

PAYG Solar powered fridge
Developing a “first time” product for low income customers



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The development of the M-KOPA Fridge (a fully solar PAYG fridge) involved several challenges relating to creating a product that is so new to the sector. Although many off-grid industry surveys report fridges in the top five appliances that customers state want in all markets¹, there are limited data on the specifics of what size refrigerator customers need, or how much they can afford, or are prepared to pay. Therefore, this project had to adopt a zero-base approach and build evidence bottom up – a process that has thrown out a significant number of lessons – and process improvements that we share here to support lesson learning by partners and colleagues in the sector.

Grant funding to M-KOPA Labs as a catalyst of social impact

M-KOPA Labs was established to accelerate the company's ability to innovate on its product (R&D) of higher impact products to commercialize. The Shell Foundation, a UK charity, with support from the UK's Department for International Development (DFID) and the United States Agency for International Development (USAID) provided funding to M-KOPA Labs to pursue R&D of larger capacity power devices capable of interfacing with grid energy, and of larger off grid appliances. Together, R&D in these areas intended to provide customers with more affordable power, and the ability to do more with their power. As set out here, support from the Shell Foundation has enabled M-KOPA Labs to undertake the development of two products:

- a larger solar system designed to support more energy-consuming appliances. This product development project focused on three main areas: powering larger appliances like refrigerators at an affordable price; developing a grid backup solution by building grid compatibility into a larger solar home system; and exploring affordable energy provision for productive use applications.
- a low-power solar refrigeration product for off-grid customers. The refrigerator is uniquely suited to solar energy, employing innovative compressor technology built by Embraco². Their compressor eliminates the power spike most compressors require to begin working and decreases overall consumption with a highly efficient design.

Development of the larger power device was undertaken in-house by M-KOPA. The development of the fridge, however, relied on partnerships to improve product development. Embraco, a world leader in refrigeration compressors, approached M-KOPA with the idea of using their innovative compressor in a solar fridge for rural Africa. The partnership grew quickly, as Embraco's expertise in refrigeration technology complemented M-KOPA's competencies in small scale solar systems and consumer finance. The distinct, non-overlapping expertise fostered a mutually beneficial, productive relationship.

Defining the price proposition for low-income households

Off grid solar home systems (SHS) for basic lighting have a very direct effect positive on household finances, whereby kerosene expenditure is displaced by a cleaner form of affordable energy. Use cases for other household appliances such as fridges are harder to quantify: particularly where the value derived by households involve less direct cash savings, or where the appliance displaces household labour requirements (particularly by women).

Providing customers with a fridge that will work effectively off-grid involves a delicate balance. Cheaper (and less expensive) fridges require more power (larger panels and more storage), whilst more efficient fridges utilise more expensive cooling technology. M-KOPA assessed various options for developing an off-grid fridge, ultimately choosing to co-develop a brand-new product in partnership with Embraco. The efficiency achieved by the Embraco compressor is substantially better than any similar designs. The M-KOPA Fridge uses on average about 150 Wh/day – this in contrast to the nearest

¹ <https://assets.publishing.service.gov.uk/media/5bb77fc0ed915d23ad91fcb3/Market-Survey-2018.pdf>

² www.embraco.com

competitor's model which uses 333 Wh/day. It appears that the competitor's is a more affordable fridge – until the cost of the solar system is factored in. Doubling the energy consumption also doubles the size requirement of the battery, increasing the cost of the solar system. A more expensive, but more efficient fridge lowers the cost of the full system by at least \$30 – savings that get passed onto the consumer.

Box 1: Classifying the Social Impact of Fridge Ownership

Research carried out by M-KOPA found four main areas of time and cost savings from fridge ownership:

- Cost savings through bulk purchasing food on the weekly market day, when wholesalers are selling at lower per-unit prices than the re-sellers who operate the rest of the week
- Cost and time savings by reducing the total number of times a household has to shop for food per week
- Cost and time savings by enabling more efficient bulk cooking, storage of prepared food, and reheating, meaning less time and fuel spent on cooking
- Cost savings through avoiding food spoilage

This is in addition to the potential of using the fridge to increase income (such as by starting to sell cold drinks to neighbours). Additionally, for the roughly 6% of Kenyans with diabetes, owning a fridge allows for safer storage of life-saving medicines like insulin.

Ideation and feasibility Study

The fridge development project started in early 2017, when Embraco approached M-KOPA about the possibility of partnering to develop a high-efficiency, pay-as-you-go solar fridge. The initial stage involved desk research on a range of questions ranging from technical to market focused.

Technical research was carried out by the joint technical teams, with engineers assessing together power requirements and overall energy consumption to understand technical feasibility. This was successful, indicating that the project should continue. Simultaneously, desk research and market size modelling were carried out to understand the possible return on investment on fridge development. Crude initial market sizing was initially undertaken using a Bass Model³, and indicated a healthy possible market, including a 5-year potential of >350,000 sales. Both indicators led to a decision to continue with the project.

Market Research Survey

The next step undertaken was to commission a market research survey to gain insight into the market dynamics and commercial viability of the product. This survey targeted both household and SME customers, with qualitative and quantitative elements and including a small volume of gas-powered fridges placed with potential customers to understand the reaction to refrigeration from off-grid individuals/businesses. For domestic customers, the research showed positive demand levels and identified four core areas of benefits/cost savings: bulk buying of food, less trips to the market, less cooking costs, and less food spoilage. These represented both financial and time savings, particularly for the women in the household. For business customers, the research showed positive demand levels and identified two main benefits: increased revenue and footfall from cold drinks, and reduced costs associated with stock spoilage.

³ “The Bass Model or Bass Diffusion Model was developed by [Frank Bass](#). It consists of a simple [differential equation](#) that describes the process of how new products get adopted in a population. The model presents a rationale of how current adopters and potential adopters of a new product interact. The basic premise of the model is that adopters can be classified as [innovators](#) or as imitators and the speed and timing of adoption depends on their degree of innovativeness and the degree of imitation among adopters. The Bass model has been widely used in [forecasting](#), especially new products' [sales forecasting](#) and [technology forecasting](#).”

Technical tests and customer feedback



The first technical test paired both 50L and 100L fridges (6x50L and 2x100L) with a “Sunbird”⁴ battery control unit. The objective was to test if it was possible to provide enough power to run the fridge under normal usage conditions from a small-scale solar unit. Data were collected from the unit and remotely sent back to M-KOPA via the GSM connection.

The test was largely successful, showed the 50L fridge’s energy consumption to be within the capacity of existing small-scale solar systems. The 100L fridge required more energy than the Sunbird could supply. This finding prompted M-KOPA to increase the battery size of and Embraco to improve the energy

consumption of its compressors. The opportunity was also taken to gather feedback from customers on the value of having a fridge, and to collect insights into how it had changed their spending levels, behaviours, and lifestyle.

Customer Focus Groups

While in the field installing prototype fridges, M-KOPA Labs conducted interviews and focus groups to explore customers’ perceptions of value and affordability. Included in these analyses were an exploration of the interest in a larger (more expensive) fridge or a smaller (less expensive) fridge. These customer discussions and focus groups produced some key insights about the market:

- More than half of people responded that a 50L fridge was sufficient for their needs; this largely did not include SME customers, who almost exclusively reported a need for 100L or more.
- Given the choice between purchasing a 50L fridge at a lower price or a 100L fridge at a higher price, 8 of 10 people chose the smaller fridge.
- Demand was increased when the pitch included a discussion that the price included electricity (given high cost of power in Kenya).

Second technical and customer test

For the second technical test, M-KOPA designed a bespoke control unit integrating Li-Ion batteries into the system with a re-designed PCB as a first prototype of a larger control unit.

The second technical test also introduced two new fridge sizes (75L and 130L), to test customer perceptions around size, refrigeration needs, and energy consumption at different sizes. It also tested optionality around using motorbikes to deliver fridges the last mile to customers’ homes.

Customers accepted the 75L size as more than enough for domestic uses, but slightly small for MSME use. The 130L fridge was well received by MSMEs and domestic customers alike. M-KOPA’s commercial and finance teams asked the development team to prioritize minimizing the price to meet the company’s customer affordability expectations and requested that the product be first rolled out to domestic customers before targeting MSMEs. As a result the development team decided that a 50L fridge was a sufficient proposition that maximized affordability while also providing sufficient value add to domestic customers.

⁴ The Sunbird was an earlier product intended to provide customers with more power, it was sold in limited numbers and suffered numerous technical difficulties but was a suitable power control unit for the initial testing of the fridge.

Survey value proposition, savings, and income potential

To validate the sizing decision, and to improve the quantitative knowledge of potential savings accrued through fridge ownership, the development team undertook two targeted market surveys. The first was to collect daily diaries from customers who were field testing the prototype fridges, and the second was a blanket survey of target customers in the Kisumu region.

The daily diaries collected data on food purchases, market visits, cooking habits, and food spoilage both before and after the customers had the fridge in their home. The results showed a clear correlation between fridge ownership and reduced spending on food, transport, and cooking fuel – with average savings above 50/= per day. Additionally, we surveyed the customers' loading of the fridge, which indicated that the 50L size was indeed enough for most domestic customers' usage (they had filled less than 50L more than 75% of the time).

The bulk buy survey conducted in Western Kenya focused on a quantitative analysis of the savings available to customers who owned a fridge, on the four identified categories of potential savings. The data showed that customers had substantial savings potential through fridge ownership, with as much as KSH 250/= per day as a reasonable target for customers with higher income, long commutes to the market, or large families.

Willingness to pay survey among existing customers

To better understand the addressable market size, growth curve potential, and demand dynamics of exiting M-KOPA customers, the development team launched an SMS survey targeted at customers of M-KOPA. The survey asked a series of questions about demand, affordability of daily payments, perception of total off-grid fridge price, and time needed to save for the deposit to gain deeper insight to sales projections among potential customers for a fridge upgrade. In all, more than 275 people responded to the survey.

Latent demand levels were above 70%, with customers reporting being able to afford 125/= per day, and demand for a fridge among those who could afford that daily rate was above 80%.

Third technical test and customer feedback

The final technical test paired 50L fridges with an upgraded battery control unit, with an improved PCB design. These were sold standalone (with no lights). The technical test was a success, after overcoming integration issues in the communication between the fridge and the control unit. These integration challenges were a helpful learning point about the difficulty of doing joint functional development, but ultimately delayed the pilot by several months.

After the challenges were overcome, sales were moderately successful. While the fridges were sold over a two month period, the effort required to pitch the product, combined with the high rejection rate, led the development team to adjust the pilot rapidly to allow the company to run a small sales pilot for 100L fridges.

Several key findings came out of the initial sales pilot in Kenya:

- Most customers want to see the fridge to get a better sense of the size before purchasing – reducing the speed of telesales conversion and causing the team to explore alternative means.
- Roughly half of the customers who came to the shop to see the fridge did not end up purchasing, even after expressing interest on the telesales call, stating that the fridge was too “small” for the price.
- Many customers who bought the fridge and then returned it did so because they were SME owners and the fridge was too small for their needs.
- Customers who bought the fridge and did not find the size too small were very happy with the purchase.

100L fridge sales pilot



Following the challenges of the 50L fridge sales pilot in Kenya, the M-KOPA Labs team pivoted the second half of the pilot to attempt sales of a higher price 100L fridge, aiming to sell 15 fridges from the same shops the 50L were sold. The pilot ran for 9 weeks, selling 13 units in that time from 4 shops, with the purpose of testing the price point for the 100L fridge and associated solar system (this system did not come with lights). The main takeaways can be summarized as:

- The 100L size was well accepted in the market.
- The price point tested was too high, and effort should be taken to reduce the price.
- The absence of lights slowed sales volumes; lighting will be included with product from the start of sales.

Low price hundred litre sales pilot

The process of product development (including the various technical tests, market research, and sales pilots) has shown that the price point of the 50L fridge is optimal for the product, but that the fridge needs to be larger in order to overcome customer perceptions and to open the small business customer segment. In other words, while the customers need a 50L fridge at the price point, what they “want” is a 100L fridge at the same point.

Product development: Key Lessons Learned

On the fridge as a product

- Customer perception of the right size for the fridge matters more than the factual customer requirements. Domestic customers will pay more for the fridge size that they want, than for the fridge size that they need⁵.
- Until the utility of domestic refrigeration use-case is proven households will make up a relatively small percentage of the possible market, whereas the initial evidence suggests very high demand from business users (including households buying fridges to set up micro-businesses).
- Proving customers willingness and ability to pay for a hardware product requires selling a test product that is close to the final product as possible. Where this involves front-loaded CAPEX costs to produce enough units to test repayments – risks exist that go beyond the scope of a product R&D exercise. There is a unique role for risk-capital to mitigate some of these risks in order to make products available to low-income customers.

On the product development process

Find innovative ways to test willingness to pay as early in the development cycle as the technology allows with the least cost yet most viable MVP. However, willingness to pay testing can only be validated to the satisfaction of the business when asking customers to part with money. Surveys and hypothesis testing can give an indication but should not be relied upon to prove WTP or reasonable price levels for commercial purposes.

⁵ Fridges placed in customers’ homes were rarely full (even the 50L model), but customers still asked for a larger fridge/more space.

LESSONS LEARNED PAPER

- Make the product right for the customer first and then incorporate perceived business constraints second. This includes ensuring that product development is based on tested evidence, not merely based on what has worked in the past.
- There are very few product adoption data available to help with the projection of new product adoption rates. In the absence of these data the team allowed a somewhat optimistic projection of early sales and could have tempered expectations of success.
- Technical integration between two independent businesses is complex and requires time to get right. In this case the development of two independent and yet interlocking firmware programmes caused some challenges. The development team did not give enough time for this task nor anticipate the complexities of managing the process.

Postscript: early sales success in Uganda

When the fridge sales were first tested in Uganda, it was clear that in terms of size, the household customers represent the largest segment to target. However, on launch, the sales team in Uganda quickly realized that domestic users questioned the utility for food storage purposes. Customers appear reluctant to batch cook and eat cold food from the fridge. And if a fridge were an option, most customers would heat the food again, reducing potential fuel and time savings. Often, rural Ugandans source their food locally, rendering few monetary savings on fare rides.

Conversely, many Ugandan customer view the fridge as a business opportunity. Cold drinks are very popular and on average, a solar fridge allows a small business to sell 30 more drinks a day, which roughly equates to UGX 6,000U (\$1.6USD) in extra profit, covering the cost of their daily rate of UGX 5,500 (~\$1.5USD).

A trend is emerging, where prospective domestic customers have bought the fridge to start a drinks business. The Market Development Team have therefore adapted their strategy to focus on trading centers (clusters of shops), with great success.

The evolving sales approach

Since the focus of initial sales efforts has switched to Micro-Small Enterprises (MSEs), the sales team has been exploring ways to further understand this target market. One constraint is limited understanding of the size of the opportunity (such as how many trading centers exist, or their locations). Because of this, use of GIS is becoming integral to the sales planning methodology.

Each product is geotagged, meaning a GPS location is known at the product installation. When these positions are overlain onto Facebook population data, a clearer picture emerges. Clusters of sales can be observed, as well as districts with lower sales.

