FIVE IMPLEMENTATION SUMMARY REPORTS FOR DEMONSTRATION ACTIONS (D4.3)

2025

Deliverable Number	D4.3
Deliverable Name	Five (5) implementation summary reports for the demonstration actions
Full Project Title	SESA – Smart Energy Solutions for Africa
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Contractual Delivery Date	31-03-2025
Actual Delivery Date	31-03-2025
Status	Final version
Dissemination level	Public
Version	V1.0
No. of Pages	75
WP/Task related to the deliverable	WP 4 / T 4.2 & T 4.3
WP/Task responsible	BTH
Document ID	SESA_D4.3_ Implementation summary reports for the demonstration actions
Abstract	This report presents a consolidated summary of five demonstration actions implemented under the SESA project across Kenya, Morocco, South Africa, Ghana, and Malawi. Each site tested context-specific renewable energy solutions ranging from solar microgrids and mobility hubs to clean cooking technologies aimed at improving energy access and community resilience. The report outlines the solutions employed, preliminary results achieved, challenges encountered, and lessons learned across the five contexts. It also offers practical recommendations for further development, with a focus on local capacity building, inclusive business models, and partnerships essential for scaling sustainable energy innovations across Africa.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101037141. This material reflects only the views of the Consortium, and the EC cannot be held responsible for any use that may be made of the information in it.

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Executive Summary

This report presents a summary of the implementation and outcomes of five demonstration actions conducted under the Smart Energy Solutions for Africa (SESA) project in a demonstration living lab- Kenya, and four validation countries- Morocco, South Africa, Ghana, and Malawi. These actions were designed as pilot sites for testing innovative, community-driven renewable energy solutions tailored to diverse socio-economic, geographic, and regulatory contexts. The overarching goal was to support inclusive and sustainable energy transitions across Africa by validating decentralized, clean energy technologies and approaches.

SESA operates within the framework of the EU Horizon 2020 programme, emphasizing real-world application, community co-creation, and knowledge transfer between European and African partners. The five country pilots were guided by a unified methodology structured around five strategic objectives:

- **SO1 – Inform**: Engage stakeholders and raise awareness on renewable energy opportunities.
- **SO2 – Inspire**: Stimulate innovation through local success stories and cross-regional collaboration.
- **SO3 – Initiate**: Build community capacity and develop localized energy ecosystems.
- **SO4 – Implement**: Deploy and test renewable energy solutions adapted to local conditions.
- **SO5 – Impact**: Create scalable, lasting change through partnerships and institutional engagement.

In Kenya, the demonstration established a Modular Living Lab in Katito (peri-urban) and Kisegi (rural), piloting solar microgrids, solar charging hubs, and productive-use appliances co-designed with communities. The approach prioritized capacity-building and long-term partnership development to expand access and scale deployment.

Morocco implemented a dual demonstration approach. In urban areas (Marrakesh, Fez, Agadir, and Benguerir), the focus was on electric mobility solutions—including e-motorcycles and EV charging stations. In rural villages, the project piloted solar PV systems to provide basic electricity access, aligning with Morocco's national climate and energy goals.

In South Africa, the pilot was conducted in Alicedale, a marginalized rural town in the Eastern Cape. The project deployed a containerized off-grid solar energy system with second-life EV batteries and micro-electric vehicle (micro-EV) charging infrastructure. This integrated solution addressed both energy access and sustainable transport, while promoting digital monitoring and local empowerment.

Ghana focused on three priority areas: 1) clean cooking using bioethanol-fueled cookstoves, 2) repurposed lithium-ion batteries for solar energy generation and storage, and 3) education and awareness through energy "infospots" in schools. These actions were implemented in Accra and Kumasi to build local capacity and support public schools and households with sustainable alternatives.

In Malawi, the demonstration targeted clean cooking and solar irrigation. The MIG BioCooker—designed to use locally produced biomass briquettes—was introduced to reduce deforestation and improve household air quality. Simultaneously, a solar-powered irrigation system was

deployed with a loan-based model for smallholder farmers, implemented in partnership with the Smart Energy Enterprise (SEE).

Common themes across the five demonstrations include the importance of co-design, local governance, and financial inclusion in ensuring the success and replicability of clean energy solutions. Key barriers encountered ranged from limited access to finance and policy fragmentation, to technical capacity and infrastructural challenges. Nevertheless, the pilots generated actionable lessons and evidence supporting the scalability of decentralized energy models in African cities and communities.

The report concludes by highlighting the relevance of these findings for policymakers, energy planners, and technology providers seeking to foster just energy transitions. SESA's integrative approach—linking technology, policy, and people—offers a blueprint for inclusive, climate-aligned development in both developed and developing countries.

Introduction

Achieving universal access to clean, affordable, and reliable energy remains one of the most urgent development challenges in Sub-Saharan Africa. While many countries have made notable progress in extending electricity coverage, large segments of the population—particularly in rural, peri-urban, and informal settlements—continue to rely on expensive, polluting, and unreliable energy sources. This persistent energy gap not only undermines health and education outcomes but also limits income-generating opportunities and community resilience in the face of climate change.

The Smart Energy Solutions for Africa (SESA) project was initiated in response to this complex challenge. Rather than adopting a one-size-fits-all model, SESA focuses on context-sensitive, decentralized energy innovations that are designed, implemented, and refined in partnership with local actors. The project operates on the understanding that sustainable energy transitions must be inclusive, participatory, and deeply grounded in local socio-economic realities.

Through five demonstration actions in Kenya, Morocco, South Africa, Ghana, and Malawi, the project aimed to test the viability and adaptability of different renewable energy technologies, business models, and governance approaches. These pilots serve not only as technical interventions, but as real-world laboratories for learning about what works, and what does not, when implementing clean energy systems in diverse African settings.

The rationale behind these pilots is two-fold. First, they help to bridge the gap between high-level policy ambitions and on-the-ground implementation by generating practical evidence and locally driven success stories. Second, they provide a platform for knowledge exchange between African and European partners, supporting innovation and mutual capacity-building through South-North and South-South collaboration.

Each demonstration site was carefully selected to reflect a unique set of challenges—ranging from low grid penetration and unreliable supply to limited productive-use infrastructure and youth unemployment. In these environments, SESA interventions were designed to align with local development priorities and to support broader goals around economic inclusion, digitalization, and climate action. By bringing together governments, businesses, researchers, and communities, the SESA project represents a systems-level approach to energy innovation; one that integrates technology with policy, finance, and social dynamics.

The following sections offer a synthesis of the implementation journey, lessons learned, and opportunities for scaling up, based on the diverse experiences across the demonstration (1) and validation (5) countries.[1] All demonstrations were guided by a shared framework of five strategic objectives: Inform, Inspire, Initiate, Implement, and Impact. These objectives shaped project design, community outreach, technology deployment, and monitoring strategies.

The lessons presented in this report serve as a practical foundation for advancing inclusive energy transitions across Africa. By linking technology to local needs and capacities, SESA offers a blueprint for scalable, equitable, and sustainable energy solutions.

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[1] It is important to mention that some of these actions were replicated in Namibia, Rwanda, Tanzania and Nigeria. However, this report only covers the demonstration and validation countries where results were extensively collected.

1.0 Kenya– Modular Living Lab

SESA established Kenya as a key demonstration site, targeting rural and peri-urban areas that remain underserved by conventional energy systems. Despite significant advancements in electrification, the country continues to struggle with uneven energy distribution, particularly in areas underserved by the national grid.

Two locations were selected for their contrasting characteristics: Katito in Kisumu County representing a peri-urban environment with growing energy needs, while Kisegi in Homa Bay County exemplified the energy challenges faced by remote rural communities.

The project was structured around five key objectives (SO1-SO5), guiding the deployment and validation of renewable energy solutions:

- **SO1: Inform** – the project aimed to inform local communities and stakeholders about the potential of modular energy systems to address their energy access challenges.
- **SO2: Inspire** – by creating successful demonstrations, the project sought to inspire broader adoption of renewable energy solutions in Kenya and other parts of Africa.
- **SO3: Initiate** – the project focused on initiating local capacity-building efforts, enabling communities to take ownership of the deployed technologies.
- **SO4: Implement** – it implemented real-world solutions, focusing on technologies like solar microgrids and solar charging hubs, tailored to the specific needs of the regions.
- **SO5: Impact** – the project aimed to create long-term impact by fostering partnerships with local governments and stakeholders to scale the Solutions beyond the demonstration phase.

This section summarizes the demonstration actions conducted in Katito and Kisegi, focusing on the activities across the various work packages (WPs) and their contributions to achieving the SESA project's strategic objectives.

1.1 Problem to address

Energy poverty remains a persistent challenge in Kenya, where millions of people, particularly in rural and peri-urban areas, lack reliable access to affordable and clean energy. In many parts of Kisumu County and Homa Bay County, off-grid households continue to rely on costly and environmentally damaging fuels like kerosene and firewood. This creates significant barriers to economic development and quality of life, particularly in areas with high poverty rates.

In addition to local needs, consortium partners in the SESA project were looking to test their innovative renewable energy solutions in a context that presented unique geographical, economic, and infrastructural challenges. This demonstration was therefore mutually beneficial as it provided consortium partners with the opportunity to adapt and refine their technologies for underserved African contexts, while Kenyan communities benefited from improved access to renewable energy.

The challenges addressed through the SESA project were aligned with the five strategic objectives (SO1-SO5):

SO1: Inform – addressing the lack of access to innovative and affordable renewable energy Solutions

The peri-urban community of Katito and the rural village of Kisegi had limited access to affordable energy solutions. In both locations, households relied on traditional fuels, which were not only expensive but also harmful to health and the environment. The SESA project sought to inform these communities about the potential of modular renewable energy solutions, such as standalone solar charging hubs, through user co creation sessions and community engagement meetings.

For the consortium partners, the project offered the chance to understand how the energy access innovations could be applied in contexts with low grid penetration, fragmented infrastructure, and economic constraints. It allowed them to adapt their tools to better suit these underserved regions.

SO2: Inspire – bridging the knowledge gap between Europe and Africa in renewable energy innovation

A significant challenge that the project sought to overcome was the knowledge gap between Europe and Africa in energy access innovation. European stakeholders were eager to learn how to adapt their technologies to African settings, while local communities in Katito and Kisegi needed exposure to clean energy technologies that had the potential to transform their livelihood. The project aimed to inspire local leaders, businesses, and innovators to take an active role in expanding renewable energy adoption in their regions.

By successfully demonstrating how solar energy systems coupled with innovative use case appliances could meet the needs of these communities, the SESA project created a blueprint that could be replicated across Kenya and other African countries.

SO3: Initiate – enabling local innovators and building capacity

A key challenge in Kenya was the lack of technical capacity to design, implement, and maintain innovative new energy access innovations solutions. The SESA project addressed this by initiating supporting capacity-building efforts of the social enterprise WeTu. This included knowledge exchange workshops, webinars and capacity building collaborations with solutions providers to ensure long term sustainability of the piloted use case appliances and respective business models. This offered a valuable opportunity to test different capacity-building models in real-world settings, providing insights into how local ownership could be developed and scaled.

SO4: Implement – overcoming co-development challenges

The implementation of the SESA solutions in Katito and Kisegi had several concerns, particularly in terms of adoption, user acceptance, community engagement, and infrastructure. In Katito, the deployment of the solar charging hub required careful planning to ensure that it met local energy needs while remaining cost-effective. The integration of various innovative use cases presented challenges such as terrain challenges and drive train issues for electric mobility and system breakdowns of the solar powered reverse osmosis unit and later low uptake of clean safe water from the water ATMs. These challenges required careful collaboration between WeTu and the various solutions suppliers to ensure that the use cases were adequately functional with little to no downtime.
In Kisegi, implementing the solar charging hubs faced challenges related to transportation and logistics due to the village's remote location. Accessing Kisegi with the necessary equipment

presented a challenge due to terrain challenges, and the project had to navigate these logistical constraints to ensure successful deployment. This was done through WeTu's commitment that included detailed planning and problem solving that enabled the successful deployment of the solar charging hubs despite the significant logistical hurdles.

The Kenyan demonstration served as a testing ground for how modular energy systems could be adapted and scaled in resource-constrained environments. This involved not only deploying the technology but also validating its performance under the unique conditions of each site. The lessons learned from these challenges informed broader efforts to scale renewable energy solutions across Africa.

SO5: Impact – ensuring long-term sustainability and partnership-building

A key consideration for the SESA project in both Katito and Kisegi was ensuring that the energy solutions implemented would have a long-term, sustainable impact. This required building strong partnerships with local communities, community leaders, diverse user groups. In both Katito and Kisegi, the project worked with local government officials to ensure alignment with local government licensing and county priorities as per energy development frameworks to ensure that the Katito, ensuring that the benefits would be tangible regionally.

In both Katito and Kisegi, local leaders and the local community were involved in the development of solar charging hubs and use case appliances with an emphasis on creating a collaborative user centered co-creation process ensuring that there was community acceptance of the renewable energy access infrastructure and innovation which was essential for the sustainability of the project. This required not only technical sessions but also dialogue with local stakeholders to ensure that they were invested in the long-term success of the project.

This was an opportunity to test how strategic energy solutions could be integrated into local governance structures and economic systems. The ability to form long-term partnerships with different stakeholder groups and user groups was critical in ensuring that the systems could be scaled and sustained beyond the demonstration phase.

1.2 Solutions employed

The SESA project deployed renewable energy systems in Katito (Kisumu County) and Kisegi (Homa Bay County), addressing energy access and testing scalable, modular solutions through a coordinated effort across multiple work packages (WPs).

The two sites are powered by standalone solar charging hubs that power the Productive Use of Energy Appliances for pilot demonstration actions.

Peri Urban Katito solar charging hub: stand-alone ac-coupled solar system

- The Katito solar charging hub operates with a robust AC-coupled solar system, integrating 64 solar modules of 570Wp each, resulting in a total installed capacity of 36.48kWp.
- The system utilizes two grid-tie SMA Sunny TriPower inverters, each rated at 15kWp, achieving a total AC output of 30kWp. To enhance energy reliability, it includes three SMA Sunny Island 8.0H battery inverters, one for each phase.
- Its energy storage relies on 24 lead-acid OPzS batteries, each with a 2V capacity of 2266Ah, delivering a total storage of 106.848kWh. This configuration supports a balanced and efficient energy solution suitable for diverse use case appliances.

Aerial view of roof mounted Katito solar panels and traditional SMA inverter system

Rural Kisegi solar charging hub: stand-alone hybrid solar system

- The rural solar charging hub in Kisegi is equipped with a stand-alone hybrid solar system designed for high efficiency, reliability and capability for a swapping system. It features 66 solar modules, each rated at 570Wp, providing a total installed capacity of 37.62kWp.
- The system's power management is supported by six inverters, each with a 5kWp capacity, delivering a total AC output of 30kWp.
- The battery and energy storage are handled by 10 lithium-ion battery packs, each with a capacity of 5.1kWh, offering a total storage capacity of 51kWh.

The thinking behind this lithium-ion system was to explore the potential of having a swappable system where the lithium-ion batteries work as storage for the system and power the respective use case appliances through swappable system.

Aerial view of Kisegi ground mounted solar panels and hybrid inverter system

1.2.1 Use Case Innovation Piloted

Solar powered electric two-wheeler (boda boda) motorcycles

The current electric converted motorcycle has a 48V 4.6 kWh lithium-ion battery, a 2kW geared motor, and an 88V 3000W controller. With a top speed of 90 KPH and a range of 120 km, the upgraded drivetrains and gear coupled motors are designed for rough terrain and equipped to meet the needs and demands of commercial boda boda riders.

Locally sourced ICE to electric two-wheeler (boda boda) commercial motorcycle

Solar powered cold room

The 27-cubic-meter solar-powered cool room features a 15-kWh battery and a 3.8 kWp photovoltaic system that runs the system. Fresh green leafy vegetables and produce are kept cool by its eight cooling units, which run on a 24V system.

Solar powered cold room

Solar powered fishing lanterns

For omena (silver cyprinid) night fishing, these solar-powered lanterns, which are leased for a daily fee and charged at the solar charging hub in the Kisegi hub provide a sustainable environmentally friendly alternative that increase fishing operations' profitability while improving the environmental health of the Lake Victoria ecosystem by replacing kerosene lamps and lead acid batteries.

WeTu staff issuing solar powered fishing lantern to fisherman

Solar powered safe clean water

Solar-powered reverse osmosis for the Katito site filters borehole water and an ultrafiltration system for the Kisegi site purifies lake water to provide clean safe drinking water. The water's availability is offered through a cashless digital water ATM network that ensures water is available 24/7. For the peri urban site in Katito for residents living away from the water ATMs, clean safe drinking water is delivered to homesteads and households using an electric powered three-wheeler (tuk tuk).

Safe clean water ATM at the Katito peri urban site

Solar-powered irrigation

The solar irrigation use case is currently powered by an 800W solar-powered irrigation pump which can deliver a maximum flow rate of 17,000 liters per hour and operates with heads of up to 50 meters. The solar irrigation use case can be powered both by solar panels or a lithium-ion battery charged at the solar charging hub to provide affordable and energy efficient solar powered irrigation to the small holder farmers in Kisegi to enhance their agricultural productivity.


Solar powered irrigation pump during solar irrigation pump testing phase

E-waste recycling

WeTu has integrated a circular economy approach in its operations to ensure recycling and repurposing to extend the lifecycle of components, such as batteries and electric motors, while ensuring safe disposal of any parts that cannot be recycled, reused or repurposed and have reached their end of life. Further to this WeTu has also initiated e-waste collection in the surrounding community of Katito to promote and ensure the safe

1.2.2 Work Packages

WP1: Development of the technology basis

WP1 partners supported the development of user needs assessment tools collaboratively to be deployed to capture the unique user needs in the respective living lab sites. Further to this a toolbox with the best approaches was launched at the SESA fourth regional event in October 2024.

Further to this, WeTu, the Stockholm Environment Institute, and WP1 task partners collaborated to conduct comprehensive User Needs Assessments (UNA). A total of 207 respondents participated in structured interviews for the assessment, which was conducted between September and October 2022 in Katito (Kisumu County) and Kisegi (Homa Bay County). The participants and respondents represented the main economic activities in the area, including traders, small-holder farmers, fishermen, boda-boda riders.

To further understand the unique energy and socio-economic needs as pertains to the SESA project focus group discussions were also conducted as part of the UNA to obtain deeper insights into the socioeconomic elements impacting the uptake of renewable energy technologies. The results of the UNA influenced the development and application of the different use case solutions, ensuring that they were appropriate for the local context and met the communities' and user needs.

Below are some of the brief insights from the user needs assessments:

Electric mobility: Insights from the electric mobility UNA results emphasize how many citizens depend on two-wheeler motorbikes, or boda bodas, for logistics purposes and as a main source of income. However, despite this local boda boda riders' net earnings are greatly reduced by the high fuel expenditures they reported each day. Although most riders indicated that they would be interested in making the switch to electric motorcycles, concerns on battery management and technical dependability were common. Financial restrictions were also cited by many riders as the reason they favored rental or leasing arrangements over outright purchasing.

Safe water access: UNA insights for access to safe water found that whereas most Kisegi inhabitants relied on surface water sources because of their proximity to Lake Victoria, which resulted in lower spending, Katito locals responded to having more access to piped and borehole water although incurring higher water expenses. Although water in Kisegi was relatively accessible due to proximity to Lake Victoria, worries about its supply and unsafe quality remained with persistent water borne disease outbreaks as per respondents. Many respondents in both sites expressed interest in solar-powered water pumping systems and being able to access water from a dependable and safe option.

Fishing lighting practices: Kisegi fishermen respondents expressed great interest in solar fishing lanterns as a cleaner and more cost-effective substitute for kerosene lamps and lead acid batteries, pointing out the financial burden of their current options. The advantages of moving to solar-powered solutions for the environment were mentioned by several respondents' key among them being reduced fuel expenditure and reliability unlike current options available. Increased availability of durable fish lighting options and flexible payment options, according to users, would promote adoption of affordable more efficient solutions such as solar fishing lanterns more quickly.

Cooling: Due to insufficient storage facilities, respondents, especially small-scale farmers and fresh produce traders reported significant post-harvest losses. To preserve perishable commodities and increase market traders' incomes, 95% of respondents indicated interest in using solar-powered cold rooms. In contrast to a price per kilogram, respondents indicated a high preference for flexible payment schemes such as price per crate and quantity of crates with produce. A significant number of respondents stressed the importance of reasonable prices and dependable operation.

Solar irrigation: To meet their irrigation requirements, smallholder farmers who were the large number of respondents stated a a preference for high-capacity solar-powered pumps (6–10 HP). Despite acknowledging the advantages of less reliance on fuel, many respondents pointed to the initial expense of solar powered pumps as a deterrent. The price and flexibility of rental and leasing options were highlighted by respondents as their preferred solutions. Farmers also stressed the value of dependable technical assistance and after-sales service as being critical to their usage of any intended solution.

WP2: Capacity building and cooperation

WP2 supported and offered guidance on capacity building and cooperation primarily focused on comprehensive technical training provided by solution providers to the WeTu operational team. These efforts centered on equipping WeTu staff with skills in operations, maintenance, and technical expertise. There were two capacity building training courses focusing on electric mobility conducted for a total of 6 WeTu technical staff. The initial training focused on conversion and maintenance of ICE to electric two wheelers and the second training was on upgrading of the drivetrain various components such as mechanical and electrical components. Following this primary capacity building phase, the WeTu team then conducted user awareness and information sessions with community members, educating them on the proper usage and benefits of the various solutions - including solar lanterns, e-mobility services, and water systems. This two-tiered approach ensured both technical excellence in service delivery and proper end-user adoption of the technologies.

WP3: Business models and market solutions

WP3 supported the refinement of business models for the different use cases tailored to the local contexts in Katito and Kisegi. In both sites different leasing and rental models were introduced and that allowed different user groups to access energy without the burden of high upfront costs. In Kisegi, battery swapping and leasing models were tested, helping local businesses and fishermen gain reliable access to energy.

Solar fishing lanterns on pay-per-use and leasing model: The solar powered fishing lanterns business model uses an innovative pay-per-use and rental leasing model, offering clean and reliable lighting solutions to omena night fishermen. From January 2023 to December 2024, the innovative business model for solar-powered fishing lanterns has demonstrated remarkable success, achieving significant environmental and social impact. Significant environmental impact has been achieved with a cumulative saving of 188,309 liters of fuel and preventing 470,771 kg of CO_2 emissions. Monthly fuel savings rose significantly, from a low of 50 at inception to a high of 14000liters per month, while avoided CO_2 emissions grew from a low of 124 kgs to 37000 kg per month.

Electric boda boda battery swapping: The electric boda business model has evolved from a leasing plus battery swapping model into an energy-as-a-service solution, allowing riders to pay only for the energy consumed. This shift from a traditional daily rental fee and bike rental deposit has increased affordability and accessibility for riders. Since fleet upgrades and drive train modifications in June 2024, the model has facilitated 1,583 battery swaps, covering a total of more than 347,000 kilometers, promoting cleaner urban mobility and reducing reliance on fossil fuels for the riders in Katito.

Clean safe water atms and e-three-wheeler deliveries: The business model piloted for clean, safe drinking water involves direct sales through a network of 24-hour self-service water ATMs and last-mile deliveries using an electric three-wheeler for Katito. Powered by solar water purification systems, this model ensures reliable access to purified water in Katito and Kisegi. By combining robust technology with sustainable delivery, over 900,000 liters of clean water have been provided, significantly improving health and sanitation outcomes in both Katito and Kisegi.

Cold storage as a service for fresh produce vendors: supporting small-scale traders, the cold storage business offers cold storage as a service business model with a per crate per day charge. The solar-powered cold room has stored over 4,000 kilograms of fresh produce, benefiting 187 local fresh produce vendors, 96% of whom are women.

Solar-powered irrigation: The solar irrigation business model adopts an energy-as-a-service model, where farmers pay only for the energy used to pump water. By leasing pumps for specific periods each day, smallholder farmers will access affordable irrigation solutions without upfront capital costs. This sustainable approach seeks to support increased agricultural productivity, conserves already scarce water resources, and promotes climate-resilient farming in Kisegi.

Electronic Waste Collection and Recycling: The electronic waste management business model focuses on the collection, recycling, repurposing, and safe disposal of electronic waste. By creating an organized e-waste management system, WeTu has prevented hazardous waste from contaminating the environment. Since the inception of the Katito site, the initiative has successfully collected 3.5 tons of electronic waste from Katito and surrounding areas to date.

This success of the various innovative business model approach highlights the importance of innovative and adaptive business models coupled with market-driven use case appliances in reducing fossil fuel dependency among fishermen and promoting climate change mitigation, delivering both environmental and social benefits.

WP4: Demonstration, validation, and replication

WP4 led the implementation of the solar energy systems in both locations. In Katito, the project installed a solar microgrid that not only provided energy but also included an ultrafiltration water purification system. In Kisegi, solar-powered water pumps and charging hubs were introduced, supporting local agriculture and households. These technologies were validated and refined through living labs, ensuring that they were tailored to the needs of the communities.

WP5: Scale-up, finance, and policy environment

WP5 worked to ensure that the solutions implemented in Katito and Kisegi could be scaled up. By engaging with local stakeholders, WP5 laid the groundwork for integrating these solutions into wider energy plans. This work package also explored financing options for expanding the reach of the solar energy systems.

WP6: Communication and dissemination

WP6 disseminated the project results to a broader audience. Audio-visual materials and toolkits were developed based on the success of the Kenya demonstration, and these were shared through online platforms, local workshops and international forums. The dissemination efforts ensured that the lessons learned from Katito and Kisegi could inform similar projects in other regions.

WP7: Project management and coordination

WP7 was responsible for the overall project management and coordination in Kenya, ensuring that activities aligned with the project's objectives and that communication flowed smoothly between technical teams, local stakeholders, and consortium partners. WP7 also ensured compliance with local regulations, coordinated risk management, and oversaw sensitive issues such as ethical considerations in the demonstration sites, playing a critical role in ensuring the project's successful implementation.

1.2.3 Innovation approach: user co-creation

WeTu's approach to delivering innovative use case appliances was implemented using a structured co-creation methodology and approach that prioritized user engagement at every stage of the pilot demonstration actions. The process began with community engagement meetings to introduce the project's objectives and gather initial feedback from the target local communities. These meetings provided a foundation for inclusive decision-making and ensured that the intended use case appliances resonated with community needs and priorities.

Following the initial community engagement meetings, successive user needs assessments were conducted for each of the use cases and business models to be piloted to identify specific requirements for each solution for each use case. Key insights such as, farmers highlighting the need for portable solar powered irrigation systems that could support small-scale agriculture, while fresh produce vendors emphasized the necessity of cold storage to preserve perishable goods as the real unmet need and demand. Such invaluable insights from the UNAs validated and guided the iteration of the use cases appliances and business models to address practical needs and challenges.

Focus group discussions (FGDs) were held with key user segments of the prospective user groups, FGDs were conducted with local two-wheeler boda riders, fishermen, smallholder farmers, and fresh produce vendors or traders. These discussions delved deeper into topics such as daily operational challenges, cultural practices or hinderance, and user preferences, ensuring that the solutions were relevant and user-friendly.

To familiarize users with the technologies and build trust, WeTu organized demonstration sessions for solutions such as solar irrigation pumps and fishing lanterns. These practical showcases allowed users to experience the benefits directly, fostering confidence and interest in adoption.

Adoption and uptake of the respective use case appliances was further incentivized through freemium models and subsidized access periods; these enabled users to trial and experience the different use case appliances without immediate initial financial commitments. Throughout these trial phases regular feedback loops were established, allowing users to provide input on the functionality and usability of the different technologies and use cases being piloted. This iterative approach ensured continuous refinement and alignment with user needs with further user satisfaction surveys to be conducted.

1.3 Challenges encountered

The demonstration actions in Katito and Kisegi faced several challenges, stemming from both local contexts and the complexity of deploying scalable renewable energy solutions. These challenges were aligned with the five strategic objectives (SO1-SO5) and had varying degrees of impact on the project's ability to fully meet its objectives in the short term.

Katito (Kisumu County)

- **Terrain challenges** – The rugged terrain in Katito presented challenges to the initial pilot of the electric mobility use case, this specifically led to mechanical breakdowns and failures of the motor and drivetrain of the initial version of the converted electric bikes. This necessitated a recall of the bikes to allow for upgrades and remedial action for the motor and drivetrain components.
- **Initial skepticism adopting new** technologies – Initial engagement with local residents and target user groups showed reluctance and hesitance towards adopting the pilot use case appliances and solutions largely due to lack of familiarity with the piloted technology. This initial skepticism was a key challenge in uptake and adoption of the use case solutions piloted across the various use cases.
- **Regulatory and policy barriers** – A significant challenge that faced deployment of innovative use case technologies such as electric mobility is the lack of understanding and alignment with service providers such as insurance companies. A lack of comprehension of risk profiles for innovative technologies such as the converted electric bikes led to limited availability of insurance packages and lack of appropriate insurance products and subsequently prohibitively high premiums. This not only further exacerbated the affordability of the technology but also led to operational delays as WeTu prioritizes compliance with safety and operational standards.

Kisegi (Homa Bay County)

1. **Rural remoteness and adverse weather**– Kisegi's remote location presented significant challenges for the construction of the solar charging hub. This was because of the poor road network which made transportation of construction material and solar components difficult, costly and time consuming. The situation was further influenced by adverse weather conditions that compounded the logistical challenges presented by the poor road network which led to delays in material deliveries and subsequently extending construction timelines.
2. **Affordability** – in Kisegi, many residents had limited financial resources to engage in battery swapping or leasing models for the solar charging hubs. The project had to explore alternative financing models to ensure affordability, which slowed the initial uptake of the technology.
3. **Technology acceptance** – the transition from traditional fossil fuel powered energy sources, such as kerosene and lithium-ion batteries, to innovative solar powered use case appliances such as the solar powered lanterns faced resistance and adoption barriers. Fishermen and users were initially hesitant to abandon long-established fishing and energy practices, and it took time to build trust in the reliability and benefits of our lantern and use case solutions.

General challenges for both sites

1. **Affordability barriers** – In both Katito and Kisegi piloting the respective use case innovations and business models was a challenge due to the limited incomes of the respective communities. Limited incomes presented a challenge in the immediate uptake

of the respective piloted technologies which significantly impacted adoption and access of the respective use case appliances.

2. **Supply Chain Challenges** – Supply chain challenges presented a potential challenge to execution of pilot activities in both sites affecting at times deployment of use case appliances and construction of the charging hubs leading to project implementation delays.

1.4 Lessons learned

The pilot demonstration actions in the Kenya demonstration sites have offered valuable insights into the implementation of renewable energy access solutions in both peri-urban and rural contexts. Several key lessons emerged from the project:

Design for durability of use case applications for rugged terrains

The terrain challenges experienced in Katito and Kisegi underscore the importance of designing and deploying durable use case appliances suited to rugged terrain. To ensure the reliability and long-term performance of PUE use case applications must be designed and tailored to withstand demanding conditions of rural and peri urban terrains. Features such as robust motors, reinforced drivetrains and durable materials are essential in addressing the challenges presented by such terrain and guarantee the effectiveness and success of e-mobility innovations in such contexts.

Affordability shapes adoption

High upfront costs and limited access to financing are significant barriers to the adoption of renewable energy technologies in most underserved regions. The sharing economy approach and circular economy approaches deployed and piloted by WeTu, such as leasing and rental models, are essential in overcoming barriers such as the high upfront costs of PUE appliances. By offering affordable leasing and rental options for PUE appliances such as solar lanterns and flexible leasing models for electric bikes and cold storage, this ensures that users with minimal financial resources can benefit from these innovations and thus increasing uptake of these technologies and subsequently renewable energy access.

User co-creation and stakeholder engagement drives acceptance

Tailoring solutions to the unique needs and cultural considerations of user groups and local communities enhances the acceptance, minimize initial skepticism, usability and adoption of new technologies. Demonstrations, pilot testing and focus group discussions that allow for hands on user experience allows users to experience the reliability and benefits of piloted technologies fostering trust and a sense of ownership. Additionally, adopting open feedback loops enables continuous iteration and improvements that ensures the technologies are suited to the end user needs enhancing adoption, acceptance and long-term sustainability.

Continuous engagement and awareness fosters behavior change

Initial skepticism and lack of familiarity with the respective piloted PUE innovations presented a potentially significant barrier during the initial phases of the pilot demonstration actions. Early and sustained engagement with potential user groups and local communities was critical to the success of the pilot demonstration actions. Prospective users and local communities involved in the planning, decision-making, and implementation fostered trust, ensured cultural acceptance, and aligned the solutions with local needs. Consistent awareness campaigns and hands-on demonstrations were essential to overcoming these challenges. By highlighting the financial savings, environmental benefits, and ease of use of solar lanterns, electric mobility, cold storage and water purification systems, it fosters trust and encourages behavioral shifts toward adopting clean energy solutions.

Capacity building and continuous iteration improves usability

Innovative new technology requires high maintenance or specialized expertise are difficult to sustain in areas with limited technical capacity. The implementation of user-friendly feedback loops with users combined with capacity building of internal WeTu team addresses the issue of maintenance and sustainability challenges. Collaborative training programs with the different technology solutions providers empowered internal WeTu technicians to be able to continuously iterate and improve the use case appliances to ensure that user feedback can be integrated into the iteration and improvement of piloted technologies especially for the electric converted two wheelers, ensuring their longevity and reducing reliance on external support.

Community engagement builds trust

Early and sustained engagement with local communities and stakeholders is critical to the success of the pilot activities and adoption of new technology. Involving communities in planning, decision-making, and implementation fostered trust, ensured cultural acceptance, and aligned the solutions with local needs. Public participation, as mandated by the Kenyan Constitution, was integral to securing buy-in from the communities in Katito and Kisegi.

Equity and inclusion enhance impact

The design and implementation of innovative use cases and business models prioritized inclusivity, addressing the specific needs of women, men, low-income households, and underserved groups. Solar-powered cold storage has primarily benefited women-led small-scale fresh produce vendors, who make up 96% of the cold room users, thus significantly reducing post-harvest losses and increasing incomes.

Solar fishing lanterns have provided clean lighting to 30 fishermen, with 24 men and 6 women, promoting productivity and reducing kerosene use. While male clients dominate this sector, female participation is a step toward inclusivity.

Electric two-wheelers offer affordable mobility, with 1 female rider among 7 users, indicating progress in engaging women in the commercial two-wheeler space and sustainable transport.

In clean water access, women remain the primary buyers, ensuring safer water for households. The equitable reach of these solutions has maximized the project's social impact, fostering resilience and economic empowerment across gender and age groups in both sites.

Focus on local needs

User needs assessments, continuous user engagement and focus groups conducted during the design phase and throughout implementation ensured that the technologies and business models aligned with community priorities. This approach enabled the project to address pressing local challenges, such as providing clean drinking water through ATMs, water deliveries and improving the economic viability of cold storage, fishing and electric mobility use case appliances.

Modular and durable systems enable flexibility

The use of modular solar charging hubs and durable use case appliances allowed for iterative improvements based on user feedback and local conditions. Solar-powered systems, electric converted bikes, irrigation pumps and use case appliances were designed to withstand the environmental and operational demands of the regions, ensuring reliability and adaptability over time. This is especially crucial to ensure the long-term sustainability of innovative PUE innovations and scaling of pilot solutions.

Innovative business models expand accessibility

WeTu’s innovative business models and sharing economy approaches, such as rentals and leasing models, played a key role in increasing adoption of the use case appliances and ensuring accessibility for various user groups. Daily rental options for lanterns, battery-swapping models for electric bikes, and flexible cold storage leasing allowed users to benefit from the technologies without incurring prohibitive upfront costs. These innovative business models and approaches and flexible financial mechanisms are proving to be critical enablers for adoption and scalability.

Policy and regulatory support for de-risking PUE innovations and technologies
To address regulatory challenges such as risk assessments and insurance provision there is a need for targeted policy and regulatory support interventions. Governments and various stakeholders such as regulatory bodies should explore the development of risk assessment frameworks tailored for innovative technologies such as electric converted vehicles. Approaches such as subsidies or guarantees to reduce the financial risk for insurers and other service providers will lead to reduced financial risk while encouraging the creation of affordable, customizable insurance products.

1.5 Opportunities for further research and development

Based on the demonstration in Katito and Kisegi, several opportunities for further research and development were identified. These opportunities align with the five strategic objectives (SO1-SO5) and offer pathways for expanding the impact of the SESA project in Kenya and beyond.

SO1: Inform

Emerging technologies: research could further explore the integration of technology-driven energy management systems to optimize energy consumption in both peri-urban and rural areas. Technology could, for instance, be used to manage energy distribution across the microgrid, ensuring that peak loads are efficiently handled.

Digital payment solutions: further research into digital payment platforms for energy services, such as mobile money integration, could make pay-as-you-go models more accessible to rural communities.

SO2: Inspire

Cross-continental knowledge exchange: future research could explore deeper partnerships between Europe and Africa, with a focus on the role of knowledge hubs. These hubs could serve as centers for ongoing innovation, connecting European researchers with African entrepreneurs to co-develop solutions.

Scaling training programs: expanding the capacity-building programs initiated in Katito and Kisegi to include broader training on energy entrepreneurship could inspire local communities to innovate further within the energy space.

SO3: Initiate

Long-term sustainability: future research should focus on the long-term sustainability of the energy innovations implemented in Katito and Kisegi. This could involve exploring various financing options for scaling successful and sustainable business models and use case appliances, ensuring that the impact and benefits extend beyond the demonstration period and actions.

Replication models: the modular systems deployed in Katito and Kisegi could serve as a basis for replication in similar peri-urban and rural areas across Africa. Research into the replicability of the business and technical models used in these areas would be essential.

SO4: Implement

Social enterprise approach: The WeTu social enterprise model and approach offers a sustainable scalable alternative to the traditional community-based approaches by combining professional management, financial accountability, and a focus on delivering social impact through renewable energy innovations. Unlike community-based approaches and cooperatives, which often face governance and resource challenges, the social enterprise model ensures long-term sustainability by integrating market-driven principles with social impact objectives. This approach empowers local communities and user groups while maintaining high-quality service delivery, making it a replicable framework for expanding renewable energy access in underserved regions.

Adapting to changing energy needs: As energy demand continues to grow in peri-urban areas like Katito, there is an opportunity for further research and development of renewable energy access solutions to enhance their scalability, sustainability and affordability. This can be done through further research that investigates integrating solar infrastructure with additional renewable energy sources such as wind or biomass to diversify energy supply and improve reliability. This approach could address evolving local energy needs effectively while ensuring long-term sustainability and resilience of energy solutions.

SO5: Impact

Policy integration: research into strategies for integrating innovative renewable energy solutions into national energy policies is needed. Engaging with local and national governments to formalize the inclusion of renewable energy access innovations such as solar charging hubs into county energy plans could enhance scalability.

Public-private partnerships: investigating new forms of public-private partnerships (PPPs) would provide further opportunities for financing large-scale renewable energy projects in Kenya and other African countries.

1.6 Conclusion

The demonstration actions in Katito (Kisumu County) and Kisegi (Homa Bay County) successfully showcased the potential of modular renewable energy solutions to address energy access challenges in both peri-urban and rural areas. Through the collaborative efforts of various work packages, the project implemented solar microgrids, solar charging hubs, and water purification systems, which provided clean energy to communities previously reliant on costly and harmful traditional fuels.

Despite challenges in logistics, community engagement, and regulatory hurdles, the project made significant strides in building local capacity, establishing sustainable business models, and demonstrating the scalability of renewable energy systems. The lessons learned from this demonstration offer valuable insights for future renewable energy initiatives across Africa, particularly in terms of adapting technologies to local contexts and ensuring long-term sustainability through community ownership and innovative financing models.

Looking ahead, the project highlights several opportunities for further research and development, particularly in integrating emerging technologies, refining business models, and expanding policy support for renewable energy solutions. The SESA project's demonstration in Kenya provides a strong foundation for scaling renewable energy access across the continent, fostering sustainable development, and addressing energy poverty in Africa.

2.0 Morocco

Morocco was selected as a demonstration site to explore the potential of renewable energy and sustainable urban mobility solutions tailored to urban and rural environments. With a national goal of achieving 52% renewable energy by 2030, Morocco is actively pursuing sustainable energy transformations, making it a strategic partner for the SESA project.

In Morocco, the project's demonstrations were centered in Marrakesh, Fez, Agadir and Benguerir for urban electric mobility and in isolated rural villages for renewable energy systems. Marrakesh's urban setting presented an ideal location to showcase electric mobility's role in reducing pollution, while the rural demonstrations allowed the project to address challenges related to reliable energy access. Together, these efforts aimed to address the diverse needs of Moroccan communities, with a focus on advancing equitable and sustainable energy solutions that could serve as models for similar regions across the continent.

The Morocco demonstration actions were structured around five core strategic objectives that aligned with SESA's mission to enable sustainable and impactful energy access:

1. **SO1: Inform** – Raise awareness among local communities and stakeholders about the transformative potential of renewable energy and electric mobility to improve daily life, reduce environmental impact, and provide cost savings.
2. **SO2: Inspire** – Encourage adoption of clean energy technologies by showcasing successful implementations in urban and rural Morocco, aiming to inspire further investment in sustainable solutions across the country.
3. **SO3: Initiate** – Establish a foundation of local technical skills to ensure long-term sustainability of the deployed technologies, building local capacity to maintain, manage, and expand upon the installed renewable energy and mobility systems.
4. **SO4: Implement** – Deploy practical, scalable solutions such as electric motorcycles for urban transport in Marrakesh and solar PV systems for off-grid community in rural areas, providing direct benefits to the communities and testing real-world viability.
5. **SO5: Impact** – Foster strong partnerships with local governments, community leaders, and private sector entities to ensure long-term scalability, integrating renewable solutions into policy frameworks and laying the groundwork for regional replication.

This section summarizes the Morocco demonstration actions, detailing the contributions of various work packages (WPs) to achieving these strategic objectives and providing insights into the project's broader impact on sustainable energy access and environmental stewardship.

2.1 Problem to address

Morocco faces two distinct energy challenges: urban pollution from fossil-fuel-powered transportation and the lack of reliable electricity access in rural communities. In cities like Marrakesh, pollution levels are significantly impacted using fossil-fuel-powered vehicles, particularly motorcycles, which contribute heavily to urban air quality degradation and have health implications for city residents. Without viable clean transport alternatives, these urban pollution issues will continue to affect public health and the overall quality of life in Morocco's growing urban centers.

In rural Morocco, many isolated communities lack access to reliable electricity, often depending on costly and environmentally damaging energy sources like kerosene and firewood. This reliance not only limits economic and educational opportunities but also presents serious health risks, especially for women and children, who are often exposed to indoor air pollution from these traditional fuels.

In addition to addressing these pressing issues, the Morocco demonstration offered European partners a chance to test adaptable renewable energy technologies in a diverse context. The insights gained from these settings were essential for refining SESA's solutions and exploring how they could be adapted and scaled for other regions facing similar energy and environmental challenges.

The Morocco demonstration aligned with SESA's five strategic objectives, designed to meet the following challenges:

SO1: Inform – raising awareness of renewable energy potential

In both Marrakesh and rural villages, awareness of the benefits and viability of renewable energy solutions was limited. Urban residents, including low-income workers and students, were limited in their experience with electric mobility as a sustainable transport option, while the rural community was really informed about solar PV systems as alternatives to kerosene and wood for lighting and cooking, out of 19 households within the rural community only 3 had PV for irrigation purposes. The project aimed to inform these communities by organizing information sessions and hands-on demonstrations, helping to build awareness of the health, environmental, and economic benefits that renewable solutions could offer.

SO2: Inspire – fostering interest and adoption of renewable solutions

A significant challenge in Morocco was the limited exposure to successful renewable energy solutions. Many communities were unaware of how sustainable technologies could address daily energy needs while reducing costs and environmental impact. To inspire adoption, the SESA project showcased the benefits of electric motorcycles in Agadir, Fez, Benguerir and Casablanca to reduce air pollution and provide affordable transportation. In rural villages, the project demonstrated how solar PV systems could provide reliable lighting and cooking alternatives to traditional fuels.

By illustrating these tangible improvements in quality of life and environmental impact, the SESA project sought to inspire both communities and local policymakers to invest in and adopt similar solutions more broadly across Morocco.

SO3: Initiate – enabling local innovators and building capacity

In Morocco, limited technical expertise posed a barrier to the sustainable management of renewable energy systems by the local community. The project addressed this by initiating local capacity-building programs (training campaigns, onsite visits to exchange with the community on how the system works and finally training onsite some locals to keep track of the installation's health status) that equipped community members and technicians with the skills to manage and maintain these systems.

In Marrakesh, training sessions were held for technicians to handle the electric motorcycles and charging infrastructure, while in rural villages, community members received training to operate and maintain solar PV systems under the name 'Onsite training on how to maintain and operate the solar PV microgrid, from the beginning of the installation of the pilot till December 2024. This training was destined for about 15 people from the rural community.

For SESA partners, this provided insights into the types of support needed to foster local ownership, with the goal of empowering communities to sustainably manage renewable technologies.

SO4: Implement – overcoming co-development challenges

Implementing renewable solutions in diverse settings like Marrakesh and rural communities required adapting the technology to the specific conditions of each location. In Marrakesh, the introduction of **electric motorcycles** targeted urban air pollution and transportation costs by offering a clean and affordable mobility solution.

In rural villages, solar PV systems were deployed to address the lack of reliable electricity, replacing costly and polluting fuels like kerosene with clean energy. This dual approach allowed SESA to test the scalability and adaptability of these renewable technologies in Morocco's unique urban and rural contexts, providing valuable data for future replications.

SO5: Impact – ensuring long-term sustainability and partnership-building

Ensuring the sustainability of renewable energy systems in Morocco required establishing strong partnerships with local governments, community leaders, and private sector stakeholders. In Marrakesh, the SESA project worked closely with city authorities to support the integration of electric mobility into urban transport planning, while in rural community, collaborations with village councils and local leaders facilitated the long-term management of solar PV systems. The partnerships with Stargate from UM6P, Act4Community and GEP were critical for embedding renewable solutions into local energy policies and infrastructure, paving the way for future scalability.

For SESA partners, the Moroccan demonstration offered a valuable model for building cross-sector partnerships that support long-term sustainability and scalability of renewable technologies in similar contexts.

2.2 Solutions employed

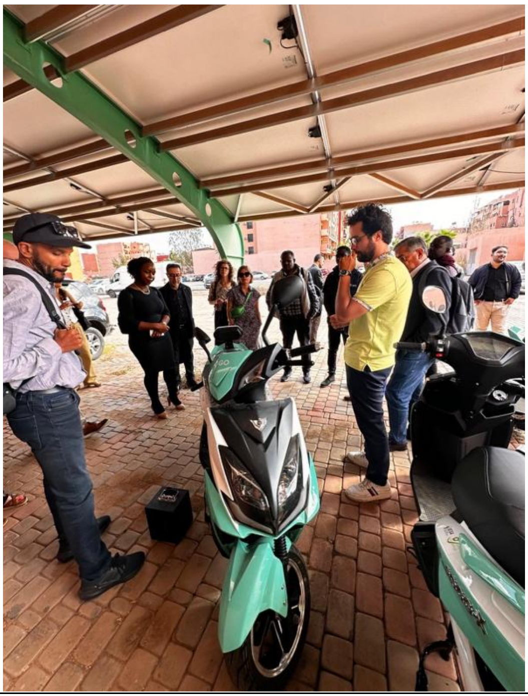
The SESA project implemented renewable energy systems in both **Marrakesh, Casablanca, Agadir, Fez and Benguerir** and selected **rural Benguerir community** in Morocco, utilizing coordinated efforts across multiple **Work Packages (WPs)** to address energy access and environmental issues through adaptable, sustainable solutions.

WP1: Development of the technology basis

WP1 was essential in establishing the technology foundation for both green electric mobility and solar solutions in Morocco. This work package conducted detailed assessments of the technical requirements for each demonstration site, ensuring that the chosen solutions were both locally appropriate and capable of meeting community needs. This was done through a user needs assessment. A toolbox with the best approaches was launched at the SESA fourth regional event in October 2024.

WP2: Capacity building and cooperation

WP2 emphasized building the technical skills needed to sustain these renewable energy systems in the long term. In Marrakesh, training programs for local technicians and community members on the maintenance and safe use of electric motorcycles and their associated charging infrastructure were provided. In rural areas, WP2 facilitated hands-on workshops to train community members in the operation and maintenance of solar PV systems, promoting local ownership and self-sufficiency. By equipping community members and technicians with the necessary skills, the knowledge needed to maintain these technologies remained within the community, supporting both local empowerments.

Capacity building event for UCA students & the launch of the SESA Toolbox Duration: 1-day Number of participants: over 100 persons  
Policy dialogue Duration: 1-day Number of participants: over 30 persons
Peer-to-peer exchange Duration: 1-day Number of participants: over 20 persons Location: Marrakech city, Morocco

Further areas for capacity building that could be built upon are as follows:

1. Technical assistance and capacity building to enable local government officials (municipalities, Ministry of Energy Transition and Sustainable development…) to implement national policies and plans at a local and regional level.
2. Providing enterprise development support in the form of pre-accelerator, accelerator and incubation programmes to SMEs, Start-ups and Innovators to build on their skills and knowledge within the clean technology sector (e.g. electric mobility and renewable energy ecosystem) to empower them to apply funding for their technology solutions and business models successfully.
3. Providing training in renewable energy and e-mobility for the local and regional workforce.

WP3: Business models and market solutions

Urban Pilot

WP3 developed tailored business models to make the renewable energy solutions accessible and affordable for Moroccan communities. In Marrakesh, the project introduced a leasing model for electric motorcycles, enabling low-income residents to use clean transportation without high upfront costs, which increased accessibility and encouraged adoption. For rural villages, WP3 designed a pay-as-you-go model for solar PV systems, allowing households to pay based on usage and manage energy costs effectively. These innovative financing approaches were crucial for addressing financial barriers, making renewable energy affordable and inclusive in both urban and rural Morocco.

Customer segments and market insights: POGO currently targets individuals aged 18 to 40 who do not own a vehicle. Among the 40 SESA e-moped users, the gender distribution stands at 40% female and 60% male. A significant proportion of these users (89%) have never driven an electric vehicle before yet report positive experiences. This customer segment represents a notable market share across key Moroccan regions, with approximately 13.3% in Marrakech, 13.8% in Rabat, and around 12% in Fez and Agadir.

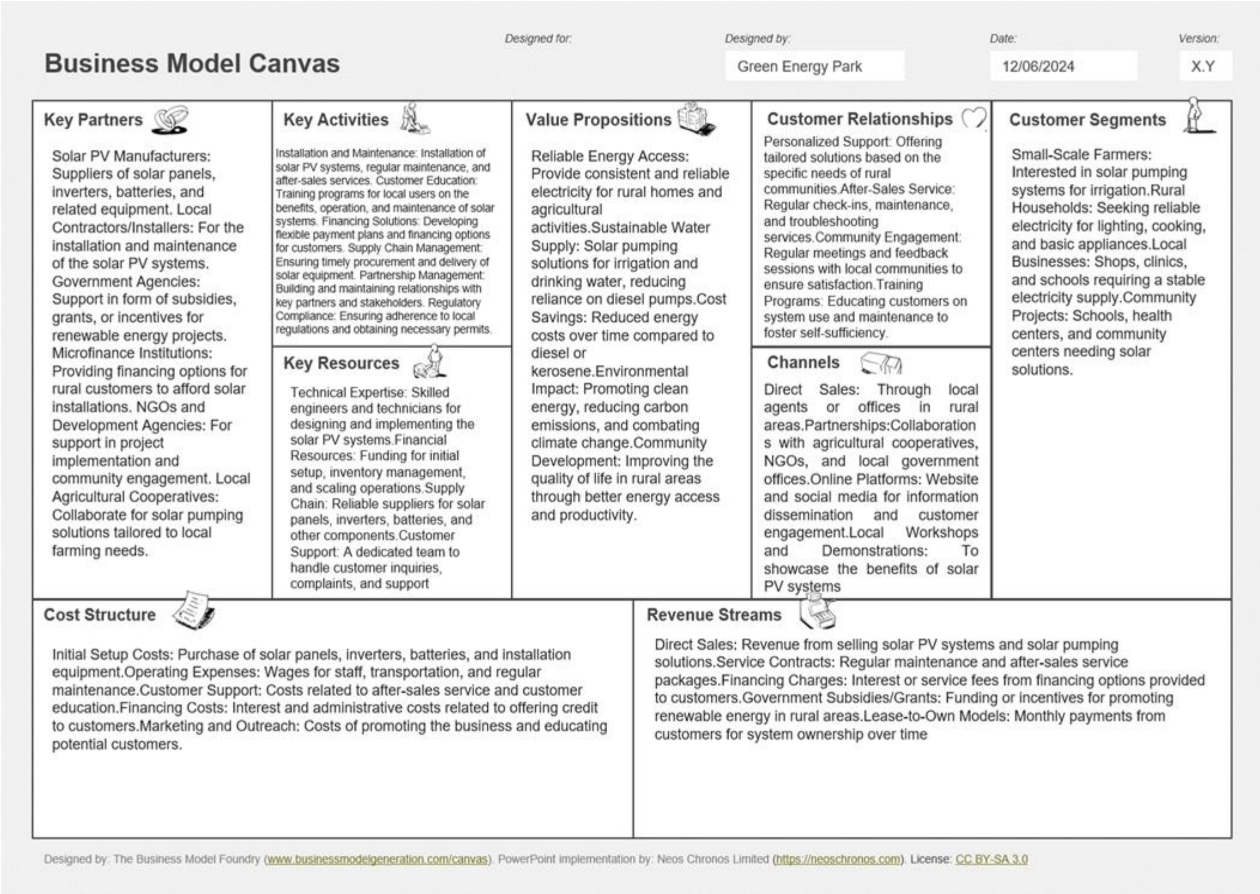
Go-To-Market strategy: The company actively promotes its services through targeted social media campaigns and collaborations with brand ambassadors. This approach is proving effective in reaching potential customers. In addition to social media marketing, investments are being made in search engine optimization (SEO) and search engine marketing (SEM) to boost both organic and paid web traffic. To further enhance visibility, POGO is participating in community events and festivals, showcasing its e-mopeds, offering free trials, and implementing referral programs with incentives such as free rides or discounts to attract new users.

To support customers efficiently, 24/7 assistance is available via the app, website, and dedicated phone lines. A user feedback system is also in place, allowing continuous improvement of service quality. Furthermore, introductory offers, discounts, and loyalty programs are being employed to improve customer retention and build a loyal user base.

Pricing model and financial viability: The company maintains a highly competitive pricing model achieving a profit margin of approximately 41% per moped. To improve accessibility for young female students in Marrakech, some mopeds have been offered at roughly 25% of the original price. Despite providing one of the most affordable e-mobility services in Morocco, POGO is still achieving profit margins comparable to higher-cost providers in Europe due to Morocco's lower operational costs, such as reduced HR salaries, warehouse rental fees, and insurance expenses.

Since its launch in July 2023, the company's revenue has been steadily increasing. This upward trend reflects effective cost management, strategic resource allocation, and consistent marketing efforts. Looking ahead, POGO is projecting substantial growth, with plans to expand its fleet to over 1,000 e-mopeds by Year 7. This expansion strategy is supported by projected revenue growth and strategic partnerships with financial institutions, enabling the company to secure leasing lines for additional vehicles. By maintaining this balance between fleet growth and cost control, POGO is positioning itself for long-term success in Morocco's evolving e-mobility market.

SESA Smart Energy Solutions for Africa


Business Model Canvas

Designed for:

Designed by: Green Energy Park

Date: 12/06/2024

Version: X.Y

Key Partners

Solar PV Manufacturers: Suppliers of solar panels, inverters, batteries, and related equipment. Local Contractors/Installers: For the installation and maintenance of the solar PV systems. Government Agencies: Support in form of subsidies, grants, or incentives for renewable energy projects. Microfinance Institutions: Providing financing options for rural customers to afford solar installations. NGOs and Development Agencies: For support in project implementation and community engagement. Local Agricultural Cooperatives: Collaborate for solar pumping solutions tailored to local farming needs.

Key Activities

Installation and Maintenance: Installation of solar PV systems, regular maintenance, and after-sales services. Customer Education: Training programs for local users on the benefits, operation, and maintenance of solar systems. Financing Solutions: Developing flexible payment plans and financing options for customers. Supply Chain Management: Ensuring timely procurement and delivery of solar equipment. Partnership Management: Building and maintaining relationships with key partners and stakeholders. Regulatory Compliance: Ensuring adherence to local regulations and obtaining necessary permits.

Key Resources

Technical Expertise: Skilled engineers and technicians for designing and implementing the solar PV systems.Financial Resources: Funding for initial setup, inventory management, and scaling operations.Supply Chain: Reliable suppliers for solar panels, inverters, batteries, and other components.Customer Support: A dedicated team to handle customer inquiries, complaints, and support

Value Propositions

Reliable Energy Access: Provide consistent and reliable electricity for rural homes and agricultural activities.Sustainable Water Supply: Solar pumping solutions for irrigation and drinking water, reducing reliance on diesel pumps.Cost Savings: Reduced energy costs over time compared to diesel or kerosene.Environmental Impact: Promoting clean energy, reducing carbon emissions, and combating climate change.Community Development: Improving the quality of life in rural areas through better energy access and productivity.

Customer Relationships

Personalized Support: Offering tailored solutions based on the specific needs of rural communities.After-Sales Service: Regular check-ins, maintenance, and troubleshooting services.Community Engagement: Regular meetings and feedback sessions with local communities to ensure satisfaction.Training Programs: Educating customers on system use and maintenance to foster self-sufficiency.

Channels

Direct Sales: Through local agents or offices in rural areas.Partnerships:Collaborations with agricultural cooperatives, NGOs, and local government offices.Online Platforms: Website and social media for information dissemination and customer engagement.Local Workshops and Demonstrations: To showcase the benefits of solar PV systems

Customer Segments

Small-Scale Farmers: Interested in solar pumping systems for irrigation.Rural Households: Seeking reliable electricity for lighting, cooking, and basic appliances.Local Businesses: Shops, clinics, and schools requiring a stable electricity supply.Community Projects: Schools, health centers, and community centers needing solar solutions.

Cost Structure

Initial Setup Costs: Purchase of solar panels, inverters, batteries, and installation equipment.Operating Expenses: Wages for staff, transportation, and regular maintenance.Customer Support: Costs related to after-sales service and customer education.Financing Costs: Interest and administrative costs related to offering credit to customers.Marketing and Outreach: Costs of promoting the business and educating potential customers.

Revenue Streams

Direct Sales: Revenue from selling solar PV systems and solar pumping solutions.Service Contracts: Regular maintenance and after-sales service packages.Financing Charges: Interest or service fees from financing options provided to customers.Government Subsidies/Grants: Funding or incentives for promoting renewable energy in rural areas.Lease-to-Own Models: Monthly payments from customers for system ownership over time

Market analysis:

Market Study: The target rural region has a growing demand for renewable energy and water for irrigation. Current energy sources mainly include expensive and polluting gasoline generators.

Competitive Analysis: Few competitors offer a combination of solar energy and water pumping services. Competitive advantage through an integrated and environmentally friendly solution.

Customer Profile: Families living in the 16 houses and farmers operating agricultural land.

Market Trends: Increasing demand for renewable energies and a growing need for efficient water management systems in agricultural regions.

1. **Marketing and sales:**
   - Marketing Strategy: Positioning as a provider of clean and sustainable energy. Use of local communication channels to raise community awareness.
   - Communication Plan: Awareness campaigns on the benefits of renewable energies. Collaboration with local authorities to promote the project.
   - Sales Strategy: Sale of electricity produced to residents of the 16 houses. Competitive pricing compared to traditional energy sources.
   - Pricing Policy: Use of provided and estimated electricity tariffs.

   Revenue Estimate:

The ROI curve:

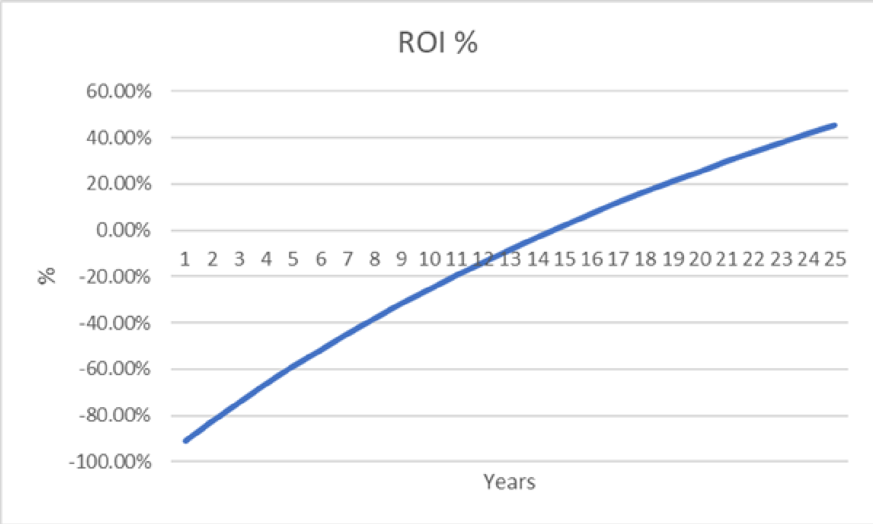


Figure 6: The Curve Over 25 years

Net Benefit curve:

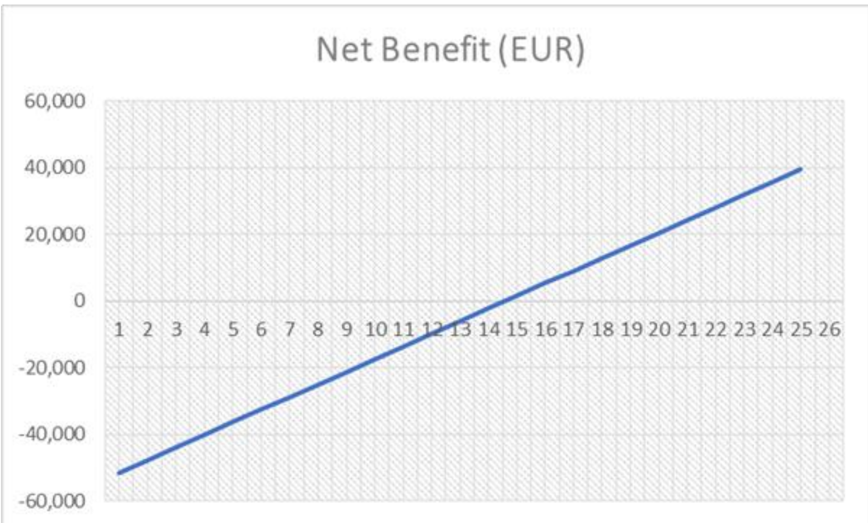


Figure 7: Net Benefit Curve Over 25 years

WP4: Demonstration, validation, and replication

WP4 led the on-the-ground deployment and testing of the electric mobility and solar PV systems to validate their effectiveness and scalability. In Marrakesh, WP4 implemented electric motorcycles, collaborating with local users to assess their practicality, cost savings, and potential to reduce air pollution. In rural areas, WP4 deployed solar PV systems establishing a living lab with community members to confirm that the systems were user-friendly and capable of meeting daily energy needs. The validation process provided crucial insights into how these technologies could be replicated in similar settings, ensuring they were adaptable and reliable.

Urban living lab: electric mobility deployment

In Marrakech, WP4 introduced electric motorcycles through a collaboration with local users to evaluate their practicality, cost-effectiveness, and environmental impact. The initiative focused on the 40 POGO electric bikes deployed under the SESA project. Feedback from users indicated that

56% found their experience with the POGO bikes to be positive or very positive, primarily due to their smooth acceleration, noiseless operation, and enhanced performance compared to conventional internal combustion engine (ICE) mopeds. While 25% of respondents felt no significant change in experience, 20% preferred previous transport options.

User patterns showed that over 30% of respondents used the POGO bikes daily for commuting to school or work. While some respondents also used e-bikes for shopping or leisure, this remained less frequent. The popularity of the POGO bikes for commuting underscored their role in providing efficient and affordable transport for students. However, in Marrakech, where 87% of adults already own a moped, repeat usage was limited. This prompted WP4 to redeploy some e-mopeds to other cities (Marrakech, Benguerir, Agadir, Casablanca and Benguerir) where demand was higher, particularly among users without access to personal vehicles.

Emissions reductions by using transportation by means of e-mobility solution replacing ICE vehicles: Pogo sharing solution transportation, total CO_2 emissions avoided using POGO sharing solution: **44 989 kg (**Calculations presented in WP1 Indicators Report)

Rural living lab: solar PV deployment
In rural areas, WP4 established a solar PV mini-grid system as part of a living lab designed to address energy access challenges. The site, located near Benguerir, was selected based on its lack of grid connectivity and the community's need for reliable power. The system included a 25 kWp solar PV array paired with 20 kWh of lithium-ion batteries, providing electricity to 16 households and supporting approximately 100 residents.

The mini grid was designed to power local businesses involved in farming, sheep rearing, and storage. Managed through a subscription-based model, users paid monthly fees based on their energy consumption. While the mini-grid infrastructure was not community-owned, clear administrative guidelines ensured its protection and sustainable operation. By demonstrating reliable performance in meeting daily energy needs, the rural living lab showcased the viability of solar PV systems in underserved communities.

Solar PV Systems

Both urban and rural deployments provided critical insights into technology adoption, user behavior, and scalability, guiding future replication efforts in similar contexts.

Emissions reduction: Microgrid, total CO_2 emissions avoided using Off-Grd solution: **2 400 kg**

WP5: Scale-up, finance, and policy environment

WP5 worked closely with local and national authorities to support the expansion and integration of renewable energy solutions into Morocco's policy and regulatory frameworks (municipality of Marrakech and Benguerir, also UNDP and GIZ). By aligning the project's outcomes with local policies, WP5 helped establish a basis for further integration of renewable energy solutions within the wider policy and regulatory frameworks (for replication purposes, we have the support of both municipalities, UM6P and OCP Group in order to target unelectrified communities in Marrakech and Benguerir regions since now they understood the barriers and challenges we faced.

WP6: Communication and dissemination

WP6 focused on sharing the project's findings and promoting renewable energy through community outreach and regional communication channels. In Marrakesh, WP6 supported workshops to raise awareness of the benefits of electric mobility, providing case studies and informational materials to engage the public and encourage adoption. In rural areas, WP6 facilitated knowledge exchange sessions where community members shared experiences with the solar PV systems, inspiring trust and wider adoption. By documenting and disseminating the project's achievements, WP6 helped raise awareness both locally and internationally, encouraging other communities to consider similar sustainable solutions.

WP7: Project management and coordination

WP7 was responsible for the overall project management and coordination in Morocco, ensuring that activities aligned with the project's objectives and that communication flowed smoothly between technical teams, local stakeholders, and European partners. WP7 also ensured compliance with local regulations, coordinated risk management, and oversaw sensitive issues such as ethical considerations in the demonstration sites, playing a critical role in ensuring the project's successful implementation.

2.3 Challenges encountered

The Morocco demonstration of the SESA project faced various challenges due to the unique conditions and needs of both urban and rural communities. These challenges impacted the deployment, acceptance, and sustainability of renewable energy solutions, aligning with the project's five strategic objectives (SO1-SO5).

Urban area (Marrakesh)

1. **Public awareness and adoption** – Limited familiarity with electric mobility initially hindered public acceptance of electric motorcycles. Many residents were unfamiliar with electric vehicles and were hesitant to switch from conventional motorcycles due to concerns about performance, reliability, and charging availability. This required extended awareness campaigns to build trust and understanding around electric mobility.
2. **Infrastructure limitations** – A significant challenge for implementing electric mobility in Marrakesh was the lack of existing charging infrastructure. Without readily accessible charging stations, the convenience and practicality of electric motorcycles were limited. Additional resources were allocated to establish initial charging points to address this gap.
3. **Policy and regulatory barriers** – Integrating electric mobility into the city's transport framework faced regulatory hurdles, as local policies and infrastructure were not fully prepared to accommodate electric vehicles. Coordination with city authorities was essential but time-consuming, impacting the project's timelines and slowing down the

overall deployment. These challenges underscored the importance of aligning renewable solutions with local policies to ensure scalability and sustainability.

Rural area (Villages)

1. **Logistical challenges for equipment transport** – Transporting solar PV systems and associated equipment to remote rural villages required extensive logistical planning, particularly given the limited infrastructure and challenging terrain. This delayed installations and required additional resources for transportation.
2. **Financial accessibility** – Despite introducing flexible payment models like pay-as-you-go, the upfront costs for solar PV systems remained a challenge for many rural households. Financial constraints prevented some households from fully benefiting from the systems, highlighting the need for additional financial mechanisms to make these solutions widely accessible. This challenge limited the ability to build local capacity by enabling broader participation.
3. **Limited technical capacity** – In rural areas, the availability of local technicians with the skills to operate and maintain solar PV systems was limited. Although training sessions were conducted, there remained a need for ongoing support and additional training to ensure the systems' long-term sustainability. This capacity gap emphasized the need for sustained capacity-building efforts.

General challenges across both sites

1. **Cultural adaptation and trust-building** – Transitioning communities from traditional energy sources to renewable energy solutions required overcoming deeply ingrained habits and preferences. Many residents were initially skeptical of the reliability and benefits of electric motorcycles and solar PV systems, necessitating prolonged engagement and trust-building efforts.
2. **Capacity gaps in local workforce** – While training programs were established to build technical skills, there remained a noticeable gap in expertise, especially for complex maintenance and troubleshooting of the electric motorcycles and solar PV systems. The lack of skilled local technicians impacted the project's ability to sustain operations independently, highlighting the need for ongoing support.
3. **Resource allocation and coordination** – Balancing resources between the urban and rural demonstration sites was challenging, especially as each location had unique requirements and logistical needs. This impacted timelines and required adaptive project management to meet the **SO4: Implement** and **SO5: Impact** objectives effectively.

2.4 Lessons learned

The Morocco demonstration provided valuable insights into the implementation and adoption of renewable energy solutions in both urban and rural contexts. Each location presented unique challenges and opportunities, leading to several key lessons that aligned with the SESA project's strategic objectives (SO1-SO5).

Urban area (Marrakesh)

1. **Community involvement drives adoption** – Early and continuous engagement with the community was essential to overcoming initial hesitation around electric mobility. Demonstrating the reliability and environmental benefits of electric motorcycles in real-world scenarios helped build trust and acceptance among residents. This emphasizes the need for awareness campaigns to ensure that communities fully understand and appreciate the value of renewable energy solutions.

   a) Technical assistance and capacity building to enable local government officials to implement national policies and plans at a local and regional level (example SESA Capacity Building, Policy dialogue, Peer--to-peer exchange pre and post preparation also the program Marrakech green city in which GEP took place in it and introduced SESA Project)
   b) Providing training in renewable energy and e-mobility for the local and regional for which GEP has several references.
2. **Infrastructure adaptation is essential** – The absence of established EV charging infrastructure in Marrakesh and several Moroccan cities highlighted the importance of infrastructure development as a foundational element for electric mobility projects. Providing reliable access to charging points proved to be a decisive factor in supporting adoption. This underscores the need for concurrent infrastructure investments when introducing new technologies.
3. **Policy alignment accelerates impact** – Working closely with local authorities to integrate electric mobility into city transport planning was essential for project success. The collaboration with UNDP and the municipality Marrakech on Marrakech Sustainable City project (Project Marrakech Ville Durable MVD) highlighted the importance of aligning renewable initiatives with local policy frameworks to facilitate scalability and ensure long-term viability.

Rural area (Villages)

1. **Localized financing models are key to accessibility** – The introduction of pay-as-you-go payment options for solar PV systems helped to make renewable energy affordable in rural communities. However, further adaptations to the financing model are necessary to meet the specific financial realities of rural households. Financial accessibility is crucial to inspiring adoption and addressing cost barriers.
2. **Sustained training ensures long-term sustainability** – Initial training programs were successful, but the limited technical expertise in rural areas emphasized the need for continuous support. Follow-up training sessions and remote support mechanisms are essential for the long-term sustainability of the technology. This lesson demonstrates that building local technical capacity is an ongoing process rather than a one-time effort.
3. **Tailoring solutions to local conditions boosts effectiveness** – The modular design of solar PV systems allowed for adjustments based on the specific needs and conditions of the rural communities. This flexibility was crucial in adapting the systems to each site's energy needs, reinforcing the importance of solution customization.

General lessons across both sites

1. **Building trust takes time** – Shifting communities from traditional energy sources to new technologies required patience, transparency, and ongoing engagement. Many community members initially hesitated due to cultural preferences and unfamiliarity, highlighting the importance of establishing trust to facilitate the transition to renewable energy. Trust-building is a key component of successful adoption.
2. **Capacity building must be continuous** – While initial training provided essential skills, there remained a need for additional, ongoing technical support, especially for complex maintenance. Sustained capacity-building efforts are crucial to achieving and ensuring local independence in managing and maintaining renewable systems.
3. **Strategic partnerships strengthen project impact** – Collaborations with local governments, financial institutions, and community leaders were instrumental in aligning project goals with regional and national development priorities. Establishing these partnerships early on facilitated smoother project execution and paved the way for future scalability.

2.5 Opportunities for further research and development

The Morocco demonstration highlighted several avenues for further research and development to expand the impact of renewable energy and sustainable technologies across urban and rural areas. These opportunities align with SESA's strategic objectives and emphasize pathways for improving scalability, accessibility, and sustainability.

SO1: Inform

Digital platforms for knowledge sharing: Research could explore the creation of digital platforms that provide real-time information on the benefits, usage, and maintenance of electric mobility and solar PV systems. This could enhance public understanding and engagement in both urban and rural areas, providing accessible information that informs community members, technicians, and stakeholders on sustainable energy practices.

Public exhibition sites: Establishing public demonstration sites in Marrakesh and other urban centers could help showcase the benefits of electric mobility to a broader audience. Research into the most effective formats for these sites, such as interactive kiosks or guided tours, could provide a blueprint for wider awareness campaigns that inspire public interest and adoption.

SO2: Inspire

Cross-regional knowledge exchange programs: Further research could explore structured programs for knowledge exchange between regions, allowing rural communities to learn from urban innovations and vice versa. This could include peer-to-peer exchanges where representatives from rural areas visit urban demonstration sites to understand how electric mobility functions and vice versa, enhancing the cross-regional adoption of diverse renewable solutions.

Case studies highlighting success stories: Detailed case studies on the outcomes from the Morocco demonstration could inspire other African cities and regions to adopt similar solutions. These case studies could focus on the environmental, health, and economic impacts of renewable technologies, serving as an inspiration for policymakers and community leaders across the continent.

SO3: Initiate

Long-term workforce development: Investing in long-term training programs that develop specialized skills for managing electric mobility infrastructure and solar PV systems would support sustainable technology adoption. Research into modular training programs, including certification and remote support options, could create a continuous pipeline of skilled technicians ready to expand and sustain renewable technologies across urban and rural Morocco.

Sustainable supply chain models: Developing supply chains for electric mobility components and solar PV parts locally would reduce costs and ensure quick access to maintenance materials. Research could examine the potential for local production or assembly of key components, which would build a resilient supply chain and foster local economic development while reducing reliance on imported parts.

SO4: Implement

Innovative financing mechanisms: Future research could explore diverse financing models, such as microfinance, community-based cooperatives, or blended finance solutions, to improve accessibility to renewable energy solutions for rural and low-income urban residents. Tailoring financial options to the specific needs of each community could help overcome economic barriers and broaden adoption.

Integrating renewable technologies in public services: Research could investigate opportunities for deploying renewable energy solutions in public services, such as powering health clinics, schools, or community centers with solar PV systems. By embedding renewable technologies into essential services, the project could demonstrate their broader societal benefits, fostering public acceptance and policy support for wider renewable energy integration.

SO5: Impact

Policy integration and advocacy: Further research into strategies for aligning renewable energy solutions with national and regional policies could provide a foundation for broader integration. Advocacy initiatives targeting local governments and regional bodies would support policy shifts that formalize the role of renewable energy in urban planning and rural development, ensuring long-term impact.

Public-private partnerships for scaling: Exploring new models of public-private partnerships (PPPs) could enhance the scalability of the electric mobility and solar PV solutions demonstrated in Morocco. Research into effective PPP frameworks could provide sustainable funding, technical expertise, and regulatory support to expand these solutions in other regions, creating a replicable model for partnership-driven renewable energy expansion.

2.6 Conclusion

The SESA demonstration in Morocco has successfully highlighted the transformative potential of renewable energy and sustainable mobility solutions in both urban and rural settings. By deploying electric mobility in Marrakesh and solar PV systems in rural villages, the project addressed pressing issues of urban pollution and energy access gaps, showcasing how adaptable, community-centered technologies can enhance quality of life and environmental resilience. Through collaborative efforts across work packages, SESA not only implemented practical solutions but also engaged local communities, built technical capacity, and developed accessible financing models, ensuring that these renewable systems are financially viable and community driven.

The project’s achievements in Morocco demonstrate the importance of aligning sustainable technologies with local contexts, from developing infrastructure for electric vehicles in urban areas to addressing logistical and financial constraints in rural communities. Although challenges in community acceptance, technical capacity, and infrastructure readiness were encountered, these barriers provided valuable insights for refining strategies to ensure that renewable energy solutions are sustainable and scalable.

Looking ahead, Morocco’s demonstration offers a replicable model for other African countries to adopt renewable energy solutions that are both environmentally and socially impactful. The project’s focus on capacity building, community engagement, and strategic partnerships lays a strong foundation for expanding the reach of sustainable technologies and promoting policy integration to support long-term change. By creating opportunities for further research and development, the SESA project has not only addressed immediate energy needs but has also contributed to building a future where renewable energy drives economic resilience, ecological health, and social equity across Morocco and beyond.

3.0 South Africa

South Africa was selected as a demonstration site due to its significant reliance on coal and the unique challenges low-income rural and semi-rural communities face in accessing reliable energy. The project's efforts in South Africa focused on Alicedale situated in the Eastern Cape Province. Alicedale is a small settlement defined as a rural area by local government authorities. Alicedale was chosen as it is considered a marginalized and vulnerable community consisting of the unemployed, elderly and youth with high levels of unemployment and who rely on social security grants from the state. The area lacks formalized public transport, and inadequate electricity infrastructure leads to regular power outages, compromising energy stability. This has created an urgent need for innovative, sustainable energy and mobility solutions.

The South Africa demonstration involved deploying a containerized off-grid solar energy system featuring PV panels, second-life EV batteries for energy storage, and charging infrastructure designed for micro-electric vehicles. This approach allowed the project to address both energy access and sustainable transport, aiming to reduce the community's dependence on traditional fuels and empower residents with reliable, clean energy alternatives. The SESA demonstration actions in South Africa were guided by the following strategic objectives (SO1-SO5):

- **SO1: Inform** – Raise awareness among the Alicedale community about the benefits of solar energy and micro-electric vehicles, focusing on environmental and economic advantages.
- **SO2: Inspire** – Showcase how renewable energy solutions, like solar PV and electric transport, can reduce emissions, decrease energy costs, and create new economic opportunities.
- **SO3: Initiate** – Develop local technical capacity for implementing and managing renewable energy systems, ensuring the community can sustain and benefit from the technology over time.
- **SO4: Implement** – Deploy containerized solar PV systems and charging infrastructure in Alicedale, providing scalable and replicable energy solutions for underserved rural and semi-rural areas.
- **SO5: Impact** – Foster partnerships with local authorities, community organizations, and private stakeholders to promote long-term sustainability and scalability, embedding renewable solutions in local infrastructure.

This report provides a comprehensive overview of the South Africa demonstration actions, detailing each work package's role in achieving these objectives and the broader impact of renewable energy solutions on the local communities.

3.1 Problem to address

South Africa faces significant energy access and environmental health challenges, particularly in underserved rural and semi-rural areas. The country's energy sector relies heavily on coal, which generates approximately 80% of the nation's power, leading to high greenhouse gas emissions, pollution, and respiratory health issues.

For Alicedale, these challenges are compounded by frequent power outages, unreliable electricity supply, and limited public transportation options. These conditions have placed a strain on local resources and hindered economic development, particularly for low-income residents who rely on costly, polluting fuels for basic energy needs. The high unemployment rate and limited access to public transport in Alicedale make access to clean, affordable energy solutions crucial for supporting economic stability and improving quality of life.

Addressing these issues through the SESA project required introducing renewable energy and clean technology solutions that could sustainably meet the community's energy and transportation needs. These challenges align with SESA's strategic objectives, which focus on awareness, capacity-building, technology implementation, and long-term impact.

SO1: Inform – Raising awareness of renewable energy potential

In Alicedale, awareness and understanding of renewable energy and sustainable transportation options are limited. Many residents are not familiar with how solar power and electric vehicles work or the benefits they can offer. The lack of knowledge about renewable solutions often results in skepticism and resistance to adopting new technologies, as community members are uncertain about their reliability, affordability, and maintenance requirements. This gap in understanding contributes to ongoing reliance on polluting fuels like coal and wood, even when cleaner, potentially more cost-effective alternatives exist.

The project aimed to **inform** communities about the environmental and economic benefits of solar PV systems and micro-electric vehicles, providing information and demonstrations to bridge this awareness gap.

SO2: Inspire – Fostering interest and adoption of renewable solutions

One of the core challenges in Alicedale is the perception that clean energy solutions are too costly or complex to be viable for low-income communities. Many residents have limited exposure to renewable energy solutions in action, leading to a belief that solar PV systems and electric vehicles are suited only for wealthier, urban settings. Additionally, the existing reliance on conventional vehicles and coal-powered electricity has set a norm that can be difficult to challenge without clear, visible demonstrations of viable alternatives.

The project sought to inspire adoption by showcasing how renewable energy solutions can work effectively in semi-rural settings, reducing costs and environmental impact while providing reliable energy access.

SO3: Initiate – Enabling local innovators and building capacity

Another major barrier to implementing sustainable solutions in South Africa is the lack of local expertise required to operate and maintain renewable energy systems. Alicedale has a shortage of trained technicians who can manage solar PV systems, battery storage, and electric vehicle infrastructure. Without technical knowledge in the community, the risk of system breakdowns or operational issues increases, making residents hesitant to invest in unfamiliar technologies. This skills gap limits local capacity to sustain renewable solutions and reduces the likelihood of community ownership.

The SESA project sought to **initiate** capacity-building efforts, providing the technical training needed to ensure the long-term functionality of the renewable systems.

SO4: Implement – Overcoming co-development challenges

Implementing renewable energy in Alicedale faced significant structural challenges. The area lacks foundational infrastructure, such as reliable charging stations for electric vehicles and secure sites for solar PV installations. Transportation of necessary equipment to these remote areas is logistically complex and costly, creating delays and impacting project timelines. Additionally, many households do not have the financial flexibility to afford upfront costs for new technology, even if it promises future savings. These infrastructure and financial barriers hinder accessibility to renewable solutions.

The project's goal was to **implement** a containerized off-grid solar PV system with accessible EV charging infrastructure to demonstrate a scalable, affordable model suited to local conditions.

SO5: Impact – Ensuring long-term sustainability and partnership-building

For renewable energy solutions to be sustainable in Alicedale, they need to be supported by both local policies and stable partnerships with government bodies and private sector stakeholders. South Africa's National Development Plan 2030 has been the framework for developing policies and strategic plans for reducing carbon emissions, establishing effective, safe and affordable public transport and public infrastructure investment focused on areas such as transport and energy to ensure environmental sustainability and resilience. Several plans are in place to allow local governments to implement policies. For example, South Africa's Just Energy Transition Investment Plan 2022-2027 supports the goals of energy security, just transition and economic growth in South Africa, as well as the country's priority investment requirements for electricity and new energy vehicles. The challenge is that there is a lack of capacity and technical assistance for local government officials to take national policy and implement it at a local level.

Currently, local governments lack the resources and capacity required to integrate national policy at a local level that encourages renewable energy adoption. Capacity and technical assistance at local government is necessary to allow for the development of strong public-private partnerships that support the adoption of renewable and clean technology solutions to mitigate the risk of these projects becoming isolated without the scalability or support needed for long-term impact.

The project aims to **impact** local policy and infrastructure by establishing partnerships and advocating for implementing existing national policy at a local level to enable renewable energy solutions to grow and replicate.

3.2 Solutions employed

The South Africa demonstration in Alicedale involved deploying renewable energy systems tailored to the local context, with contributions from various Work Packages (WPs).

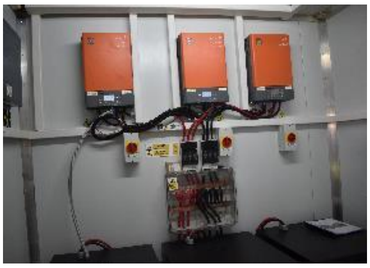
WP1: Development of the technology basis

WP1 was essential in establishing the technology foundation, specifically focusing on a containerized off-grid solar PV system that could support the implementation of renewable energy solutions in Alicedale. The system included PV panels, second-life EV batteries, and charging stations for micro-electric vehicles. This work package conducted detailed assessments of the technical requirements for the demonstration site as well as user needs assessments, ensuring that the chosen solutions were both locally appropriate and capable of meeting community needs. The SESA fourth regional event launched a toolbox with the best approaches in October 2024. The SESA toolbox is an accessible platform that allows community members to learn more about the specific technologies being deployed in Alicedale, specifically around energy and mobility. An infospot was deployed at the living lab to allow for better network signal strength to enhance the internet services provided to the community, together with data collection and monitoring of the performance of the off-grid containerised system.

The technical specifications

The off-grid containerised solar energy system comprises PV panels in combination with second-life electric vehicle batteries for stationary energy storage. The solar energy system is also used to charge the two micro electric vehicles.The technical specifications for the off-grid containerised system, which was set up in collaboration with GREEN Solar Academy (the SME selected from the first Entrepreneurs call), are as follows:

- Container size: 20 ft / 6 m
- Inverter capacity: 3 x 5KW Phocos AnyGrid Hybrid Inverter
- PV canopy (mounted off container for additional shelter below): 20 kWp
- 3 x Revov - 2nd LiFe 16 cell 51.2V 200Ah 10.2 kWh Battery totalling 30.6 kWh
- Wireless internet and Information spot




Technical specifications for the vehicles are as follows:

Table 1 Micro Utility EVs

Selected cargo e-3 wheeler	**Selected passenger e-4 wheeler**
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 the 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 the vehicle Power monitor to be fitted to 220V charging socket to monitor and log consumption by vehicle (Green Solar)
	
Source: procured locally	**Source: Imported**

User needs assessment

Passenger transportation

The user needs assessment showed that 92% of the respondents faced commuting challenges when it comes to transportation; their predominant mode of transportation was walking while 47% of the participants travelled short distances of approximately 0-5km a day followed by 22% who travelled distances of 11-20 km per day.

Cargo transportation
Interviews with businesses in Alicedale showed that approximately 49% used their own vehicle to transport goods for businesses, such as liquor, groceries and perishables. In comparison, approximately 29% used a combination of their own vehicle and supplier vehicles (see Figure 4), and 83% of the businesses expressed openness to sharing the electric -3-wheeler cargo with other businesses in Alicedale.

12The community of Alicedale faces transportation challenges due to the absence of public transport, with 93% of respondents acknowledging commuting difficulties. This indicates a prevalent and significant issue. Additionally, 98% of respondents travel outside Alicedale for necessities, as essential amenities are unavailable locally. Similarly, businesses also mentioned travelling long distances outside Alicedale weekly to stock up on goods, experiencing high petrol costs. For local amenities, such as small grocery stores and liquor stores, people rely on catching a lift or walking, posing challenges for vulnerable groups, especially in adverse weather conditions.

Based on the user needs assessment, two use cases were defined for the South Africa Living Lab

- Use Case 1: Solar off grid containerized hub for productive use
- Use case 2: Micro-utility EV for passenger and cargo

WP2: Capacity building and cooperation

WP2 emphasised building local skills to manage and maintain the off-grid solar containerized system together with the support of micro electric vehicles by charging infrastructure. Technicians and community members were trained in system maintenance, focusing on ensuring long-term sustainability. This capacity-building effort empowered the community to operate the infrastructure independently, fostering a sense of ownership and responsibility for the renewable energy systems.

The number of people trained in-person in the Alicedale community is as follows:

Solar/PV Training
GREEN Solar Academy held basic theory and practical solar training with the solar centre interns and solar centre manager

Number of people trained: 5

Duration: 4-day

Electric Vehicle training

uYilo held a basic introduction to electric vehicles and charging infrastructure training for the solar centre manager and 2 drivers

Duration: 1-day

Number of people trained: 5

WP3: Business models and market solutions

WP3 developed a business model incorporating public-private partnerships (PPPs) that allow transportation services to be affordable to the community through a subsidy and thus make the solar PV systems and EV infrastructure accessible to low-income residents. The aim is for the PPPs to be put in place from October 2025, after the conclusion of the SESA project and to allow for the future and long-term sustainability of the off grid containerized solar energy system and its productive use cases. These models were designed to meet the economic realities of Alicedale, ensuring financial viability for the renewable systems.

A pay-per-trip taxi and a pay-per-trip cargo service were introduced to support the Alicedale community's transportation needs. The community was divided into 3 core customer segments: Alicedale community members, CARE Alicedale Community Centre, Alicedale business owners and tourists.

SME from 1st Entrepreneurs Call

GREEN Solar Academy is testing and validating a build-operate-share business model for a self-sufficient rural solar energy hub and analyzing its replication potential. The following activities to support income generation were implemented: An internet café, selling PV charging systems for homes and offering services to charge small devices. These activities support the living lab activities by providing affordable and inclusive access to renewable energy for communities that cannot afford or do not have access to electricity.

WP4: Demonstration, validation, and replication

WP4 was responsible for the practical deployment and testing of the solar PV system and EV charging infrastructure. By collecting feedback from Alicedale community members, WP4 validated the systems' performance, identifying any adjustments needed for optimal functionality. This validation phase was crucial for determining the feasibility of scaling the model to other similar communities in South Africa. The following data is currently being collected monthly to assess reductions in CO_2 emissions, NOx emissions and PM emissions for[2]:

a) Use Case 1: Solar off-grid containerized hub for productive use
b) Use case 2: Micro-utility EV for passenger and cargo

<u>Use Case 1: Solar off-grid containerized hub for productive use</u>

<u>Emissions Reduction: Solar Off-grid Containerized hub for productive use</u>

Total CO_2 emissions avoided using solar PV: **3198.78 kg**
Total NOx emission avoided using solar PV: **9.64 kg**
Total PM emissions avoided using solar PV: **3.22 kg**

[2] All formulas and calculation methodology are presented in WP1 Report on KPIs. Formulas used to calculate the preliminary results are guided by the D1.4 Evaluation Framework dated 11 January 2024.

Emissions Reduction: using second-life electric vehicle batteries for stationary energy storage use

Total CO_2 emissions avoided using second-life electric vehicle batteries for stationary energy storage: **1330.84 kg**
Total NOx emissions avoided using second-life electric vehicle batteries for stationary energy storage: **3.24 kg**
Total PM emissions avoided using second-life electric vehicle batteries for stationary energy storage: **1.08 kg**

Use case 2: Micro-utility EV for passenger and cargo

Emissions Reduction: by using transportation by means of e-mobility solution replacing ICE vehicles: Eleksa Micro Utility EV: cargo transportation

The average CO_2 emission factor for South Africa's grid is around 0.99 kg CO_2 per kWh
The approximate emission factor is 3.0 grams of NOx per kWh for grid electricity in South Africa
The approximate particulate matter emission factor for grid electricity in South Africa is approximately 1 gram per kWh.

Total CO_2 emissions avoided using micro utility EV for transporting cargo: **242.70 kg**
Total NOx emissions avoided using micro utility EV for transporting cargo: **0.74 kg**
Total PM emissions avoided using micro utility EV for transporting cargo: **0.25 kg**

Emissions Reduction: by using transportation by means of e-mobility solution replacing ICE vehicles: Melex Micro Utility EV: passenger transportation

Total CO_2 emissions avoided using micro utility EV for transporting passengers: **905.97 kg**
Total NOx emissions avoided using micro utility EV for transporting passengers: **2.75 kg**
Total PM emissions avoided using micro utility EV for transporting passengers: **0.92 kg**

WP5: Scale-up, finance, and policy environment

South Africa has several policies and plans that support the country's transition to a low-carbon economy. For example, The Just Energy Transition Plan, The Green Transport Strategy and the Electric Vehicle White Paper. Critical gaps which need to be closed to enable scale-up and financing of similar projects within South Africa's policy environment include:

1. Technical assistance and capacity building to enable local government officials to implement national policies and plans at a local and regional level.
2. Providing enterprise development support in the form of pre-accelerator, accelerator and incubation programmes to SMEs, Start-ups and Innovators to build on their skills and knowledge within the clean technology sector (e.g. electric mobility and renewable energy ecosystem) to empower them to apply funding for their technology solutions and business models successfully.
3. Providing training in renewable energy and e-mobility for the local and regional workforce.

WP6: Communication and dissemination

WP6 raised awareness of the project's outcomes by disseminating information about the project on online platforms to inspire other South African communities to adopt similar technologies. Dissemination efforts included workshops with the Alicedale community members and thought leadership initiatives such as Nelson Mandela University's Research and Innovation Week, during which the project was discussed and presented to multidisciplinary delegates.

WP7: Project management and coordination

WP7 was responsible for the overall project management and coordination in South Africa, ensuring that activities aligned with the project's objectives and that communication flowed smoothly between technical teams, local stakeholders, and European partners. WP7 also ensured compliance with local regulations, coordinated risk management, and oversaw sensitive issues, such as ethical considerations at the demonstration site, playing a critical role in ensuring the project's successful implementation.

3.3 Challenges encountered

The deployment of renewable energy solutions in Alicedale presented different challenges in each context due to the specific conditions and infrastructure limitations of semi-rural areas. These challenges, which are aligned with the project's strategic objectives (SO1-SO5), reflect the need for tailored approaches to renewable energy implementation as listed below:

Community awareness and trust-building – In Alicedale, a semi-rural area, limited exposure to renewable energy solutions created initial resistance among residents. Community members were uncertain about the reliability of solar PV systems and electric vehicles, requiring targeted awareness campaigns to build trust and understanding of the new technologies. This challenge aligns with SO1: Inform**,** highlighting the need for ongoing efforts to increase awareness and acceptance of renewable energy.

Lack of established infrastructure for EV charging – Alicedale lacked adequate infrastructure to support electric vehicle charging, a critical component of the project's electric mobility initiative. The absence of EV charging stations and the costs associated with setting up this infrastructure slowed down adoption, impacting the project's ability to demonstrate scalability. This infrastructure gap is connected to SO4: Implement, as it underscores the importance of reliable support infrastructure for clean energy technologies.

Policy and regulatory considerations: – Due to a lack of basic awareness of clean technology solutions such as renewable energy and electric mobility, introduction to electric mobility and electric vehicle charging infrastructure and renewable energy courses are required to build capacity amongst local government officials to assist them with implementing a national policy that supports the adoption of e-mobility and renewable energy technology solutions within their municipalities.

This lack of awareness barrier impacted the project's success in achieving SO5: Impact**.** Local government officials need a capacity-building drive to give them the technical assistance and tools they need to take approved national policies and implement them locally.

Logistical challenges and limited accessibility – In the semi-rural area of Alicedale, logistical difficulties in transporting solar PV systems and EV infrastructure delayed project timelines. The remote location and limited road infrastructure increased the cost and complexity of equipment delivery, impacting the project's ability to implement the systems effectively. This challenge highlighted the importance of logistical planning for remote energy projects.

Financial barriers for low-income households – Many residents in Alicedale faced economic challenges that made it difficult to afford upfront costs for new energy technology, even when future savings were anticipated. This financial barrier limited the immediate accessibility of renewable solutions by reducing the reach of capacity-building efforts.

Technical capacity and training gaps – A lack of local expertise in operating and maintaining the solar PV systems in Alicedale presented a challenge. While initial training was provided, there was an ongoing need for support to ensure sustainable operation and management of the systems. This capacity gap community acceptance and cultural shifts –In Alicedale, there was a hesitation in transitioning from traditional energy sources to renewable solutions. Many community members were accustomed to conventional fuels, leading to a cultural resistance to change. This underscored the need for awareness campaigns that address both technical and cultural aspects of renewable energy adoption.

Capacity and resource limitations in the local workforce – Although training sessions were conducted, there remained a significant need for continuous capacity-building to ensure that community members could operate and maintain the renewable energy systems. The limited technical resources in Alicedale affected the sustainability of the systems, highlighting the importance of building a strong, knowledgeable local workforce.

Resource allocation and coordination – Balancing resources and coordinating activities in a marginalized and vulnerable community that is also based in a semi-rural area is challenging. The need to allocate resources effectively led to project delays and required adaptive project management. This highlighted the importance of efficient resource management and flexible project coordination to meet diverse community needs.

3.4 Lessons learned

The South Africa demonstration actions in Alicedale revealed critical lessons for renewable energy implementation in semi-rural contexts. These lessons presented the importance of context-specific approaches and are aligned with the project's strategic objectives (SO1-SO5)

1. **Early and targeted community engagement** – Engaging the Alicedale community early and providing consistent, targeted information about the benefits and reliability of renewable technologies proved essential for building trust and acceptance. Awareness

campaigns tailored to a semi-rural audience helped address initial skepticism. They demonstrated that informed communities are more receptive to new technologies. The e-mobility awareness campaigns included half-day interactive sessions with the community members to give them a basic understanding of e-mobility and the e-mobility ecosystem. GREEN Solar Academy also conducted solar PV training with the community to give them a broader understanding of this technology and its environmental benefits. The living lab was also used as a hub to explain the basics of technology for e-mobility, solar energy,y and stationary energy storage to the broader community, particularly when they visited and made use of the services provided by the living lab.

2. **Infrastructure is critical for technology adoption** – The lack of EV charging infrastructure in Alicedale highlighted the necessity of developing foundational support infrastructure alongside renewable energy solutions. Reliable infrastructure directly influenced the scalability of electric mobility, demonstrating that infrastructure investments are integral to sustainable energy adoption in rural and semi-rural settings.
3. **Policy engagement strengthens scalability** – Working with local authorities to build awareness that aligns renewable solutions with national policy allowed local government authorities to respond favourably to initiate activities that support the implementation of South Africa's Just Energy Transition Plan at a local level. This was essential for ensuring long-term scalability. Capacity building and technical assistance for implementing existing national policy at a local level can enable renewable energy projects to expand and integrate more seamlessly into local energy systems.
4. **Flexible business models improve accessibility** – The pay-as-you-go model for solar PV systems helped make renewable energy solutions more accessible to Alicedale residents where financial constraints were significant. Affordable payment models tailored to economic conditions can drive adoption in low-income, semi-rural areas. The business model in Alicedale will be feasible through public-private partnerships that can subsidise transportation services from the micro electric vehicles and operational services of the off-grid containerised systems. Detailed financial projections and modelling to showcase how this PPP could work are currently being reported in D4.3 Business Models reporting documents.
5. **Sustained capacity building is essential** – While initial training provided a foundation, the limited technical expertise in Alicedale underscored the need for ongoing support to maintain renewable systems. Continuous training sessions and remote support options will ensure long-term functionality by reinforcing the value of sustained capacity-building efforts in semi-rural communities. E-Mobility, renewable and sustainable energy solutions technologies are emerging and dynamic in South Africa. Therefore, continuous training will be required to keep the community abreast of new technological advancements and solutions for electric vehicles, solar PV, and stationary storage.
6. **Logistical planning is key for remote implementation** – The logistical challenges faced in delivering solar PV systems to Alicedale demonstrated the importance of comprehensive logistical planning in semi-rural settings. Successful renewable energy deployment in remote areas depends on well-organized transport and supply chain solutions. Successful renewable energy deployment in remote areas depends on well-organized transport and supply chain solutions. Continuous stakeholder engagement is

necessary to determine the popular transportation routes and pilot specific transport routes to analyse their demand on specific days and times. Continuous stakeholder engagement is also essential to ensure that the renewable energy solution that has been deployed is meeting the community's needs.

7. **Trust-building is essential for technology adoption** – Shifting from conventional fuels to renewable energy required more than technical training; it required building trust and addressing cultural attitudes towards energy usage. Engaging the community early and transparently proved essential for fostering acceptance. Successful adoption of renewable technologies relies on trust-building and continuous community engagement. Building trust with the community means continuously engaging with them and managing relationships with them in a manner that is aligned with their customs and culture. For example, when visiting community leaders or members in Alicedale, bringing a small, inexpensive gift is customary to show that you appreciate the relationship. It is also crucial that you do not start talking about business immediately; you must spend some time talking about personal matters, such as asking how their family and children are.
8. **Sustained capacity building is necessary for long-term sustainability** – Initial training alone was insufficient and demonstrated the need for ongoing technical support to build confidence and skills in managing renewable systems. Building a capable local workforce is a long-term investment, not a one-time effort.
9. **Adaptive resource management and coordination support for diverse needs** – different customer segments of Alicedale highlighted the importance of adaptable resource management. Project success relied on flexible timelines, responsive logistics, and resource allocation tailored to meet the unique requirements of the different customer segments. Flexibility and responsiveness in project coordination are essential when working across a range of customer segments.

3.5 Opportunities for further research and development

The demonstration in Alicedale identified several areas for future research and development, offering pathways for expanding the impact of renewable energy solutions across semi-rural South African communities. These opportunities are organized according to the strategic objectives (SO1-SO5).

SO1: Inform

Digital platforms for renewable energy awareness: Research could explore the development of digital platforms that provide accessible information on renewable energy benefits, technical guidance, and maintenance tips for solar PV systems and electric vehicles. Such platforms could enhance public understanding and support long-term engagement with renewable solutions in semi-rural and rural communities.

SO2: Inspire

Case studies highlighting success stories: Creating case studies that document the environmental, economic, and social impacts of renewable technologies in Alicedale could serve as a resource for other South African communities. These case studies could inspire wider adoption of renewable solutions by demonstrating tangible benefits. Examples of case studies include the progression of the off-grid containerised hub and how it has supported job creation in the community. Another example is how transportation services have been used to benefit the day-to-day life of the community members, where they no longer need to walk to their destinations because an affordable, accessible transportation service is now available.

Cross-regional knowledge exchange programs: Further research into structured knowledge exchanges could provide a framework for other African regions to learn from Alicedale's experiences, enhancing awareness of effective renewable technologies through peer learning.

SO3: Initiate

Sustainable workforce development programs: Research could explore establishing training and certification programs for renewable energy technicians, ensuring that local communities have the expertise to sustain and expand these systems. This workforce development could enhance local capacity and economic resilience.

Supply chain models for renewable components: Developing localized supply chains for components like solar PV panels and EV batteries would reduce costs and improve the accessibility of renewable energy solutions. Research could explore local production and distribution options to support community-level energy projects.

SO4: Implement

Innovative financing models: Future research could explore financing mechanisms such as microfinance, cooperatives, or blended finance models to make renewable energy systems more affordable and accessible, especially for low-income households in semi-rural areas.

Expansion of charging infrastructure for EVs: Research into scalable and cost-effective EV charging solutions suited for semi-rural areas could provide a model for expanding electric mobility beyond major urban centres, ensuring reliable transport options.

SO5: Impact

Policy advocacy and integration: Research into strategies for aligning community-level renewable solutions with national and regional energy policies could promote broader adoption. Advocacy initiatives, capacity building, and technical assistance interventions targeting local governments on how to adopt national policy and adapt it for implementation at the local government level could support the adoption and integration of decentralized, renewable energy models within policy frameworks.

Public-private partnerships for scaling: Exploring new public-private partnerships (PPPs) models could provide sustainable funding and technical expertise, supporting the scale-up of renewable energy solutions across South Africa. Research into effective PPP frameworks could enable broad community impact and long-term support for renewable energy infrastructure.

3.6 Conclusion

The SESA demonstration actions in Alicedale provided a practical, scalable model for implementing renewable energy solutions in semi-rural and rural South African communities. The project addressed critical issues of energy poverty, high emissions, and limited transportation access by deploying a containerized solar PV system and establishing electric vehicle infrastructure. These renewable energy solutions offered clean, reliable alternatives to traditional fuels, reducing pollution and dependency on fossil fuels while supporting the local economy and creating new opportunities for community development. The demonstration achieved its primary objectives and illuminated the essential role of community engagement, capacity building, and adaptable infrastructure in ensuring the sustainability of renewable energy projects.

The South Africa demonstration highlighted key lessons for expanding renewable energy access across Africa, including the importance of early community involvement, adaptable financing models, and sustained capacity building. In Alicedale, tailored awareness campaigns and community workshops proved essential in fostering trust and acceptance of the new technologies. These outreach efforts demonstrated that renewable energy adoption is not solely about technology deployment; it requires cultivating an informed and engaged community that sees the long-term benefits of clean energy. The project’s targeted training sessions for local technicians and community members built foundational skills in managing off-grid solar PV renewable energy systems, micro electric vehicles and their corresponding charging infrastructure, a critical factor in achieving long-term sustainability and local ownership of the renewable systems.

From a broader perspective, the demonstration actions in Alicedale provide a replicable model for renewable energy initiatives in other South African regions. Establishing public-private partnerships in underserved communities can make clean technology solutions for mobility and renewable energy more accessible and affordable, especially for low-income households in rural and semi-rural areas. This approach underscored the value of financial inclusivity, showing that accessible payment structures can significantly increase the reach of renewable solutions and drive widespread adoption. Additionally, the project highlighted the importance of policy alignment and partnership-building for renewable energy initiatives. Collaborations with local authorities, community organizations, and private sector stakeholders laid a foundation for future scalability, demonstrating that integrated support from diverse stakeholders enhances renewable solutions' long-term impact and sustainability.

Looking ahead, the South Africa demonstration presents a strong foundation for scaling renewable energy access across both semi-rural and rural African settings. The insights gained from Alicedale reveal how adaptable and community-driven renewable energy projects can contribute to economic resilience, environmental health, and energy equity. By refining training programs, developing new financing mechanisms, and expanding policy advocacy.

The project offers pathways for broader replication. Future initiatives can build on these foundations to support Africa's transition towards a sustainable, resilient energy landscape, promoting social equity, economic growth, and environmental sustainability. The outcomes in South Africa reinforce the SESA project's vision of creating clean, community-centered energy solutions that can be sustained, scaled, and adapted to address the unique challenges of underserved regions across the continent.

4.0 Ghana

Ghana, characterized by its growing energy demands and high reliance on traditional fuels in rural areas, was chosen as a key validation site. The Ghana Living Lab focuses on three core areas: validating waste-to-energy solutions for clean cooking and locally produced cookstoves in public schools across Accra and Kumasi, enabling energy access for off-grid communities with an emphasis on nighttime learning for students, and building stakeholder capacity and public awareness to support sustainable energy solutions.

Key demonstration actions in Ghana included repurposed lithium-ion batteries for solar generators and power systems, and bioethanol-fueled clean cookstoves and educational interventions, such as the establishment of **info spots in public schools**, were also prioritized to inspire the next generation of energy leaders.

The project was guided by five core objectives (SO1-SO5), each aligning with specific strategies for addressing local energy needs and supporting economic growth:

1. **SO1: Inform** – Raise awareness about the potential of renewable energy solutions, specifically waste-to-energy for clean cooking and photovoltaic systems for energy supply.
2. **SO2: Inspire** – Drive the adoption of innovative energy solutions across Ghana by demonstrating their benefits and the improvement in quality of life achieved through the integration of clean cooking technologies and the repurposing of old lithium batteries for solar energy storage.
3. **SO3: Initiate** – Enable local capacity-building to manage and maintain the deployed technologies by providing training and guidance to local communities.
4. **SO4: Implement** – Establish practical, real-world solutions with a focus on biogas waste-to-energy systems and the use of bioethanol as an alternative to wood and fossil fuels to mitigate deforestation and health issues. Additionally, they demonstrate the feasibility and potential of recycled lithium batteries for solar energy storage systems.
5. **SO5: Impact** – Ensure long-term sustainability by fostering partnerships to enable scalability beyond the demonstration phase. In Ghana's Living Lab, communication and engagement with diverse stakeholders, including both public and private entities, are key to securing long-term implementation and enhancing the quality of life and self-sufficiency of the communities.

This report summarizes the demonstration actions conducted in **Ga North Municipal Assembly** (urban) and **Atwima Nwabiagya Municipal Assembly** (rural), highlighting contributions from various work packages (WPs) and their alignment with the project’s strategic objectives.

4.1 Problem to address

In Ghana, energy access remains unevenly distributed, with both urban and rural areas facing unique challenges that hinder economic development and quality of life. The national electricity grid in Ghana is unreliable, characterized by frequent power shortages and a lack of coverage in most rural areas. Thus, in rural regions like Atwima Nwabiagya Municipal Assembly, off-grid households rely heavily on traditional energy sources such as firewood which contribute heavily to deforestation and have adverse health effects due to indoor air pollution. Moreover, the use of diesel generators or Liquefied Petroleum Gas (LPG) is often prohibitively expensive and unaffordable for households in the area, which primarily rely on agriculture. These technologies are not only costly but also contribute to greenhouse gas emissions and negatively impact both human and environmental health.

Meanwhile, urban areas such as Ga North Municipal Assembly struggle with waste management issues, particularly electronic waste (e-waste), which could otherwise be harnessed to create energy solutions. These challenges highlight the urgent need for affordable, sustainable energy access that not only meets the immediate needs of households but also contributes to environmental conservation and economic resilience.

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 using efficient cooking fuels and stoves would bring greater freedom and opportunities to the rural cookstove user.

Beyond Ghana's immediate needs, European partners in the SESA project sought forsites to test and refine renewable energy solutions in contexts that presented distinct geographic, economic, and cultural conditions. Ghana offered an ideal setting to trial waste-to-energy and circular economy solutions in urban areas and solar-based energy systems in rural settings, both of which address pressing local issues while allowing European partners to adapt their innovations to new contexts.

Through the 1st SESA Call for Entrepreneurs, two companies were selected to test and validate business models around 1) waste-to-energy solutions for clean cooking for low-income households (Econexus) and 2) solar generators made from electronic waste for individual households as well as micro-grids for off-grid rural communities.

The Ghana demonstration actions were structured to tackle five key challenges associated with the project's strategic objectives (SO1-SO5):

SO1: Inform – Addressing the knowledge gap in renewable energy solutions

In both Ga North and Atwima Nwabiagya, there was an inadequate level of awareness and understanding of renewable energy technologies and their benefits. Households and local institutions often viewed traditional fuels as the only viable options for their energy needs. Most people do not even consider using greener energy sources, either because they are unaware of them or perceive them as unfamiliar and difficult to access. One of the main challenges was the lack of awareness about local companies offering these types of services and the limited knowledge on how to access them.

To tackle this, the SESA project aimed to inform these communities about the potential and availability of clean cooking solutions such as the biofuel produced out of agricultural waste by Econexus and the locally manufactured cookstoves.

By showcasing these renewable systems through local demonstrations, the project worked to change perceptions and build trust in these alternatives, helping communities to see renewable energy as a reliable and preferable option. Moreover, it helps to raise awareness of SMEs and related stakeholders working with these technologies, who often face challenges in reaching local communities.

For European partners, this phase offered an opportunity to understand the information gaps that might affect the acceptance of renewable energy technologies in rural Ghana and to tailor their outreach strategies accordingly.

SO2: Inspire – Fostering interest and adoption of renewable solutions

The adoption of innovative energy solutions in Ghana has been limited due to both financial constraints and limited exposure to successful models. To address this, the SESA project aimed to inspire local governments, businesses, and communities by demonstrating tangible benefits from renewable energy systems, such as reduced energy costs, improved health outcomes, and enhanced environmental sustainability. Involving a wide range of stakeholders was a key goal in the Ghana LL as a collaborative effort between the population and the government is fundamental for the long-term implementation of the technologies.

The project's urban focus in Ga North involved showcasing the potential of a circular energy economy by recycling e-waste to create affordable energy storage options, while the rural demonstration in Atwima Nwabiagya promoted solar PV systems as a sustainable alternative to kerosene and firewood. By building enthusiasm around renewable energy and proving the viability of these systems, SESA hoped to catalyze interest and investment in similar initiatives across Ghana.

SO3: Initiate – enabling local innovators and building capacity

In Ghana, there is a recognized need for skilled local technicians who can install, operate, and maintain renewable energy systems, particularly in rural areas. The socio-economic profile of the Atwima Mponua District of the Ashanti Region in Ghana, highlights a community predominantly involved in agricultural activities with a low level of education, where specialized technical training is scarce. The technical skills required for maintaining systems such as solar PV setups, bioethanol cookstoves, and recycled battery storage are not widely available, and this limits the scalability and long-term utilization of renewable energy projects.

The SESA project addressed this by initiating local capacity-building programs in both demonstration areas. In Atwima Nwabiagya, community members received training on the operation and maintenance of solar PV systems to ensure reliable energy for lighting and cooking, while in Ga North, technicians learned to manage waste-to-energy systems and battery storage derived from recycled e-waste. For European partners, the Ghana demonstration provided a testing ground for capacity-building modules, enabling them to understand the types of training and technical support needed to sustain energy solutions long-term.

SO4: Implement – overcoming co-development challenges

Implementing modular and scalable renewable energy solutions in Ghana's diverse environments posed a unique set of challenges. In Ga North, the demonstration involved waste-to-energy systems for cooking (i.e. bioethanol made from agricultural waste) as well as recycling electronic waste materials, addressing both urban waste management and energy needs. On one hand, the repurposing of used lithium batteries for energy storage, and on the other hand the installation of bioethanol cookstove for clean cooking. However, sourcing a steady supply of e-waste and ensuring effective integration of the modified cookstoves and bioethanol fuel systems into existing energy infrastructure required meticulous planning and community engagement.

In Atwima Nwabiagya, deploying solar PV systems required overcoming logistical challenges such as transporting equipment to remote locations with limited infrastructure. The lack of reliable road access and financial barriers for residents made the rollout of these systems more complex. The SESA project tackled these implementation challenges by adapting the solutions to the local socio-economic and geographic conditions, ensuring that both urban and rural communities could benefit from sustainable energy innovations.

SO5: Impact – ensuring long-term sustainability and partnership-building

Ensuring the long-term impact of the Ghana demonstration actions required strong partnerships with local government bodies, community leaders, local companies such as the selected enteprises from the 1st SESA Call for Entrepreneurs as part of the SESA Incubator Programme and financial stakeholders. For the waste-to-energy demonstration in Ga North, SESA collaborated with municipal authorities to integrate waste recycling for productive use into the city's waste management strategy. This partnership aimed to create a sustainable model that could be replicated in other urban areas.

In Atwima Nwabiagya, the project engaged with local leaders to build support for the solar PV systems and ensure that communities took ownership of the technology. This focus on local partnerships was essential to creating a foundation for sustainable growth and scalability of the renewable solutions. For European partners, the Ghana project provided insights into how renewable energy systems could be integrated into local governance structures and policies, ensuring that the systems would continue to function effectively after the project's conclusion.

4.2 Solutions employed

Ghana demonstrations involved innovations solutions that tested solar and second life batteries for solar off grid applications and bioethanol for cooking systems. The aim is to improve stakeholders' knowledge, skills, trust and capacity in the design, construction, operation and maintenance of these technologies.

WP1: Development of the technology basis

WP1 was essential in establishing the technology foundation for both waste-to-energy and solar solutions in Ghana. This work package conducted detailed assessments of the technical requirements for each demonstration site, ensuring that the chosen solutions were both locally appropriate and capable of meeting community needs. This was done through a user needs assessment (UNA).

The comprehensive UNA that included user surveys and observations, with 35 respondents participating in structured interviews was conducted in the first week of November 2023. The assessment was conducted in the Bedabour Community in the Atwima Mponua District, primarily engaged in agriculture.

Two structured questionnaires on bioethanol cookstoves and PV systems collected data. The questionnaires sought to understand these technologies' use, benefits, drawbacks, and community opinions. Interviewers fluent in the native language ensured understanding and correct responses without bias.

Key Findings:

Cookers made with bioethanol

All responders cooked with firewood from public and private forests. Over 80% cited high costs as a major barrier to adopting better cookstoves. There were few improved cookstoves in the area, making adoption difficult. Over 60% of respondents reported health risks from smoke inhalation from traditional cooking methods.

Despite the benefits of better stoves, cultural dependence on traditional cooking methods necessitated awareness and teaching initiatives.

PV Systems

Different educational levels may affect PV technology uptake and understanding. While individuals possessed a general understanding of PV systems, their comprehension of technologies such as second-life lithium batteries was limited. The primary obstacles identified by 96% of the respondents were economic in nature, specifically the initial investment required for installation.

The community shows interest in healthier and more sustainable cooking options. Key obstacles include high initial costs and a lack of local suppliers. Targeted interventions to reduce costs and increase local availability, alongside education on the health benefits, are recommended. In addition to the UNA, a toolbox with the best approaches was launched at the SESA fourth regional event in October 2024.

WP2: Capacity building and cooperation

WP2 focused on building local capacity to maintain and operate the deployed systems. Two key events were organized in Ghana to enhance capacity and cooperation. The first was a Climate Finance Workshop in Accra. Attended by 28 participants, including government officials, private sector representatives, and SESA partners from Ghana, Kenya, South Africa, and Malawi, the workshop focused on unlocking climate finance through project development. A notable outcome was the co-development of a waste-to-energy project by officials from Ga North and Ashaiman Municipal Assemblies.

Officials from Ga North and Ashaiman Municipal Assemblies, in Ghana, co-developing a waste-to-energy project concept.

The second event, held in Kumasi, brought together 110 participants (100 in person and 10 virtually) for practical sessions on renewable energy. Topics included brick cookstoves, biofuel cookers, and solar installation/maintenance. Participants also engaged in breakout discussions on cookstoves and solar energy, fostering hands-on learning and collaboration.


Section of participants at the Kumasi training

NASTECH, in partnership with Dream Renewables, the SNV-Green project, and the National Vocational training Institute (NVTI), has provided up to 225 people with training in solar energy installation.

Further, enhancing the SESA project's sustainability, a capacity-building manual on the installation and maintenance of PV systems was developed, alongside the establishment of a BSc Renewable Energy programme currently undergoing final accreditation process from Ghana Tertiary Education Commission (GTEC). This initiative ensures the training's longevity beyond SESA, reinforcing the infrastructure for ongoing education in renewable energy. The BSc Renewable Energy programme is now available for other partner universities to adapt and implement in their universities and countries across the SESA consortium.

A workshop on energy decarbonization, focusing on efficiency and conservation methods, further broadened the scope of capacity building, illustrating a comprehensive approach to addressing energy challenges through education, practical application, and policy engagement. This workshop was organized by AAMUSTED regional training and innovation center on the 13th of March 2024 and attended by 51 participants including policy makers (Ghana Energy Commission), certified wiring professions, SMEs, and engineering students.

Additionally, a manual on installation and maintenance of PV systems has been developed to enhance local capacity.

WP3: Business models and market Solutions

WP3 led the selection of suitable companies as part of the SESA Incubator Programme and sub-contracted two companies for the implementation and validation of bioethanol cookstoves and solar PV systems.

Nastech Power Solutions (NASTECH) has validated innovative solar energy solutions combining micro-grids and individual solar generators made from electronic waste with the vision to improve sustainable energy access in off-grid communities. Throughout the SESA project, NASTECH provided subscription-based micro-grid solutions for off-grid communities, including two 20 kW systems for the Berdabuor community with over 200 households and a 10-kW system for the Kwamedwaa community with 50 dwellings.

Nastech tested micro-grid systems in rural, low-income communities using a subscription model to improve energy access. However, the micro-grid approach presented challenges, including high capital expenditure, maintenance costs, complex infrastructure requirements for connecting homes, payment delays with the subscription model, and slow customer onboarding due to trust-building needs. These issues made micro-grids difficult to scale and impacted the profitability calculations from the business side. In response, Nastech pivoted to providing individual solar home systems while continuing to offer Paygo options for rural off-grid communities with low purchasing powers. This shift allowed for more flexible deployment, reduced overhead, and improved cost recovery.

NASTECH's subscription-based model and direct sales have enabled electrification of rural homes and businesses, boosted local economies and created 52 jobs.

Ghana Waste-to-Energy Business Plan

Econexus developed and tested two industrial-scale ethanol-gel fuel stove models tailored for public secondary schools and institutional-scale cooking and introduced economies of scale in order to increase local production levels of their clean biofuels made from agricultural waste.

Households, senior high schools, small and medium-sized businesses, agriculture, municipalities, local governments, and NGOs are targeted. The tested and validated business model includes direct sales, online platforms, local retailer partnerships, community events, and government procurement. It recognizes the need for waste-to-energy education and awareness, especially in less familiar sectors.

The following models were employed to cater for the various categories of customers:

- **Leasing Model:** Offer consumers the option to lease the waste-to-energy system. They pay a standard fee to utilize the technology.
- **Fixed Pricing:** Establish a monthly or yearly fee that is fixed for the Ecogel and Ecofuel service.
- **Dynamic pricing:** Adjust pricing based on variables such as usage, location, and seasonal demand.

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. Additionally 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. Approximately, 40% decline in revenue was recorded in June 2023, that translated into about 205 users abandoning the products.

The feedback highlighted that customers frequently compare new cooking fuel options with established ones like LPG. 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.

WP4: Demonstration, validation, and replication

WP4 supported the implementation of bioethanol cookstoves and solar PV systems, validating their effectiveness in the Ghanaian context in close collaboration with WP3. These technologies were implemented by the two selected SMEs: Econexus for the bioethanol fuel and stoves, and NASTECH for Solar PV applications.

Solar micro-grid electrification

The solar micro grid solutions have been executed using two approaches, the main micro-grid has been provided to two communities Berdaabuo and Kwamedwaa, where the third community Beposo have been provided with an individual solar generator system for each home in the community.

In the first community BERDAABUO community two separate 20 kW 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 have 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 occupancy of 6 people and at most 10 people per home.

20 MW PV Microgrid system at Berdaabuo

The second community Kwamedwaa also with about 50 to 60 homes is provided with Solar Generator systems for home. Here a 2-kW system has been installed for each home. Currently 12 homes have been provided electricity, with a total combined capacity of 24 kW and plans are under way to increase the number of subscribers.

Technical specification of the 2000W solar generator

Summary of NASTECH Activities:

Objectives as per service agreement	Quantity
Solar micro-grid installation	3
Solar training	225
Waste Battery repurposed	253tons
Marketing and sales	775
Micro Grid subscriptions	54
Solar Gen subscriptions	40

Biofuel and Stoves

Bio Ethanol cooking fuel was developed largely from sugarcane molasses, cashew apples, cellulose gel and water was provided in the form of Ecogel to the selected senior high schools. The figure below illustrates the bioethanol fuel production from organic waste.

Operation Cycle of the bioethanol fuel

Ecogel as a waste-based production promotes sustainability and waste reduction. Soot-free cooking with Ecogel prevents black flame marks on pots, indicating cleaner combustion. The fuel is also non-spill, non-explosive, and non-toxic energy source making it very safe for the consumer. About 500 liters of the fuel was supplied to the schools for the testing phase. The first 100 liters were initially supplied with the first prototype and the remaining 400 liters with the improved stove. Three prototype stoves were originally developed and supplied to the schools for the testing during the lunching of the Ghana living lab in October 2023.

First Ecogel Stove prototype

Feedback from the schools on the testing of the cookstoves concludes to be promising in both urban and rural environments, by its fuel refill ability, cooking efficiency, and eco-friendliness. Nonetheless, stability, flame regulation, fuel economy, and usability require refinement.

Based on these findings, an upgraded design incorporates a flame regulator and strengthened stability and longevity, particularly when handling large pots. Two of these improved stoves were delivered to Nkawie and Toase for testing on the 15th of April 2024. Follow-up feedback will be undertaken to determine the level of satisfaction and efficiency with the new design.

Improved Ecogel stove with flame regulator

WP5: Scale-up, finance, and policy environment

WP5 worked to integrate the demonstrated solutions into regional energy policies and explored financing options for scaling the waste-to-energy and solar PV systems. Collaborations with local authorities in both Ga North and Atwima Nwabiagya aimed to establish a policy framework that would support the broader adoption of these systems.

WP6: Communication and dissemination

WP6 developed case studies and informational resources to document the Ghana demonstration. These materials were shared with local stakeholders, neighboring communities, and international audiences to highlight the potential for waste-to-energy and solar PV solutions to address energy poverty in both urban and rural Ghana.

Several online training videos and webinars were done and up-loaded into the SESA Capacity building archive. These training sessions focused on the potential of technologies with an emphasis on practical application, as well as strategies and manuals for the operation and maintenance of the equipment. The goal of these training courses was to empower the community to make it as self-sufficient as possible. Training the local community and disseminating the knowledge acquired during the project are essential for the long-term maintenance of the installed equipment and the tested technologies.

Moreover, based on the research conducted within the framework of anaerobic digestion, an abstract has been submitted to the 11th International Conference on Sustainable Solid Waste Management conference, and work is underway on the publication of a scientific paper.

WP7: Project management and coordination

WP7 was responsible for the overall project management and coordination in Ghana, ensuring that activities aligned with the project's objectives and that communication flowed smoothly between technical teams, local stakeholders, and European partners. WP7 also ensured compliance with local regulations, coordinated risk management, and oversaw sensitive issues such as ethical considerations in the demonstration sites, playing a critical role in ensuring the project's successful implementation.

4.3 Challenges encountered

The Ghana demonstration encountered various challenges, influenced by the specific contexts of implementing the off-grid PV systems, bioethanol, and cooking stoves in the study areas. These challenges were aligned with the project's strategic objectives and impacted short-term outcomes.

Solar PV Technology

- **E-Waste collection and management** – The development of recycled battery storage systems relied on a steady supply of electronic waste, which proved challenging due to limited collection and recycling infrastructure. This necessitated the establishment of local partnerships to secure a consistent supply of raw materials.
- **Regulatory hurdles -** Difficulty obtaining permits and licenses due to legal restrictions allowing only Electricity Company of Ghana (ECG) to sell power and Ghana Grid Company (GRIDCo) to construct transmission lines. Modifications to the original implementation plans hindered project scaling and expansion.
- **Operational setbacks -** Delays in engaging ECG for fee collection and reliance on GRIDCo subcontractors for distribution network construction. Resistance to monthly maintenance fee payments, with some users avoiding payments entirely over time.
- **Integration with waste management policies** – Aligning the waste-to-energy demonstration with local policies required extensive collaboration with city officials. Regulatory barriers and delays in obtaining the necessary permits slowed down the timeline.

Bioethanol for Cooking

- **Regulatory and market barriers** - Low demand for ethanol-based fuels due to higher retail prices compared to LPG. Customers perceived ethanol fuels as inefficient and expensive, leading to reduced patronage and significant revenue declines.
- **Feedstock limitations -** with cashew apple offering better ethanol yield but requiring higher transportation costs due to its distance from production facilities.
- **Operational difficulties** - High production costs driven by increasing prices of fermentation inputs and the gelling agent. Rapid fuel consumption due to high ethanol concentration, which discouraged long-term use.
- **Economic constraints -** The inability to achieve a sustainable product market fits with the current pricing and cost structure. Competition with established alternatives like LPG, which are more affordable and familiar to users.

General challenges across both technologies

- **Capacity gaps** – While technicians were trained, there were still noticeable capacity gaps in the workforce, impacting system maintenance and operation. This extended the training period and necessitated more frequent follow-ups than initially anticipated.
- **Cultural adaptation** – Shifting from traditional cooking and lighting sources to biogas and solar solutions required a cultural shift. Building trust in these new technologies took time and consistent community engagement

4.4 Lessons learned

The Ghana demonstration offered valuable insights into implementing waste-to-energy and solar solutions in both urban and rural settings. Key lessons included:

Solar PV Technology

1. **Partnerships are essential for resource availability** – Establishing partnerships with local e-waste collectors and municipal waste management services was critical for maintaining a steady supply of materials for recycled battery storage.
2. **Regulatory compliance -** Engage regulatory authorities early to secure necessary approvals and navigate legal restrictions. Collaborate effectively with entities like GRIDCo and ECG for smoother project implementation.
3. **Financial sustainability -** Develop better customer engagement strategies to ensure compliance with payment agreements. Implement stronger enforcement mechanisms to improve fee collection.

Bioethanol Technology

3. **Community engagement drives adoption** – Regular workshops and information sessions were instrumental in overcoming community resistance to waste-to-energy solutions. Transparent communication and demonstrations of system reliability helped build trust.
4. **Market insights** - The importance of pricing competitiveness and ensuring cost-effectiveness of ethanol fuels to attract and retain customers. Customer feedback is critical for refining product design and improving performance to meet user expectations.
5. **Operational adjustments -** Feedstock selection with a focus on high ethanol yield materials like cashew apples can enhance production efficiency and reduce costs. Transitioning to lower ethanol concentration fuels may improve efficiency and address consumer concerns about rapid fuel consumption.

6. **Strategic direction -** Diversification of product lines, including ethanol gel for food warming and sanitary-grade ethanol for institutional use, can provide alternative revenue streams.

Both Technologies
Capacity building needs continuous support – Initial training sessions were not sufficient for long-term operation and maintenance. Refresher courses and ongoing technical support were essential to ensure local technicians were equipped to manage the solar PV systems.

Adaptability to local conditions – The deployment of solar PV systems demonstrated the importance of adapting installation schedules to account for seasonal and logistical challenges. Moreover, regarding the waste-to-energy solution, it is crucial when dealing with vegetable waste, such as fruits and vegetables from local markets, to make a thorough study on the type of operation and the challenges it may present for an anaerobic digester.

4.5 Opportunities for further research and development

Based on the demonstration in the urban Ga North Municipal Assembly and the rural Atwima Nwabiagya Municipal Assembly, several opportunities for further research and development were identified. These opportunities align with the five strategic objectives (SO1-SO5) and offer pathways for expanding the impact of the SESA project in Ghana and beyond.

SO1: Inform

Community-led awareness programs: Further research could focus on developing community-led initiatives to increase understanding and trust in biogas and solar technologies. Engaging local leaders in awareness programs may enhance acceptance in both urban and rural communities.

Digital knowledge platforms: Exploring digital platforms for knowledge-sharing and troubleshooting could provide rural technicians with remote access to technical support, reducing dependency on in-person training. Furthermore, continuous access to information would enable long-term maintenance and allow the local community to share knowledge.

SO2: Inspire

Cross-continental knowledge exchange: future research could explore deeper partnerships between Europe and Africa, with a focus on the role of knowledge hubs. These hubs could serve as centers for ongoing innovation, connecting European researchers with African entrepreneurs to co-develop solutions.

Scaling training programs: expanding the capacity-building programs initiated in the two assemblies to include broader training on energy entrepreneurship could inspire local communities to innovate further within the energy space.

Public demonstrations of circular economy benefits: Demonstrating the socio-economic impact of e-waste recycling for battery storage could inspire policy changes and community involvement in waste management.

SO3: Initiate

Long-term sustainability: future research should focus on the long-term sustainability of the energy innovations implemented in Ga North and Atwima Nwabiagya Municipal Assemblies. This could involve research into training programs that prepare a sustainable workforce for managing renewable energy systems ensuring that local capacity meets the growing demand for skilled technicians.

Replication of waste-to-energy systems: Evaluating the replicability of waste-to-energy solutions in similar urban environments across Ghana could provide a scalable model for municipal waste management and energy generation.

SO4: Implement

Financing mechanisms for rural and urban energy systems:
Further research could explore innovative financing models tailored to both rural and urban settings for PV systems. In rural areas, cooperative-based models or microfinance could make solar PV systems more accessible to low-income households. The pay-as-you-go model, though functional, yields low returns, especially among rural customers. Conversely, the same model performs better in urban areas, generating positive returns. To ensure sustainability, the focus has shifted to direct product sales targeting middle-income customers in major towns who can afford upfront payments.

Integration of additional renewable sources: Future studies could investigate hybrid systems that combine multiple renewable energy sources to meet diverse energy needs in both urban and rural settings. In Ga North, a mix of biogas and solar PV could improve the resilience of waste-to-energy systems, while in rural Atwima Nwabiagya, adding biomass or small-scale hydro to solar PV systems could address fluctuating demand and seasonal availability of sunlight'.

SO5: Impact

Policy integration: Research into policy frameworks that support circular economy models, particularly in waste management and e-waste recycling, could drive broader adoption in urban and rural areas.

Public-private partnerships: Exploring public-private partnership models for waste-to-energy systems would provide financing opportunities to expand these solutions and integrate them into local economies.

4.6 Conclusion

The demonstration actions in Ga North and Atwima Nwabiagya successfully showcased the potential of waste-to-energy and solar PV systems to address energy access challenges in urban and rural areas of Ghana. Through the collaborative efforts of various Work Packages (WPs), the project implemented, tested and validated sustainable business models around bioethanol cookstoves and recycled battery storage in Ga North, as well as solar PV systems in Atwima Nwabiagya and analysed their potential for replication. These technologies provided clean and sustainable energy solutions to communities previously reliant on expensive, environmentally harmful fuel sources.

Despite challenges in logistics, community engagement, and regulatory barriers, the Ghana demonstration made significant strides in establishing sustainable business models, building local capacity, and validating renewable energy systems suited to Ghana's unique context. The lessons learned offer valuable insights for future energy initiatives across Africa, particularly in adapting technologies to local conditions and ensuring long-term sustainability through community ownership and tailored financing models.

The Ghana demonstration highlighted numerous opportunities for further research, including expanding financing options, fostering public-private partnerships, and integrating additional renewable energy sources. With the foundational work of the SESA project, Ghana is well-positioned to scale these renewable energy solutions, providing a blueprint for addressing energy poverty and fostering sustainable development across Africa.

5.0 Malawi

Malawi, characterized by its low rural electrification rate (below 5%) and heavy dependence on biomass for energy, was chosen as a key validation site to demonstrate the transformative potential of clean energy technologies.

In Malawi, the SESA project has focused on implementing clean cooking technologies and briquetting technology to enhance energy access and reduce environmental impact. A key initiative involves the adaptation and validation of a clean cooking stove called MIG BioCooker, to be implemented as a commercial product in the Mchinji district, in the Central Region of Malawi and other regions. The stove utilizes locally sourced biomass as sunflower briquettes and bagasse pellets to provide a sustainable and efficient cooking solution. The living lab also developed a local fuel supply chain based on manufacturing of briquettes from locally available biomass residues as sunflower stalks and saw dust to reduce deforestation. The briquettes have been sold and distributed to the households that are using the MIG BioCooker but also households with other cooking stoves.

Additionally, it focused on deploying solar PV systems integrated with solar-powered irrigation technologies and tailored to the needs of rural communities. These interventions were conducted in partnership with Smart Energy Enterprise (SEE), a local company selected through the 1st SESA Call for Entrepreneurs as part of the SESA Incubator Programme to empower smallholder farmers with affordable, loan-based solar pump solutions.

The efforts are aligned with SESA's strategic objectives (SO1-SO5), which emphasize technology deployment, capacity building, and long-term sustainability:

- **SO1: Inform** – increased awareness among rural communities about the benefits of renewable energy solutions, bridging the knowledge gap through workshops and demonstrations.
- **SO2: Inspire** – Showcase the feasibility of using clean cooking, clean fuels, solar-powered irrigation to catalyze adoption and replication by improving livelihoods and reducing deforestation.
- **SO3: Initiate** – Build local capacity through training programs, empowering communities to assemble, operate and maintain sustainable fuel production, clean cooking solutions and renewable solar systems.
- **SO4: Implement** – Deploy clean cooking solutions, scalable briquetting production and solar irrigation systems tailored to local conditions, addressing health, energy and agricultural needs in rural areas.
- **SO5: Impact** – Foster partnerships and align renewable energy with national policies to ensure long-term scalability and sustainability.

This report summarizes the implementation, challenges, lessons, and opportunities from Malawi's demonstration actions.

5.1 Problem to address

Malawi faces a dual challenge of low energy access and high environmental degradation. Approximately 90% of the population relies on unsustainably harvested biomass, contributing to deforestation and inefficient cooking stoves contributing to indoor air pollution. Simultaneously, smallholder farmers, who form the backbone of the rural economy, lack access to reliable energy sources for irrigation, limiting agricultural productivity and economic growth.

The specific challenges addressed by the SESA project are aligned with its strategic objectives:

SO1: Inform – Raising awareness of renewable energy potential

In rural households in Malawi the use of biomass for cooking is likely to persist over the near term, it is important 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 raising awareness about the environmental and health impacts of traditional cooking methods, providing access to affordable and clean cooking technologies, supporting the development of sustainable fuel supply chains, and ensuring capacity building and financial support for vulnerable communities.

In many rural communities in Malawi, renewable energy solutions such as solar-powered irrigation are poorly understood or unknown. Farmers and households often lack information about the potential of these technologies to improve productivity, reduce energy costs, and support environmental sustainability. This knowledge gap perpetuates inefficient traditional farming practices, limiting opportunities for innovation and growth.

SO2: Inspire – Fostering interest and adoption of renewable solutions

There is a lack of end-user knowledge about the health and economic impacts of traditional cookstoves, and the benefits from the use of clean cookstoves and fuel briquettes. Only a well-informed consumer will purchase the clean cookstove or fuel, and only a well-trained consumer will use the cookstove in the correct way so that the benefits can be realized.

Many community members and policymakers in Malawi view renewable energy technologies as impractical or unaffordable for rural settings. This skepticism stems from limited exposure to successful examples and a lack of trust in the reliability of new technologies. As a result, communities are hesitant to invest time and resources in adopting solar-powered systems, even when they are subsidized or loan-based.

SO3: Initiate – enabling local innovators and building capacity

The successful deployment and maintenance of renewable energy solutions require skilled personnel capable of managing installations, conducting maintenance, and troubleshooting issues. In Malawi, rural areas face a notable shortage of trained technicians and entrepreneurs. With limited local capacity, renewable energy solutions are often underutilized or fall into disrepair, threatening their long-term sustainability and impact.

SO4: Implement – overcoming co-development challenges

Logistical challenges, such as poor road infrastructure and limited access to transportation, make it difficult to collect agro-waste to the briquette production, deliver fuel briquettes to sale agents, deliver and install renewable energy equipment in rural Malawi. Furthermore, the upfront costs of clean cooking solutions, solar PV systems and irrigation technologies are beyond the financial reach of most households and smallholder farmers. Even with innovative financing options such as pay-as-you-go models, affordability remains a significant barrier to widespread adoption.

SO5: Impact – ensuring long-term sustainability and partnership-building

There is limited awareness among farmers about the value of the agro-waste as raw materials for fuel briquettes. Continuous farmer mobilization through cooperatives to enhance raw material supply and exploring all possible partnerships to stabilize supply chains is needed. Explore subsidy opportunities or partnerships to lower costs and selling price of both stoves and briquettes and develop partnerships with reliable retailers for broader distribution.

Smallholder farmers do not have access to sustainable irrigation equipment due to the high operating and upfront costs of fuel water pumps and solar pumps respectively.
Partnership with financial institutions to provide access to agricultural loans allows farmers to acquire solar pumps, while the supplier benefits from the sales and receives payments directly from the financial institutions. This can ensure financial growth and address the challenges faced by farmers

In a nutshell:
Rural electrification rate: Below 5%, one of the lowest in Africa.
Biomass dependency: 90% of households rely on firewood or charcoal for energy, contributing to deforestation.
Health risks: Access to clean fuels and technologies for clean cooking (% of population) in Malawi was reported at 1.4 % in 2022.
Deforestation: Malawi loses over 1% of its forest cover annually, driven by charcoal production and firewood use.
Agricultural productivity: Smallholder farmers, who constitute most of the rural population, face inconsistent water supplies and lack energy for irrigation, which reduces yields and perpetuates poverty cycles.

The SESA project in Malawi sought to address these interconnected challenges by deploying innovative renewable energy technologies, building local capacity, and fostering an enabling environment for sustainable energy access.

5.2 Solutions employed

The Malawi demonstration actions were implemented through a coordinated effort across work packages (WPs), with local assembling and validation of clean cooking solutions, production of sustainable fuel briquettes and integration of solar-powered irrigation solutions. The Malawi demonstration employed a multi-technology approach to address energy poverty and improve livelihoods.

Key technologies deployed included:

Solar-powered irrigation solutions:

- Solar PV systems: Deployed for community use and agricultural support, enabling reliable access to energy.
- Solar-powered irrigation: Targeted smallholder farmers, improving agricultural productivity and water management.
- 25 solar-powered irrigation systems to 46 smallholder farmers
- A digital loan and pump management system to ensure proper operation of the pumps and streamline business processes.
- Result of action: achieved a 96% loan recovery rate
- 100% increase in production from rain fed agriculture which has improved farmers levels of income.

Fuel briquetting production:

- Briquetting and shredder technology: Implemented to process sustainable biomass from agro-waste into clean-burning briquettes, offering an affordable alternative to firewood and charcoal.
- Clean cooking fuel: Targeted rural households, small businesses, and local institutions i.e schools and hospitals
- Raw material: 90 farmer clubs delivered sunflower stalks for the briquette production
- Result of action: 2 employees are working with the briquette production
- Briquettes are sold to households by 12 selling agents selling across villages surrounding the factory. 5–10 customers per seller per day
- Improved financial stability due to additional income from briquettes sales.
- 100 households use the briquettes monthly substituting firwood and charcoal

Clean cooking technologies:

- MIG BioCooker: An ISO tested (tier 4-5) biomass-based, fan-assisted clean cooking solution integrates a solar panel and using briquettes and pellets as fuel
- Assembling tools: 20 MIG BioCooker stoves assembled and distributed to 19 households for long term validation, capacity-building and awareness
- Result of action: Solar panel and power bank for lighting (torches) and phone charging. In average 2–4 hours lighting per day
- Reduced emissions of CO and PM2.5 by 80% and improved health
- Reduced cooking time by 50 %
- Financial improvements were noted by all, with 70% citing reduced fuel costs and 30% gaining more time for income activities.

Cooking with MIG BioCooker

Collecting sunflower stalks from farmers

WP1: Development of the technology basis

WP1 was essential in establishing the technology foundation specifically focusing on solar PV systems for rural agricultural use, incorporating small-scale solar pumps to support irrigation. These solutions were customized for Malawi's agricultural needs, ensuring affordability and scalability for smallholder farmers. Additionally, WP1 supported the development and validation of the **MIG BioCooker,** a biomass-based, fan-assisted clean cooking solution that integrates a solar panel and using sunflower briquettes and bagasse pellets as a sustainable alternative to traditional cooking fuels. Shredder and **briquetting technology** were also tested and installed to process agricultural residues into clean-burning fuel briquettes delivered to households in rural areas. Briquetting technology was chosen because it focuses on a wider range of biomass material and is less expensive to operate and maintain and usually demands less power than pellets technology. The disadvantage is that briquettes are larger in size and less dense compared to pellets. However, the briquetting technology that was chosen in the SESA project produces a small size of briquettes (3cmx3cm), suitable for cooking stoves.

This work package conducted detailed assessments of the technical requirements for each demonstration site as well as user needs assessments, ensuring that the chosen solutions were both locally appropriate and capable of meeting community needs.

The result from the assessment showed the need for a local production of improved cook stoves, In the assessment respondents stated that improved cookstoves are not easily accessible and there is lack of production in the local community. The result also showed the need for increased awareness and the importance of developing local fuel production to offer sustainable fuels with improved cook stoves. 84% claimed that they might still use the three-stone fires after acquiring improved cook stoves because of ease of use, and availability of firewood. Based on the survey, it was found that 32% of the respondents reported being unaware of the advantages associated with the use of improved cookstoves, particularly in terms of their ability to reduce fuel consumption and cooking time.

To prepare the stove for the market, the project team have conducted several pilot trials to gauge customers' level of acceptance and satisfaction with the new stoves and fine-tuned designs based on this feedback. To implement a local cook stove production end-user, need to be trained in operation, maintenance, and safe usage of their stoves.

A toolbox with the best approaches was launched at the SESA fourth regional event in October 2024.

WP2 focused on empowering local communities by conducting hands-on training programs for technicians, farmers, and households. These sessions emphasized the operation and maintenance of solar PV systems, irrigation technologies, briquetting technology and clean cooking solutions. For example, community members were trained to assemble, use and maintain the MIG BioCooker and solar irrigation systems, fostering local ownership and ensuring the sustainability of the deployed technologies.

Irrigation schemes management

46 Smallholder farmers from Karonga (60% males and 40% females) were trained by SEE in Irrigation schemes management. This would ensure the sustainability of the irrigation schemes cooperative and those trained carry out training in their individual clubs.

MIG Bio cooker assembly and repair

A total of 7 individuals (All males) were trained in the assembly and repair of the BioCooker, these now act as Going Green ground repair team that are scattered across communities. This created local ownership, sustainability and local jobs for community members.

Clean fuels and cooking solutions

Going Green conducts three training courses to 5,000 farmers each year. The training is in crop production, post-harvest handling, and village savings and loans after produce sales. During all these trainings, clean cooking solutions are routinely integrated into the curriculum and thus far Going Green has been able to train 5,000 people (3,703 females and 1,297 males) on clean cooking solutions.

Most community members are now fully aware of the importance of using clean cooking solutions including clean fuels that are made from Agri waste. They now appreciate the importance of storing and selling their Agri waste that would then be used for making fire briquettes. The only challenge is the availability of clean cooking solutions, which is now the focus of Going Green and Make it Green to expand the briquetting technology including Stove production.

Overall, these trainings have reached beyond the 5,000 smallholder farmers as the training models requires community members (a higher percentage being farmers as this is the main occupation in rural Malawi) to train their fellow neighbours in the communities.

BioCooker operation

Going Green trained a total of 34 people (19 males and 19 females) from 19 households on the operation and management of the MIG Bio Cooker. This training enabled local households to take ownership and master the solutions provided and increasing potential for long-term results.

Assembling MIG BioCooker

Distribution of MIG BioCooker and briquettes to households for long term validation

WP3: Business models and market solutions

WP3 introduced innovative financial mechanisms to make renewable energy solutions accessible. A loan-based model was developed for small-scale solar irrigation systems, enabling farmers to spread payments over time. Additionally, community-focused business models were implemented for production and selling of fuel briquettes, ensuring affordability and scalability for rural households. WP3 also explored market opportunities for scaling the MIG BioCooker by engaging local entrepreneurs in its production and distribution.

Business model for solar irrigation

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. The lease-to-own business model was tested through sales and distribution of 25 solar pump 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.

Business model for briquetting

A validation of the business model for sales of briquettes is ongoing. Sunflower stalks are bought from contracted sunflower growers by GG. Two people are working with briquette production. Sales are managed by GG and there are 12 sells agents currently selling briquettes across villages surrounding the factory. These agents are already in the business of selling firewood and charcoal. Going Green supplies these agents with briquettes using a motorbike, the furthest being 19 kilometers from the factory. A bag of 20 kilograms is sold to the agents, and they sell these briquettes in small quantities to households.

WP4: Demonstration, validation, and replication

WP4 was responsible for supporting and coordinating the practical deployment and testing of the solar PV system, briquetting technology and clean cooking technologies. By collecting feedback from community members, WP4 validated the systems' performance, identifying any adjustments needed for optimal functionality. These systems were validated in a living lab approach, where farmers and households provided feedback on their effectiveness, enabling iterative improvements and scalability planning.

WP5: Scale-up, finance, and policy environment

WP5 facilitated partnerships with private partners and financial institutions to support scaling renewable energy solutions. By aligning the project with local policies, WP5 helped create a policy framework that would allow for future expansions of solar irrigation systems, while supporting local innovators to seek further funding opportunities for long-term development.

A proposal has been submitted that focuses on scaling up stove manufacturing and fuel processing while expanding access to rural households, to improve health, household economies, and environmental sustainability.

WP6: Communication and dissemination

WP6 focused on raising awareness about the benefits of renewable energy and clean cooking technologies. Community workshops and outreach campaigns were organized to showcase the solar irrigation systems, MIG BioCooker, and briquette production. Success stories from early adopters were shared widely to inspire broader adoption and replication. In Malawi, the workshops and outreach campaigns were effective means to raise awareness and facilitate adoption of clean cooking solutions across the villages surrounding Going Green and beyond.

Going Green maximized already existing multiple community training in Agronomy reaching out to 5,000 direct participants. The workshops were intended to be cooperative and collaborative with local farmers who make up the highest population, technicians, and households.

Trainings related to clean cooking solutions focused on the practical aspects for effective usage and maintenance of the MIG technology, Clean cooking solutions and Agri waste to energy.

Local traditional leaders and government extension workers were behind the organisation of the trainings, mobilization of the training participants and pioneers of the capacity building sessions.

On Household Level, demonstration on how to assemble, use, and care for the stoves were included in the sessions so that participants gained the skills or confidence to independently handle the technology.

On community level, the focus was on benefits of clean cooking technologies, encouragement on the waste to energy through their harvested Sunflower stalk and awareness on the availability of briquettes in the communities

Barriers and solutions

1. Logistical barrier- The trainings were conducted in 200 villages and travelling between villages was a challenge at times

2. Local resistance to new technology- In order to address this, Going Green made use of the traditional leaders and Agricultural extension works who acted as role models in the communities and assisted in making the participants understand that the technologies have good benefits.

3. Financial barriers- Capacity building requires adequate funding in the case Malawi local context, participants for each training require transport re imbursement (bicycle taxi), food, refreshment and allowances for the traditional leaders and extension workers. The budget allocation was not foreseen and Going Green made use of existing project to combine the trainings into one.

Community reception:

The trainings were well received, and community members were eager to learn more and interest in accessing these technologies. They are now fully aware of the benefits of clean cooking solutions and dangers of using unsafe solutions to their health.

5.3 Challenges encountered

The deployment of briquetting technology, clean cooking technology, and solar powered irrigation solutions in Malawi presented several unique challenges, reflecting the realities of implementing such technologies in rural and underserved areas.

Cultural and behavioral resistance: In rural Malawi, the strong reliance on traditional biomass fuels, such as firewood and charcoal, created resistance to the adoption of new technology and fuels. Many residents were accustomed to existing energy practices and were skeptical about the reliability and long-term benefits of renewable energy solutions and more sustainable fuel options. Extensive community outreach and awareness campaigns were needed to build trust and shift perceptions.

Logistic barriers to deployment: The remote location presented logistical challenges, particularly in transporting solar equipment and materials. Poor road infrastructure and lack of reliable transport networks delayed the timely delivery and installation of solar irrigation systems, increasing costs and impacting project timelines. Smallholder farmers are widely spread, so collecting their sunflower stalks for briquette production tends to be expensive. To reduce the transportation cost mobilizing farmers to prepare their stalks at the same time as collecting sunflower grain is needed.

Access to electricity: Access to electricity is a challenge in Malawi and some parts of the year electricity are not available every day which reduces briquette production periodically. When scaling up production a solution is to have several small-scale production plants in different places. This will also decrease the collection costs of raw materials.

Inconsistent supply of raw material: Agricultural waste is only available during the growing season. There is a need to use different types of biomass waste for briquette production during the year to decrease the risks of running out of raw materials.

New fuel product on the market: 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 which increase need of stronger environmental messaging.

Financial constraints for households: For many households, even subsidized renewable energy solutions were perceived as expensive compared to their current reliance on firewood and charcoal. Limited disposable income among rural residents posed a significant challenge to adoption, necessitating the exploration of innovative financing mechanisms, such as pay-as-you-go models, to improve accessibility.

Lack of sufficient credit and financing for clean cooking solutions: In Malawi significant reductions in emissions will be needed to achieve meaningful health benefits for cookstove users. Higher-performing advanced cookstoves as the MIG BioCooker, including clean fuel options, as briquettes, have the potential to improve the efficiency and reduced emissions by 80-90%, Use of advanced materials for cookstove combustion chambers and the addition of technology to allow for increased functionality, such as the charging of batteries for cell phones or lighting, offer other values but also increases the costs.

The financing programs demand the stoves to be ISO tested and perform at a high tier level, further increasing the cost for the stoves. Lack of sufficient credit and financing for clean cookstove and fuel purchases makes it difficult for consumers to cover the high initial cost of clean cookstoves. World Bank's Energy Sector Management Assistance Program recommend support to end users to obtain improved cooking technologies and training of NGOs and local partners to increase their capacity to deliver cooking technologies in Malawi. Further the access to finance support to stove/fuel enterprises and business incubation support to small and medium-sized enterprises (SMEs), including those focused on stoves and fuels are other recommendations.

Capacity gaps in technical expertise: While the training programs provided an initial foundation for the installation of solar powered irrigation solutions, the limited availability of local technicians with advanced skills posed a challenge for system maintenance. The lack of a skilled workforce to troubleshoot issues and conduct routine maintenance risked system downtime and reduced efficiency.

Regulatory and policy misalignment: The integration of solar microgrids into Malawi's broader energy strategy faced regulatory challenges. National energy policies historically emphasized grid expansion rather than decentralized energy solutions, requiring ongoing engagement with policymakers to advocate for renewable energy initiatives.

Sustainability of community ownership: Ensuring that communities took ownership of the installed solar powered systems proved challenging. In some cases, a lack of long-term financial and technical support diminished the sense of responsibility for maintaining the systems, risking reduced system longevity and community engagement.

5.4 Lessons learned

In Malawi, the project focused on verifying a clean cooking solution through the ISO-tested (Tier 4-5) MIG BioCooker stove, powered by locally produced biomass briquettes. A local fuel supply chain was developed to produce briquettes from agricultural waste such as sunflower stalks and sawdust substituting firewood and charcoal.
Project activities included adapting and validating the MIG BioCooker, producing and distributing fuel briquettes, and building capacity through training for local technicians, farmers, and households. Loan-based business models for solar irrigation systems and community-focused models for briquette production and sales were also developed.

Results showed that the MIG BioCooker reduced CO2 and PM2.5 emissions by 80 % and halved cooking time. The use of briquettes led to economic improvements for households through reduced fuel costs and increased income for sales agents from sales of briquettes. The project highlighted the importance of community collaboration, tailored financing models, and ongoing capacity building to ensure wider adoption and long-term sustainability. Challenges such as logistical barriers, financial constraints, and the need for tailored policies were also identified. The conclusion was that renewable energy solutions hold transformative potential for rural communities by reducing energy poverty, improving health, and driving economic growth.

Community trust-building is essential: Proactive and consistent engagement with community members was crucial for overcoming skepticism. Awareness campaigns tailored to local concerns, such as Local resistance to new technology, affordability and reliability, played a pivotal role in building trust and acceptance of renewable energy solutions.
On community level, the focus was on benefits of clean cooking technologies, encouragement on the waste to energy through their harvested Sunflower stalk and awareness on the availability of briquettes in the communities. To address resistance to new technology, Going Green made use of the traditional leaders and Agricultural extension works who acted as role models in the communities and assisted in making the participants understand that the technologies have good benefits. For the solar irrigation systems SEE has established a network of highly committed Agriculture Extension and Development Coordinators (AEDCs) who also work as SEE sales agents. These AEDCs have a very good knowledge of the community, farmers' needs and can identify potential buyers.

Affordable payment models drive adoption: 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 to increase uptake of such irrigation systems. The lease-to-own business model was tested through sales and distribution of 25 solar pump irrigation

systems. The lease-to-own model for SEE is economically feasible, especially when bundled with 2 main after-sale services as 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.
Market support; which enables SEE or its partners to offtake the produce from farmers at reasonable prices thereby empowering farmers to boost their income and revenues.

Importance of user feedback and demonstration: Based on the user feedback, adjustments and improvements of the MIG BioCooker were made. Demonstrations in the field showcased stove benefits effectively. Capacity building of users on benefits of clean cooking was crucial for overcoming initial skepticism of the stove and briquettes. Demonstrations and user training-built trust.

Innovative options for financing local manufacturing are necessary: To start local manufacturing of the MIG BioCooker partnerships with local companies, it is necessary to balance local resources with imported materials to maintain lower cost. Financing is still necessary to decrease the high upfront cost. Results-based financing options, and funding through carbon credits, are a promising way for investment, but need careful project design since the project developers need to track and quantify the actual emission reductions achieved and monitor fuel usage through household surveys, fuel wood collection tracking, or charcoal purchase receipts. Stove and fuel are another business mode. This involves bundling the upfront cost of the stove with fuel costs through fuel purchase contracts. This enables consumers to reduce the high upfront cost by spreading the burden over time.

Infrastructure planning improves efficiency: The logistical challenges of transporting equipment for solar powered irrigation underscored the importance of advanced planning and partnerships with local transport providers. Establishing supply chain networks early in the project lifecycle would have mitigated delays and reduced costs. Continuous farmer mobilization through cooperatives to enhance raw material supply for briquetting production to decrease cost and develop partnerships with reliable retailers for broader distribution of briquettes. is needed.

Capacity building must be sustained: One-off training sessions, while effective initially, were insufficient for ensuring long-term system sustainability. Continuous training and the establishment of local technical support networks are essential for empowering communities to manage and maintain renewable energy systems independently. There is Limited awareness among farmers about the value of the waste materials, and it is important to mobilize and train farmers on how to collect agricultural waste for the briquette production. Consumer awareness and education regarding the health, environmental, and efficiency benefits of clean cookstoves is important to stimulate demand for clean cookstoves in rural areas. In SESA 74 percent of the trained individuals were women who serve in leadership roles at the local level in communities and farmer clubs. They played a big role in organizing and facilitating capacity-building sessions.
Women were specifically targeted as they are the primary users of clean cooking solutions, ensuring the technology is adopted and sustained at the household level.

To promote more women participation there is need for technical training for women in stove maintenance and establishing women-led cooperatives for clean cooking at grassroot level and increase access to microfinance to enable adoption of clean cooking solutions.

Policy engagement enhances scalability: Early and sustained engagement with national and regional policymakers can help align the project with Malawi's energy goals. Policy alignment not

only facilitates smoother implementation but also sets the stage for scaling renewable energy solutions across the country.
There is need to engage policy makers and senior decision makers at national level across several government department like Health, Agriculture and Forestry and conduct training on the importance of clean energy since these departments are highly affected by the effects of using unclean energy.

The kind of training needed at national level is behavior change as behavior change starts at national level and if they are made aware then the rest at grassroot level will follow.

At grassroots level, there is need to promote training in usage of clean energy solutions and business management training to retailers and maintenance personnel in the community.

Specific measures are needed to ensure sufficient budget allocation for clean energy programs at national level that would support initiatives like subsidy programs for cook stoves to ensure rapid adoption rate.

Community ownership ensures longevity: When communities were actively involved in the decision-making and management of the systems, they demonstrated greater ownership and commitment to maintaining them. This lesson highlighted the need for participatory approaches in designing and deploying renewable energy solutions.

Through traditional leaders and government extension workers, communities were involved in the capacity building of clean fuel and cooking. Firstly, we trained 200 club leaders plus traditional leaders, these training courses were done by government extension workers and supervised by Going Green. In the second phase, 200 trained leaders together with Going Green and govt extension workers each trained 25 members of their clubs making a total of 5,000 trained. 5 of the technical leaders were trained in the assembly of the stove.

This approach installs ownership of the technology because the leaders who were trained will always train and act as champions in clean cooking. It is very sustainable, unlike having an external trainer involved, which wouldn't be sustainable. It also ensures widespread information and can be easily managed through collection of signatures of all the trainees attending the sessions.
In addition, since the training was done by locals in their own communities, monitoring and evaluation of the impact would be easy as it will be easy to know how many people are using the technology including briquettes, and maintenance issues would be easily resolved through these leaders trained.

5.5 Opportunities for further research and development

The demonstration actions in Malawi highlighted several opportunities for further research and development, with a focus on improving the accessibility, scalability, and sustainability of clean cooking solutions, briquetting production and solar irrigation systems. These opportunities align with the SESA project's strategic objectives (SO1-SO5).

SO1: Inform

Enhancing awareness campaigns: Future research could explore the use of mobile technology and community radio to disseminate information about solar PV systems and their benefits. These platforms could provide tailored messaging to reach a wider audience and build trust in renewable energy. There is a need to further work with awareness campaigns about the value of the agro-waste materials for fuel production during farmers' training on crop production. Consumer awareness regarding the health, environmental and economic benefits of clean cookstoves and sustainable fuels is critical to stimulate demand for clean cookstoves.

SO2: Inspire

Scaling living lab models for broader adoption: Expanding the living lab approach to additional rural areas in Malawi could provide valuable insights into the adaptability of renewable solutions. Research into community-driven innovation hubs could inspire replication in other regions.

SO3: Initiate

Developing long-term workforce development programs: Investing in ongoing training programs and certification schemes for renewable energy technicians would ensure a steady pipeline of skilled personnel capable of supporting technology maintenance and expansion.

Exploring microfinance for rural energy access: Further research into microfinance models could help low-income households access renewable energy technologies without significant upfront costs. These models could include community-based financing or cooperatives.

Exploring carbon finance and models for stove and fuel finance: Explore scale-up funding and opportunities or partnerships to lower manufacturing costs and selling price of both stoves and briquettes.

SO4: Implement

Investigating modular system designs: Research into modular solar PV systems that can be easily transported and assembled in remote areas could improve deployment efficiency. Modular designs would reduce logistical challenges and provide flexibility for scaling.

Integration of renewable energy with agricultural practices: Future studies could explore how solar PV systems can support agricultural activities, such as powering irrigation systems, storage facilities, or processing units, to enhance rural livelihoods. Agricultural activities also provide raw materials for briquettes to be further explored.

Scale-up the briquetting production: Expand production of briquettes and deepen community engagement for proper coordination. To scale up the production demand for more electricity can be a challenge. A solution to explore is several small-scale production plants at different locations. This could also decrease the collection costs of agricultural residues.

Investigating monitoring solutions: There is a solid foundation for clean cooking in the region. Develop partnerships with local material suppliers and with reliable retailers for broader distribution. Investigating monitoring solutions for clean cookstoves enables opportunities for pay-as-you-cook financing and carbon financing.

SO5: Impact

Advocating for decentralized energy policies: Research into policy frameworks that support decentralized energy solutions could facilitate the integration of renewable energy into national strategies. This includes exploring incentives for off-grid systems and subsidies for low-income households.

Public-private partnerships for renewable energy expansion: Investigating models for public-private partnerships (PPPs) could attract investment and technical expertise to scale renewable energy solutions. These partnerships could support the sustainability of microgrids and other decentralized systems.

5.6 Conclusion

The SESA demonstration in Malawi has shown that renewable energy solutions, when carefully designed and tailored to local contexts, can address some of the most pressing challenges facing rural communities. By deploying clean cooking stoves, sustainable fuel briquettes, solar-powered irrigation systems, the project unlocked new opportunities for households by reducing their dependency on unsustainable firewood and charcoal and improving air quality when cooking. Further, it also unlocked new opportunities for smallholder farmers to enhance agricultural productivity.

These interventions have had a transformative impact on livelihoods, empowering communities to break free from the constraints of cooking poverty and energy poverty and environmental degradation.

Switching from inefficient smoky cook stoves to the cleaner MIG BioCooker has a major health, social and environmental benefits: improved air quality, reduced cooking time, reduced fuel costs and access to lighting via power banks. Producing briquettes from sunflower stalks and selling of briquettes is giving environmental and economic benefits: The production creates a sustainable fuel, local jobs and improve financial stability due to additional income from briquettes sales.

The collaboration with Smart Energy Enterprise (SEE) introduced innovative, loan-based solar irrigation solutions that were both scalable and accessible. These systems provided a lifeline for smallholder farmers, enabling them to irrigate their crops efficiently, improve yields, and secure their incomes. Additionally, the deployment of modular solar PV systems demonstrated the potential of decentralized energy solutions to support sustainable development in areas underserved by traditional grid infrastructure.

While challenges such as financial barriers, logistical issues, and policy misalignment were encountered, the project highlighted the importance of community engagement, capacity building, and tailored financing mechanisms in overcoming these obstacles. Farmers and local technicians were not only introduced to the technologies but were also trained to assemble, operate and maintain them, fostering a sense of ownership and ensuring the long-term sustainability of the solutions. The success of these capacity-building efforts underscores the critical role of local expertise in driving the adoption and replication of renewable energy solutions.

The insights gained from the Malawi demonstration provide a roadmap for scaling these solutions across other rural areas in Africa. The project emphasized the need for an integrated approach that combines technical innovation with supportive policies, strategic partnerships, and community-driven models. By aligning renewable energy interventions with national strategies and agricultural priorities, the SESA project has laid the groundwork for further expansion and institutional support.

Looking ahead, the opportunities for further research and development are abundant. From refining business models and exploring new financing mechanisms to integrating renewable energy into broader agricultural and rural development initiatives, the possibilities for growth and impact are significant. The success of the Malawi demonstration serves as a powerful example of how renewable energy solutions can act as a catalyst for social and economic transformation.

In conclusion, the SESA project in Malawi has proven that renewable energy is not just a technical solution but a pathway to creating resilient, empowered, and sustainable communities. The lessons learned here will not only inform future projects in Malawi but will also inspire broader efforts to achieve universal energy access across Africa. By continuing to innovate, engage, and collaborate, SESA and its partners can drive meaningful change, paving the way for a more equitable and sustainable energy future.

Summary

The five demonstration actions implemented under the SESA project provide notable evidence of how clean energy solutions that are both locally appropriate and inclusive can accelerate sustainable transitions across African contexts. These pilots were not limited to the deployment of technology; rather, they embraced an integrated approach that brought together elements such as community co-creation, the use of digital tools, circular economy practices, and dedicated capacity-building efforts.

Tested in Kenya, Morocco, South Africa, Ghana, and Malawi, the demonstration actions tackled varied dimensions of economic marginalization. Each country's context presented unique challenges—ranging from rural agricultural needs and energy gaps in urban townships, to youth unemployment and under-resourced communities. Despite these contextual differences, all pilots shared a strong emphasis on advancing social equity, enhancing climate resilience, and fostering long-term transformative impacts.

While the outcomes were largely positive, the implementation process was not without obstacles. Several systemic challenges were encountered along the way. These included policy and regulatory uncertainties—particularly in relation to licensing processes, subsidy structures, and local governance of energy systems. Financial barriers were also prominent, with limited access to affordable capital hindering the involvement of local entrepreneurs and the viability of cooperative ownership models. Additionally, capacity limitations persisted, especially in rural areas where technical and business development skills are often lacking. Building community trust and raising awareness required continuous engagement and clear communication, underscoring the importance of social processes alongside technical interventions.

Despite these hurdles, the pilots proved to be fertile ground for learning. The participatory nature of co-creation workshops, the establishment of living labs, and the application of open data tools helped to build trust and ensure that solutions remained relevant to local realities. A particular strength of the demonstrations was their intentional focus on women, youth, and marginalized populations—groups often excluded from traditional energy planning. Their inclusion was central to fostering innovative ecosystems that are not only effective but also equitable.

Looking ahead, the demonstration actions serve as a strong foundation for replication in other regions facing similar socio-economic and energy access challenges. The lessons learned from these pilots offer valuable guidance on how to design and implement clean energy interventions that are both technically sound and socially inclusive. Moreover, the pilots have the potential to influence policy at both local and national levels by providing concrete, context-specific evidence of what works on the ground. This can support the development of more responsive regulatory frameworks and support structures that align with community needs.

The successful implementation of these pilots also enhances their attractiveness to investors. Tangible, on-the-ground results create a persuasive case for public-private partnerships and increased access to climate finance. In this sense, the SESA demonstrations are not only technical achievements but also catalysts for mobilizing financial and institutional support.
Finally, the knowledge generated through these experiences contributes to broader learning across the continent and fosters exchange between African and European stakeholders. The pilots offer a platform for mutual capacity building and innovation sharing, helping to bridge gaps between global best practices and local realities.

In essence, the SESA pilots go beyond being mere proof-of-concept—they represent proof-of-change. They demonstrate that with the right combination of local leadership, inclusive design, and supportive ecosystems, Africa can lead the way toward a cleaner, more equitable, and more resilient energy future. This report calls on policymakers, practitioners, and researchers to draw on these experiences and join in shaping a shared vision of sustainable development for the continent and beyond.

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