ACELERON

Exploring the opportunitites and impact of sustainable batteries in East Africa

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This project was funded with UK aid from the UK government

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Shell Foundation

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Transforming Energy Access

INTRODUCTION

Battery usage across the African continent has been increasing in recent years, which has contributed significantly to the rise of electricity access in Africa from 25% to 47% of the population.[1] However, key challenges still need to be addressed in order to serve the remaining 600 million people who lack access to electricity such as high costs, the large amount of waste created when batteries reach their end of life and in some cases, reaching it much earlier than expected, which increases the overall cost of ownership of the battery and reduces the reliability of the solution. In order to address the "energy trilemma", all battery solutions must find a balance between sustainability, reliability and affordability.

Aceleron has taken on the challenges of improving access to services for rural Africans by reducing the cost of ownership of e-mobility for taxi-driving and by ensuring consistent access to energy for productive use through the use of novel mini-grids. Specifically, our partnership with technology integrators has allowed us to create innovative solutions which integrate Aceleron batteries into e-mobility vehicles and mini-grids, effectively addressing these challenges. In the e-mobility sector, Aceleron has demonstrated how their repurposed/second-life batteries can be used to affordably power rural communities' transportation needs and how the technology can be used in higher-powered applications to power two-wheeler (boda-boda style) taxis, typically used in urban areas. Aceleron's mini-grid projects have demonstrated the success of an innovative battery which can be linked together to increase the project's capacity and power outputs, as well as the success of an advanced data communication functionality to allow remote monitoring of the battery data, providing customers with reliable energy.

This report was produced by Aceleron, based on desk-based research as well as data collected while working with our collaboration partners across Africa. This report has synthesised findings from our partners, such as the Kisii Smart Community which were produced through their interviews with the local community they serve. This report was commissioned by Aceleron and the Shell Foundation, co-funded by UK aid from the UK Government, as part of the Transforming Energy Access platform. The objective of the research was to test the feasibility of second-life battery packs in larger standalone productive use and mini-grid settings. The findings outlined in this report provide promising data to confirm second-life batteries are feasible in these settings and can provide benefits to local people.

1. https://medium.com/batterybits/challenges-of-the-battery-industry-in-africa-solutions-e2a17a48966a

ABOUT ACELERON

Aceleron is an award-winning clean technology company started when co-founders Dr. Amrit Chandan and Carlton Cummins dismantled and tested hundreds of battery packs and realised that batteries were not designed to be maintained. Anticipating a future with tonnes of unnecessary battery waste and a lack of energy access in many parts of the world, they designed a technology platform for energy storage which was built with sustainability in mind. Based on this technology platform, Aceleron has developed the world's most sustainable lithium battery packs in a full circular economy approach so that they are maintainable, upgradable and recyclable. Aceleron is empowering global communities by increasing access to energy storage solutions.

Imagine you are driving down a road and your car breaks down, you wouldn't throw it in the bin, would you? Instead, because you recognise the vehicles' value, you would get it serviced. So why don't we do this with lithium batteries? Typical lithium ion battery packs, are manufactured through permanent assembly methods using welding and glues to keep the many internal parts together. This is a quick and reliable format to producing battery packs, though it does not consider what happens to the batteries once they reach their end-of-life. The Aceleron battery design specifically addresses this, as the patented design utilises compression, to create a non-permanent manufacturing method. This enables the battery packs to be serviced and maintained throughout their lives, by opening them up and easily replacing broken parts, effectively extending their lifetimes indefinitely. The battery pack design directly stops needless waste or recycling before the product is ready, increasing sustainability of batteries and reducing their negative impact on the environment.

Aceleron has been working extensively in Kenya since 2018 and has since expanded into Uganda and Sierra Leone to increase access to energy in these countries. The company's efforts have focused on utilising their innovative batteries in two key areas: e-mobility and mini-grids. In the e-mobility sector, Aceleron has conducted two pilot projects, one in Kenya focused on small three-wheel vehicles and battery systems which can be swapped out for charging or repair and the other in Uganda on two-wheelers. Meanwhile, in the mini-grids sector, Aceleron has also conducted two pilot projects, one in Sierra Leone focused on a scalable mini-grid and another in Kenya on a mobile mini-grid capable of transporting the energy to new locations. This report aims to provide an overview of Aceleron's efforts in increasing access to energy in these regions, focusing on the impact of their sustainable battery solutions in e-mobility and mini-grids.

USE CASE 01

The combined solution of the sustainable Aceleron batteries with the three-wheeled vehicles has allowed a complete reduction in cost of logistics to local farmers

HOW ACELERON BATTERY USE CAN IMPROVE ACCESS TO SERVICES FOR RURAL AFRICANS

Implementation of Aceleron batteries into e-mobility vehicles in Kenya has proven sustainable batteries can be successfully used to improve access to services for rural Africans. Aceleron batteries are now being used by the Kisii Smart Community in Kenya to power light e-vehicles (three-wheelers), enabling farmers and rural communities to access opportunities not previously available to them, such as transporting goods on market day. Our partners the Kisii Smart Community completed extensive research with the local community and the hundreds of farmers they work with to understand the benefits and impacts of the solution.[2]

Figure 1: Typical use of three-wheel vehicles (Source: Aceleron Ltd, 2022)

2. https://ke.linkedin.com/company/kisiisc

The research concluded that the combined solution of the sustainable Aceleron batteries with the three-wheeled vehicles has allowed a complete reduction in cost of logistics to local farmers. Previously, without this solution, logistics for getting their goods to market was prohibitive and meant that frequently local farmers would have to use the goods for their own consumption or accept far below market price which could be obtained closer to home, providing the farmers with an uplift in their income. Further impact has been achieved by working with other small companies who can benefit from logistics, such as companies in dairy farming, one of whom reported sales growth from 10 (before the intervention) to 300 litres daily after the use of the three-wheelers with Aceleron batteries. Without the Aceleron powered three-wheel solution, the companies were limited to serving their local area and by utilising the sustainable three-wheeler, they were able to increase their geographical reach and increase their sales revenues.

Aceleron batteries were installed into fifteen new vehicles through a pilot project in 2022 to assess their ability to power the vehicles reliably. Training was provided to staff in the Kisii smart community by Aceleron employees to ensure safe usage of the batteries when charging and swapping batteries between vehicles. The images above show typical uses of the vehicles, and their potential cargo, including milk and agricultural goods.

The pilot project was successful and resulted in a strong relationship with Aceleron's partner, the Kisii Smart Community. A further 100 packs are expected to be delivered in Q3 2023 to be rolled out to 25 more vehicles. The main lessons from this pilot focused on how the packs could be optimally used. For example, battery swapping which can be used to prevent the downtime of the vehicle during battery charging by swapping depleted batteries with freshly charged packs, should be completed in as little time as possible to compete with traditional fuel refilling, such as petrol.[3] However, in some cases due to the location of the batteries in the vehicle and the difficulty to access them when cargo was in place, 30 minutes were needed to swap the batteries. In changing the location of the packs, whilst still considering safety, this time was reduced to less than 10 minutes. Furthermore, Aceleron provided local support, through its engineers who both installed the initial battery packs and provided servicing for when they were in use. This resulted in optimising their use and ensuring reliability, which likely would not have occurred if the partners had used a battery pack from a large manufacturer, who are not able to provide this type of hands-on support.

3. https://www.wired.co.uk/article/battery-swapping-tech-gives-electric-motorcycles-an-edge

USE CASE 02

If the battery can be treated as an asset, rather than as a consumable, the owner is able to realise the residual value which generates more lifetime value from the battery

HOW ACELERON BATTERY PACKS CAN REDUCE THE COST OF OWNERSHIP FOR THE END USER

Our research has shown that Aceleron batteries are able to reduce the cost of ownership for end users. We know that the light e-mobility market including e-motorbikes and e-three-wheelers are often powered by cheap and short-life lead-acid batteries.[4] It is expected as this market develops that faster charging and more efficient lithium batteries will begin to dominate. However, the big challenges that remain with these types of battery packs are their typically high cost and the difficulty in recycling or reusing them.[5] Aceleron are working with an e-mobility partner to tackle this problem. They have a PayGo rental model for e-motorbikes used as taxis in Uganda. Their model involves the rental of a robust e-motorbike which is designed for easy use. If the battery can be treated as an asset, rather than as a consumable, the owner is able to realise the residual value which generates more lifetime value from the battery compared with a traditional battery assembly methods.

The table below shows an illustrative example of the additional value generated over a battery life cycle when using Aceleron batteries compared to traditional batteries.

	Spot-welded assembly	Aceleron assembly
New (first) usage	72V 36Ah battery **e-2/wheeler for taxis**	72V 36Ah battery **e-2/wheeler for taxis**
Cycles used in application	1,000 cycles	1,000 cycles
Range provided	135 km	135 km
Serviceable	NO	YES
Second usage	Module sold to 3rd party for another use	72V 30Ah battery **e-3/wheeler for logistics*** **there would be multiple modules in this application; thus, it would not be as strenuous on an individual module as a 2-wheeler application*
Cycles used in application	N/A	500 cycles
Range provided	N/A	100 km
Recycling	YES	YES

Table 1: Product Life cycle

Please note:
- The figures quoted are based on Aceleron current costs/prices and information from our supply chain.
- It is assumed the volume pricing is the same in both cases to create a like-for-like comparison.
- It is assumed that the cells are capable of 1,000 cycles in an e-mobility application, and another 500 cycles in a lower power/capacity application.
- Aceleron would be able to sell the battery as a 72V 36Ah battery in the first instance, and once serviced, the serviced battery could be sold as a 72V 30Ah battery (based on lab testing done by Aceleron).

4. https://www.mordorintelligence.com/industry-reports/e-bike-battery-pack-market
5. https://www.sciencedirect.com/science/article/pii/S2451929421004757

Based on the above scenario, the costs are shown below:

	Spot-welded assembly ($/kWh)	Aceleron assembly ($/kWh)
New cell sale price **New cell cost**	184.78 (161.50)	184.78 (161.50)
1st Margin on cells	23.28	23.28
'Reused' cell sale price** **'Reused' cell processing cost**	10.00 –	123.16 (20.00)
2nd Margin on cells	–	103.16
Recycling cost	(17.19)	(17.19)
Total value	**16.08**	**109.24**

Table 2: Costs of spot-welded assembly versus Aceleron assembly

**Current cell pricing for standard and lower performance cells has been used to give an indication for the price dynamics between both New Cell Sale Prices and Reused Cell Sale Prices.

Cell Parameters	Cell Cycles	Cell Price (per cell)
3.2V 3.6Ah	2,000	$1.86
3.2V 3.6Ah	1,200	$1.64

Table 3: Cell price comparison

What becomes clear from *Table 2* is that the total value of an Aceleron assembly technology ($109.24) is almost 7 times greater than the value from the spot-welded assembly ($16.08). This is because the cells from the spot-welded assembly cannot be reused and therefore do not have further value. *Table 3* above shows a comparison of costs provided through quotes from suppliers which have been used for the calculations in the tables previously.

By working with customers to not only use batteries in their first life but to reuse them and employ them in a second scenario, we can reduce the overall costs of the pack for the partner company and can even provide new revenue streams for them. In the case of rental models such as those e-mobility companies frequently employ, a smaller monthly sum can be charged to the end user, making the system more affordable and therefore accessible to more people.

USE CASE 03

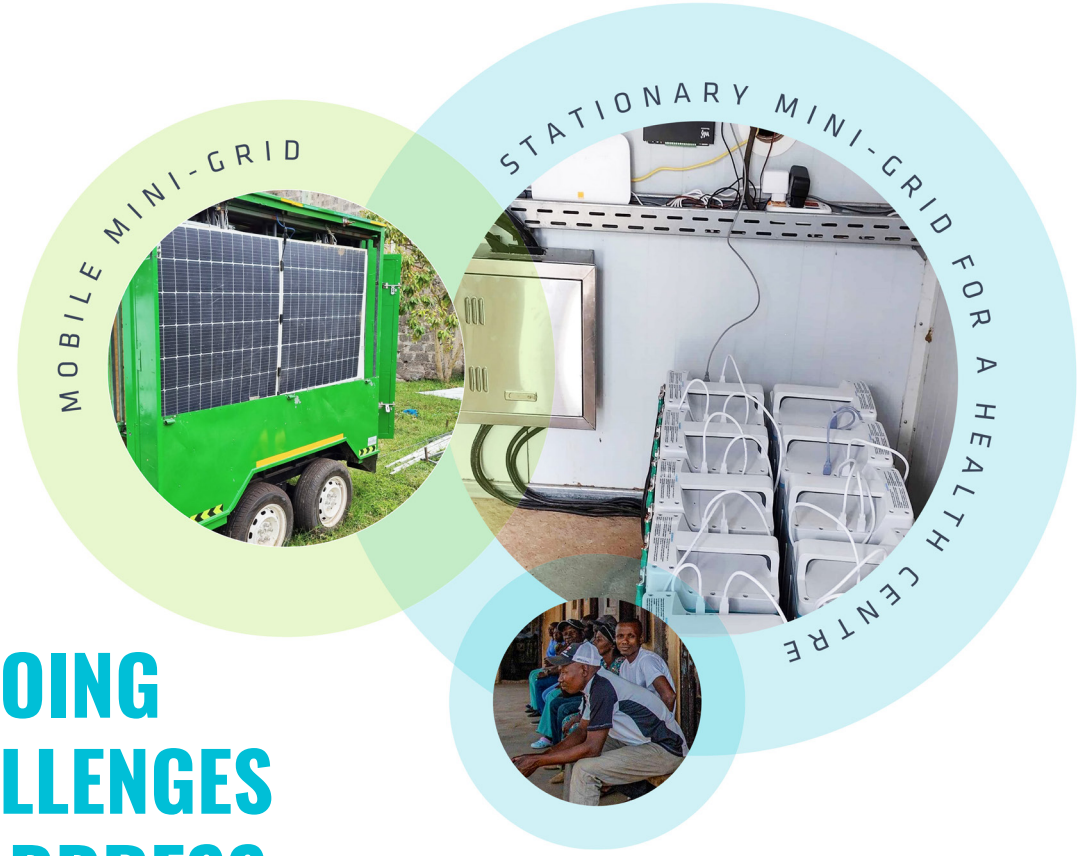
A communications device and supporting software allows for remote monitoring and data collection of the mini-grid system

HOW ACELERON CAN PROVIDE CONSISTENT ACCESS TO ENERGY FOR PRODUCTIVE USE

In addition to working in the e-mobility sector, Aceleron also works toward scaling up and making mini-grids sustainable and profitable in order to promote consistent access to energy for productive use. Research shows that the best model for mini-grid installation is to install a smaller mini-grid which can be increased in size once the energy use increases by local people; this increase is typically created through productive use.[6] This scale-up technique is difficult because lead-acid batteries power 66% of mini-grids in Sub-Saharan Africa and can be difficult to upgrade or scale without replacing the entire grid, which has large cost implications.[7] Additionally, mini-grids can struggle to provide access to higher loads (more than 10 kWp) which are required for some larger productive use equipment, such as flour milling and welding, which are typically used intermittently.

To address these challenges, Aceleron has developed a communications device and supporting software to allow for remote monitoring and data collection of the mini-grid system whilst it is in the field.[8] This is a critical factor in the creation of business plans for systems, as it allows operators to record and analyse exactly when the energy from the mini-grid has been used to establish who to charge and how much. The use of Aceleron batteries in such a system can bring huge benefits to the operator by having the reliability of a battery that is high-performance and capable of being maintained easily within the field without the need for specialist equipment, allowing the mobile mini-grid to resist breakdown and continue working to successfully provide reliable, sustainable access to energy for significant productive use. This solution can also be used for typical mini-grids which are not built to be mobile ("static mini-grids"), in order to ensure consistent access to the mini-grid, by preventing breakdowns of the battery pack and therefore the mini-grid. Using second-life battery packs combined with the communications device in both mobile and static mini-grids can provide a sustainable, reliable energy solution.

6. https://www.usaid.gov/energy/mini-grids/technical-design/key-steps
7. https://www.frontiersin.org/articles/10.3389/fenrg.2022.1089025/full
8. As the project is still in its infancy, proof of reduced down time has yet to be seen from the installation and is therefore currently still an assumption.



ONGOING CHALLENGES TO ADDRESS

Remaining challenges as evidenced by Aceleron's demonstration pilots in Sierra Leone and Kenya include the ability to ship second-life cells and packs across borders. This barrier has added cost and increased timeframes for delivery and has been identified as a key area for improvement. Aceleron is currently working with a consultant to improve its ability to ship second-life cells across borders, particularly in East Africa, which is where most of its operations currently lie. Aceleron is also working with the UK government to explore methods to improve access to second-life packs and aim to work with standards bodies, in the hope that once standards are in place for second-life cells, it will increase the confidence of logistics companies in the technology.

Additionally, to promote battery swapping as a sustainable model for the electrification of transportation and responsible waste management in rural areas across Africa, additional efforts are needed to encourage more of the communities to adopt electric vehicles (EVs) in this manner. This will require the commitment of technology integrators to increase sales in the region and promote positive marketing around electric vehicles. In particular, charging infrastructure must be developed first, as demonstrated in other areas of the globe where EVs have been taken up. Multifaceted projects from development stakeholders are required to ensure communities feel the full benefit of this technology. Aceleron continues to implement pilot projects and conduct case studies to increase its research and development (R&D) efforts, as well as design projects with wholistic project teams to ensure the communities themselves are consulted.

CONCLUSION

Aceleron's mission is to reduce the barriers of access to energy outlined in this report. Our partnership with technology integrators has allowed us to create innovative solutions that integrate Aceleron batteries into e-mobility vehicles and mini-grids, effectively addressing these challenges. Aceleron's technology provides significant benefits in the e-mobility and mini-grid sectors by providing a maintainable solution that offers long-term economic benefits. The development of remote data communications device for the Aceleron batteries is another key benefit offered by our technology that enables innovative solutions such as remote monitoring and data collection and business models such as PAYGO. Lastly, by promoting a circular economy with the use of repurposed/second-life batteries, we provide a responsible waste management process and hope to lower the initial cost of the battery systems promoting sustainable energy growth for the future. Effort is now required from external stakeholders to influence regulatory bodies and standardisation committees to encourage the sale, transportation and usage of second-life products.

WITH SPECIAL THANKS TO PARTNERS

Kisii Smart Community

Smart Villages Research Group

EnergiCity

Vittoria Technology

MAY YOUR BATTERIES ALWAYS BE MAINTAINED!

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