InnovateUK Energy Catalyst Round 8

Project 75522

“Innovative Mobile Minigrid-scale Service and Storage for Rapid Scaling of Rural Energy Access in Kenya”

Community Site Survey And Specifications

February 2021

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SMART VILLAGES
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1. Abstract

Smart Villages Research Group and Chemolex surveyed more than 11 remote communities in Central and Western Kenya to find a suitable location for trialling of a mobile minigrid system. The Maasai Mara communities around Narok proved most promising, as these were the only ones yet to have grid connection. A primarily service-provision system was determined to be the most feasible business model, and iInterviews and focus groups were run in these communities to determine the highest priority services. From those services, the ones which a mobile minigrid could provide include a freezer, barbershop and salon, mobile charging, fridge, electric sewing machine, electric miling machine, milk cold storage, electric welding machine and security lighting.

2. Introduction

A full understanding of community characteristics and priorities is essential before beginning the design of any technology solution to ensure it meets end-users needs, will have demand and be used effectively. In January-February 2022, Chemolex and Smart Villages Research Group surveyed more than 10 communities and researched several more, to inform the design of a mobile mini-grid system, and finalise the communities in which the first prototype would be trialled. This report summarises the results of this research.

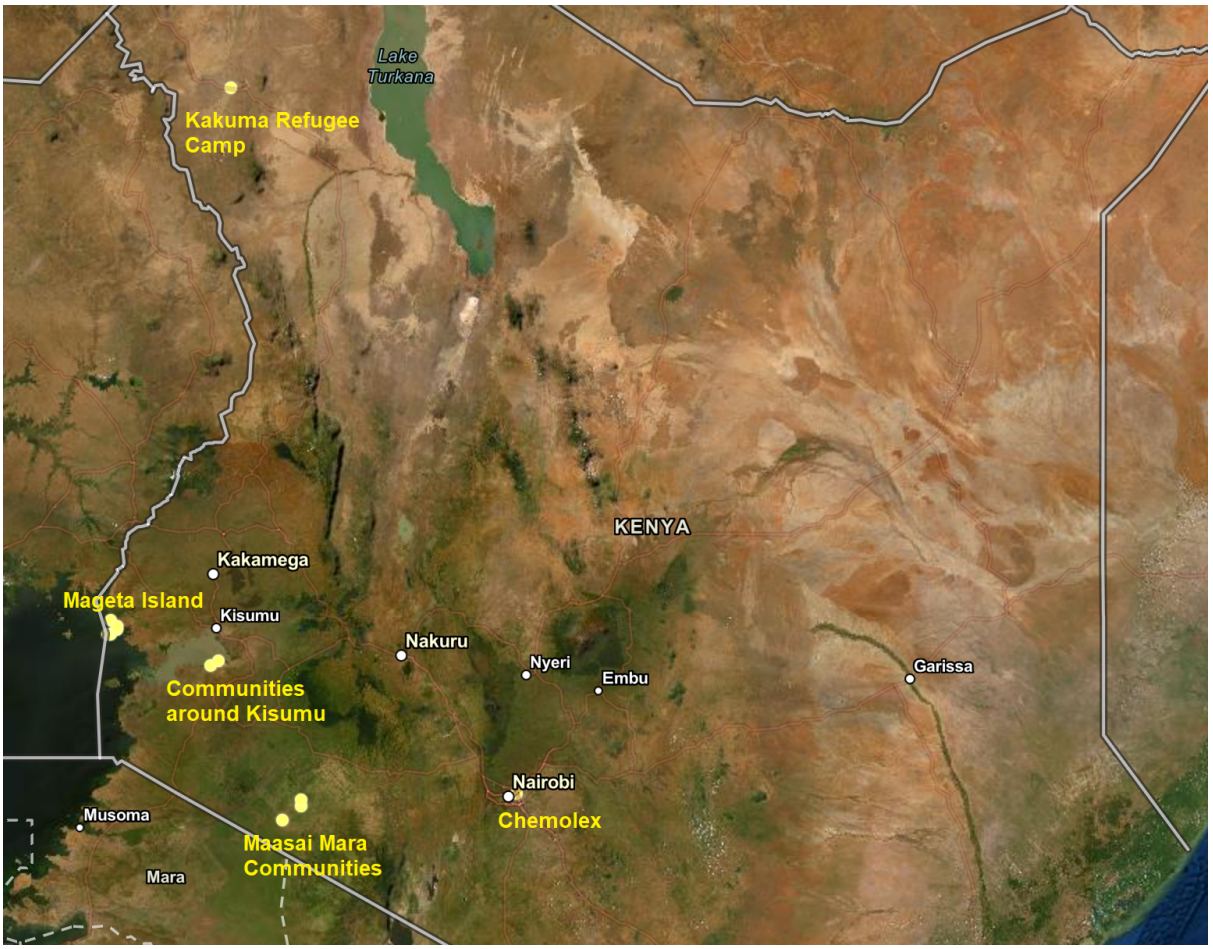
3. Target Community Characteristics

Chemolex conducted a preliminary remote review to identify potential communities for further investigation. Their selection criteria was kept broad as the exact use case of a mobile mini grid had not yet been defined. The use case would be informed by the community research findings. The selection criteria was therefore:

"Communities which could benefit from reliable energy provision on a regular basis".

This resulted in 4 groups of communities to investigate; each with a unique use-case for a mobile minigrid.

1. Maasai communities around Narok, Tanzania/Kenya border
    a. Approx 5 hours drive from Nairobi, within the Maasai Mara conservatory
2. Communities around Kisumu, Western Kenya
    a. Approx 9 hours drive from Nairobi (or 45 min flight)
3. Mageta Island, Lake Victoria
    a. 9 hour drive from Nairobi (or 45 min flight) + 1 hour ferry from the mainland
4. Kakuma Refugee camp, North West Kenya
    a. Approx 14 hours drive from Nairobi



Although power provision for events on a mobile basis around a refugee camp is an interesting use case, the long travel distance from Chemolex's base in Nairobi would make development difficult. Kakuma was therefore declared out of scope for this project, but an interesting case to investigate once the technology has been proven to work. They have high power demand for events (on a periodic basis) with lots of businesses and economic activity which is promising for financial viability. Neighbouring villages such as Kalobeyei are also not yet grid connected and could equally benefit from services.

As many of the Chemolex team are from Western Kenya, it was felt that monitoring projects there would not be infeasible despite the long journey times.

4. Community Site Survey Results

Three KoBo surveys were designed for each community visit to ensure a thorough understanding of the community characteristics, land availability, and productive uses.
The scoping visits illustrated that of the 3 surveyed community clusters, only the Maasai Mara communities would be suitable for mobile minigrid development. Almost all community centres have been grid connected through Kenya's last mile connectivity project, and grid connected communities, however unreliable their connection may be, are unlikely to have any demand for periodic mobile energy/service provision.

Although this may make the business prospects of a mobile minigrid seem slim, once the technology has been developed, there is huge potential for deployment in other countries with a lower electrification rate, such as Tanzania, where there are many more communities with characteristics matching those of the Maasai Mara in Kenya. From prior work in the region, we also know that these communities already have a weekly market structure which would make a mobile system ideal for enhancing services on market days. The technology can also be adapted on a smaller scale for travelling businessmen who need power on a mobile basis for

events/machinery at new sites. These different use cases will be examined in more depth in the Mobile Minigrid Use Case Report.

Scoping visit findings are summarised in the following sections.

4.1 Maasai Mara Communities

These communities are generally quite small and not yet grid connected. In the more developed centres, shops could benefit from higher power provision whilst in the less developed centres, community members could benefit from provision of powered services. The region is fast growing as a tourist destination, with 2 larger centres - Talek and Oleseres - one of which is served by an expensive solar minigrid.

The remoteness of the communities within conservatory grounds contributes to their lack of grid connection, but also requires a high entry fee for foreign tourists (up to $200 per person). This proved challenging during initial scoping visits, but it is believed these fees should be avoidable once a site has been finalised and research grants obtained. Alternate routes exist to reach each site, avoiding any entry guards, though these routes may add time, and due to river crossings may be impassible during the rainy season.

All communities are accessible via dirt tracks. Although these may be bumpy, they should be navigable by a mobile minigrid. There are no river crossings between villages so the minigrid should be able to operate effectively throughout the rainy season. Four main communities were scoped, each at a different stage of development. None of the villages have a fixed market day, although larger communities before entering the Maasai Mara have a market day on Thursdays which results in lower business in communities within the Mara on that day. Business is consistent but slow throughout the week.

Village Name	Oleseres	Talek	Mbitin	Endoinyo Erinka/Ole Orok
Estimated number of businesses	50	500	10	7
Estimated number of businesses currently using electricity (including weak solar lights)	20	300	2	0
Schools/Medical centres that could benefit?	Yes - Health centre has limited power so does not operate all the time	Yes	Yes, though inhabitants say the school has solar and doesn't need	No

			more	
Number of surrounding villages that use services here	3	5	2	0
Grid Electrification Status	Not connected. Many shop owners have small solar lights/plugs (M-Kopa), though it is unaffordable for some. Unlikely to be grid connected soon as there is not enough demand.	Not yet connected, though KPLC are preparing to connect them in the next few months. Expensive solar minigrid currently in operation - Talek power. ($1/kWh) Likely to run into conflict with these two providers if we bring a minigrid here	Not connected and unlikely to be connected soon due to small size and demand.	Not connected and unlikely to be connected soon due to small size and demand
Estimated village population	800	8000	200	100
Main livelihoods	Shops, Bodaboda, Small businesses	Small businesses, Tourism (guides for people doing safari)	Some small businesses, though mostly rely on services from nearest town - Oleseres	
Average level of Education	Good level of English spoken by many shopkeepers. Some older community members speak only kimaasai	Two high schools. Most people running shops are illiterate. Community is exposed to swahili and english tourists regularly so language skills are generally higher that average.	Most people speak only Kimaasai	Most people speak only Kimaasai
Underlying social needs	Water, Electricity, Healthcare	Water-There is only one public and one private borehole and they produce salty water. Lorries	Water	

		need to deliver fresh water.		

4.1.1 Talek

Due to the existing energy solar minigrid, and imminent presence of grid electrification, this site was deemed unsuitable for further investigation, despite having a clear market for more affordable energy. Our technology will not be developed before the grid is deployed, and if implemented, we would be unable to compete with either the grid's low prices, or the continuous reliable operation of the fixed solar minigrid (due to the travelling component of the minigrid).

4.1.2 Oleseres

This small village has shops clustered around a large, open, central square - ideal for mobile minigrid deployment. Most shops already have some form of weak electrification through M-Kopa/ D-light, though there is clear demand for an improvement to this service that can provide lighting later into the night as the batteries rarely last for long. Businesses shut between 5-9pm depending on the reliability of their power source, though some customers from further away leave early due to the lack of security lighting when returning home. Many businesses have more customers directly as a result of the seasons (e.g. milling) whilst others are indirectly affected as people generally have better spending power in the rainy season.

Due to the central square layout, it may be possible for the mobile minigrid to distribute electricity to existing shops around the centre, though the added complexity and hazards of temporary extension cabling mean that a battery charging and rental model would be preferred. In either case, shops would need to install new, compatible equipment, which may result in poor uptake.

A technically easier solution would be to use the mobile minigrid to provide services. The village already has most productive use services that they need, although there is desire for these to be more affordable and reliable (diesel-run milling machines and welding equipment is expensive and dependent on the ability to transport diesel through the rainy season). There is also demand for a fridge for cold drinks and cold milk

storage facilities to keep produce fresh for sale to Ongalale village. Services needs are examined in more detail in the 'Community Needs and Preferences - Field Work Results Report for Maasai Mara Communities'.

Key information from the productive use surveys conducted is summarised in the following table. This survey was conducted to get an overview of current energy costs and what would be affordable to the community. It also allows exploration of how a mobile minigrid could fit in or improve upon existing powered services. Questions which were not answered are marked with an 'x'.

Service Description	**Power status**	**Price of service**	**Technical information**	**Additional services that would run if had better power**	**Is 60 KES/kWh affordable?**	**Running costs of current power supply**
Evening Bar	Solar + Battery	x	x	Selling cold beer Playing music & TV	Yes	None as solar is owned
Agri inputs shop with light	Solar + Battery	x	x	Fridge for animal medication	Yes	MKOPA charges 50 ksh/day
TV, light + phone charging	Solar + Battery	x	x	Fridge, charging phones commercially	Yes if there is business	Bought outright (not using m-kopa) 15,000 ksh for solar, 7500 ksh for battery and 3000 ksh for inverter.
Maize mill	Diesel Genset	20 KSH per 2KGs	7.4 kW machine	De-husking machine. Switch to electric milling machine	x	300 kg of maize milling uses 3L of diesel. Diesel costs 150 ksh/litre. They buy it locally. In the high season, the quantity of maize milled is doubled.
Water pumping	Solar + Battery	x	200W (two panels)	Can't increase service provision until have a deeper pipe and more powerful pump.	x	None as solar is owned
Clothes shop + Phone charging	Solar + Battery	x	Small solar panel 100W and battery for radio,	Improved phone charging. Salon	Yes if there is business and	100kes per day for solar panel rent

			lights.		security	
General shop + coca cola fridge	Solar + Battery	Average cost 50KES	D lights and solar panel for fridge	An additional fridge	40 kes would be more affordable	None as solar is owned
Motorbike cleaning water pump	Diesel Genset	Charges 300KES per bike to clean, and cleans 2-50 motorbikes per day	Small diesel pressure washer	x	x	Approx 3000kes per day for petrol

4.1.3 Mbitin

This small community currently has very few shops so would benefit from service provision by a mobile minigrid, over direct electricity provision. Community members are unlikely to have sufficient start-up capital to benefit from electricity provision as they would need to buy significant amounts of new equipment.

Only one shop was clearly in operation with existing power provision during our scoping visit. This salon charged 100 KES per person, 50 KES per child, and was open daily from 7am-6pm. He has customers from Oleseres and other surrounding villages, and had to pay a 70,000 KES set-up fee for the solar powering the salon. As a side business, he also runs phone charging. The popularity of his shop (up to 50 people a day), shows that although the village centre is small, there is high demand.

A service value test (focus group) was conducted in Mbitin which illustrated the key demands were for security lighting, clean water, a hospital with a secure medicine supply, an improved road, mobile network, fridge and freezer, female hair salon, another barker shop, and a school. Services needs are examined in more detail in the ‘Community Needs and Preferences - Field Work Results Report for Maasai Mara Communities’ [1].

4.1.4 Endoinyo Erinka

This community is the smallest of the Maasai Mara communities visited. It had only a few buildings and was seemingly deserted when visited by Chemolex. The buildings indicate there could be a significant community present but it is likely due to the nomadic nature of the Maasai, they may only frequent the centre during certain seasons.

The route to reach the village was extremely difficult to navigate due to the poor roads, and it may not be possible to tow a mobile minigrid all the way to the centre of the community. From their initial scoping visit, Chemolex do not feel this site will generate enough business to be suitable for the mobile minigrid.

4.2 Communities around Kisumu, Western Kenya

This collection of fishing villages around Lake Victoria was initially selected as it was thought the more developed centres would result in more business for a mobile minigrid and therefore better financial returns. Two groups were examined, those near Mageta island, and those nearer Kisumu and Homa Bay. Although the village centres were all grid connected, the electricity provision is poor with frequent power cuts, making it difficult for shops to operate continuously and reliably. It was believed that these power cuts occurred predictably each week and to different areas, providing a good opportunity for a mobile minigrid to visit on the days when the existing power was down. The towns also have regular market days, which a mobile minigrid could tap into, optimising visits for days with maximum business. Key services demanded by the fishing communities include charging batteries for fishing boats (for which a service did exist at Usenge), and ice production for cold storage of fish (fishermen currently have to travel to neighbouring larger towns to buy ice each morning).

Unfortunately, the scoping visits illustrated that developed centres tended to be highly clustered with no space for a mobile minigrid. This would make distributing energy to existing shops highly impractical, technically challenging and out of the project scope. In addition, the power cuts also proved to be unpredictable - sometimes lasting weeks, sometimes days. This would make a service provision model difficult to implement effectively, as it would be impossible to plan visits for when other shops lacked power, and any services provided would be competing with existing, more centrally located and trusted, businesses. Due to the grid connectivity, schools and health centres are unlikely to benefit from, or want to pay for, energy from a mobile minigrid.

For these reasons, it was decided not to proceed with needs assessments and mobile minigrid development in these communities. The results of the scoping visits are summarised below, for completeness. Two additional small fishing communities were visited around Homa Bay, but one was within 200m of a grid connected centre, and the other was already grid connected. Their characteristics were very similar to those of Osieko, though both were slightly smaller in size.

Village Name	**Usenge**	**Osieko**	**Uhanya**
Access	Good tarmac roads	Good dirt road	Good tarmac road
Market Day	Sundays	Monday	Monday and Thursday
Estimated number of	600	40	600

businesses			
Estimated number of businesses currently using electricity (even if just weak solar lights)	600	10	600
Estimated village population	14000	800	40000
Underlying social needs	1. Fresh water from lake needs purification 2. Flooding - forces people to leave their homes/shops 3. Lots of people come from Uganda, as close to the border, but they are not treated equally 4. Over-reliance on the lake for business - more sources of income needed for when fishing outputs are poor 5.High school fees lead to school dropouts (especially for girls) when business is poor		

Osieko

Uhanya

The only open space near the village centre in Osieko was the playing field, which would not be practical for service provision or energy distribution

4.3 Mageta Island, Lake Victoria

This 5km-length island was chosen due to its medium size, and remote location meaning that grid electrification was unlikely to occur. The thriving fishing community meant there would be several commercial centres which could benefit from power or service provision, and people have spending power to make the business model viable. There are 5 schools on the island, mostly using solar power.

The scoping visit demonstrated that although most businesses have already invested in solar systems (M-Kopa) these are unreliable on cloudy days, sometimes without power for a month in rainy seasons, and only lasting 1 hour into the evening due to poor battery capacity. Community members were apprehensive as to the usefulness of a solar mobile minigrid system as their greatest priority was for a reliable continuous power supply, not a periodic supply. People were concerned that if they signed up to a periodic minigrid system, they would not get connected to other more permanent grids in the future.

Further investigation led to the discovery of a World Bank project in collaboration with Kenya Power, aiming to connect the entire island to a solar minigrid by the end of March 2022. This would remove any demand for a mobile minigrid. The service value test conducted in the village also highlighted how the communities priorities

do not currently relate to electrified services, except in the case of increased reliability, which a mobile system could not provide [2]. A summary of findings is included below for completeness:

Population Demographics

- 10,000 registered to vote, probably another 3000 children/unregistered.
- Lots of people from mainland come to stay and rent during the week to do fishing businesses - they would also benefit from shops and services
- The local economy is heavily dependent on fishing industries

Accessibility

- 1 hour's boat ride from the mainland port at Usenge, though only small fishing boats depart from there. Larger ferries operate from a port on the other side of the island - Mbita
- A good dirt road runs the length of the island, connecting fishing communities
- Community centres and housing areas are densely packed so a minigrid couldn't be set up in the centre. It would need to be parked at the edge of the shopping/housing area.

Service needs

- People need fridges for fish storage at market. People fish in the day and put in ice boxes to sell in the morning (6-7am).
- They want freezers, as current freezers are not cost effective to run: They require 15 litres of diesel at 140 KSH for 8-11 hours
- Saturday and Sunday churches use a lot of power for sound equipment
- Reliable lighting: M-Kopa small battery systems do not last into the night
- Welding machine: Insufficient power to operate a machine at present

5. Community-based design specification

This design specification is tailored to implementation of a mobile minigrid system in the Maasai Mara Communities. For more developed communities, an energy provision model is preferred, though this would be more complex to implement effectively. For less developed communities with few in-operation businesses, a service provision model would be preferred. The system should be designed to provide benefits for both.

5.1 Service Provision

In-demand services were identified through service-value tests (explained in detail in a separate report [1]), and community interviews. This section summarises the services suggested and whether they should be included in a mobile minigrid:

High Priority
The following services should be implemented due to high demand and good economic returns:

- Freezer
- Barber for Men
- Mobile Charging
- Fridge for Drinks
- Electric Sewing Machine
- Electric milling machine
- Milk Cold Storage

Medium Priority
The following services were requested by the community, and bring high economic returns, but will be harder to implement due to their high power consumption.

- Electric welding machine
- Salon for Women

Low priority
These services have little to no economic return and are hard to implement so should not be prioritised.
- Security lighting

Out of Scope
These services were suggested by the communities but have no electrical infrastructure component and so are out of the scope of this project:
- Clean Water
- Hospital and Medicine
- Improved Road
- Business Training
- Mobile Network
- School
- Market for livestock

Additional Services
These services were not directly suggested by the community but it is believed they could give good returns.
- Printer/photocopier
- Juicer
- Battery charging
- Pressure washer
- Ice machine

To run multiple services in parallel, operators from the villages may be required. The cost of an operator will vary depending on the skill level required. To reduce complexity, only the high power, expensive services will be provided with the mobile minigrid, which community members would otherwise be unlikely to be able to buy or access. Cheaper services requiring significant time, skill and supplies, such as a barbershop and salon, would be left to the community to set up on the days the minigrid is present, or using batteries. For simple services like phone charging and printing, these could easily be incorporated without the need for additional operators.

The cost charged for services must be in line with community expectations and current market prices.

5.2 Energy Provision

Temporary energy distribution to surrounding shops will be difficult to implement, both from a safety and cost perspective. For this reason, we have decided not to include wired distribution as an option, unless shop owners choose to relocate their machinery/shop directly next to the solar minigrid during operation, or are within 50m of the grid (on a case-by-case basis). Instead we will run a battery rental business. Users must have their wiring verified before battery rental is permitted, and misuse will result in removal of the system. Community members can also bring their own batteries to charge.

Research shows that people in the Maasai communities are used to paying between 55 to 100 KES a day for all-inclusive solar phone charging and light systems. For larger systems including a TV, people pay up to 140 KES a day for a solar home system. Across the country, KPLC may charge between 17 - 30 KES/kWh for grid connections, with lower prices for rural locations. Solar minigrids may charge around 60 KES/kWh to cover their costs (in Talek they charge even higher - 70 KES/kWh, with a connection cost of 13,000 KES).

5.3 Business Model Development

During the next quarter of the project, further research will be conducted to finalise the initial business models for both energy and service provision, which will be implemented when the mobile minigrid is first deployed. These are likely to be adapted whilst in operation based on new findings, and demand.

6.0 References

[1] Community Needs and Preferences - Field Work Results Report for Maasai Mara Communities 2022-03-26
[2] Service Value Test: Analysis for Mageta Island 2022-03-26