pump, battery, solar panels, and irrigation kit proved more effective and user-friendly than fragmented components. • Iterative Testing and Adaptation Are Crucial. Failures with earlier pump models led to the adoption of the Impact Pump, which offers remote monitoring, better durability, and local support.
Morocco	E-mobility / E-scooters	• User-Segment Validation is Critical. Early targeting of female university students faced limited uptake due to free existing transport, safety concerns, and institutional reservations. Thorough pre-launch validation is critical. • Dynamic Fleet Deployment. Active relocation of vehicles to higher-demand cities (Agadir, Fez, Benguerir, Casablanca) significantly improved utilisation rates, demonstrating the value of responsive asset management. Preserved inclusivity for the original target group via voucher access while redeploying underused assets. • Pricing Strategy Balancing Affordability and Sustainability. At 0.99 MAD/min or 1.9 MAD/km, POGO undercut competitors while maintaining a ~30–41% margin due to low local OPEX. Short-term (daily/weekly) and long-term (monthly) rental options supported multiple customer profiles. • Strong Potential for Scale. Financial analysis, grounded in the operational performance of the 40 e-scooters deployed during the pilot, indicates strong potential for scale. Assuming the addition of 1,030 e-scooters to the fleet over the next five years, projections demonstrate a robust return on investment and healthy cash flows. These revenue forecasts are considered credible, as they are derived from actual pilot performance data. • Early Stakeholder Engagement Important for Operational Readiness. Delays in securing parking permits and aligning insurance policies slowed rollout, underscoring the need for early and continuous coordination with municipal and regulatory bodies. • Environmental Benefits Are Tangible and Measurable. Over 650,000 km driven by the SESA fleet saved an estimated 51 tonnes of CO₂. Tree-planting pledge (1 tree per 1,000 km) enhanced the sustainability narrative.

Malawi	Briquetting (Bio-cooker)	• Agricultural Waste Can Power Clean Cooking Solutions. The project demonstrated that sunflower stalks—previously discarded or burned—can be transformed into efficient, clean-burning briquettes. By tapping into this underutilized resource, and by building on its existing relationship to the sunflower producing farmers, Going Green (GG) created an additional business opportunity that not only reduces waste but also provides a sustainable alternative to firewood and charcoal. In addition, GG is also exploring other biomass sources such as sawdust, maize cobs, and rice husks. • Farmer Networks Are Key to Raw Material Supply. GG leveraged its existing network of 200 farmer clubs to source sunflower stalks. Initially, only 90 clubs participated, but the potential to expand sourcing from all 200 clubs could dramatically increase production. Mobilizing farmers and offering attractive prices for stalks is a critical aspect of the model to ensure consistent feedstock and to grow production capacity. • Small-Scale Production Validated Market Demand. Using a compact briquetting press and shredder, GG produced over 5,400 kg of briquettes across two seasons. Though limited in scale, this setup allowed for testing of operations, training staff, and refining processes. It also confirmed strong local demand, with all briquettes sold through 10 agents serving over 100 households. • Production Planning Improved Efficiency. In 2025, GG introduced structured production cycles, better feedstock preparation, and real-time monitoring. These changes led to more predictable output and reduced waste. With improved planning, GG increased monthly production from 600 kg to 1,500 kg and expects to reach 8,000 kg per season. • Scaling Requires Investment and Strategic Partnerships. To meet growing demand, GG plans to purchase a larger briquetting machine, expand farmer contracts, and build storage facilities. Partnerships with financial institutions, cooperatives, and local retailers will be essential to scale production, distribution, and awareness.
	Solar Irrigation (SEE)	• Flexible Payment Model. The lease-to-own model with a Pay-As-You-Grow approach proved highly effective for smallholder farmers. Bundling the irrigation system with extension services and market linkages significantly increased loan repayment rates (96%) and farmer income. • Product Innovation. SEE developed the Kanyumba Solar Pump Irrigation System, a movable pump house that: Enhances security and portability. Protects equipment from flooding and theft. Offers on-farm accommodation for farmers. Embedded digital loan and pump management systems improved monitoring and reduced default risk. Improving the strategy and product gave SEE an advantage over its competitors. It also developed trust among the customers for their product and services.

		• Customer Segmentation & Market Strategy Initial focus on resource-poor farmers was challenged by dry spells and low income. SEE improved their existing outreach methods to the target customers during the SESA sub-contract period. SEE diversified their target customers by including new customers/farmers who have higher ability to adopt the solution and make payment for the product in short duration of time. Referral marketing via Agricultural Extension and Development Coordinators (AEDCs) replaced costly community sensitization meetings and proved more effective. • Impact on Farmers. Farmers doubled their rice production from 3 tons/ha to 6.2 tons/ha. Income increased from MWK 2.4M/ha to MWK 5M/ha, improving food security and livelihoods. Farmers now earn MWK 15.8M/year from combined rain-fed and solar-irrigated farming. • Growth & Replication Strategy. Plans to expand regionally to Zambia, Tanzania, Mozambique, and Zimbabwe. Development of smaller-scale solar irrigation systems for horticulture. Launch of Agro-Dealer Shops and rice processing plants to diversify income. Integration of construction services and digital technologies to widen reach and improve efficiency.
South Africa	E-Vehicles for CARE	• Community-Centered Design Drives Adoption: The micro-EV initiative in Alicedale was tailored to meet the mobility needs of a vulnerable, low-income community. The project demonstrated that early engagement, user needs assessments, and inclusive service design, tailored culturally sensitive awareness campaigns and continuous capacity building to foster trust, develop local skills are critical for adoption and to ensure long-term success. High user satisfaction (96% for passenger EVs, 79% for cargo EVs) confirmed the relevance of the solution. Limited community exposure to renewables requires trust-building and targeted awareness campaigns to overcome initial resistance. • Operational Efficiency and Data Collection Are Crucial: The use of QR codes, vehicle logs, and power meters enabled real-time monitoring of vehicle usage, charging patterns, and user feedback. This data-driven approach helped refine service delivery and informed business model development. Reliable EV charging and supporting infrastructure are essential for scaling e-mobility and renewable energy in rural settings. • Affordability Is Essential for Sustainability: Despite strong demand, the business model was not financially viable without subsidies. The community's willingness to pay (R10 per trip) was significantly lower than the cost-recovery threshold. This highlights the need for public-private partnerships (PPPs) or government subsidies to bridge the affordability gap in low-income settings. • Subsidies Enable Viability and Scalability: Financial modeling showed that subsidies covering 80–100% of costs in the first two years, and 50% from years 3–15, allowed the business to become profitable. Without subsidies, neither the passenger nor cargo micro-EV models reached break-even

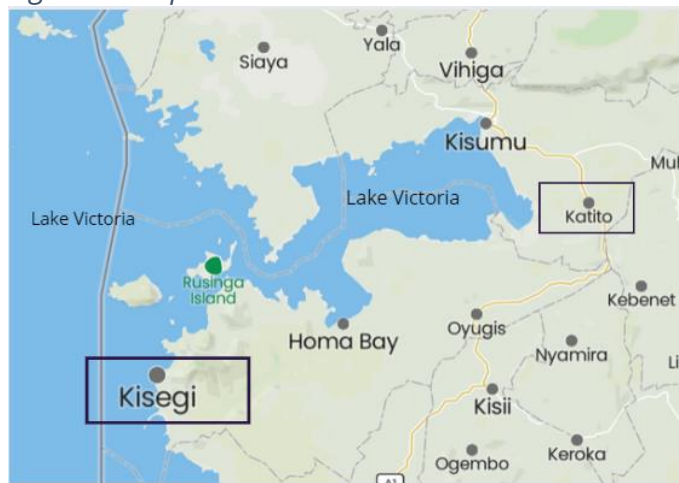
		over 15 years. This underscores the importance of strategic public financing aligned with national policies like South Africa's Just Energy Transition Plan (JET-IP). • Policy alignment boosts scalability – Collaboration with local authorities aligning with national policy 'South Africa's Just Energy Transition Plan' has supported long-term scalability of solutions. • Flexible business models improve access – Pay-as-you-go and PPP-subsidised models made e-mobility services more affordable for low-income residents. • Adaptive management meets diverse needs – Demand adapted timelines, responsive logistics, and tailored resource allocation support varied customer segments for increased use of the services. • The Alicedale Living Lab model has increased interest from other provinces, with Limpopo already engaging stakeholders to replicate it. Case studies and innovative financing models could expand e-mobility with renewable energy adoption in underserved semi-rural communities.
Ghana	Microgrid and battery recycling (Nastech)	• Revenue Model Limitations: The pay-as-you-go model is viable but unsustainable with low-income rural users due to extended payback periods and reduced consumption. • Target Market Shift: To ensure financial sustainability, Nastech shifted focus to middle-income customers in urban areas who can afford upfront payments and larger systems. • Regulatory Barriers: Legal restrictions on power sales and transmission by non-government entities significantly hindered micro-grid implementation and scalability. • Operational Adjustments: Regulatory constraints forced Nastech to subcontract GRIDCO and modify its monetization strategy, which led to challenges in fee collection and user compliance. • Community Engagement Challenges: Initial willingness to pay declined over time, highlighting the need for stronger community engagement and reliable payment mechanisms.

4 Kenya

4.1 Introduction to the SESA Demonstration Living Labs

The use cases are developed around two energy hubs in Katito (urban site), a peri-urban community in Kisumu County, and Kisegi (rural site), a rural village in Homa Bay county (See *Figure 6*). Both demonstrations are solar charging hubs that house PV modules, central Li-ion battery storage, and balance-of-system (BoS) to increase energy accessibility for a range of electrical needs within the local community. These PV hubs are providing support to various productive use linkages such as lanterns for fishing community, water pumping, water purification, e-mobility, and e-waste, and combining energy solutions with local Info Spots for access to information, on energy, climate, and digital skills.

Figure 6: Proposed SESA demonstration sites: Katito and Kisegi⁶



Services to be piloted under the 1st site - Kisegi Hub 36kW

- 1) Leasing fishing lanterns;
- 2) water filtration system for drinking;
- 3) water pumping for irrigation.

Services to be piloted under the 2nd site - Katito Hub 36kW

- 1) EV bikes leasing and battery swap;
- 2) water filtration systems for drinking;
- 3) solar cooling solutions for agricultural produce.

⁶ Google. (n.d.). [Google Earth map of SESA Katito site]. Retrieved February 10, 2022, from <https://www.google.com/maps/d/u/1/edit?hl=en&mid=1Dq1GUt366jITvyLmpPsQxaXl4JgRk78l&ll=0.22370030413879016%2C32.85904763205721&z=6>

Justification of selected pilot use cases for the SESA Demonstration Living labs

Mobility: In the region, the reliance on petrol and diesel engines remains predominant, with minimal awareness or adoption of electric vehicles despite their potential benefits. Current e-mobility initiatives are limited in scope, targeting specific groups such as county officers and meter readers. WeTu's proposed solution of leasing electric motorcycles with swappable batteries addresses a critical need by providing a sustainable and efficient alternative for transportation. This approach not only reduces dependence on fossil fuels and lowers emissions but also enhances operational efficiency and accessibility, paving the way for broader adoption of electric mobility in the region.

Fishing: For fishing lights, many Omena (silver cyprinid) fishermen use small bulbs attached to a motorcycle lead-acid battery or kerosene pressure lamps. The main energy source for lighting around Lake Victoria has been kerosene, which is inefficient because only 0.1 % of the burnt kerosene is converted into light, resulting in relatively high CO² emissions. WeTu has proposed solar-powered fishing lanterns to support the communities. In addition, WeTu is also exploring solar powered cold chain facilities to keep the produce fresh after harvest.

Electricity: There are significant differences in access to electricity between urban and rural households. In rural areas, 46.5% of families lack access, compared to only 11.8% of urban households. Grid users face the greatest disparity. While over 80% of the urban population has grid connection, fewer than 20% of the rural population does. In the lack of grid access, many rural homes rely on off-grid sources, with solar solutions dominating the field, followed by rechargeable batteries and diesel generators.

Agriculture: The region's dominant economic activities are fishing and subsistence farming. Despite favourable climatic conditions, agricultural productivity remains low due to the use of traditional farming methods as well as cultural practices of generational land subdivision, which has resulted in the dominance of small land holdings with limited agricultural activities. In terms of fishing, hazardous fishing methods such as the use of non-compliant fishing nets, kerosene lamps, and lead acid battery powered lamps have resulted in declining fish stocks and lake pollution. WeTu is exploring a range of solutions targeting small-holder farmers including solar-powered irrigation, electric tractors, energy efficient agricultural appliances etc.

Safe Drinking Water: Water quality throughout the lake basin has been severely harmed by both point and non-point pollution sources, with the latter being closely linked to land use and management practices. Water quality throughout the lake basin has been severely harmed by both point and non-point pollution sources, with the latter being closely linked to land use and management practices. WeTu has set-up solar-powered filtration, and

treatment for safe drinking water to rural communities in its previous hubs and in both the SESA hubs.

4.2 About the implementing partner

WeTu is a social enterprise that uses innovative products and services to improve the lives of rural Kenyan communities. WeTu is primarily based in the Lake Victoria region with solar charging hubs in Homabay, Kisumu, Migori, and Siaya counties. WeTu is dedicated to improving the quality of life in rural Western Kenya through sustainable solutions in Safe Drinking Water, Clean Renewable Energy, Electric Mobility, Electronic Waste Management, Solar Cooling, and soon Climate Smart Agriculture.



Source: WeTu

4.3 Kenya: E-mobility Use Case

4.3.1 Introduction - problem and solution

Motorcycles have become a crucial mode of transportation in Africa, which is characterized by areas with limited motorized mobility alternatives, and high vehicular traffic congestion particularly in urban areas. Motorcycles provide a highly efficient and affordable transportation solution that caters to the needs of both urban and rural environments. The rapid adoption of motorcycles can be attributed to their affordability, versatility, adaptability, and ability to navigate complex terrains in rural areas and through congested roads in times of heavy traffic in urban areas. They have proven to be essential in providing connectivity for individuals in need of employment opportunities, educational resources, and access to various services. This trend has been driven by factors such as the increasing demand for affordable public transport solutions, the availability of myriad financing options, and the entry of competitively priced imports from manufacturers in China and India. Although motorcycles enhance accessibility, they also give rise to environmental apprehensions because of their dependence on gasoline-powered internal combustion (ICE) engines. The engines emit pollutants that contribute to climate change and degrade air quality.

In the Kenyan market, two-wheeler motorcycles, commonly known as "boda bodas," have emerged as a crucial component of the transportation ecosystem, specifically in regions where alternative transportation options are scarce, unreliable, costly, or where roads are not motorable or congested by vehicular traffic. The motorcycle market and by extent the boda-boda market in Kenya has exhibited notable expansion, establishing itself as the most rapidly developing vehicle category in the nation. The pace of growth exhibited by boda bodas exceeds that of other types of motor vehicles, highlighting the significant contribution that boda bodas make to improving transportation in urban and rural areas.⁷ These vehicles serve as crucial suppliers of transportation for both passengers and products in Kenya. Despite the undeniable advantages, the dependence on gasoline engines in motorcycles presents significant environmental and health concerns. The emissions generated by these vehicles, encompassing particulate matter, nitrogen oxides, carbon monoxide, and hydrocarbons, have significant impacts on local air quality and contribute to the significant release of greenhouse gases. Considering the extensive and rising adoption of motorcycles and the consequent environmental implications, it is imperative to promptly tackle these issues and shift towards a sustainable mobility future.

Recent Trends and Economic Implications

As shown below in *Figure 7*, in 2022, there was a 15.9% decrease in new motorcycle registrations compared to 2021,⁸ and a further 15.2% decrease in 2023 compared to 2022.

⁷ Kenya national Bureau of Statistics. "Economic Survey 2022." <https://www.knbs.or.ke/>, 2022. <https://www.knbs.or.ke/wp-content/uploads/2022/05/2022-Economic-Survey1.pdf>.

⁸ Kenya national Bureau of Statistics. "Economic Survey 2022." <https://www.knbs.or.ke/>, 2022. <https://www.knbs.or.ke/wp-content/uploads/2022/05/2022-Economic-Survey1.pdf>.

This decline can be attributed to several factors, including the introduction of higher taxes on motorcycles and escalating fuel prices. These factors have collectively rendered motorcycles less affordable for a substantial portion of the population, particularly those residing in economically disadvantaged regions⁹.



Figure 7: New Registration of Road Motor Vehicles and Motorcycles, 2019-2023¹⁰

Environmental Concerns and Sustainable Mobility

Despite the undeniable advantages, the dependence on internal combustion engine (ICE) in motorcycles and the rapid rise and demand of two-wheeler boda bodas presents significant environmental and health concerns. The emissions generated by this class of vehicles, encompasses particulate matter, nitrogen oxides, carbon monoxide, and hydrocarbons which have a significant impact on local air quality and contribute to the significant release of greenhouse gases¹¹.

The need for change is evident shifting and adopting electric mobility offers a feasible approach to address the negative environmental impacts associated with conventional ICE powered motorcycles. By adopting electric motorcycles, Africa, including Kenya, has the potential to significantly mitigate greenhouse gas emissions, enhance local air quality, and actively contribute to global initiatives aimed at addressing climate change. The pursuit of electric mobility is driven by the urgent necessity to mitigate vehicular emissions and adopt sustainable solutions. Given the integral role that particularly two-wheeler motorcycles play in daily life and local economies, the shift towards electric two- and three-wheelers is a strategic initiative that effectively tackles current challenges while driving Kenya towards a future that is both environmentally sustainable and economically prosperous.

⁹ Kenya Revenue Authority, 2023

¹⁰ Kenya National Bureau of Statistics. (2023). *Economic Survey 2023*. Kenya National Bureau of Statistics. Retrieved from <https://dc.sourceafrica.net/documents/121310-Economic-Survey-2023.html>

¹¹ International Energy Agency, 2022

4.3.2 Existing Initiatives and Business models in Western Kenya

The e-mobility sector in Western Kenya is presently characterized by restricted involvement of players with most e-mobility pilot activities focused on the capital city of Nairobi. The primary initiative of significance arises from a strategic collaboration between the government of Kisumu County, a consortium comprising local stakeholders, and the Shenzhen Shenling Car Company Limited (TAILG). The objective of this collaborative effort was to include electric two and three-wheel vehicles into the current urban transportation system in Kisumu County. This pilot project, which was funded by the United Nations Environment Programme (UNEP) and the International Climate Initiative (IKI) of the German Ministry for the Environment, was scheduled to span a duration of 6 to 12 months in the year 2021. This instance of transportation innovation in the region is notable for its progressive nature.

The Kisii Smart Community (KSC) is an additional commendable endeavour within the e-mobility industry in Western Kenya. The KSC is a collaborative initiative between the Toyota Mobility Foundation and its partners, with the primary objective of enhancing rural livelihoods in Kisii County. This is achieved through the implementation of new technologies and business models. The objective of this initiative is to augment rural development through the utilization of off-grid power generation, information, and communication technology, and solar-charged electric cars. The primary objective of this effort is to facilitate sustainable development in Western Kenya through the improvement of mobility, connection, and provision of clean energy access in rural regions.

Powerhive, a firm specializing in renewable energy mini-grids, has also been involved in the implementation of e-mobility solutions in rural Western Kenya as part of its initiatives. In partnership with the Department for International Development (DfID), Powerhive has implemented the integration of electric vehicles (EVs) within their mini-grid installations in Kisii County. These EVs consist of electric three-wheeled tricycles, often known as tuk-tuks, as well as electric motorcycles, also referred to as boda-bodas.

Owing to the limited availability of e-mobility initiatives and a prevailing reluctance to disclose operational specifics, there exists a dearth of information pertaining to their revenue streams, income generation mechanisms, and the duration required to recoup investments across various business models. The limited transparency poses a significant obstacle in comprehending the financial dimensions of these initiatives, thereby impeding the capacity to evaluate their efficacy and sustainability in the long run.

4.3.3 Market Assessment and User Needs Assessment

The User Needs Assessment (UNA), conducted collaboratively by WeTu and the Stockholm Environment Institute, employed a mixed-methods approach to evaluate mobility needs of potential users in the two living lab demonstration sites of Katito in Kisumu County and Kisegi in Homa Bay County from 22nd September to 6th October 2022. Data collection

methodologies included user surveys, focus group discussions, and direct observations, with a total of 207 respondents interviewed (97 from Katito and 110 from Kisegi).

Key Findings on E-Bikes Adoption

The UNA revealed that all surveyed boda-boda riders in Katito and Kisegi currently rely on aging internal combustion engine (ICE) motorcycles, which incur significant environmental and financial costs. The prevalence of older, inefficient motorcycles exacerbates operational inefficiencies and necessitates frequent maintenance, further straining riders' finances. Respondents expressed strong interest in transitioning to electric motorcycles (e-bikes), citing their potential to reduce upfront acquisition costs, lower fuel expenditures, and minimize maintenance burdens. This shift could substantially improve riders' profitability while advancing sustainable transportation objectives.

Fuel Expenditure and Income Patterns

The UNA results provided detailed insights into daily fuel spending patterns among riders. Analysis revealed that fuel expenses increase proportionally with both distance travelled and number of working days (see Figure 8). Notably, riders reporting lower fuel expenditures tended to have higher daily wages. However, a counterintuitive pattern emerged showing that increased working days correlated with decreased daily net income. This suggests that riders working more days per week ultimately earn less per day, likely due to accumulated maintenance costs from extended road time and accelerated wear and tear of old ICE bikes, exacerbated by the rugged road terrain in both areas.

Operational Dynamics and Cost Implications

These findings underscore the direct relationship between fuel economy, distance covered, and operational frequency. Riders traveling longer distances over more working days face compounded costs from higher fuel consumption and frequent maintenance requirements, which significantly erode their daily earnings. This economic pressure highlights the urgent need for more efficient mobility solutions that can break this cycle of diminishing returns for hardworking boda-boda operators.

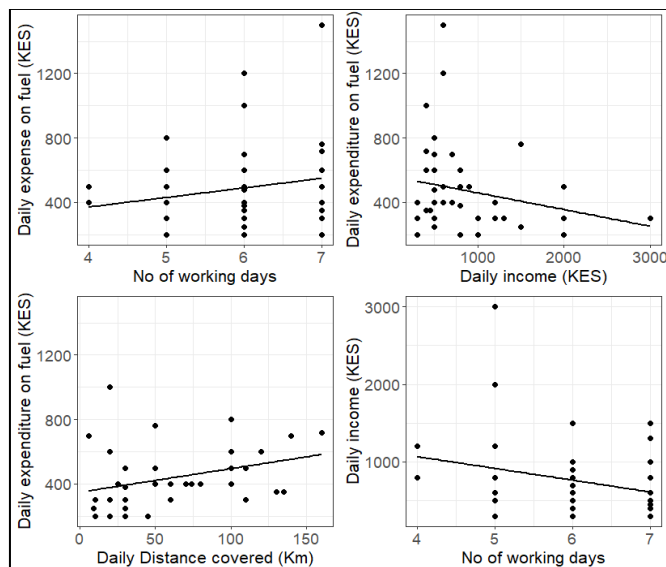


Figure 8: Daily Expenditure on Fuel, Distance Covered and Impact on Income

Willingness to switch to E-bikes

The results of the UNA indicate that a substantial majority of the participants, up to 86%, demonstrated a high level of inclination towards adopting e-bikes as their preferred mode of transportation (See

Figure 9). The main driving force behind this transition is the belief that electric bicycles present a more economically advantageous substitute for conventional motorcycles that rely on petrol. Furthermore, a lesser percentage of participants indicated curiosity as a motivating element. Conversely, individuals who were hesitant to adopt e-bikes expressed reservations over the technology, and some individuals shown a preference for traditional fuel-powered bicycles.

It is worth noting that initially majority of the riders exhibited a strong preference for a rental model when it came to e-bikes, rather than opting for outright purchase or pay-as-you-go alternatives. There was a lack of interest among the respondents in making cash payment for the acquisition of e-bikes. To enhance the proliferation of e-bike usage, it is imperative to thoroughly investigate the fundamental rationales for this inclination, encompassing aspects such as cost considerations, perceived risks associated with the technology, and other unexplored determinants.

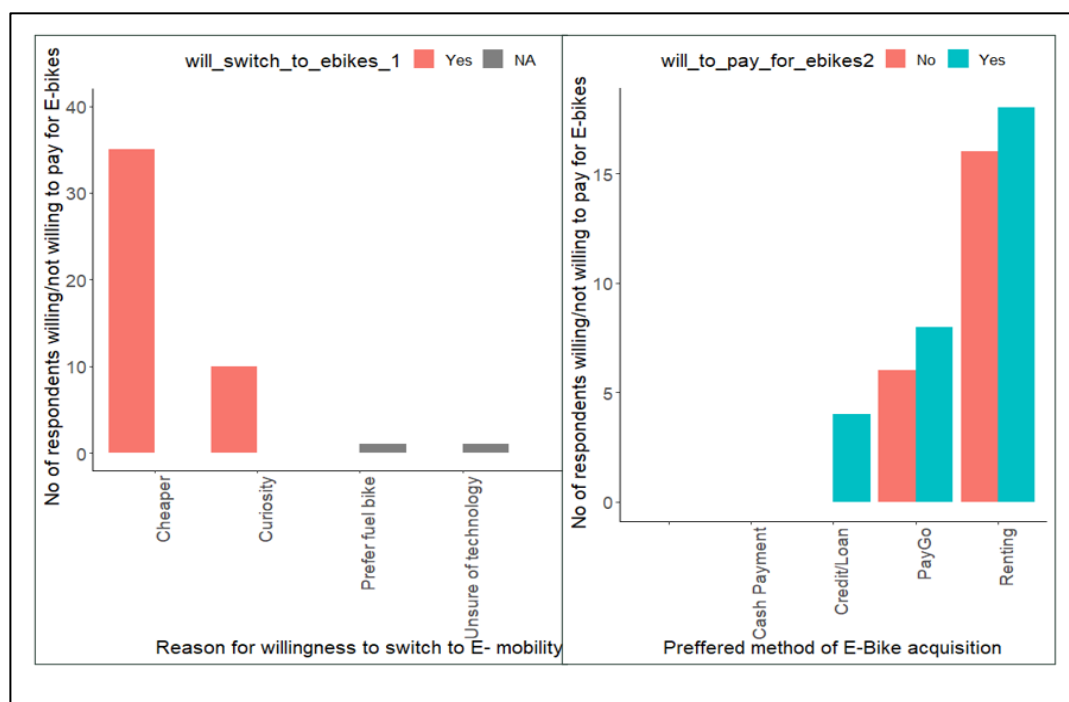


Figure 9: Reasons for willingness to switch to e-bike versus Preferred method of e-bike acquisition

The Significance of Early Adopters and Findings from Focus Group Discussions (FGDs)

Alongside the UNA, focus group discussions conducted with boda boda riders yielded interesting information, highlighting the significant influence of curiosity and affordability on riders' inclination to adopt e-bikes. When selecting a motorcycle, riders take into account various variables that are deemed crucial, including fuel efficiency, the accessibility of replacement parts, and the overall durability of the machine. Hence, it is imperative to expand the scope of analysis about the adoption of technology, with a particular emphasis on the facets that resonate with users. Acknowledging the importance of early adopters is crucial, since numerous motorcycle enthusiasts are keen on personal observation of the efficacy, performance, and consumer reception of electric motorcycles, drawing insights from the experiences of their counterparts.

The findings, derived from the UNA survey performed among boda boda riders in Katito, Kisumu County, and Kisegi, Homabay County, provide significant guidance for the commercial development of e-bike business development for WeTu. The UNA emphasized the willingness displayed by riders in adopting e-bikes, while also emphasizing the significance of addressing issues related to pricing and user concerns in order to promote a smooth and effective transition.

4.3.4 Business model aspects tested and validated

WeTu's e-bike business model and approach for the SESA living lab in Katito began with the procurement of Bajaj 100 internal combustion engine (ICE) motorcycle, which were then converted into electric drivetrains at WeTu's Homabay technical centre and subsequent conversions at the Kaito solar charging hub. The conversion involves replacing the conventional internal combustion engine with an electric drivetrain powered by lithium-ion batteries. WeTu has partnered with Gogo, a Ugandan e-mobility expert specializing in lithium-ion battery assembly and electric vehicle (EV) drivetrain conversions and have developed top notch power trains that fit into established vehicle platforms such as the Bajaj platform. The conversion process involved Gogo converting a few initial units alongside WeTu's technical staff, after which WeTu's team took over the conversions independently. This collaboration has enabled WeTu's technical team to become fully capable of performing these conversions in-house with minimal ongoing support from Gogo.

Adopting EV technology to convert ICE two-wheelers into electric vehicles internally, rather than buying or importing complete EV units, is a financially prudent approach aimed at reducing the cost of EVs and related EV conversions. This strategy helps minimize import expenses, and allows for the use of existing infrastructure, which were to include pre-owned boda bodas. However, challenges emerged when many boda-boda operators lacked proper ownership documentation for their motorcycles. As a result, WeTu opted to procure new ICE Bajaj 100 frames and perform the conversions in-house. There are plans to sell the replaced ICE engines after addressing legal considerations on resale of the ICE engines. This approach ensures compliance and clear ownership while maintaining the cost-efficiency of the conversion process.

The e-bike conversion and business model is strategically designed to cater to the unique needs of commercial boda-boda riders operating in rural and peri-urban areas. The business model an approach seeks to address the transportation demands of underserved regions by providing electric two-wheelers with swappable batteries and associated technologies. Boda-boda operators rely heavily on their vehicles as their primary source of income, highlighting the importance of having efficient and advanced environment friendly mobility solutions. To support this, the e-bikes coupled with solar-powered hubs offer a battery-swapping service, which sets WeTu apart with this unique value proposition. This service eliminates the need for lengthy charging times, enabling uninterrupted operations and superior service. It is especially advantageous as these areas lack charging infrastructure which ensures that the battery swapping service remains functional and reliable.



Figure 10: Bajaj 100 ICE bike conversion into e-bikes at WeTu's Technical Centre

This approach aligns with the practical requirements and challenges faced by boda-boda riders, enhancing their incomes, operation reliability and asset accessibility. By offering a dependable and efficient solution, WeTu not only support the livelihoods of these operators but also contribute to the overall improvement of clean affordable transportation solutions in rural and peri-urban areas that have been massively underserved with regards to sustainable mobility solutions.



Figure 11: Converted Bajaj 100 from ICE to e-bike

Battery Technology Choice

WeTu selected lithium-ion batteries over lead-acid batteries for its electric mobility use case due to their numerous advantages. Lithium-ion batteries are more efficient, with lower energy losses during charging and discharging. While lead-acid batteries experience losses of 15-20%, lithium-ion batteries boast efficiencies of 92-98%. This improved energy utilization translates into longer driving ranges and better performance for electric vehicles. Lithium-

ion batteries excel in fast charging and adapting to different weather conditions. Lead-acid batteries have long charge cycles, typically lasting 2 to 4 hours.¹² This characteristic can be problematic in bad weather, leading to incomplete charging and shorter battery life. Lithium-ion batteries can charge quickly, typically taking 1 to 2 hours. These batteries are highly efficient at absorbing energy quickly. Additionally, these batteries can withstand extended periods with partial charges without degradation or sulfation issues. This attribute ensures reliable operation even when the battery doesn't fully charge, which is common in cold weather with lead-acid batteries.

Business model canvas

Building on the innovative e-bike approach, the Business Model Canvas below captures the operational framework that enables affordable, sustainable transportation powered by clean energy. By converting ICE bikes to electric drivetrains and offering a lease-and-swap system, WeTu addresses cost barriers for boda-boda operators while advancing clean energy adoption.

The canvas below in

Table 10 outlines the key partnerships, activities, and revenue streams that drive this model—from retrofitting and solar-powered charging to user engagement and performance tracking—demonstrating how WeTu balances financial viability with environmental and social impact.

¹² Battery University. "BU-409: Charging Lithium-Ion," September 14, 2010. <https://batteryuniversity.com/article/bu-409-charging-lithium-ion>.

Table 10 Summary of BMC for e-bikes

Business Model Canvas E mobility WeTu				
Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
Boda Boda Operators Electric drive train suppliers Electric two-wheeler suppliers Technical solutions partners Battery manufacturers and suppliers Local authorities and regulators SESA Consortium partners Insurance providers	Purchasing ICE bikes Retrofitting ICE bikes Purchasing electric drive trains Monitoring systems for Battery (Battery Management System) Charging System monitoring and maintenance User sensitization (boda boda operators) and awareness campaigns Customer service and support Purchasing lithium-ion batteries and battery management system Marketing and awareness campaigns Construction of battery charging station Asset Monitoring and Tracking System Battery Swapping protocols Key Resources Charging System monitoring and maintenance Sufficient swappable batteries inventory Battery Management System for Battery Health and Performance Monitoring Functional charging station Monitoring and tracking software for ebike tracking Customer Communication channels and feedback mechanisms Marketing and communication material (safety reflector jackets, branded helmets) Cashless payment system Daily/Weekly/ Monthly User and Use case appliance data	Affordable and convenient electric mobility Enhanced income generation for boda boda operators Environmental protection and pollution reduction	Operator support and education Frequent proactive marketing and awareness drives Frequent proactive marketing and awareness drives Continuous user engagement and feedback Channels Local community and residents Meetings with boda boda saccos Outreach and operator surveys Bulk messaging Media (Radio talk shows) Focus Group Discussions Community meetings Branded WeTu rider safety merchandise Meetings with individual boda boda operators	Local two-wheeler riders (boda boda) operators
Cost Structure		Revenue Streams		
- Purchase of ICE bikes, Batteries and Backup batteries and Charging Infrastructure - Electric Drive Train and Associated Components - Battery Management System - Energy measurement and monitoring system - Maintenance and Service costs - Insurance costs - Rider, Bike and Battery - Depreciation costs - Overheads (Admin team support. Internet, IT Equipment - ETR machines, internet bandwidth, stationery), Marketing and communication costs - Operation (Consumption Costs) - Energy Cost for Battery Charging		Battery Swapping Charge Monthly service fees		

Evolution of the WeTu E-bike

The first version of the electric bike, of which three bikes were introduced with local boda boda riders in November 2022, had a 2kW direct drive motor and a 72V 3000W controller. It also featured a 4.6 kWh 48V lithium-ion battery with a 15T front sprocket and a 54T rear sprocket, achieving a top speed of 55 KPH and a range of 120 kilometres. While the direct drive motor provided a smooth riding experience ideal for urban commuting, it could not withstand the rugged terrain of peri-urban and rural environments and the demands of boda-boda riders. This led to numerous drive train breakdowns and various electrical component breakdowns that led to the grounding of the fleet from March 2023 to April 2024.

During this period there was constant engagement with the supplier Gogo for modifications on the drive train.



Figure 12: Version 1 WeTu electric converted two-wheeler

The current electric bike, of which 7 bikes were re-introduced in May 2024, features a 2kW geared motor, enhancing performance and efficiency to handle rugged terrain. It includes an 88V 3000W controller and a 4.6 kWh 48V lithium-ion battery, offering substantial energy storage. The drivetrain, with a 14T front sprocket and a 42T rear sprocket, allows the bike to reach a top speed of 90 KPH and offers a range of approximately 120 kilometres. This model balances speed and range while maintaining a high load capacity, meeting the demands of boda-boda riders.



Figure 13: Version 2 WeTu current version converted two-wheeler electric bike

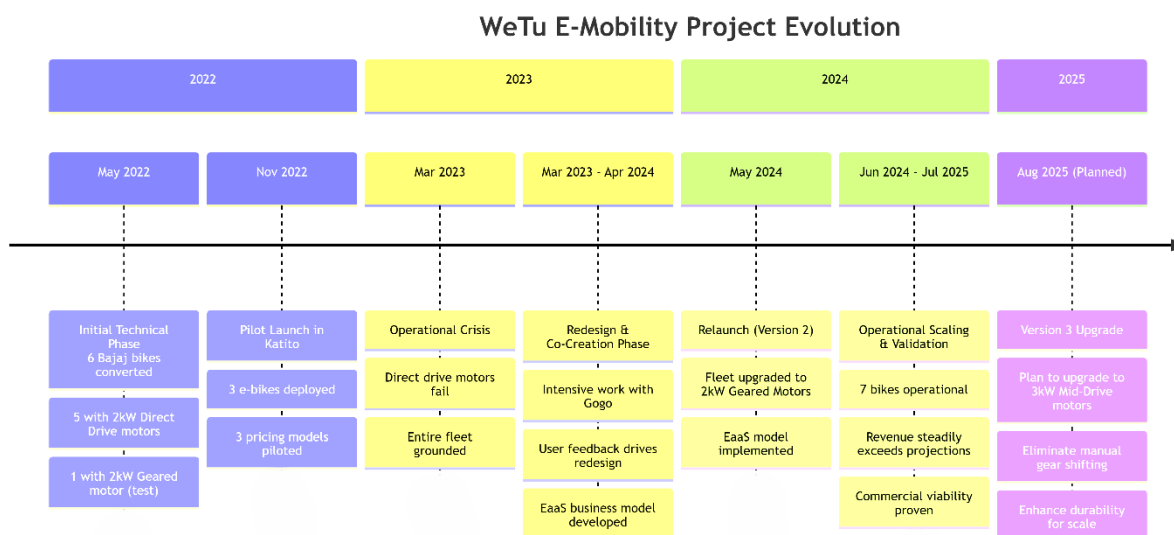


Figure 14: WeTu e-bike evolution timeline

Ebike Performance Data

Figure 15 and Figure 16 present the operational performance of WeTu's electric bikes in Katito, tracking both total distances covered since deployment in November 2022 and battery swap frequency since resumption of service in May 2024. The data shows marked growth in both metrics throughout 2024 and 2025, reflecting successful enhancements to the e-bike use case. These improvements which included drivetrain optimizations, component upgrades implemented in May 2024, and continuous refinements coupled with user co-creation sessions collectively increased system reliability and rider adoption. The positive correlation between distance covered and swap frequency demonstrates how these technical and operational advancements have strengthened market acceptance while improving the overall efficiency of the e-bike use case and WeTu's approach.

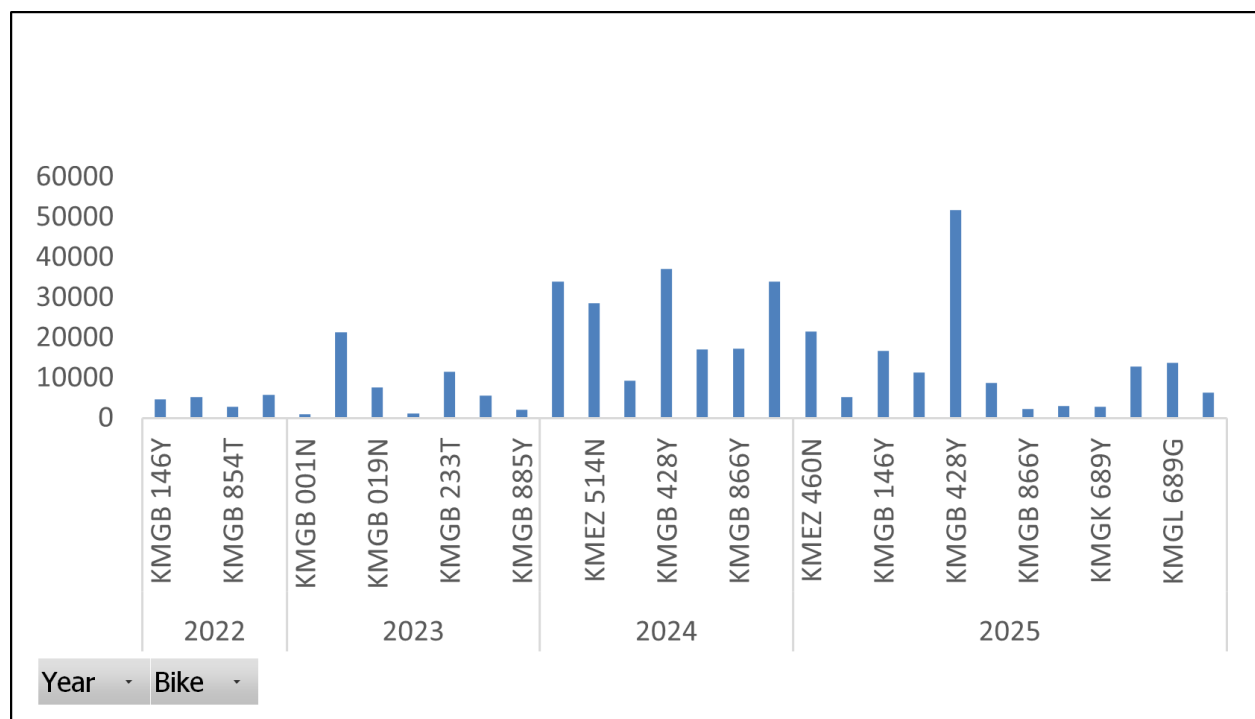


Figure 15: Total Distance Covered per E-Bike in in Katito November 2022- July 2025

The battery swap trends at the Katito Hub reveal steady utilization of WeTu's energy-as-a-service model, from the swaps recorded monthly from June 2024 to July 2025 after reintroduction of the new drivetrains and business model. The figures indicate consistent active engagement from boda boda operators, reinforcing the efficiency and reliability of the swapping system in supporting continuous eBike operations. This consistent swap activity aligns with WeTu's goal of providing seamless, renewable energy access while minimizing downtime for riders.

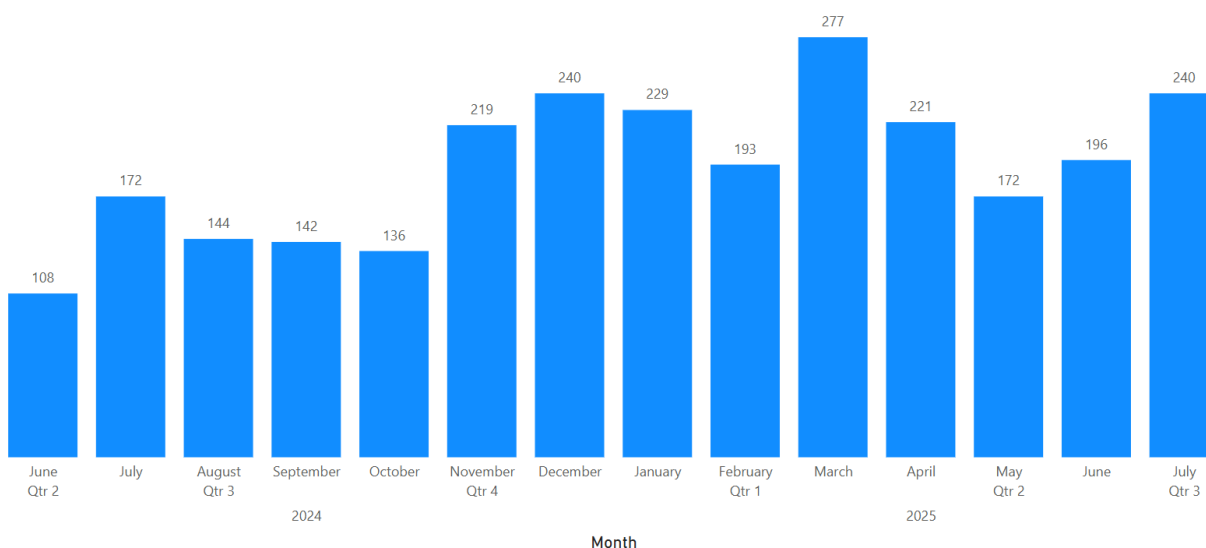


Figure 16: Number of battery swaps from June 2024 to July 2025

Planned Iterations for Enhanced Durability and Data-Driven Operations (Post-August 2025)

Building on critical lessons from field operations from June 2024 to July 2025, WeTu plans to implement significant technical upgrades to enhance e-bike durability, performance, and operational intelligence. The core of these iterations involves phasing out the current geared coupled motors in partnership with solutions provider GOGO. The gear coupled motors have proven vulnerable to rider induced overload from incorrect gear shifting. The motors will be replaced with a more robust 3KW mid-drive motor system featuring a significantly improved ingress protection mechanism to seal out water and dust, which has also been a major cause of past failures of the e-bike motors. This new motor will be paired with a robust new controller engineered to manage power delivery more efficiently. This motor and controller upgrade is designed to prevent overloads, water ingress into the motor during the rainy season, optimize battery charge and discharge cycles, and deliver consistent performance without relying on manual gear changes, thereby eliminating a key failure point.

Alongside this core drivetrain upgrade, there will also be comprehensive refurbishment of the peripheral components to address wear and tear of the same. This will include replacing worn-out tires, upgrading to reinforced double stands, installing new 12V harnesses, and strengthening critical load-bearing parts like the steering handlebars and cargo rest frames. Furthermore, to enable deeper operational insights, a new GPS tracking system from a specialized local Kenyan e-mobility solutions provider is planned to be integrated into the fleet. This improvement seeks to provide granular data on riding patterns, route efficiency, and vehicle usage, enabling data driven decision making to improve and gain insights on route mapping, rider training on route optimization, and overall service management. This holistic approach of improving the hardware components and deploying smart analytics is

an essential upgrade that seeks to extend the asset lifespan, enhance safety, and ensuring the long-term sustainability of the emobility service.

Pricing strategy

Initial Pilot Pricing Options for Electric Bike Leasing

Based on the insights from the initial user needs assessments (UNA) and focus group discussions (FGDs) with the riders, the key findings and pricing options are detailed below:

- **Average E-Bike Range:** During the pilot trial, we determined that the average distance an e-bike could cover on a single charge of a 48V battery was approximately 120 kilometers.
- **Average Daily Distance Covered by Riders (ICE):** It was observed that riders using traditional ICE bikes covered an average distance of 140 kilometers per day.
- **Daily Fuel Consumption:** Riders using ICE bikes consume roughly 2 liters of fuel per day. At the prevailing fuel prices, this is translated to a daily expenditure ranging from approximately 2.36\$ to 2.7\$.
- **Total Daily Cost for ICE Riders:** A rider using a rented ICE bike would, therefore, spend KES 700 (5.4 USD) per day, comprising a daily rent of KES 300 (2.3 USD) for 6 days a week and fuel costs of KES 400 (3.1 USD) per day. For riders operating 7 days a week, this expense would amount to $\{(300 \times 6) + (400 \times 7)\} = 4,600$ KES (35.5 USD). It's worth noting that this figure was expected to increase in line with rising fuel prices.

WeTu then formulated and piloted three distinct pricing options for the electric bike leasing service in Katito, where 5 bikes were deployed, and an additional 6th bike served as a courtesy bike. These options aimed to offer competitive and economically sustainable choices to the riders and are showed in *Table 11*.

Table 11: Piloted pricing options

Option 1: Flat Rate	Option 2: Flat Rate	Option 3: Mixed
- Price: 600 KES per day (approximately 5.0 USD) for 6 days a week. - Battery Swaps: No charges for battery swaps on all days. - Approximate Weekly Sum: 3,600 KES (approximately 30 USD).	- Price: 500 KES per day for 7 days (approximately 4.1 USD). - Battery Swaps: No charges for battery swaps on all days - Approximate Weekly Sum: 3,500 KES (approximately 29 USD).	- Price: 300 KES daily bike lease for 6 days a week (approximately 2.3 USD). - Day 7: No charge for day 7. - Battery Swaps: 250 KES for each battery swap. - Approximate Weekly Sum: 3,550 KES (approximately 29 USD).

Based on user feedback, none of the models were optimal for the users, which led to continued experimentation and development of the pricing model.

Iterative Pricing Model and Sales Projections

Following the deployment of the three pricing models and subsequent series of user co-creation sessions and learnings from the initial pilot phase and trials with the different pricing options in the initial phase of going to market in November 2022 to September 2023, WeTu further optimized the pricing model to improve use case solution uptake, increase widespread adoption of the technology and long-term viability of the business model and approach. Based on previous learnings and user co creation sessions WeTu revised the business model to be an Energy As a Service (EaaS) model with a pricing structure that included a monthly service fee of 1000 KES (7.7 USD) per bike and a daily charge of 300 KES (2.3 USD) for battery swapping. This approach shifted the focus away from initial leasing approach of paying a daily rental or leasing fee and battery swapping fee. Instead of paying to lease the electric bike and subsequent battery swapping fee, users pay only for the energy they consume through battery swaps. The riders are charged a fee per swap, providing a flexible and cost-effective model that looks to suit the riders needs while also ensuring business and operational sustainability for WeTu.

With a fleet of seven e-bikes, each performing an average of one swap per day working for 6 days, the anticipated average monthly income per bike is 8,200 KES (63.3 USD). Consequently, the fleet is expected to generate a total monthly revenue of 57,400 KES (443.2 USD).

Current Pricing Model

To iterate further on the pricing and after the initial successes of the EaaS model and subsequent feedback based on the energy as a service period from September 2024 to April 2025, WeTu further revised the pricing for the emobility service. The current pricing features a refundable deposit fee of 3000 KES (23 USD), Monthly rental fee of 2000 (15 USD) and a battery swap fee of 300 KES (2.32 USD). The refundable deposit fees are designed to cover any major damages due to negligence on the ebike in the event the rider is done with the service. These iterations to the pricing follow consultative user co creation sessions with the riders to factor in changing market dynamics and to ensure little to no fleet operation downtime.

Payment Frequency

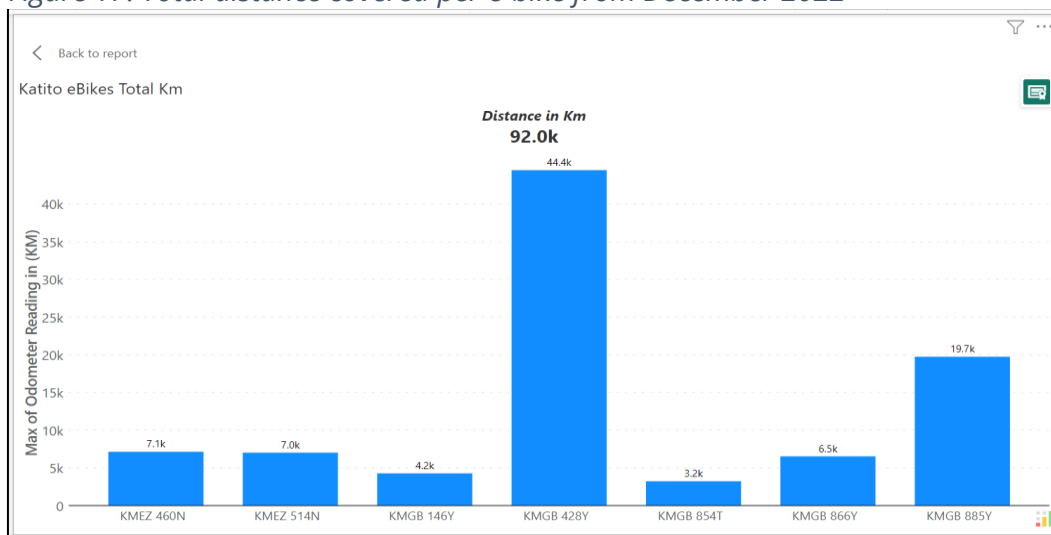
WeTu's innovative Energy-as-a-Service model integrates a lease-and-swap system within a sharing economy framework, aligning payment structures with the daily financial realities of boda boda operators. By adopting a per-swap fee alongside a modest monthly lease, WeTu ensures affordability and matches riders' daily cash flow, reducing default risk and enabling sustained operation. This approach not only provides "transport as a service" without high upfront costs but also reinforces a sustainable, user-centric mobility solution tailored to local economic conditions.

Total Distance Covered During the SESA project period

During the electric bike demonstration conducted in Katito, WeTu has achieved remarkable results, with the total distance covered by the e-bikes reaching an impressive 92,000 kilometres since launch of the electric bikes in Katito. This distance was accumulated from November 2022, to March, 2023, when the first version of the e-bike was temporarily withdrawn from Katito due to technical challenges, and mid-May 2024 to June 2024 when the new improved version of the e-bike was re-introduced back into Katito.

There is a massive disparity between the bike number KMGB 428Y which was a gear coupled bike since inception. The idea was to have six automatic, and one gear coupled bike to test their performance. The distance covered below is indicative of the performance of the gear coupled drivetrain that eventually led to the conversion of the six remaining bikes.

Figure 17: Total distance covered per e-bike from December 2022



It was WeTu's contention that the pricing model would effectively achieve a harmonious equilibrium by providing affordable rates for the riders. The provision of environmentally sustainable transportation alternatives that cater to the specific mobility requirements of the Katito community is in accordance with the organizational objective. WeTu anticipates ongoing expansion and achievement within the e-bike leasing and battery swapping industry through the implementation of this enhanced pricing framework.

User Co Creation and Participatory Design

The WeTu e-bike initiative in Katito was built with user co-creation as the foundation of continuous collaboration with riders, local authorities, and partners, ensuring that every aspect of the use case from site identification and use case design to pilot rollout and implementation was shaped by the needs and insights of the users. This participatory approach proved critical in developing a use case and business models that are not only

technologically viable but also environmentally, economically, and socially sustainable for the boda boda community and Katito transport sector.

Before the first e-bike was deployed onto the Katito roads, WeTu prioritized understanding the ecosystem in which it would operate. Through structured engagements with boda boda riders and their savings and credit cooperatives (SACCOs), the team identified key pain points, such as the high cost of fuel and frequent maintenance of traditional ICE motorcycles. These discussions also revealed a strong preference for flexible rental models over outright ownership, a finding that would later shape the business model approach and market entry strategies. Parallel dialogues with local National Government officials and Kisumu County officials helped clarify regulatory requirements, such as licensing and safety standards, while collaborations with insurance providers led to tailored insurance coverage plans that protected riders, passengers, and WeTu's assets which is a critical step in mitigating risks unique to commercial e-bike operations.

The initial pilot phase November 2022 to Mar 2023 served as a live test bed for the use case, with rider feedback driving continuous iterations. Focus group discussions and hands-on testing unearthed unforeseen challenges, particularly the inadequacy of direct-drive motors for Katito's rugged terrain. This insight subsequently led to the complete motor and drivetrain overhaul of the initial version one e-bikes deployed, culminating in the May 2024 rollout of geared coupled motors designed for durability. Similarly, rider resistance to daily flat-rate leasing models led to the innovative Energy as a Service (EaaS) approach, which aligned costs with actual battery usage. Meanwhile, concerns about battery range and performance under heavy loads spurred upgrades to improved lithium-ion battery technology and the optimization of swapping protocols. These adjustments were rooted in real-world data and riders' feedback, ensuring that the use case appliances and business models were not just technically sound but also embraced the users' precise needs based on actual data.

The reintroduction of the improved e-bike fleet in May 2024 marked the beginning of a new chapter, defined by even deeper uptake and solution acceptance. Continuous co-creation sessions became a platform for riders to test prototypes and improvements before deployment to validate operational changes, like daily battery swapping fees.

The results of this user-centric approach speak for themselves as initially 86% of riders expressed willingness to adopt e-bikes after participating in co-creation sessions, while the 92,000 kilometers covered post-iterations demonstrates the durability of the iterative business model and responsiveness of the riders to WeTu's approach. Just as importantly, the model has fostered a sense of ownership among riders, who see their input translated into tangible improvements.

4.3.5 Sustainability and impact

The early entry and active engagement of WeTu in the Western Kenyan e-mobility market specifically focusing on rural and peri urban areas and a pioneer of electric mobility in Western Kenya highlights WeTu's commitment towards sustainable mobility. This has been achieved by undertaking comprehensive analysis and rigorous testing of different electric bikes (e-bikes) in WeTu's Homabay Technical Centre , showcasing the dedication to fostering innovation and proven solutions that are sustainable, durable and specific to the local context. Furthermore, WeTu has established a strong reputation not just for implementing innovative solutions and business models but also for providing reliable feedback to various stakeholders in the industry to enable improvements in the e-mobility and transport sector. This feedback includes useful information into the performance, efficiency, and sustainability of e-bikes to manufacturers and suppliers of e-bikes and related components.

An integral component of WeTu's approach is cultivating partnerships and collaborations with reputable technology providers in Kenya and in the region, namely Roam (formerly known as Opibus) and Gogo (formerly known as Bodawerk), both recognized as leading suppliers of electric mobility technologies within the East African region. Through establishing partnerships with such reputable suppliers WeTu not only strengthens its own capacities but also makes a valuable contribution to the joint endeavor of shaping a more sustainable and environmentally conscious transportation framework within the region. This coupled with WeTu's innovative business model and value proposition sets itself apart in the Kenyan e-mobility market through the integration of a sharing economy and circular economy approaches which look to prolong the useful life of use case appliances and careful consideration for the management of end of life of products.

This distinct sustainability approach surpasses traditional financing options such as PayGo, Loan, Lease, and others currently available in the market especially targeted to the commercial boda boda riders. In contrast to conventional models that prioritize ownership or fixed leases, WeTu offers boda boda operators an opportunity to access affordable, flexible, and efficient energy access and mobility solutions without the high upfront investment cost. The business model operates within a dynamic sharing economy principle, that enables boda boda riders to lease the e bike assets from WeTu. By doing so, operators can benefit from a comprehensive service that includes the management of operational and maintenance costs, among other aspects while they focus on income generation. This has allowed boda boda operators to conveniently utilize electric two-wheelers on an as-needed basis, thereby reducing the required high upfront initial expenses and alleviating the financial responsibilities associated with ownership. Simultaneously, it also serves to advance the cause of environmental sustainability.

WeTu's unique value proposition is in the incorporation of an innovative business model coupled with battery swapping, thereby mitigating the limitations associated with extended charging durations. The solar-powered charging hub and infrastructure developed by WeTu enable efficient and seamless battery swaps, thereby guaranteeing

uninterrupted operations for boda boda operators. The unique characteristic of this feature effectively reduces the operational downtime commonly experienced by electric vehicle users because of charging limitations and long charging times. As a result, WeTu's business model is particularly well adapted for areas with inadequate charging infrastructure. Through the integration of these innovative aspects, WeTu's methodology not only offers economically viable electric mobility options for boda boda operators, but also effectively tackles environmental considerations, thereby accelerating the adoption of sustainable electric mobility and energy access within Kenya's transportation sector.

The long-term sustainability of the e-bike model use case and business model is intrinsically linked to the participatory design process that has defined it from inception. By embedding continuous rider feedback into every stage of development, WeTu has secured crucial rider and community buy-in, significantly reducing attrition rates and building a foundation of trust that has been essential for increasing uptake of the solution. This co-creation approach extends to technology partners, such as Gogo and Roam, who have incorporated user insights from Katito into their core product upgrades, enhancing the durability and performance of components for the broader market. This collaborative co creation process has ensured that the solution evolves in lockstep with user needs, guaranteeing its relevance and resilience over time.

4.3.6 Challenges, learnings and next steps

Challenges

The implementation of the e-bike use case in Katito has served as a profound learning experience, revealing a series of complex challenges inherent to deploying innovative technology in a demanding rural environment. These obstacles, while significant, have provided invaluable insights that have directly shaped the strategic iteration of both the technology and the business model. The journey from initial deployment to the current stable operations underscores a commitment to continuous improvement through adaptive learning and user collaboration.

The primary challenge encountered was the fundamental inadequacy of the initial technology for the specific use case. The Version 1 direct-drive motors, while suitable for urban commuting, proved incapable of withstanding the rigours of Katito's rugged terrain and the intense demands of commercial boda-boda operations. This resulted in frequent drive train failures and necessitated a complete recall of the fleet from March 2023 to April 2024, a period dedicated to technical overhaul and re-engineering. This experience underscored a critical lesson: technology cannot be transferred generically but must be engineered for context-specific durability. Furthermore, operational resilience was tested by vulnerabilities in the supply chain, including delays in procuring critical components and variable part quality from suppliers, which highlighted a dependency that risks operational continuity.

A significant parallel challenge was the high initial capital expenditure (CAPEX) for establishing the solar charging hub, acquiring bikes, batteries, and charging infrastructure, which poses a substantial barrier to scaling with the current fleet size.

Although the model demonstrates operational sustainability, it is designed for a small fleet and lacks the financial runway to expand quickly despite clear and growing rider demand, limiting its economic and social impact. Additional hurdles include insurers' reluctance to cover commercial boda boda riders and high electric vehicle premiums, which hindered deployment and operations. These were compounded by user-induced stresses from overloading and improper battery management, accelerating wear on key components and raising operational costs.

Learnings

These challenges have crystallized into several core learnings that now form the core of WeTu's mobility business model and strategy. The most pivotal learning is that technological solutions must be inherently designed for the harsh realities of rural commercial use, where resilience and reliability are paramount over theoretical specifications. Secondly, the business model is as crucial as the technology itself with the transition from a rigid leasing fee to a flexible Energy-as-a-Service (EaaS) model being a direct response to user feedback and proved essential for increased uptake of the use case and rider adoption. This shift confirmed that financial models must align with the cash flow patterns and economic realities of the end users.

A key financial learning is that while the model can achieve operational breakeven, the capital-intensive nature of the asset heavy mobility use case necessitates strategic financing mechanisms beyond grant based pilot funding. The demonstrated revenue growth and rider demand validate the commercial viability but also highlight that to truly scale and meet market demands and rider needs, a transition from project financing to more sustainable growth capital is required.

Finally, the pilot demonstration actions demonstrated that continuous user co-creation is not merely beneficial but essential for business case and use case viability. The successful reintroduction of the fleet in May 2024 was a direct outcome of embedding rider feedback into every stage of the redesign, proving that engaging users as active partners in the development process is the most effective strategy for ensuring solution acceptance and long-term sustainability.

Next Steps

Moving forward, WeTu will execute a focused strategy built upon the lessons from the pilot Katito demonstration actions looking to successfully move from a technology pilot into a phase of operational validation. WeTu's immediate priority is the implementation of the planned technical upgrades, specifically the phased replacement of the current geared coupled motors with a more robust 3KW mid drive system featuring enhanced water ingress protection to safeguard the motors against water and dust penetration. This will be complemented by the integration of a comprehensive GPS tracking system to enable data-driven decision-making for maintenance, route optimization, and rider training.

Concurrently, a critical next step is to secure growth financing to scale the e-bike service in Katito to meet the increased rider demand. This will involve developing compelling investment proposals based on the proven unit economics and revenue data from the

pilot demonstration actions to attract impact investors. This financing will be strategically deployed to fund the rapid expansion of the fleet and expanding the charging infrastructure, allowing WeTu to systematically meet the confirmed rider demand and achieve economies of scale.

Alongside this, WeTu intends deepen its commitment to user engagement by formalizing a structured rider training program to minimize operational costs of repairs and service. This program will focus on awareness raising sessions on optimal riding techniques for the different e bikes, load compliance, and battery management, aimed at extending asset lifespan and subsequently improving rider profitability.

A key new initiative will involve developing a clear strategy for the end-of-life management and resale of the replaced ICE engines, exploring opportunities for a secondary market or repurposing to enhance the circular economy approach. Finally, the organization will leverage its proven unit economics and secure financing to execute a clear scale-up plan, transforming the Katito pilot into a replicable model for broader deployment in Western Kenya and similar African contexts.

4.4 Kenya: Cold Room Use Case

4.4.1 Introduction – problem and solution

Food loss and waste refer to food that is not consumed due to various causes throughout the food supply chain – from harvesting, processing, distribution, and to retailing/sales. This amounts to a decrease in both quantity and quality of food supply. While food loss occurs from harvest up to distribution, food waste occurs at the retail/sales and consumption levels.

According to UNEP Food Waste Index (2021)¹³, an estimated 14% of total global food production (from harvest to retail) is lost, while about 17% got wasted within the levels of retail (2%), food services (5%) and the last mile or household level (11%). The UN Sustainable Development Goal 12.3 places emphasis on halving global food waste and reducing food loss by 2030. This is particularly important since food loss and waste not only amount to economic losses, food insecurity, but also adversely impact our environment. Nearly 10% of global greenhouse gas (GHG) emissions come from food loss and waste. Despite this, it has only limited inclusion in NDCs submitted by most countries (UNEP 2021) mostly due to lack of data, and limited understanding of the drivers and impacts of food loss and waste.

Minimizing food loss and waste requires actions from ‘farm to shop’, and from ‘shop to fork’ by ensuring smarter ways of shopping, cooking, eating, and storing food items. Cold storage powered by solar electricity provides viable solutions to food loss and waste across food supply and consumption chains respectively.

Lack of cold storage contributes to about 526 million tonnes per year of food waste globally (UNEP 2021) and this could get worse given the rising food demand by the growing population. In Kenya, over 5 million tonnes of food are discarded annually (UNEP 2021), whereas the country still grapples with food insecurity stalling the attainment of the SDG #2 goal on zero hunger. With the limited market access and the poor handling of harvests resulting in about 40% of food waste, Kenya presents good opportunity for cold storage deployment to mitigate the trend. In addition, the cold chain infrastructure market size for fresh fruit and vegetable is projected to increase by 50% from USD 511 million in 2019 to over USD 1 billion by 2030 (Energy 4 Impact, 2023)¹⁴.

Solution

The EU funded SESA project has supported a **solar-powered cold room** initiative for retail market vendors and wholesalers¹⁵ to reduce food waste at Mbita market (retail level) in Homabay County, Kenya – working closely with a private sector partner, WE!Hub Victoria Limited or WeTu, and a technology partner, SelfChill, supported by KFW's Be Cool Project. Food waste in Homabay county is mostly due to poor cooling infrastructure, inefficient handling and storing practices by market vendors, and mismatch in food supply and

¹³ United Nations Environment Programme (2021). Food Waste Index Report 2021. Nairobi <https://www.unep.org/resources/report/unep-food-waste-index-report-2021>

¹⁴ E4A (2023) Assessment of the Cold Chain Market in Kenya. <https://efficiencyforaccess.org/publications/key-cold-chain-infrastructure-markets>

¹⁵ Retail vendors or vendors refer to those selling products directly to customers (B2C) whereas wholesalers can sell both to retailers (B2B) as well as directly to customers.

demand at retail level¹⁶, among others. The Mbita region in Homabay predominantly depends on fishing for livelihoods and there is limited local production of fresh vegetables and fruits. Hence, there is reliance on the produce transported from large distances in the range of 150 – 600 kilometres. Poor handling of produce and lack of cold storage – both during transport and at retail levels reduce their shelf life. Furthermore, many rural locations in Kenya and across Sub-Saharan Africa have no or unreliable access to grid electricity to power external cooling solutions, hence the need for modular off-grid cold storage alternative¹⁷. The deployment of solar-powered cold room helps provide sustainable/climate-friendly storage option; reduce food waste/loss due to lack of storage or transport; raise the income generated from selling stored fresh food and preserve food quality.

Existing solutions in the Kenyan market for cooling of fresh vegetables and fruits

Cold rooms¹⁸ are stationery and temperature-regulated rooms suitable for preserving the freshness and quality of fruits and vegetables and significantly extend their shelf life. They come in various sizes suitable for both smallholder farmers, market vendors, and large agrifood businesses and processors.

There are different cold room systems by different technology providers as explained in the following table below:

Table 12: Common cold room providers, their solution description, and deployment model

Cold room provider	Description	Deployment model
ColdHubs Deploys off-grid and modular solar-powered cold rooms for 24 hours all day preservation of perishable fresh fruits and vegetables – extending their shelf life from 2 to 21 days. ¹⁹	The cold rooms deployed by ColdHubs usually operate at a maintained temperature of 5°C; stainless steel floors made with 0.8 – 1mm aluminium to prevent slippage and rust; energy efficient mono-block refrigeration unit with the environmentally friendly R290 propane refrigerant connected to a set of inverters and batteries that supply energy; batteries charged by solar panels, which generate about 5.7 kWh of energy; Capacity for 2-3 metric tons of perishable food arranged in at least 150 units of 0.03 metric tons plastic crates.	The units can either be leased to farmers who run them and are paid a commission per crate used or purchased by a farmer's cooperative under a subsidized repayment plan. ²⁰ 

¹⁶ <https://www.coldsolutionskenya.com/storage-solutions/tackling-food-waste-in-kenya-turning-spoilage-into-sustainability/>

¹⁷ Blyth, Leo Joseph; Hartley, Ben. *Sustainable Cooling in Off-Grid Rural Areas: The Nexus between Access to Energy and Clean Cooling (English)*. Washington, D.C.: World Bank Group. <http://documents.worldbank.org/curated/en/099053124150533090>

¹⁸ The focus of the report is only on cold storage rooms and not small refrigerators or freezers. A cold room is a large, walk-in refrigerated space for storing bulk quantities of goods, while a refrigerator is a smaller, self-contained appliance for personal or small business use. A freezer is not suitable for fresh produce (vegetables and fruits) which require a constant temperature of around 7-8 degrees Celsius.

¹⁹ ColdHubs. <https://www.coldhubs.com>

²⁰ CNN (2015). "A radio show host may have fixed Nigeria's worst problem." <https://edition.cnn.com/2015/12/22/africa/cold-hubs/index.htm>

InspiraFarms Focuses on designing, developing, and supplying modular and energy-efficient cold rooms that are either on or close to farm centres in emerging markets including Ethiopia and Mozambique in Africa.	The cold room solution deployed by InspiraFarms is equipped with pre-cooling capabilities through air-forced cooling and a humidifier, which rapidly lowers the temperature of fruit's pulp to maintain optimal quality; Capacity to store up to 20 metric tons of perishables; and could increase average net income of smallholder farmers by 30%.	The units are mostly sold to medium and larger farms and distributors or large agri-businesses through asset-based finance model. 
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Source: USAID (2022): Power Africa Nigeria Power Sector Program: Productive Use Cold Storage Systems in Nigeria

Existing business models for off-grid cold room in Sub Saharan Africa and Kenya

For off-grid solar-powered modular cold room (not powered by mini-grid), the common business models being used in Kenya and sub-Saharan Africa include lease-to-own (LTO), asset financing, sale, and lease back, rental, and Cooling-as-a-service (CaaS) or Pay-as-you-store (PAYS) models. Each of the models has benefits and challenges, type of customers targeted, and ownership structure.

Table 13: Summary of the business models, their benefits, and challenges

Business model/description	Benefits	Challenges
Lease-to-own (LTO) Customers include cooperatives, aggregators, large-scale farmers and processors in need of cold solutions but are unable to pay upfront or purchase a cold room but instead lease.	Negotiable repayment plan based on the customers' ability to pay; Better cashflow forecast since rental costs are fixed.	More expensive in the long-term than upfront purchase
Asset financing Financial institutions (FIs) provide the upfront finance for the acquisition of the cold storage assets on behalf of customers who subsequently repay the FIs with interest.	Improved due diligence and asset maintenance	More expensive in the long-term due to interest rate escalation
Sale and lease back Financial institutions (FIs) purchase the cold storage on behalf of a large-scale farmer or processor and then leases it back to them. Unlike in asset financing, this model does not involve payment of interest since the financier retains the ownership of the cold storage.	No cost of debt financing or interest rate; improved liquidity from the sales of tied-up assets	Ownership is retained by the financier who may decide to lease the cold storage to another user during the time of competing need

Rental In this model, customers pay a flat rental fee either on annual or monthly basis; or based on the weight of produce stored per day (as in the CaaS model).	More efficient maintenance since the asset is managed by the owner; more affordability and accessibility to modern cold storage solutions.	Customers may have to pay the same rent during the time of low usage of the cold storage since it is rented for an agreed or fixed period
Cooling-as-a-service (CaaS) or pay-as-you-store (PAYS) This is a repayment model in which users pay a fixed rate for using the cold storage per weight and duration rather than outright purchase of the asset. Target customers are retail vendors and small-scale farmers.	Cheaper option since no upfront cost is involved; more affordability and accessibility to modern cold storage technologies.	Large scale deployment of CaaS or PAYS model requires a third party to manage the contracts since it can be tedious for the supplier to handle them directly, and an operator of the cold room to handle the crates.

Source: E4A (2023) Assessment of the Cold Chain Market in Kenya

Pay as you go or pay per use or cooling-as-a-service (CaaS) that allows for instalment payments on per-use basis, which is emerging as a common approach in sub-Saharan Africa, linked also to mobile money innovations particularly in East Africa. In service-based models, customers pay for a service instead of purchasing and owning an application²¹ The service provider retains ownership of the appliance being used, and assumes responsibility for its installation, operation, and maintenance. In CaaS models, companies operating in Sub-Saharan Africa like Koolboks (see *Figure 18*), ColdHubs, and Sokofresh²², among others offer smaller decentralized cooling solutions that can be used by individuals or small groups of customers directly at the marketplace. Depending on the contractual model, they can purchase cooling services based on periodic quarterly, monthly, weekly, or even daily payments. It is also important to note that CaaS model is a relatively nascent business model, and many companies are in the preliminary years of operation and commercial viability has not yet been definitively proven.

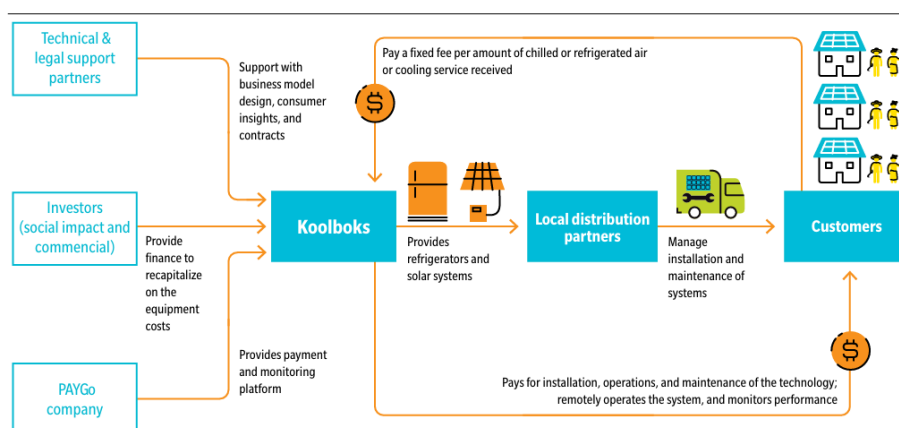
The common financing options for the subsidized models include grant financing, asset-based financing and result-based financing. In grant financing, donors provide grants or patient capital to cover the high upfront costs and may also provide technical assistance to the technology providers to support market entry and/or increase the awareness of the users. In asset-based financing, the lenders use assets as collateral allowing business to obtain loan or credit with short repayments. In result-based financing (RBF), incentives are provided by the donors to offset the high upfront costs – RBF has not been applied to cold room but to standalone refrigerators/freezers in African countries including Kenya (E4A, 2023).

Figure 18 - Illustration of Business Model Innovation, with an example of Koolboks Nigeria²³

²¹ <https://energy-base.org/wp-content/uploads/2021/04/Business-model-innovations-addressing-affordability.pdf>

²² https://www.caas-initiative.org/wp-content/uploads/2022/04/Case-Study-Sokofresh_April6.pdf

²³ <https://koolboks.org>



Local Context for the intervention - Mbita, Homabay²⁴

As part of SESA, two solar PV hubs were set-up in Katito and Kisegi, in Kisumu County and Homabay county respectively in Kenya. While the cold room was planned to be in Katito market, but due to challenges with land, the location was moved to Mbita instead in Homabay County where WeTu has had a longer presence and an existing solar PV hub. The existing relationships with the sub-county, Suba North, government and local leaders allowed for ease of an additional use case of cold room. Mbita is located along the shoreline of Lake Victoria, and the primary economic livelihood is fishing based.

The economy is geared around fishing and to a lesser extent agriculture and horticulture production as well as tourism. Mbita Point serves as a significant commercial centre for fish trade in the region, as well as a primary landing site for fish catch from the lake. The area's fertile soil and favourable climate makes it ideal for the cultivation of a variety of vegetable and fruit crops, however discussions with vendors and data also indicates that the agricultural production is low, and primarily subsistence oriented.

The Mbita market and the local region is significantly dependent on transport of fresh produce from various parts of the country including large distances, even from Nakuru and Nairobi. The vendors face challenges pertaining with handling and transporting the produce in sub-optimal conditions and due to lack of cold storage, they experience high food wastage leading to reduced profits and income. The market vendors operate on a small-scale basis with small stalls, and a majority of them are women – the income losses only aggravate their vulnerability.

Policy Context for Cooling

Kenya has a National Cooling Action Plan in place as of 2023²⁵ which provides a supportive framework by promoting energy efficiency for cooling equipment, natural refrigerants, and agricultural cold chain improvements. The objectives include:

- i) creating an enabling environment for the cold chain market
- ii) expanding fiscal benefits to cold storage systems
- iii) raising awareness on the benefits of the cold chain
- iv) supporting R&D for adapting technical solutions to local contexts

²⁴ The local context draws information from first-hand experience and also from a market assessment and trader interviews conducted by WeTu in November 2022.

²⁵ https://www.environment.go.ke/wp-content/uploads/2023/06/230607_NCAP-for-Kenya22high.pdf

- v) promoting access to innovative business models
- vi) designing finance models targeted to small holder farmers

However, the specific incentives and regulations are not scoped adequately yet. As the Energy for Efficiency report states²⁶, even in cases where regulation exists, it does not cover all value chains. Additionally, enforcement of these policies remains challenging due to the limited number of certified inspectors or regulators supporting these value chains and the widespread informal markets incentivizing disaggregation. Policies governing other sectors, such as renewable energy, also influence the cold chain sector, which can have either positive or negative impacts. For instance, the 2021 reinstatement of VAT exemptions for renewable energy components provided a reprieve to off-grid solar companies. However, there is no assurance that the government will not reimpose VAT at a future date.

4.4.2 About the cold room

As part of SESA project, WeTu has piloted an off-grid solar powered cold room in Mbita, Homabay and has partnered with a technology provider, Self-Chill for the same in order to reduce food waste, and income loss for vendors and wholesalers.

WeTu is a social enterprise in rural Western Kenya implementing projects since 2019 to enable the provision of sustainable solutions including safe water, clean energy, e-mobility, cooling and irrigation. WeTu provides these services through a “hub concept”²⁷ and guided by the principles of shared and circular economy and is currently operating 16 Water-Energy-Hubs in four Counties in Western Kenya.

SelfChill is a registered trademark and a cooperation of three institutions (i.e., Phaesun, Solar Cooling Engineering and University of Hohenheim) that bring individual expertise for product development, research activities, training, and product sales. SelfChill has won Global Leap Award for its innovative off-grid PV-powered modular cooling solution, and for its energy efficient system across the lifecycle in terms of GHG footprint.

SelfChill intends to operate via a distributor model whereby it sells the “product”, that is the cold room, and provides all the services to the customer (i.e., WeTu) including construction, training, and operational support. SelfChill has managed technical installation more than 10 cold rooms in Africa so far. It received funding from DEG (KfW) to take the next step and test the business case and operations in Kenya, and this is clubbed with SESA piloting, which subsidizes the Mbita cold room costs for WeTu, which primarily has to bear the operational expenses only.

As there is risk of pilots not taking off the ground if not catered to properly, with SESA, there was a clubbed opportunity to conduct baseline and pre-installation assessments, to have an anchor business for operational ownership and support, and to also collect data through SESA on the business model and viability aspects, and to also develop a concept

²⁶ [Assessment of the cold chain market in Kenya and Nigeria - Sun Connect News](#)

²⁷ Hubs refer to a central unit of WeTU which offers a range of portable services including off-grid solar lights on lease for the fishing community, drinking water services priced at per-use basis, cold boxes to vendors, and e-bikes on lease basis etc.

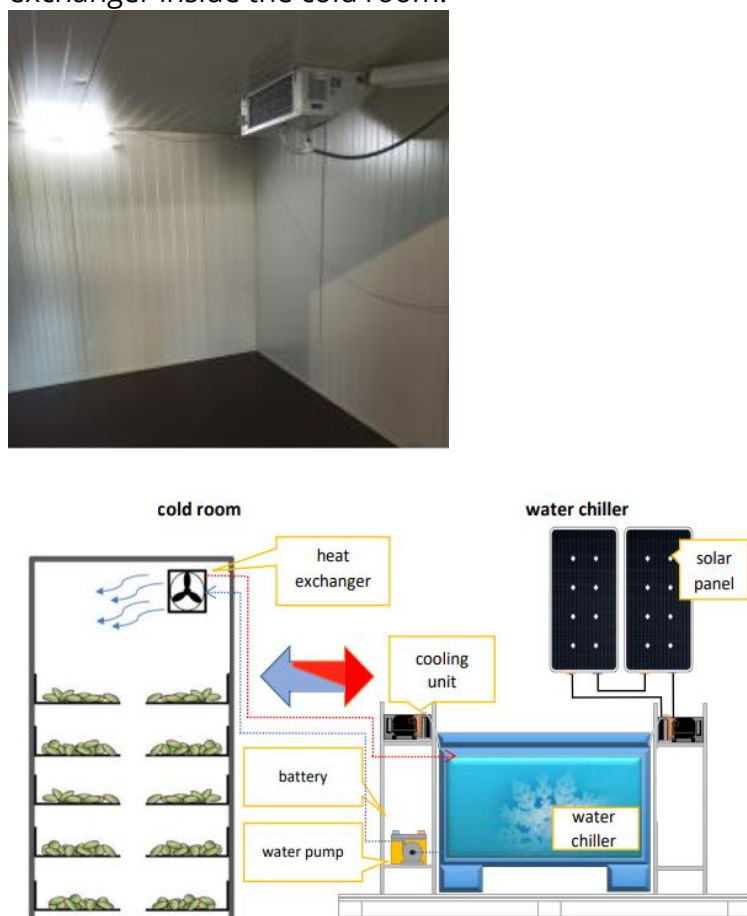
note for scaling-up the cold room in other such rural and peri-urban locations with a need for fresh produce storage.

Technology specifications and features²⁸

The SelfChill cold room, employed for this project, is a 20 m³ walk-in insulated chamber powered by direct current from solar PV modules as shown in *Figure 16*. It uses natural refrigerants with low global warming potential and has optional thermal storage (in the form of ice) capability in lieu of electrical storage. The system has optional battery storage as a backup to extend cooling hours in times of low or no sunshine. The chamber has air-water heat exchanger connected to water chiller (ice reservoir) via two hoses, and the chiller/cooling unit is powered by the solar PV modules installed at suitable angle near the cold room. The a-w heat exchanger inside the chamber creates cold air out of the water coming from the chiller system at temperature of about 4°C. SelfChill can provide up to 8°C cooling inside the cold room chamber at 45°C which is the maximum design ambient temperature.

Figure 19 -SelfChill Cold Room system

This shows the SelfChill cold room system, with the right picture showing a heat exchanger inside the cold room.



²⁸ Data for this section has relied on various technical documents of SelfChill.

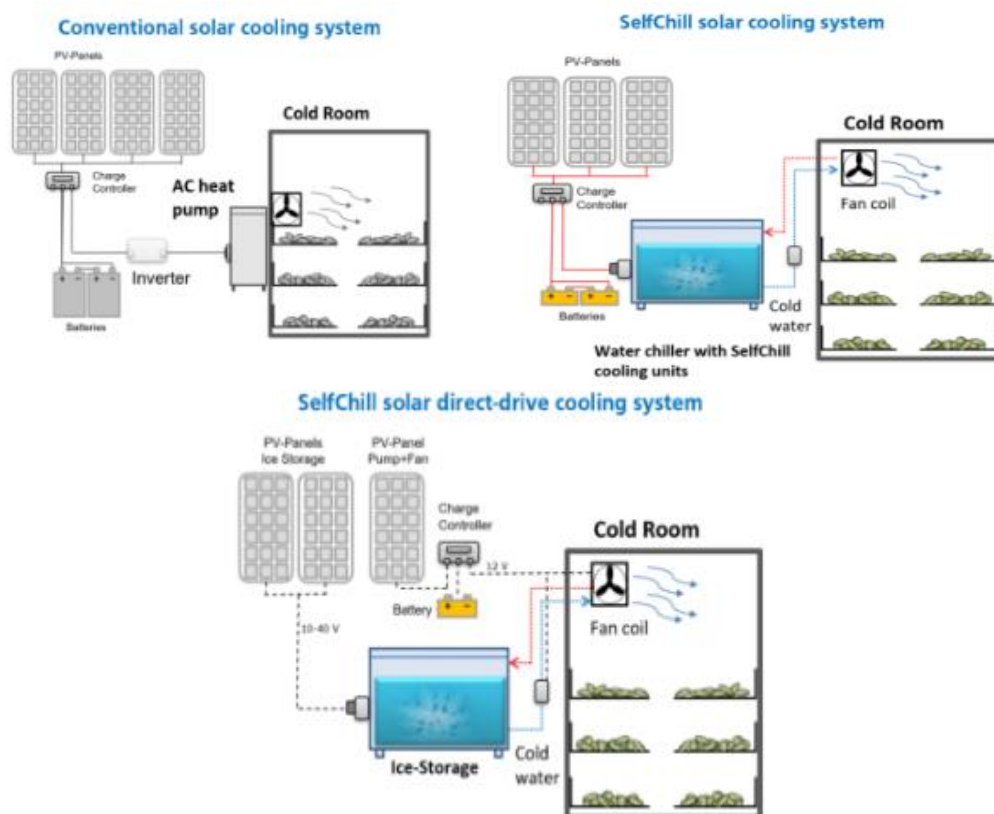


Figure 20 - SelfChill Cold Room system compared with the conventional cooling system

A SelfChill cold room features two independent PV systems, each consisting of a PV generator and batteries. The primary system is used to power the cooling units, while the secondary system operates the pump and fan within the water-air heat exchanger. The separation of these subsystems enhances the overall system's robustness.

Conventional solar cooling systems rely on the utilization of AC cooling devices, which require the use of an inverter and larger batteries. These are often not designed for solar appliances, have a high start current, and use refrigerants with a high GWP (global warming potential), and don't offer options for thermal storage. In contrast, SelfChill solutions count on innovative (and patented) cooling units which run on DC, use natural refrigerants with low GWP, and allow the use of thermal storage instead of electrical storage. SelfChill is designed for solar energy and for high ambient temperatures of even up to 45° C.

Table 14 - Technical Specifications of the Cold Room

Category	Parameter	Technical Specifications	Validity and Maintenance	Imported or locally sourced
Solar-powered Cold Room	PV system	11 panels 380Wp = 4180 Wp (including charge controllers, cables, connectors)	25y	Imported

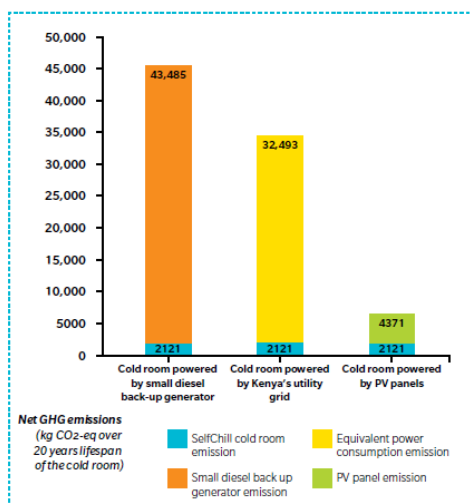
	Batteries	3x LiFePO4 batteries (each 5kWh/24V)	6y (longer than normal, as we will store them inside the cold room) ->10 years	Locally sourced
	Water chiller	including pipes and connectors	25y	Imported
	Cooling units	8pcs (75Wel, 150Wth per pcs)	10y (up to 15y)	Imported
	Cold cell	20m3 (100mm insulation thickness)	25y	Locally sourced

Climate and Additional Co-benefits of the proposed solution

1. Significant reductions in the food loss and food waste, which has a direct impact on increased incomes (e.g., for farmers and retailers) and positive livelihood implications.
2. Increase in food security and assurance of reliable food supply across the region.
3. Improved basic level of nutrition as cold rooms can ensure supply of critical cereal crops including rice, wheat, maize etc.
4. Reduction in the GHG emissions. It is estimated that nearly 10% of GHG emissions come from food loss and waste. Renewable powered cold chains that use alternative refrigerants have a lower carbon footprint (in comparison to HCFCs or HFCs). Comparative life cycle assessment of using the SelfChill cold room with solar PVs, using it with small diesel generator or utility grid revealed that running this cold room with solar PV will lead to 86% or 81% less GHG emissions reduction respectively. The Mbita cold room in Homabay consumes about 6kWh per day. The Kenyan grid emissions are about 500gCO₂/kWh. Hence, the avoided emission from the grid is nearly 3000g CO₂/kWh per day. Furthermore, 1t of food spoilage emits about 1t of CO₂eq.
5. Opportunities for enhanced technical skills and capacities, and job creation opportunities due to exposure to RE powered cold chains, construction/installation, along with operations.
6. Buffering the food supply and overcoming seasonal shortfalls (thereby supporting vulnerable communities that are at a high risk of hunger and poverty).
7. Spillover benefits – more awareness of cold chain solutions, opportunities for technological enhancement, technical capacity building, R&D and innovation capacities in-country.

Figure 21 - Comparison of 20 m³ SelfChill coldroom powered by different energy sources²⁹.

²⁹ Source: Jamieson et al (2023) available at [01-ENE119_001_Policymakers-Report_FINAL_2023-06-19-161447_ryul.pdf](https://efficiencyforaccess.org/01-ENE119_001_Policymakers-Report_FINAL_2023-06-19-161447_ryul.pdf) (efficiencyforaccess.org)



4.4.3 Market assessment and user needs

Approach and Methodology

In July 2023, user needs, and baseline assessment was conducted – in the form of semi-structured and structured surveys and interviews. The survey covered nearly 43 market vendors (of which a few were also wholesalers) to understand the trading practices, the type and volume of produce being wasted, the rationale and usage of a cold room, and to assess and quantify the volume of food waste in the market, and the food waste chain. In addition, 6 bilateral informal discussions were also carried out with the vendors and wholesalers. Further, a focus group discussion (FGD) was conducted with 15 members of the Mbita Market Association (including the Vice-Chair of the Association) along with a few members of the Suba Sub-County Government in Homabay.

The aim of the FGD with the market leadership committee and county government officials, following the market user needs assessment with market vendors in Mbita, was to gain an in-depth understanding of finer issues and nuanced challenges that might not have been fully captured by the user needs assessment questionnaire or interviews. By engaging in open and interactive discussions, we seek to explore the underlying factors affecting the market ecosystem, uncover hidden pain points, and identify potential opportunities for improvement for the solar cooling project. This collaborative approach aims to tap into the collective wisdom and expertise of the market leaders and government officials, enabling us to develop more comprehensive and tailored solutions that address the specific needs and aspirations of the vendors and the broader community. Through this enriched understanding, we strive to create a more resilient and responsive market environment that supports the sustainable growth and prosperity of all stakeholders involved.

The FGD was designed to gain comprehensive insights into the storage practices of vendors and market participants concerning their fresh produce, as well as their aspirations for future storage solutions. A set of guided questions, as outlined in Annex II, was prepared to structure the discussion. However, participants were encouraged to engage in open dialogue, allowing for the exploration of unforeseen issues and perspectives. The participatory session involved interactive demonstration of similar cold

rooms installed by SelfChill in Rwanda and other parts of East Africa (through photographs on phone). During the discussion, participants were actively invited to share their thoughts and feedback on the compatibility of the intended system with both their current and desired cold storage practices. This inclusive approach aimed to facilitate collaborative discussions and foster an in-depth understanding of the vendors' needs and preferences, ultimately informing the development of tailored and effective cold storage solutions for Mbita market.

All participants (vendors and traders) indicated a need for cold storage and expressed their willingness to pay, reiterated during the FGD conducted with the Market Committee and the representatives of the Sub-County Government.

Findings from the User Needs Assessment and Willingness to Pay

The preliminary findings indicate that there is a high interest in and the willingness to use the cold room to reduce income losses and food waste as well. This is particularly true for the produce with low shelf life such as leafy vegetables (Sukuma wiki), tomatoes, papayas, bell peppers, cabbages, avocados, which are among the most frequently traded items. Prior to the cold room, most vendors stored their produce in a conventional way such as on the floor or leave it on the stall in the market area covered with a mat, and often excessive sprinkling of water on leafy veg also leads to wilting. The survey also highlighted that when the produce begins to go bad (i.e., clear visual signs), the vendors fetch 50-60% less price than what they would when the produce is fresh, which causes a substantial income loss.

Food wastage occurs in Mbita Market due to fluctuations in demand and limited storage facilities, along with improper handling of produce during transportation, and lack of cooling facilities to extend the shelf life of the produce. For example, when the demand is low, around 8% of Irish potatoes and a significant portion of Sukuma wiki go to waste.

Commonly Traded Produce and Shelf Life

The market trades a variety of products, with the following items being traded in high volumes: tomatoes, onions, cabbages, kienyeji (local leafy vegetable), bananas, sukuma wiki (collard greens), and fruits. Certain products are traded throughout the year, including onions, avocados, kienyeji, bell pepper, coriander, banana, and eggplant. On the other hand, tomatoes, cabbages, potatoes, and sukuma wiki are seasonal and their availability is subject to fluctuations. The commonly traded products include avocado, bell pepper, banana, cabbage, tomatoes, onions, watermelon, oranges, kienyeji, spinach, mangoes, pawpaw, and sukumawiki. The least common include butter nuts, carrots, cassava, coriander, irish potatoes, lemon, pepper, and apple.

Figure 22 - Overview of the most traded produce in Mbita



The shelf life for some of the commonly traded farm produce are listed in the table below. Depending on the produce and their means of natural storage, shelf-life ranges from 2 to 10 days.

Figure 23 - Summary of the shelf-life of commonly traded produce

Product	Shelf-life (in days)
Cabbage	5 - 7
Tomatoes	3 - 5
Sukumawiki	2 - 3
Kienyeji	2 - 3
Pawpaw	2 - 5
Avocado	3 - 5
Bananas	3 - 4
Ball pepper	3 - 5
Oranges	3 - 5
Spinach	2 - 3
Mangoes	3 - 7

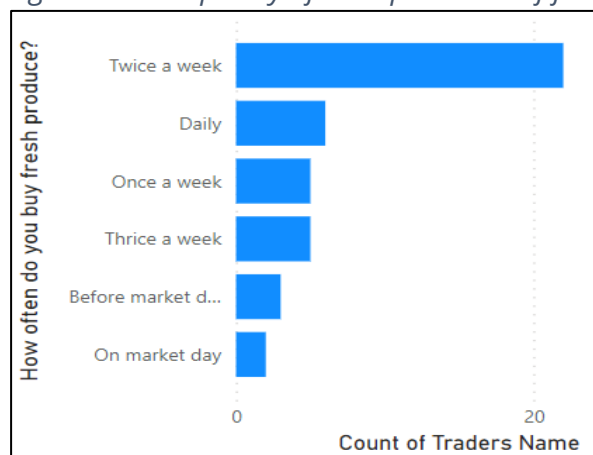
Revenue losses due to spoilage in most cases are in the range of 30% to 100%, with an average of 63%. For example, a piece of cabbage which is sold fresh for 80 KES could be sold as low as 40 KES (0.31 USD) when bad, while a bunch of fresh Kienyeji selling for 10 KES (0.08) could fall to 5 KES when bad (0.04 USD).

Produce Sourcing and Transport

The locations where products are bought include Gwasi, Homa bay, Kissi, Busia, Narok, Nakuru, Nairobi, Sindo, Suba, and Mombasa which are located at distances ranging from 30 to 1000 kilometers, with an average of 284 km (about 176.47 mi) from Mbita market. Although produce is transported from distant areas such as Kisii, Bondo, Nakuru, Kitale, and Nairobi, there is some local agricultural production in the Mbita area. Sukuma wiki, tomatoes, and kienyeji are sourced locally from areas like Sindo, Kirindo, and Luanda, but in relatively low quantities. With the operational cold storage room, it is expected that the

frequency of produce transport would decrease, resulting in reduced transport costs. The easy accessibility of the cold room would save vendors money, which they can allocate to purchasing other produce.

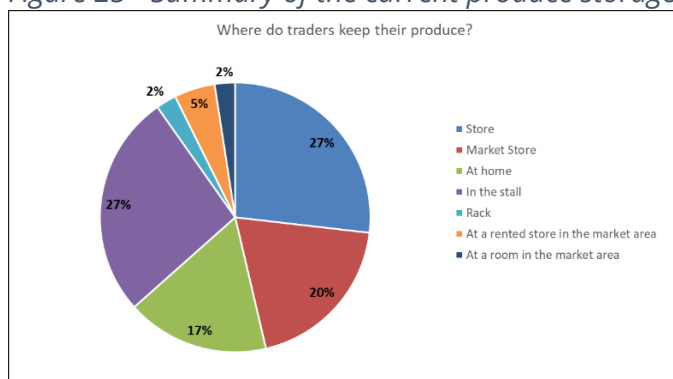
Figure 24 - Frequency of transportation of fresh produce



Current Cooling Options and Produce Getting Spoilt

Most of the produce is stored at rented stores, followed by stores located within the market. However, few ones are stored at home inside kibanda hut or arranged on the racks. Many vendors typically sprinkle water on their produce to make them appear fresh and to keep them cool, however the increase in the moisture content and inappropriate storage only worsens the produce quality further.

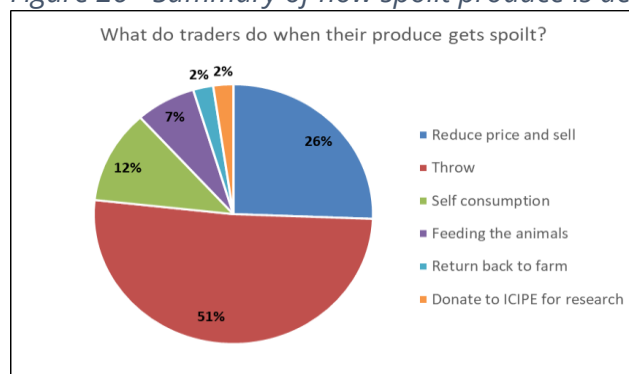
Figure 25 - Summary of the current produce storage locations



When the produce gets spoilt, the most common response among vendors is to simply throw the produce, if it is beyond the stage of being able to salvage. If some of it can still be salvaged, the prices are reduced by a significant portion (around 40%-60%) and sold. In other instances, they are also used for self-consumption, which might lead to hygiene and health concerns as well.

The vendors stated that they usually give away the spoilt produce to feed animals/cattle and in a few instances return the produce back to the farm/farmer, and one or two respondents also mentioned about donating the spoilt produce to ICIPE (International Centre for Insect Physiology and Ecology) – located in Mbita town Homabay – for research purposes.

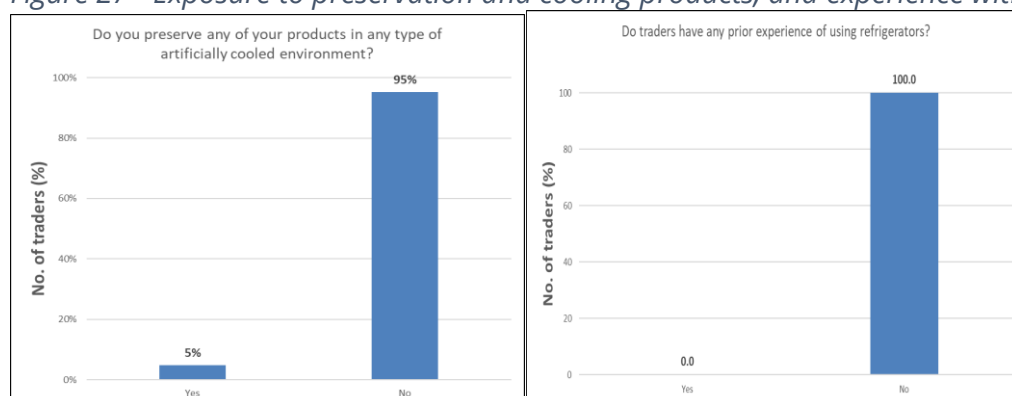
Figure 26 - Summary of how spoilt produce is dealt with



Currently, most vendors are not preserving produce in any type of artificially cooled environment. This is confirmed also by Figure 27 whereby vendors state to have never used refrigerators in the past.

A few vendors have previously used cooler boxes only for a short period, which were provided by WeTu to test the feasibility and secure feedback on the relevance and challenges of the cooler boxes. However, as they were provided for free during the initial period, there was limited uptake for the same product when introduced on a commercial paid-service basis with a leasing fee. This has been a learning experience whereby the cold room will be charged, and this is explicitly clarified upfront.

Figure 27 - Exposure to preservation and cooling products, and experience with refrigerators



Price and Willingness to Pay

Vendors express their willingness to pay fees for using the cold room, although the specific fee was not ascertained yet. Out of the surveyed vendors, nearly 95% of them have expressed a willingness to pay a reasonable fee to preserve/store their produce in a refrigerated environment.

The payment would contribute to covering the installation and operational costs. Vendors suggest that the fee for using the cold room could be based on the number of crates they have loaded. This suggests that the payment would be proportional to the quantity of produce being stored.

Figure 28 – Vendor willingness to pay for cooling service

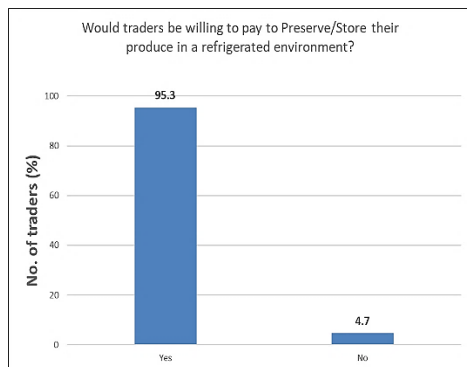
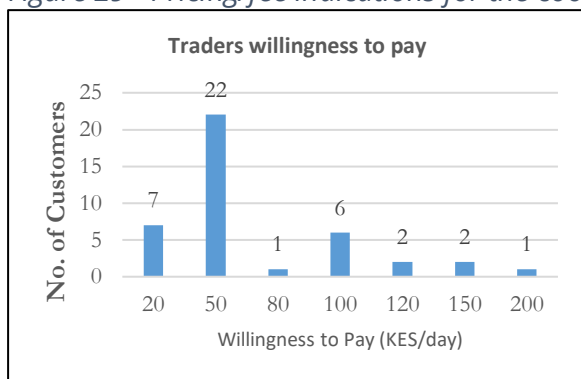


Figure 29 - Pricing/fee indications for the cooling service



Additional Information regarding market operations

The typical market operating hours in Mbita are from 6 am to 8 pm. Trading activities are busiest in the morning, and after 8 pm, there are no further trading activities. Vendors and wholesalers pay various fees for security, market space/stalls, storage space, and porters. Each member contributes 50 KES (0.39 USD) for security per month, pays according to the space allocated for market stalls, and pays 800 KES (6.2 USD) per month for storage. Porters are paid individually based on the number of trips and the load they carry.

There are approximately 25 porters working in the market, and they are paid individually based on their work. The market's security measures include closing all gates at 6 pm, except for one gate that remains open until exactly 8 pm when the vendors exit.

Snapshots of the market and food waste in Mbita market



4.4.4 Business model aspects tested and validated

Table 15 provides a summary of the features of the business model using the canvas and provides a qualitative description of the core value proposition, the end-user segments, and relationships along with the type/nature of costs expected.

Business Model Canvas

Table 15 -Summary of the BMC for Cold Room

Key Partners  The key partner is the technology provider that is responsible for constructing, assembling the cold room along with provision of training of staff for the operational period. The Mbita market association committee is also a key partner in helping secure buy-in for the project and to enable users to use the cold room. WeTu will hire a full-time employee as the person responsible for operating the cold room and for ensuring smooth input and output of produce.	Key Activities  The key activities includes ensuring smooth operations for cold room, continuously engaging with user feedback, data monitoring of the usage, and ensuring that the pricing and affordability allows for continuous customer retention and new acquisition and ensuring that the tech app allows for transparency. .	Value Propositions  The cold room alleviates the problem of food waste, and income loss, and provides a cooling solution for storage of fresh produce and fruit to increase the shelf life. Because of the off-grid, solar powered modular nature, the cold room is easily accessible and the payment of per crate per use basis also provides an affordable option to the traders and wholesalers. The cold room will be in the market area, allowing for easy loading and unloading of produce.	Customer Relationships  The customer relationships are integrated already with the business model of the WeTu Mbita hub that provides drinking water service, solar lighting service, along with the new cold room engagement. The acquisition and retention will be done	Customer Segments  Traders and wholesalers of the Mbita market are the most important customers of the cold room. In addition, some of the farmers/who are occasional traders also can avail of the cold room. From a baseline assessment and FGD conducted, the market committee and individual traders have expressed a clear willingness to pay to avail of the cold room service to reduce their income losses.
Cost Structure  During the installation/construction phase includes -Purchase of equipment, assets, technology components (including the cold room unit, cooling units, solar panels, batteries, heat exchanger, etc.) -Labour costs for installing, constructing the cold room, supervising the construction process, and imparting/receiving trainings. During the operational phase -Salary cost for one full-time employee for the cold room -Maintenance costs for the cold room, cooling units, technology app, crates/boxes, other components etc.		Revenue Streams  The revenues will be primarily sourced on a leasing basis, payment for per crate per use basis from the traders and wholesalers. The collection will be managed by the WeTu staff in local currency. The willingness to pay has been unanimously expressed, and the pricing will have to be reasonable to make the service affordable. This proportion will have to be less than the income loss being incurred due to food waste and take into cognizance other fees being paid already for existing storage to the sub-county government and the market committee.		

Pay as you store or Cooling as a Service (CaaS): In this model, customers pay a fixed rate for using the cold room facility for a particular weight and time duration rather than purchasing the infrastructure upfront. For example, retailers can pay per crate/kg of produce stored in the facility. Cooling as a Service is an innovative business model that enables customers to base their decision on life cycle cost rather than on the purchase price of cooling equipment.

This model offers key advantages for the customers, notably sparing them the upfront investment of installing the equipment, minimising operation and technology risks, and reducing the overall utility costs. Moreover, by leaving the responsibility of equipment maintenance, including repairs and update to new regulations, to the technology providers, end-users can focus on their core business and using leasing/ or sharing economy models for energy-efficient appliances.

In the following paragraphs, the business model features for the Mbita cold room are further elaborated along with the detailed cost structure, revenue stream and the projections for payback periods based on certain assumptions.

Value Proposition

The value proposition is the solar powered cooling service offered by WeTU in the Mbita market for the market vendors and traders. The cold room offers to keep the produce (i.e., the perishable goods) fresh for a longer period and thereby reduces food waste and enhances the income generation for the end-users. Prior to the cold room, the market vendors would store it under a tarpaulin or in a sack bag in their respective stall. There

was reportedly a need expressed by the Mbita region customers regarding ice flakes, refrigeration or cooling service both for fish as well as fresh produce. Located in the lake region, there is a demand pertaining to cooling service for fish as well. WeTu has been gaining experience and insights with operating ice flakes business in Homabay prior to the SESA project.

Key Partners, Resources and Activities

The key technology partner engaged with WeTu for the SESA hub is Self-Chill. Self-Chill has provided its proprietary cooling technology and equipment, and solar equipment from Germany, along with technicians for installing, training and guidance on operating the cold room to the WeTu staff. Such services continue to be provided since inception. WeTu and Self Chill have been working in partnership on all aspects of the functionality of the cold room, testing and monitoring of the technical performance, multiple visits by the experts from Germany for in-person guidance and training, along with weekly calls to follow-up on progress, challenges etc. Self-Chill has been continuously gathering feedback on its technology and drawing insights from its various pilot cold rooms underway in the Africa countries, esp. also in Zambia and Rwanda under different modalities and set-ups.

An app has been developed to enable digital capture of live data and streamline cold room operations. It is designed to support cashless transactions, cold chain tracking, and efficient management of storage activities, including recording the type of produce, duration, weight, customer name, and price paid. While the app is fully developed and ready for deployment, integration with KopoKopo (the mobile money payment gateway) remains a challenge. Since mobile money functionality is essential for daily transactions, WeTu cannot roll out the app until this integration is complete. The complexity of accommodating various produce types and customer profiles has also required more development effort than initially anticipated.

WeTu owns and operates the cold room, and Self Chill provides technology support and guidance along with trainings to the WeTu staff. There is a dedicated operator for the cold room, a full time WeTu staff along with the local Mbita team providing support on-need basis.

Customer Segments, Channels and Relationships

The key customer segment targeted for the cold room include:

1. Mbita market vendors or retailers – This is the primary target group for the cold room. Currently 55 vendors are using the cold room, of which 54 are female vendors.
2. Small local businesses – e.g., juice vendors. These are the secondary target group, which primarily includes fruit and juice vendors in the nearby area to Mbita marketplace.

In addition to the above (entailed B2C transaction), a new customer segment is being explored for B2B transaction i.e., larger businesses or supermarkets (e.g., Stable foods in Homabay).

To engage with the key customers, a collaborative approach including open dialogues, continuous bilateral interactions, FGDs, surveys, consultative sessions was adopted. This enabled to tap into the collective wisdom and expertise of the market leaders and local government officials, to understand pain points, income and profitability margins, enabling WeTu better address the specific needs and aspirations of the traders and the broader community.

The WeTu Mbita hub has been in operation since 2019, with 4 hub staff and the WeTu operations manager stationed at the hub. WeTu's Mbita hub is located close to the Mbita market (around 5-7 mins walking distance). Some of the market vendors are existing customers of WeTu as they lease off-grid solar fishing lights and/or purchase drinking water at a nominal charge. WeTu has established relationships in the local community area, and the staff representatives are in continuous contact and engagement with the local government as well as with the market committee.

For the cold room, a strong focus has been put on continuous customer engagement since project inception. The following approach was adopted:

Before the cold room installation:

- Bilateral engagement to gauge the interest in the cold room
- Surveys and baseline assessment to identify the needs and willingness to pay
- Meetings with the sub-county officials pertaining to land and regulatory clearances
- FGDs with the market committee, market vendors and traders for an open consultation process regarding the cold room – allowing them scope to pose questions, express concern, discuss the modalities of leasing fee etc.
- Sensitization and trainings pertaining to handling and management of produce to reduce food waste

After the cold room installation and during operations:

- Non-chargeable onboarding phase: Nearly seven weeks of trial phase (March 13th to May 6th, 2024) allowed the fresh produce market vendors and horticulture farmers to become acquainted with the cold room system before its official launch with pricing for storage service.
- Development of operational protocols: To ensure efficient use of the walk-in cold room, protocols, and procedures have been developed and continue to be developed to ensure optimal operation of the system and convenience for the users and their produce.
- User engagement sessions: Feedback sessions with fresh produce retail vendors and horticultural farmers around Mbita Market have allowed us to better understand their storage needs and behaviour, as well as gather insights into the produce purchasing value chain.
- Symbolic visit: On March 11th, 2024, dignitaries including the Homa Bay County Governor, alongside the EU Ambassador to Kenya, together with the Ambassadors

of Austria, Germany, France, Sweden, and Poland visited the cold room facility, highlighting its significance.

April 14-15, 2025:

- SelfChill Conference and Tour: on 14-15 April 2025, Phaesun hosted the "SelfChill Conference & Tour," featuring a conference program in Kisumu on the first day, followed by a site visit to cold room installations in Mbita and Homa Bay on the second day. The 40 participants learnt about the background of solar cooling for agricultural produce, receiving in-depth information on the cooling technologies and sustainable construction concept. Participants included representatives from the Federal Ministry for Economic Affairs and Climate Action Germany, the German Energy Agency, the German Embassy in Kenya, and the Kenyan Ministry of Energy.
- End-user training: Small-scale farmers, wholesalers and market vendors are the direct target group for cooling services. Within the project, training material is being developed highlighting the aspects and benefits of cooling methods.
- Communication and awareness creation: Activities for communication and awareness creation such as media cooperation, networking at public events and conferences for the professional audience will be organized.

Cost Structure and Revenue Streams

The most important cost drivers include cooling equipment, solar panels and batteries, civil and structural works entailed in installing the cold room, along with other equipment costs and importation costs. Most of the equipment was imported from Germany and assembled locally.

Initially a single fixed fee was introduced of 50 KES (0.39 USD)/per crate. However, several vendors, particularly those selling leafy vegetables provided feedback to lower the fee as their volumes and margins were small. As a result, a differentiated pricing structure was introduced based on the weight of the produce along with factoring in the income potential, seasonality and price at which the produce is sold. For instance, leafy vegetables, which are among the most traded produce fetches less income and is priced at 25 KES (0.19 USD)/per crate, compared to tomatoes at 50 KES (0.39 USD)/per crate or fruits such as watermelons at 75 KES (0.58 USD)/per crate. The price of the produce in turn is subject to the production/supply patterns along with seasonal fluctuations and climatic changes. The maximum crate occupancy of the cold room in case of full capacity is around 50-55 crates.

The main revenue stream for the business is the pay-per crate or per use by the direct users of the cold room at the marketplaces (i.e., the retail vendors). This is a fairly safe revenue stream as the vendors can witness the higher value gained from fresh produce vis-à-vis the income loss.

Below are examples in SSA of other cold room providers and their current prices:

Cold Hubs

- **Pay per crate:** Typically charges a cooling fee of around 0.27 USD per crate³⁰

Sokofresh

Rental fees for whole cold room of 20m3:

- 700usd/month (mind. 6 month), 3500KES/day

³⁰ https://energypedia.info/wiki/ColdHubs_-_Solar_Cold_Rooms_in_Nigeria

4.4.5 WeTu Insights from Cold Room Operation

Preliminary Insights into the first 6 months of post-cold room installation

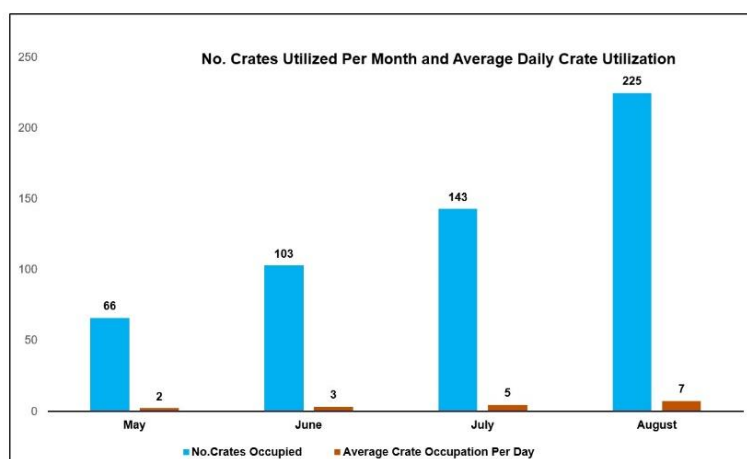
Initial observations on the Mbita Market Cold Room's "Cooling as a Service" from the operational phase May-August 2024 were as follows:

Trial Phase (March–May 2024): The cold room underwent technical testing during this period, which also served as an introductory phase for market vendors. Vendors—mostly women—were encouraged to explore the service, understand its benefits, and observe its impact on produce preservation. This phase was offered free of charge, generating significant interest and engagement.

Transition to Paid Service: To facilitate vendor onboarding and provide a hands-on experience, the service remained free until the end of May. Once a flat-rate storage fee was introduced, usage initially dropped to just 3–4 crates per night. However, over time, usage steadily increased, reaching an average of 10–12 crates stored daily, typically for overnight storage.

Gradual Uptake Through Continued Engagement: With sustained outreach and vendor engagement, crate occupancy rose to an average of 8–10 crates per night. Refer to *Figure 30* for dashboard data illustrating monthly totals and average daily storage figures.

Figure 30 - Number of crates utilized per month and average daily crate utilization initial trial period



Fluctuating food prices due to seasonal and inflationary forces have imposed financial limits on adoption. For instance, there was a low production of tomatoes during the rainy season of March to May which affected the supply of tomatoes in the market and consequently storage of tomatoes in the cold room. Subsequently after the massive floods there has been depressed production and supply of green leafy vegetables further affecting storage uptake by green leafy vegetable vendors.

The initial limited uptake emphasizes the need for consistent awareness efforts among vendors and farmers about the benefits of cold storage. There have been misperceptions about the efficacy of the cold room. In a few early instances, the vendors observed wilting of leafy vegetables post-storage – which is attributable mainly to the quality of the produce at the time when it was stored. The cold room operator received further training to undertake a quality check of the produce being stored.

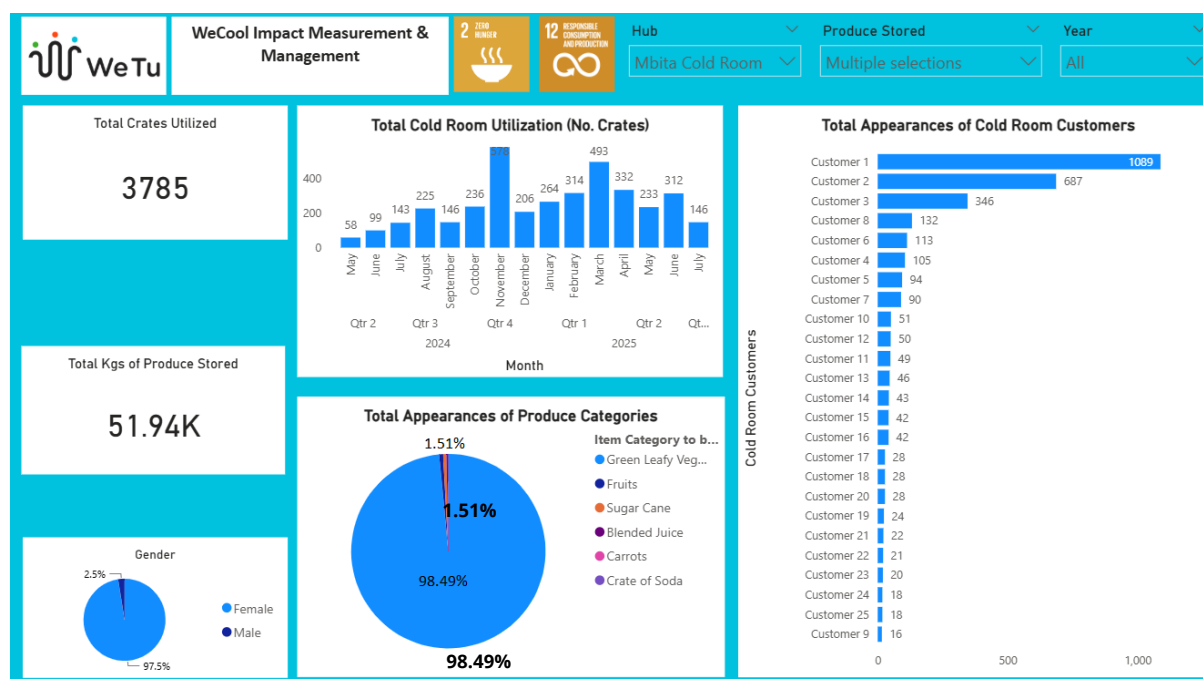
The initial assumption was that perhaps the cold room might encourage less transport and more storage, thereby reducing the transport costs borne by the vendors, has proven incorrect. The retail price is factoring in transport, and it is difficult to break the vendor-transporter/wholesaler nexus as a locally established dynamic.

To overcome these challenges, WeTu is considering expanding service offerings to different user groups such as local businesses (B2B) which could increase overall cold room utilization. However, these are tentative plans to be implemented only after exhaustively exploring all options to ensure the market vendors take up the service have been exhausted.

Insights from One Year of Cold Room Operations

Over its first year of operation, the Mbita cold room demonstrated strong adoption among female vendors, who comprised 97.7% of users, while also preserving 56 tons of produce through 3,773 crate storages. Women comprise the highest proportion of vendors in the market. Cold room utilization peaked seasonally, with fresh green leafy vegetables dominating storage at 98 percent reflecting both market demand and the cold room's alignment with vendors' primary goods or commodity most traded. However, the concentration among a core group of repeat users like Customer 1 (1089 appearances) and Customer 2 (687 appearances) suggests uneven broader market penetration. The minimal storage of high value produce such as fruits or sugarcane highlights opportunities to diversify the customer segments and produce types to improve operational resilience and revenue streams. Seasonal fluctuations in monthly crate usage such as those seen in November 2024 further underscore the need for adaptive pricing which factors seasonal variations and/or promotional strategies to stabilize year-round demand for cold storage service.

Figure 31 Dashboard Snapshot: of the cold room since inception up to July 2025



Storage Pricing and Tiered Pricing Evolution

The tiered pricing structure currently in operation reflects an evolution from the initial flat fee model to a more user centric approach informed by user feedback from focus group discussions (FGDs) and trial testing period. This was after extensive user feedback from trial periods and focus group discussions. The structure now reflects produce value and trader economics, with leafy greens priced accessibly at KES 25/crate while higher-value items like watermelon command KES 70/crate. This differentiation emerged directly from fresh produce vendors' input, attempting to balance affordability for small-scale vendors with revenue needs. The model particularly accommodates women vendors who dominate leafy vegetable trade, while creating room for high value premium produce such as fruits.

Table 16- Tiered for Different Produce Categories

Currency: KES			
ITEM CATEGORY	PRICE	QUANTITY	DURATION
TOMATOES	50	CRATE	DAILY
WATER MELON	70	CRATE	DAILY
CABBAGE	50	CRATE	DAILY
SUAGER CANE	25	CRATE	DAILY
BLENDED JUICE	25	5 LITRES	DAILY
GREENY LEAFY VEGETABLES	25	CRATE	DAILY
20 LT JERICCAN FULL	25	PER JERRICAN	DAILY
CRATE OF SODA	25	24 BOTTLES	DAILY
FRUITS	50	CRATE	DAILY

Optimizing Cold Room Operations Through Collaborative Research

As part of the SESA project's commitment to user centric innovation through collaborative approaches, WeTu and the technology partner SelfChill partnered with Kijani Testing, a local organization focused on agricultural research, appliance testing and energy efficient renewable energy appliances. The technical tests were also done actively with the market vendors and vendors. This collaboration looked to examine critical factors such as ethylene sensitivity, optimal storage parameters, optimal crate loads and storage durations for most stored produce types directly linking technical research with practical cold room operations alongside the cold room users.

The findings enabled data driven refinements to storage protocols while maintaining the project's participatory approach with local organizations. For instance, research on leafy greens' humidity needs informed both operator training and vendor education materials. This integration of scientific validation with community engagement created a feedback loop where technical insights could be immediately applied and adjusted based on user experience.

Assessment of different types of produce

This approach demonstrated that postharvest handling and storage practices play a critical role in determining the shelf life and market value of different types of produce. Below are key results from this research partnership that enhanced both produce preservation and cold room efficiency.

1. Kale

Under ambient conditions, kale deteriorates rapidly - losing visual quality, weight, and marketability within two to three days. The absence of cooling infrastructure and reliance

on open display and minimal hygiene practices contribute to daily losses of up to 2.5 kg per vendor, translating into a 25% revenue loss. Moreover, informal washing methods using recycled water introduce further risk of contamination and spoilage, limiting the crop's economic return over time.

By contrast, the solar cold room offers a practical and cost-effective solution to extend kale freshness and reduce postharvest losses. The study shows that when kale is stored under optimal crate load conditions (half-load configuration), the crop maintains high quality for up to seven days. Economic analysis reveals a 44.1% increase in vendor profit when cold storage is used—underscoring the value of combining cooling with improved handling practices. The cold room also provides flexibility in market planning, enabling vendors to stagger sales without compromising product value. However, proper training of cold room operators remains essential to ensure appropriate sorting, dry loading, and crate hygiene—even when water is scarce.

To maximize the benefits of solar cold storage, it is recommended that vendors and cold room operators:

- Adopt optimal crate loading practices to ensure consistent cooling and airflow;
- Avoid washing kale before storage and instead perform gentle soaking just before display;
- Improve crate sanitation through dry cleaning methods, as water is limited;
- Continue vendor sensitization and training to promote confidence in cold storage as a service;
- Monitor temperature and crate rotation to support efficient storage cycles.

By implementing these improvements, cold room utilization can be increased, spoilage reduced, and vendor profitability significantly enhanced—paving the way for more resilient and sustainable postharvest management of kale in informal market settings.



Figure 32 - Kale Value Chain

2. Spring onion

The traditional value chain for spring onions at Mbita market, without cooling infrastructure, poses significant challenges for farmers, and market vendors. Without access to proper storage, onions deteriorate quickly due to exposure to high temperatures and direct sunlight, leading to weight loss, wilting, and reduced market value see *Figure 33*. Small vendors are forced to sell their produce rapidly to minimize losses, often mixing older onions with fresher ones to maintain sales. This lack of cooling

capacity results in high postharvest losses, lower income for vendors, and increased food waste, reducing the overall efficiency and sustainability of the value chain.



Figure 33 - Spoiled onions during trading

The introduction of solar cold storage presents a major opportunity to improve the storability and economic value of spring onions. The assessment on optimal loading capacity demonstrated that a three-quarter crate load (7.6 kg per crate) balances cooling efficiency with storage capacity, reaching the optimal 10°C within 30 hours. This configuration allows vendors to store larger quantities of onions while maintaining freshness, extending their shelf life from one day to up to four days. This extended storage window enables vendors to plan sales better and reduce rush selling, ultimately leading to higher profits and reduced losses.

The quality assessment further confirms the benefits of refrigerated storage, maintaining temperature stability around 10°C and relative humidity between 85-95%, conditions that significantly slow down wilting, dehydration, and spoilage. However, noticeable quality changes, such as wilting, yellowing, and slight texture degradation, were observed beyond four days of storage. Despite some weight reduction (0.45 kg per crate over ten days), the controlled environment still outperforms traditional open-market storage, where onions deteriorate much faster under direct sunlight.

Cold room operators emerge as key stakeholders in the value chain, bridging the gap between market vendors and cold storage service utilization. By understanding optimal handling techniques and the storability of onions, operators can provide better guidance to small market vendors and vendors, encouraging wider adoption of cold storage

solutions. Furthermore, ensuring proper environmental monitoring inside the cold room is crucial, as fluctuations in temperature and humidity could impact storage performance. Increasing the utilization rate of the cold room remains a challenge, but demonstrating the clear economic advantages of extended storage could drive more vendors to adopt this solution.

Based on these findings, several recommendations can be made. First, market awareness campaigns should be conducted to educate vendors and vendors on the economic benefits of using cold storage. Second, cold room operators should actively monitor storage conditions and adjust parameters as needed to optimize performance. By integrating these strategies, the Mbita solar cold storage system can contribute to a more resilient, profitable, and sustainable agricultural value chain for spring onions.

3. Tomatoes

The assessment of the tomato value chain at Mbita reveals significant vulnerabilities to postharvest losses due to the absence of effective cooling infrastructure. Under current market conditions, tomatoes are subjected to rough handling during transportation, high ambient temperatures, and prolonged exposure to low humidity. These factors contribute to accelerated ripening, mechanical damage, and spoilage—resulting in daily losses ranging from 0.5 to 4.5 kg per vendor. While vendors use basic techniques such as open-air or rack storage with polythene coverings, these methods are largely ineffective in preserving tomato quality beyond 2–3 days. Consequently, vendors are often forced to sell at discounted prices or dispose of unsellable produce as animal feed or food service input.

The introduction of the solar cold room at Mbita provides a promising solution to this challenge. Tomatoes stored in the cold room maintained visual appeal, firmness, and quality for up to 14 days—compared to just 6 days under market conditions. The cold room enabled better planning of sales and reduced the urgency of same-day turnover, giving vendors greater flexibility. However, some concerns remain, particularly regarding potential spoilage after removal from cold storage due to condensation, and limited storage capacity during peak market days.

The role of the cold room operator is central to ensuring the success of this intervention. By actively sorting tomatoes during storage and maintaining stable temperature conditions, operators help prevent spoilage and preserve product value. Their oversight ensures that the cold room remains a reliable and efficient service, promoting vendor trust and broader adoption. In this context, the cold room operator is not just a facility manager but a critical stakeholder in reducing postharvest losses and improving the overall resilience of the tomato value chain.

To enhance the impact of the solar cold storage system, the following recommendations are proposed:

- Promote vendor awareness about the benefits of cold storage through targeted training and demonstrations.

- Strengthen cold room operational protocols, especially around handling, sorting, and consistent temperature monitoring.
- Explore the expansion of cold room capacity or scheduling mechanisms to accommodate higher volumes on peak market days.
- Develop guidelines for managing post-storage handling, including techniques to minimize condensation and extend shelf life after removal.

By implementing these measures, the Mbita cold storage system can become a sustainable model for reducing food loss, improving vendor income, and supporting local food security.

Figure 34 - Preparation of the tomatoes to be stored in the solar cold room



4.4.6 User Acceptance Studies for the Mbita Solar Powered Cold Room

WeTu and the SESA project partner Stockholm Environment Institute (SEI) conducted user acceptance studies in July 2025 for the cold room users from inception till then to assess technology adoption amongst the users, energy access and whether the innovative approach, business models and technology are delivering on the dual promise of sustainable energy access and economic empowerment for Mbita's market vendors. The surveys covered a total of 47 cold room users, including current users and all those who had used the cold room from inception to the time of the survey in July 2025. The study focused on certain aspects key amongst them being operational performance (reliability, ease of use), financial viability (pricing models, willingness-to-pay), and social inclusion (gender-specific adoption patterns), with particular focus on women vendors who comprise 97% of the cold room user base.

By capturing both quantitative and qualitative feedback after more than a year of operation, the surveys revealed how real-world conditions such as seasonal produce

fluctuations to informal market dynamics have influenced the technology's impact on reducing post-harvest losses and increasing energy access. The findings will not only guide immediate improvements to cold room operations but also seek to generate transferable insights for scaling similar solutions across SESA sites and similar Africa contexts, ensuring future solar cooling deployments are grounded in empirical evidence of what works for last-mile energy users from their own perspective. The following are some of the insights from the user acceptance surveys:

1. System Accessibility and Reliability

The cold room system demonstrated strong operational performance, with 80% of surveyed users reporting it was always accessible when needed during their operational hours. Only a small minority less than 5 percent experienced occasional accessibility issues. This high reliability rate is particularly important for perishable goods vendors who depend on consistent access to preserve their produce and access their produce ready for market. The minimal downtime reported suggests that the flexible and effective operational protocols are in place that fit into their unique needs.

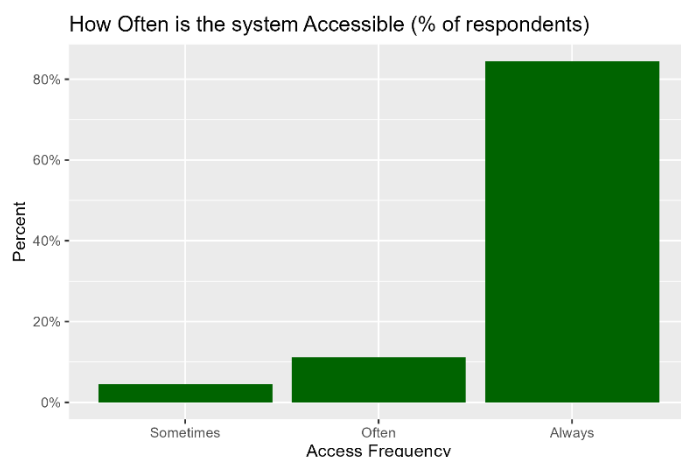


Figure 35 - Cold Room Accessibility Frequency

2. User Experience and Ease of Operation

Three-quarters of respondents (75%) found the cold room system straightforward to use, rating it either "Easy" or "Very Easy" to operate. A gender breakdown revealed women users were slightly more positive, with 52% selecting "Very Easy" compared to 43% of male users. These findings indicate the system's design successfully accommodates users with varying levels of technical familiarity, which is crucial given the diverse educational backgrounds of market vendors.

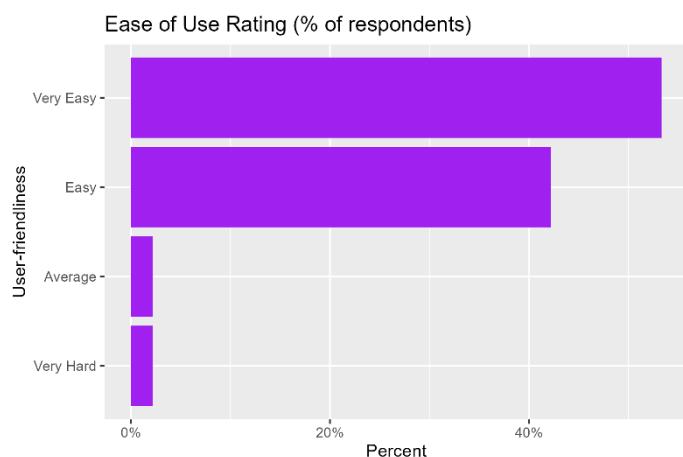


Figure 36 - User-Friendliness Ratings

3. Correlation Between Accessibility and Usability

The survey also revealed an alignment between system accessibility and ease of use with all respondents who reported reliable access also rated the system as easy to operate. This correlation suggests that when the cold room is available, users find its operation intuitive and manageable, creating a positive feedback loop that reinforces continued usage.

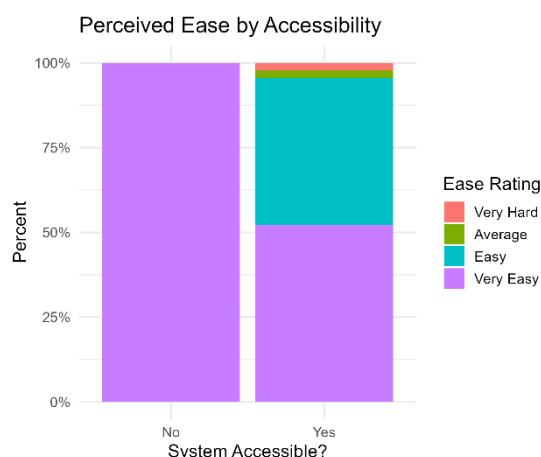


Figure 37 - Perceived Ease of Accessibility by Gender

4. User Retention and Continued Use

An overwhelming majority (80%) of respondents indicated they were very likely to continue using the cold room service in the future. This strong retention indicator demonstrates that once vendors adopt the service, they recognize its value and intend to maintain usage, providing a stable base for ongoing operations and potential expansion into other customer segments.

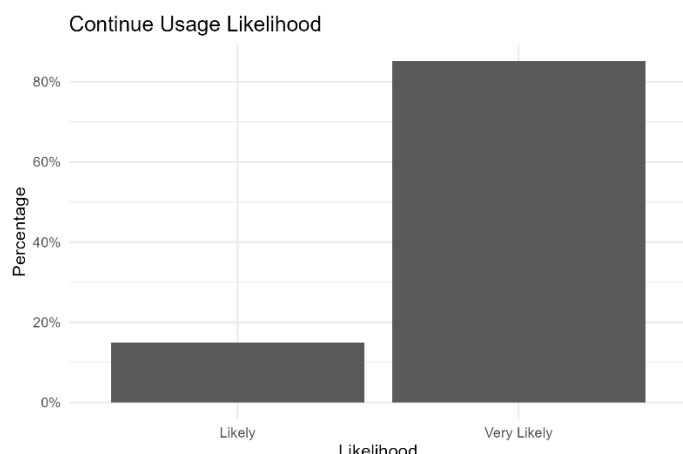


Figure 38 - Intention for Continued Use

5. Pricing Structure Acceptance

The tiered pricing model implemented after initial testing phases received critical feedback, revealing critical insights into the affordability and perceived value of the tiered pricing model and its acceptance. Contrary to initial assumptions, 35% of respondents expressed strong dissatisfaction with the current pricing structure, overshadowing the 32% who were very satisfied with a further 28% satisfied and 5% remain neutral. The responses indicate the need for careful pricing consideration, particularly in addressing the needs of price sensitive user base while seeking to maintain operational and financial viability.

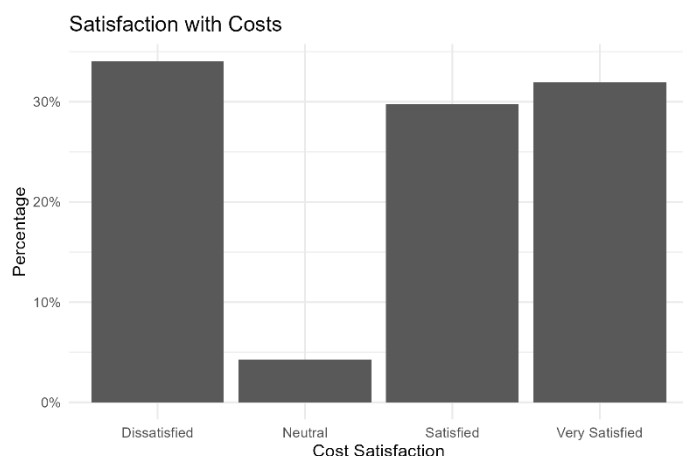


Figure 39 - Pricing Approval Ratings

6. Overall Service Satisfaction

When asked about their general satisfaction, 60% of users reported being overall very satisfied with the cold room service, while neutral responses accounted for just 10% of feedback. These results confirm that the service is successfully meeting core user needs and expectations as envisioned.

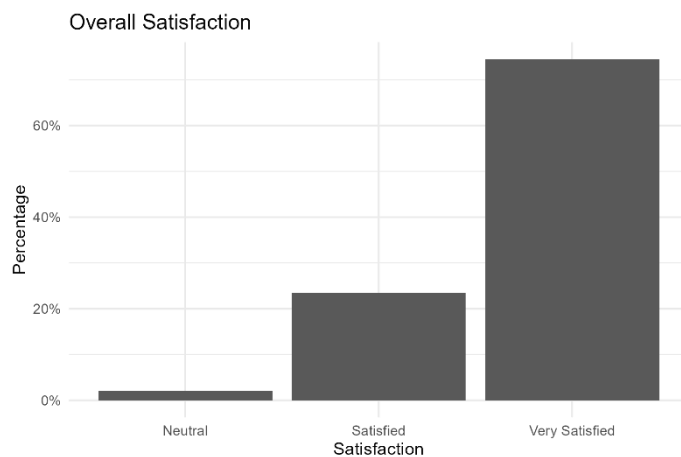


Figure 40 - User Satisfaction Levels

7. Customer Advocacy Potential

The study found exceptional advocacy potential, with 80% of users stating they would strongly recommend the cold storage service to others. Such high recommendation rates indicate organic growth opportunities through word-of-mouth promotion within the Mbita trader networks and market community that has seen consistent usage albeit with low storage.

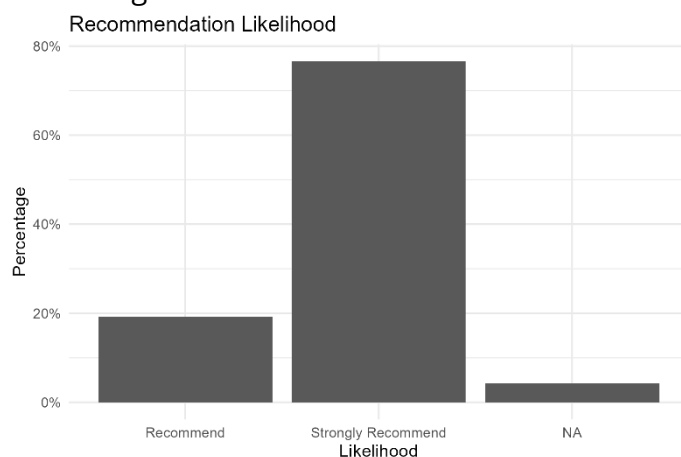


Figure 41 - Recommendation Rates

8. Gender-Specific Adoption Patterns

Women users dominated the customer base at 97.7% of total users, with 52% of female respondents rating the system as very easy to use. This gender disparity in adoption reflects both the composition of the market trader population and the system's successful adaptation to the needs of women fresh produce vendors in the informal retail sector.

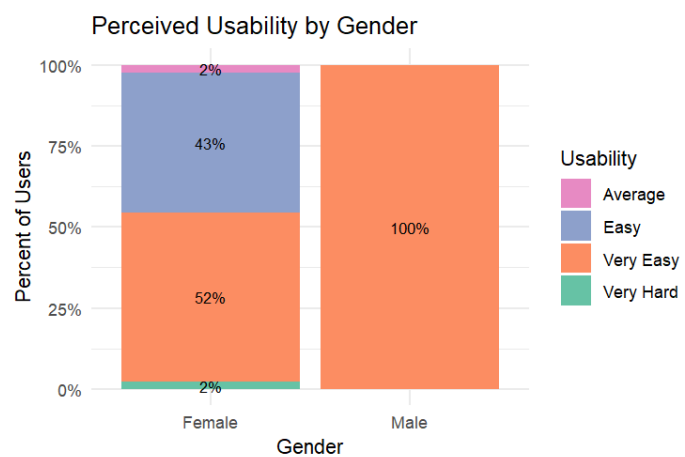


Figure 42 - Perceived Usability by Gender

4.4.7 Key Challenges and Learnings

- **Adoption Challenges with Cooling Technology** - Vendors often rely on low-cost, informal storage methods—such as leaving produce on stalls or covering it with tarpaulins. Transitioning to cold room-based storage introduces not only a technological learning curve but also a new cost structure. Many vendors focus on the upfront fees, overlooking the potential for increased earnings through reduced spoilage and improved produce quality.
- **Technical integration:** The mobile app integration has been problematic and delayed due to backend interface issues and difficulties in capturing real-time data, which is being done manually via an excel sheet currently.
- **Limited Local Support Capacity** - WeTu's ability to provide ongoing vendor support is constrained by limited local resources, making it difficult to maintain consistent engagement over time pertaining to technological awareness, produce handling, effect on ripeness due to storage in a cold room, among others.
- **Need for Comprehensive Evaluation Before Deployment** - Effective placement of cold rooms depends on a detailed analysis of food waste levels, seasonal variations in produce and pricing, farmer income impacts, and consumer willingness to pay. External factors like transportation infrastructure also play a critical role.
- **Low Utilization Despite Affordable Pricing** - Even with a flexible “price-per-crate-per-use” model tailored to vendor affordability, cold room usage remains below 40% of capacity. Operating margins are low, making the model commercially unsustainable without external financial support such as grants or concessional loans.
- **Segmented Pricing May Improve Viability** - A tiered pricing strategy based on produce type and associated income margins could be more effective than a flat-rate model, potentially improving utilization and financial sustainability. Based on this reflection, the Mbita cold room pricing strategy was revised. In addition, seasonal variations in produce categories might also support dynamic pricing based on continuous gathering of market intelligence.
- **Gradual Uptake Indicates Latent Demand** - Data shows a steady increase in crate usage over several months, suggesting that while demand exists, adoption is slow due to the time required for users to become familiar with the technology.
- **Secondary Markets Reduce Perceived Waste** - Damaged produce is often repurposed by restaurants and hotels, serving as a cost-effective ingredient source. This existing coping mechanism reduces visible food waste and weakens the perceived need for cold storage solutions.

4.4.8 Next Steps and Scaling Strategy

Building on the initial learnings from the construction and uptake of the Mbita cold room and cooling service, WeTu initiated a research and development project in collaboration with Self-Chill, Solar Cooling Engineering, Energy Saving Trust, local Kenyan architects, and Swiss architectural company JOM Architects to develop a low-carbon, solar-powered cold room. The project aimed to explore the possibilities of constructing a cold room using locally available materials to minimize greenhouse gas emissions and reduce installation costs, thereby improving the system's financial viability. The goal was to create an energy-efficient, high-quality cold room utilizing solar photovoltaic panels, thermal and battery storage, and natural, environmentally friendly materials for wall insulation.

Implemented in Homa Bay Municipal Market, the initiative has focused on designing and installing a low-carbon, cost-effective cooling solution with minimal environmental impact while enhancing financial viability by lowering the costs of cold room systems - a significant barrier to sustainability. Funded by the Siemens Cents4Sense initiative with support from Siemens Stiftung, the cold room integrates solar panels, battery storage, and natural insulation materials to offset emissions from active cooling. Its design features recycled eco-board walling, straw bale with eco-board insulation, and a roof-mounted solar panel system on timber brackets. A charcoal-based cooling system reduces heat in the technical room, improving equipment efficiency. Additionally, a Remote Monitoring and Control System provides real-time data on temperature, humidity, and equipment performance.

In April 2025, the second cold room, not directly supported by SESA, was launched in Homabay County, Kenya - building on the experiences of the first installation while establishing a viable business model for rural markets. The design employs innovative green building principles with low-carbon thermal insulation properties, significantly reducing the lifecycle greenhouse gas impacts of cold room operations.

In parallel to the cold room development, WeTu has expanded its ice production for fish storage, beginning with the Mbita location in 2022 and expanding to Muhuru Bay in 2024 with a 2-ton production ice plant. This expansion has contributed to the growth of WeTu's cooling business vertical. According to WeTu's 2024 impact report, the number of ice customers grew significantly from 68 in 2022 to a cumulative total of 2,767 by the end of 2024.³¹ Notably, in 2024 alone, WeTu sold 5,239 sacks of ice, amounting to 545 tons. Building on this success, WeTu is installing a 3-ton ice production machine in Usenge, with plans to launch operations before the end of 2025.

Currently, WeTu's strategy focuses on scaling the financially sustainable and proven ice production business model, demonstrated by growing revenue, users, and tonnage across the Mbita and Muhuru Bay sites. Simultaneously, the organization continues exploring alternative approaches to increase adoption and usage of walk-in cold rooms in rural and peri-urban markets.

³¹ <https://www.siemens-stiftung.org/wp-content/uploads/2025/06/publikation-wetu-impact-report-2024.pdf>

WeTu is currently focused on consolidating lessons from the Mbita and Homa Bay cold room pilots to develop a financially sustainable model before scaling further. Insights from user needs assessments, focus group discussions (FGDs), continuous feedback sessions, and acceptance surveys are being analysed to refine operations, pricing, and service offerings. The goal is to identify other alternative revenue stream such as serving wholesalers, out growers, transporters, or farmer group seeking to ensure operational sustainability and financial viability while maintaining accessibility for small-scale vendors, particularly women.

Key considerations include diversifying user segments beyond retail vendors, such as leasing space to market associations or specific produce categories, to improve occupancy rates and revenue stability. Financial data from the pilot phase is being closely examined to determine cost recovery thresholds and optimal pricing structures that balance affordability with operational sustainability. Testing different models, such as bulk storage contracts or seasonal subscriptions, will help establish the most practical approach for rural and peri-urban markets.

The immediate priority is to validate a sustainable business model for the existing two cold rooms before expanding further. By integrating technical performance data, user feedback, and financial insights, WeTu aims to create a replicable framework that ensures long-term viability while preserving the project's social impact goals. This phased approach allows for iterative improvements, ensuring that scaling decisions are grounded in evidence and aligned with market realities.

Additional next steps include:

1. **Strengthening User Engagement** - Efforts are underway to enhance engagement with users and vendors to boost interest and adoption of the cold room solution. The goal is to demonstrate its value through evidence of reduced post-harvest losses and increased income. To achieve this, additional co-creation sessions and user assessments are being organized to better understand specific needs and concerns related to cold storage. These will be complemented by sensitization activities aimed at increasing usage. These initiatives are planned for both Mbita and Homabay. Insights gained from Mbita are being actively applied in Homabay—for example, vendors from Homabay are being invited to visit the Mbita facility to interact with experienced users and learn firsthand about the benefits of cold room usage.
2. **Broadening the Customer Base from B2C to also B2B** - The initiative is broadening its customer base by engaging not only individual users (B2C) but also business clients (B2B), including supermarkets and wholesale produce vendors. This includes outreach to grower aggregators such as Stable Foods, who distribute fresh produce and have reported significant food waste at their facilities. The cold room solution is being positioned as a reliable option for consistent produce storage to help mitigate these losses. These efforts are being implemented at both the Mbita and Homabay facilities.
3. **Enhancing Data Diagnostics and Evidence-Base** - Efforts are being made to improve the quality and consistency of data collection, with a focus on increasing precision and

reducing reliance on manual processes. One potential step is the adoption of a digital application to streamline data entry and analysis, thereby minimizing human effort and improving reliability. Strengthened data systems will enable better pattern recognition and insights, which can inform business development strategies—particularly around optimizing pricing models for the cold room to make it more attractive and accessible to users.

4. **Dynamic Pricing Adjustment** - To better respond to seasonal trends, market fluctuations, and user feedback, pricing strategies for the cold room are being reviewed and adjusted. The aim is to ensure affordability and relevance for users while maintaining a sustainable payback period for operations. This approach complements ongoing efforts to strengthen data collection and analysis, enabling more informed pricing decisions that align with user behaviour and business development goals.

4.5 Kenya: Solar Irrigation Use Case

4.5.1 Introduction - problem and solution

Agriculture is the backbone of food security and rural livelihoods, yet farmers in many parts of the world face serious challenges in accessing reliable and affordable irrigation. This is also the case for the rural farming communities in Kenya, where the traditional irrigation methods are often dependent on rain or costly fossil-fuel-powered pumps. These methods are becoming more unreliable due to increasingly erratic rainfall patterns and rising fuel prices. At the same time, many farming communities are located in remote areas where access to grid electricity is limited or non-existent. The transportation of fuel to remote locations increases its price, making it unaffordable for the rural farming communities. Solar irrigation systems have immense potential to address this gap by providing a clean, renewable, and decentralised energy source to pump water for crops, helping farmers secure consistent production and improve resilience to climate change. Solar Irrigation can resolve several issues faced by farmers and rural farming communities in the Kenyan context. These include:

- High cost of conventional irrigation: Fossil-fuel-based pumps are expensive to operate and maintain, especially in rural areas where fuel and spare parts are difficult to access.
- Unreliable energy supply: Solar irrigation systems ensure independence from grid-related issues such as power outages or unavailability of fuel, etc.
- Environmental Impact: Solar irrigation systems can reduce this environmental footprint, which is usually higher in the fossil-fuel-based pumping systems.
- Regulate water usage: Solar irrigation systems allow for better control and efficient water use and reduce stress on groundwater resources. This can help in tackling under-irrigation and over-irrigation issues.
- Income and productivity constraints: Solar-powered systems support multiple growing cycles, thereby improving income stability and food availability to overcome reduced yields and not restrict farmers to one cropping season.

Solar irrigation systems are better alternatives compared to other available products and solutions, as they stand out for their economic, environmental, and social advantages:

- Cost-effective in the long term: While upfront investment can be high, solar irrigation systems have low operating costs and long lifespans, making them cheaper over time than diesel or electricity-dependent pumps.
- Scalable and modular: Solar irrigation systems can be designed for smallholder farmers or scaled up for larger farms and community-based farming setups.
- Environmentally sustainable: By harnessing renewable energy, solar irrigation aligns with climate change mitigation efforts and sustainable agricultural development goals.
- Empowering rural communities: Solar irrigation provides energy independence, reduces farmers' reliance on fluctuating fuel markets, and enhances resilience against climate-induced risks, including unpredictable rainfall patterns.
- Technological advancements: Innovations such as smart pumping systems, hybrid models, and financing solutions (pay-as-you-go, leasing, subsidies) are making solar irrigation increasingly accessible and attractive compared to conventional methods.

Current status of solar irrigation implementation

Kenya's Vision 2030³² and the Big 4 Agenda³³ emphasize irrigation as a critical strategy for drought mitigation, aims to expand irrigated land to over 1.3 million hectares, and to place 100,000 acres under irrigation annually. The National Water Master Plan 2030 targets an expansion to 803,000 hectares, with solar irrigation. Tax waivers on solar pumps and county-level funding initiatives are supporting adoption. National Irrigation Sector Investment Plan (NISIP): Prioritizes decentralized solar irrigation as part of Kenya's Vision 2030 and climate resilience strategies. Kenya's solar irrigation programmes and projects include Kenya Productive Use of Renewable Energy (PURE) Program, supported by the State Department for Renewable Energy and IKEA Foundation, Kenya Water Security and Climate Resilience Project (KWSCR) and the 'Solar Irrigation for Smallholder Farmers' project by Climate Impact Partners. Companies like Futurepump and SunCulture, have own branded products supplying low-cost systems for small holder farmers, supported by REEEP, offering a full-spectrum solution including solar pumps, drip irrigation, agronomic support, and financing, resulting in yield improvements of over 300%³⁴. Dalberg Advisors and Mercy Corps AgriFin conducted a study³⁵ identifying barriers to adoption and proposed smart subsidies and microfinance partnerships. Their projections suggest that 1.7 million farmers could increase daily income by 177% over the next decade. Efficiency for Access and Dalberg also launched a pilot program to train rural youth for employment in the solar irrigation sector, expected to create 7,000 to 10,000 jobs by 2027³⁶.

Common Business models for solar irrigation in Kenya and other African countries

There are various solar irrigation systems that have been previously deployed and continue to be deployed in the several African countries. The report on GGGI technical report of Solar-Powered Irrigation Systems (SPIS)³⁷ showcases the potential of these systems in the African context. Several business models have been discussed that can be used for developing the business around solar irrigation systems. These business models aim to provide affordability, financing and accessibility and solve related challenges to promote sustainable adoption of solar irrigation systems. Some of these business models are discussed below:

- Leasing from suppliers: In this model, the companies supply solar irrigation systems to contracted farmers and technical support for operation & maintenance of the systems is provided. Farmers use flexible payment mechanisms such as harvest payments or regular lump-sum payments to pay for the irrigation systems.
- Group financing models: This model allows farmers to access financing from multiple sources, such as the initial capex contributions, state subsidies, agricultural aid funds, support funds for women's income-generating activities, etc., which may reduce loan amounts and repayment burdens.
- Partnership-based business model: In this model, stakeholders such as the farmers, technology suppliers, produce buyers, financial institutions, etc., align to

³² <https://vision2030.go.ke/>

³³ <https://big4.delivery.go.ke/>

³⁴ [Solar-Powered Irrigation in Kenya: SunCulture | REEEP](#)

³⁵ [AgriFin-Solar-Irrigation-Report-Full-Length.pdf](#)

³⁶ [Unlocking Green Jobs for Rural Youth in Solar Irrigation - CLASP](#)

³⁷ chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://gggi.org/wp-content/uploads/2024/10/Version-3_24404_GGGI_TechReport_v03_RC.pdf

collaborate on common business interests. Farmers gain access to irrigation technologies, suppliers can access new markets, buyers receive produce supplies, and financial institutions might reduce their monetary risks.

- Developer-centred model: In this model, companies set up the solar plants and provide solar irrigation services. In this, farmers may lease land to solar companies and adopt solar power as a remunerative crop.

4.5.2 About the Use Case and Set-up

The solar irrigation use case in Kisegi is intended to demonstrate how robust, clean energy technology can transform smallholder farming in rural settings. The current use case setup features an 800W solar-powered irrigation pump, supported by solar panels or a lithium-ion battery system, engineered to provide farmers with a more reliable and sustainable alternative to expensive fossil fuel powered diesel and petrol pumps. WeTu's solution seeks to directly addresses key challenges identified in earlier robust test phases and pilots specifically, mechanical fragility and a lack of maintenance support from irrigation pump suppliers by prioritizing durability and remote serviceability with an efficient leasing service and approach. This approach seeks to empower smallholder farmers to:

- Increase agricultural productivity through dependable, year-round irrigation,
- Reduce operational costs and uncertainty by eliminating fuel dependency and minimizing downtime, and
- Adopt climate-resilient farming practices powered by clean affordable renewable energy.

The integration of a swappable system that features both solar panels and/or with battery storage ensures energy access is consistent, making farming in Kisegi more productive, profitable, and sustainable.

Figure 43: Ennos 2.0 HP pump with lithium ion battery pack during pilot test phase



About the Solar Irrigation Technology and Features

WeTu's current solar irrigation leasing model represents a significant evolution from earlier trial test pilots, integrating a complete, mobile, and intelligently managed system designed for the realities of smallholder farming. The core of this solution is the Impact SolarPlex 800 pump, procured through a partnership with the local solutions provider Drop Access and supported directly by the manufacturer, Impact Pumps. This collaboration ensures access to quality technology as well as local technical support and troubleshooting support to minimize downtime and ensure capacity building of WeTu staff to be able to troubleshoot and resolve issues as they arise.

The system is mounted on a robust two-wheeled cart, creating a portable irrigation unit on wheels trolley cart. This mobility seeks to allow farmers to easily transport the pump, battery, and accompanying hardware between distant water sources and their fields, directly addressing the challenge of rugged terrain and long distances that rendered previous pumps ineffective.

This integrated solution was selected specifically to overcome the technical setbacks of earlier models, prioritizing ruggedness, operational clarity, and long-term serviceability.

Some of the key features that seek to address past challenges include:

- **Integrated Remote Monitoring & PAYG Platform:** The system is managed via a cloud-based platform that provides WeTu with pump payment control, real-time data on pump performance, energy usage, and system health. This enables proactive maintenance and remote diagnostics, preventing the kind of unexpected and catastrophic failures that halted operations with previous models. The integrated remote monitoring and payment technology facilitates real time payment options for farmers while creating a sustainable revenue model for ongoing service and support.
- **Rugged, Service-Oriented Design:** The pump is explicitly engineered for durability in harsh farm conditions. Critically, the partnership model with Drop Access and Impact Pumps is designed to build a local inventory of critical spare parts and develop local technician skills, directly solving the previous show-stopping issue of parts unavailability and lengthy repair times.
- **Optimized and Simplified Energy System:** The system features a clearly defined and compatible configuration of solar panels and batteries, eliminating the downtime, system lags and compatibility issues that caused performance drops during cloudy weather in earlier trials. This ensures reliable operation and maximizes water delivery per unit of solar energy.

Some of the specifications of the pump are shown in the table below and in Figure 47 Technical data sheet: Solar irrigation pump at the end of the chapter. (technical data sheet attached, <https://www.impactpumps.com/solarplex/the-solarplex-range/solarplex-800/>).

Figure 44: Solar Irrigation Pump (Impact SolarPlex 800)



Strategic Shift to the Impact Pump

The test phase from December 2023 to September 2024 revealed critical failures in the previously selected Ennos 2.0HP pump, which was selected after testing multiple pumps that included the Delan 48 surface pump, the Delan 3DPC3 submersible pump, the Delan DCPM50 surface pump, and the Ennos 0.5HP surface pump. The Ennos pump, while initially powerful, suffered from two fundamental flaws namely component fragility and a lack of local serviceability and support despite claims to the same. The pump's controller was prone to catastrophic failure, despite being a key expensive component this could not be repaired locally, support from supplier was slow and not possible to source quickly. This led to operational downtime from September 2024 until July 2025 when a new pump (Impact Pump) was introduced as the technology of choice after testing in Homabay. Furthermore, the brand's lack of a local spare parts ecosystem meant every breakdown became a major logistical and financial problem, eroding farmer trust in the solution.

These experiences underscored that a high-flow pump is not sufficient if it is not robust and supported by the solution provider. WeTu's model requires a technologically advanced yet fundamentally durable solution that can withstand rugged farm conditions and be supported by a local maintenance network. This is why the model is now deploying the Impact Pump.

The Impact Pump represents a strategic pivot towards reliability through simplicity and data-driven management. Unlike the previous pump and system, it has an integrated remote monitoring platform which provides WeTu with a payment management platform, real-time data on pump performance, energy usage, and potential issues, enabling proactive maintenance and minimizing sudden frequent failures.

4.5.3 User Needs Assessment and Market Assessment

The Influence of the User Needs Assessment on Implementation Strategy

Within the SESA project's framework, the User Needs Assessment (UNA), conducted from 22nd September to 6th October 2022, served as a first step to embed user-centricity into the core the solar irrigation use case. Recognizing that technological innovation alone cannot guarantee adoption, WeTu and the SESA partner the Stockholm Environment Institute (SEI) conducted a comprehensive assessment during this period to ground the use case in the empirical realities of the end user. This commitment to a co-creation approach ensured that the resulting solution was not designed in isolation only from technically field tests but was shaped by and for the smallholder farmers, aligning technological capability with tangible user needs and socio-economic realities.

The UNA's most profound influence was the validation and refinement of WeTu's Energy-as-a-Service (EaaS) business model and approach. The discovery that a full 50% of the farmer population already preferred renting pumps over owning them provided critical, data-driven confidence to proceed with the leasing model approach. This insight justified the strategic decision to structure the pilot around a pay-per-use system, where farmers pay only for the energy consumed during an irrigation session. Consequently, the implementation was designed to eliminate the barrier of high upfront capital cost, which was identified as the primary obstacle to adoption of solar powered irrigation technology. The UNA's quantification of existing irrigation expenses directly informed the initial pricing strategy. This and subsequent Focus Group Discussions (FGDs) with the farmers and farmer groups allowed the WeTu team to set a competitive and compelling leasing fee of KES 500, a price point designed to offer immediate and obvious economic relief to potential users, thereby accelerating market uptake.

Furthermore, the UNA's findings on technology preferences dictated a pragmatic and flexible approach to hardware procurement. The expressed farmer preference for higher capacity pumps in the range of 5 to 10 HP, tempered by an acute sensitivity to cost, led WeTu to test a portfolio of pump sizes rather than a single model. This understanding led to the pilot's strategy of deploying different solar irrigation pump capacities, such as 0.5HP and 2.0HP units, to assess which best delivered the balance of performance, reliability, and value that the UNA identified as the key to user acceptance. This avoided the critical pitfall of deploying a one size fits all solution that would have failed to meet the varied needs of the user base.



Figure 45: WeTu Team and Farmers during Co-Creation Session

Finally, the assessment's focus on high-value, perishable crops like tomatoes and kale sharpened the pilot's value proposition and messaging. Implementation activities, including farmer training and awareness campaigns, were tailored to highlight how solar irrigation directly improves agricultural productivity, improves yields and has the potential of improving income for the farmers. This ensured that communication resonated deeply with the immediate economic concerns and aspirations of the farmers, as captured by the UNA.

Price and Willingness to Pay

The household incomes of small holder farmers in Kisegi who are the primary users for the irrigation use case as reflected in the User Needs Assessment conducted between 22nd September to 6th October 2022, are modest yet consistent with the broader economic context of rural Homabay County. With a mean daily income of approximately KES 737, households operate within constrained financial means, where expenditures are heavily prioritized toward essential needs such as food and education. Monthly spending on water is negligible with less than KES 250 as most residents rely on free surface water sources like streams and Lake Victoria. This limited disposable income underscores the importance of affordability in any introduced solution. The pricing of WeTu's irrigation leasing service is therefore aligned with these economic realities, to ensure that the cost does not impose a prohibitive burden on household budgets.

Despite these financial constraints, there is a strong willingness among farmers to pay for solar irrigation solutions, provided the pricing is perceived as fair and competitive relative to existing fuel powered alternatives. Currently, farmers incur significant costs renting fuel powered pumps with approximately KES 1,300 spent per irrigation session, on fuel, pump rental, and additional associated maintenance in the event of pump breakdown. During the focus group discussions (FGDs) conducted on the 17th of September 2024, farmers expressed unanimous agreement to a standard price of KES 500 per session for the solar irrigation leasing fee if it involves familiar flood irrigation methods. They also indicated a readiness to pay more for advanced and efficient systems like drip or sprinkler irrigation, especially if these are bundled with supporting infrastructure such as water tanks and pipelines. This willingness reflects a clear recognition of the limitations of current practices and a desire for more reliable and cost-effective irrigation options.

The WeTu solar irrigation leasing approach is well-positioned to address the core needs and challenges faced by farmers in Kisegi. The high operational costs, unreliable performance, and limited reach of fuel pumps especially for farmers located more than 100 meters from water sources have severely constrained agricultural productivity and profitability. By offering a solar powered alternative, WeTu can significantly reduce the variable costs of irrigation, enhance reliability, and extend services to previously underserved farmers. Moreover, the proposed leasing business model aligns closely with local preferences and existing practices, as most farmers are already accustomed to renting rather than owning equipment. The integration of efficient irrigation methods like drip systems could further reduce water and labour requirements, addressing both economic and agronomic challenges.

Cost

Initial pricing for farmers: 500 KES per irrigation session

Retail listing price Solar Plex SPX-800-5 800 W DC Pump: 126.000 - 140.000 KES³⁸

4.5.4 Business Model Features of Solar Irrigation Use Case

WeTu's solar irrigation leasing business model using the energy-as-a-service approach, seeks to enable farmers to pay only for the energy consumed to pump water, rather than investing in costly infrastructure. Through a pump-leasing system, smallholder farmers gain access to affordable irrigation by renting pumps for specific periods each day, removing the barrier of high upfront capital costs. This model offers several key benefits:

- Affordability and accessibility: Farmers in the region may no longer face the financial burden of purchasing pumps, making irrigation accessible to even the most resource-constrained households.
- Sustainable resource use: By optimising water pumping schedules and usage, the model helps conserve already scarce water resources, promoting responsible and efficient irrigation practices.
- Enhanced agricultural productivity: Reliable and affordable irrigation empowers farmers to cultivate more crops year-round, increasing yields, improving household food security, and opening opportunities for higher income.
- Climate-resilient farming: As rainfall patterns become less predictable, solar irrigation provides a dependable and renewable energy source, strengthening farmers' resilience to climate change while reducing reliance on fossil fuels.

The following figure provide a summary of the features of the business model using the canvas and provide a qualitative description of the core value proposition, the end-user segments, and relationships, along with the type/nature of costs expected.

Business Model Canvas

³⁸ [SolarPlex SPX-800-5 800W DC Pump – Davis & Shirtliff](#)

Table 17 - Business model canvas

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segments
- Solar Irrigation pumping solution providers - Community members	- Calculating the area of farm to be irrigated - Setup up the solar irrigation system from the water source to farm - Measure the energy used for pumping and payment calculations	- Providing access to energy and water for irrigation in remote rural areas - Cost-competitive solution as compared to diesel-powered irrigation systems - Affordable service with no obligation to purchase the solution - Improved agricultural productivity	- local farmer associations - Farmer unions workshops - target groups trainings & capacity building - awareness creation activities on solar irrigation & sustainable irrigation practices	- Smallholder farmers - Farming groups and associations
	Key Resources		Channels	
	- Water resources for irrigation - Solar irrigation setup - Personnel (sales, marketing, finance, etc.) - Technicians for day-to-day operations, maintenance & repairs		- Awareness creation through word-of-mouth campaigns locally - In-person sales and feedback sessions	
Cost Structure			Revenue Streams	
- Cost for purchasing solar pumps - Operating expenses for the transportation of pumps from one farm to another - Costs for the maintenance of the pumps			Energy-as-a-service: revenues from the usage of pumps by farmers (500 KES per pumping session)	

4.5.5 Experiences and Insights from the Operational Phase

In the following are some of the key experiences and insights gained during the testing and pilot phase:

The solar irrigation pump performance benchmark is set by fossil fuel powered pumps

Farmers' acceptance of the technology was contingent on the solar pump matching the performance of the familiar 2.0HP petrol or diesel pumps. Initial pump models that were tested like the Delan 48 and Ennos 0.5HP were immediately deemed inadequate and labelled as inferior by farmers. Their significantly lower flow rates required farmers to spend over four hours to irrigate a small plot which was a task a fuel pump could complete in three hours with much greater water volumes and consistency without factoring irradiation. This performance gap made the early technology technically unsuitable and economically unviable for farmers, for whom time is a critical resource.

Technical Specifications are of low value without local service support

The most catastrophic failure was not with the low-capacity pump but with the high-powered Ennos 2.0HP model. While it initially met the hydraulic water demands, its sophisticated components specifically the pump controller were fragile and impossible to repair locally. When this failed, the total absence of a local spare parts availability and slow supplier support resulted in extended operational downtime from September 2024 to July 2025. This experience was a pivotal lesson which highlighted that a pump's value is negated if it lacks a robust local support system. Reliability is defined not by initial performance but by the ability to be quickly repaired in the field.

Technology must be bundled with application methods

A fundamental disconnect was identified between the technology deployed and the dominant prevailing farming practice. Most farmers engaging in irrigation largely practice flood irrigation, which is both highly water and energy intensive. Deploying solar powered pumps which are inherently most efficient with a steady, moderate flow for this purpose magnified their perceived weakness. The key insight is that solar irrigation cannot be deployed as a standalone fuel pump replacement. Its success depends on an integrated approach that either bundles the solution with a high flow pump capable of meeting flood irrigation demands or, more sustainably, bundles it with water efficient additional technologies like drip or sprinkler kits, which are a better suited for solar irrigation pumps output profile.



Figure 46: Farmer Using Solar Pump for Flood Irrigation

The success of the service model is dependent on technology reliability

With UNA and FGDs confirmed a strong farmer willingness to pay a standard fee of KES 500 per session, as it eliminates prohibitive upfront costs and mirrors their existing rental practices for fuel pumps. However, the pilot also proved that the financial sustainability of this model is highly dependent to technology uptime. This is as revenues inflows ceased entirely during pump downtimes, making the business model acutely vulnerable to the technical failures experienced. The solar irrigation use case and leasing approach cannot be scaled without a supremely reliable asset and accompanying technology.

User-Centric Co-Creation is Non-Negotiable

The early involvement of farmers through the UNA and FGDs was confirmed as the single most valuable process. Their input directly shaped the pump selection, testing phase, leasing fee, the decision to test multiple pump sizes, and the understanding that they are purchasing energy as a service not a piece of hardware. The testing and pilot operational phase underscored that farmers are the ultimate experts on their own needs and constraints, and continuous engagement and user co creation of the solution are essential for designing a solution that is not only easily adopted but also valued and sustained.

4.5.6 Challenges, Learnings and Next Steps

In the following are some of the key experiences and insights gained during the testing and pilot phase:

Challenges

Technical Performance and Reliability Gaps

One big challenge was the significant technical performance disparity between the tested and piloted solar powered pumps and the established fuel-powered benchmark. Farmers, accustomed to the raw power of 2.0HP petrol pumps capable of delivering 90,000 litres in a single three-hour session, found the different solar alternatives lacking in efficiency and time consuming. Initially piloted models like the Delan 48 and Ennos 0.5HP were consistently described as poor due to their inferior flow rates. Due to this

initial performance gap, the first group of pilot farmers had to spend excessively long hours to collect only a small volume of water for irrigation. This inefficiency, especially when compared to traditional fuel-powered pumps, led to significant apprehension, low adoption rates, and even user drop-off. This increased the likelihood of further technology rejection in the initial stages.

Conversely, high-capacity pumps like the Ennos 2.0HP proved unreliable, suffering from frequent breakdowns and a lack of locally available spare parts. A critical design flaw was most pumps incompatibility with battery storage, which was essential for the mobile, on demand service model. This made most of the pumps incompatible and unable to operate outside of direct sunlight irradiation hours with, severely limiting their usefulness and reliability from the farmer's perspective.

Financial Stability of the Leasing Model

WeTu's primary approach of a leasing model, was strategically chosen to overcome the high initial investment that is a barrier for smallholder farmers. However, this model introduced a financial challenge strike balance between farmer affordability and the WeTu's own cost recovery and long-term operational sustainability.

The lease fee had to be set at a level accessible to low-income farmers, yet simultaneously be sufficient to recoup the substantial upfront capital outlay and cover all ongoing operational costs within a viable payback period. Therefore, the selection of highly reliable technology and a resilient pricing structure was paramount, as any significant operational downtime or disruption in farmer payments. directly threatened the model's path to financial self-sufficiency.

Inconsistent Farmer Land Sizes and Pricing Complexity

The service model was complicated by the vast range in farmer plot sizes, making a single flat fee unfair. WeTu had to choose a usage-based pricing metric, but each option had major drawbacks. Charging by energy (kWh) was technically accurate but hard for farmers to understand. Charging by time was simpler but felt unfair if flow rates changed. Charging by water volume was aligned with the value farmers received but required complex and costly metering equipment. Finding a model that was both administratively simple and perceived as fair was a significant challenge.

Intermittent energy supply and operational planning

The pilot highlighted the vulnerability of solar technology to meteorological conditions. The performance of photovoltaic panels diminishes significantly during cloudy weather, leading to reduced water output and creating water pumping and scheduling uncertainties. This reliance on optimal sunshine and irradiance stood in sharp contrast to the dependable, on-demand operation of fuel pumps, presenting a significant perceptual and operational barrier to adoption for farmers who need guaranteed access to water on demand and during optimal peak irrigation hours.

Absence of Localized Maintenance and Repair Capacity

Critical failures were experienced especially with regards to appliance suitability and the surrounding support ecosystem of the same. The most challenging and severe in this regard was the complete absence of a local maintenance network and spare parts inventory for all the initial pumps piloted and tested. When sophisticated components like the pump controller on the Ennos 2.0HP unit failed, they were not only costly to replace as they were to be imported from Europe but also impossible to source or repair locally. This resulted in prolonged use case downtime, severely undermining farmer confidence and creating apathy on the technology with the users.

Misalignment with prevalent agricultural practices

A clear disconnect emerged between the technology tested and piloted and the prevalent irrigation methods. The region's farmers predominantly use flood irrigation, a highly energy and water intensive practice. Deploying medium and low flow solar pumps for the purpose of irrigation magnified the time burden of irrigation on the farmers and significant energy consumption of both the panels and battery pack. This was compounded by the lack of an integrated approach that seeks to provide sufficient hydraulic power for conventional flood irrigation methods or, coupling the pumps with water-efficient technologies like drip irrigation that are better suited to the solar pump's output profile.

Underdeveloped Value Proposition and Service Tiering

From a business model perspective, the high upfront capital cost of a complete solar system presents a prohibitive barrier to ownership for most smallholders. While a rental or lease-to-own model is strongly preferred by farmers, the business model needs to be refined into a clear, tiered, and tested pricing structure to cater to the diverse needs of the different farmers. Farmers have expressed a need for equity and fair pricing indicating that the service cost must be further iterated against their current per-session expenditure on fuel, pump rentals, and equipment for the solar pumps to be deemed a practical, viable and attractive alternative.

Learnings

Reliability Defines Adoption

The tests and pilot confirmed that the most important factor determining farmer adoption of solar irrigation is reliability. Farmers consistently benchmarked the solar pumps against the familiar performance of 2.0HP petrol or diesel pumps that they are familiar with. Early models such as the Delan 48 and Ennos 0.5HP were quickly rejected because of their low flow rates and extended irrigation times, which made them economically and practically unsustainable. Even the higher-capacity Ennos 2.0HP pump, while initially meeting flow expectations, failed catastrophically due to fragile components and lack of service support. These experiences underline that for smallholder farmers, reliability is not defined by technical specification sheets and laboratory specifications but by sustained field performance under real operating conditions. Only solutions that deliver consistent uptime and dependable water flow can achieve lasting adoption.

Local Service and Spare Parts are Non-Negotiable

Another important lesson was that technical strength alone does not guarantee success of the use case. The absence of local spare parts and real time repair options proved more damaging than the technical weaknesses of any pump. When the Ennos 2.0HP controller failed, the lack of local repair capacity resulted in nearly a year of downtime, eroding trust in both the technology and the business model. Farmers have equated service interruptions with unreliability, regardless of the pump's potential. A locally available maintenance and spare parts system is therefore of vital importance. Reliability, from the farmer's perspective, is more than just strong initial performance but the assurance that breakdowns and downtime can be resolved quickly and affordably within their community.

Technology Must Match Application Methods

The tests and pilots revealed a critical disconnect between solar pump design and prevailing irrigation practices. Most farmers in Homabay and Kisegi rely on flood irrigation, a method that is highly water and energy intensive. Solar pumps, which perform best with steady, moderate flows, were perceived as weak when applied to flood irrigation. This mismatch reinforced the perception of inferiority and limited farmer adoption and subsequently satisfaction. Thus, it is critical to understand that use case appliances and technology cannot be introduced in isolation and must align with how farmers actually irrigate. Bundling pumps with water efficient methods such as drip and sprinkler systems is essential, both to improve the technical match and to reduce the time, labor and energy burden on farmers. Without it, solar irrigation will appear less effective than fossil fuel alternatives.

Business Model Success Depends on Technology Uptime

Despite the leasing model and approach being well received as it removed prohibitive upfront costs and mirrored existing rental practices for fuel pumps. The financial viability of the model is entirely dependent on continuous consistent technology uptime. Every period of pump downtime translates directly into lost revenues for WeTu undermining both cost recovery and farmer confidence in the model and technology. This interdependence between technology reliability and financial sustainability highlights a core insight that a service-based model cannot succeed unless the technology itself is robust, has local available support, and is consistently available. Any technical fragility risks collapsing the entire business model.

Co-Creation with Farmers is Essential

The User Needs Assessment and subsequent focus group discussions proved to be invaluable. Farmers' perspectives and insights directly influenced the choice of pump sizes, the decision to test multiple models, and the establishment of a leasing fee that reflected their willingness and ability to pay. This co creation approach confirmed that farmers are not passive recipients of technology but the most knowledgeable experts on their own challenges and constraints. User co-creation is therefore not a supplementary activity but the foundation of successful implementation. Without continuous farmer and user engagement, the risk of misaligned solutions and low uptake is high. With co-creation, solutions become user driven, trusted, and better adapted to real needs.

Integrated Systems Outperform Standalone Pumps

A further lesson was that value lies not in individual components but in the integration of a complete system. Pumps alone, no matter how well designed, are insufficient if they are not paired with the right energy source, mobility features, and irrigation application methods. Farmers value solutions that are mobile, rugged, and easy to use in varied field conditions. The concept of a trolley-based system for the Impact pump with integrated battery and panel storage and accompanying pipes and sprinkler illustrates how a full ecosystem approach responds better to real-world conditions than fragmented components. This shift in approach and model from only leasing a pump to delivering an integrated irrigation service has emerged as a crucial insight.

Iteration and Improvement are Continuous

Finally, the technical tests and pilots underscored that technology deployment is not a one-off event but a long-term process of iteration and improvement. The Ennos pump failure, while costly, was also instructive in steering the business model and approach toward the more reliable Impact Pump. Each pilot phase iteration has generated critical learning that informed refinements in technology selection, business modelling, and farmer engagement. These cycles of testing, failure, adjustment, and re-deployment must be embraced as part of the business model and use case development journey. The pilot demonstrated that adaptability, continuous iteration, co creation, patience, and sustained supplier partnerships are necessary for building business models and use cases that are sustainable and can ultimately scale.

Next Steps

Structured Validation of the Impact Pump

The next phase for WeTu is the formal, structured pilot implementation of the Impact Pump. This pilot will involve a representative cohort of farmers from Kisegi and be designed to capture real-world data on reliability, flow rates, energy efficiency, and user satisfaction. Close collaboration with the manufacturer Impact pump and distributor Drop Access will ensure that performance feedback directly informs product improvements. This structured validation will provide the evidence base required to confirm whether the Impact Pump can deliver the reliability and consistency needed for scale.

Develop Integrated Mobile Field Units

Building on farmer demand for portability and ease of use, WeTu has developed a rugged irrigation trolley that combines the pump, battery, irrigation kit and panels into a single, mobile unit. This integration seeks to reduce set-up time, improve mobility across uneven rugged terrain, and enhance overall user experience. This approach ensures that farmers are offered a complete and practical solution rather than a fragmented set of components.

Build a Local Service and Maintenance Network

To sustain farmer trust and minimize downtime, WeTu is exploring options of establishing a localized maintenance ecosystem. This includes training of hub staff and

building spare parts inventories and partnering with nearby workshops or service technicians. Local service capability will not only ensure rapid response to breakdowns but also signals long-term commitment to farmers, thereby strengthening uptake and loyalty.

Pilot Tiered Pricing Models

Pricing remains a delicate balance between affordability for farmers and sustainability for WeTu. The next phase seeks therefore to test tiered pricing models which are co-created with the farmers. Options could be based on session length, energy consumption, or water volumes, ensuring that diverse farm sizes and income levels are fairly accommodated. By piloting these models transparently with farmer groups, WeTu will refine a pricing structure that is both equitable and financially viable.

Introduce Water-Efficient Irrigation Kits

To address the mismatch between solar pump output and flood irrigation practices, WeTu has introduced a bundled sprinkler irrigation kit alongside the pump. Further to this WeTu will look to develop a demonstration plot that can showcase the labor, water, and energy savings these systems deliver, creating both practical and aspirational value for farmers. WeTu envisions that over time, bundling pumps with efficient irrigation technologies will transform solar irrigation into a premium, higher-value service tier.

Strengthen Continuous Farmer Engagement

Finally, WeTu is looking to institutionalize co-creation as an ongoing process. This means maintaining regular farmer engagement through focus groups, training sessions, and joint evaluations of the business model and technologies. The small holder farmer voices will continue to shape technology adaptation, pricing adjustments, and service design. Continuous engagement will ensure the business model and use case appliances evolve with farmer needs, build trust, and secure a pathway to long-term adoption and scale.

Figure 47 Technical data sheet: Solar irrigation pump



SOLARPLEX SPX-800-5

The SolarPlex SPX-800-5 is a solar powered horizontal multistage centrifugal water pump which can operate with solar PV panel configurations rated anywhere from 100W-800W, straight from the box. This allows head and flow to increase simply by adding more PV panels. Advanced MPPT software and electronics, combined with low-light operability means more water per day at a lower cost.

SOLUTION OVERVIEW

Flow Rate	max. 5.4m ³ /h
Head	max. 75 m
Power Range	100W to 800W / ½hp to 1hp

DIMENSIONS AND WEIGHTS

Length	380mm
Height	250mm
Width	140mm
Weight	9kg
Thread size	1"
Hose size	1¼"
Box dimensions	430 x 200 x 260mm
Total shipping weight	12kg



BENEFITS

- More water per day at a range of heads
- Reliable design
- 2 year warranty
- No fuel required
- Easily user maintained

KEY FEATURES

- Direct PV connection and pump operation from integrated controller (no separate controller)
- Integrated high efficiency MPPT (incremental conductance Maximum Power Point Tracking)
- Automatic protection from overload, overtemperature, reverse polarity & locked rotor (i.e. impedance protected)
- Continuous duty pump with a fan-cooled motor and temperature sensor integrated into motor windings
- Maintenance-free brushless DC (BLDC) motor, NSK bearings, and unlimited lifetime metal-film capacitors for voltage regulation
- Power limiter control mode allows users to set maximum flow rate to prevent dry running
- Switch control inputs for dry run protection and tank overflow

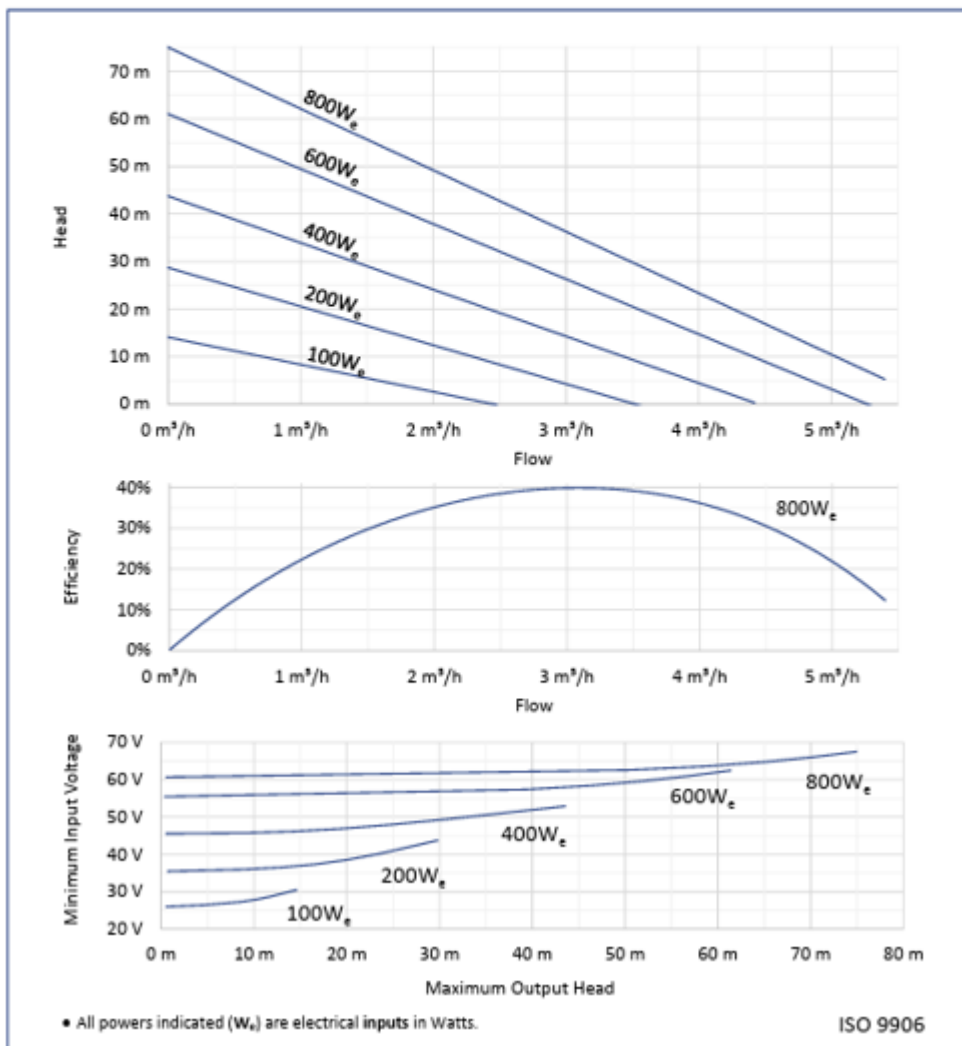
Source: www.impactpumps.com

TECHNICAL DATA

Efficiency	max. 40%	Insulation Class	F
Max Input Voltage (Voc)	105 VDC	Water Temperature	0°C - 50°C
Min Input Voltage (Vmp)	See chart below	Ambient Temperature	max. 50°C
Motor Current	max. 14 A	Premium Materials	Stainless steel AISI 304
Enclosure Class	IP56	Impeller Stages	5

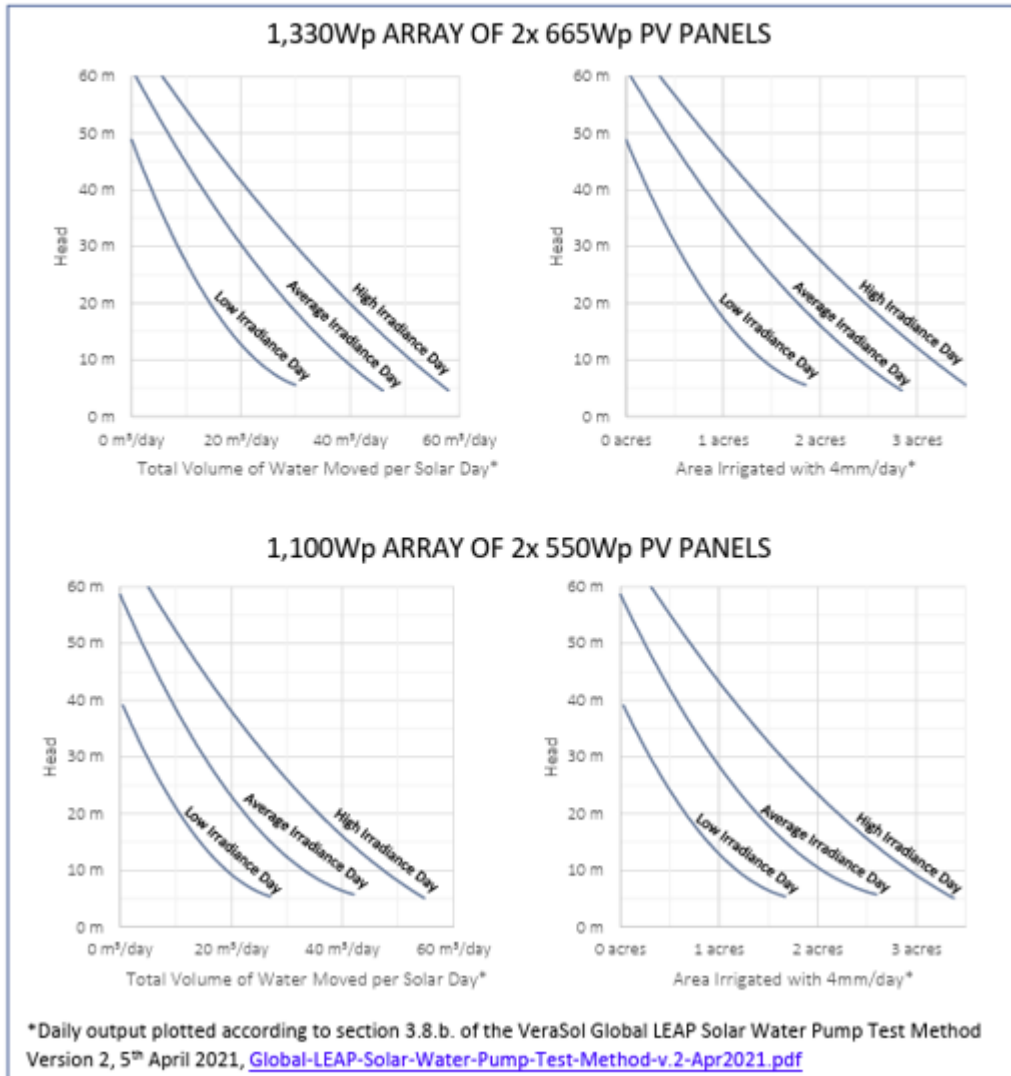
• 2 PV panels connected in series are generally required for heads over 20m and/or power levels over 200W.

PERFORMANCE CHARTS



Source : www.impactpumps.com

DAILY OUTPUT CHARTS



Source : www.impactpumps.com

5 Morocco

In Morocco, the transport sector consumes 38% of the country's energy mix and represents the second largest CO₂ emitting sector in the national market. Ministry of Energy, Mines and Sustainable Development, adopted a National Strategy for Sustainable Development by 2030 including a national goal to reduce transport energy consumption by 35% in 2030. Furthermore, despite Morocco impressive achievements in securing energy access to 99.8% of its population there are still poor rural households that do not have access to electricity. The needs of these remaining households will be met through decentralized solar PV installation.

5.1 Introduction to the use case

E-mobility

Conventional gasoline fuelled scooters and motorcycles are widely used in Marrakesh City where it contributes to huge pollution of the atmosphere. With a fleet exceeding 300,000 gasoline-powered motorcycles, this mode of transport occupies a large part of road traffic in Marrakesh. The original objective of this demonstration was to provide electric motorcycles for female students from around Marrakesh who is living in the students' accommodation halls called Dar Ettalliba supported by the local NGO Association pour la Scolarisation de la Jeune Fille Rurals. The main objectives were to introduce electrical mobility as an alternative to ICE motorcycles, with a focus on female users (as females are highly represented among motorcycle drivers in Marrakech), to support the pursuit of higher education of these students while reducing pollution in Marrakesh. The customer segment of female students was briefly tested in cooperation with the NGO Association pour la Scolarisation de la Jeune Fille Rurals (engl.: Association for school rural female students) in the city of Marrakech, which provides female university students coming from poor rural and isolated areas with accommodation, food, etc.). As living lab implementation partner, the private company POGO was chosen for providing business concepts to support the sustainability of the demonstration. Over time the focus of the demonstration shifted from the customer segment of female students to a broader customer segment consisting of young people who do not own a motorcycle in the age range of 18-40 to ensure viability of the business model.

5.2 About the implementing partners

Green Energy Park (GEP) (SESA consortium partner)

GEP is a solar energy test, research and training centre located in the green city of BenGuerir. It was developed by the Institute for Research in Solar Energy and New Energies (IRESEN) with the support of the Ministry of Energy, Mines, Water and the Environment as well as the OCP Group.

POGO

For the Moroccan Urban Living Lab, the SESA partner Green Energy Park (GEP) had selected through a tender round in 2022 a local venture (Moroccan enterprise) named

POGO to support the implementation of the urban living lab by taking over the testing and validation of the business model component. POGO as an independent company already provides electric mobility solution in Morocco, however, had not entered the Marrakech market and as such, was interested in contributing to the SESA living lab by validating a sustainable business model that could be replicated after the SESA project ended.

5.3 Morocco Urban: E-Bike Use Case

5.3.1 Introduction & Problem-Solution-Fit

The main problem that SESA focused on solving in the Moroccan living lab together with POGO has been the lack of reliable public transportations systems which are sometimes unavailable and sometimes not punctual. GEP as living lab facilitator and POGO are also endeavouring to limit the transportation field high carbon print in Morocco since it's deemed as the second highest carbon emitting sector within the country.

In Morocco, the national policies and government goals regarding electric vehicles (EVs) are part of broader strategies to promote sustainable transportation and reduce environmental impact. Below is an overview of key documents and initiatives:

1. **Moroccan National Strategy for Sustainable Development:** This strategy includes goals for reducing greenhouse gas emissions and promoting sustainable transportation. It emphasizes the need to support alternative energy sources, including electric vehicles.
2. **Moroccan Electric Mobility Strategy (2020):** This strategy outlines Morocco's commitment to developing a robust electric mobility sector, including incentives for EV adoption, infrastructure development, and public awareness campaigns.
3. **National Energy Strategy (2020):** This strategy focuses on increasing the share of renewable energy in the national grid and includes provisions for supporting electric vehicles as part of the transition to cleaner energy.
4. **Moroccan Green Plan:** Part of Morocco's broader environmental strategy, this plan includes measures to encourage the adoption of electric vehicles and the development of related infrastructure.
5. **Moroccan Law No. 99-12 on Renewable Energy:** While primarily focused on renewable energy sources, this law supports initiatives that include the promotion of electric mobility as part of the broader clean energy goals.
6. **Cities' Local Plans:** Several Moroccan cities, including Casablanca and Marrakech, are developing local policies and pilot projects to integrate electric vehicles into public transportation and urban mobility solutions.

With the aim to improve access to environmentally friendly electric mobility solutions in the Moroccan transport sector, the technology implemented in the living lab have been 40 electric mopeds (e-mopeds; see below for technical information). The Moroccan living lab has been piloting the fleet of 40 e-mopeds since May 2023 up to date. The official launch took place in November 2023 in Marrakech together with all SESA partners

involved and with government representation. It was originally planned to have all e-mopeds stationed in Marrakech to target the customer segment of female students at universities; however, given further market assessments, customer feedback and low returning customer rates, from January 2024 onwards, parts of the fleet were moved to other Moroccan cities where demand was high and revenues could be generated, thus, enabling a validation of the Paygo / leasing business model.

Solution

The primary objectives of the SESA living lab in Morocco was to promote and introduce electric mobility as a sustainable alternative to ICE motorcycles, with a particular emphasis on targeting various user groups, especially female users. Additionally, the intention has been to collaborate with the Association pour la Scolarisation de la Jeune Fille Rurals, a non-governmental organization that supports female university student from economically disadvantaged rural and isolated regions by providing accommodation, meals, and other essential services. In addition, the demonstration's sustainability is backed by a private company that executed the business model.

The SESA living lab partner GEP has been leveraging the collaboration with a local company, POGO, to enhance the user experience of e-mopeds in a densely populated Moroccan city, known for its vibrant tourism industry and the highest concentration of cars and motorcycles in the country. This initiative aimed to promote the adoption of environmentally friendly transportation options. One of the primary goals was to address the various issues associated with densely populated cities, such as reducing waiting times for public transit, improving service quality, and enhancing reliability. The POGO e-mopeds service, developed together with GEP for SESA urban living lab, proposed both value increase and cost saving. As shared EVs are emission free, fast and more affordable than traditional competitors like taxis and public transport operators, they present a compelling alternative.

The SESA EVs are designed for easy visibility and to user-friendly operation through a simple mobile App. In POGO operational cities, people could enjoy a better urban environment with less air pollution and reduced traffics in addition to much less noise pollution since the electric mopeds are not only emissions free but are also soundless to the opposite of fuel motorcycles that are very noisy.

This collaboration between POGO and GEP, under the SESA Urban Living Lab, has already improved air quality in these cities, with up to 1T of CO₂ emissions saved for every 6,000 km driven by electric mopeds.

Specifically, within the SESA project (25 months of operation), 40 e-mopeds have collectively travelled approximately 650,000 km, which equates to a savings of 50.8 tons of CO₂ emissions (note the formula is detailed below). This progress aligns with the UN sustainable development Goals (SDG11 & SDG13), demonstrating POGO and Green Energy Park's commitment to building sustainable cities and protecting the environment. Additionally, POGO has pledged to plant a tree for each 1000 Km driven,

which means 650 trees will be planted in recognition of the 650 000 kilometres already covered by SESA EVs.

Method for calculating the emission savings:

Calculation formula = $121\text{g/km} \times 135\,000\text{km} =$

Taxi emission on 1 km driven with 2 customers onboard: $121\text{gCO}_2/\text{km}/2$ (customers) /1000 x 135 000 km (driven by pogo each month) = 8,167 T CO₂

Bus emissions for 12 clients onboard: $121\text{g CO}_2/\text{km}/12$ (customers) /1000 x 135 000 = 1,361 T CO₂

Car emissions: 16,335 T CO₂

POGO charge this EVs with electricity coming from 80% natural gas and 20% renewable energy.

This means the formula is as follow:

$(500\text{g CO}_2/\text{kWh (emissions natural gas)} \times 0.8 \text{ (ratio)} + 50\text{g CO}_2/\text{kWh (emissions of renewable energy)} \times 0.2) \times 700 \text{ kWh (electric consumption for the whole fleet)}$
= 287 kg of CO₂

Average transportation emissions are $(\text{Car} + \text{Taxi} + \text{Bus})/3 = 8.621 \text{ T of CO}_2$

POGO e-mopeds save approximately: 8.334 T of CO₂ each month

Table 18 Technical information of the e-mopeds

	Evaluation criterion	CPS
Motorization	Engine Type	Electric Engine
	Type of motorcycle	Scooter
	Engine Power	Greater than or equal to 1200 W
	Lithium-Ion Batteries / Removable and Portable	Lithium-Ion Batteries / Removable and Portable
	Capacity	Greater than or equal to 1.3 kWh
	Battery life cycles	Greater than or equal to 1000 cycles
	Range/Kilometre (full charged battery)	50 - 60 km
	Maximum speed	Greater than or equal to 45 km/h
	Full recharge time	Less than 6h
	Wheel Type Jante	Alloy
	Automatic transmission system	Automatic transmission system
	Front tire min	Tubeless 90/90-10
	Back tire min	Tubeless 90/90-10
	Dashboard and View	Digital dashboard showing speed, load level, distance travelled, USB port, LED lights and time
Sharing (Cloud Platform)	Acquisition module	
	Card Type	Any compatible GPS
	Connectivity	
	GPS	
	4G	
	Cloud Platform	
	mobile application	
	Cloud service	
Maintenance and Engagement	maintenance	
	maintenance duration	24 months
	pièce de rechange	available
	guarantee	24 months
	assistance and commissioning	
	Commitment	
	Maintenance contract	2 years including the cloud and com part
	Engine warranty	2 years
	Battery Guarantee	2 years
	Commitment to spare part availability	
	Supplementary - construction commitment of solar hub and the pick-up point (option)	
Certification and approval	Approval	
	Certification	
	EEC (European standards)	

What makes the solution outstanding

The SESA living lab and validation action, in cooperation with POGO, stands out due to its seamless and innovative approach to electric mopeds sharing through a single mobile App. The POGO App, available for both Android and iOS users, allows users to locate the nearest EV on a map, unlock it, pause their ride, end their trip and even pay through their credit cards – all within the app.

Another component which the Moroccan validation of e-mopeds wanted to test was a business model that can financially supports low-income female students that cannot afford e-mopeds due to financial hardship through a voucher program (reduced price offerings and special deals) in collaboration with the local NGO, Association pour la Scolarisation de la Jeune Fille Rurals.

Thirdly, the living lab pricing strategy was strongly adapted to the Moroccan clientele and invoiced by each minute of mopeds usage. POGO charged its clients 0.99 MAD (0.092 Euro)/min, which is a very suitable and competitive price within the Moroccan public transportation system.

In the competitive matrix below, the main factors of POGO's competitiveness in the market amongst its urban customer segments is demonstrated. Speed is here related to travel time from point A to B.

Table 19 Main factors of POGO's competitiveness

	Cost	Accessibility	Speed	Capacity	Regularity
Pogo	Medium	High	High	Medium	High
Taxi	High	Medium	Medium	High	Medium
Uber	High	High	Medium	High	High
Bus	Low	Low	Low	High	Low

Technical Functionalities

The SESA e-moped solution is emission free, easily accessed through POGO's mobile App, affordable, fast and very fun to drive which makes the offered services better than those proposed by traditional mobility operators in the Moroccan and the North African market in general. In other words, POGO provide an eco-friendly (emission free), fast, affordable and digital urban mobility revolution for people.

Technical aspects of the solutions are that each moped is equipped with an IoT which enables POGO to communicate with the hardware through Transmission Control Protocol (TCP) commands. Each IoT is containing a local SIM card through which POGO enable communication between the IoT and its internally developed Application Programming Interfaces (APIs).

Summary of milestones

The initial milestone involved operationalizing the fleet, which encompassed securing the necessary permits from local authorities, establishing insurance coverage, and identifying suitable deployment locations. A demonstration phase was then conducted to validate the technical functionality and viability of the business model.

The second milestone marked the official launch of the Living Lab, organized by Green Energy Park, with the participation of the SESA coordinator and key regional stakeholders in Marrakech.

The third milestone consisted of the introduction of the first key performance indicators (KPIs), the onboarding of initial clients, and the receipt of positive feedback regarding the service.

Up to date POGO as part of the urban living lab has achieved the following KPIs shown below:



+8 000 active



+650 000km
traveled km



+ 50.8Tons of
saved CO2



40 e-mopeds
Deployed

5.3.2 Business model validated and tested

Business model canvas

The original business model is short and long term EVs sharing through the dedicated POGO App.

Business Model Canvas		Designed for: Click to add text	Designed by: Ouzachakradi Zakariae	Date: 11/10/2022	Version: 2.0
Key Partners  MOTIVATIONS FOR PARTNERSHIPS: Optimization and economy, Reduction of risk and uncertainty, Acquisition of particular resources and activities Our main partner is POGO which is the first ever multimodal micro mobility sharing start-up in Africa. Through POGO's technological assets (App, APIs, Backend...) we would be able to implement an local, innovative and digital urban mobility revolution which would also enhance the sharing economy within our operational cities.	Key Activities  What Key Activities do our Value Propositions require? Our Distribution Channels? Customer Relationships? Revenue streams? - Leasing - Publicity - Transportation of citizens - Ecological tourism	Value Propositions  What value do we deliver to the customer? Which one of our customer's problems are we helping to solve? What bundles of products and services are we offering to each Customer Segment? Which customer needs are we satisfying? New concept and era of green and smart transportation, Rental of vehicles at the GO, Best PPK (special pricing for female students), availability, accessibility everywhere, no need to have licence to drive it. To sum up, we will provide a fast, ecological, <u>shearable</u>, and affordable urban mobility substitute which would be tangibly beneficial for all our users.	Customer Relationships  Customer expectation to be met (segment 1): O&M Services, Best PPK (Price Per Kilometre), expansion of the fleet vehicles, Best subscriptions for students. (Segment 2): Availability 24/7, Online Platform for E-Payment, tracking of the driving and performances, third party apps and best PPK.	Customer Segments  - The first target population is female students who live in a student's shelter affiliated with the association of rural young women's education; they all share a similar financial status. - Second Segment is everyone in need of a way of transport at the lowest rate possible specifically in Marrakech - At the beginning, this second segment would be a narrow niche entitled to the following criteria: - Age : between 20 – 35 yo* - Probably students - Own a credit card (optional)	
Cost Structure  O&M (Batteries replacement, Rental points enhancement) There is practically no most expensive activities. Not to forget that our business is more Value Driven (focused on value creation, premium value proposition) at a fixed Costs (rents, utilities)		Revenue Streams  Our analysis indicates that the female students travel about 25-36 kilometers daily to get to their institutions, it is an hour of driving everyday without counting the waiting time for a taxi or the night prices that aren't affordable by most student which is around 2.5 euros per ride. These students prefer a subscription that we can offer. Not to forget that the drives are 5-6 minutes driving meaning the vehicles would be used for just 10% of the time a day. For our second segment the revenue is located in this types of customers, they're needing a transportation solution at the lowest rate possible, they're renting the vehicles for a good amount of km driven, so this type of usage will generate almost 90% of the revenues and used about 90% of the time.			

Designed by: The Business Model Foundry (www.businessmodelgeneration.com/canvas). PowerPoint implementation by: Neos Chronos Limited (<https://neoschronos.com>). License: CC BY-SA 3.0

Figure 48 Business Model canvas for SESA Moroccan urban living lab

Customer Feedback on tested Business Model

Customer feedback on POGO's electric vehicle (EV) sharing initiative has been positive thus far. This is particularly noteworthy given that electric mopeds remain a relatively novel concept in the Moroccan market, sparking curiosity among pilot users. Upon experiencing the service, users have expressed appreciation for the overall offering, citing the affordability of rentals, as well as the quiet, emission-free, and smooth driving experience provided by the mopeds.

In Marrakech, the feedback received about the 40 mopeds was good. Clients provided feedback that they enjoyed the e-mopeds, however, most clients owned their own mopeds and thus would not be recurring customers. They came to try out this new electric mobility service but were not interested in becoming paying customers. The testing with the Association pour la Scolarisation de la Jeune Fille Rurals for female students was terminated earlier than anticipated due to a lack of willingness and interest of the NGO to encourage the use of the e-mopeds amongst the students and as such, the

e-mopeds were not used as planned. After months of no operation of the e-mopeds placed at the Association, it was decided to terminate the collaboration since the e-mopeds must be used to validate the business model.

After a more in-depth assessment of the Marrakech market, it became apparent that 87% of adults in Marrakech already own a moped which was a huge barrier for implementing sharing services of the 40 SESA e-mopeds. This pushed POGO to look for new cities with higher demand and a different mobility behaviour to deploy some of the SESA e-moped. Following detailed market assessment in other Moroccan cities, higher demand was noticed in Agadir, Fez and Casablanca and the decision was taken together with the respective SESA partners, to move some of the un-used e-mopeds from Marrakech to other cities to generate income and collect validation results of the leasing-business model.

At the start of 2024, 20 e-mopeds were operational in Marrakech city. As mentioned above, to maximize the revenue generation of the fleet and to test and validate the business models, 7 e-mopeds were transferred to Agadir, 3 to Benguerir and 3 to Fez in January 2024 plus the 7 mopeds placed at the Association were also transferred from Marrakech to Fez in July 2024. During 2025 to date, in order to maximize the revenue generation of the fleet, 10 e-mopeds have been operational in Agadir, 6 in Benguerir and 14 in Fez in January 2024 plus 10 e-mopeds have been operational in Casablanca city. The number of e-mopeds at the different locations may change going forward depending on the needs and to keep the service revenue higher or equivalent to the breakeven cost.

In addition, the SESA partner, UNH, lead the UNAs analysis while Green Energy Park lead the data collection process in collaboration with POGO and the association of schooling rural girls. The UNA showed that the community faces challenges with access to public transport, the integration of new technologies that reduces dependencies to fossil fuel as respondents found that their experience using the POGO bike was positive compared to the modes that had been used earlier. All respondents stated that their experience was positive, that is for both user categories (hostel girls, and city users).

Table 20: Overview of the research methodology & number of respondents

Methodology	Number of respondents	Tool applied
Users Survey	16	Questionnaire through Google Forms

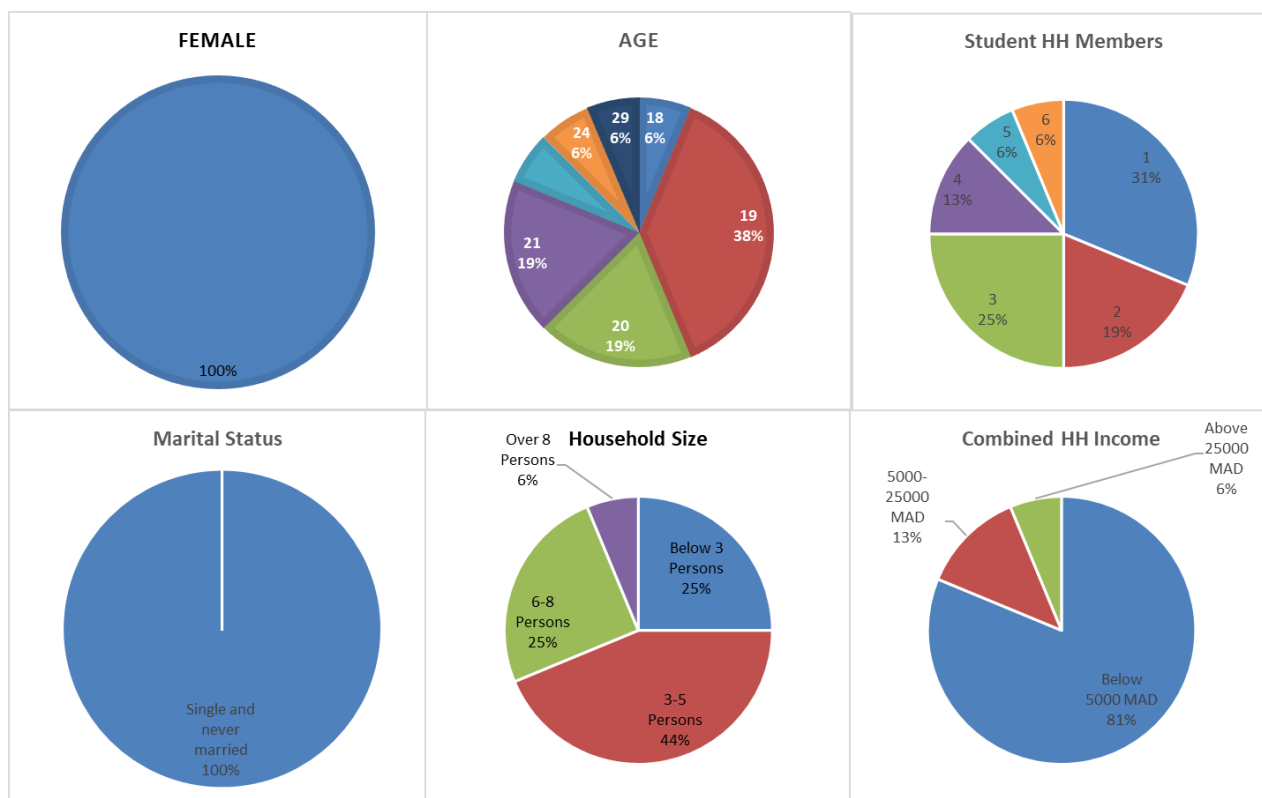


Figure 49: Socio-economic profile of the respondents

About 19% of the respondents came from families who owned one bicycle, about 30% were from families with one or more motorcycles, and 30 % were from families who owned a car. As a large section of the respondents did not own vehicles, they will be dependent on using public transportation or walking for all travel purposes. Also, vehicle ownership is high in larger households, and it is expected that the earning members of the household will probably be using motor vehicles, so it can be considered that most respondents are dependent on public transport modes and walking modes for travel.

The positive experience of using the electric mopeds has mainly been because these vehicles are better in performance and handling compared to similar other options, as electric mopeds are known for their instant torque, and smooth acceleration and are quieter compared to conventional similar ICE engine vehicles.

The experience with the Association further showed that partnerships must be carefully evaluated in terms of actual willingness and capacity to integrate shared mobility into daily routines. Simply placing vehicles with an NGO partner without strong buy-in or alignment with user needs resulted in non-usage and wasted resources, reinforcing the lesson that stakeholder engagement is as critical as customer demand.

When the mopeds were relocated to Agadir, Fez, and Casablanca, where ownership levels were lower and mobility needs more pressing, recurring customers began to appear, validating that the leasing and rental models can generate sustainable demand if market conditions are appropriate. This transfer strategy also illustrated the value of maintaining operational flexibility, allowing resources to be redirected to more promising markets rather than persisting in unfavorable ones.

Challenges Identified specifically for the female student user group hosted by the Female Student Association:

Free Bus Subscription Cards:

Many female students possessed subscription cards that allowed them to use buses for free. This significantly reduced the added value of the e-mopeds service for them, as they had access to an alternative transportation method without any additional cost.

Perceived Lack of Added Value:

Given the availability of free bus services, the e-mopeds did not offer a compelling advantage or value proposition for the female student user group. The convenience and cost-effectiveness of the bus service made it a preferred choice over e-mopeds.

Parental and Association Concerns:

Another significant challenge was the reluctance of parents and the Female Student Association to take responsibility for the e-mopeds. Concerns about potential accidents or damage to the e-mopeds led to hesitancy in endorsing the service for female students.

Insurance Considerations:

To address these concerns, one potential learning was the need for adjustments to the insurance policy. By modifying the insurance so that no responsibility falls on the customer, it could alleviate fears and encourage more female students to use the service.

Market Analysis

Customer Segments

All of POGO's operational cities client's segment is the same. Clients are between 18 and 40 years of age who don't own a vehicle. Users of the 40 SESA e-mopeds during 2024, are split between male and female users in the following ratio split: 40% female and 60% male. 89% of users of the 40 e-mopeds have either never driven an EV before and they really like the experience. This segment represents a market size of nearly 13,3% in Marrakech region, 13,8% in Rabat region, 11,7% in Fez region and approximately the same for Agadir region.

For 2025 to date, Users of the 40 SESA e-mopeds, are still split between male and female users in approximately the following ratio split: 40% female and 60% male. 61% of users of the 40 mopeds have either never driven an EV before and they really like the experience. This segment represents a market size of nearly 95% in Agadir region, 80% in Casablanca region, for the Fez region and for Benguerir region is still the same.

By strategically managing the allocation of e-mopeds and addressing the specific concerns of female students, the company was able to enhance the overall sustainability of the business model. This approach not only maximized the service's utilization during low-demand periods but also preserved the inclusivity of the service, ensuring that all potential users had access when they chose to use it. Additionally, considering insurance

changes could further strengthen the service's appeal to this group, potentially increasing future usage and contributing to long-term success.

- **Reallocation During Holidays:**

In response to the low usage by female students, especially during the school year, the company opted to temporarily reallocate the e-mopeds when the female students were on holiday. This allowed the company to maintain higher utilization rates and generate stronger Key Performance Indicators (KPIs), which in turn strengthened the business model.

- **Insurance Adjustments:**

Moving forward, one key consideration is to revise the insurance terms to remove any potential liability from the customers, particularly the female students. All repair costs will be carried by POGO. This adjustment could help mitigate the concerns of parents and the Female Student Association, making the service more appealing and accessible to this demographic.

Go-To-Market Strategy

The main marketing channel is social media coverage of POGO's services in addition to affluent brand ambassadors. These two promotional channels enable efficient marketing and promotional campaigns of the EVs sharing services. In the Moroccan e-mobility market, establishing a strong online presence is essential, starting with a comprehensive website that details services, pricing, promotions, and includes a web-based booking system. Optimizing this website for search engines (SEO) and investing in search engine marketing (SEM) drives both organic and paid traffic. Social media platforms such as Instagram, Facebook, and Twitter should be utilized for targeted advertising, promotions, and customer engagement. Active community engagement is also crucial; participating in local events and festivals to showcase e-mopeds, offering free trials, and implementing referral programs with incentives like free rides or discounts helps attract new customers. Providing 24/7 customer support through an app, website, and dedicated phone lines, along with a feedback mechanism for users to review and improve service quality, builds trust and enhance user experience. Lastly, promotional campaigns with introductory offers and discounts, along with loyalty programs that reward frequent users, are vital strategies for attracting and retaining customers.

Pricing



Total fixed cost : 23 167 MAD
Lifespan : 60 000 KM



Average Price/KM : 1,9 MAD
Gross income : 114 000 MAD



Variable expenses : 25 833 MAD
Total expenses : 49 000 MAD



ROI : 132%

Figure 50: Bases of cost calculations CAPEX & OPEX

The pricing strategy is very clear and straightforward. It's 0.99MAD (0.092 Euro)/min or 1.9MAD (0.18 Euro)/Km. This pricing is one of the lowest when it comes to urban mobility in Morocco (see below competitor's prices). Profit margin from this pricing is around 41% per moped. SESA project enabled POGO to propose some mopeds at extremely affordable prices approximately 25% of POGO original price to some young girls in Marrakech who live in dorms and who need a mobility mean to move back and forth from their university to the dorms.

There were no price adjustments for using the sharing service since POGO is already the cheapest and most competitive on the market. A short-term rental which is 24 hours deal for customers that want to prospect the Marrakech old medina and monuments for a quick tour. Then POGO provided the customers with a day and a seven day to a month option (One day 10 euro, 7 days 55 euro and a month 150 euro) aiming for a long stay or locals that need an alternative way of transportation (people with a vehicle under maintenance, sold their vehicles or others).

The Moroccan e-moped ecosystem is emerging as a promising market with various companies providing e-mobility solutions. These companies focus on creating a comprehensive online presence, participating in community engagement, and offering robust customer support. Their pricing models typically include pay-per-ride options, subscription plans, and promotional discounts to attract a wide range of users. Introductory offers and loyalty programs are also common, designed to incentivize frequent use and retain customers. The ecosystem emphasizes convenience, accessibility, and customer satisfaction to promote the adoption of e-mopeds in Morocco.

Below are examples of other e-mobility providers in Marrakech and their current prices:

Yassir Express:

- **Pay-per-ride:** Typically charges around 1.5 MAD (0.14 Euro) per minute, with an initial unlocking fee of 5 MAD (0.46 Euro).
- **Subscriptions:** Offers a weekly pass for 150 MAD (14 euro), providing unlimited rides under 30 minutes.

Lime:

- **Pay-per-ride:** Generally costs 2 MAD (0.19 Euro) per minute with a 6 MAD (0.56 Euro) unlocking fee.
- **Promotions:** Often runs promotions such as 50% off for the first ride or discounted rates for students.

TIER Mobility:

- **Pay-per-ride:** Charges around 1.8 MAD (0.17 Euro) per minute with a 4 MAD (0.37 Euro) unlocking fee.
- **Subscription plans:** Offers a monthly subscription for 300 MAD, which includes 30 free unlocks and reduced per-minute rates.

The pricing proposed by POGO which is on average 1.9 MAD (0.18 Euro)/Km is enabling POGO to generate a profit margin of around 32%. The fact that POGO are charging much less than sharing companies in Europe and the US but yet still generating the same profit margin or even a bit more is due to the fact that operational costs in Morocco are significantly cheaper than in Europe or in US. Those cheaper operational costs include but are not limited to HR salaries, warehouses rental, electricity costs, insurance costs.

5.3.3 Sustainability and impact

The POGO service cost as mentioned above is already very affordable and as part of the SESA living lab, POGO managed to make it even more affordable for DAR TALIBA girls' students through SESA Project. The user needs assessment showed a strong demand for transportation services within the community. Therefore, this business model was on track with promising results after some adjustments in the distribution of the fleet and a concrete understanding of the e-moped's market analysis in the Moroccan market since the vehicles were delivered to the living lab on 13 November 2023. From 1 April 2023 to 18 April 2024, the vehicles generated promising KPIs and showed that the business model is going as expected. The purpose of this was to pilot vehicles for the transportation of passengers, which is named a sharing solution service, and it's open to the public at a fee via a dedicated app for booking and payments of rides. The current fee that passengers pay for each minute of transportation within Marrakech City, Agadir, Fez or Benguerir is 0.99 EUR per minute driven and 0.2 EUR per minute of parking the vehicle. The per-trip price for the passenger micro-electric vehicles is competitive, considering that the only cheaper means of transportation is the buses that take too long for the user to reach their desired destination.

The project expanded over Marrakech, Fez, Agadir and BenGeurir. The service provided using the 40 e-mopeds created a significant added value since it provided an easy to use, fast, ecofriendly and affordable shared electric mopeds. Which is the first sharing system in Morocco powered by POGO. Since the use rate of the solution in this region exceeds 70% - 80% of the available fleet, the solution has proven its reliability and adequation to the regions Market. User feedback across media platforms and onsite surveys performed for UNAs D1.6 has shown this output.

Between July 2023 and February 2024, there was a notable rise in consumer growth, including a 200% spike in August 2023. The customer growth % trend fluctuates but shows a generally favourable trajectory, with a significant increase in December 2023. The frequency of repeat consumers is consistently rising, indicating enhanced client retention over a period of time. The increased distance travelled suggests an extension in operating scope or service coverage in Marrakech city, together with changes made during the operation. This is an optimal dispatch of the e-mopeds across different cities, maintaining at least 50% of the mopeds in Marrakech. The CO2 savings, a key measure of environmental effect, have been steadily increasing in line with the project's sustainability objectives. CO2 savings more than doubled by March 2024 compared to the initial projection in July 2023.

During 2025, POGO was able to expand its services in a new city and gain extra customers which maintained the revenues during 2025 but the challenge of spare parts availability in time lowered the ability for the service to reach out to new customers as expected.

Barriers to upscaling

1. Authorization

The only challenge is entitled in getting activity authorization across POGO's operational cities. POGO are working on acquiring many new authorizations across different new cities in Morocco.

2. Financial Barrier

At the start of POGO the lack of capital for purchasing more bikes was obviously a barrier to expand the fleet also note that banks are not helpful to support young local start-up loans or the loans are not much of a help talking about initiatives that give a maximum of 10 000 to 25 000 euro.

3. Road structures

E-mopeds cannot be taken outside of Marrakech city centre since they do not go faster than 45km/h and the road linking city centre with outskirts, cars and scooters need to go 70km/h. This road is very dangerous for e-scooters to use with their slow speed for this matter POGO excluded the trajectories to and from the private university of Marrakech UPM and the category of female students are 18 years old and above.

5.3.4 Challenges, learnings and next steps

The challenges that the SESA living lab faced during the first-time implementation:

- The long and time-consuming administrative process to get public spots for parking e-mopeds was hard and still ongoing which was a challenge back at the time of implementation.
- A juridical process for adequate insurance policy and suitable for a sharing solution, taking into consideration was needed to be authorized to Green Energy Park although GEP did not have the legal right to operate the e-scooters themselves. However, after continued discussions with all relevant stakeholders, the juridical consultant cleared these issues, and GEP found a way to continue the implementation work.
- The exchanges related to the availability of spare parts is time consuming, discussions with vendors
- Exposing the EVs to high ambient temperature increases the rate of defection and parts malfunction

After the obtention of the legal papers, insurances and all the technical aspects were sealed, early KPIs showed a fall in customer attraction, a negative profit and no margin at all. As a result, POGO tried to analyse the data collected and conducted some site surveys to better understand the problems related to the implementation of the business for urban living lab. The results were that POGO and GEP needed to dispatch some of the unused mopeds in other locations in Fez, Agadir and Benguerir. Which, as stated per POGO, were demanding while POGO as implementing partner of the urban SESA living lab had some hard times in Marrakech city, the results of the adjustments were fantastic as explained in the table for KPIs tracking.

The EVs short- and long-term rental is working well in Morocco and SESA Fleet has been deployed successfully with very promising KPIs. Until now, there's the environmental and the operationalization of the fleet in extreme weather conditions, about 41 to 50 degrees Celsius it appears that OPEX cost can deviate sometimes from the estimated costs.

6 South Africa

6.1 Introduction to the validation use case

Alicedale, a small town in South Africa's Eastern Cape Province, was identified as a validation site for e-mobility solutions under SESA. Alicedale, comprising the urban center and the semi-rural township of KwaNonzwakazi, faces multiple socio-economic and infrastructural challenges. With a combined population of nearly 4,000 residents and an unemployment rate exceeding 70%, the community struggles with limited access to affordable transportation, essential services, and reliable electricity. Public transport is virtually non-existent in Alicedale, forcing residents to rely on costly, privately operated taxis from neighboring towns. This system is inefficient, expensive, and inaccessible for many, especially those needing regular travel for work, healthcare, or government services. Additionally, the town lacks basic amenities such as banks, clothing stores, and government offices, further isolating the community and increasing dependency on travel.

Electricity supply is unreliable due to frequent loadshedding, and there is minimal adoption of renewable energy technologies. To address these issues, the uYilo programme at Nelson Mandela University has established a Living Lab in Alicedale. This initiative introduces a solar-powered energy center and two micro-electric vehicles—one for passengers and one for cargo—designed to provide affordable, sustainable transport and energy solutions. The solar center utilizes second-life EV batteries for off-grid energy storage and supports internet access through InfoSpots. The electric vehicles aim to improve mobility, reduce transport costs, and stimulate local economic activity.

6.2 About the implementing partner

UYilo (SESA consortium member)

Nelson Mandela University (NMU), established in 1882, hosts the uYilo eMobility Programme which act as the SESA implementing partner of the validation case. It has been operational for 8 years, promoting sustainable development in South Africa in energy and mobility. It encompasses government advocacy, industry involvement, enterprise growth, expertise development, and smart grid systems, focusing on battery tech, vehicle systems, and mobility. NMU and uYilo will be responsible the demonstration case.

UYilo has experience in eco-tourism technology and electric micro-mobility. uYilo eMobility Programme also worked on an electric bicycle sharing pilot showcasing different forms of e-mobility, including an electric bicycle sharing pilot from 2018 to 2020. E-bikes were available at the Nelson Mandela University North and South Campus in Gqeberha for staff and students, powered by solar-charging stations. In 2023, the project resumed with improved electric bicycles for staff, and there's potential to expand to students after the staff pilot phase.

Co-development partners (non-consortium members)

Table 21: Co-development partners

Government actors	• National Government • Provincial Government • Local Government
Community Partners	• CARE Alicedale Community Centre • Community Leaders
Private Sector Partners	• Tour Guide • Shamwari Private Game Reserve • B&Bs, Game Lodges and Nature Reserve • Service providers of off-grid containerised energy hub (solar centre) • Automotive OEMs, Large, Medium, Small and Micro Enterprises within the Automotive and Energy Sector

National, Provincial and Local Government

Government departments and agencies will support the initiative and help gain community buy-in, government buy-in and government funding support from multiple government funding streams and funding calls.

The South African government has approved the Just Energy Transition Implementation Plan (JET IP) which sets out to support the country's transition to a low-carbon economy without leaving marginalised and vulnerable communities behind. The plan includes electrifying and decarbonising the transport sector. The aim is to establish a public-private partnership (PPP) under the JET-IP to support transport services provided to Alicedale community members and CARE Alicedale. uYilo and NMU are working with the following departments to develop a funding proposal to replicate opportunities and promoting the business concept.

- National Government: Department of Science and Innovation, Department of Transport, and Department of Trade, Industry and Competition and Department of Mineral Resources and Energy
- National Government Agencies: Technology Innovation Agency (TIA), South African National Energy Development Institute (SANEDI)
- Provincial Government: Eastern Cape of Department of Economic Development, Environmental Affairs and Tourism
- Provincial Government Agencies: Automotive Industry Development Centre Eastern Cape (AIDC-EC)
- Local Government: Makhanda Municipality: Directorate: Local Economic Development and Planning.

CARE Alicedale Community Centre

Care Alicedale is the main user of the micro-electric vehicles for the transportation of passenger and cargo and the Alicedale community. The vehicles will also provide services for the local community for passenger and cargo transport on demand, outside the time

allocated for CARE Alicedale. The needs and demand for transportation services explored through the demonstration will support in defining the business opportunities for micro EVs in this location. Staff and volunteers at CARE will promote transport services to ensure community-buy-in for the transport business.

Community Leaders

Community leaders will work with the uYilo and NMU to promote the transport services to ensure community buy-in for the transport business. Community leaders include South African Police Services (SAPS), Ward Councillor, ward committee members, school principals and pastors and priest of churches.

Tour Guide

Tour guide will assist the Solar Centre Manager with promoting services to customer segment 3: tourists.

Shamwari Private Game Reserve

Key activities required: Owners and Staff of Shamwari Private Game Reserve to actively promote transportation services provided to tourists.

B&Bs, Game Lodges and Nature Reserve

Key activities performed: Business owners and Staff. Actively promote transportation services provided to tourists.

Service providers of off-grid containerised energy hub (solar centre)

- Professional drivers of micro-electric vehicles: Key activities performed by these partners include driving passengers to and from their requested destinations within the Alicedale area and assisting the Solar Centre Manager with the transport business's day-to-day operations.
- Solar Centre Manager: Key activities performed by this partner include overseeing the services provided by the professional drivers and managing the day-to-day operations of the transportation business.
- Interns working at Solar Centre: Key activities performed by this partner: Assisting the Solar Centre Manager with bookings for transport services for all use cases.

Automotive OEMs, Large, Medium, Small and Micro Enterprises within the Automotive and Energy Sector

Key resources required: Locally manufactured and/or locally assembled vehicles and related components from MSMEs. PPP to support the transport business under South Africa's JET-IP framework.

6.3 South Africa: micro-electric vehicle use case

6.3.1 Introduction - Problem and solution

The validation demonstration site for the SESA project in South Africa is Alicedale. Alicedale is in the Sarah Baartman District Municipality located in the Eastern Cape Province. Alicedale has an area of 4.7km² and it is made up of two main areas, an urban

area called Alicedale, and a non-urban semi-rural area called KwaNonzwakazi, which is also a township. According to SESA (D4.2), there are 467 households in Alicedale and 593 households in KwaNonzwakazi. Alicedale has a total population of 3868 residents, 1930 in Alicedale and 1938 in KwaNonzwakazi.

Problem analysis

Alicedale community faces challenges on the access to affordable and reliable transport due to lack of public transportation. Since walking or asking for lifts when they need to travel within the town is not always feasible, they need to hire a privately owned transport services (taxi), which is expensive and the booking system take time. Alicedale has **high unemployment rate** which has affected their paying capacity for any kind of (new) services, as well as there is a **lack of accessibility to amenities** in and around the location. Besides that, Alicedale also has poor electricity supply (experiencing 'loadshedding') and **low or no adoption of renewable energy**. These problems are shortly described below:

Lack of affordable transportation service in Alicedale

Even though Alicedale was a railway training facility in the late 1800s and 1900s, access to affordable and reliable transport is a challenge due to lack of public transportation. Since there is no public transport available in Alicedale, residents either walk or ask for lifts when they need to travel within the town. There are different privately owned transport services, but they are located in the bigger towns such as Gqeberha and Grahamstown. An individual needs to contact the private transport provider ahead of time and make a reservation for their seat before the operator travels to Alicedale. The transport has a standard rate and the operator tries to fill up their vehicle with at least three people. The driver will not go to Alicedale for only one person, unless the person pays for the remaining empty seats as well. One person can call for a group or people can ask around if anybody is going with the private transport and if there are any free seats available. One seat costs R135 (6,69€) and the main routes are from Alicedale to Gqeberha and Alicedale to Grahamstown. If the operator does not make a stop in an area that is relatively close to your intended destination, you will be required to pay an additional fee, the minimum additional fee is R50 (2.50€).

Regarding cargo services, SESA (D4.2) states that a return trip to transport goods and services can cost up to R1920 (95€). This service would mainly be to transport anything that cannot fit into a normal passenger vehicle such as beds, equipment for shops and physical goods. As most of the population is unemployed, they cannot afford to pay the costs for privately owned transport services.

Lack of accessibility to amenities in and around Alicedale

Alicedale has no bank branch and only one Automated Teller Machine (ATM). The town also has no government offices such as a South African Social Security Agency (SASSA) office. Alicedale has a post office, funeral parlour, bottle store, pharmacy, grocery store (Usave) and B&Bs, however there is also no clothing store. Residents have to travel far for governmental services and necessities such clothes and medicine, and while there is a pharmacy, it is not well stocked. Therefore, residents have to travel to the nearest town, Grahamstown, at least once a month. As most residents are unemployed and cannot

afford the transport costs to get to the nearest town that has government offices and retail stores, residents who are unable to travel can give money to someone else to buy stuff for them. Before reaching Alicedale, (the stretch of road between Gqeberha and Alicedale) there is a nature reserve. Businesses have taken advantage of this location by creating accommodations such as B&Bs and game reserves around the area.

High unemployment rate

The economic activity in Alicedale used to be dominated by the Bushman's Sands Hotel which is no longer operational (MM 2009). Currently the main major industry is a Mohair factory (MM 2023).

	No income	R 1 - R 4800	R 4801 - R 9600	R 9601 - R 19 600	R 19 601 - R 38 200	R 38 201 - R 76 400	R 76 401 - R 153 800	R 153 801 - R 307 600	R 307 601 - R 614 400	R 614 001 - R 1 228 800	R 1 228 801 - R 2 457 600	R 2 457 601 or more
EC104: Makana	2721	905	1266	4163	4382	3030	2172	1491	867	254	77	56
Riebeeck East	23	17	41	65	84	24	15	9	5	0	0	0
Makana NU	133	73	85	428	534	333	145	95	87	41	11	5
Rhini	613	226	340	946	959	696	473	255	95	15	8	3
Grahamstown	1776	533	731	2495	2535	1815	1460	1105	672	196	59	48
Alicedale	57	25	25	86	117	91	51	10	5	0	0	0
KwaNonzwakazi	120	32	45	140	141	66	28	18	3	0	0	0
Sidbury	0	0	0	3	12	5	0	0	0	0	0	0

Figure 51: Annual household income in South Africa Rand³⁹ (STATSSA 2013)

Figure 51 displays the annual household income in Alicedale and KwaNonzwakazi, based on the most recent official data from 2013 (STATSSA). Alicedale has an average unemployment rate of 72.5% between the two main areas (ibid).

Poor electricity supply and low adoption of renewable energy

Due to the South African energy crisis, Alicedale also experiences 'loadshedding', an ongoing period of widespread, countrywide electricity supply blackouts. Loadshedding in Alicedale can be so extreme that it interferes with telephone networks and access to Wi-Fi. SESA (D4.2) states that the most recent information from Makana Local Municipality shows that there is no availability of solar or renewable energy in KwaNonzwakazi. When uYilo visited the area in March 2022, there were no observable indications of solar energy infrastructure in place.

³⁹ 1 Euro = 21 South African Rand



Figure 52: Mapping of Alicedale

Solution – solar centre and micro-EVs

Addressing and assessing that problem, the uYilo programme of Nelson Mandela University (NMU) has set up a Living Lab in Alicedale consisting of a solar centre combined, introducing renewable energy services in the community, with two electric vehicles, one for passenger transport and one for transportation of goods. The electric vehicles aim to increase the accessibility of the mobility services that are affordable to the community with innovative business model, considering involvement of private sector partners.

The demonstration will:

- extend the productive use of renewable energy for the community, and also offer sustainable charging of a small fleet of micro utility electric vehicles
- understand the technical and commercial feasibility, performance, and replicability of the system for rural and peri-urban applications in South Africa and across the African continent
- understand performance, value and repurposing potential of electric vehicle batteries for stationary storage applications
- provide InfoSpots for internet services

Solar Centre

The solar centre aims to test, validate and replicate a containerized off-grid renewable energy system comprising of solar photovoltaic panels and utilising second life electric vehicle batteries for stationary energy storage. In addition, the Solar Centre will also test productive use of energy appliances such as a small fleet of micro-utility electric vehicles and support providing Infospots for internet services

Micro-electric vehicles

The feasibility assessment around the performance and technical testing of two zero-emission micro-electric vehicles is carried out by CARE Alicedale to support their transportation needs (passenger and cargo) for the community that they serve. These services intend to be expanded to other stakeholders to increase the mobility accessibility in the area as well as economic viability for the public transport in the long run.

In this report, the use cases of electric vehicles and the potential of its business opportunities is explored and is explained in the following sections. The following vehicles will be housed and charged at the South Africa Living Lab on Main Road in Alicedale.

6.3.2 Implementation overview

Technical specifications of the two e-vehicles

Table 22 provides an overview of the technical specifications of the two e-vehicles, carefully selected to address operational requirement for the testing period. Cargo e-vehicle was procured locally while passenger one was imported.

Table 22: Technical specification of the two implemented Micro-EVs

Cargo e-vehicle	Passenger e-vehicle
Eleksa Imphi H21 Specifications (according to manufacturer): • Overall dimensions: 3150 x 1180 x 1800 mm • Cargo box size: 1600 x 1100 x 280 mm • Loading capacity: 400 kg • Battery: 64V 60Ah lithium • Max speed: 45 km/h • Charging time: 6-8 hours • Charger: On-board charger. 220V connection required • Mileage per charge: 65 km GPS tracker to be fitted to vehicle Power monitor to be fitted to 220V charging socket to monitor and log consumption by vehicle (Green Solar)	Melex Road Legal Hi-Rise LWB Passenger Specifications (according to manufacturer): • Overall dimensions: 3765 x 1290 x 2060 mm • Loading capacity: 450 kg • Battery: 52V 100Ah lithium • Max speed: 50 km/h • Charging time: 6-8 hours • Charger: On-board charger. 220V connection required • Mileage per charge: 60 km GPS tracker to be fitted to vehicle Power monitor to be fitted to 220V charging socket to monitor and log consumption by vehicle (Green Solar)
	

Source: procured locally	Source: Imported
Cost: 80 597 ZAR (4 015.58 EUR)	Cost: 289 688 ZAR (14 433.11 EUR)

Customer segments

The micro-electric vehicles will be used primarily by CARE Alicedale for transportation of passengers and cargo, during the project period. The vehicles will also provide services for the broader Alicedale community for passenger and cargo transport on demand, outside the time allocated for CARE Alicedale. Lastly the EV will be used for tourist services. Understanding the use case, collecting the information on the demand will support defining the business opportunities for micro EVs. See overview of customer segments in Table 23.

Table 23: Customer segments for the two EVs

Customer segment	Passenger EV	Cargo EV
Customer segment 1: Alicedale Community Individuals	x	
Customer segment 1a: Alicedale Community Businesses		x
Customer segment 2: Care Alicedale	X	x
Customer segment 3: Tourists	X	

Customer segment 1: Alicedale Community Individuals

Passenger transport

Outside the times allocated for CARE to have the vehicles, the vehicles will be available to the community of Alicedale, booked via a booking system. Surveys and interviews have been carried out to receive responses to the questions.

Customer segment 1a: Alicedale Community Businesses

Cargo services

There are currently other businesses in Alicedale such as a post office, funeral parlour, pharmacy, grocery store and B&Bs that could also make use of the micro EVs.

Customer segment 2: CARE Alicedale

Passenger and cargo transport

The initial trial of micro EVs took place with CARE Alicedale. They were given an agreement to sign, which clearly detailed when they have access to the vehicles for free (until SESA project period). CARE has documented the activities that require transportation. This assisted in establishing a practical schedule for micro-EV usage and what type of vehicles are currently serving the same purposes. Activities include food delivery from soup kitchen, transport of clients to the clinic/delivery of medicine, visit from caregiver and

laundry support, garden visits (harvesting and delivery of vegetables) and grocery shopping for preschool.

Customer segment 3: Tourists

Passenger transport

Shamwari Private Game Reserve, a key stakeholder for the South Africa Living Lab, has several luxury lodges in near Alicedale targeted at international tourists. The aim is to package tour offerings to Alicedale and promote them, in collaboration with Shamwari, to tourists who visit their Private Game Reserve. After each tour, tourists will be asked to fill out an online survey about their experience. The feedback received will improve the tour experience and increase the number of tours provided.

Operational aspects

The passenger and cargo micro-EVs vehicles can be booked directly by the drivers. Drivers can log the itinerary of the travel. The data logging can also help in understanding the travel pattern and demand of such vehicles. It is suggested to develop a booking app later.

Only drivers who are both designated, and EV trained to operate electric vehicles (EVs) will be permitted to drive the vehicle. The drivers will be required to sign both an identity form and a standard operating procedure document before driving the vehicle. Those who are not included in the list of approved drivers will not have the authority to drive the vehicle. The Wilderness Foundation can aid by presenting CVs of potential individuals capable of driving the vehicles. Candidates selected to drive the vehicles will receive a stipend for doing so. The drivers will receive a stipend between the approximate range of 2500 ZAR (124,56 EUR) and 3000 ZAR (149,47 EUR) per month.

Nelson Mandela University (NMU) will own these two electric vehicles for the project's duration and will take full responsibility of the vehicle insurance maintenance. During the demonstration period, user needs and market assessment is carried out (details in section 6.3.2), including the type and frequency of vehicle maintenances and services. This will help analyse the local capacity needs to continue the services.

At the end of the project, a decision will be made on who the university will pass ownership of the vehicles to operators to sustain and expand the services

6.3.3 Market assessment and user needs

User Needs Assessment (UNA) was carried out in Alicedale to collect essential information for the implementation of e-mobility solutions, aligning with the SESA Task 1.3. The assessment aimed to verify the suitability and approach of the e-mobility solutions in meeting the needs of the users and other stakeholders. Key aspects explored include commuting patterns in and around Alicedale, challenges in relation to access to transportation and energy, potential benefits of e-mobility solutions and possible barriers to implementation. A summary of the UNA is provided in in this section, with a more detailed report available in SESA D1.3: User Needs Assessment (SESA D1.3, 2024). For the

customer segment Alicedale community, user surveys, interviews with businesses and observation were used for the UNA. See *Table 24* for details.

Table 24: Overview of the research methodology

Methodology	Number of respondents	Tool applied
Users Survey	48	Questionnaire through Google Forms
Interviews	Seven businesses	Semi-structured questions
Observation	The study team observed the socio-economic context through a site visit	Observations

Data for the customer segment Care Alicedale was collected by uYilo on a separate occasion. The results are organised according to customer segments and focuses on customer segment 1 and 1a, Alicedale community and customer segment 2, CARE Alicedale.

Customer segment 1: Alicedale Community for Passenger micro-EV

A survey was carried out with 48 members of the Alicedale community. This section provides a summary of the results from the survey.



Figure 53: UNA taking place in Alicedale (SESA D1.3, 2024)

Socio-economic profile of the users

The primary participants in the UNA were women, constituting 56% of the respondents. Respondents ranged in age from 21 to 76, with the average age of 45.

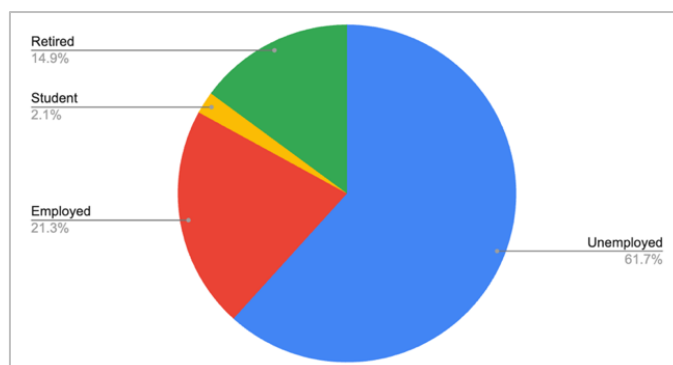


Figure 54: Occupation status of the residents in Alicedale (SESA D1.3, 2024)

62% of the respondents were unemployed showing financial constraints could impact their ability to afford a paid mobility service (Figure 54). 21% are employed which could positively impact the financial sustainability of the project. The retired population, comprising 15%, represents a market with unique mobility needs. Balancing the considerations for both employed and unemployed demographics is crucial for designing an inclusive and economically viable e-mobility solution that meets the diverse needs of the community (SESA D1.3, 2024).

Transportation context

Walking was the main mode of transportation in Alicedale, with 70% of the respondents relying on this means. Taxis (through private transport providers) served as the primary mode for 26%, indicating a demand for motorised transport, likely for longer distances or situations where walking is less practical. A smaller portion, 4%, opted for cycling (SESA D1.3, 2024). 93% of the respondents acknowledged facing commuting challenges in the Alicedale indicating a widespread and significant issue (ibid).

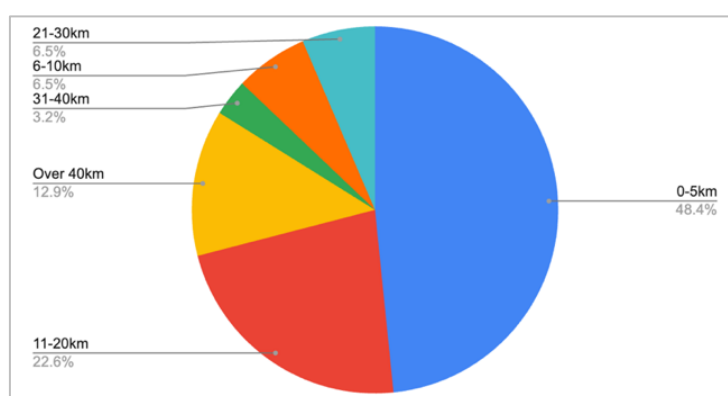


Figure 55: Distance of travel for daily activities (SESA D1.3, 2024)

As shown in Figure 55, the survey shows that 48% of respondents travel short distances (0-5 km) daily, indicating a significant need for localized transportation, which aligns well with e-mobility solutions. Another 23% travel 11-20 km daily, suggesting a demand for solutions for moderately longer commutes, possibly requiring strategic partnerships or supplementary options. Additionally, 30% have short commuting times (0-15 minutes) using mixed transportation modes, reinforcing the need for quick and efficient travel solutions. However, 23% have commutes exceeding an hour, indicating a demand for

transportation options that also cater to longer journeys. Longer journeys are linked to the need to travel outside Alicedale for basic needs, with 98% respondents affirming this.

Some respondents mentioned that carpooling is used as an alternative for local travel within Alicedale. Prices vary from R30 (1.74 USD) to R50 (2.89 USD) for a single trip from KwaNonzwakazi to town. Despite the high transportation costs, the community is often willing to pay, sometimes borrowing money when in urgent case and negotiating costs with the transport owner when necessary.

Further challenges that the community faces include difficulties in traveling during adverse weather conditions such as rain and hot weather. For community members who commute by walking adverse weather conditions present direct challenges to personal safety and comfort. Heavy rain, storms, or extreme heat can create hazardous walking conditions, especially for vulnerable populations like the elderly or those with health issues.

Feedback from community members on the passenger EV

Demand

In the context of transportation challenges in Alicedale, 81% of respondents recognised a consistent daily need for accessible, affordable, reliable, and safe transportation, with all mentioning the importance of environmentally friendly options (*Figure 56*).

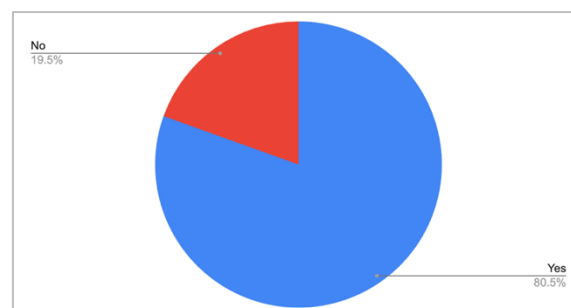


Figure 56: Demand for solution

Operability and pricing of e-vehicles in the community

Respondents shared various opinions on key routes for shared transport, such as convenient pickups at homes and essential destinations like the clinic, the Main Road, and external areas such as Gqeberha and Grahamstown. This would address the lack of public transport to town for local groceries and the reliance on wheelbarrows or hired special transport

84% of respondents are willing to pay between R5 (0.29 USD) and R20 (1.16 USD) per trip, significantly lower than the usual R50, indicating a strong need for more affordable transportation options due to high unemployment and financial constraints in the community.

Barriers to implementation

Respondents in Alicedale raised concerns about e-mobility solutions, including safety during adverse weather, road conditions like potholes, and charging challenges during load shedding. Other issues include potential community resistance to paying, demands for punctuality, slow vehicle speed, and theft risks.

Customer segment 1a: Alicedale community businesses for Cargo e-3 wheeler

Semi-structured interviews were carried out with seven businesses over a period of three days. This section provides a summary of the responses from the interviews.

Current transportation context

Between the seven business the goods that were transported include liquor and groceries. One business stated that while they do not transport goods, they still need to travel to buy groceries.

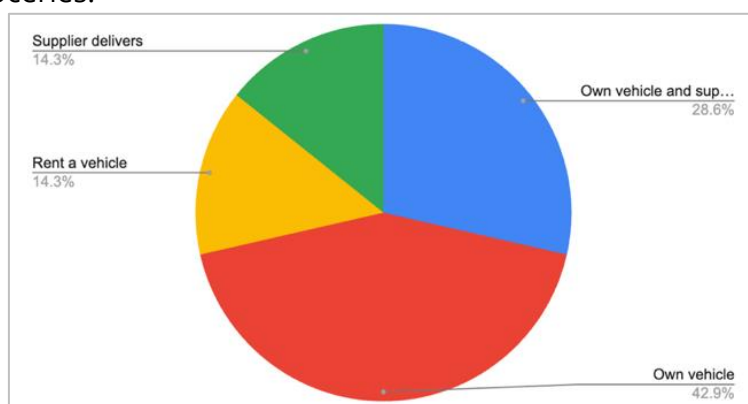


Figure 57: How transportation of goods is carried out

As shown in *Figure 57*, businesses use a mix of owned, rented, and supplier-delivered vehicles for transportation, with 43% involving the business owner's vehicle. While half of the businesses report no transportation issues, others face challenges such as irregular delivery schedules, occasional late or damaged goods, and concerns about petrol costs and road conditions.

The main operational costs that were mentioned by the business were petrol costs. Usage of vehicles for business purposes varies in frequency. Usage ranged from weekly to multiple times a week, with one participant opting for a monthly frequency.

Majority of the businesses (83%) mentioned that their most common destination to travel to is Gqeberha which is approximately 100km from Alicedale. Only one business mentioned Paterson as a destination point.

Feedback from businesses on the cargo EV

Demand

As shown in *Figure 58*, 83% of the businesses expressed openness to sharing the cargo e-3 wheeler with other businesses in Alicedale. A motivating factor was the potential savings that may come from the idea of shared EV and while the majority were supportive, one business mentioned that it would depend on the cost involved.

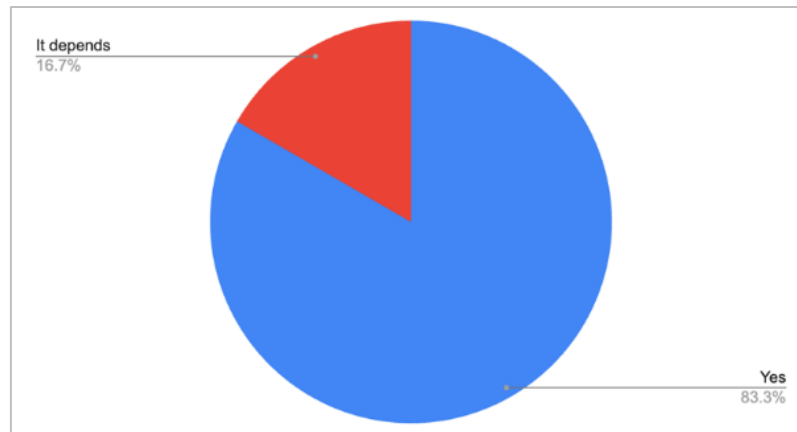


Figure 58: Openness to shared mobility for businesses

A majority of businesses (57%) were not aware of the charging facilities at the Solar Centre and none of the businesses have charging facilities.

While most businesses considered environmentally friendly transportation options in the community important or high on their priority list, others emphasised a partial importance with more focus on cost savings from petrol.

Barriers to implementation

Respondents in Alicedale raised concerns about e-mobility solutions, including electricity, specifically mentioning concerns about load shedding, battery performance especially on the Alicedale terrain, adverse weather conditions and maintenance.

Customer segment 2: CARE Alicedale

CARE Alicedale will carry out the initial feasibility assessment around the performance and technical testing of the micro-EVs. This will aid in supporting their transportation needs for the community that they serve.

CARE currently takes on the following activities:

- Soup kitchen delivery (Tuesday and Thursday 12:00-13:00)
 - The soup kitchen or lunch is brought to the KwaNonzwakazi community by CARE. They ask local people to help distribute food to those who need it. Many people need help in KwaNonzwakazi. By using micro-EVs, CARE could do this faster (in an hour or less). Currently, CARE carries out this activity by walking. People from KwaNonzwakazi walk to CARE, get food, and then walk back to deliver it. If the CARE Director is there, CARE representatives can use her car, as it is the only car at CARE.
- Clients to the clinic/delivery of medicine (made through appointments – Wednesdays 8:00-16:30)
 - The clinic is located in KwaNonzwakazi and is a provincial clinic. It operates from 8:00 to 16:30. CARE suggests using micro-EVs to transport chronically ill community members to the clinic for medication and consultations at scheduled times that can be agreed upon with the clinic. Currently, people use wheelchairs, catch a lift,

or walk. This service would help those with chronic conditions who need regular check-ups and medicine.

- Caregiver sees people and helps with laundry (Monday to Thursday – 9:00-13:00)
 - CARE has a caregiver that checks on immobile/disabled individuals on a weekly basis. The caregiver also handles their laundry by taking it to CARE for washing, drying, and ironing before returning it. The caregiver carries out this activity by walking. If the CARE Director is there, CARE representatives can use her car, as it is the only car at CARE. This time period is flexible and open for discussion. It only takes so long because the caregiver is walking.
- Garden visits (27 gardens in the location – every Wednesday 10:00-13:00; assist with harvesting and delivery of vegetables)
 - There are 27 vegetable gardens in Alicedale. A CARE representative checks on the gardens every Wednesday by walking. During harvest season, more frequent visits are required to the vegetable gardens. The vegetable gardens also service the soup kitchen.
- Groceries for preschool (weekly)
 - There is a preschool located at CARE. CARE takes weekly trips to the grocery store (Usave) to stock up on basic supplies such as tea, milk, rice etc.

These activities will assist in establishing a practical schedule for micro-EV usage and identify the types of vehicles currently serving the same purposes.

Considering this market assessment and user needs, business model aspects can be identified and verified, which is explained in section 6.3.4.

6.3.4 Business model aspects tested and validated

Operational data collection to identify the business prospects of micro EVs

The micro-EVs were handed over to CARE Alicedale to conduct the test case for free from the period between 4 April 2024 to 30 June 2024. The aim of the testing was to provide transportation of passengers and goods before the vehicle transportation services opened to the public at a fee. Data was collected from passengers and drivers.



Figure 59 Pictures of the two micro-EVs

Methods for data collection

A QR code was placed in the vehicles to collect data from passengers during the test case period (see *Figure 60*). When a passenger scanned the QR code with their phone, it would take them to an online survey form. Since the trips within Alicedale are short, uYilo recommended a maximum of 5 questions that required short answers. Since there is only one passenger micro-EV to serve the community of Alicedale, the questions focused on waiting times, trip duration, safety and trip fares.

Number of respondents: 20. The initial data collection was performed on a digital format using a questionnaire on Office Forms. Following this, the data was converted into XLSX format, and the subsequent steps of cleaning and analysis were conducted in Google Sheets. The following section of this report will provide a detailed analysis of the data collected within the specified timeframe. The data for operability was also collected through a QR code that was placed on as a sticker on the solar container where the vehicles are charged. The online form served as vehicle log and tracked vehicle usage and charging. Additional data was also gathered through Micro-EV power meter (see *Figure 61*).

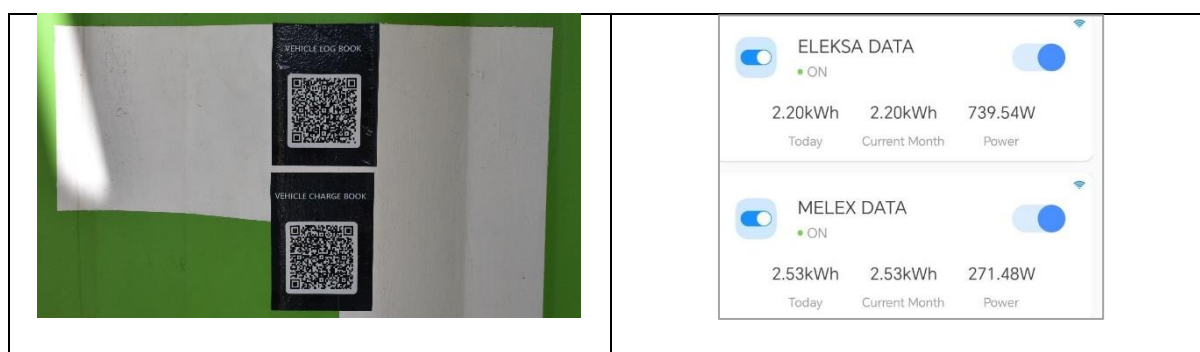


Figure 60: QR code for vehicle data logging Figure 61: Micro-EV power meter

Results of data collection

Waiting time

45% of commuters using the passenger micro-EV reported that their waiting time was between 0-5 minutes. This was followed by 25% who waited for 6-10 minutes. See figure below.

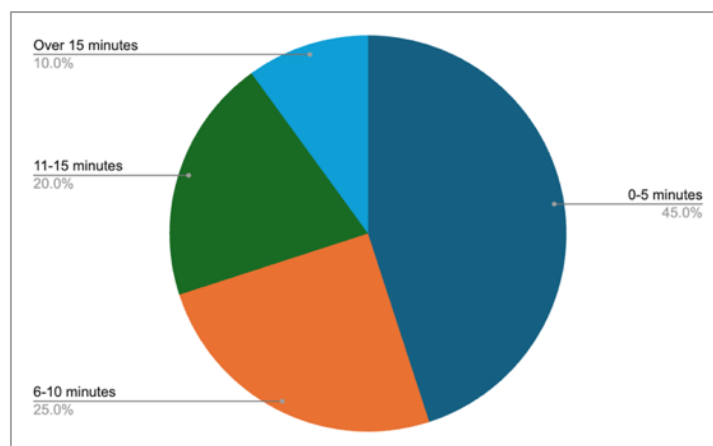


Figure 62: Actual waiting time for transport service

Given that this is the only passenger micro-EV serving the community during the test case and that the vehicle only carries four passengers at a time, the waiting times are exceptionally short. While *Figure 63* indicated that 70% of passengers waited between 0-10 minutes for the transport services, figure below shows that 85% of passengers are also only willing to wait up to 10 minutes.

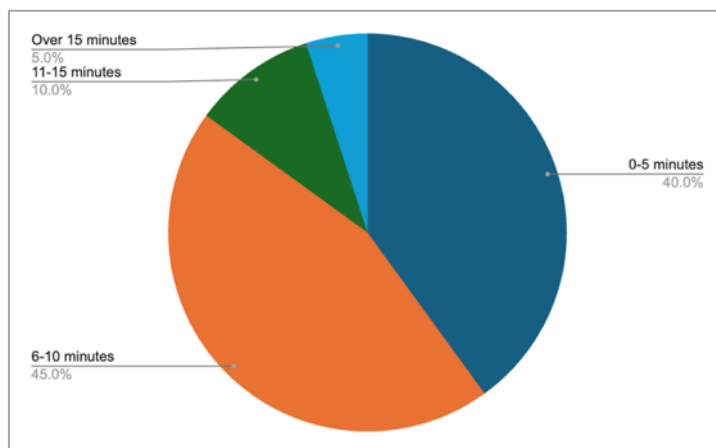


Figure 63: Time passengers are willing to wait for transport services

Only 5% of respondents mentioned that they would be willing to wait more than 15 minutes. This shows the importance of keeping short waiting times to ensure high satisfaction and that passenger expectations are met.

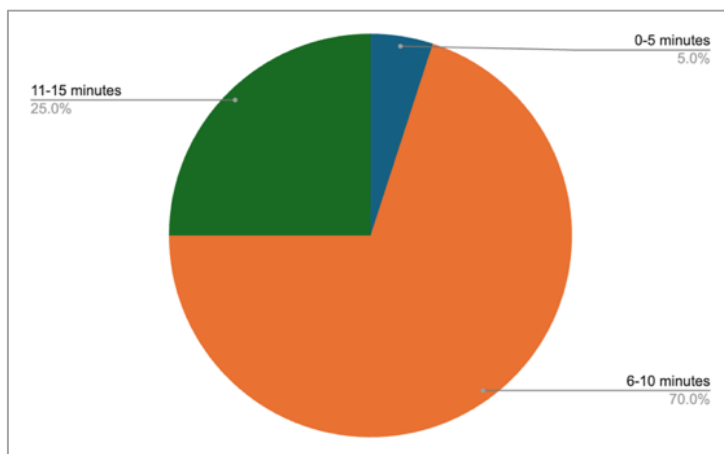


Figure 64: Length of trip

70% of passengers reported that their trip took 6-10 minutes. 25% reported it took 11-15 minutes, while only 5% mentioned that it took 0-5 minutes (*Figure 64*). This could suggest that the majority of trips fall within a relatively short time frame, indicating the service is efficient for most users.

Pricing

The UNA initially showed that 16% of respondents were willing to pay R5 (0.29 USD) for their trip, 26% were willing to pay R6-R10 (0.35-0.58 USD), and 40% were willing to pay

R11-R20 (0.64 - 1.16 USD). These figures reflected the potential costs that the community was prepared to pay before experiencing the service. However, after testing the passenger micro-EV, 90% of participants mentioned they would be willing to pay R10 (0.58 USD), and only 10% indicated a preference for paying R5 (0.29 USD) (figure below).

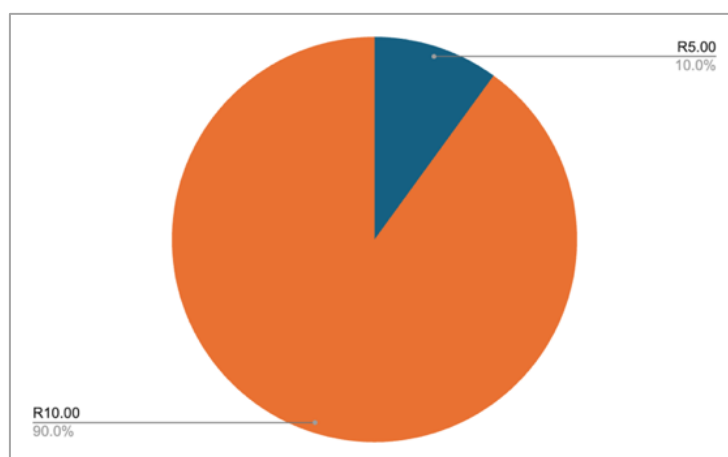


Figure 65: Desired fare for trip

During the test, passengers could choose from four fare options: R5 (0.29 USD), R10 (0.58 USD), R15 (0.87 USD), and R20 (1.16 USD). Notably, no passengers were willing to pay more than R10 (0.58 USD), which is contrary to the UNA results. This shift suggests that after experiencing the service, passengers were able to better assess its value. Even in a community like Alicedale, which faces a high unemployment rate, the perceived value of the service aligns with a willingness to pay a reasonable fare.

Vehicle operation

The following table provides the operability results of the micro-EVs during the test case period. Findings are divided between the types of vehicles.

Table 25: Micro-EVs operability results

Operations	Passenger micro-EV	Cargo micro-EV
Vehicle operation before charge required	Vehicles operate for 36 km (3 round trips of 12 km each) before needing a charge.	
Battery charging time	Charging takes 6-8 hours to go from 0% to 100%, depending on the battery state.	
Time of the day vehicles are usually charged	Vehicles are charged after each trip to avoid reaching 0% battery, despite high usage and unpredictable travel times.	
Issues with energy required from the solar hub	Vehicles are charged using a containerised solar system. Monitoring is sometimes hindered by poor Wi-Fi. There was an incident where solar energy was insufficient over a weekend, but it did not affect the community as the vehicles were not in use.	
Capacity	6 passengers	1 passenger

Operational difficulties		The cargo micro-EV had a handbrake issue that was recently repaired.
Safety incidents	A technician added side steps to the Melex to assist elderly passengers in getting on and off the vehicle more easily.	

Business Model Canvas

The operational data collection, in the previous section, clearly shows the readiness of the micro- EV services in the Alicedale. This is a key source to streamline the development of business model canvas, considering the roles of key stakeholders in sustaining the business aspects of the services as well as identification of how additional vehicles in future (from October 2025) will generate revenue and increase accessibility.

Passenger micro-EV business model canvas

Table 26 details the business model canvas of the passenger micro-EV.

Table 26: Passenger micro-EV BMC

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
Key user: CARE Alicedale Community Centre Business supporter: Shamwari Private Game Reserve B&Bs, Game Lodges and Nature Reserve Community Leaders National and local Government departments and agencies for public-private partnerships (PPP) Tourist services Service providers of off-grid containerised energy hub (solar centre) Tour Guide Local Start-ups	Reliable and affordable transportation services Inspection and maintenance of the micro-electric vehicle. Planning daily, monthly and weekly travel routes to ensure efficient and optimal vehicle use to customer segments 1, 2 and 3. Key Resources One passenger micro electric vehicle with two drivers, charging infrastructure, Parking areas, Service and maintenance plan, Vehicle insurance and Equipment for vehicle booking and monitoring	Customer Segment 1 and 2 (Alicedale and CARE community members): First and last-mile reliable and affordable transportation services to address their personal needs by: Online and telephonic booking system, Discounts for early booking services; services understanding customer problem or customer need Customer Segment 3 (Tourists): Drive through the township with a tour guide, Customer problem or customer need that has been satisfied:	Prompt passengers from Alicedale and CARE community members to provide regular feedback on their ride experience and maintain relationships through regular meetings and visits. A relationship has been established with Shamwari Private Game Reserve for tourist services; meetings and engagements have already taken place to develop package tour offerings and promote them Channels Referrals by word-of-mouth, posters and in-person regular visits at key community gathering sites for Alicedale and CARE community members and maintaining the relationship through telephone communication and social media channels. For Tourists: Posters and pamphlets at accommodation businesses and in their social media channels	Customer Segment 1: Alicedale Community members Customer segment 2: CARE Alicedale members Customer Segment 3: Tourists From September 2024 to September 2026, the business will provide transportation services within a 5-20km radius of Alicedale From October 2026 onwards, an additional passenger vehicle will be acquired, which will be able to provide service up to 160km radius with additional charges, additionally to tourists
Cost Structure			Revenue Streams	
1. Cost of purchasing the micro-electric vehicle 2. Maintenance costs of the micro-electric vehicle 3. Daily charging of micro electric vehicle 4. Cost for services provided by drivers with professional driving licence permit (PDP) 5. Cost of services provided by Solar Centre Manager 6. Cost of services provided by Solar Centre Interns 7. Cost of comprehensive insurance for the vehicles, which covers drivers, passengers, and third parties. 8. The cost of maintaining and building customer relationships includes purchasing data, making telephone calls, in-person visits, printing posters and pamphlets, advertising and promotion on B&B and Game Reserve Websites, newsletters, and social media pages. 9. Cost of GPS tracking and fleet management system 10. Cost of purchasing apparatus such as Wi-Fi Router, InfoSpots, Laptop			Pricing per trip based on distance: For Customer Segments 1 and 2: July 2024 – September 2026: R10 per trip for the service distance up to 20 kms. From October 2026: Pricing per trip out to nearby towns, R100 per person For Customer Segment 3: Tourists with guide: R50 per person for drive through the township, R100 per person for “hop on-off” service (excluding purchasing of items), R150 per person (excluding stops for meals at restaurant)	

Cargo micro-EV business model canvas

Table 27 details the business model canvas of the cargo micro-EV.

Table 27: Cargo micro-EV BMC

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
CARE Alicedale Community Centre Community Leaders: National and local Government departments and agencies for PPP Service providers of off-grid containerised energy hub Locally manufactured and/or locally assembled vehicles and related components from automotive OEMs, Large, Medium, Small and Micro Enterprises within the Automotive and Energy Sector	Reliable goods transportation services, Inspection and maintenance of the micro-electric vehicle. Planning daily, monthly and weekly travel routes to ensure efficient and optimal vehicle use to customer segments 1 and 2 Key Resources One cargo micro electric vehicle with two drivers, charging infrastructure, parking areas, service and maintenance plan, vehicle insurance and equipment for vehicle booking and monitoring	Customer Segment 1 (Alicedale business owners and organisations): first and last-mile goods delivery services. Customer Segment 2 (CARE Alicedale): first and last-mile goods delivery services are needed to optimise the delivery of goods to support the community centre's services. Bundles of products and services offered to both segments include: options for fast delivery vs standard delivery vs pre-booked times.	Relationships have been established with Alicedale business owners and organisations and CARE Alicedale. prompt customer segments to provide regular feedback on the service, and maintain relationships through regular meetings and visits. Channels Referrals by word-of-mouth, in-person relationship building through regular visits, posters at key gathering sites for Alicedale and CARE community members, social media channels and maintaining the relationship through telephone communication and social media channels.	Customer Segment 1a: Alicedale community business owners and organisations Customer Segment 2: CARE Alicedale From September 2024 to September 2026, the business will provide transportation services within a 5-20km radius of Alicedale. From October 2026 onwards, an additional cargo vehicle will be acquired, with technical specifications allowing it to transport cargo to and from nearby towns.
Cost Structure			Revenue Streams	
1. Cost of purchasing the micro-electric vehicle 2. Maintenance costs of the micro-electric vehicle 3. Daily charging of micro electric vehicle 4. Cost for services provided by drivers with professional driving licence permit (PDP) 5. Cost of services provided by Solar Centre Manager 6. Cost of services provided by Solar Centre Interns 7. The cost of comprehensive insurance for the vehicles, which covers drivers, passengers (even though this is a goods vehicle, a passenger might be travelling with the driver), and third parties. 8. Cost of maintaining and building customer relationships: Costs of purchasing data, making telephone calls, in-person visits, printing posters and pamphlets, advertising and promotion on community social media pages and WhatsApp groups 9. Cost of GPS tracking and fleet management system 10. Cost of purchasing apparatus such as Wi-Fi Router, InfoSpots, Laptop			Customer Segment 1 For Customer Segments 1 and 2: July 2024 – September 2026: Minimum cost per trip is R50, depending on the weight, distance and nature of the goods to be delivered. From October 2026: Out-of-town collections and deliveries: Minimum R350 per trip	

6.3.5 Conclusion, recommendation and next steps

The location of the living lab in Alicedale was selected to provide an opportunity to offer innovative, sustainable energy and mobility solutions to a marginalised and vulnerable community that relies heavily on government social security grants due to high levels of youth unemployment, a large elderly population, and women-headed households. Access to public transport was limited and expensive for the community. At the same time, inadequate electricity infrastructure made the area prone to regular power outages. The aim was to provide this community with access to affordable, sustainable energy and mobility solutions that could improve their livelihoods.

The break-even point for both vehicles in the South Africa-specific case is negative without a subsidy, meaning that the business in that specific location will not be viable without a subsidy. Despite these challenges, the user acceptance interviews show a positive impact in the community for improving the mobility services.

User Acceptance

Based on interviews conducted on 30th July 2025 with 28 community members of Alicedale:

- 96% of the interviewees used the passenger vehicle for transportation services
- 79% of the interviewees used the goods vehicle for transportation services
- 89% of the interviewees stated that the passenger vehicles fully met their transportation services needs.
- 79% of the interviewees stated that the goods vehicle fully met their transportation services needs
- 92% of the interviewees stated that the cost of using the goods and passenger transportation services was more affordable than other types of transportation services that they use.
- 89% of interviewees stated that they are likely to continue using the passenger transportation services once the SESA project is finished.
- 71% of interviewees stated that they are likely to continue using the goods transportation services once the SESA project is finished.

The South Africa-specific case demonstrated that the business model was only profitable when a subsidy was included, allowing customers to pay R10 per trip for their transportation needs, as this was the amount that the passengers could afford to pay. Their affordability was informed by a user needs assessment conducted with community members before the introduction of the micro EVs into Alicedale. Therefore, a business model incorporating public-private partnerships that can subsidise the annual capital and operating costs of the containerised hub and micro EVs is required for the business model to be sustainable in Alicedale, primarily due to the economic realities of its inhabitants.

uYilo and NMU are working with the following departments to develop a funding proposal to replicate opportunities and promoting the business concept.

- National Government: Department of Science and Innovation, Department of Transport, and Department of Trade, Industry and Competition and Department of Mineral Resources and Energy
- National Government Agencies: Technology Innovation Agency (TIA), South African National Energy Development Institute (SANEDI)
- Provincial Government: Eastern Cape of Department of Economic Development, Environmental Affairs and Tourism
- Provincial Government Agencies: Automotive Industry Development Centre Eastern Cape (AIDC-EC)

Recommendations for further development of the business model and replication across South Africa's provinces and other African countries could work by carefully choosing locations where a) customers earn a regular income that allows them to afford to pay the transportation services at a price that allows the business to break-even and make a profit without the requirements of a subsidy through public-private partnerships, or b) the business can secure public-private partnerships that bring down the cost of the transportation services to the customer allowing them to pay a price that they can afford, for the service.

7 Malawi

7.1 Introduction to the validation use cases

The SESA Malawi Living Lab aims to validate two solutions: one on waste-to-energy and clean cooking and one on solar powered irrigation. Inefficient cooking practices result in negative impacts for climate, environment and human health and inefficient production and unsustainable use of biomass in Malawi is contributing to environmental degradation, such as high deforestation. This living lab will thus address the need for sustainable cooking solutions and for the use of agricultural waste for briquette production. The waste-to-energy and bio-cooker use case is implemented by the SESA partners Going Green, Make it Green and RISE.

Furthermore, a lack of clean energy access across Malawi continues to put a brake on the pace of progress and the efforts to make lasting improvements in people's lives for example through higher agricultural productivity, and broad economic transformation in rural areas. The second validation case will thus test and validate a business model for supplying solar powered irrigation solutions to small farmers and support for improving agricultural output. This validation case is implemented by the SME partner Smart Energy Enterprise (SEE) sub-contracted under T3.4 by Siemens Foundation.

Use case 1: Briquetting

The validation demo has developed a new value chain and a business model for local entrepreneurs by producing fuel briquettes from new biomass alternatives as sunflower stalks to reduce reliance on unsustainable alternatives like charcoal. It has also adapted and validated the MIG BioCooker - a clean cooking stove - as well as produced and distributed biomass briquettes to MIG BioCooker users and other cooking stove users in the region. The Malawi Living Lab briquetting initiative has aimed to demonstrate the potential of locally sourced and sustainable innovation.

Use case 2: Solar irrigation.

As part of the 1st SESA Call for Entrepreneurs 2022, a solar irrigation company in Malawi was selected to validate the selected technology and business model for solar irrigation. Smart Energy Enterprise (SEE) in Northern Malawi is validating a leasing business model with submersive solar pumps for smallholder farmers and surface water (such as lakes) as natural water sources. The process for setting up a living lab for a solar-powered irrigation system was mainly based on the demand and the location of Smart Energy Enterprises (SEE) business. In this regard, Karonga was selected as the living lab for solar-powered irrigation systems in Malawi. Karonga district is the primary producer of high-quality rice in Malawi. The district lies along the shores of Lake Malawi and has several perennial rivers, making it ideal for irrigation activities. Nevertheless, in Karonga District, only 2,500 hectares of rice fields out of a potential 13,000 hectares are under irrigation, representing just 19% of the available area. Those involved in rice irrigation farming are mainly those in government-instituted rice schemes and those supported by non-governmental organizations. Consequently, approximately 130,000 smallholder rice

farmers in Karonga face food and income insecurity due to drought and dry spells. Various designs and systems of solar-powered irrigation technology have been tested with the sole aim of meeting the needs of smallholder farmers in Malawi.

7.2 About the implementing partners

Use case 1: Waste-to-energy and biocooker

Going Green (SESA consortium member)

Going Green (GG) manufactures sunflower cooking oil and sunflower cake. GG is working with smallholder farmers in Mchinji and Kasungu districts on contractual basis, 80% of which are women and the youth. GG is a female owned company with a female dominated management team. The company provides inputs such as sunflower certified seed and agronomic technical support to the contracted farmers to ensure that they obtain high yields and produce grains of uniform quality.

At the end of the farming season, GG buys the produce from smallholder farmers at competitive prices to prevent the contracted farmers from side-selling the produce to vendors and ensure that they remain incentivized to continue producing the crops for the company. The key byproduct of the vegetable cooking oil is sunflower cake. GG sells the cake to animal feed manufacturing companies and other farmers who are engaged in commercial livestock production.

Currently GG sells more crude oil than refined oil because it does not have its own refinery machine. GG is an integrated ecosystem business model which brings together farmers, extension service providers, business support and external partners in a well-coordinated model which allows GG to sell high quality sunflower crude oil and cake and efficient collaboration with its stakeholders in the value chain.

The target customers include social service institutions, cooking oil distributors, and food vendors located around Mchinji district and parts of Lilongwe. Going Green in partnership with Make it Green (MIG) under the SESA project has developed a local manufacturing of the clean cooking stove MiG BioCooker. The target group includes local farmers under contract with Going Green, who grow sunflowers.

Make it Green (SESA consortium member)

[Make it Green](#) (MIG) is a Swedish SME providing cleaner cook stoves and related products as the solutions for people in rural areas. The company is striving to continuously bringing new ideas and solutions to solve different energy and environmental problems.

In the SESA project, MIG has developed and validated the ISO tested clean cooking stove MIG BioCooker. The MiG BioCooker is an innovative, eco-friendly stove designed to improve lives by providing fast, smoke-free, and sustainable cooking. Powered by solar energy, ignited with sunflower oil, and fuelled by briquettes or pellets made from agricultural waste, it offers a cleaner and more efficient alternative to traditional cooking methods. To prepare the stove for the market, the project team in Malawi has conducted several pilot trials to gauge customers' level of acceptance and satisfaction with the new stoves and fine-tuned designs based on this feedback.

MIG has provided equipment for assembling the stoves in Malawi and trained the staff at GG in the assembly and repair of the MIG BioCooker. MIG has provided material for 20 stoves, assembled in Malawi.

RISE (SESA consortium member)

RISE is a Swedish research institute and technical leader for the Malawi living lab and has long experience in testing and validating technology in the energy sector. RISE has supported MIG in the development work of the MIG BioCooker by testing the stove in lab environment, done measurements on emissions and done analysis on the biomass feedstock. RISE has also been responsible for finding, testing and deliver a briquetting and shredder technology that can use feedstock as sunflower stalks. RISE has supported GG and MIG in all validation work.

Use case 2: Solar irrigation

Smart Energy Enterprise (SEE) (SME partner contracted under T3.4 by Siemens Foundation)

SEE was established on March 6, 2017. The executive office is located in northern Malawi, with a dedicated team of 11 professionals. SEE specializes in selling affordable solar pump irrigation systems to small-scale farmers that aims at enhancing their food and income security while mitigating the effects of climate change. SEE was contracted as a SME partner under Task 3.4 led by Siemens.

7.3 Malawi Briquetting Business

7.3.1 Introduction – Problem and Solution

Problem

As part of the SESA project's objective to deliver sustainable energy solutions in Africa, the Malawi Demonstration Living Lab is focused on transforming agricultural waste, specifically sunflower stalks, into clean energy through biomass briquetting. This initiative addresses critical health, economic, and quality-related challenges in the current household energy ecosystem.

The predominant use of firewood and unregulated charcoal for cooking in simple stoves in households in Malawi results in severe indoor air pollution. Families are routinely exposed to harmful smoke, contributing to a high prevalence of respiratory illnesses, eye problems, and other smoke-related health conditions. Women and children, who typically spend more time near cooking fires, are disproportionately affected⁴⁰. The transition to clean cooking stoves and clean-burning briquettes offers a direct pathway to reducing household air pollution and improving public health outcomes.

Charcoal, particularly when unlicensed, is illegal in Malawi, which complicates its transport and distribution. As a result, the charcoal supply chain is unstable, contributing to fluctuating prices and inconsistent availability⁴¹. These costs and supply uncertainties are passed on to end-users, creating an economic strain for low-income households. Furthermore, charcoal production is contributing to deforestation. The briquetting model offers a locally sourced, legal, and more stable and sustainable alternative energy source that can mitigate these economic and environmental burdens while contributing local development and job creation.

Traditional charcoal and firewood are marked by variability in quality and inconsistent burning characteristics. Households report charcoal with low quality that requires frequent refuelling, increasing daily consumption and overall cost. In contrast, biomass briquettes made from sunflower stalks provide a uniform, longer-lasting, and cleaner-burning energy source. This results in improved energy efficiency and reduced fuel consumption, ultimately lowering household energy costs and supporting energy security.

Solution

By introducing a sustainable, local briquetting business model using sunflower stalks, the SESA Malawi Living Lab is addressing these interconnected problems and contributing to clean energy access, rural development, and environmental protection.

⁴⁰ Das, I., Jagger, P., & Yeatts, K. (2017). Biomass Cooking Fuels and Health Outcomes for Women in Malawi. *EcoHealth*, 14(1), 7–19. <https://doi.org/10.1007/s10393-016-1190-0>

⁴¹ NATIONAL CHARCOAL STRATEGY 2017–2027. (2022). REPUBLIC OF MALAWI The Ministry Of Natural Resources, Energy And Mining. Retrieved April 11, 2025, from https://afr100.org/sites/default/files/2022-11/Restoration_Malawi_Charcoal-Strategy_lowq.pdf

The briquettes offer higher energy efficiency thanks to their compact and dense structure which ensures longer burning times and slower consumption rates compared to firewood. This improved efficiency directly reduces the amount of fuel needed per cooking session, helping households save both time and money. With more consistent and longer-lasting energy output, users experience more reliable cooking performance and reduced daily fuel expenditure. With the MIG BioCooker stove the cooking time is reduced up to 50 % using the briquettes compared to using firewood in traditional stoves.

Beyond efficiency, the solution promotes better health outcomes. Together with the MIG BioCooker the briquettes are smokeless, emitting significantly fewer pollutants, making them a cleaner and safer cooking option that aligns with public health goals and environmental sustainability.

Another key advantage is product consistency; briquettes offer uniform performance due to their consistent shape and density, which leads to predictable and steady burns. This predictability allows households to better manage their fuel consumption and budget planning. Additionally, because the briquettes are made from agricultural waste, resources that are both renewable and readily available, the cost of production is kept low. This results in a more affordable product for end users.

The abundance of these agricultural residues across Malawi ensures raw material availability and production stability, strengthening local supply chains and enhancing resilience against energy disruptions.

7.3.2 Current state of briquette production technologies in Malawi

Briquette production in Malawi is mainly driven by small community projects and NGOs. These efforts often focus on helping vulnerable groups, like women and young people, by teaching them how to make briquettes from common waste materials such as rice husks, maize cobs, sawdust, and paper. The larger goal is to provide a cleaner, healthier, and more sustainable energy choice, while also creating ways for people to earn money.

For instance, the Hara women's group in the Karonga district uses a machine provided by [Christian Aid](#) to convert rice husks and wood shavings producing approximately 2,000 kg of briquettes a month, which are then sold locally and used by the women for cooking.

Similarly, the organization [Tingathe](#), with support from [UNDP](#), trains community members to make briquettes from carbonized groundnut shells and rice husks bound with cassava flour, creating a smoke-free alternative to charcoal and firewood. These initiatives also help to reduce the time and effort women spend on collecting firewood, which often involves long distances.

Despite the clear advantages of briquettes, their widespread adoption as a substitute for wood charcoal in Malawi remains very limited. The industry faces significant challenges.

For example, the prevalence of low-priced, illegally sourced wood charcoal significantly impacts the briquette industry in Malawi. This makes charcoal a more appealing and affordable energy choice for many consumers suppressing the demand for briquettes.

Despite its illegality, charcoal remains a deeply entrenched part of Malawi's energy sector. This established market for illicit charcoal, characterised by its low prices and wide availability, creates a challenging competitive landscape for briquettes and other alternative fuels⁴².

The production costs for briquettes per unit of energy are generally higher than for charcoal, which can make them less attractive to consumers despite being a more efficient fuel⁴³. This is because the initial capital investment required for briquetting technologies can be a significant barrier for small-scale producers. The financial viability of a briquetting operation is highly dependent on factors like the cost of raw materials, labor, and transportation, as well as the scale of the operation and the specific technology used⁴⁴. While the initial costs are higher, modern briquette production lines offer a faster return on investment and potential for long-term growth compared to traditional methods.

The quality of briquettes can vary significantly depending on the available stock, which can affect their performance and the user confidence. For briquettes to be effective, they need to have key qualities such as low moisture content, high density, and a consistent burn. Poorly made briquettes may produce more smoke, have a lower calorific value, and not burn as long as traditional charcoal, which can deter consumers from adopting them⁴⁵.

A major challenge facing Malawi's briquette industry is the lack of a supportive policy environment, even though the government has acknowledged the importance of alternative cooking fuels in official documents. The National Charcoal Strategy (2017-2027)⁴⁶ and the Renewable Energy Policy⁴⁷ both recognize the role of briquettes in mitigating deforestation and promoting energy sustainability.

Nevertheless, the Malawi Living Lab's briquetting initiative directly aligns with the country's national policies on health, forestry, and environmental management. A key objective of the Malawi National Forestry Policy⁹ is the conservation and sustainable management of forests to combat deforestation and land degradation, which is often driven by the reliance on firewood and unregulated charcoal for cooking.

Furthermore, the Living Lab solution's emphasis on clean cooking directly supports public health goals outlined in documents like the Health Sector Strategic Plan III (HSSP III) 2023-2030¹⁰. Which prioritizes improving health status by addressing socio-economic determinants of health, a category that includes environmental health. The reduction of indoor air pollution, which disproportionately affects women and children, is a primary

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https://www.researchgate.net/publication/46496402_The_forbidden_fuel_Charcoal_urban_woodfuel_demand_and_supply_dynamics_community_forest_management_and_woodfuel_policy_in_Malawi

⁴³ <https://openknowledge.fao.org/server/api/core/bitstreams/da09aff6-dd44-45fa-b05c-5b226c472c3d/content>

⁴⁴ <https://www.mdpi.com/2071-1050/12/11/4609>

⁴⁵ <https://almassiyah.com/ensuring-quality-biomass-briquette-quality-assurance/>

⁴⁶ <https://conrema.org/wp-content/uploads/2019/01/Malawi-National-Charcoal-Strategy-Draft-Final-June-17-2017.pdf>

⁴⁷ <https://lexafrica.com/2024/05/renewable-enrgy-laws-malawi/>

outcome of the briquette and MIG Biocooker solution, contributing to Malawi's public health agenda.

The Living Lab's establishment of a local, legal, and stable briquetting business directly contributes to the the National Energy Policy¹¹ and the long-term national development blueprint, Malawi Vision 2063¹² by creating a new, domestically sourced energy supply chain. This approach fosters a more resilient and predictable market, mitigating the economic strain caused by fluctuating prices and inconsistent charcoal availability.

However, the growth of new briquette businesses is hampered by specific regulatory hurdles and a lack of targeted tax exemptions. The absence of an explicit policy framework that promotes briquettes makes it difficult for this technology to flourish and scale up. While the government has implemented some tax incentives for the private sector in the renewable energy sector, these are primarily focused on large-scale projects and may not directly benefit small-scale briquette producers.

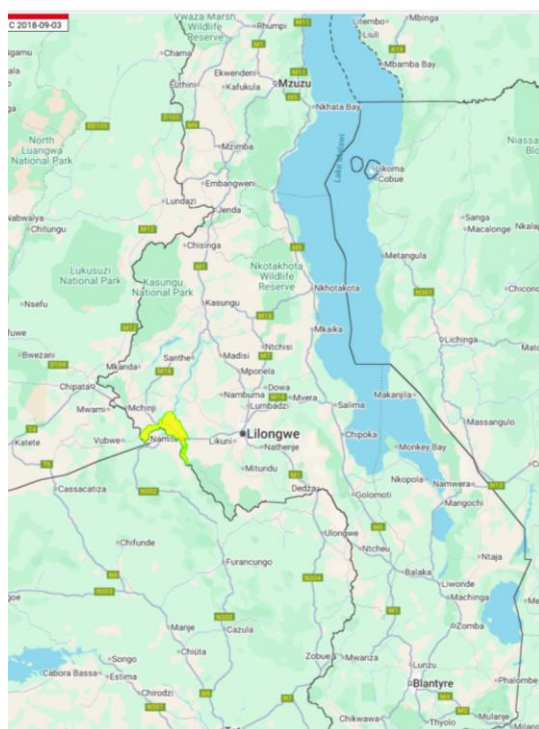
Many briquette initiatives in Malawi have been supply-driven, with a focus on production rather than understanding consumer preferences and building a viable market⁴⁸. This approach has limited the widespread adoption of briquettes, as projects have often failed to consider what consumers look for in a fuel beyond its basic availability.

To stimulate wider adoption and create a viable market, the Malawi validation team has addressed this gap by engaging with end users to better understand consumer preferences regarding factors such as affordability, ease of use, smoke production, and burning time. However, further policy, technical, and marketing interventions are needed to address these barriers and ensure all the relevant conditions are in place including briquette products meeting the needs and expectations of a diverse consumer base, access to biomass supply as well as machinery, skills and training for optimisation of production, etc.

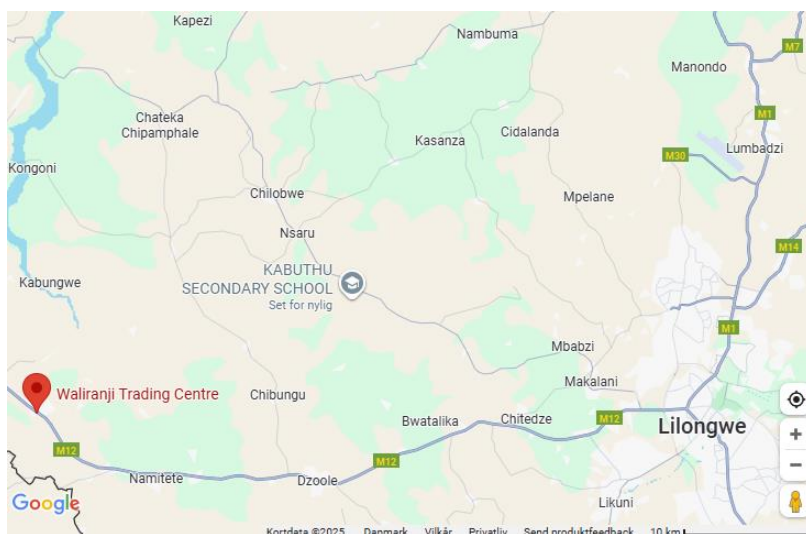
7.3.3 Local context for the intervention

In Malawi, Going Green (GG) and their production facility where sunflower cooking oil is produced, is located in Waliranji Village in the Mawere Traditional Authority in Mchinji district 60 kilometers West of the capital city Lilongwe. Mchinji District covers an area of 3356 km² land and has a population of approximately 602.000 of which 102.000 live within the Mawere Traditional Authority. Waliranji Village is a local trading centre in a rural area and has approximately 3000 inhabitants. The main sources of income for people in the area are farming. More than 90% of the economically active population deriving their income from farming.

⁴⁸ <https://www.tropentag.de/2023/abstracts/posters/325.pdf>



Google. (2025). *Map of Lilongwe*. Retrieved August 1, 2025, from <https://maps.app.goo.gl/e9LWWci2u3re718o7>



Google. (2025). *Map Waliranji Trading Centre and Kabuthu Secondary School*. Retrieved August 1, 2025, from <https://maps.app.goo.gl/qljjjZABJ9o5XSFX6>

Figure 66. Location of living lab: map of Malawi, Mawere Traditional Authority (yellow highlight) (above) as well as Waliranji trading centre and Kabhuthu (below).

GG's existing business includes sourcing sunflower seeds from a network of more than 5,000 small-scale contracted farmers organized through 200 farmer clubs who grow Sunflower on primarily small scale. Farm sizes are in the range of 1-2 acres. GG also offers training on agronomy in sunflower, soya, and groundnuts farming. GG sells certified seeds to smallholder farmers and at the end of the season buys back their

sunflower grains and finds other buyers for their soya and ground nuts. In 2024, GG bought 230,000 kg of sunflower grains from the 200 farmer clubs.

Prior to the SESA project, the agricultural waste from the sunflowers in the area was not fully utilized. During the SESA project, GG has expanded their business to also include briquetting of the sunflower stalk residues after harvesting. The sunflower stalks are bought by 90 of the same 200 farmer clubs that sell sunflower grains to GG. GG is collaborating with sunflower farmers around the entire traditional authority Mawwere as well as in Kabuthu. Grains and residues are transported to GG's factory in Waliranji from within a radius of approximately 40 km.

There are no competitors producing similar fuel briquettes for cooking stoves in the area, making the business environment favorable. The Going Green factory is located near Dzalanyama forest reserve, which is under pressure from deforestation. Developing briquetting of agricultural waste can assist in the reduction of deforestation and overall environmental degradation. Briquetting production can directly employ women and youth in the region to work in briquettes production, sales and distribution. It will also offer indirect employment to smallholders' workers under the Going Green Ltd through the supply chain of sunflower stalk, transporters and other distributors.

With the community's emerging awareness of the consequences of traditional fuels like charcoal and firewood on health and environment, the demand for clean cooking is increasing in the target area. In rural households the use of biomass for cooking is likely to persist over the near term, increasing the need to modernize the biomass fuel sector and promote improved/advanced bio-based cookstoves. To achieve a shift towards clean cooking, various enabling factors must be addressed. These include i) raising awareness about the environmental and health impacts of traditional cooking methods, ii) providing access to affordable and clean cooking technologies, iii) supporting the development of sustainable fuel supply chains, and iv) ensuring capacity building and financial support for vulnerable communities.

A key initiative in the SESA project involved the adaptation and validation of the clean cooking stove MIG BioCooker, to be implemented as a commercial product in the Mchinji district. The MIG BioCooker is an ISO tested (tier 4-5) biomass-based, fan-assisted clean cooking solution that integrates a solar panel and uses briquettes and pellets as fuel.

To manufacture the MIG BioCooker in Malawi demands local tools for assembling, knowledge and materials as metal parts, fan, power banks and solar panel. A set of tools for assembling the cooking stove was delivered to GG at the same facility as oil production and the staff at GG were trained in the assembly and repair of the MIG BioCooker. 20 stoves were assembled of which 19 stoves were distributed to 19 households for long term testing and validation during 2024 and one remained at the premises of GG for demonstration and testing purposes. The stove users are using sunflower stalk briquettes as fuel.

The goal is to scale up and develop a local stove production. To increase the use of clean cooking solutions in the region funding for the manufacturing is needed. A business

model involving also fuel briquettes ensures a stable supply of fuel and is often demanding to get funding for scale up local stove production.

In Malawi significant reductions in emissions will be needed to achieve meaningful health benefits for cookstove users. Increased use of clean fuel briquettes cannot solve this alone. Higher-performing advanced cookstoves like the MIG BioCooker, including clean fuel options, as briquettes will be needed to make significant improvement in reducing emissions.

7.3.4 About the Briquetting solution

In SESA a small-scale production line for sunflower briquettes was developed and sales of sunflower stalks briquettes to small holder farmers and through sales agents were validated.

The harvest of sunflowers takes place between April-August. The waste from the sunflower is today used for cooking in their natural state with limited pre-treatment such as drying, on traditional open fires or rudimentary stoves. To get higher efficiency and lower emissions when used as cooking fuel in clean cooking stoves the agricultural waste needs to be dried and briquetted (more energy-dense). Below is an overview of key activities, key actors as well as key challenges and opportunities for the briquetting business which will be described and discussed further throughout the report.

Table 28 Overview of key activities, key actors and key challenges and opportunities

Key activities	Key actors	Key challenges	Key opportunities
Identified, tested and purchased two technologies for producing briquettes from sunflower stalks	RISE and MIG	Identifying appropriate shredder and press tech for briquetting production (local availability, appropriate tech for sunflower stalk etc.)	Testing production in smaller scale before buying larger machinery
Sourcing and handling of raw material	90 farmer clubs contracted by GG	Time bound harvesting season (April-August)	Expanding farmer agreements to increase supply of biomass Adding storage space for handling larger quantities of biomass
Production of briquettes	GG in their existing factory	Limited production capacity Stocking, drying, preparing sunflower stalks for production	Expanding production capacity (extend production time, and/or acquire new machinery) Optimizing preparation and production flow
Sales	10 Agents who are already in the	Customer awareness	Increasing training, sensitization

	business of selling firewood. Current reach: 100 customers	Limited customer reach	Expanding agent network
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Technology specifications and features

Malawi living lab has identified, tested and purchased two technologies for producing briquettes from sunflower stalks, one shredder and one briquetting press.

Testing of the technology (2023)

Malawi living lab has identified, tested and purchased technologies for doing briquettes from sunflower stalks in Malawi. Sunflower stalks is a challenging raw material that comprises two quite different parts: pith and bark (*Figure 67*). The lightweight and porous pith occupies the maximum volume of the sunflower stalk and is composed of many closed air-filled chambers. Not all briquetting technologies can handle this material.



Figure 67 Sun-flower stalks before processing.

In SESA two types of briquetting machines have been tested with sunflower stalks. The sunflower stalks used in the tests were harvested from a field in Sweden and dried at the laboratory at RISE.

The first technology that was tested was a briquetting machine Biomasser® Duo type BS241-3 from the Polish company Asket. The technology is scalable and developed and used for briquetting agro-waste as straw. The press has been delivered to many countries including Africa. The dried sunflower stalks were packed (*Figure 68*) and sent to Poland for the briquetting test.



Figure 68 Harvest and packing of sunflower stalks in Sweden

Before the briquetting the material was chopped into smaller pieces using a shredder Tomasser RK7. The material after chopping was of good length and quality. The material was then fed into the briquetting machine where the material is heated and pressed. When the chopped material got into the briquetting chamber, it blocked the movement of the briquette, and in consequence, the machine stopped. Different temperatures were tested starting from 210°C down to 130°C and still the same situation appeared – the machine got blocked. A stronger machine was also tested.

The conclusion was that the chemical composition of the stalks is responsible for the troubles when briquetting. Its “melting” temperature is low and in consequence, it sticks onto the surface of the briquetting sleeve blocking this way the smooth movement of the briquette out of the sleeve. More tests were also done at lower briquetting temperature, 100°C and with drier raw material. The briquette was first formed well, looked fine and hard when being in the stabiliser. Unfortunately, when the briquette left the second clamp of the stabiliser, it appeared that the fractions are not connected, not “glued” with each other when using this low temperature. The conclusion was that this machine was not suitable to produce briquettes from sunflower stalks.

The second technology that was tested was a Briquetting press Falach Cube 20 manufactured by the FALACH company in the Czech Republic (Figure 69, Briquetting press Falach Cube 20). The company also produces bigger machines with higher capacity.

This machine uses a different press technique compared to the Biomasser duo. The machine only uses high pressure, and no heat is added which avoids problems with material that is melting. The size of the briquettes is very suitable for a cooking stove (30 mm x 30 mm).



Figure 69 Briquetting press Falach Cube 20

Before the test the sunflower stalks were shredded with a Rapid granulator at RISE in Sweden before the material was sent to the Czech Republic. The material worked very well in the machine during the first briquetting test and the produced briquettes could be sent back to RISE for testing in the cook stove.

To be able to set up a fuel production in Malawi, a shredder was needed. The first idea was to get a shredder with much higher capacity than the briquetting machine to be able to scale up the briquetting technology in the future. An older Danish straw chopper was tested with sunflower stalks (*Figure 70*) at a farm in Sweden. The result showed that the material was a bit coarse so the sieve in the shredder was changed to a sieve with smaller holes (10 mm). With this sieve the quality and size of the material looked fine.



Figure 70 Tested straw chopper

The conclusion was that this type of shredder could be an option of shredder when briquetting sunflower stalks in Malawi. Another sample of shredded sunflower stalks was sent to the Czech Republic for a briquetting test to be sure that the machine worked well with material from different shredders.

After some discussions with Going Green it was decided to also look for a shredder with lower capacity since the electricity will be too expensive in Malawi with a large shredder. Today there is one transmitter for many people and usage is shared sparingly at the location for the briquette production. This will be a problem as it will require an own transmitter which costs too much.

After some research by RISE another smaller shredder was found, a Danish shredder, Frej, 2.2 kW, capacity 100-200 kg/hour (*Figure 71*). The shredder has a 4- or 6-mm sieve, giving a fine material. For the test sunflower stalks were sent to a dealer, Skånekraft in Sweden. The test went very well, and the result was a nice and even material in particle size, which improves the hardness of the briquettes. The conclusion was that this was a good choice of shredder for Malawi since the power demand was low.



Figure 71 Shredder for sunflower stalks and shredded material.

Chosen briquetting press

The chosen briquetting press technology is a FALACH Cube 20. It is a small compact briquetting press that provides high operational efficiency, low consumption and produces square-shaped briquettes 30 x 30 mm. It is a single purpose machinery that serves to process dry clean biomass to briquettes. Mains voltage 400 V AC, 50 Hz, input

2.3 kW. A hydraulic system, wire conveyor with a bag revolver are parts of the machine. Modifications differ in input powers. The design principle and the used elements remain identical. The equivalent level of acoustic pressure at the operator's post does not exceed 70,0 dB (62 dB). The machine demands clean (from soil, sand etc.) and dry biomass (<20 % moisture content). An extra press head (spare part) was also included in the package since it needs to be changed when it is teared down. Other maintenance can be fixed locally in Malawi. The briquetting machine has an output of 10-25 kg per hour depending on used raw material. Wood based material has a higher output compared to agro-waste. Before the material is fed into the briquette press, it needs to be decomposed.

Chosen Shredder

The chosen shredder is a Frej of 2.2 kW, a powerful but at the same time compact and easy-to-use mill for fine distribution of dry hay, straw, manure and the like. It also can shred wood material, but the production rate is lower. Technical parameters can be seen below:

- Biomass/feed capacity: 100 – 300 kilos per hour
- Capacity wood: 80 – 120 kilos per hour
- Maximum diameter of wooden material: 3 cm
- 2.2 kW electric motor (3-phase)
- Sieve plate: 4 mm fitted as standard (6 mm included)
- Weight: 75 kg/95 kg with packaging

Installation and Operational Setup: The briquetting technology was delivered to Malawi living lab in May 2024. Upon arrival in Malawi, the installation and startup of the briquetting process was relatively efficient, thanks to thorough preparation and testing conducted in Europe. It took approximately one day to unpack and commence operations. MIG assisted with the operational startup and trained local staff from GG to handle the machinery. Local farmers provided dried sunflower stalks for the initial operation.

7.3.5 Implementation summary of briquette production 2024 to 2025

Two harvest and production cycles have been validated during the SESA project. The first from May to October 2024 and the second from May to August 2025. The main determining factors for the levels of production output (kg) are i) access to supply of raw materials and ii) the capacity at the production facility (machinery, staff, processes, etc.). In 2024, 2,400 kg of briquettes were produced from end May to end September (4 months). The sunflower stalks were collected over a period of three months primarily by hand labour to the point of collection, and by oxcarts and a truck from point of collection to the factory.

The briquetting process was not running in full capacity in 2024 because of the operator still learning (low skill on Falach Cube 20), operational stoppage due to contamination in the raw material, an irregular power supply from the grid, roads in bad shape and poor farmer awareness caused delays and some loss of raw material.

In 2025, the collection of sunflower stalks continues, and production of briquettes is very much improved, recording 3000 kg produced from end May to end August (3 month). The

machine is running more consistently with better predictability than in the 2024 due to better operator training, more efficient feedstock preparation and better and more space for storing material.

Sourcing of sunflower stalks, production and sales 2024

From end May to end September 2024 approximately 2400 kg briquettes were produced. Two persons are working with the production to feed and operate the machine. However, as this is not a full-time job, the same people are also working with other parts of the GG business as sunflower oil production.

The sunflower stalks were bought from contracted sunflower growers from 90 farmer clubs (representing approximately 2250 farmers) out of 200 farmer clubs that Going Green contracts for sunflower grains. The farmer clubs collect the sunflower stalks from the farmers and the number of stalks varies depending on the size of the farm and availability. Some farmers use the stalks as fuel and are not willing to sell. The stalks were collected over a period of 3 months. This was done by Going Green extension workers by truck at the same time they were collecting the grains from the farmers. When the briquetting machine was running it was operating for approximately 6 to 8 hrs pr day and it took approximately 26 to 30 days to produce 2400 kg (not consecutive days).

Due to a lack of biomass material due to preparation started late in the season, the machine could not be operated after end September, until the next harvest season. Since there is limited storage space at the production site, other type of biomass will need to be contracted/collected when the growing season of sunflower stalks has ended.

Sales of briquettes are managed by Going Greens Marketing officer through 10 sales agents some of which are also contracted farmers. These agents are already in the business of selling firewood. Going Green supplies these agents with briquettes using a motor bike. Currently GG can only manage to target markets (agents) that are closer to the factory The furthest agent being 19 kilometres from the factory. Three of the ten agents are picking up the briquettes at the factory. One bag of 20 kilograms briquettes is sold at 7,000 kwacha (3.5 Euro) to the agents. Agents sell these briquettes in smaller quantities to customers usually not measured in kilograms. In 2024, the briquettes were sold on by the agents to approximately 100 customers.

The market impact of this marketing model reaches beyond the immediate target area as each agent serves customers from all over their own village and quite several customers travel between 1 and 8 km and sometimes much further to reach the market to buy the briquettes. This decentralized structure allows to cover a large geographic area without the cost and formality of a retail shop. It also creates local stake by enabling smallholder farmers to participate in the sales process, even as it ensures access to clean cooking fuel in various rural communities. The briquettes have also been delivered to the 18 MIG BioCooker users who live in 18 villages of Traditional authority Mavwere approximately within 40 kilometers from the factory.

The selling of briquettes is being integrated in GGs existing business of selling sunflower crude oil and sunflower cake. Going Green sells about 8 to 10,000 liters of sunflower crude oil per month and sells it to a group of 10 to 15 wholesalers in Lilongwe and Mchinji

district. Some of these wholesalers are regular customers, and others purchase seasonally and on demand. Sunflower cake (a by-product), a high nutrient-value diet for animals is mainly sold to two big clients based in Lilongwe (Mount Meru and Sun seed Oils Company) on a quarterly basis in bulk quantities (80 to 90,000 kgs). Besides these, GG serve a few individual customers who visit the factory in Waliranji to buy sunflower cake for their own use or small-scale farming.

Table 29: Production and sale numbers 2024

	End May – end September 2024 (4 months)
Production	2400 kg (600 kg per month)
Sales	120 bags (20 kg)
Price	7000 Kwacha (3.5 Euro)
Sales agent	10 sales agents
Number of customers reached	100
Total revenue	84000 Kwacha (420 Euro)

Sourcing of sunflower stalks, production and sales 2025

One of the main changes that took place in 2025 was improved planning and control of the briquetting process which has proved the production process to be more economical, less wasteful and more predictable.

The production plan comprised of planned working hours, regarding drying of the stalk and removing of sands stuck to the stalks, clearly defined work tasks, preventive maintenance, real-time monitoring and recording of all production parameters in terms of a more controlled and scalable briquette production.

From end May to end August 2025, 3,000 kg of briquettes were produced. The production was organized as a weekly working cycle with the machine operating 3 days/week with an average production of 90 kg/day. The other two days a week the focus is on pre-processing, particularly crushing and preparing the sunflower stalks, that will be fed into the machine to guarantee an easy and continuous briquetting on the production days. This well-structured and balanced plan has shown to be efficient.

The production volume in one month is an improvement over the same month production in 2024, when that period briquetting was more irregular and unstructured. Per month production has increased from 600 kgs pr month to 1000kgs pr month. The progress of this year's operations indicates an improved production planning; operator training and pre-processing systems are showing an effect. Also, all the briquettes made in this period have already been sold to 10 agents, who are selling them in their communities which is a proof of a great demand.

The production volumes will continue to rise going into September as collection of stalks is still underway. GG expects to collect up to 6500 kg sunflower stalks from the 90 farmer clubs to the end of October. With a conversion rate of 1kg stock to 0.9 kg briquettes, this will result in a total expected production of approximately 5850 kg of briquettes in the season of 2025. This positive start to the 2025 production cycle will allow to meet the

increase in demand of clean cooking fuel and provide a new revenue stream for farmers and agents and further support end users access to sustainable cooking fuel.

Considerations regarding increasing production further

Increasing the supply sunflower stalks. There are two immediate ways to increase raw material supply. Either to increase supply from the 90 farmer clubs who are already supplying or to extend agreements to the remaining 110 farmer groups. GG plans to recruit more farmers into selling sunflower stalks by offering a competitive price for the stalks in order to harvest more stalks.

Currently, GG is buying approximately 250,000 kg of grains in a season from the 200 farmer groups. These clubs are in two districts and GG only have stalk sale agreement with the 90 groups in Mchinji region surrounding the factory. According to research on sunflower production, the residue-to-product ratio for sunflower is 1.5-2⁴⁹. This indicates a potential of 375.000 - 500,000 kgs available raw material from the 200 farmer clubs. However, currently, farmers are only willing to sell part of their waste material to GG as they are relying on some of it for other purposes.

One option to increase supply of raw material from current levels could be to increase the price paid to the farmer as well as to recruit more farmers to join sunflower farming among the 200 clubs under GG.

Going Green is slowly reaching maximum monthly production capacity during harvest season of sunflower stalks based on the current production method (2 days preparation and 3 days production cycle). Further improvement in the production cycle or longer operating hours may improve monthly production capacity. According to its specifications, the machine's production capacity is 10-25 kg per hour (depending on feedstock). At an assumed production capacity of 17 kgs pr hr and if run for 8 hrs pr day for 22 days the total maximum output is 2992 kgs pr month. At the current production cycle, the machine can be run for 13 days pr month with a maximum capacity output of 1768 kgs / month.

While optimising the production and operation process may increase production slightly, it will not enable a larger scale up in production which is needed both to feed the market demand as well as to ensure viability of the business case. GG is therefore considering the purchase of a larger scale briquetting machine. Expanding production will have to be combined with expanding supply of biomass as well as expanding the customer base.

Table 30 Production and sale numbers 2025

	End May – End August (3 months)
Production	3000 kg (1000 kg pr month)
Sales	150 bags (20 kg)
Price	7000 Kwacha (3.5 Euro)
Sales agent	10
Number of customers reached	100 rural households, 50 semi-urban HH and 1 business (according to sales agents from user need assessment survey)

⁴⁹ [Herbaceous biomass – Resources](#) and [Sunflower Residues-Based Biorefinery: Circular Economy Indicators](#)

7.3.6 Market for cooking fuel and user needs

Current fuel for cooking

In the target area, firewood and unlicensed charcoal are common. Sunflower briquettes are slowly picking up by families that have tried them as a cheaper alternative source of fuel. There is not any other production of fuel wood in the area and the firewood that is currently used is mainly bought from Mozambique and some firewood is locally sourced in their fields.

As shown in *Figure 49* charcoal is now selling at 25 to 30,000 kwacha (12.5 – 15 Euro) per 50 kg bag. It is reported by end users in the area that charcoal has increased in price and is usually of bad quality and contains a lot of dust. Average price for firewood is Euro 0.29–0.49 per kg (in rural areas). The price for liquefied gas is \$1.00–\$1.50 per kg.

Table 31 Prices of fuel

Item	Description price	price / Kg MWK	price / Kg euro	Source
Briquettes	20 kg is sold at at 7,000 kwacha (3.5 Euro)	350	0.175	SESA report
<u>Charcoal</u>	50 kg selling at 25 to 30,000 kwacha (12.5 – 15 Euro)	1,000 - 1500	0.49 - 0.79	Evidence from Malawi living lab interview: Local market information
<u>Firewood</u>	Average price in rural areas	500 - 1,000	0.29 - 0.49	Evidence from Malawi living lab interview: Local market information

While the energy content in charcoal of good quality is higher compared to sunflower stalks briquettes, the energy content in charcoal of poor quality is lower compared to sunflower stalks briquettes. Since charcoal has become of poorer quality and contains a lot of dust, the amount of fuel per volume is decreasing, which increases interest in good quality sunflower briquettes.

Table 32 Energy density

Item	Description energy density	Price / MJ	Source
Briquettes	16,5-17,3 MJ/kg	19.0	SESA report
Charcoal	28-33 megajoules per kilogram (MJ/kg)	18.3	SESA report

User's motivations for switching to briquettes and factors influencing customers' purchasing decisions

In rural areas, the majority of briquette users are in low-income households where price is a major factor in determining purchasing. Another factor is availability and accessibility; consumers are more inclined to buy briquettes when they are available in their localities. While affordability and accessibility are the main determining factors, many rural households are now better informed and understand the impact of unsustainable fuel use and are motivated by a desire to reduce deforestation and environmental damage.

People understand that briquettes made from agricultural waste offer a sustainable alternative to cutting down trees for firewood.

In semi urban-urban areas, health benefits are more important. Briquettes that generate less smoke and fewer harmful emissions than conventional fuels such as charcoal or firewood are attractive, especially in households with children, elderly people and people suffering from respiratory diseases. Health-conscious customers will choose cleaner options to reduce indoor air pollution. In semi urban-urban areas social influence is also more important; customers are more willing to adopt a product if some influential people in society are using the same and give recommendation. Delivery or ease of purchase is another factor for user's motivation for switching to briquettes. Urban customers will easily purchase if briquettes are delivered directly to homes or nearby vendors.

Frequency of fuel use and purchase

According to GG local observation, there are different patterns in how households purchase fuels. Rural customers tend to buy less quantity but buy frequent because most households are piece rate earners from activities like farming, casual labour, or small-scale trade, and they buy fuel on day-to-day basis. Rural customers usually buy in quantities of approximately 3-5 kgs. In semi-urban areas households generally have more stable incomes and are more willing to purchase in bulk. On average semi-urban households purchase 20 kg bag of briquettes which lasts a month since briquettes are mostly second source of fuel.

Barriers that might prevent adoption of briquettes

There are several barriers that can prevent adoption. These are described below.

Cost Sensitivity: Although briquettes are cheaper than charcoal and purchased fuelwood in the long run, the initial purchasing price or investment in briquettes, a product which they may not yet know the benefit of, could be a constraint for low-income households or small businesses. The high initial cost of buying briquettes compared to firewood (especially when they are not yet readily available in the local market) can be a big disincentive for customers who still collect their own firewood for free.

Availability in Small Quantities: In some cases, buyers may be looking to purchase small amounts of fuel regularly, something that's less possible with briquettes due to the need to sell in bulk to achieve an economy of scale.

Access to Briquettes: In rural and remote areas, the supply of briquettes is sometimes irregular. Distribution networks have not yet spread widely and transportation costs for delivering briquettes are high (delivery of small quantities over large distances). Because of the limited supply of briquettes in retail outlets, customers may not be able to switch fully and may continue utilising the fuel that they are used to and the fuels that are most available to them.

Traditional Beliefs and Practices: Firewood or charcoal use is rooted in tradition, and there is reluctance to adopt alternative sources of energy. The ritual of collecting firewood

particularly in some rural communities and the tradition of using charcoal as a cooking fuel create resistance for switching to new sources of fuel, such as sunflower briquettes.

Market analysis: Potential market size

Going Green is addressing the dependency on unsustainable fuels and currently over 90% of households still use firewood and charcoal. In the target district alone, there are over 100,000 households and many other small food enterprises that require clean cooking solutions including briquettes. There are also other institutions like schools, restaurants and food vendors that currently rely on unsustainable fuels. This reflects a huge demand for the briquettes which requires stable supply to meet the current demand.

Through the agent's model situated in 10 communities across the villages surrounding the factory, GG are serving approximately 100 end users per month since each agent serves tens of regular customers. With additional 50 farmer clubs agreement through their existing farmer network, GG could double or triple the current reach to at least 300 or 450 household. This would however require a similar increase in production and is therefore only possible with increasing in supply of raw material and increasing machinery capacity for production.

The current reach is modest due to production limitations with the current machine. With additional 50 farmer clubs (out of the remaining 110) agreements for supply of sunflower stalks and increased supply for existing farmer clubs, GG sees a potential for acquiring an additional machine with a capacity of 50 000-80 000 kg per month. GG will in this case be increasing the sourcing of sunflower stalks from current levels to gradually reach over the next five years the maximum potential of 200.000-500.000 kgs in the current catchment area. Strategy for increasing biomass supply will include price incentives for farmers to sell the stalks. This, if combined with other feedstock like wood chips and saw dust would contribute towards a stable year-round production and GGs reach could scale up to 1,000 end users within the next five years. Increasing the production and market reach would strengthen the business by increasing revenue and profitability.

Mchinji district has a population of over 100,000 household and other food businesses. Currently 0.1 % has adopted the use of briquettes and GG anticipate that with increased awareness the potential market demand could increase significantly.

7.3.7 Business model aspects tested and validated

Business model canvas

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
Supplier Sunflower farmers (contracted sunflower growers)	Sourcing of sunflower stalks from farmers Production of sunflower stalks briquettes Sales of briquettes.	High efficiency briquettes compared to conventional fuels; stability in pricing; easy to handle, store, and transport. Solution as alternative to the illegality of unlicensed charcoal in Malawi	Support and training for agents and customers Engagement with customers and gathering feedback Running awareness campaigns	Customer 1 - Rural households' low-income families Customer II - Low to middle-income families' semi-urban households Customer III - Localised businesses and small-scale entrepreneurs
Business supporter: Rise Make It Green (MIG)	Key Resources A steady supply of sunflower stalks. A briquetting press (FALACH Cube 20) and a shredder (Frej of 2.2 kW). A factory for production and storage. Local staff and trained operators. A network of 10 sales agents. Motorbike transportation for delivery to agents. Bags for packaging. Marketing officer and sales agents to build and maintain relationships. A decentralized structure that allows agents to cover a large geographic area.	For Rural households: Briquettes in small quantities that can be purchased daily. For Semi-urban households: Briquettes in 20kg bags for bulk purchase. For local businesses: Briquettes in 20kg bags for bulk purchase. For all segments: Briquettes can be bundled with the MIG BioCooker stove as a starter kit.	Channels Currently, GG is reaching customers through an agent-based model, with 10 sales agents selling the briquettes in their communities. Using local agents as sales agents through motor bike transportation. GG is also testing direct sales at the factory and through the 18 MIG BioCooker users. The agent model accommodates the purchasing habits of rural customers who buy small quantities of fuel frequently. The business is exploring mobile vendors and micro-distribution channels to make briquettes more accessible and fit into the daily routines of rural customers who are used to purchasing charcoal and collecting firewood.	
Cost Structure			Revenue Streams	
OPEX: transportation, electricity, staff, sunflower stalks, and bags for packaging. Sunflower stalks: The cost of the sunflower stalks is approximately 0.01 Euro/kg. Bags: Packaging bags for the briquettes cost 0.08 Euro/bag CAPEX: The briquetting machine and shredder are significant costs. Machinery: The briquetting machine (FALACH Cube 20) and the shredder (Frej of 2.2 kW) are key resources with high initial costs. Costs listed according to highest cost 1. Cost of briquetting machine 2. Cost of shredder machine 3. Raw material transport from farms to manufacturing 4. Energy required for manufacturing 5. Maintenance of machinery 6. Marketing costs 7. Distribution costs			Selling briquettes to sales agents and customers. 0.175 Euro per kg. which is either sold per kg or per 20 kg bag (3.5 Euro). Selling the MIG BioCooker stove as part of a starter kit. Offering subscriptions for regular briquette deliveries. Providing discounts for bulk purchases	

Until now, briquette production has mainly been about testing the market and laying down good foundations for commercialization. Customer feedback has been collected from MIG BioCooker users on cooking time, use of briquettes, time saving and the general convenience of using a clean cooking stove with sunflower briquettes.

Currently the briquetting production is in a second production phase. GG is continuing to conduct market testing to understand what consumers want. This also includes evaluating how much customers will pay.

In a growth stage, GG will be increasing its production capacity, expanding the market reach, driving sales volume and profitability. In a scale up phase, GG will focus on product diversification and geographic expansion and focus on obtaining more institutional contracts. To reach more customers that are using simple cooking stoves, the expended technology could be a local machine that produces non wood char coal briquettes from sunflower stalks.

Customer Segments

The briquetting business is targeting three customer segments:

- Customer segment 1 - Rural households' low-income families
- Customer segment 2 - Low to middle-income families' semi-urban households
- Customer segment 3 - Localised businesses local restaurants, small food vendors and Small-scale entrepreneurs

Customer Segment 1: Rural Households Low-Income Families

The main target are the rural households which are mainly smallholder farmers. They do not have easy access to electricity or clean cooking options. Most of these households use wood-based fuels for cooking but are increasingly searching for affordable and cleaner alternatives. By June 2025, 100 rural household were buying briquettes on a regular basis and had bought briquettes from 10 sell agents across the target area surrounding the factory.

Customer segment 2: Low to Middle-Income Families semi-Urban Households

The second largest customer segment includes semi urban households, especially low-income and middle-income inner city in trading centers of Waliranji, Nsundwe, Mpingu and Namitete. These customers mainly prepare meals using charcoal or electricity, but as charcoal costs increase, or as it becomes harder to find, or as the environmental impact of collecting firewood becomes harmful, they are increasingly using briquettes. By June 2025, 50 semi-urban households had bought briquettes from the 2 agents located at the Waliranji market and directly from the factory.

Customer segment 3: Localised Businesses Local restaurants, small food vendors, and small-scale entrepreneurs that depend on cooking with fire. These businesses rely on methods that have proven to be cost-effective and continuously available to run their businesses with minimal expenditure. Local retail traders including supermarkets, hardware shops, and smaller shops, especially in urban and peri-urban areas serves as distributors of briquettes. These retailers, have already customers walking through their

doors looking to purchase the traditional fuels, such as charcoal and firewood, and by the briquettes to their stock, they can offer a cleaner, more efficient fuel alternative. It also allows retailers to diversify their product mix and cater to the increasing demand for sustainable products which is becoming a new trend in the communities. By August 2025, 1 local business had bought 1 bag of briquettes.

Distribution channels

Various distribution models are being tested: direct sales via market stalls, agent-based sales and local retailer partnerships. So far agent-based sales are dominating, approximately 70 % of the production. The rest of the briquettes are sold by cooperatives and farmer groups. Other potential sellers are:

- ***Local Retailers and Shops*** who already act as distribution points for everyday staples such as food and fuel.
- ***Mobile Vendors*** In some rural settings, transportation infrastructure is not widespread enough, making use of mobile vendors who pass through villages on motorbikes and bicycles is ideal. These vendors sell briquettes to customers daily, fitting both small purchases and the purchasing habits of people living in rural areas.
- ***Micro Distribution*** supply of briquettes using small delivery vehicles or tricycles to ensure that customers do not have to travel very long distance to reach a briquette selling point.

Pricing strategy

So far, the main part of the produced briquettes has been sold by weight to sales agents in 20 kg bags for 3.5 Euro.

Other potential pricing strategies to explore when the production increases are:

- **Subscription Model:** customers sign up for regular, scheduled deliveries of briquettes, at a discounted rate on weekly and monthly basis.
- **Bulk Purchase Discounts:** provide price reductions for larger purchases to incentivize higher volume sales.

The goal is to provide multiple pricing structures and packaging options to appeal to a wide range of customers as they can address various needs and budgets. Smaller pack sizes at lower price points attracts low-income households and first-time buyers who might want to trial the briquettes before making larger purchases. These small packages would create convenience for urban customers also who need an affordable and quick solution for daily cooking. Discounts for first-time buyers or trial packs further lower the entry barrier and give customers confidence in the value of the briquettes. Bulk packaging at a lower cost would appeal to institutional consumers (e.g., schools, hospitals) and larger families who need a long-term, cost-effective solution.

Retail and distribution strategy

Going Green already works with farmer club leaders as retailers for briquettes and there are more potentials for partnerships with local vendors, cooperatives and community groups for the distribution of the briquettes. Going Green is currently also working with firewood vendors who include briquettes in their offering while catering to the same market. GG intends to work with large wholesalers in community markets to increase availability at scale.

With increased production more retailers need to be involved in the sales of briquettes as it improves distribution and access. The following can be their incentives:

- Offering of incentives like discounts for bulk purchases, or credit facilities, or promotional support to encourage them to get involved.
- providing marketing materials, training on product benefits and point-of-sale displays.
- Discounts on first-time purchases.

Giving discounts and promotions would increase sales of briquettes and offering discounts for first-time buyers will also help hesitant customers give briquettes a try and lead them to feel these benefits. Bulk purchase incentives for households, vendors, and institutions will enable large-scale adoption. Various promotional strategies like free trials and repeat customer discounts will create loyalty.

The above approaches will help in driving demand and achieving a customer retention that would incentivize briquettes over firewood and charcoal in the long run.

Additional Revenue Opportunities

An additional revenue model is to sell briquettes with the MiG BioCooker. Through selling as a starter kit, that provides customers that buy the MiG Bio Cooker an initial supply of briquettes at a lower price. This helps demonstrate how the stove and the fuel work together more efficiently.

Two other potential business models that support selling together are:

1. Subscription model where households can get a monthly supply of briquettes at a significant discount, enabling a steady flow of fuel while promoting the continuous usage of the MiG BioCooker.
2. Pay as you go where households can buy the MiG BioCooker in instalments and regularly buy briquettes.

Growth strategy

The growth strategy and scenario for an ambitious scaling of the briquetting business looks as follow:

Scaling Approach

- Acquiring a larger briquetting press: Purchase an industrial briquetting press and 1 big shredder to increase monthly output from current levels (1000 kgs/month) to up to 50,000 kg per month over five years.
- Increase sourcing of stalks from existing supplier base as well as contracting of new farmers.
- Building networks through expanding the existing network of 10 sales agents to 100 in Mchinji, as well as more local retailers, mobile vendors and cooperatives.
- Awareness Campaigns to Capture market by creating awareness among household, schools, restaurants and food vendors to drive the adoption scale up.

Requirements to Scale

- Capital Investment. Bigger briquetting press, advanced shredder and storage space.
- Training and development of agents, coops and vendor's sales techniques training on product benefits.
- Logistics Support through purchase of commercial tricycles to facilitate last-mile delivery.

Growth Scenario (ambitious scenario)

1. Short Term (Year 1–2)

Produce 3,000 to 5,000 kg briquettes/month in the current 4 months season and expand to 6 months production year to. Reach 200 to 500+ households in the Traditional authority we currently serve. This will need an additional briquetting machine from year two.

2. Medium Term (Year 3–4):

Produce 5,000 to 20,000 kg of briquettes/ months and increase to 9 months production per season. Reach 500 – 1,000 households expanding from the 40 km to 80 km the entire Mchinji district. This would be possible with a bigger capacity machine and the addition of the sunflower stalk contracts (100-150 farmer clubs).

3. Long Term (Year 5+)

Operate and distribute monthly capacity of 50,000 kg briquettes/month; supply to big institutional customers in the region.

This would mean expanding the factory and building storage for both more stalks and briquette storage. This will need addition of the sunflower stalk contracts (200 clubs that

grow on at least 1 acre of sunflower. Farmers are within Mchinji district, Dowa and Kasungu (200 to 300 km from factory).

7.3.8 Challenges, learnings and next steps

Limited capacity on the briquetting machine

The briquetting technology that was delivered to Malawi is a smaller machine with limited capacity. The machine has been used to test different local biomass material, increase the knowledge of the process and investigate if there is a local market for the fuel briquettes. The machine is unique in Africa, and the briquettes are different from the briquettes that are used on the market, mainly charcoal briquettes and fuel logs. To scale up and increase the production a second larger machine is needed. Fuel dealers have showed interest to sell the briquettes, but they demand larger volumes than the machine can produce. GG is seeking financing for another machine through grants application.

Access to raw material and quality

Sunflower stalks are abundant during harvesting season and readily available in the region, making them a cost-effective option for local production. GG is strengthening partnerships with sunflower growers to increase supply of raw materials. A challenge is that sunflower stalks are only available under a certain time of the year. To extend the production time, storage facilities is needed. There is a limited awareness among farmers about the value of these waste materials. To be able to produce briquettes and use it as fuel it must be treated right and be of good quality. Therefore, it is Important to mobilize and train farmers for enhanced supply. There is also a need of partnerships with further farmer clubs to stabilize supply chains.

To use different type of biomass during the year as other agro-waste and saw dust will decrease the risks of running out of raw materials. The briquetting machine is flexible and working well with most biomass materials that are dry and free from contaminations. Saw dust is bought from carpenter workshop within the community. There is potential that they could be potential buyers. To control the energy content of the raw material can be a challenge because of high costs to analyse the material in test labs. A challenge is the pricing of the briquettes needs to be adapted to the energy content and the price of the used raw material. A solution is to make analysis on each new raw material since the variation within same material is usually not so big.

High cost in collecting raw materials

Smallholder farmers are widely spread, so collecting their sunflower stalks tend to be expensive. To reduce the transportation cost GG intend to mobilize farmers to prepare their stalks at the same time when the company collecting sunflower grain.

Access to electricity

Access to electricity is a challenge in Malawi. Some parts of the year electricity are not available every day. To scale up the production demand more electricity which can be a challenge. A solution is to have several small-scale production plants at different places. Compared to pellets production briquetting production is also economic using smaller

plants due to more simple and cheaper technology. This will also decrease the collection costs of raw material.

New fuel product on the market

To sell a new fuel product on the market is always a challenge. Selling of briquettes by agents is slowly picking up. Making local partnerships to sell briquettes for commercial purposes is one solution. Sales is managed through 10 sales agents. These agents are already in the business of selling firewood. Going Green supplies these agents with briquettes using a motor bike. Users appreciated convenience over firewood.

Even if the price is competitive, it is still seen as expensive compared to free or cheap firewood in other communities. Firewood sellers dominate the market and there is a need of stronger environmental messaging.

Concluding remarks and next steps

The SESA Malawi Living Lab has successfully demonstrated briquetting that leverages agricultural waste to produce clean cooking fuel. The pilot has validated key aspects of the value chain—from raw material sourcing and production to distribution and customer engagement—while highlighting critical challenges and opportunities for scale.

The initiative aligns well with Malawi's national energy and environmental goals, offering a pathway to reduce deforestation, improve public health, and create local employment. However, to transition from pilot to commercial viability, strategic investments and policy support are essential. Below is an overview of next steps for GG.

1. *Invest in Scalable Technology:* A larger briquetting machine and improved shredding capacity are needed to meet growing demand and achieve economies of scale. Going Green is exploring access to finance from suitable calls to increase capacity in production while exploring other available machinery for briquetting in the country.
2. *Diversify Feedstock:* To ensure year-round production, Going Green is exploring other biomass sources such as sawdust, maize cobs, and rice husks. Going Green aims to diversify a briquetting product type that can suit many types of stoves in the communities to expand market reach. This includes a machine making briquettes from non-wood char coal.
3. *Expand Farmer Engagement:* Strengthen partnerships with farmer clubs through training, incentives, and awareness campaigns to secure consistent biomass supply. Efforts to strengthen local agents for sales are being developed.
4. *Optimize Logistics:* Transportation costs are a major operational expense. Decentralized production and improved delivery systems (e.g., tricycles, mobile vendors) can reduce costs and improve access.
5. *Strengthen Policy Advocacy:* Collaborate with government and civil society to promote briquetting as a recognized clean energy solution and secure favorable regulatory conditions.
6. *Secure Funding:* Pursue donor support and impact investment to cover upfront capital costs and support scale-up activities.

7. *Promote Consumer Awareness:* Continue sensitization campaigns to educate communities on the health, environmental, and economic benefits of briquettes and clean cookstoves.
8. *Monitoring and evaluation* will be on going to enable product development and future improvements.

7.4 Malawi: solar irrigation use case

7.4.1 Introduction - problem and solution

Problem

Malawi is an agro-based economy where agriculture accounts for one-third of the GDP and 90% of the export revenues. In addition to that, agriculture employs 80% of the population in Malawi. Studies have shown that only 15% of the arable land is under irrigation in Malawi (AICC, 2017). Specifically, Karonga district has over 13,000 hectares of land under rice cultivation, only 2,500 hectares is under irrigation representing only 19% of the potential area. This is mainly because smallholder farmers do not have access to sustainable irrigation equipment due high operating and upfront costs of fuel water pumps and solar pumps respectively. Consequently, income and food security is erratic due to high dependence on rain-fed agriculture which is seasonal and prone to climate change related effects like dry spells and drought. Pillar 1 of Malawi Vision 2063 also prioritises promotion of sustainable irrigation technologies to avert adverse climatic variability for a resilient productivity (Malaw's Vision 2063, 2020).

Solution

Smart Energy Enterprise (SEE) improves energy accessibility by selling solar powered irrigation systems to individuals and groups of smallholder farmers on loan basis using a lease-to-own business model on Pay-As-You-Grow arrangement. Farmers only assume complete ownership of the irrigation system after full loan recovery. The unique selling position of this business model is in its flexibility to accommodate the most resource-poor farmers through pay-as-you-grow basis.

Technical Functionalities

The irrigation package consists of a surface water pump with the capacity to pump up -to 50,000 litres of water per hour at maximum head of 17 meters. This pump is therefore most ideal for surface water sources like perennial rivers, lakes, reliable shallow wells and dams. The pump is ideal for rice cultivation because most rice farming activities occur along the lake shore areas which have abundance of surface water sources.

Pump Description	Specifications
Discharge	50,000 Litres/hr
Head	17 Meters
Power rating	1,500 Watts
Outlet	3 inches

Table 33 Solar pump specifications



Figure 72 Kanyumba Solar Pump Irrigation system

Kanyumba Solar Pump Irrigation system (*Figure 72*) is a movable pump house which is designed to accommodate farmers on farm to provide security and safety for the pump and crops all times while also protecting irrigation package from damage during rainy season since it can be moved up land.

How the solution addresses market needs

SEE utilizes a lease-to-own business model that offers solar pumps on a Pay-As-You-Grow basis. Under this model, farmers use the irrigation system while making payments over time, eventually gaining full ownership of the equipment. This model is designed to address affordability issues associated with solar pump irrigation systems. This is done by dividing the payment for the system into a 20% commitment fee followed by two instalments which are temporally aligned with the harvesting seasons. The Kanyumba Solar Irrigation Package is released for use to the clients upon payment of the commitment fees. Farmers initially pay MWK 1,260,000.00 (718 USD) only to acquire the durable and customized solar irrigation package which has an overall cost of MWK 6,300,000 (3,591 USD). This irrigation system pumps enough water to irrigate a 6-hectare rice field. Additionally, SEE has established local partnerships with financial institutions such as NBS Bank and National Economic Empowerment Fund (NEEF) at the district level, facilitating connections between farmers and banks to obtain soft loans for purchasing solar pump irrigation systems. The two following installments are paid post-harvest in year one and year two.

How the solution differs from existing solutions in the market

The solar packages on the market are mainly tailored for estates and have an average cost of MWK 28,000,000⁵⁰ (15,960 USD) and maintenance costs of around MWK 6,570,000 (3,745 USD). Not only that, the price for motorized petrol and diesel pumps ranges from MWK 565,000 (322 USD) to MWK 1,200,000 (684 USD) however, they have an average running cost of MWK 1,550,000 (883.5 USD) in rice farming for a single production season. The running costs of the motorized pumps are high due to the high cost of petrol and the consumption rate. This has an effect on the profit margins. Much of the resources are used to buy fuel and maintain the pumps. The next competing product is the submersible pump, but with the high initial costs, they are not accessible to farmers. Besides, once the pump has been supplied, there are no after services to support the same.

The Kanyumba Solar Irrigation Package is useful because it comes with a comprehensive package. It eliminates high initial cost barrier through Lease to Own approach; it also provides after-sale services which include extension services to ensure profitability of rice farming and to assist the farmers to repay the loans. Linkages to profitable markets is another competitive advantage. Thus, the company is not only after the sales of pumps, but also accompanying the farmers as they grow over a period of two years. These do not have similar adaptations like the ones the Kanyumba Solar Irrigation Package. Small holder farmers usually have access to FS solar pumps which support vegetable farming and cannot support rice farming. Thus, Kanyumba Solar Irrigation Package, tailored for rice farming at an equivalent price of MWK 8,167,485 or approximately \$4,705.88. This will be paid over a period of two years. Thus, this will be affordable for small-scale farmers.

7.4.2 Implementation summary

The SESA project has enabled SEE to develop and dispatch 25 solar irrigation systems which has proven successful in the market by addressing the pressing needs of smallholder farmers.

SEE successfully procured all 25 solar-powered irrigation packages within the project period. All 25 solar pump irrigation systems have been sold and distributed to 46 smallholder farmers, falling short of the target of 375 smallholder farmers. This reduction in the number of clients reached was primarily due to dry spells that impacted the income of most farmers, making them unable to make commitment payments for the irrigation systems. Financially capable farmers were not inclined to work in groups, as they were primarily commercially oriented individuals.

The procurement process experienced delays due to forex shortages in Malawi, impacting suppliers and causing a scarcity of solar pumps in the country. Some pumps had to be sourced from Lusaka, Zambia. Additionally, the process was affected by unexpected price increases for solar pumps due to the devaluation of the Malawi Kwacha, leading to high

⁵⁰ Exchange rate used: 1 Euro = 1911 Malawian Kwacha

inflation rates. Nevertheless, the overall objective of the SESA project was not affected by these challenges.

The business has experienced annual revenue growth rate of 65% during the SESA project period which has generally improved the cash flow and income of the business both in the short and long run. SEE has also engaged with financial institutions such as NEEF and NBS bank in promoting solar related irrigation loans where SEE Ltd is the supplier of the irrigation equipment to these Financial Institutions on cash and carry basis, which has also helped to enhance cash flow for the business. SEE has established a network of agents (AEDCs) who market and facilitate the sales of solar pump irrigation systems to smallholder farmers. These agents operate on a commission basis using a referral-based marketing strategy.

During the project's duration, SEE also developed a digital loan and pump management system to ensure proper operation of the pumps and streamline business processes. Additionally, the SESA project has empowered SEE to partner with financial institutions in providing irrigation loans to smallholder farmers, thereby increasing accessibility to pumps and boosting SEE's cash flow. Due to the impact and track record established during the SESA project, financial institutions are now willing to collaborate with SEE in offering irrigation loans to smallholder farmers.

7.4.3 Business model aspects tested and validated

SEE has tested and validated sales of innovative solar powered Irrigation systems to smallholder farmers using a lease-to-own business model while through various marketing strategies in order to increase uptake of such irrigation systems. Solar pump irrigation system embedded with digital components was developed and tested effectively. In addition to that, referral marketing strategy was also tested replacing the old-aged community sensitization meetings. The lease-to-own business model was also tested through sales and distribution of 25 solar pump irrigation systems in Karonga district.

Business model canvas

	KEY ACTIVITIES	VALUE PROPOSITIONS	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENTS
Suppliers of Solar Pumps • DIFFUL • FISD • DIGTALK • LORENTZ Off-Takers • Home Industries • NASFAM • Rukuru Women Rice Cooperative Financial Funding • Donor Aid • Financial Institutions	• Market Research • Customer Identification • Establishment of water-user groups (WUG) • Provision of trainings to stakeholders/farmers • Procurement of Solar pumps, solar panels & all related equipment's • Solar pumps Installation • Field visit (for extension services) • Buying and selling of farm produce • Loan Management • Business development	Value Propositions • Sale Solar Pumps for Irrigation System on Pay as You Grow basis (Lease-to-Own) • Provision of ready market outlets to farmers (Purchase farmers produce/Link to off-takers) • Provision of technical know-how/extension services to farmers at zero-cost • Direct production of rice to create demonstration farms for the communities • Digitized loan and farm management and monitoring systems	• Customer Needs will be satisfied by tailor-made pumps • Long-term Engagement leading to more trust and loyalty • Farming-arrangement by contract • Customers will gain Legitimacy through engagement with SEE which can enable them to access financing and other benefits from various stakeholders	• Smallholder Rice Farmers (WUG/Individuals) • Smallholder Horticultural Farmers • Malawi Government • NGOs/INGOs • Commercial Farmers
	KEY RESOURCES • Professional Staff/Staff members • Financial Capital (Money) • Assets/Equipment (incl. Solar Panels) • Abundant water sources • Availability of land suitable for irrigation practices • Office premise • Motor Vehicles and motorcycles for logistics purposes		KEY CHANNELS • Business to Customers (B2C) • Business to Business (B2B)	
	COST STRUCTURE		REVENUE STREAMS	
1. Fixed Cost • Salaries • Rentals • Water & Electricity Bills • Wages • Direct labor 2. Variable Cost • Repairing & Maintenance cost • Transportation/Fuel cost • Direct materials consumed 3. Mixed Cost • Water and Electricity bills • Office Stationery		• Grants • Installment payments from pump sales (through commitment fee and after harvest payments) • Sale of spare parts for Solar Irrigation Systems • Buying and selling of farm produce (e. g. Rice) • Sale of farm inputs (e.g. Seeds) • Loans • Agricultural production (Farm) • Equity (Shareholders) • After sale maintenance and repairing service fee		

Table 34 business model canvas Kanyumba solar powered irrigation system

New customer segments

SEE initially targeted the very poor farmers. Unfortunately, this customer segment has been financially affected by prolonged dry spells rendering them unable to pay commitment fees. A new customer segment of commercial farmers emerged and paid commitment fees quickly with ease. These farmers are demanding more solar pumps while inspiring the very poor farmers to also acquire solar powered irrigation technology. NGOs are also buying irrigation products on cash and carry basis. On the other hand, financial institutions are also providing irrigation loans to farmers that are channeled to directly purchase irrigation pumps from SEE on cash and carry basis.

New Product Developed

Based on thorough market assessment and valuable customer feedback, SEE has developed an innovative product known as the Kanyumba (meaning 'house') Solar Powered Irrigation System. This system is meticulously designed to address the pressing challenges that farmers face on their farms. It effectively tackles issues related to safety, security, mobility, and vandalism while still fulfilling the essential irrigation needs of the farmers. By integrating these critical features, SEE ensures that the Kanyumba system not only enhances the efficiency and reliability of irrigation practices but also provides peace of mind to the farmers regarding the protection and portability of their equipment. This irrigation package is also embedded with digital loan and pump management system which enables SEE to improve the efficiency and effectiveness of the pump and business management.

This newly developed product is also being promoted by engaging with financial institutions. This has enabled SEE to scale up its cash-based revenues since the solar pumps are sold to farmers through the financial institutions who make direct full cash payment for the pump to SEE thereby enhancing revenue growth and sales volume.

New Marketing Strategies

SEE has adopted a referral marketing model that has proven to be both cost-effective and sustainable, in contrast to the previously costly community sensitization meetings. SEE has established a network of highly committed Agriculture Extension and Development Coordinators (AEDCs) who also work as agents on commission-based remuneration. These AEDCs have a very good knowledge of the community and potential buyers which has significantly improved the sales of solar pump irrigation systems for SEE.

Market Analysis

SEE has a market share of approximately 5,000 smallholder and commercial rice farmers and 12 NGOs working on various projects in agriculture in Karonga district with 16,300 smallholder and commercial farmers and 19 active NGOs working on agriculture.

Figure 73 demonstrates the three customer segments and a detailed market analysis on pain points of each segment (Pains), their products (features), the unique selling point that SEE is having (USP) and the offerings that SEE has used to address this customer segment.

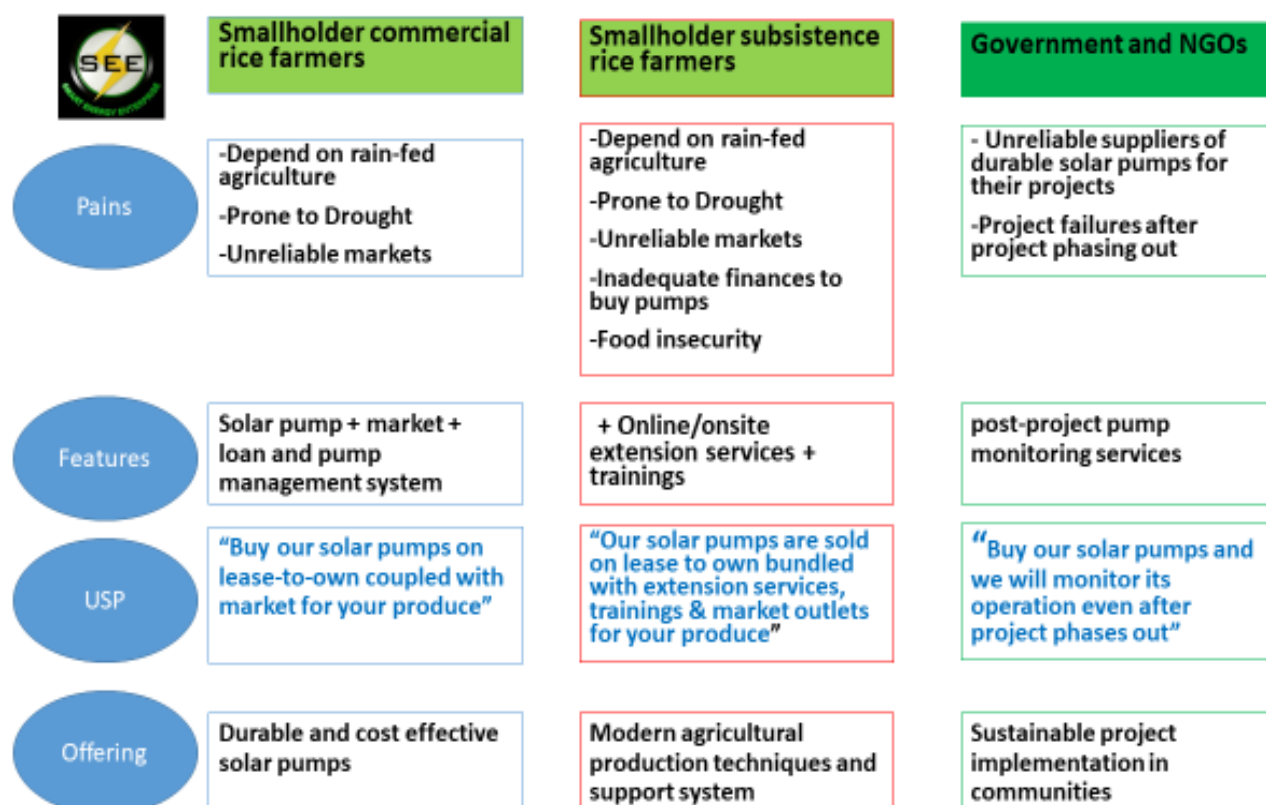


Figure 73 Customer segments

Customer segment and development

During the reporting period, SEE identified 2 more customer segments in addition to targeting small-holder farmers which consist of the following;

- i. Commercial Farmers
- ii. Non-Governmental Organizations (NGOs)

SEE engaged with smallholders and commercial farmers through referral marketing strategy which enables SEE to get customers who are most likely to pay the initial 20% commitment fee requirement. For most farmers, trust was built through SEE's continued supply of high-quality products which ensure that the solar-powered irrigation systems meet the needs of the customers. Consistently delivering on promises has built a solid foundation of trust. SEE has further been very transparent about product specifications, pricing, and any associated costs to avoid any surprises for the customers. SEE has further provided after-sales services such as extension services, responsive support, maintenance services, and a robust warranty policy.

The primary feedback from 31 surveyed customers indicates that the lease-to-own model aligns well with their needs and financial capacity. However, they highlighted concerns regarding the security, safety, and portability of the previous solar pump irrigation system, leading to the development of the Kanyumba Solar Pump Irrigation system. This innovation has significantly increased product demand. Additionally, some farmers have

requested smaller solar-powered irrigation systems for maize and other horticultural crops. SEE are currently considering the type and design of pumps that will be specifically tailored to meet the needs of this group of customers.

The feedback led to the development of Kanyumba Solar Pump Irrigation system which addresses safety, security and portability. Kanyumba solar irrigation system consists of a movable solar pump house which can be trolled from one place to another to keep the irrigation system safe from flooding during rainy season. In addition, Kanyumba solar pump irrigation system provides accommodation to the farmer on-farm to provide security and safety to the solar pump irrigation system as well as the crops in fields from thieves and livestock respectively. Furthermore, new innovation on smaller but more durable solar powered irrigation systems are under development to address the feedback from the customers.

The customers surveyed also assured of their economic growth and independence. Their production has increased drastically even from the rain-fed agriculture mainly because rain no longer has influence on their productivity due to solar powered irrigation. Previously, farmers only earned average revenue amounting to MWK 2,400,000 (1,368 USD) per hectare per year from rice harvests. Farmers are now able to earn a total income of MWK 5,000,000 (2,850 USD) per hectare per year from both rain-fed and solar irrigated rice proceeds. In this regard, on average, farmers indicated a 100% increase in their production from rain-fed agriculture which has improved their levels of income.

SEE has achieved a 96% loan recovery rate over the project period. Customers have generally been able to pay instalments on time. However, 4 out of 25 groups experienced a 14-day delay in their second post-harvest payments due to issues with transporting produce to the market. Farmers highlighted two main causes for delay i) Prices offered on the market were not satisfactory to them which rendered them to wait a little bit for possible increase in prices ii) Some farmers are located in very remote areas with very poor road network that makes it very difficult for farmers to transport their produce to the market for them to make quick and duly loan payment for the pump. SEE purchased the rice from most farmers and some were connected to the legitimate off-takers who purchased their produce from their farms. No default has been experienced. This made it possible for the farmers to make timely loan payment.

Farmers are enjoying a very good relationship with SEE due to quick response to the problems that arise to the customer on farm and solar pumps. The surveyed customers hinted on the reliability of SEE to the contract agreement and extension services which has enabled farmers to transform their farming techniques.

Go-To-Market Strategy

The business further leveraged an inbound sales strategy, enabling SEE to create engaging posts on social media platforms that successfully attracted the attention of NGOs and government agencies. Simultaneously, an outbound sales strategy was employed to engage with financial institutions, facilitating discussions on partnership agreements and the signing of Memoranda of Understanding (MOUs). Additionally, the

business utilized a B2C distribution channel, with AEDCs (Agricultural Extension Development Coordinators) and agents serving as facilitators in the transaction process. This multifaceted approach has strengthened SEE's market presence and expanded its network of collaborators and customers.

Key components of the promotional plan for launching the product/service in the new customer segment/ new region:

- **Market Research and Analysis**
SEE will frequently conduct surveys and focus groups to understand the needs, preferences, and pain points of potential customers in the new region or/and new customer segment to develop solar powered irrigation systems that are tailor-made to their situation.
- **Partnership and Collaboration**
SEE has partnered and will continue to partner with financial institutions to generate cash-based revenue through the direct sale of solar pumps. These institutions will then offer the pumps to their customers under agricultural loan portfolios, thereby enhancing the cash flow of the business. Additionally, SEE will engage with NGOs and government agencies to further drive sales and expand its impact.
- **Events and Exhibitions**
SEE will also organize a launch event to create excitement and attract media attention. Additionally, taking part in trade shows and expos will help to display the product. Live demonstrations in busy areas will be carried out to draw in and inform potential customers.
- **Digital Marketing Campaign**
SEE has been and will extensively advertise its irrigation products on digital platforms like Facebook, LinkedIn, X and many more to attract the attention of potential buyers.

Product Accessibility for End-Users

Accessibility of solar pump irrigation systems for customers will be improved through ongoing enhancements to digital systems, which will aid in the proper management and monitoring of these irrigation systems. Furthermore, establishing connections with international suppliers will allow SEE to procure solar pump irrigation systems at more competitive prices, ultimately reducing the cost for prospective customers, thereby improving accessibility of the solar pumps. Most target customers (smallholder farmers) in the rural areas are more willing to pay the MWK 1,260,000 (718 USD) commitment fee than to use fuel or diesel-powered pumps which have high operational costs. This is evidenced by increased demand for SEE's solar powered irrigation systems with an average of 4 solar pumps sold on a monthly basis. Customers think, accessibility is well enhanced, but they also requested for relatively small scale solar powered irrigation

systems designed to cover smaller chunks of land ranging from 0.5 to 2 acres which is currently under scrutiny and consideration by SEE.

Partnerships and planned collaborations to enhance market reach

SEE has been and will partner with financial institutions to earn cash-based sales which will improve the cash flow of the business. The business will further engage with NGOs and government agencies to increase sales and impact. SEE is also intending to partner with international suppliers of solar pump irrigation systems to enhance continued supply of solar pump irrigation systems even in times of forex shortages.

Pricing

SEE used cost-plus pricing strategy which involves adding a fixed profit margin to the production costs of goods or services in order to generate a desired rate of rate of return. Under the SESA project, price for solar pumps was increased to maintain profit margin. The increase in product price is partly due to the sporadic fluctuations in the value of the Malawi Kwacha, which lead to frequent increases in the price of raw materials for producing solar-powered irrigation systems and partly due to increase in production cost. In 2023, SEE needed to sell 5 solar pumps to break even, while in 2024, due to changes in cost and price dynamics, SEE only needed to sell 4 pumps to achieve the same result. Such price adjustments based on the product cost dynamics enables SEE to maintain or increase profit margin while satisfying market needs.

Further pricing for the system's instalments was determined through meticulous calculations, taking into account various commitment rates to ensure affordability and financial viability for small-scale farmers. These calculations considered factors such as repayment periods, and the economic conditions of the target market, aiming to provide a sustainable and manageable payment plan for the users of the solar pump irrigation systems as depicted in the table below.

This strategy will greatly enhance affordability and profitability in the future when SEE gains access to international manufacturers and suppliers offering raw materials at relatively subsidized prices.

Aligning pricing strategy with the overall market positioning of the product

The cost-plus pricing strategy aligns very well with the overall market positioning of Kanyumba solar pump irrigation systems. This is mainly because the pump design (a house for the farmer to sleep in) is very unique with more social and economic benefits attached to it than those offered by the competitors. This pricing strategy further increases accessibility of solar pumps irrigation systems. Kanyumba solar pump irrigation system is sold at MWK 6,300,000 (3,591 USD) and farmers are only required to pay MWK 1,260,000 (718 USD) commitment fee for them to acquire the irrigation package with the following payments made on pay-as-you-grow basis. On the other hand, SEE's competitors are selling solar pump irrigation systems at very high initial prices which are far beyond the financial capacity of most smallholder farmers. Most submersible solar

water pumps have a price range of MWK 28,000,000 (15,960 USD) to MWK 45,000,000 (25,650 USD) sold on cash and carry basis. Other surface water pumps are sold on cash as well at prices ranging from MWK 4,000,000 (2,280 USD) to MWK 18,000,000 (10,260 USD) which still propagates the high upfront costs associated with solar pumps.

Fuel water pumps likewise have very high operational costs which are greatly affected by increasing costs of petrol which is currently being sold at MWK 2,730 (1.56 USD) per Litre which means farmers spend over MWK 1,550,000 (883.5 USD) by the end of the growing season in rice irrigation over a 5 to 6 ha piece of land. Due to forex shortages in Malawi, petrol is frequently scarce which poses some farm operation risks. Besides, these petrol water pumps have very high risk of wear and tear due to their combustion mechanism.

Smart Energy Enterprise Company Ltd is currently selling one Kanyumba Solar Pump Irrigation System at MWK 6,300,000 (3,591 USD) which is payable in 3 installments, mostly post-harvest over a period of 24 months.

Profits are expected to increase over the next 3 to 5 years due to a rise in sales volumes and revenues. SEE aims to further improve the profit margin by directly importing solar pump irrigation systems from international manufacturers and suppliers by the end of 2024, which is anticipated to result in a 20% increase in the business's profit margin.

Breakdown of Instalments Payment

Table 35 Instalment payment plan for the solar irrigation system

	Description	Commitment Fee (MWK)	First Instalment (MWK)	Second Instalment (MWK)	Total Package Cost (MWK)
			Year 1 After Harvest	Year 2 After Harvest	
1	On Registration	1,260,000.00			1,260,000.00
2	First Instalment		2,520,000.00		2,520,000.00
3	Second Instalment			2,520,000.00	2,520,000.00
				Total	MWK 6,300,000.00

Price adjustments through the SESA-Project to increase affordability

In May 2023, Karonga district encountered prolonged dry spells which affected most smallholder farmers and their productivity. The income of most smallholder farmers was greatly affected in so much so that they were not able to pay initially proposed 30% commitment fee. Thus, during the SESA project, the commitment fee arrangement was adjusted to 20% which was tested and validated as more ideal to both the farmers and

SEE. This was done on the other hand to counter high inflation rates which occurred due to the devaluation of the Kwacha. SESA project empowered SEE's lease-to-own business model which has enhanced affordability among smallholder farmers. Through SESA project SEE has gained the potential to partner with suppliers who are willing to offer solar pump irrigation systems at subsidized prices which will in turn help to promote affordability aspect for the farmers.

7.4.4 Sustainability and impact

The lease-to-own model for SEE is very feasible more especially when bundled with 2 main after-sale services as follows;

- i.) **Extension Services;** which enables SEE to frequently monitor and train farmers in modern farming practices which helps farmers to improve their productivity which enables them to easily make post-harvest payments for the solar pumps in time.
- ii.) **Market;** which enables SEE or its partners to off-take the produce from farmers at reasonable prices thereby empowering farmers to boost their income and revenues.

These two services have proved to very important in a lease-to-own business arrangement which has improved because it completes the business model. Not only do SEE provide the solar pump irrigation products, but SEE also empower farmers with the modern farming knowledge and market outlets for their produce.

Despite all this feasibilities, this business model has the following major risks;

- i. **Default;** as indicated in Section 3.4 above, this risk has been mitigated primarily through the digitization of SEE's business model. This includes the establishment of a digital loan and pump management system, which allows SEE to shut down the irrigation system until payment is made. By directly purchasing produce from farmers, SEE and its partners ensure that payment for the pump is deducted first before disbursing the remaining amount to the farmers.
- ii. **Theft of Solar Panels;** which has been eliminated by development of mobile kanyumba (house) solar irrigation system which provides accommodation to the farmer on-farm to secure the pump and accessories, allowing them to be stored safely

This business model has proved very successful in the Northern part of Malawi, specifically in Karonga district. The model has made solar pump irrigation systems more accessible to smallholder farmers. A total of 46 smallholder farmers (households) has been impacted by the business during the SESA project period. Previously, farmers were harvesting 18,000 Kgs of rice from 6 ha piece of land which has been complemented by extra 19,200 Kgs of rice from winter cropping using SEE's solar pump irrigation systems. This means farmers have doubled their production from 18,000 Kgs to 37,200 Kgs per annum. Their annual production capacity and income has exponentially increased by an average of 100% from MWK 12,100,000 (6,897 USD) to MWK 24,900,000 (14,193 USD) on the same 6 ha piece of land due to their ability to produce twice a year and their ability to regulate supply of water to the crops as per crop water requirement on daily basis.

Kanyumba Solar Pump Irrigation System has the capacity to irrigate 6 hectares of rice fields depending on soil water holding capacity and water source (dynamic head). As depicted in Table 36, the cost of producing rice on a 6-hectare piece of land is MWK 6,060,000.

Table 36 Capital expenditures (CAPEX) for farmers on a 6 ha rice farm.

	Description	Inputs	Quantity	Unit Cost	Amount (MWK)
1	Rice Production Costs (6 Ha)	Fertilizer	30 bags	85,000	2,550,000
		Seed	45 kgs	1,500	67,500
		Herbicides	10 bottles	18,000	180,000
		Sacks	360	500	180,000
		Labor	1	562,500	562,500
		Solar pump	1	2,520,000	2,520,000
				TOTAL	6,060,000

Table 37 Projected income for one Water User Group (smallholder farmers) cultivating 6 hectare rice farm

	Description	Area (Ha)	Yield per Ha (Kgs)	Total Yield (Kgs)	Selling Price per Kg (MWK)	Amount (MWK)
1	Rice Production	6	3,000	18,000	800	14,400,000.00
Total Income						14,400,000.00
Production Costs						6,060,000.00
Gross Profit per WUG						8,340,000.00

Upon full production of rice on a 6-hectare piece of land, farmers realized an average profit of MWK 8,340,000 (4,754 USD), even after post-harvest payment for the pump. This means that farmers earn an additional MWK 8,340,000 (4,754 USD) from solar-powered irrigated rice, on top of their usual earnings from rain-fed agriculture, resulting in an average total income of MWK 15,800,000 (9,006 USD) per year. This increase in income has enhanced food security for smallholder farmers throughout the year, significantly improving the livelihoods of the target customers in the Karonga district.

Table 38 Impact of SEE business in terms of yields and income on the customers

Variables	Before Irrigation	After Solar Powered Irrigation
Yields	3 tons per ha	6.2 tons per ha
Income/revenue	MWK 2,400,000 per ha	MWK 5,000,000 per ha

As illustrated in Table 38, the business has significantly improved both yields and income for customers. Annual yields have increased from 3 tons per hectare to 6.2 tons per hectare, and income has risen from MWK 2,400,000 per hectare to MWK 5,000,000 per hectare, resulting in enhanced food security for customers.

Growth Strategy and replication potential tested

During SESA program SEE tested and planned the following growth strategies:

Regional expansion into neighbouring countries

SEE aimed to improve its revenue flow by selling solar pumps on a cash basis to clients with the financial capability. As a result, SEE identified and partnered with a new customer segment consisting of financial institutions, which purchase pumps directly from SEE and provide them to their respective customers on loan. Over the next five years, SEE intends to extend its operations into several neighbouring African countries, including Zambia, Tanzania, Mozambique, and Zimbabwe. This strategic regional expansion aims to diversify and strengthen revenue streams, thereby reducing dependency on a single market. By broadening its geographic footprint, SEE will be better positioned to navigate and mitigate the risks associated with exchange rate fluctuations of the Malawi Kwacha. This move not only enhances financial stability but also positions SEE as a prominent player in the regional irrigation industry which fosters resilience and long-term growth.

Agro-Dealer Shop as another income stream

SEE plans to shift from its current stock storage system to continuous marketing and supply of branded rice in the market, aiming to improve revenue flow and establish itself as one of the major suppliers in Malawi. This goal will be achieved through contract-based supply of rice to reliable regional markets. To facilitate this, SEE will construct a modern rice processing plant for processing and packaging rice. This is a crucial step for SEE to obtain a license from the Malawi Bureau of Standards (MBS) and become a legitimate rice supplier. SEE will also integrate an Agro-Dealer Shop outlet to broaden its product range and diversify revenue sources with climate-smart agricultural products. These products

will include sustainable cooking stoves, seeds, fertilizers, farming machinery, construction materials, and irrigation-related spare parts. This initiative will create a one-stop centre for smallholder farmers.

Digitalise business model for widening reach

Another growth strategy is to digitize SEE business by adding a chip to pumps to complement extension services, improve monitoring of pump performance and enforce loan repayment. This digital transformation will eliminate geographical and other barriers, enabling seamless management and sales of the product across diverse regions and time zones. By integrating IoT technology, SEE can monitor and control the irrigation systems remotely, ensuring optimal performance and timely maintenance, which will enhance customer satisfaction and operational efficiency.

Construction Services as another income stream

SEE also integrated this business model with construction services, specifically in the irrigation sector. As a result, SEE has successfully won tenders for government-funded small and medium irrigation construction projects, continually boosting its revenues. These projects have empowered SEE to become one of the major players in the irrigation industry in Malawi.

7.4.5 Challenges and Learnings

SEE's target customers initially consisted of resource poor small-scale farmers. But this did not work due to prolonged dry spell which affected their income resulting in their inability to pay 20% commitment fee for solar powered irrigation system. SEE changed the focus to target farmers with ability and zeal to pay depending on the power of demand on the market. This really worked well for SEE as demand for SEE's solar pumps miraculously spiked excessively within a short period of time.

SEE used to conduct community sensitization meetings as a marketing strategy for solar pumps. However, this did not effectively yield positive results since several meetings were conducted with only a few buyers obtained out of it. In this regard, SEE transitioned from this marketing strategy to referral marketing strategy which has enabled SEE to capture a huge market at very minimal cost.

The business initially intended to sell solar pump irrigation systems to water user groups consisting of 25 smallholder farmers per group. This did not work due to financial instability among most farmers thus lack of group cohesion in paying the 20% commitment fees requirement. SEE targeted individuals and small groups of 2 to 5 members and in rare cases 15 members each who organized themselves based on mutual trust that is enforced by strict group constitution and by-laws. This has really worked well as farmers are maintaining proper business group dynamics.

SEE uses field officers for period monitoring of the farm and loan management exercises. This has proved futile especially as the company is growing over greater geographical spaces. SEE has now adopted digital loan and farm monitoring and management systems.

8 Ghana

8.1 Introduction to the validation use cases

In Ghana, two validation use cases have been implemented under the SESA project: (i) waste-to-energy (bioethanol) and clean cookstoves, and (ii) solar micro-grids and individual energy access solutions. Both interventions were selected to address pressing national challenges of clean cooking, waste management, and reliable access to electricity in rural and peri-urban communities.

The first, involves waste-to-energy - bioethanol from agricultural waste - and cookstoves implemented at four secondary schools by SME partner Econexus (subcontracted by Siemens Foundation under T3.4) in collaboration with AAMUSTED. The aim is to introduce clean-burning bioethanol cooking fuels and cookstove solutions to new customer segments, specifically public secondary schools in Ghana.

The second use case, is a micro-grid combined with individual solutions to improve energy access for rural communities, urban households and businesses implemented by SME partner Nastech (subcontracted by Siemens Foundation under T3.4). As part of the SESA project, Nastech has scaled the company's operations, increased productivity, expanded its market reach and provided skills training to young Ghanaian youths in solar energy technologies by equipping them with the knowledge and skills to increase job creation potentials. Nastech has through the SESA project increased its production capacities, acquired the machinery that will support operations and increase production of products, expanded the e-waste recycling and collection process and provided solar micro-grid and individual electrification solutions to off-grid Ghanaian communities.

8.2 About the implementation partners

The Ghana Living Lab involves two primary validation partners—Econexus Ventures Limited and Nastech Power Solutions—supported by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) and the SESA consortium partner LEITAT.

LEITAT (SESA consortium partner)

LEITAT is a private non-profit organization with more than 10 years of experience in industrial innovation. LEITAT contributes technology expertise and provides technical support to the bioethanol and cookstove activities. It also supports training, knowledge dissemination, and overall management tasks, ensuring alignment of Ghana's validation activities with broader SESA objectives.

Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) (SESA consortium partner)

AAMUSTED, a Ghanaian member of the SESA consortium, provides technical expertise, research coordination, and capacity-building. The university supports implementation by facilitating stakeholder engagement, monitoring outcomes, and training students and

professionals. It also ensures that insights from the Ghana validation use cases are disseminated nationally and across other SESA partner countries

Econexus Ventures Limited (SME Partner sub-contracted under T3.4 by Siemens Foundation)

Econexus Ventures Limited is a Ghanaian social enterprise that produces and distributes bioethanol fuel from organic waste and agricultural by-products. Within SESA, Econexus leads the bioethanol and clean cookstove use case, focusing on public secondary schools as a primary customer segment. Its role is to demonstrate the technical and commercial viability of waste-to-energy solutions while reducing reliance on biomass and LPG for cooking.

Nastech power solutions (Nastech) (SME Partner sub-contracted under T3.4 by Siemens Foundation)

Nastech Power Solutions specializes in decentralized solar energy technologies, particularly through upcycling electronic waste into affordable solar generators, inverters, and lithium battery banks. Nastech leads the micro-grid and individual energy access use case, piloting innovative models to extend electricity access to off-grid communities and low-income households. It also incorporates skills training for young people, advancing circular economy practices and employment creation.

8.3 Ghana: waste-to-energy and cookstoves in schools use case

8.3.1 Introduction – problem and solution

In rural Ghana, the poor, constitute most of the people who rely mainly on biomass for cooking and lighting. From 2000 to 2011, biomass accounted for the majority of the country's total energy supply, while oil has since become the primary fuel and a vital part of the Ghanaian economy. In 2020, biomass accounted for around 36% of the total energy supply, with oil and natural gas accounting for 34% and 25%, respectively. The remainder is catered for by hydroelectricity and a small percentage (0.003%) from solar.

The 2021 Ghana energy statistics indicated that about 82.8% of households in Ghana were connected to the national electricity grid. Electricity remained the main source of power for lighting for 93% of urban households, and electricity use for lighting in rural households was less than 72%. The report also highlighted that energy for cooking was primarily from biomass, largely in the form of firewood and charcoal (74.4%), LPG (25.3%) and only about 0.3% electricity. The LPG penetration is however lower in rural areas with only about 12.8% of the rural population using LPG compared to 34.1% in the urban settlement. There is however higher dependence on the use of biomass in the rural areas.

Indoor smoke from burning wood, charcoal, and other fuels used in cooking kills several million people, mostly women, and children, each year, while the use of biomass fuels contributes to environmental damage. Half of Ghana's population residing in urban or peri-urban areas, and over 75% of those urban dwellers use fuels such as charcoal or wood for cooking. In addition, more than 95% of rural Ghanaians are reliant on solid fuels

for cooking, and in regions where incomes are generally lower, and fuel is unaffordable, significant amounts of time are spent collecting fuel wood in increasingly degraded forests. Time saved through the use of efficient cooking fuels and stoves would bring greater freedom and opportunities to the rural cook stove user. At the same time, Ghana confronts a significant waste management challenge, with few disposal options for its increasing waste volumes. The waste problem is exacerbated by ineffective waste collection systems, insufficient landfill space, and environmental contamination. This situation not only endangers public health but also contributes to greenhouse gas emissions and impedes sustainable development.

Most communities in Ghana are connected to the national grid. This is also the case of the four selected validation sites. The electricity supply from the national grid is however not reliable as it is characterized by power outages, especially during peak hours. The community and schools, therefore, rely on standby diesel generators, which have high operating costs due to the high cost of fuel. On average, each of the schools spends about 1036.5\$ monthly on Electricity Bills, whilst a total of 1209\$ is spent each month on the purchase of Liquefied Petroleum Gas (LPG) to provide energy for cooking in the schools. Boarding senior high schools in the districts spend an average amount of 605\$ each year on emptying a total of 11 Septic Tanks and food waste within the schools' premises. The schools also rely on mechanized wells for the supply of potable water. Due to the erratic power supply, they are not able to pump water when needed.

8.3.2 Implementation summary

Econexus Ventures Limited in pursuance to the objective of the SESA sub-contract of developing growth and replication strategies with new customer segments such as public secondary schools in Ghana with its clean-burning bioethanol cooking fuels and cookstove solutions sought to validate its business model and business scalability. To validate the business model, new customer segments were selected and addressed throughout the sub-contracting period of 12 months⁵¹.

The following activities were deployed to validate the business model, test local production and new customer segments and explore growth strategies around waste-to-energy solutions in Ghana during the implementation phase.

Table 39 Overview of activities

Testing	1) Testing of local manufacturing of cook stoves through establishment of stove manufacturing facility in cooperation with AAMUSTED (SESA Living Lab Facilitator) to decrease capital expenditures through expensive imports of stoves from Sweden and to be able to implement economies of scale.
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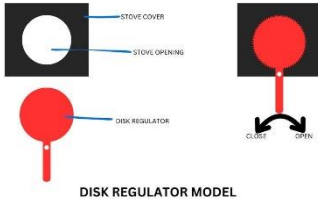
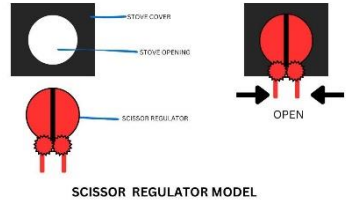
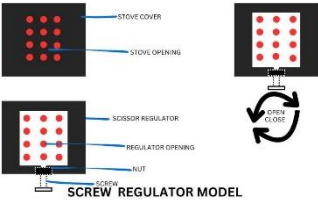
⁵¹ The contract with the SME partner was terminated by Siemens Foundation on 8 May 2024, due to actions by the SME partner that led to loss of trust in the collaboration from the consortium partners. See Deliverable 3.3 for more information.

	2) Testing of industrial cookstoves and ecofuels with new customer segments (for example, at four public secondary schools (St. Johns Grammar Senior High School & Amasaman Senior High, Technical School, Nkawie Senior High/Technical School and Toase Senior High) to increase demand and test growth strategies.
Increase fuel production	3) Analyzing the value chain of agricultural waste for increased production capacity 4) Increase fuel production capacity in with additional Ethanol micro distillery to meet demand
Establishment of retail	5) Establishment of new retail outlets in four new regions in Ghana

Testing

To date the 9 industrial ecofuel-fuelled stoves have been fabricated with three different regulator design models (disc type, scissor-like and screw type regulators) and 3 household ecofuel-fuelled stoves models are being developed at the new manufacturing space (Figure 74).

Figure 74 Three regulator design models

Disc type regulator design	Scissor-like regulator design	Screw type regulator design
 DISK REGULATOR MODEL	 SCISSOR REGULATOR MODEL	 SCREW REGULATOR MODEL

Econexus developed and tested two industrial-scale ethanol-gel fuel stove models tailored for public secondary schools and institutional-scale cooking. These stoves have been deployed to three out of the four targeted public secondary schools: St. Johns Grammar Senior High School, Nkawie Senior High/Technical School, and Toase Senior High School.

Initially the schools were supposed to be four, but the first feasibility visits revealed that the fourth school (thus Amasaman Senior High School) was not a boarding school and did not provide food for its students, thus leading to its exclusion from the testing.

In all, six industrial stoves have been developed and deployed in the respective schools for testing. The tests were conducted in two phases. In each test phase, two sets of stove prototypes were deployed, thus first prototype, and second/beta design prototype.

Figure 75: First and second prototype tested

First Prototype	Second Prototype
	
Without Flame Regulator	Flame Regulator included

First prototype testing feedback

The first prototype model was designed to have an open fire cooking application in the schools with a manual canister closure-switch-off mechanism. During the field testing which lasted for 12 weeks (from September 2023 to November 2023), the industrial ethanol stove showed promise with strengths in cooking efficiency, and environmental friendliness.⁵² However, improvements are needed in stability, and flame regulation to avoid fuel burning faster. Users recommended the following:

1. The integration of flame regulators.
2. Improved Mechanism for switching off the stove
3. Enhance stove stability and durability, especially for heavy pots

⁵² https://docs.google.com/document/d/1YUmbCVno9cYrib6SztF_VXaEi-bRQI1K/edit?usp=sharing&oid=100144424431336290680&rtpof=true&sd=true

Second Prototype Testing Feedback

The feedback received from the field testing led to several significant improvements in the second prototype which was deployed in all three schools in March 2024. The stoves have been used for cooking for 8 weeks now.

One key enhancement is the integration of a regulator, which offers better heat control during cooking operations. This feature not only ensures more precise temperature management but also enhances overall safety in the school kitchen environment. The addition of an improved mechanism for switching off the stove represents a significant advancement in user safety, operational efficiency, and overall product reliability. Lastly, to ensure enhanced stove stability and prevention of potential accidents or spillages during cooking by users, the second prototype had pot support reinforcement to provide greater stability during use (especially for heavy pots).

Observations made by users, regarding the flame regulation integration, stove switching off mechanism, and pot support reinforcement, indicated that the second prototype was seen to be better than the first prototype. However, the users had challenges with regulating the flame and switching off the stove hence they recommended that an improved regulator design which can easily switch off the stove completely be made⁵³.

These were gathered through interviews and observations during monitoring activities, primary calls and visits. Econexus technical team has taken the feedback into improving the design of new stoves being produced with three new regulator designs (namely, disc-type, scissor type and screw type regulators)

Increase fuel production capacity with additional Ethanol micro distillery

Econexus has procured ethanol micro-distillery with capacity of 1000-liter per day fuel production. This additional asset increased the production capacity from the initial 500 liter per day capacity to a total of 1,500 liter per day fuel production capacity. In order to increase fuel production, a value chain analysis on agricultural waste was also conducted in collaboration with a local research institute.

Tests on three agricultural waste sources, including cashew apples, pineapple waste, and fruit waste from major market centers in Accra (Dome and Madina Markets) have been conducted to determine ethanol yield, fermentable sugar content, the fiber material content of each waste source and evaluate the feasibility of utilizing these waste materials for increased ethanol fuel production at Econexus. The test was conducted by an independent chemist contracted by Econexus and a standard lab at the Department of Nutrition and Food Science of the University of Ghana was used to conduct tests.

Based on the test result analysis, the agricultural waste feedstocks that should be prioritized for increase fuel production are as follows:

⁵³ <https://docs.google.com/document/d/1XtrdIbjrnS8-hwvHx4kyk3sP7Q0eBsqt/edit?usp=sharing&ouid=100144424431336290680&rtpof=true&sd=true>

1. Cashew Apple Waste is to be prioritized due to its high ethanol yield potential. Despite its lower fermentable sugar content, it yielded the highest amount of ethanol, this suggests that the efficiency of conversion makes it a suitable feedstock for efficient ethanol production.

2. Pineapple Waste should be considered as a secondary option due to its moderate ethanol yield and could be a viable option with appropriate processing.

3. Mixed Fruit Waste with its high fermentable sugar content recorded the least ethanol yield. However, optimizing the fermentation process could unlock its full potential for ethanol production.

In assessing the ethanol production potential of each agricultural waste feedstock, cashew, apple show great suitability as feedstock for increased ethanol fuel production, despite its lower fermentable sugar content, it produced the highest ethanol yield. This suggests that the efficiency of conversion of the feedstock compared to the rest.

Establishment of new retail outlets in four new regions in Ghana

In order to increase product visibility of products (both fuels and stoves). Five new retail outlets were established in partnership with existing local convenience shops in five regions namely; Western-north region (Bibiani), Volta region (Ho), Western region (Takoradi), Central region (Cape Coast) and Eastern region (Nsawam) of Ghana. These outlets serve as distribution points to reach consumers effectively.

Sales made by the retail outlets since establishments as follows:

Table 40 Retail outlets established and sales since establishment

Regions	Fuels Sold (Liters)	Stoves Sold (Units)
Volta (Ho)	575	39
Western-North (Bibiani)	460	42
Western (Takoradi)	198	15
Central (Cape Coast)	227	27
Eastern (Nsawam)	115	15

Overall, about 438 stoves and about 1,575 liters of fuels have been sold at these retail outlets.

8.3.3 Business model and results of business model validation

Business model Canvas

Table 41 Summary of BMC for waste-to-energy

Business Model Canvas for Waste-to-Energy				
Key Partnership	Key Activities:	Value Propositions:	Customer Relationships:	Customer Segments:

Waste collection and processing companies. Research institutions for technology development Biofuel distribution networks Government agencies for permits and regulations.	Waste collection and sorting Biomass conversion to biofuel Quality control and testing Marketing and sales Regulatory compliance	Sustainable and eco-friendly biofuel production Reduction of waste and greenhouse gas emissions Reliable and consistent biofuel supply Cost-effective biofuel solution	Regular communication on biofuel availability and benefits Customer support for inquiries and issue resolution Feedback collection for continuous improvement	Commercial and industrial facilities seeking green energy solutions. Municipalities and waste management companies Government agencies promoting sustainability. Biofuel distributors and retailers Senior high schools Hospitals Hotels
	Key Resources: Waste sorting and processing facilities Biofuel production equipment Skilled technicians and engineers Access to biomass sources		Channels: Direct sales force Website and online platforms Biofuel trade shows and industry events Partnerships with waste management companies Distributor networks	
Cost Structure: Equipment and facility maintenance Raw material procurement (waste) Labour costs Research and development expenses Marketing and sales expenses Regulatory compliance costs			Revenue Streams: Biofuel sales to customers Licensing technology to other biofuel producers Government incentives and grants Subscription-based models for waste collection partnerships	

Lack of demand for products due to high prices

With the initial projection that economy of scale would be a gamechanger in achieving suitable cost reduction advantages, the expected demand failed to materialize despite the significant increase in production capacity from 500 liters per day to 1,500 liters per day. This was attributed to a number of factors ranging from high production input cost (especially increasing yeast costs for fermentation and gelling agent cost for gel ethanol fuel production as a result of market inflations) and high operation costs. As a result, retail prices of fuels became expensive for users.

The collected customer feedback highlighted that customers frequently compare new cooking fuel options with established ones like LPG. The per litre price of LPG is \$ 1.05⁵⁴.

⁵⁴ <https://www.myjoyonline.com/ghanas-lpg-prices-rank-among-the-highest-globally-lpg-marketers-association/>

In this case, customers made direct comparisons between the cost and performance of ethanol-gel fuel and LPG. LPG is a well-known and widely used cooking fuel, and its perceived advantages, such as convenience and familiarity, can make it a tough competitor. Customers found LPG to be a more attractive option in terms of price and, potentially, longevity.

Users expressed significant concern about the cost of the ethanol-gel fuel, which was priced at \$2 per liter. This pricing structure was perceived as high, particularly when compared to alternative cooking fuels like LPG. Customers, especially those in regions where household budgets are often tight, are particularly sensitive to pricing. The cost of fuel can be a significant factor influencing their choice of cooking fuel.

Customer feedback indicated that the cost and perceived rapid consumption of ethanol-gel fuel had a significant impact on user adoption. Some users, both new and existing, abandoned the product due to these concerns. This highlights the critical role that pricing and cost-effectiveness play in driving consumer choices. Users are more likely to embrace new cooking fuel solutions if they find them affordable and cost-competitive compared to existing options.

Approximately, 40% decline in revenue was recorded since June 2023 and the following months, that translated into about 205 users abandoning the products.

Low ethanol yield from Feedstock

Low ethanol yield from cellulose-based pineapple waste feedstock which was relatively closer to the Econexus factory compared to cashew apples which was recommended for its suitability for high ethanol yield per the result of the feedstock analysis study raised fuel production cost. Cashew apples unlike pineapple wastes are located about 315 kilometers (196 miles) away from the factory which would have resulted in higher transport cost. Due to this, users found the fuels to burn fast leading to frequent refills and they discontinued its patronage; this led to decline in revenues. Ecogel was also seen by users to have low heat intensity.

It has become evident that economies of scale will not just solve the pricing concerns alone if feedstock suitability is not assured. Feedstock suitability extends to raw material inputs for fuel production. Feedstock with higher ethanol yield ratio can be a gamechanger and this is necessary to achieve the desired cost advantages.

Ensuring suitable heat intensity was not the only challenge to be addressed under fuel efficiency but also the fast/rapid depletion of the ethanol fuel. In addressing it, management investigated the cause of the rapid depletion/fast burning of fuels and identified that high concentration ethanol fuels burn faster than low concentration ethanol fuels.

A test was carried in-house where 250ml of a high ethanol concentration (95% ethanol concentration fuel) lasted for 1 hour and 25 minutes but the low ethanol concentration fuel (70% ethanol concentration fuel) lasted for 2 hours and 30 minutes. It follows the logic that the higher ethanol concentration the faster it burns and vice versa.

8.3.4 Challenges and recommendations

In terms of fuel consumption in comparison to LPG, ethanol fuels may not be affordable for household cooking because the energy density of ethanol fuel is 26.8 megajoules per litre (MJ/L) whereas that of LPG is 46.1 megajoules per litre (MJ/L), meaning that more ethanol may be needed to produce the same amount of leading to higher consumption and potentially increased costs over time.

Research did not yield any new results and as such, Econexus has been considering by early 2024 a closure on this business model with biofuels made from agricultural waste as it cannot continue with discounting product prices for users which on a long run is still expensive for them.

Ethanol or alcohol-based fuels are either liquid or gel and do not produce smoke since they undergo complete combustion. Ethanol-based stoves and fuels have proven to be resilient technologies that can help reduce greenhouse gas emissions. For example, a study on the emissions reduction potential in Kenya showed that ethanol stoves reduced the climate impact of black carbon by 91% and 83% compared to kerosene and charcoal stoves, respectively. Ethanol fuels are widely used in the eastern and southern parts of Africa. In Ethiopia, ethanol stoves are relatively cheaper than LPG-based stoves. Typically, the monthly cost of utilising ethanol stoves and fuels is about 52% less than the cost of using LPG stoves and fuels

Recommendations

For widespread and mass adoption of ethanol fuels for cooking the following recommendations can be considered:

- Increase R&D in stoves' design and fuel production: Manufacturers and Producers must heighten research on the most efficient ethanol-based cookstoves to replace the existing ones with design and operational flexibility challenges. Research and development must focus on improving the canister's design, the stove's strength and ease with refuelling. Again, the manufacturers and producers must increase the R&D potential for ethanol production to create options to improve the efficiency of the ethanol production process, thereby minimising costs.
- Government policy must focus on boosting the local production of ethanol. In Ghana, ethanol-based fuels are used by a negligible proportion of households. The 2021 census indicates that about 0.04% of households use cooking gels such as ethanol as their primary fuel. Again, national policies on climate change and sustainable energy hardly promote ethanol-based fuels and stoves. A scan of the country's policies on clean cooking does not reveal a deliberate attempt to encourage the use of alcohol-based fuels and technologies, although they are also classified as clean fuels. The ethanol market is another sector that can boost the economy. Increased demand for ethanol for industry and cooking provides a supply potential with opportunities for income generation and job creation. Government support through subsidies, tax incentives, and favourable policies can play a significant role in reducing the cost of ethanol fuels. Policies aimed at promoting biofuel for cooking and reducing reliance on biomass and fossil fuels derived LPG can encourage the growth of the ethanol fuel market.

- Ethanol fuel for cooking business must streamline production processes to reduce costs: Manufacturers must have an efficient means of production to minimize production costs, these include lean systems, affordable power and bulk purchases and production.
- Ethanol fuel for cooking can consider the potential of receiving carbon credits to offset costs. The clean nature of ethanol-based fuels provides a unique opportunity for producers to obtain carbon credits. These credits can be used to offset production costs to reduce the price of stoves and fuels on the market.

8.3.5 The way forward for Econexus

To maintain financial viability, Econexus plans to commit 70% of its business operations in areas outside ethanol fuels for cooking domain since at present the business model is not sustainable and product-market fit cannot be achieved. This strategy is to help Econexus monetize its current assets in recurring revenue streams business models that have sustained product-market fit. The business shall commit 30% of its business operations to research and development on improving its bioethanol fuel for cooking solutions.

Foremost, Econexus will explore avenues and products which will directly make use of the acquired micro distillery under the SESA project to produce Ethanol related products that have ready market and uptake.

These products include:

1. Ethanol gel chafing fuel for food warming applications in hotels and restaurants.

Ethanol gel chafing fuel is a type of fuel made from ethanol, a renewable resource, and is used to keep food warm in chafing dishes. It is often packaged in small cans and is popular for catering, buffets, and other food service applications due to its clean burn, ease of use, and relatively low odor. Ethanol gel chafing fuel is preferred over traditional liquid fuels because it reduces the risk of spills and burns with a consistent, manageable flame⁵⁵.

Canned Ethanol Gel for Chafing Applications

⁵⁵ <https://www.webrestaurantstore.com/choice-ethanol-gel-chafing-fuel-2-hour/999CGFE2.html>



Figure 76 Canned ethanol gel for chafing applications

Market Size Potential in Ghana:

The market potential for chafing ethanol gel in Ghana is promising, particularly in the context of a growing hospitality and events sector. The global chafing fuel market, which includes ethanol gel, is expanding due to increased demand in hotels, restaurants, catering services, and event management.

Ghana had a total of 4,613 licensed tourist accommodation establishments in operation as of 2023. The number increased from the previous year when 4,190 such enterprises were registered. A steady increase from 2016 onwards has been observed.⁵⁶ This figure represents a significant increase in the number of accommodations available, reflecting the growth in Ghana's hospitality sector. Many of these establishments are concentrated in urban areas like Accra and Kumasi, catering to both domestic and international tourists as well as business travelers

Key factors influencing the potential market size include:

Hospitality Industry Growth: The hospitality sector in Ghana is growing, driven by tourism and local events. Hotels, restaurants, and event organizers are primary users of chafing fuels. The increasing number of events, both corporate and social, is likely to drive demand for reliable heating solutions like ethanol gel.

Market Segmentation: Potential customers for chafing ethanol gel include:

- **Hotels and Restaurants:** Regular users due to constant need to keep food warm.

⁵⁶ <https://www.statista.com/statistics/1250228/number-of-tourist-accommodation-establishments-in-ghana/#:~:text=Ghana%20had%20a%20total%20of,2016%20onwards%20can%20be%20observed.>

- Event Organizers: High demand during weddings, corporate functions, and social gatherings.
- Catering Services: Mobile catering services that require portable and efficient fuel solutions.
- Households: Although less frequent, there is a market for personal gatherings and special occasions.

Current Product Price and Size:

Currently, there are no local manufacturers of chafing gel in Ghana, the ones sold on the market are imported by distributors. They are packaged in sealed cans and are sold and distributed in malls and supermarkets. Their sizes range are 195 grams and 200 grams (195ml and 200ml; Liter eq.), which costs \$0.98 and burns for 1.5 Hrs. Currently, the same volume (200ml) of ethanol gel burns for 2.5hrs and a liter is sold for \$ 2. Comparing prices, Ecogel will be 5 times cheaper when sold at even this discounted price but for profitability's sake, the start price will be \$4.0 per (meaning each can be sold for \$0.50) This will position Econexus to have a competitive edge over the market.

2. Sanitary-grade ethanol could be sold to hospitals and property cleaning agencies for cleaning and sanitary purposes. Econexus already have product lines such as sanitizers and rubbing alcohol that could be sold in hospitals and schools as additional sources of income for the business.

	
FDA certified hand sanitizers (a product from the distillery)	FDA certified Rubbing Alcohol for disinfection in hospitals, restaurants and schools.

Figure 77 sanitizers and rubbing alcohol

3. Food-grade ethanol from the micro distillery could be sold for the food/beverage and cosmetics industry, to generate revenue for the business.

4. Econexus have also discovered through research that the distillery could also be used to produce essential oils and hydrosol, and the team will be investigating these possibilities to ensure the profitability of Econexus where the need arises. A market survey will be initiated to explore the potential cost-benefit analysis of these additional product lines.

Secondly, experiences gathered over the years in the ethanol fuel and cookstove space will be leveraged to explore the potential of manufacturing LPG stoves locally utilizing the stove manufacturing assets acquired under SESA project. This decision is in line with declared government policy direction towards LPG stoves for rural areas through the National LPG program of Ghana.

The National LPG Program of Ghana, officially known as the National Liquefied Petroleum Gas Promotion Programme (NLPGPP), aims to increase the use of LPG as a cleaner alternative to traditional cooking fuels like wood and charcoal. This program is an extension of the earlier Rural LPG Promotion Programme (RLPGPP) and focuses on both household and commercial/industrial use of LPG. The main objectives of the NLPGPP are to ensure that at least 50% of Ghanaians have access to LPG by 2030, thereby reducing deforestation and improving health outcomes by decreasing indoor air pollution from solid fuels⁵⁷.

⁵⁷ <https://ghanatoday.gov.gh/news/50-of-ghanaians-to-have-access-to-lpg-by-2030-energy-minister/>

8.4 Ghana: microgrid and individual solutions for energy access

8.4.1 Introduction – problem and solution

Problem

In Ghana over 50,000 tons of waste batteries are generated each year. Due to their toxic nature this waste is very difficult to recycle and most of it ends up in landfill sites and at scrap yards where they are burnt by scrap collectors to extract its metal components. This leads to air pollution and other environmental hazards from these centers as well as contributing to greenhouse gas emissions. Though there are no recycling plants and facilities capable of utilizing waste batteries, these waste batteries can be utilized through repurposing to develop energy solutions to tackle some major electrification challenges battling most communities in Ghana. Access to electricity is one major challenge that most communities are facing today. Nearly 40% of Ghana's rural communities have no access to grid connectivity this has left nearly 5% of the population in darkness contributing to slow development and minimal economic activities in these rural communities. Again, the constant power outages faced by those on the national grid is significantly impacting business operations and hindering growth for most small scale businesses in Ghana. Many Ghanaians today have limited options when it comes to accessing electrification and the available solutions aside the national grid is either too expensive or unreliable. Most of these people end up using torchlights, candles, lamps and lanterns as a means of getting a form of electricity, mostly at night. Even in cities and large towns there are people and businesses that do not have access to the national grid.

Solution

Nastech Power Solutions (Nastech) provides affordable and reliable energy solutions to rural communities, individuals, and businesses through a circular economy model. They collect, recycle, and repurpose electronic waste, particularly lithium-ion batteries from devices like laptops and power tools, to create high-density energy storage systems, batteries, and power inverters. Nastech focuses on increasing electricity access in off-grid rural areas by developing micro-grids and providing individual solar generators to households. To make their solutions more affordable, they offer a pay-as-you-go model and subscriptions, reducing the initial cost and ensuring uninterrupted power for users, especially in marginalized and low-income areas.

Technical Functionality

Nastech's product capacities ranges from 1KW to 50KW for hybrid inverters and 2.5KWh to 30KWh for Lithium battery packs as well as producing solar generators from 1KW to 10KW capacities. All systems are designed to operate within 12V to 48V operating voltage range. *Figure 78* shows technical specifications of the 2000W solar generator.

Figure 78 Technical specification of the 2000W solar generator



Compared to other competitor products, the Nastech solar generators, inverters and battery packs are uniquely designed to handle heavy loads and fused with many safety and protection mechanisms. Systems are easy to operate, portable and designed to carry only Alternating current load which makes it simple to use without many complications.

8.4.2 Implementation summary

Table 42 provides an overview of activities implemented during the project.

Table 42 Activities implemented

Activity	Midway Results By October 2023	Final Results By July 2024
Solar micro-grid installation	3 micro-grids completed 22 subscriptions	3 54 subscriptions
Solar Gen installations/subscriptions	0 subscriptions	40 subscriptions
Waste Battery repurposed	43tons recycled	253tons
Production and Sales	115 products sold	775 products sold (1455 produced)

In addition, in the period from March 2023- July 2024, Nastech has provided technical training in solar energy installation for 225 people in partnership with dream renewables, SNV-Green project and the National Vocational Training Institute.

Solar micro-grid and individual solar generators installations

Electrification of rural communities has been executed using two approaches: connection through micro-grid and connection through individual solar generators. Micro-grids have been installed in two communities Berdaabuo and Kwamedwaa. The third community,

Beposo has been provided with individual solar generator systems for each home in the community. A total of 54 homes has been provided with electricity through micro-grid connection. This access to power has significantly improved economic activities in the communities as well as impacted on the living condition of people in the area.

In the first community Berdaabuo community two separate 20KW solar models have been installed for the community, which is designed to meet the energy needs of over 200 homes in the community, currently a total of 36 homes has been connected to the system including the school facility in the community which is to aid students and teachers academically. Out of the 36 homes currently connected each home has a minimum occupant of 6 people and at most 10 people per home.

The installation is also meant to boost economic activities within the communities, and several individuals have already set up their stores to use the power for economic activities. In Berdaabuor there are two provisions stores, and one cold store currently using the power for business operation whilst in Kwamedwaa one provisions store operates with the power.

Table 43 Microgrid Subscriptions

Community Name	Number of subscribers
Berdaabuor	36
Kwamedwaa	18
Total	54

Table 44 Solar Generator Subscriptions

Towns/ Communities	Number of Subscribers
Kwame Dwaa	12
Beposo	12
Boadi	2
Berdaabour	4
Toase	6
Kentinkrono	4
Total	40

Technical issues faced

The micro-grid in Berdaabuo is encountering some difficult technical challenges which has made its operation and efficiency drop. In May 2024, a thunder strike damaged the inverter. After the system was repaired, Nastech noticed a noticed high apparent power causing 15 KW excess load on the system which is mostly caused by issues with the distribution network or faulty appliances used by those on the systems and causing the batteries to run down quickly at night. Tracing and resolving the challenge became problematic and by the time Nastech were able to resolve the hitch, the batteries were weakened and efficiency of the entire system reduced significantly, and batteries needed replacement. Today, although the entire system is designed to run 24/7, the users mostly get a maximum of 20 hours of running time with the system shutting down midnight each day. Also, initially, the batteries were over exposed to heat due to their placement directly under the solar panels which caused massive heat absorption.

Waste Batteries repurposed

A total of 425,668 lithium batteries packs from waste laptops and power tools have been collected and repurposed so far since the start of the project. These have been used to develop second life battery banks for Nastech's solar generators and for clients.

In all 2,552,234 cells have been processed from the 425668 waste batteries that have been received, processed and recycled. These battery cells have been used to develop battery banks for the solar generators produced, for micro-grid applications and developing large battery banks for off-grid solar applications for homes.

In all about 223 tons of lithium battery cells, 52 tons of plastics, and 35 tons of metals, transformers and other e-waste have been collected and recycled.

Production and Sales

A total of 1455 products have been produced so far and marketed. Of which 320 power inverters were developed, using transformers from e-waste, 775 battery banks from the lithium processing unit and 360 solar generators.

Table 45 Products produced.

Item description	Quantity (products produced)
Battery banks	775
inverters	320
Solar generators	360
Total	1455

Nastech's marketing and sales activities have been intensified over the period, which has helped the company to increase their performance by over 85% (performance increase is calculated based on comparisons of data on revenue growth, assets increase, jobs created and quantity of repurposed batteries before and after the project). Nastech have been able to make a total revenue of GHS1,890,000.00 (119,637 USD) from March 2023 to July 2024. For increased marketing activities, Nastech expanded their promotion digital platforms, as well as intensifying their marketing outreach, and creating a company website.

Revenue of sold products from March 2023 to July 2024

Table 46 Products sold from March 2023 to July 2024

Product and service name	Quantity (sold)	price	Total revenue
Microgrid subscription fees	54	700	37800
Micro-grid monthly utility fees	54	100	5400
Solar generator subscription fees	40	1500	60000
Solar generator monthly utility fee	40	100	4000
1000W Generator Sales	199	2500	497500
2000W Generator Sales	119	4200	499800
5000W solar generator sales	15	23000	345000
Battery bank sales	83	4000	332000
Solar installation services	31	3500	108500

	Total		1,890,000.00
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Job Creation

To date, Nastech has created 52 jobs in total: 22 direct jobs and 30 indirect jobs. The direct jobs are workers directly working in Nastech's production and operation lines and are part of their management and operational team. The indirect jobs are created through the waste collection section, installers for the solar generators, electricians for house wiring in the villages, whose services are required and are paid upon delivery of services.

Table 47 Jobs created

Direct Male	Direct Female	Indirect Male	Indirect Female
16	6	20	10

Certification

Within the project period Nastech has been able to certify and license all its products as well as secure the permits needed for production of our systems. We have secured GSA AND EPA certification for all products and operations.

Table 48 Summary of Activities

Activity	Result
Waste recycling	255 tons recycled
Micro-grids systems	54 customers
Metering solutions	42 subscribers metered
Production	1225 produced
Job creation	40 jobs created
Revenue targets	2,185,282
Solar training	225 trained

8.4.3 Business model aspects tested and validated

Business model canvas

Table 49 Business model canvas

OUR KEY PARTNERS	KEY ACTIVITIES	VALUE PROPOSITION	CUSTOMER RELATIONSHIP	CUSTOMER SEGMENTS
- Suppliers of solar panels, batteries, and inverters - Local and international partners for sourcing recycled materials - Government agencies and NGOs promoting renewable energy solutions - Installation and maintenance teams (in-house and outsourced) - Financial institutions and investors	- Manufacturing and designing solar generators and inverters - Installation and maintenance of solar energy systems and microgrids - Energy audits and solar training programs - Recycling electronic waste to produce solar power solutions - Continuous research and development in energy efficiency and storage	- Comprehensive solar services, from design to maintenance, for both grid-connected and off-grid areas - Solutions tailored for customers in energy-deficient areas, including portable generators for outdoor and emergency use - Reliable and constant access to power - Instant connection to micro-grid upon subscription. - GHs 20 prepaid upload on first subscription - Pay-as-you-go model for more flexible payment options	- Personalized service through solar system design, installation, and training - Long-term relationships built on maintenance services and continuous support - Community engagement through education on solar energy benefits	- Off-grid communities in rural areas without access to the national grid - Small businesses in remote locations - Middle-income homeowners seeking sustainable and cost-effective energy solutions with building in new sites - Real estate developers - Commercial institutions
	KEY RESOURCES	IMPACT	CHANNELS	
	- Expertise in renewable energy, particularly solar power - Trained technicians for installation and maintenance - Solar generator and inverter production facilities - Access to recycled electronic materials - Strong brand reputation in the Ghanaian solar energy market	- Affordable and reliable solar energy solutions for residential and commercial customers - Clean energy that reduces carbon footprint and energy costs - Unique use of recycled materials in product manufacturing, promoting sustainability	- Active community outreach - Direct sales via the company's website - Word-of-mouth and reputation in local communities - Social media and digital marketing efforts - Participation in renewable energy initiatives and exhibitions	
COST STRUCTURE			REVENUE	
- Manufacturing and material costs (solar panels, inverters, batteries) - Labor costs for installation and maintenance services - Logistics and distribution costs - Marketing and customer acquisition expenses - Legal fees and certifications			- Subscription fees - Monthly bills - Credit Purchase - Sales of solar generators, inverters, and related products - Installation and maintenance service fees - Energy audits and consultancy services	

New customer segments

Throughout the project, Nastech has targeted individuals and homeowners in marginalized communities in Ghana with their products and services. Many of the customer segments are individuals within the low- and middle-income bracket located in off-grid locations and newly developing sites both in the cities and rural communities. The main system deployed for the subscriptions is a 1000W and 2000W solar generator system which are installed for individual customers. Nastech started the subscription-based model in the rural areas and significant adoption is now validated in the urban communities mainly for small shops and homes in outskirts of most newly developing areas.

Through the support of the SESA project, Nastech has now been able to advance its battery technology and come up with new high-capacity battery banks with capacities ranging from 12KWh to 35KWH capable of sustaining large facilities and companies for all their energy needs. This is the new market segment that Nastech wants to explore, with their target focused on large industries and bigger facilities both residential homes and institutions.

New revenue model

Nastech's new business model and strategy is to build high-capacity solar generators and embed them with metering systems, and utilize the subscription-based approach, in making revenue. Customers will have to subscribe and pay a subscription fee based on the subscription package they are opting for. The target is businesses and organizations

with high energy needs. Nastech's revenue model is to utilize pay as you go, based on energy usage using the billing system. Nastech will increase their revenue through the subscriptions and sale of products like inverters, batteries, solar generators without embedded billing systems, installation works, repair and maintenance for already installed systems, as well as the subscriptions fees and billings from the micro-grid and solar generator models.

New pricing strategy

Nastech's pricing is calculated based on the cost of product or the entire operational cost inquired about producing a particular product with a margin of profit added. Nastech also evaluated and determined their prices based on the target market, and their economic capabilities to acquire a particular product package and consider the cost of producing such products. For some products, Nastech also considers competition and market in deciding pricing, evaluating competitor pricing for the same or similar products and providing very competitive pricing for the same or similar products.

For the micro-grids a fee of GHS700 (44.3 USD) is charged per subscriber this fee caters for the connections to the grid, the metering, and for future maintenance. A monthly user fee of GHS 100 (6.33 USD) is also charged per user.

With solar generators models based on which model the user chooses either the 1000W or 2000W model, a subscription fee of GHS 1000 and GHS 1500 are charged respectively. On average based on their usage, a customer on the 1000W system will be paying a GHS50 (3.16 USD) to GHS 100 (6.33 USD) monthly while a customer on the 2000W model will be paying a fee of GHS 100 (6.33 USD) to GHS 200 (12.7 USD) monthly for using our systems. Prices for the 1000W and 2000W solar generators were adjusted downwards to increase accessibility and increase sales. For systems like 5KW and 10KW models, Nastech maintain up to 20% lower prices as compared to competition.

When customers subscribe to the system, Nastech provides them with enough panels for generation, battery for storage and inverters to meet their exact energy needs, to ensure they are ensured power 24/7.

For the larger systems which are designed for large-scale applications Nastech employ competitive pricing, against other products and brands while still considering cost of production in determining the pricing of the systems. For this new product they compare pricing of similar models from other brands and provide a competitive price point for their products. Nastech has maintained stable pricing throughout the project period regardless of inflation and economic depreciations and hardships. Nastech's pricing model and strategy is expected to increase demand and overall sales translating into revenue growth. Also considering the target market, Nastech's pricing model aligns with goals to increase accessibility and improve adaptation, ensuring overall improved access to Nastech's products by the target market.

New product

Nastech have currently introduced their new 18.68KWA battery pack used for both residential and industrial applications. Battery weights 200kg and capable of sustaining heavy load for longer runtime, rated at 58.2V, DC for 48V applications it has a higher peak

power rating than any other battery and can outperform many other products in the market with its run time, and load factor. 8 products have been sold so far. Nastech is tracking their performance and monitors its operations over time.

New marketing strategies

Nastech has intensified social media publications, ads, and video contents to boost their reach. They have intensified their branding and improved overall awareness of their products.

Market Analysis

Nastech power solutions as a solar energy provider specifically target customer segment located in areas with minimal energy accessibility and may need its service and product. Nastech has three customer segments: rural households, urban residential households and businesses. The target groups include individuals within the low- and middle-income sector.

Within the SESA project the target groups were mainly businesses and rural communities within marginalized areas without access to power for their daily operation and may need access to electrification for their daily activities.

For businesses their main pain point is the lack of electricity for boasting their business operation. Some have access to the national grid but due to constant power outages struggles to keep up their operations. Some are in off-grid locations without any means of electrification and therefore depends only on diesel fuel generator. The cost of fuel is too high and affect their operational sustainability and therefore will need an affordable alternative.

Lastly, there are also those who do not have access to any means of electrification at all and looking for options to keep their operations electrified.

For residential households, our target group are homeowners in newly developing sites both in major cities, towns and villages where the grid lines are difficult and expensive to access. The main pain point for this group is the cost of acquisition and availability of options for their home energy needs. People have built their home far away from national grid distribution lines and the cost to transfer power lines to their homes are far too expensive. Lastly, there are also those that completely want to move to solar energy due to high energy bills and power outages.

For rural households, their pain point is the lack of accessibility as well as affordability for energy solutions. In Ghana about 40% of rural settlements are yet to be connected to the national grid. In general, about 4 million people lives in communities like this without any national grid connectivity and with no proper form of energy access. From the Ghana statistical data on population census, over 2.2 million new settlements are established each year in Ghana, which also indicates new building structures constructed for settlements. This project a market size of about 2 million new homes built which may need access to electrification.

Customer Engagement & Development

Three main customer segments were engaged during the validation process.

1. Rural households
2. Residential households
3. Businesses

For the rural customer segment Nastech focused on individuals in marginalized locations where there is no access to power. With these Nastechn supported them with access to affordable power using micro-grid and solar generators. Individuals were provided with subscription-based systems that offered them with energy access and customers pay per use.

For the residential customer segments, which consists of individual homes with energy needs not exceeding 10kw Nastech provide both pay as you go and direct sale depending on customer needs and financial capabilities.

For businesses Nastech utilized larger systems such as the newly developed 18.6kwh battery storage system and 5kw -15kw solar generators. Customers purchase these systems on instalment payment plans, using hire purchase arrangement for businesses as well as individual residential apartments with a maximum payment duration of 6 months. Systems are also embedded with remote monitoring.

Pricing (Charges and fees for subscriptions)

Micro-Grid subscriptions

Customers subscribing to the solutions provided are required to make payment before installation or connection to the service, again based on the power usage they are to make monthly payment for their power consumption. For the micro grid a subscription fee of GHS 700 (44.3 USD) is charged per user and an average monthly payment of GHS 100 (6.33 USD) per user. With a total of 54 subscribers the total revenue from the subscriptions is GHS37,800 (2,393 USD). With the average monthly fee of 100 (6.33 USD) per user Nastech can make GHS5400 (342 USD) monthly.

Table 50 Microgrid subscriptions

Subscription fees for microgrids	Average monthly payment
GHS 700	GHS100

Total months calculated	Average fee	users	Total revenue
12	GHS100	54	GHS 64,800

Individual solar generator subscriptions

Customers can choose, based on their power needs, the size of system to be installed for their facility based on their needs. Nastech offers between 1000W to 5000W models for the subscriptions. However, for the communities we installed mostly 1000W and 2000W models. The subscription fee for the 1000W model is GHS 1000 (63 USD) and customers pay GHS1500 (95 USD) to subscribe to the 2000W system.

The table below illustrate the subscription payment and average monthly payment per user on the solar generators models provided

Table 51 Individual subscriptions

Communities	1000W system	2000W systems
Kwamedwa	8	4
Beposo	12	0
Berdaabuor	4	0
Toase	2	4
Kentinkron	0	4
Boadi	0	2
Total	26	14

Table 52 Subscription fees per system

Subscribers	1000W	2000W
26	GHS 26000	
14		GHS 21000

A total of GHS 47000 (2,975 USD) has been made through the subscription fees for the solar generators. Based on the amount of power consumed an average monthly fee of GHS 100 (6.33 USD) paid per user for the 1000W system and GHS 150 (9.49 USD) for the 2000W system. On average a total revenue of GHS2600 (165 USD) from the 1000W systems and GHS 2100 (133 USD) from the 2000W systems, a total revenue of GHS 4700 (298 USD) combined per month. Within the last 12 months a total revenue of GHS 56,400 (3,570 USD) has been made from the solar generators.

Go-To-Market Strategy

Nastech's approach to market is to increase awareness of products, utilizing effective social media marketing and direct publicity using mostly community engagement. To increase sales Nastech increase branding of its product and company and utilize e-commerce platforms to boast sales. Nastech's main sales channels are Jiji online store, Tonaton, and Jumia online store where all products are hosted and showcased; Nastech also utilize its website and shopping feature at the website to increase sales. For promotion marketing and advertisement Nastech utilize all social media handles on YouTube, Facebook and Instagram to promote their products and services to increase awareness and reach.

Lastly, Nastech make its product accessible at its physical store where the products are showcased for walk in customers.

Feedback collected throughout SESA living lab implementation

Among all of Nastech's products the ones with highest customer preference is the 2000W systems, Nastech collected very positive feedback from customers on its performance. Even though the 1000W is more affordable base on the energy needs and use case customers usually prefers to have the 2000W. One of the critical considerations is the fact that on average most of the customer load in the house easily exceed 1000W not

more than 2000W in most cases. This limits the usage ability for customer if they are using the 1000W as compared with when they are using 2000W.

In addition, Natestech noticed that most customers prefer to have larger battery bank to keep their things running for long and most of them are will to pay extra to have their system run for longer hours. Which always required modification and customization for the customers. For which reason, Natestech decided to modify the 5000W solution and redesign it in such a way that such customers could opt for different categorizations of the same model to meet their exact requirements.

One major feedback Natestech initially were receiving from customers was the fact that the batteries take longer hours to recharge even on sunny days and that due to the longer charging hours their batteries do not get to fully charge during the day which also affected how long it last running their load at night mostly.

Natestech found that because customers wanted to have larger battery banks, they increase the battery capacity of their systems which, however, which did not usually correspond with the panel sizes matched with the battery and the charge controller model utilized in most of the system (PWM). This prevented the batteries from charging faster while lots of the energy generated usually get wasted. Natestech 's response to this feedback was to redesign the battery packs reduce the sizes to align with the panel required and also to change the charge controller to (MPPT models) to resolve the challenges and improve performance.

Again, the feedback has enabled Natestech to rethink its designs and modify the products to increase performance for the user. For instance, Natestech also realized the main reason a system like 5kw to run down faster even with very minimal load was caused by the type of inverter used. In most cases, Natestech utilized transformer base inverters for most of their systems, however, due to the high energy consumption of the transformer inverter designs it was impacting product performance negatively. By conducting various tests and changing to transformer less inverters, Natestech's system performance picked up significantly and able to run 24/7 with max load something previously impossible with transformer type inverters.

8.4.4 Challenges and learnings

Products and market segment: Micro-grid vs individual solution

Due to the problems Nastech encountered implementing the micro-grid they decided to introduce standalone solutions for subscriptions, and the utilization of the standalone systems seemed to work better in terms of its implementation and payment. It's a lot easier to install the solar generators in the homes of the users than to extend the micro-grid lines to same places as well as more time efficient to implement the solar generator models installation than executing a whole micro-grid approach.

Revenue model

The pay as you go model works, but the returns are very low, especially with the rural target group. For instance, a subscriber is provided a system costing GHS 4200 (266 USD) and Nastech calculated a monthly payment of GHS 150 (9.49 USD) which means in a year Nastech expect GHS 1800 (114 USD) and a return on investment within 3 years. After installation the customer decides to reduce their consumption to save on bills and ends up paying only GHS80 (5.1 USD) a month which sum up to GHS 960 (61 USD) a year resulting in a complete loss for the business. Same model executed for someone in the city yields different result with a positive return. Nastech's approach is now to ensure sustainability by increasing revenue through direct sale of its products focusing more on the customer segment within the middle-income range, those in major towns with financial means to make an upfront payment. Nastech's production operations will now be focused mainly on producing bigger systems to meet the demand from higher income earners, mainly for commercial business operations.

Regulatory environment

One of the major setbacks in implementing the micro grid project was the difficulties encountered with the regulatory authorities in securing the right permits and licenses for operationalization. Legally, no other organization aside the electricity Company of Ghana (ECG) is permitted to sell power and only GRIDCO is permitted by law to construct transmission line. This became a major setback. Nastech consulted the energy commission for advice on how to proceed and the feedback was to let GRIDCO contractors execute the transmission and distribution network, and to get ECG involved for any fee collection. These huddles modified the original plans Nastech had in implementing the micro-grids and a main reason why scaling and expanding the micro-grid projects was not possible. Upon interacting with the energy commission, the feedback is that due to the current penetration rate of the national grid, the government have decided not to grant any license or permits for individual projects, unless it's a donation to a community which will not be monetized.

For the distribution network Nastech contracted GRIDCO as sub-contractors to install and construct the power lines through the communities, however Nastech could not get ECG on board and had to change its monetization plans. For monetization Nastech made arrangement with users to pay a statutory fee for maintaining the systems, a fee to be paid monthly for maintaining the systems and for usage. Payment collection, however, was a challenge. In the beginning, users were willing to pay but as time went by, some

refused to pay and even left their homes when NastechH staff went to the community for payment collection, to avoid paying.

8.4.5 Sustainability and impact

Micro-grid solution

The scalability of micro-grid projects in Ghana presents significant challenges, primarily due to restrictive government policies that hinder private sector participation in the energy sector. The cessation of licensing for Independent Power Producers (IPPs) to develop mini grids has severely limited expansion efforts. Furthermore, the absence of a clear and functional permitting process for micro-grid operations constitutes a major barrier to implementation. Despite the urgent need for micro-grid solutions to serve rural communities, the prevailing regulatory environment remains unfavourable, impeding progress and discouraging investment.

Battery repurposing

Repurposing lithium batteries has great potential in ensuring energy accessibility. This creates affordability while meeting the exact energy needs of businesses and people in need. Today the Ministry of Environment, Science and Technology together with the Environmental Protection Agency (EPA) and GIZ have commissioned the Integrated Development Partnership Project to increase collection and recycling of waste lithium-ion batteries from the environment. The Ministry of Environment is developing the recycling facility for lithium-ion batteries end of life to protect the environment. At the adoption of EVs continues the need for companies to adopt methods to refurbish and repurpose lithium batteries into other products continually become relevant. There is a high potential for scalability. Nastech and GIZ has signed a GHs1million contract to boost the collection and repurpose of waste lithium-ion batteries to support the scaling of providing affordable energy solutions for businesses in need of affordable energy solutions for their operations.

Individual subscription model

Providing subscription base solutions for rural electrification are viable only with standalone systems, this is due to the challenges and experiences gained during the validation phase of the SESA implemented micro-grid solutions. When subscription base solutions are deployed with standalone systems, its effective implementations and monetization as well as adoption is easy to commercialize as compared with the commercialization of micro-grid solutions.

Affordability

Utilizing second life batteries has the greatest advantage of reducing prices for customers while presenting the opportunity of a larger energy density and power density options for customers. Today new lithium ion batteries for solar energy applications are prices very high for instance a 100AH 48V lithium battery pack sells between GHS 30000 (1,899 USD) to GHS 38000 (2,405 USD) depending on the brand, similarly a 200AH lithium battery 48V rated sells between GHS 40000 (2,532 USD) to GHS50000 (3,165 USD) a price range that the average Ghanaian could not afford, using second life batteries, Nastech is able to sell

a 150AH 48V lithium ion battery for as low as GHS12000 (760 USD) and the 280AH 48V for GHS 20,000 (1,266 USD), less than half the price for the new models. Additionally, Nastech are able to add more capacity to the batteries to compensate for their second life usage to help prolong their life span; because of this, Nastech provide a 150AH battery for the value of a 100Ah and 280 AH for the value of 200Ah. This also provides the customer with a battery value and performance even than the new ones.

9 Cross-Case Insights

The deployment of climate-smart technologies across diverse geographies has revealed a set of recurring lessons that are critical for shaping future interventions. These insights span financial viability, adoption dynamics, customer engagement, and the role of local ecosystems and are elaborated below.

1. Diverse revenue streams are key for seasonal business models

Businesses with seasonal operations require diversified revenue streams to remain sustainable year-around. Businesses facing seasonal constraints—such as seasonal irrigation needs and customer payments aligned with harvest cycles (SEE’s solar irrigation in Malawi) or feedstock availability for briquette production (GG in Malawi)—successfully mitigated these challenges by offering complementary services and products. SEE offered construction services for government clients and became a rice buyer for customers to solar irrigation solutions. GG made sunflower products based on and tailored to the same farming communities, ensuring continued engagement and income beyond peak seasons.

2. Scaling is crucial for high-cost viable technologies

One of the consistent challenges across pilots—from e-mobility in Kenya and South Africa to solar irrigation in Malawi—was the high upfront cost of technology or the steep initial investment required. These capital-heavy solutions often struggle to reach financial viability unless deployed at scale. For instance, Kenya’s e-bike and South Africa’s micro EVs initiatives highlight this issue.

This underscores the importance of designing business models with scalability in mind. Early-stage financial support—whether through grants or concessional loans—is not just helpful but often essential to bridge the viability gap. Most proof-of-concept cases in the SESA incubator programme eventually showed operating profits (without considering the costs of setting up the infrastructure) which highlights the variability in outcomes even within similar contexts.

3. Financial Support as a Catalyst for Validation and Proof-of-Concept

Grants have played a catalytic role in enabling experimentation and building viable business cases. In Malawi, donor funding supported briquetting pilots to test production models and refine customer targeting. South Africa’s community-centered e-mobility model was made possible by subsidies covering initial costs. Morocco leveraged pilot data to attract scale-up investment, demonstrating how evidence-based approaches can unlock further funding.

Two SMEs—SEE and Nastech—achieved financial viability within the project timeline, thanks to market-driven models such as subscription services for solar home systems (Nastech, Ghana) and lease-to-own contracts for solar irrigation (SEE, Malawi). These examples illustrate that grants are not merely financial tools; grants are for African early-stage entrepreneurs one of the main sources of finances to test, validate and scale their business model. Grants help de-risk innovation, enable learning, and build the case

for commercial or public-private investment and are thus filling the missing middle financing gap.

4. Technology Adoption Varies by Technology Type

The nature of technology, whether it substitutes an existing solution or introduces a new one, significantly affects adoption. E-bikes in Kenya and Morocco replaced petrol bikes, offering immediate cost savings and requiring minimal behavioral change. In contrast, cold rooms and solar irrigation introduced new practices and cost structures, necessitating more intensive user engagement and trust-building.

This distinction is crucial: substitution technologies tend to scale faster, while new technologies require longer runways and robust support systems to gain traction.

5. Payment Flexibility Drive Uptake

Understanding the financial realities of end users and tailoring payment models accordingly proved vital. Kenya's e-bike initiative adjusted its payment structure to match riders' variable incomes. South Africa's micro-EV model used pay-as-you-go systems and subsidies to serve low-income communities.

Solar irrigation cases used post-harvest installments as payment method and lower commitment fees to also attract smallholder farmers in addition to more commercial farmers who managed to purchase the pumps through direct sales.

6. Local and International Networks Enable Sustainable Implementation

Projects that leveraged existing local networks and partnerships — such as farmer cooperatives, extension officers, and community champions as well as technical partners and financial institutions — experienced smoother implementation and better outcomes. In Malawi, SEE and Going Green (GG) tapped into farmer clubs for outreach and sourcing. SEE offered solar irrigation to help farmers increase yields and partnered with local financial institutions to provide loans based on a proven lease-to-own model. This approach not only doubled farmers' incomes but also demonstrated low default rates, validating the business model.

GG, which sources sunflower grain, used its farmer network to procure biomass for briquetting. Kenya's e-bike pilot relied on trusted users to build credibility and worked with a technical partner for internal skills building, while South Africa's success was rooted in community-centered design and local capacity building.

International partnerships also played a role. For example, WeTU benefited from access to philanthropic networks and technical collaboration with German partners, illustrating how global connections can enhance local impact.

7. Business Models Must Align with User and Market Needs

The pilots experimented with various business models, including subscription-based microgrids (Nastech), pay-as-you-go systems or pay per use (WeTu and Uyilo), and leasing arrangements. A key factor among these business models was the focus on -as-a-service models vis-à-vis outright purchase and asset ownership-based model. The former has enabled significant uptake of these green solutions while ensuring

affordability for various income groups and also better align with income periods (e.g., harvest periods). In addition, success often also depended on aligning the model with user needs and organizational strengths. For instance, WeTU modified its bike design to suit user preferences and rugged terrain, although this was outside its core expertise. Meanwhile, Pogo offered more affordable bikes across a more diversified customer segment, demonstrating that cost-effectiveness can be a competitive advantage. Cold storage pilots applied tiered pricing based on produce type, while Morocco's e-mobility project shifted focus from students to a broader customer base with higher purchasing power. This shift, combined with the use of off-the-shelf bikes, led to a lean and efficient operation.

These experiences reinforce that one-size-fits-all pricing models are ineffective. Business models must be adaptive, evolving in response to real-world feedback and user needs.

Annex A – Business Model and Plan Report Template

D3.4 Business Models (6-8)

The report should explain all the details of the business model, employing BMC, focusing on the ways to create and deliver value to customers (Processes) and on how to generate revenues (Monetization).

The business models report must not exceed 5-8 pages in length. Information can be collected through primary data and secondary data (interviews with specific businesses for further insights into their operations and business models)

Proposed use cases:

- 6-8 could be use-case specific business models (Solar-powered cooling, leasing E-bikes and swappable batteries, Off-grid PV, drinking Water, Waste-to-energy, Biocookers)

Drawing on Business model Canvas framework:

The Business Model Canvas

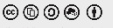
Designed for:

Designed by:

Date:

Version:

Key Partners Who can help us reduce risk or increase chances of success? Who can help us increase sales? Who can help us reduce costs? Who can help us increase efficiency?	Key Activities What must we do to make our business model work? What must we do to create value? What must we do to deliver value?	Value Propositions What benefits do we deliver to the customer? What problem are we solving for the customer? What benefits do we deliver to the customer? What problem are we solving for the customer?	Customer Relationships What type of relationship do we want with our customers? What type of relationship do we want with our customers? What type of relationship do we want with our customers?	Customer Segments Who are our target customers? Who are our target customers? Who are our target customers?	Key Resources What resources do we need to make our business model work? What resources do we need to make our business model work? What resources do we need to make our business model work?	Channels Through which channels do we reach our customers? Through which channels do we reach our customers? Through which channels do we reach our customers?
Cost Structure What are the most important costs in our business model? What are the most important costs in our business model? What are the most important costs in our business model?			Revenue Streams How do we generate revenue? How do we generate revenue? How do we generate revenue?			



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Suggested Structure

1. Intro/Background

- Few lines to introduce, describe the problem and need (ex: food losses in the case of solar powered cold storage)
- Describe the solutions, use cases (product/service), target customers, and expected impacts
- Baseline conditions, willingness-to-pay, affordability

2. Problem and Solution

- Problem - Provide some background information and describe the exact problem, or the pain points, which you focus on
- Solution - Describe your solution to the problem in one sentence. After that, provide a passage that details your solution further, if needed.
- About the founding members and directors - As much as possible show how the founding members have a complementary skill set, skin in the game, industry experience and a proven track record “building things” from scratch and being resourceful

3. Business Concept and Additionality

- More about the specifics of the technology, and the services offered
- Market size and dynamics, projected market share for the tech/service
- Info on the site-specific baseline conditions, why this location, some reflections on the consumer livelihoods and affordability - how this demo has been tailored to the local context.
- Local ownership, local partners, and their key roles
- Local stakeholder and community engagement in pre-construction, construction, and operational phases

4. Overview of business model / Value Proposition (Drawing mainly on the business model canvas)

In this section, you should explain all the details of your business model, focusing on the ways you are going to create and deliver value to your customers, and on how you are going to generate revenues, and reflect on the 9 BMC components.

- Value Proposition - value is delivered to the customers? What bundles of products and services are on offer to the customer segments? What is your unique point?
- Governance form: Private-public operator model / Community-based model / Hybrid model /... Customer focus - types/customer segments, demand profile, customer relationships, and channels to reach the customers. Include a few customer interviews
- Cost structure - what are the most important costs inherent to the business model? (Fixed, variable) - Business is cost driven vs value driven. Which resources and activities are most expensive? Economies of scale? Layout assumptions for costs.

- Revenue Streams - what value are customers willing to pay. revenue collection systems (leasing model, fee-for-service, PAYG, fixed pricing or dynamic pricing). Compare your price against the best alternative option / solution. why would customer switch. Where already possible explain which revenue streams are secured vs. projected.

5. Financial Analysis

- Important nos. on total investment, breakdown of the capex and opex costs
- Documentation of the revenues from the product and/or service
- Estimations regarding payback period and providing insights into scale-up possibility and investment requirement

6. Existing Business Models and Experiences -

- Describe what is already known and has been experimented with regard to the proposed solution
- Description of existing business models under application in developing country contexts
- Describe their revenue streams, revenue generation, payback periods under different business models.

7. Experience and Additionality by the SESA demos (Before/In parallel with business plans)

- BMC for the SESA LL and how the new BM plans to address the identified problem
- Describe the additionality and experience from SESA pilots - what is new?
 - Additionality / Differentiation - What is it exactly that truly helps your solution to stand out, and differentiates it from your competition? Describe in one short passage (3-4 sentences). Why is another hub needed in this region and industry? What is currently not being covered? What proof of early success do you have? What is an "unfair" advantage you have, which can't easily be replicated by someone else.

8. Challenges Faced by Existing Businesses and Learnings (Before/In parallel with Business Plans)

- Briefly describe the challenges faced by the existing businesses - supply-side issues, working with smallholders, pricing and taxation issues, financing issues etc.
- Key learnings/lessons from existing businesses and the need for new business models.

9. Risk and Mitigation

- Risks and considerations
- Reflections on scalability, replicability

10. Conclusion

Annex B – Exemplary Questionnaire for Baseline and Market Assessment (Cold Room Use Case, Kenya Living Lab, Questions for Individual Traders)

Part 1: About the produce and trade

1. Where do you normally buy products?
2. Where do you normally sell products?
3. How often do you buy fresh produce? Choose one - Daily, Once a week, twice a week, thrice a week, On market day, Before market day
4. What kind of products do you buy/sell? List.... Sukuma
5. What do you do when the produce gets spoilt? List of options - Self consumption, Throw, Reduce Price and Sell, Other etc. (semi-structured)
6. How do the products get to you (if it differentiates for different products please indicate)
 - delivery from the producer
 - delivery from an agent (e.g., the boda guy from the producer)
 - pickup by an agent (e.g., your boda guy)
 - self-pickup
 - other ____
7. What distance/radius do you cover for buying the products (if it differentiates for different products please indicate)
 - Produce brought to market gate
 - <200m
 - <1km
 - <5 km
 - <10 km
 - <20 km
 - <...
 - >50 km
8. How much is the cost of transporting produce from the supplier to the marketplace?
9. Where do you store your products (if it differentiates for different products please indicate)
 - yes at home
 - yes market stall
 - yes market storage
 - yes a place ____
 - no, because ____

Part 2: About Existing Solutions for cold Storage and willingness to pay

Do you store any of your products in any type of artificially cooled environment?

If no:

10. How do you preserve your products naturally?
 - Ash
 - Store on the floor
 - Sprinkle water

- In a hole
- Other

If yes:

1. Which artificial storage method do you use?

- Use electric powered fridge
- Use cooler box (with ice flakes/Ice blocks)
- Use cooler box (without ice)

2. How long can the products be preserved/stored with this method before taking them to a wholesaler / to a market? • < 1 day • < 2 days • < 3 days • < 1 week • 1-2 weeks • > 2 weeks

3. Do you buy ice to store products? Yes • No •

4. How much do you spend on ice purchase per week? • < 500 • 501-3500 • 3501-7000 • > 7000

5. What are the challenges with using ice? (Open)

6. Do you have any prior experience of using cooler boxes? If yes, what did it cost?

7. Do you have any prior experience of using refrigerators? If yes, what did it cost?

8. Would you be willing to pay to keep store your produce in a refrigerated environment? If yes, how much per day (leave open ended)

Part 3: Food waste Chart

Name of the interviewee: _____

Products (5 main)	At what price did you buy this? (kes/unit)	How much of this produce did you buy? (unit)	After how much time the produce starts to go bad? (In days)	How much of this produce gets fully spoiled or thrown? (unit/day)	What is the lower price before throwing it away? (kes/unit)	At what price did you sell the fresh produce? (kes/unit)

Project partners



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