

GRID POWERED REFRIGERATION FOR PRODUCTIVE USE

Study of 172 micro-enterprises in Uganda
to understand the case for off-grid appliances

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Background

- The [2016-17 Global LEAP Awards Off-Grid Refrigerator Competition](#) aims to identify and promote the best in class off-grid refrigerators.
- Three \$200,000 cash prizes for products that demonstrate market-leading innovations in (1) Energy Efficiency, (2) Overall Value, and **(3) Appropriate Design and User Experience**.
- Lab test (run by CLASP) to determine winner of (1) & (2).
- Field testing (by Energy 4 Impact) targeting end users will be conducted to determine the winner of (3).

Objectives of the Field Test

1. Establish how well products perform in a 'real life' situation.
2. Gather information from end users about their experience of the products.
3. Provide information for the basis of awarding the **'Appropriate Design and User Experience' award**.

Justification

Why conduct an on-grid refrigerator survey?

- Off-grid refrigeration is nascent. There isn't enough off-grid appliance penetration in Uganda to form a sensible baseline.
- **Understand the context** within which we will be running the field test, i.e. Ugandan micro-enterprise owners use refrigeration as part of their operations. How did they come to a decision to acquire a fridge? What value are they getting from using a fridge?
- **Provide a benchmark** for evaluation of results of the field test. By understanding the valued parameters for micro-businesses, we can better evaluate the output of our field test.

Survey Methodology

Location: 7 districts in Uganda (on the ground partner advised on most suitable locations).

Survey participants: micro-entrepreneurs running businesses with **grid powered refrigerators**.

Methodology: deliver the survey to business owners to understand the value and decision-making around acquisition and use of refrigerators.

Process:

- a. Identify small businesses that use refrigerators – approx. 100.
- b. Schedule visits to business premises to conduct surveys.
- c. Analyse surveys to draw conclusions on use and value of refrigeration in the 7 districts.

Survey validity and reliability

- This is a qualitative survey and its validity is based on 1) using the right methodology, i.e. in person interviews and 2) survey questions designed to answer the intended objectives.
- Training of enumerators was carried out to increase reliability in addition to visual validation of portions of the data collected e.g. power rating.

Scope and limitation

This survey is not intended to be statistically valid as a population cannot be established. No data can be found giving the population of small-scale businesses with refrigeration capacity in Uganda.

Executive Summary

- There is a clear business case for fridge acquisition for retail micro-businesses selling drinks.
- Fridge acquisition closely follows the need for grid connection.
- Fridges enable diversification of products sold, provide additional revenue streams to non-retail related businesses and improve a business' competitiveness.
- The main challenges for interviewed microenterprises are;
 - High energy costs related to high energy consumption of the fridges.
 - Power supply interruptions.
 - Appropriateness of the products to their business needs, i.e. robustness, design features and usability.
- A typical product for a micro-enterprise is a 100-150L fridge costing \$250 with the most valued characteristics being energy efficiency and autonomy.
- Based on fridge characteristics from this study, solar refrigerators (i.e. refrigerators designed only to be compatible with SHS or DC grids) at their current cost do not make a sufficient economic argument for a micro-business. They are unaffordable. However, the technology trajectory looks promising with, at best, a 3-year payback period for the power supply of a \$546 170L fridge.
- There is a clear business case for energy efficient refrigerators (AC powered) for on-grid enterprises as well as for off-grid users.

SURVEY RESULTS

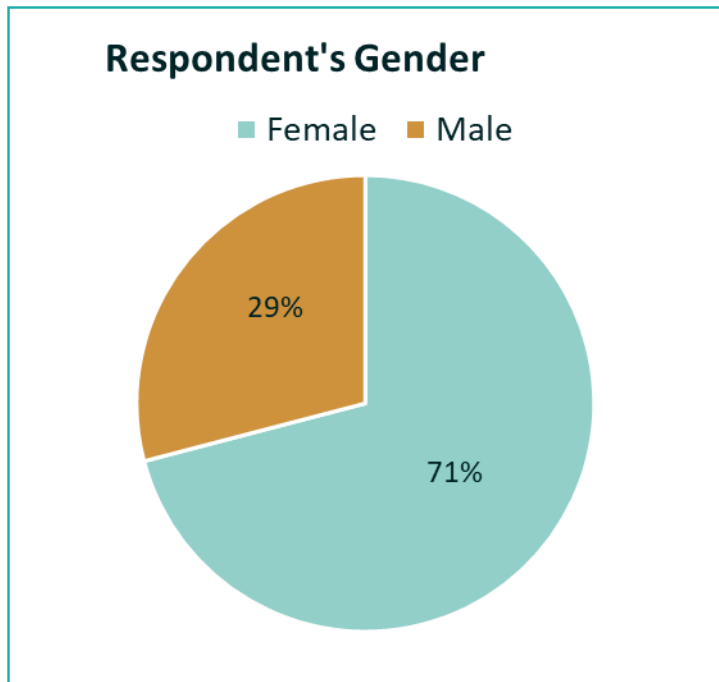


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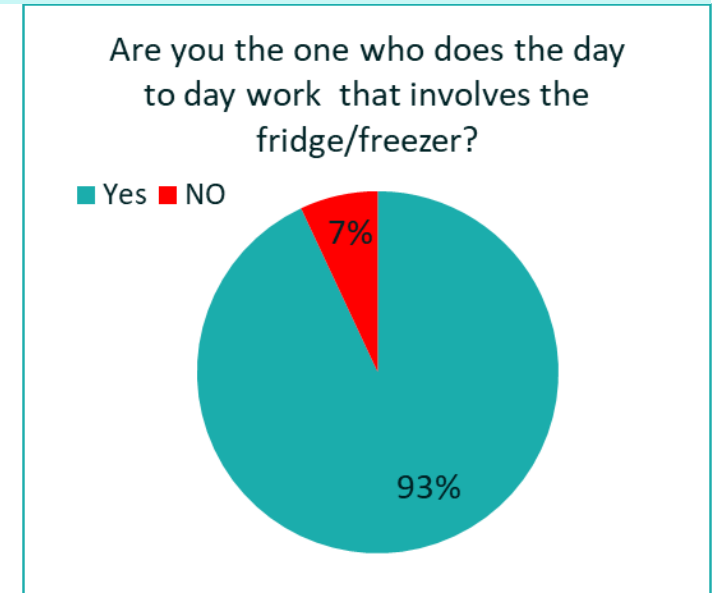
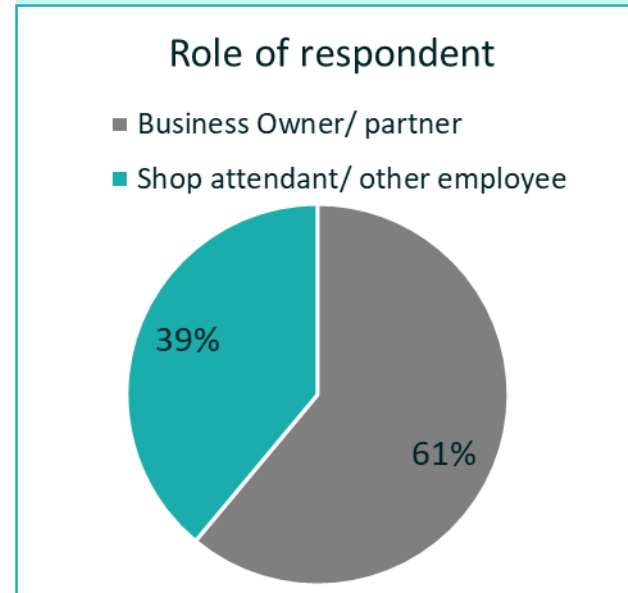
Study respondents

- The typical fridge-owning business was a small retail shop run by a couple or family.
- The gender split of respondents was heavily skewed towards women.
 - However, business ownership was on similar proportion between genders (with a slight skew towards women). This reflects the family-run nature of such micro-enterprises.

42% - Male and 58% - Female



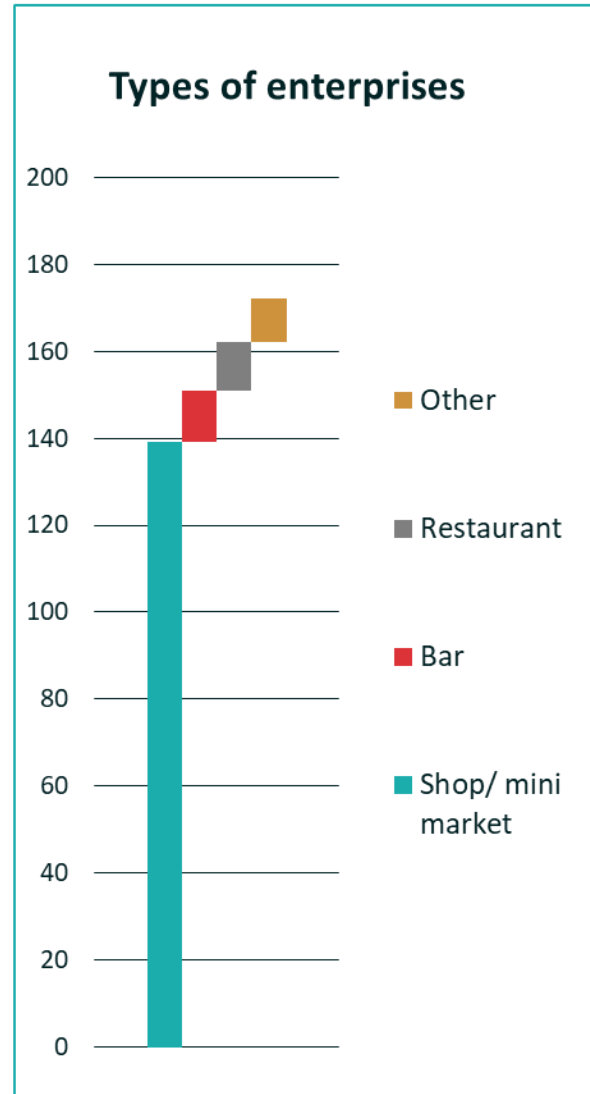
- Majority of respondents were business owners or their partners.
- In 93% of the cases, the respondent was also the person who typically uses the fridge.



Business Demographics

The businesses were typically located along the main highway in small trading centres.

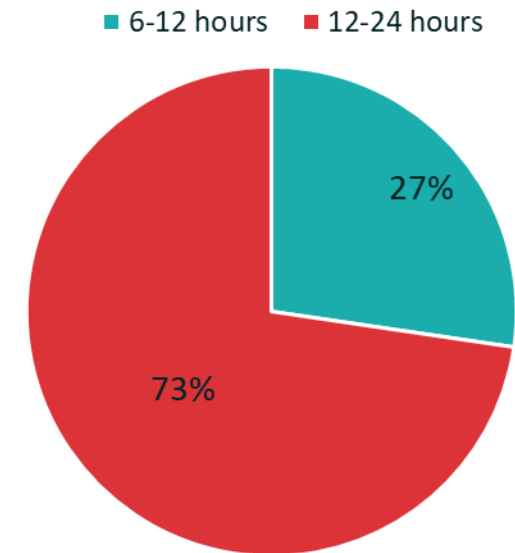
Location (Districts)	No of Businesses
Mukono	32
Mpigi	26
Kampala	22
Wakiso	32
Luweero	30
Masaka	6
Mityana	24
Total	172



Typical business characteristics

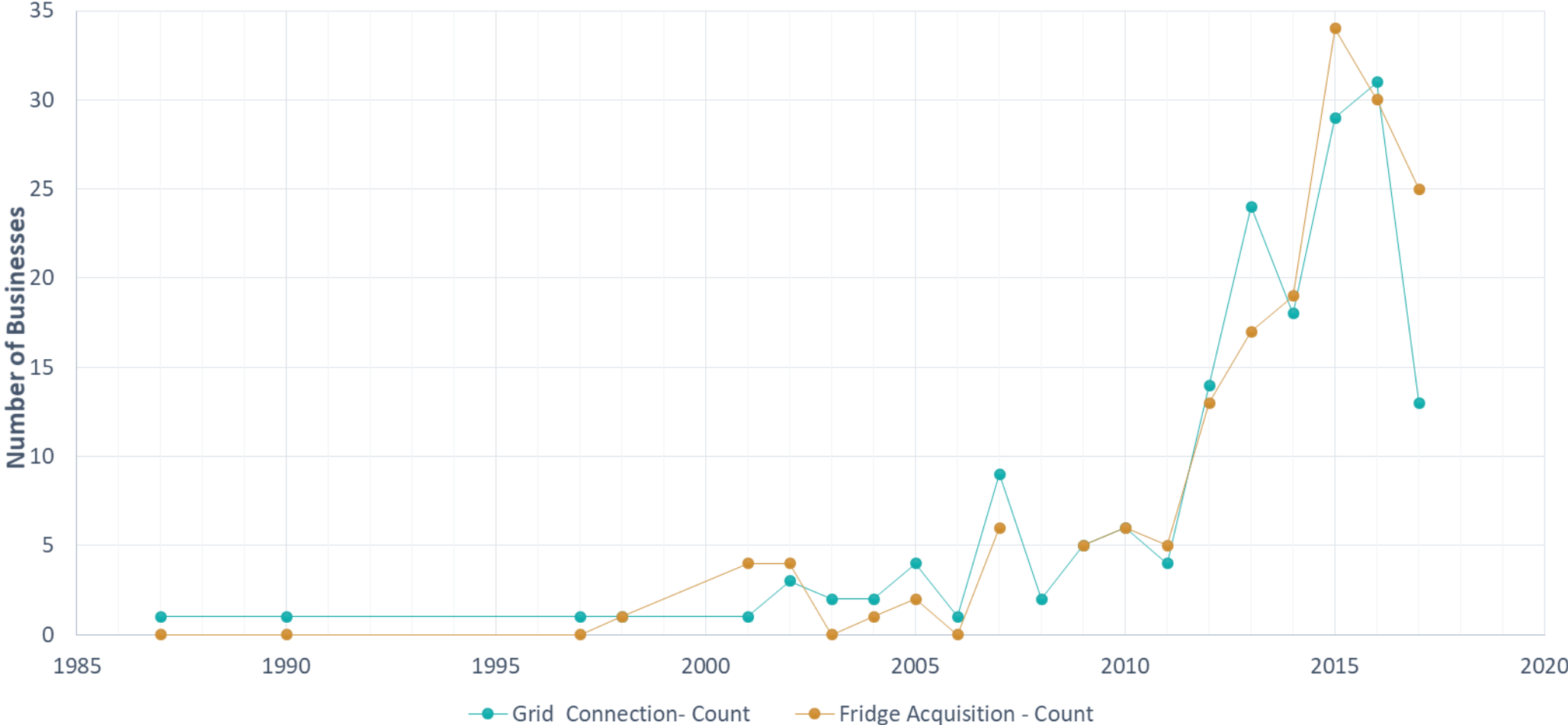
Characteristics	Value
Duration of operation	4-5 years (average)
Number of employees	1-2 (average)
Hours of operation	More than 12 hrs/day

How many hours a day do you operate?



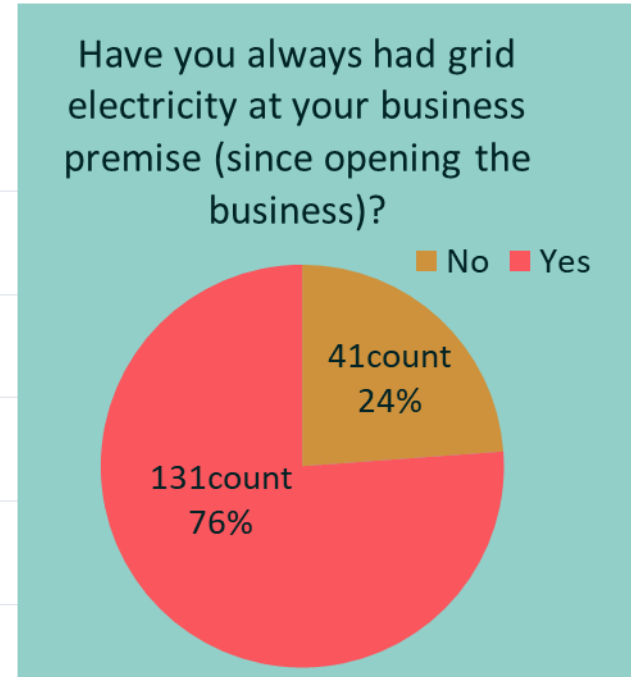
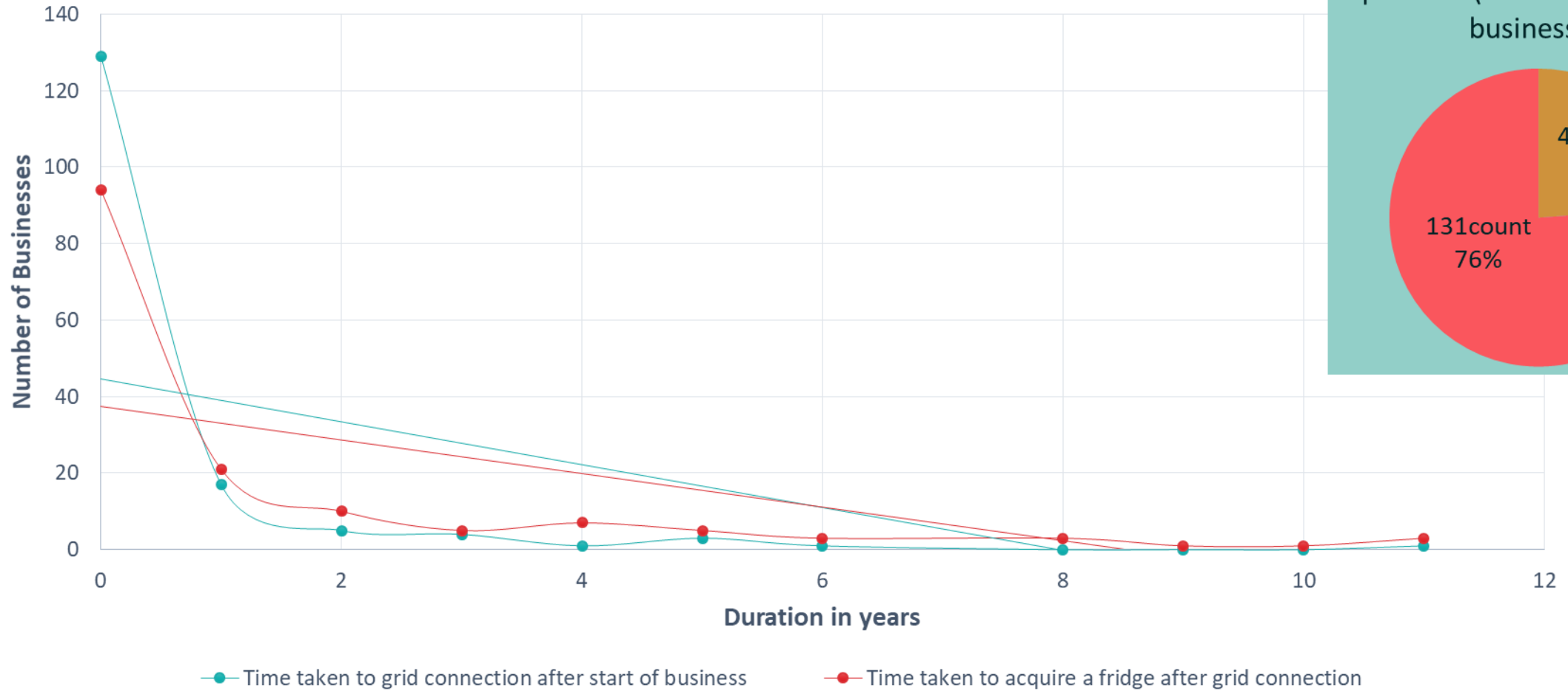
Fridge acquisition and grid connection

Grid connection vs Fridge acquisition dates



Fridge acquisition on grid connection

Most businesses acquired a fridge immediately on business set up or on grid connection



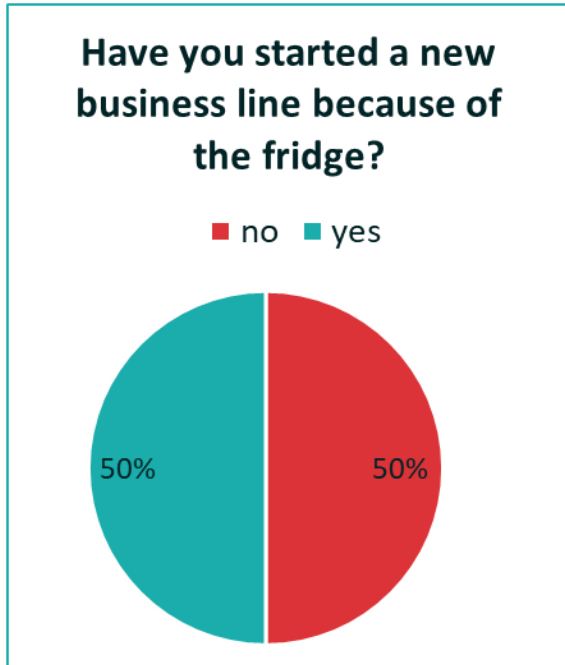
Fridge acquisition on grid connection

- Majority of micro-businesses started in the last 7 years. By this time, the district centres of the selected locations were already electrified. It is, therefore, not surprising that many of the businesses got connected at the start.
- Moreover, fridge acquisition seemed to follow the same pattern as grid connection but with a small lag of about 5-6 months. This suggests that fridges are an invaluable, if not indispensable, part of these retail businesses.
- Many participants did not associate solar power with refrigeration, expressing unawareness when the purpose of the study was explained to them. However, there was keen interest (noted by field researchers) in the potential of solar fridges.

["The interviewee is a farmer. He is delighted about the idea of solar fridges."] | ["The client would like to see if, indeed, there is a solar fridge."]

["The idea of a solar fridge, which is not so costly, is very welcome here, during the interview. Many people who work near this shop came around and were all very interested."]

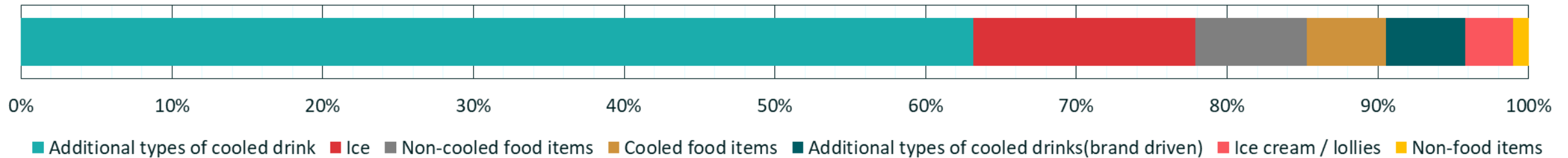
Business Value



- 50% of businesses have diversified their operations or started new product lines because of the fridge.
- Majority of business lines are around new/additional types of cold drinks and production/sale of ice.
- For some enterprises, the fridge is an add-on revenue stream to an unrelated business line, e.g. salon, electrical workshop, clinic.

“Our fridge was primarily to make our patients feel at home, but it turned out to be a business venture as well.” Health Centre worker.

What new product are you selling/ business line have you began since getting a fridge?



Business Value

A fridge is seen as a vital part of the business by many of the businesses interviewed.

- In some cases, the fridge is indispensable and the business shuts down when the fridge is unusable.

“A fridge is very good addition in the business. Without it, there is no business here in Mpigi.”

“This business is so dependent on the fridge. When it breaks down, there is no business.”

- Fridges are adding value to retail businesses, increasing incomes and enabling diversification of services as well as creating add-on revenue streams.

“...income has increased because of this fridge. It can pay rent and other things.”

“Adding the fridge to this business has boosted my profits.” Electronics shop owner.

[“The interviewee is happy that the fridge is enabling them to make an extra income from selling refreshments,” field researcher]

“The main objective of acquiring this fridge was to attract more [salon] clients because the clients are offered free drinks if they are to spend more than an hour.”

[“This is a unisex saloon, earning an extra income from the sale of cold drinks to people nearby. The interviewee would like to engage in more business lines, though the power consumption of this fridge is limiting them.” field researcher]

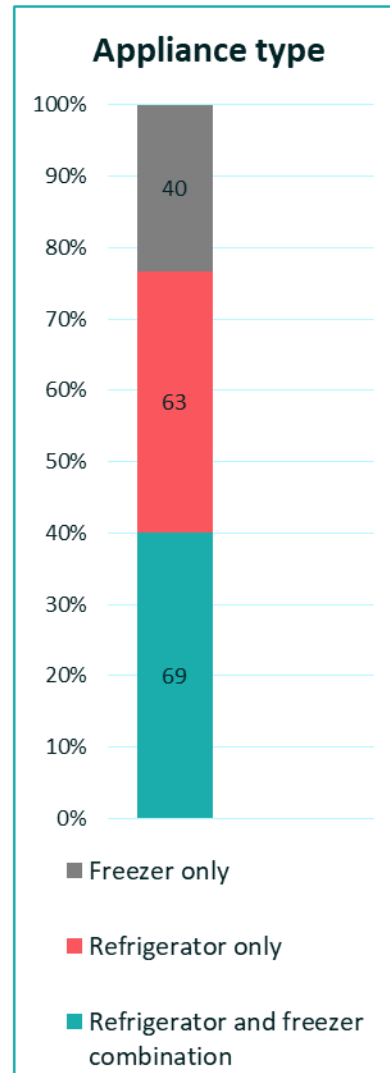
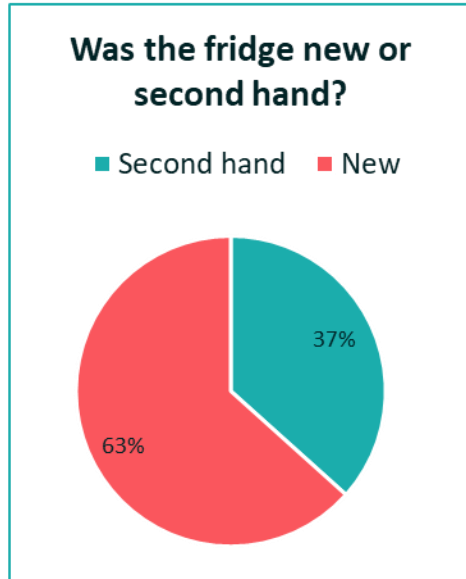
- Fridges allow businesses to be competitive.

“There are many people with fridges, so competition is high.”

[“A fridge has made her remain in business. She has managed to compete favourably with her competitors.”]

Fridge Characteristics

More than a third of the fridges were bought second hand



Typical fridge characteristics

Characteristics	Value
Capacity*	Fridge: 100-150L
	Freezer: 80-140L
Power Rating*	200 W
Cost of appliance (average)	800k – 1Million UGX (\$230-270 USD)
Cost of Power**†	35K-52K UGX (\$10-\$14) a month
* Average values where reported	
** not all power consumption is attributed to the fridge. However, in a majority of shops, there were no other high consumption appliances observed.	
† More than one fridge observed at multiple locations.	

Fridge Characteristics

- Though a lot of the fridges are reportedly bought new, their condition varies with many of them poorly insulated. A field researcher reported some of them leaking.
- There seems to be an equal proportion of fridges and a combination (fridge/freezers) with a smaller proportion of standalone freezers.
- However, we found that users do not always make a distinction between a fridge and a freezer in the way they use them. For example, some respondents mentioned the need to control the fridge to prevent bottles from bursting and switching off the freezer before the item is frozen solid. This suggested that **their needs are cooling rather than freezing** in most instances. However, participants buy whatever products are available to them then adjust how they use them to suit their requirements.

“If you don’t control it, you risk having a bottle breaking or cracking.”

- The desired size range seems to be between 100-150L for a fridge and slightly smaller for a freezer. This reflects the sizes of the businesses interviewed.
- The average product cost is US \$250. This is much lower than anticipated and much lower than the typical cost of a solar refrigerator, which range from approx. \$600-\$15000 (without including the costs of the SHS to power the product).

Fridge Characteristics

- Rated power consumption of the products is 200W on average.
- The average cost of electricity is \$12 a month.
- Take the scenario below, if a SHS system was used instead of the grid for a 100-180L refrigerator:

Case 1: Typical DC fridge (139L) (wholesale cost of product \$500)

- Rated power of 100W assuming energy consumption at 1.2Kwh/day.
- One would need at least a 300Wp system at a total cost of approx. \$1,500.
- At the same monthly instalment rate as electric bills, it would take more than **10 years to pay back** the system alone.

Case 2: Energy efficient DC fridge (170L) - designed specifically for use with SHS (wholesale cost of product \$546)

- Rated power of 40W with energy consumption of 0.2Kwh/day.
- Here, a 50Wp system may be sufficient at a cost of \$400.
- It would take almost **3 years** to pay back the system alone.

Based on the average on-grid fridge characteristics, solar refrigerators at their current cost do not form a positive economic case for the micro-entrepreneurs. The products are too expensive and their associated power provision is also unaffordable. However, the trajectory in energy efficient design is positive with products designed specifically for use with SHS making a better economic argument.

CHALLENGES



Challenge 1: Power Availability & Consumption

I. Power interruptions are frequent and destabilising for businesses.

“Lately, power has become unreliable and we have been forced to adjust to where we started from; we have to boil all the milk when the power is off. This is very costly in terms of charcoal and time.”

[The interviewee was busy boiling 500litres of milk she had in stock when the interview was going on.” field researcher]

II. Many entrepreneurs complain of high power consumption of their fridges, and therefore high electricity bill.

“The fridge has contributed so much to my business. The only problem I have is that it consumes so much power. A solar fridge would be a good alternative to erratic electricity.”

“ The electricity bill is always high.”

III. Businesses try to manage power consumption by switching off fridges intermittently.

IV. Some consequences include lower profit margins and retardation of business growth (despite high potential for growth related to the use of fridges).

“The fridge consumes so much power. We could sell things like ice cream but the cost of power is too high.”

“the fridge consumes a lot of power and this decreases the profit margin.”

[“the electricity bills seem too alarming for her since she gets little profits from the fridge.” Field researcher]

Challenge 2: Appropriateness of Appliances

Businesses report that the fridges are unsuitable for their needs in various ways (beyond the high power consumption).

- I. Fridges are not long-lasting. They often breakdown, requiring expensive repairs or replacements. This frustrates business owners.

“I have had to change fridges many times as they are not durable.”

“Most fridges are fragile. The plate for the deep freezer should be harder.”

“The fridge is faulty. I bought it because the previous one was faulty too. She is so frustrated by the current fridge.”

“Sometimes, the fridge gets faulty and mechanics ask for a lot of money for repairs.”

- II. Fridges provided by beverage firms are particularly power hungry and restrictive of/limiting to some business practices.

“I got tired of [drinks] company fridges. Those people control you so much. You always don't have freedom”.

“At this shop, there are fridges from Coca Cola and Pepsi. These are mainly for displaying sodas. I switch them on for one hour every day to save power.”

[“In this shop, they had two smaller fridges from both Coca Cola and Pepsi beverage companies. They purchased these particular fridges to create more space for storing other products.”]

- III. Some businesses are forced to purchase multiple fridges if they want to stock products outside those provided by beverage companies like Coca Cola or Pepsi.

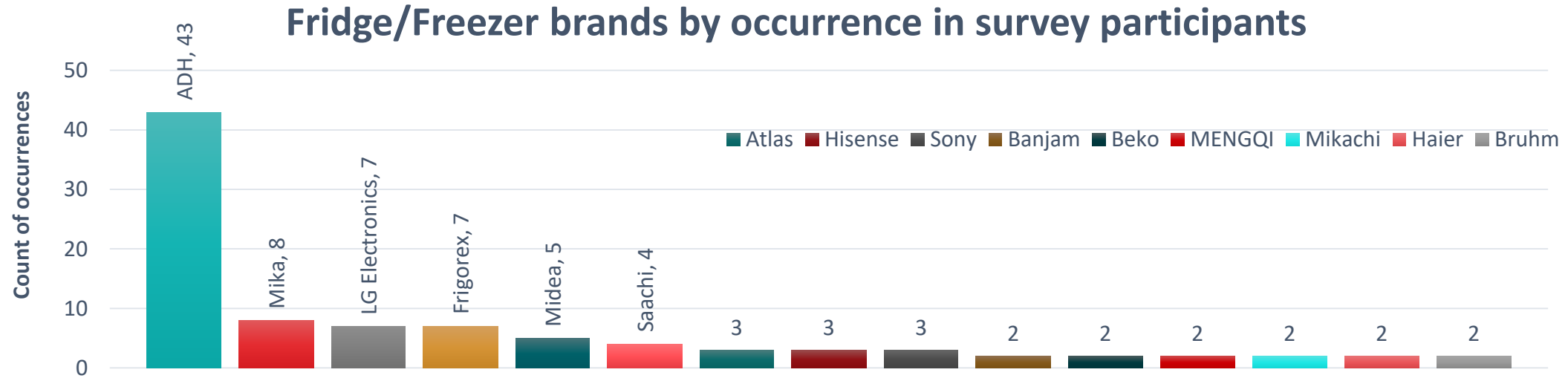
[“The interviewee has three fridges; two from the soda companies she uses as display at her shop, and the Kodama chest freezer, which is packed with ice she buys from a friend’s home and it helps keep her refreshments chilled throughout the day.” Field researcher]

USER TECHNOLOGY FEEDBACK



User technology feedback

A few fridge brands appear to stand out as preferred by businesses.



“We got a good deal purchasing this fridge. Ever since we purchased it, it has never broken down. It works efficiently and does not consume a lot of power.”

[This Meiling model, according to the participant, is really efficient, though its size [65lites] limits the quantity of products they can stock.

“The ADH freezers as opposed to other freezers, are efficient and don't consume as much power compared to the other brands we use.” Mini mart, Seeta Town.

“This freezer [Haier] is able to make ice in just two hours and it keeps it frozen for many hours. It’s really good for this business.”

[“This is one of the newest models of LG fridges in the country. The interviewee is quite impressed with its performance though she says it does not have a display to show what she is selling.”]

User technology feedback

- The most valued characteristic of a fridge is **autonomy** (i.e. the ability to maintain cool temperatures without additional power input). In some cases, autonomy is used to justify high purchase cost or power consumption.
 - “Good, it keeps the coldness for 3 days.” | “It really works. It takes us 6 days to switch it on again.”
 - “It takes 2 days when things are still cold” | “It keeps coldness for 3 days. I like it.”
 - “This fridge was very expensive, but it’s worth it. It is very efficient and retains the cold temperature for long. This place has other fridges offered by Coca Cola company, though they are usually switched off to save on power costs.”
 - “The fridge consumes a lot of power but it’s worth it.”
- Interviewees also value the ability of the fridge to function as a display too, i.e. see through front loading design.
- During the study, field officers observed a lot of low quality, poorly insulated, leaking and old products. Businesses appeared to keep ill-functioning appliances for as long as possible, perhaps due to the high cost of replacement.
- The ability to partition products in the fridge compartments was also seen as a positive characteristic.
 - “I want a freezer with partitions so that I separate my products.”
- Participants also use business fridges for domestic uses.
 - [“She uses the fridge for the business and also to keep other things such as tomatoes and water for use at her home.”]

CONCLUSION AND FIELD TEST LESSONS



Conclusion and Field Test lessons

- I. Though, an economic case for solar refrigerators cannot yet be made, the business need for energy efficient refrigerators is apparent.
- II. The Global LEAP refrigerator awards and field testing are pushing the sector in the right direction towards more efficient products that will ultimately reduce energy related costs to an affordable level.
- III. Product design will also need to consider the features that matter most to their target demographic. Overall, autonomy is the stand-out desired feature.
- IV. Cold drink manufacturers, who also supply refrigerators (e.g. Coke and Pepsi), should be prompted towards energy efficient products to increase the product's utility to customers and reduce energy costs.

Field Test Learnings

The ideal field test participants:

- Will be micro-enterprises running retail shops that have an element of selling drinks. (This correlated with existing field test protocols Energy 4 Impact developed).
- Will be located in towns/trading centres along busy roads. Participant selection process (currently ongoing) has been directed to reflect this.

The field test will be making available assets that are beyond the economic reach of the participants. We need to consider the effects of this on their responses on the **appropriateness of design and their user experience.**



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