CROSSBOUNDARY

Appliance Financing 3.0 *Innovation Insight*: preliminary findings on grain mills and fridges

Grain mills increase mini-grid profitability by 11–44%, fridges by 6%

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Disclaimer

The Lab is supported by Energy 4 Impact, who is responsible for ensuring charitable intent and monitoring social impact, and by the University of Massachusetts Amherst, Rochester Institute of Technology, and Duke University, who support experiment design and analysis of results. The Lab's work and the results presented here are strongly endorsed by the Africa Minigrid Developers Association (AMDA).

The Lab's *Innovation Insight* series provides ongoing, early insights on the prototypes so mini-grid developers, governments, and funders can act on the results as they emerge. All results and analysis in these series is therefore shared as *actionable business intelligence* rather than scientific evidence.

While these series are not intended to meet the standards of an academic paper, the Lab will publish more complete reports at the end of each prototype, and has partnered with University of Massachusetts Amherst, Rochester Institute of Technology, and Duke University to publish academic papers on certain prototypes.

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Executive Summary:

Grain mills increase mini-grid profitability by 11–44%, fridges by 6%. Uptake is limited by diesel alternatives and unreliable power

Grain mills increase mini-grid profitability by 11–44%, fridges by 6%. However, uptake is limited where diesel-powered alternatives exist and mini-grid power is unreliable

1. The top 20% of customers, who use income-generating machines like grain mills and fridges, account for 80% of consumption

2. Electric-powered agricultural machines such as grain mills can increase mini-grid profitability by 11%. Converting all diesel mills to electric mills could increase a mini-grid's profitability by 44%. However, electric mills are not always competitive with diesel mills on performance, hindering uptake

3. Commercial equipment such as fridges increase mini-grid profitability by 6%. High quality power is critical as commercial customers have zero tolerance for poor reliability

4. The Lab is working with partners such as the World Bank, ESMAP and CLASP to develop the building blocks to get energy-efficient, electric-powered income generating machines to market at scale

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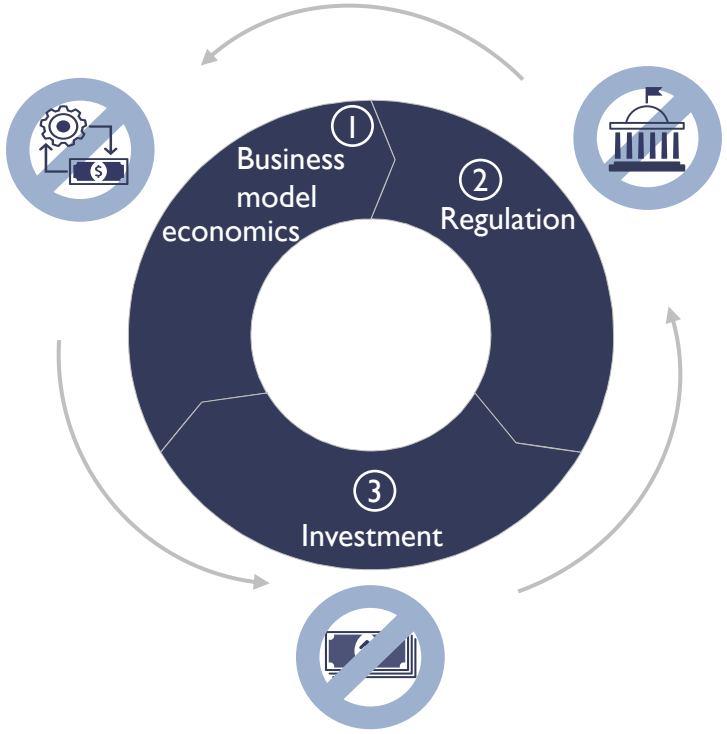
The Innovation Lab:

The Lab tests innovations to improve the mini-grid business model and bring modern energy to 260M people in Africa

The Lab tests innovations to improve the mini-grid business model, and shares evidence with developers, governments, and funders so they can act

Mini-grids have historically hit three barriers to scale…



…each of which the Lab addresses…

1. Testing innovations and scaling those that are most effective
2. Convincing governments mini-grids are the least cost option to providing electricity to rural communities
3. Sharing evidence of successful innovations to attract investment to the mini-grid sector

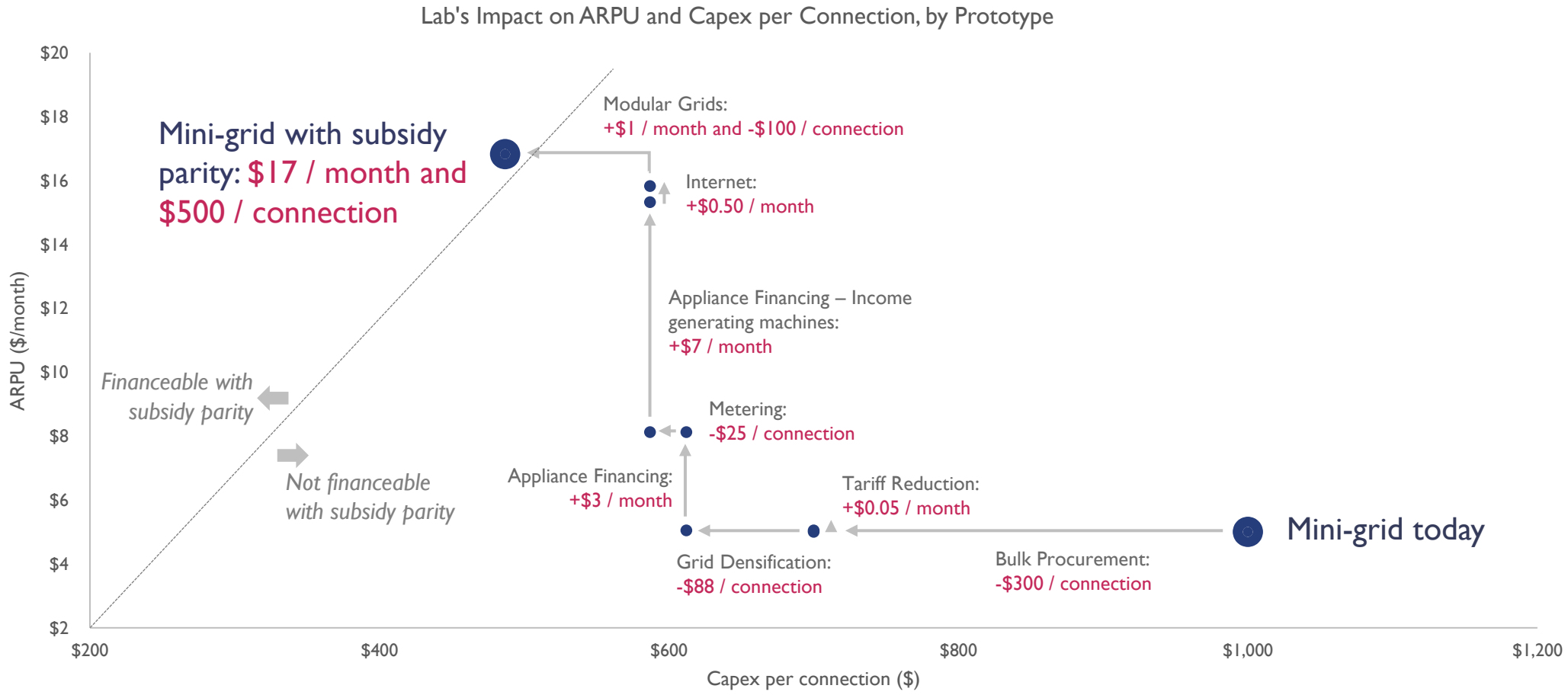
…to bring the Modern Energy Minimum to 260M Africans

Mini-grids provide least cost electricity to homes and businesses for 260M Africans

The Modern Energy Minimum is 1,000kWh per person per year

Note: For further information on the Lab, please visit our website: crossboundary.com/labs
Source: Energy Access Outlook 2017, World Energy Outlook Special Report. International Energy Agency (IEA)

The Lab has identified 10 innovations that could improve the mini-grid business model to be financeable with subsidy parity

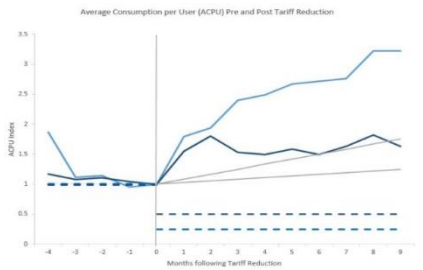


Notes: Modular Grids consists of two distinct innovations (Increasing Capacity and Extending Reach). A grid would, however, only be eligible for one of the two innovations at any given time. The Connecting Beyond the Meter innovation is excluded from this graph as it delivers the combined impact of Appliance Financing – Income generating machines and Grid Densification.

The Lab's *Innovation Insight* series provides early, actionable business intelligence on results from innovations tested in rural Africa; this issue focuses on Appliance Financing

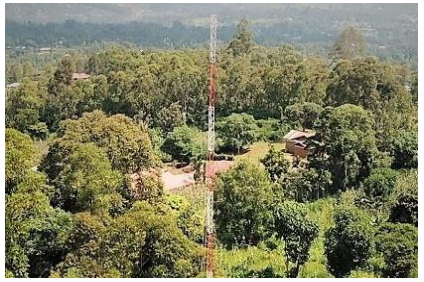
1
Financing programs for household and income generating machines

2
Assessing the price sensitivity of rural customers



3
Competing with the arrival of the main grid

4
Providing internet services alongside electricity



5
Providing appliances alongside a connection to electricity from day 1

6
Deploying larger, denser grids in anticipation of customer demand

7
Testing smart meter technologies

8
Negotiating lower equipment price through bulk procurement

9
Increasing a mini-grid's capacity modularly

10
Extending a mini-grid's reach modularly

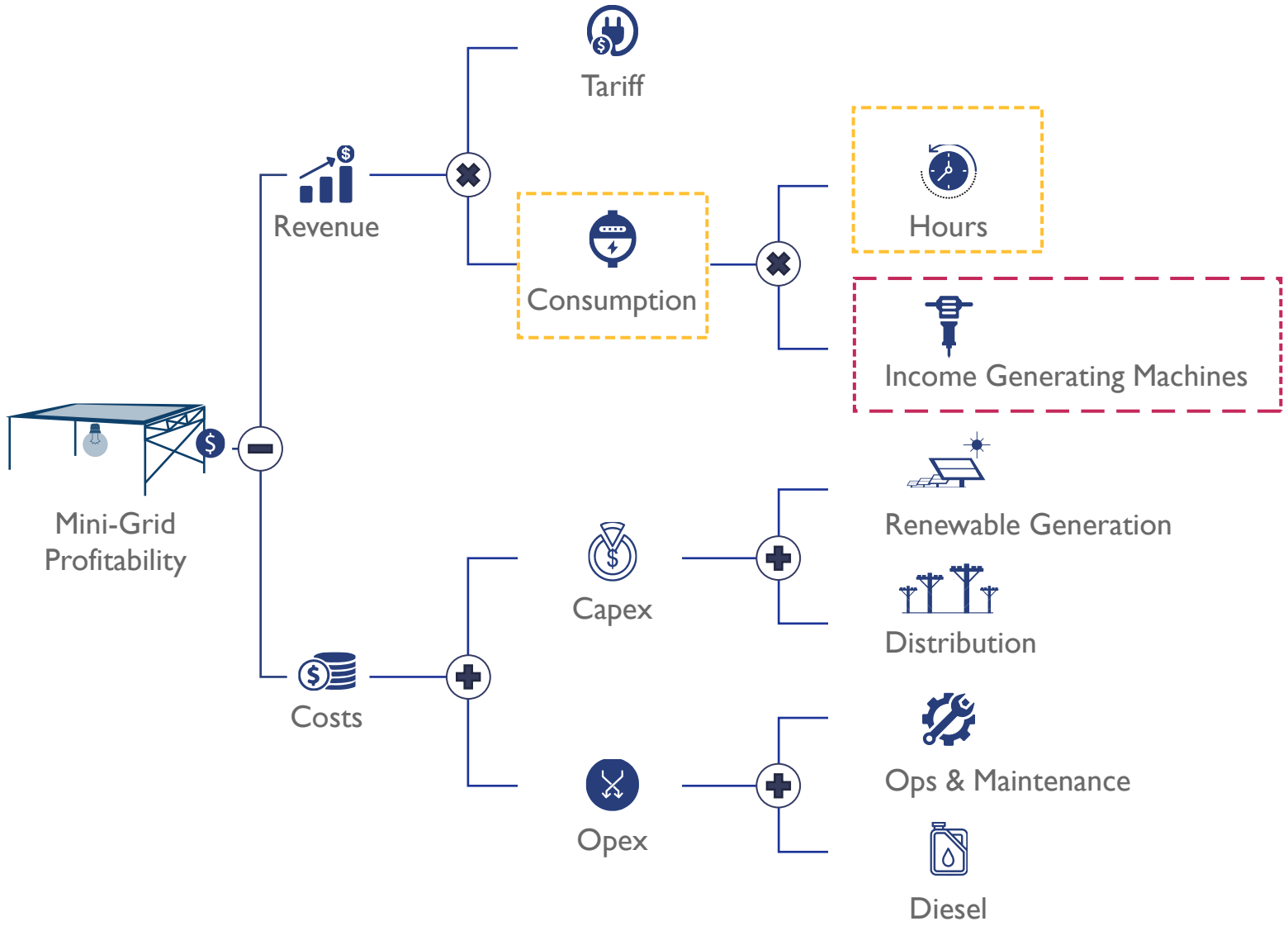
3

How we test appliance financing:

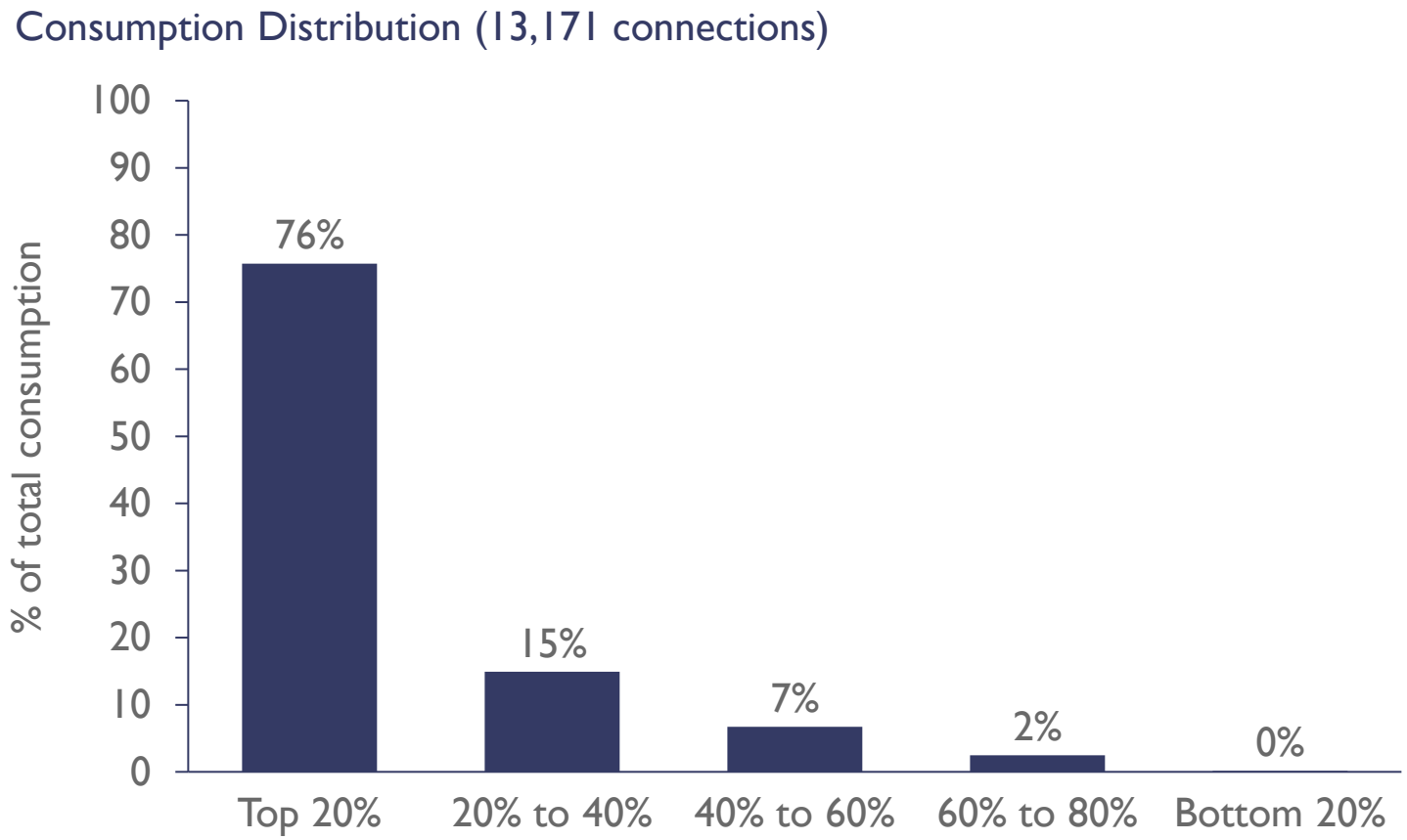
The top 20% of customers, who use income-generating machines like grain mills and fridges, account for 80% of consumption

The Lab expects that offering customers income generating machines on credit will increase electricity consumption because they:

- Are high-powered appliances and are typically used for long periods of time; and
- Help customers grow their incomes to afford more power



Almost 80% of energy consumption on mini-grids comes from the top 20% of customers



Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter

The top 20% of customers are mostly businesses. They consume energy to drive their business and generate income.

Supplying income-generating machines to those top 20% of customers will have an outsized impact as they account for 76% of the consumption.

Earlier trials of appliance financing showed that income generating machines have the greatest impact on the business model. However, they must be customized for off-grid use

Appliance Financing 1.0 tested household appliances

In our Appliance Financing 1.0 *Innovation Insight*, we show that:

- Offering household appliances such as TVs on credit had no significant impact on mini-grid consumption and revenues
- Income generating machines showed the highest potential for increasing consumption

Appliance Financing 2.0 tested off-the-shelf grain mills

Offering generic machines that aren't targeted for off-grid use in Africa require extensive modifications to work:

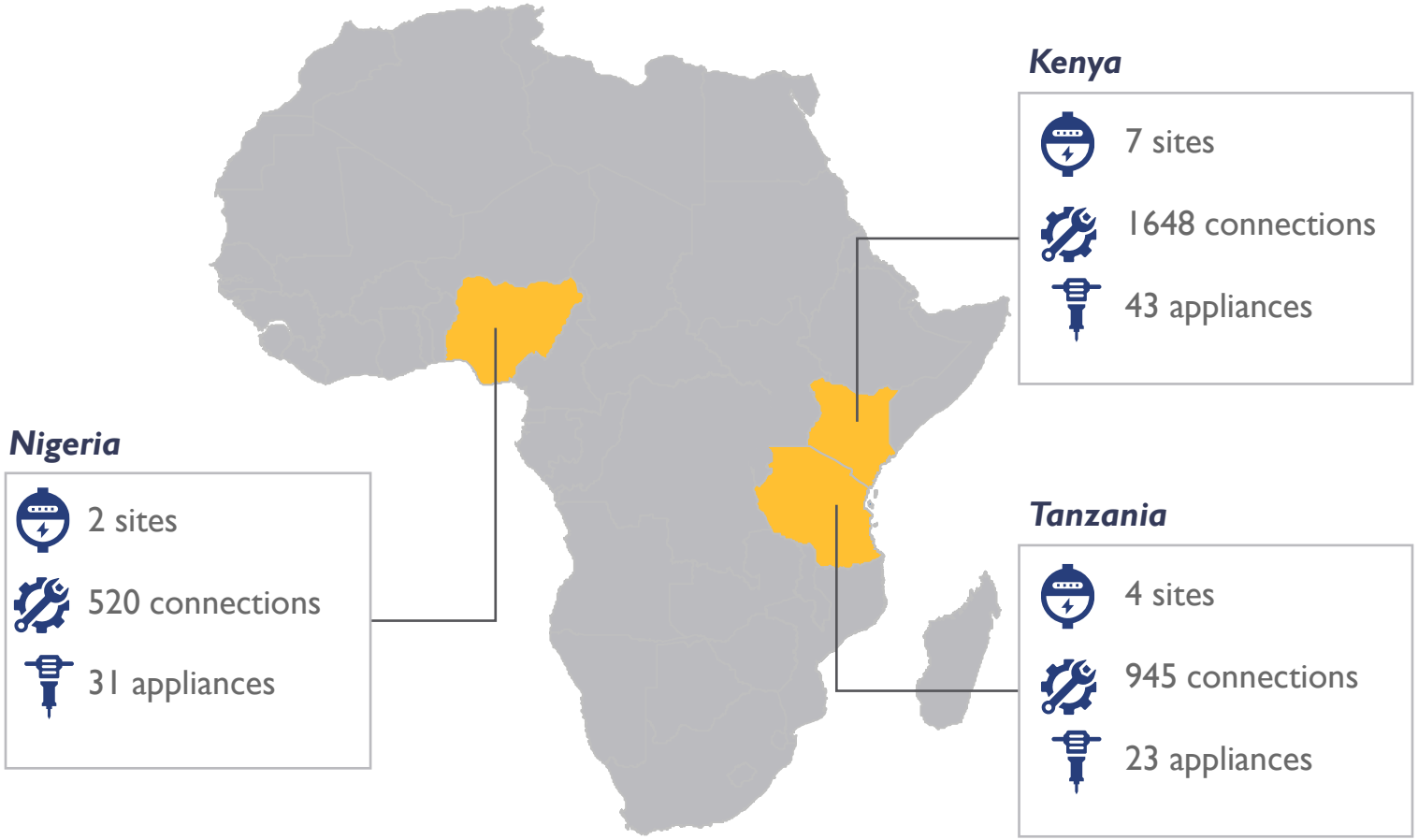
- Installing larger pulleys to increase throughput by 50%
- Replacing 1.5mm sieves with 0.8mm sieves to produce finer flour per local preferences
- Installing soft starters to ensure inrush current doesn't overwhelm the inverters
- Adding a switch to run the mill's rice huller and maize grinder separately to improve efficiency

Appliance Financing 3.0 tests machines customized for off-grid use

In this preliminary report, we show that

- Grain mills consume 8x more than the median user and could improve mini-grid profitability by 11%–44%
- Fridges/freezers have marginal impact of 6%

The Lab funded developers who deployed 97 income generating machines on credit to customers across 13 sites in Nigeria, Kenya and Tanzania



Notes: 1 Terms were revised and extended after launch of the program due to feedback from customers

Appliance selection was developer-led

- Developers conducted technical and financial assessments to determine which appliances to deploy and which customers to provide financing to
- The Lab collected consumption, payment, and loan repayment data from each site on a monthly basis

Financing terms were benchmarked to SHSs

- Set to reflect commercial standards, benchmarked against similar programs offered by solar home system providers
- Financing was offered according to a 12 to 24-month loan term, with a 10-20% upfront deposit and a 2.55% monthly (i.e., 14% p.a.) interest rate[1]

Developers found that marketing roadshows, credit checks based on electricity bills, and customer training are critical for appliance financing programs success

Developers selected and marketed appliances to customers

- Chose appliance offerings according to customer demand, the mini-grid's ability to sustain the load, and feasibility of procurement and distribution
- Collected technical data and information of existing appliances to assess whether the machines can be retrofitted, or new ones will need to be purchased[1]
- Marketed appliances to potential customers by conducting roadshows in the community – showcasing the income generating machines

Developers performed a credit assessment on customers

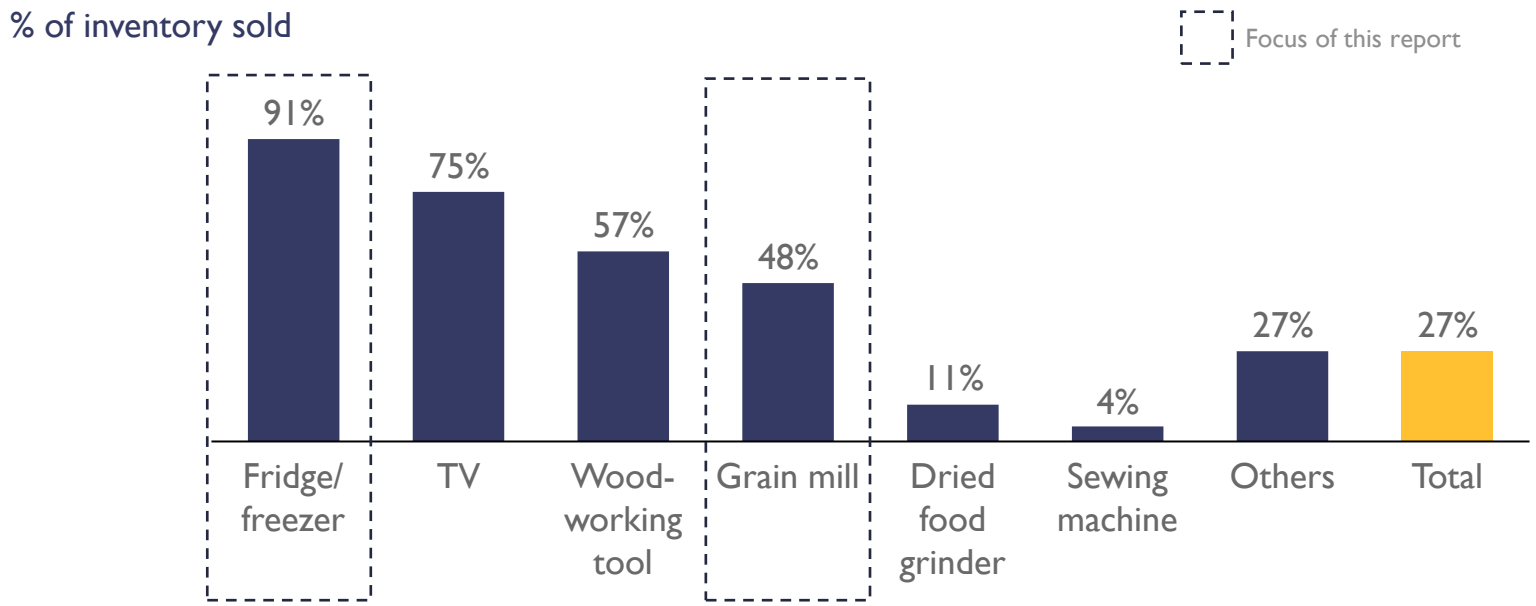
- Interviewed interested customers to ensure that the customer had:
  - A business use for the appliance within the community
  - Income that was significantly higher than the loan repayments and estimated electricity bills
  - No outstanding debt
- Assessed the historical consumption and bill payment of the prospective customer
- Ensured that a local community leader signed-off on the loan agreement as a notary/guarantor

Developers provided after-sales support to customers

- Installed the machines for customers
- Trained the machine operators on how to effectively use their machines
- Made technicians available to repair the electrical components of the machines
- Supported the machine operator in procuring spare parts as needed

Notes: 1 None of the fridges/freezers or mills spotlighted in this Innovation Insight were retrofitted

Grain mills and fridges were spotlighted due to high potential impact and high customer demand respectively



Power[1] (kW)	0.2	0.05	1	2.2	1.7	0.1	N/A	N/A
Cost[1] (US$)	350	150	100	550	100	100	N/A	N/A
# sold	40	6	4	10	19	2	16	97
# requested	44	8	7	21	172	45	59	356

Note: 1 Average
Source: Developer data

Data from Appliance Financing 2.0 showed that grain millers can consume up to 50x more energy than the median customer.

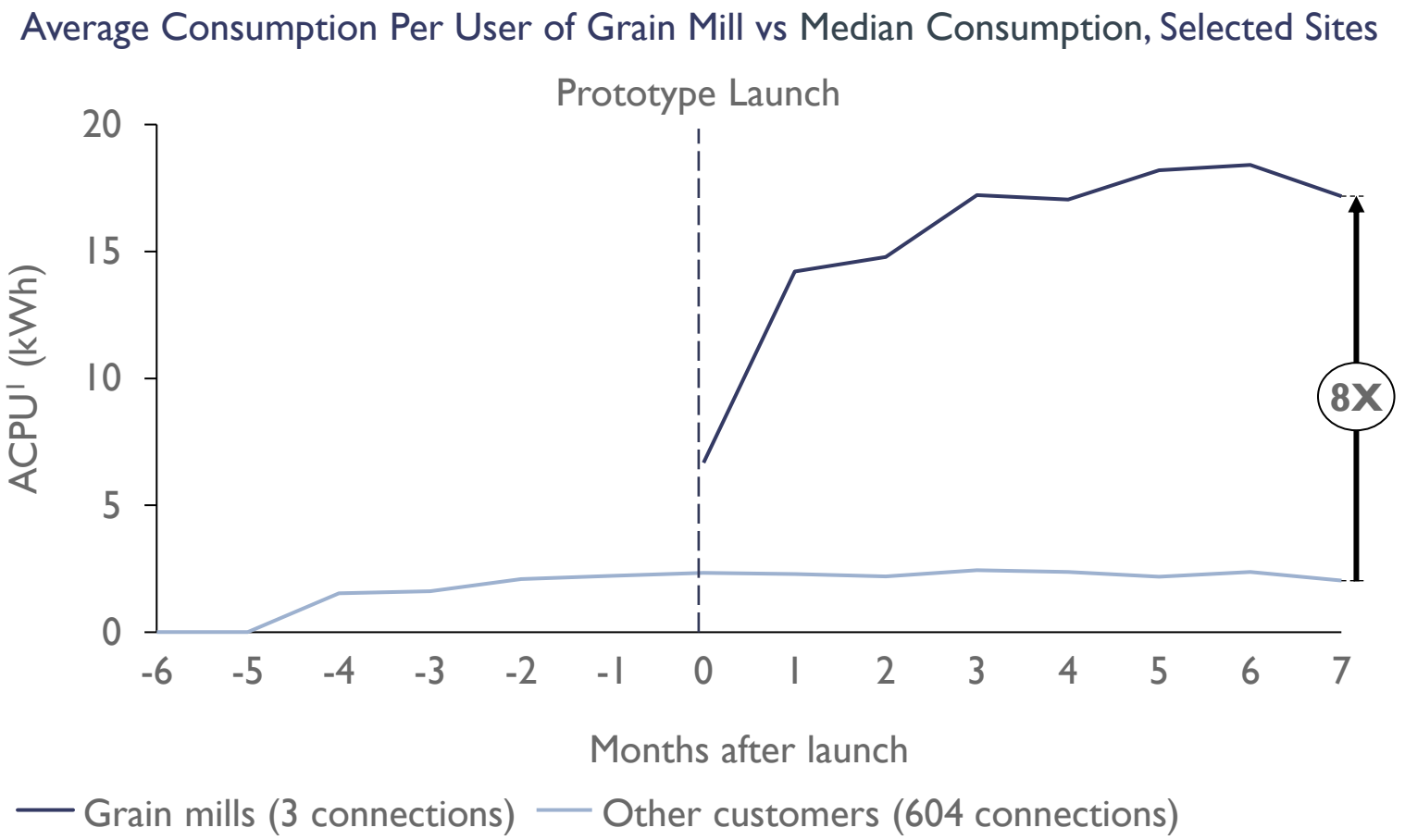
Fridges are in high demand in rural areas. Developers sold 91% of their stock because most people do not have alternatives for keeping food and drinks cool.

4

Results – Grain Mills:

Grain mills increase mini-grid profitability by 11%, and up to 44% if all diesel millers switch to electric mills. However, diesel mills are faster

Grain millers used 8x more energy than median customers. Running mills at full utilization could increase that to 60x



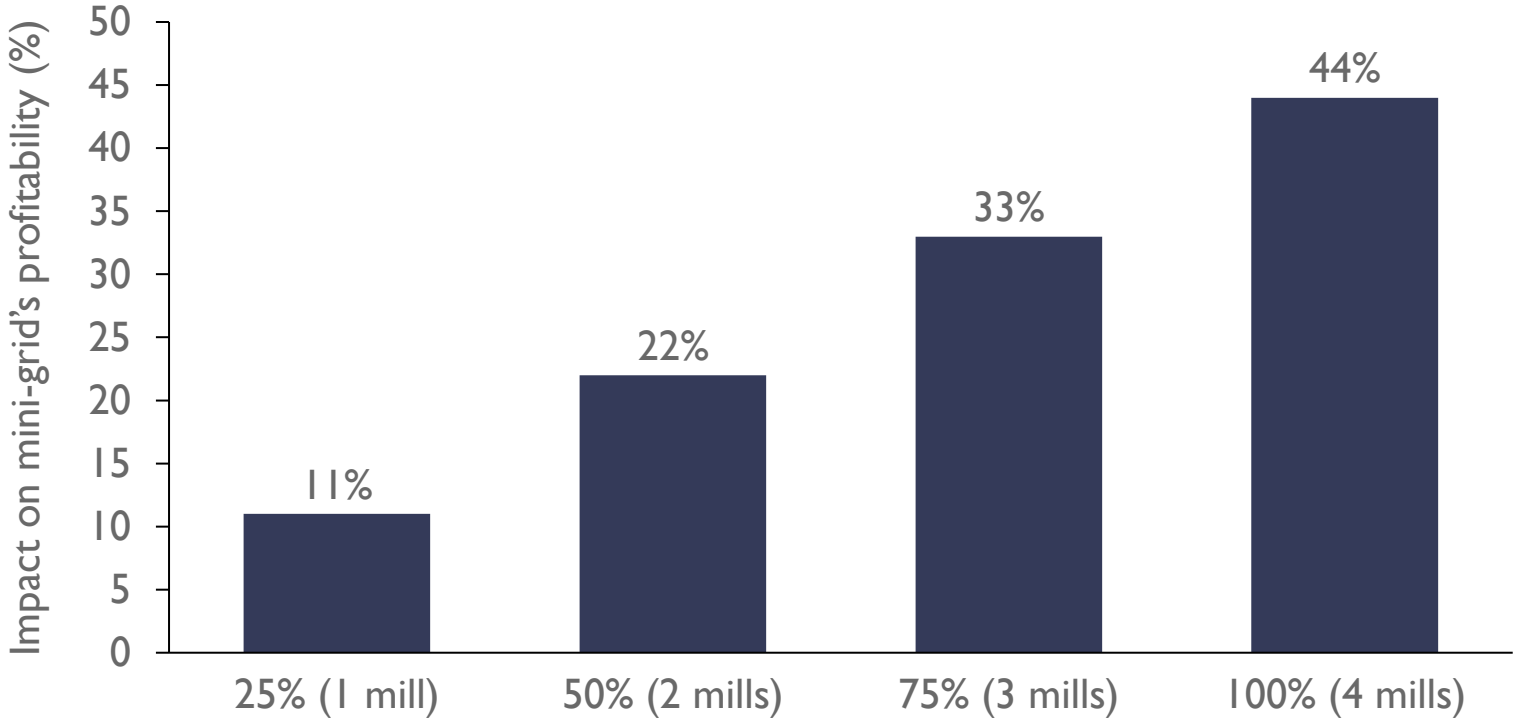
Notes: 1 ACPU calculated as a 3-month rolling average;
Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter

On average, grain millers only ran their mills for half an hour a day.

Increasing the utilization of electric-powered mills to 4 hours per day will increase consumption to 60x of the median consumer.

One grain mill can increase mini-grid profitability by 11%, rising to 44% if all diesel mills convert to electric power

Projected impact of replacing diesel mils with electric mills on mini-grid profitability



Assumptions: 300 households (hh) per community, 15kg of grain consumed/hh/week, grain mill throughput is 85kg/hr, power rating is 2.2kW, profitability is calculated as the increase in the IRR of the mini-grid (from a benchmark IRR of 7%) due to increased consumption from milling
Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter; Developer interviews; Grain mill product catalogues

A mini-grid's grain milling market is typically saturated with an average of four mills per site.

Replacing every diesel mill in the community with an electric mill will maximize the mini-grid's profitability, increasing by 11% with each mill.

Grain millers will only switch to electric if the cost is significantly lower and they can produce grain as fast as their customers want.

However, diesel mills are still faster than electric mills, and cheaper to run unless tariffs are below $0.55/kWh

Better than diesel | At par with diesel | Worse than diesel

Metric	Diesel mill[1] (20–25 kW)	Electric-powered mill[1] (2.2kW)
CAPEX ($)	1,000	550
Energy spend ($/kg)	0.02	0.01–0.03[2]
Throughput (kg/hr)	150–300	85
Efficiency (kg/hr/kW)	7.5 – 12	39

Notes: 1 Lifetime of both mills is ~10 years; 2 Calculated at tariff of $0.4/kWh to $1.2/kWh;
Source: Developers; Solar milling: exploring market requirements to close the commercial viability gap, Efficiency for Access (2020)

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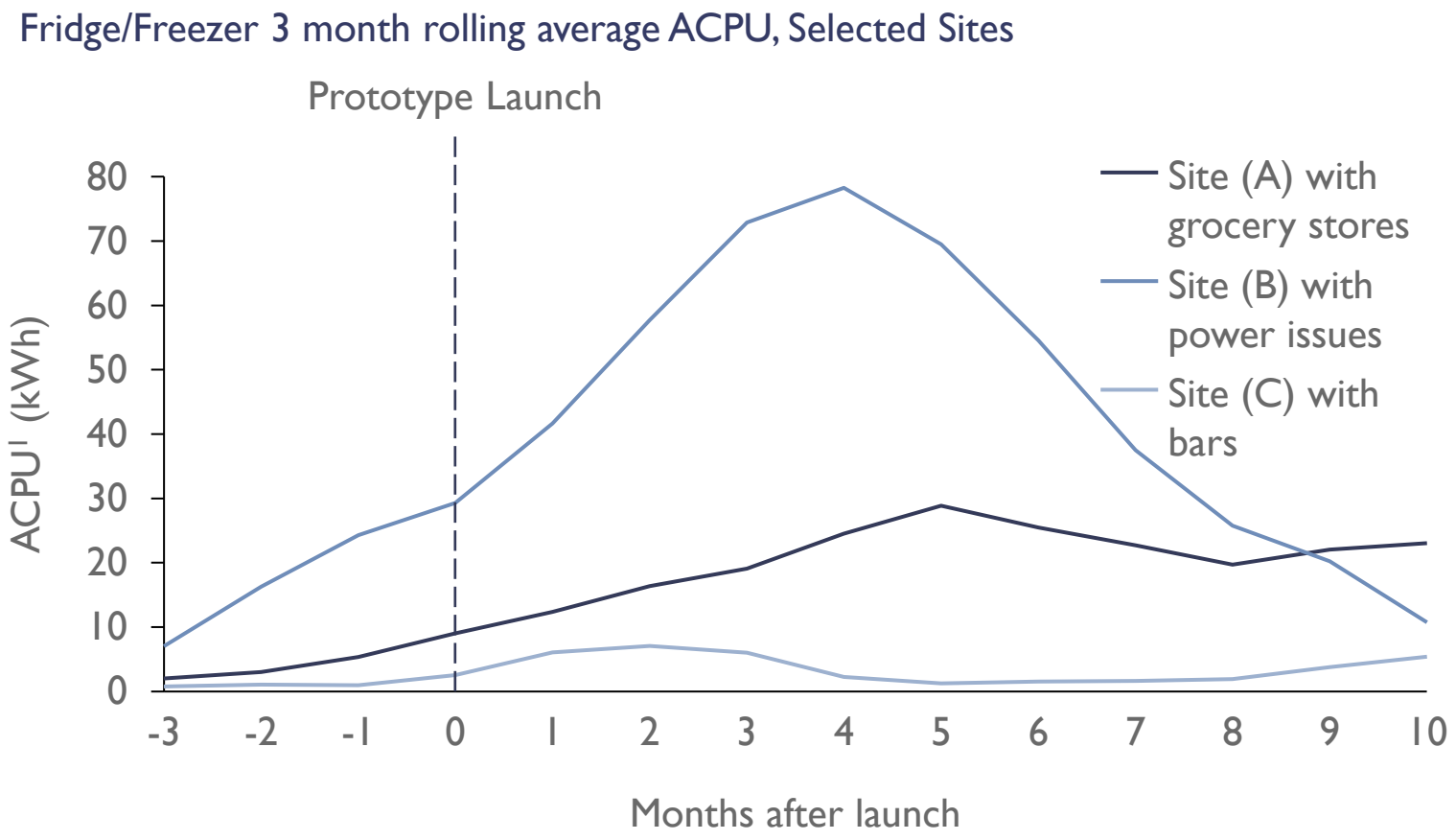
Results – Fridges:

Fridges improve mini-grid profitability by 6%. However, commercial customers have zero tolerance for unreliable power

Grocery stores provide regular demand for fridges. However, businesses can't function without reliable power



Notes: 1 >70% fridge/freezer owners kept their appliance constantly switched-on during usage hours and did not periodically switch off and on as observed in other studies; 2 Technical issues were not related to the appliance deployment
Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter

Site (A) and Site (B) have grocery stores that operate for long periods everyday, with a high, regular demand for power.

However, power reliability is critical. Site (B) lost some of its best customers after month 4 when it suffered technical issues[2].

Site C has sports bars that typically operate infrequently and have weak demand for power.

Case Study: Commercial customers have zero tolerance for poor reliability

There is demand for cold storage in rural areas

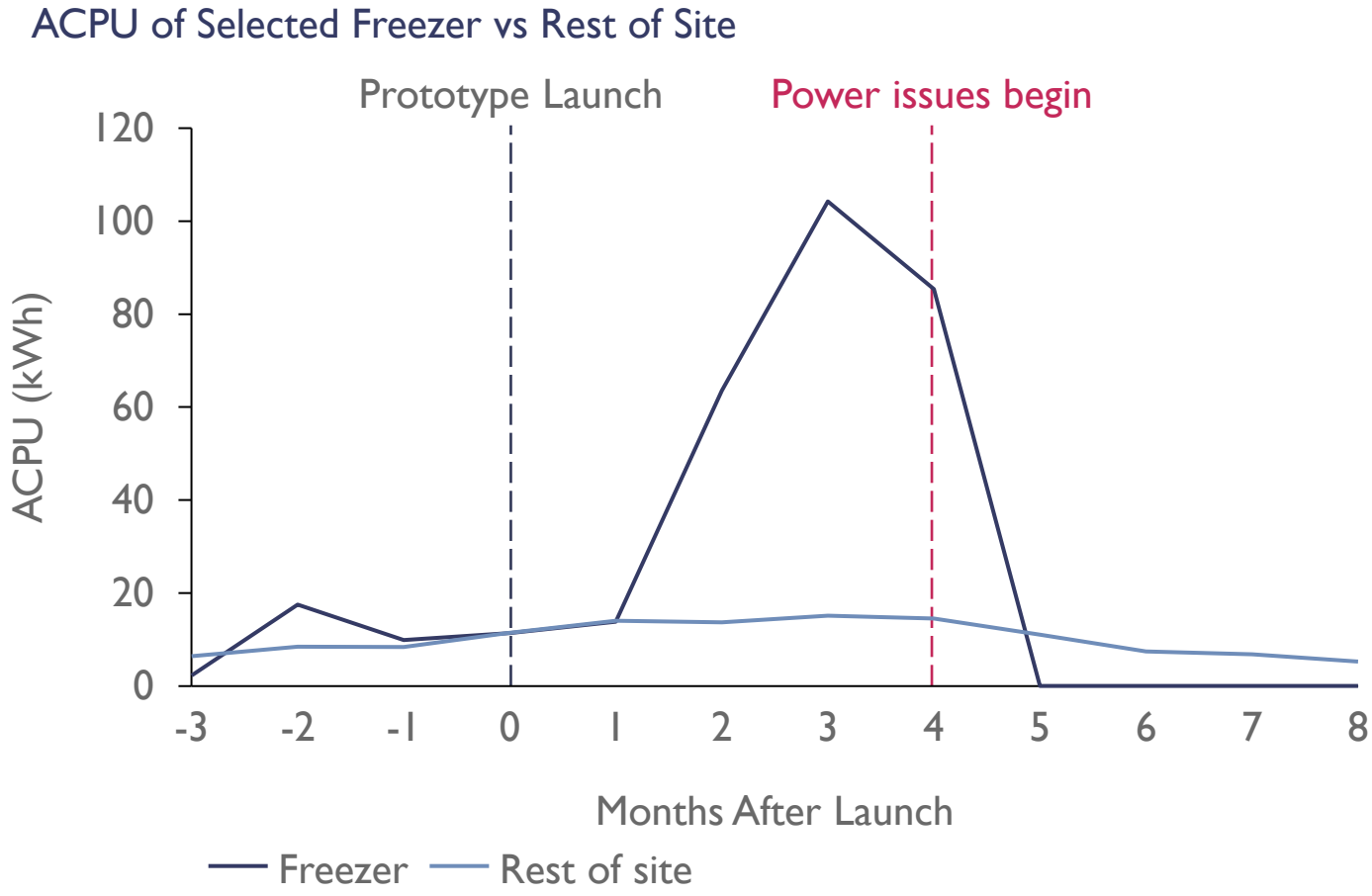
- There is a lack of fridges and freezers in households in most rural communities

Michael[1] took advantage of the opportunity to grow his business

- Michael owns a shop in his community
- He purchased a freezer to keep his produce cold as well as serve cold drinks to customers

The developer has lost Michael as a customer due to a lack of consistent power

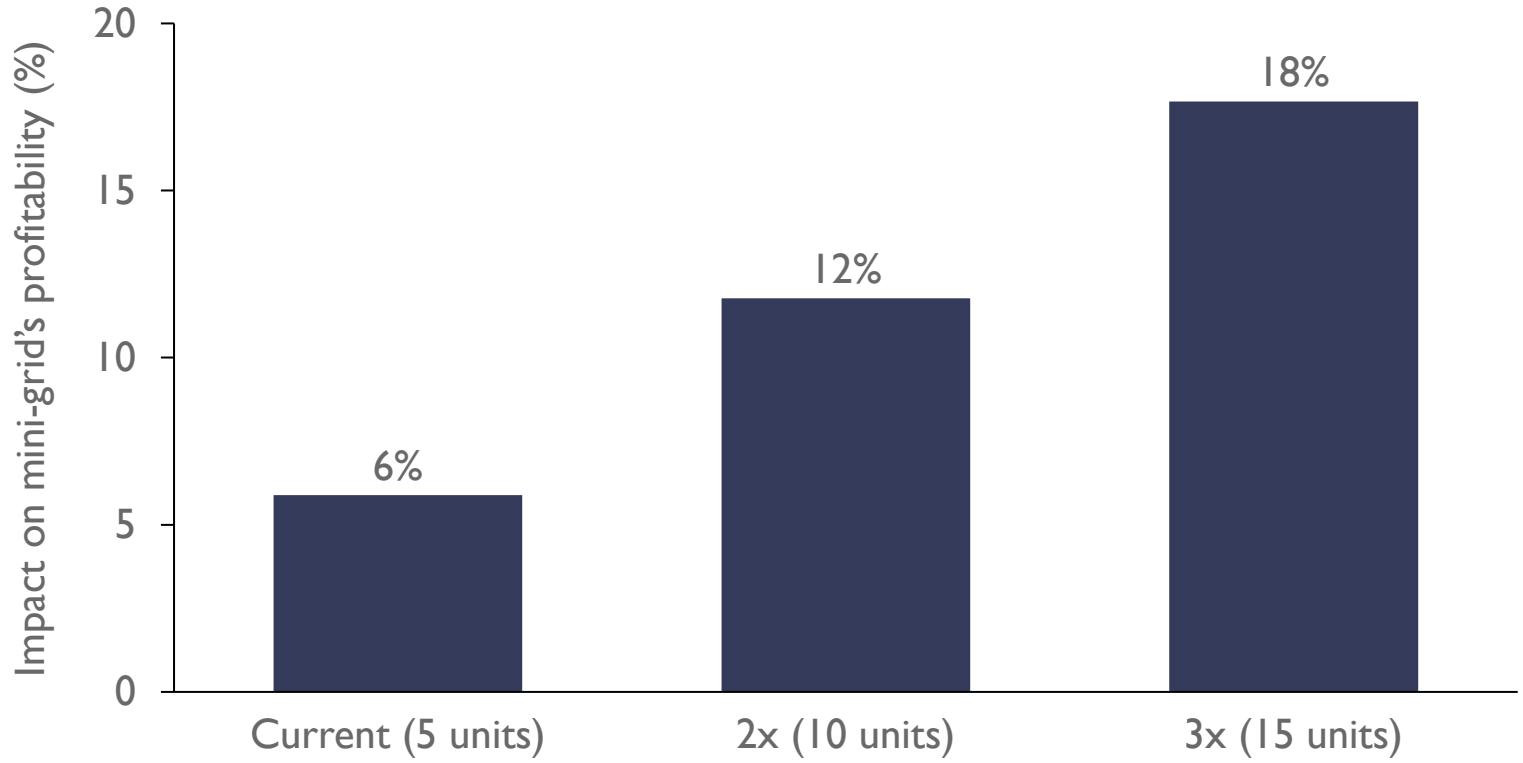
- Due to technical issues, the power supply at the site has been intermittent for a few months
- Michael has stopped using power on the mini-grid
- He has not repaid his loan for several months



Notes: 1 Name changed for privacy
Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter; Developer interviews

On average, five fridges increase mini-grid profitability by 6%. Doubling uptake has the same effect as one grain mill

Projected impact of increasing number of fridges/freezers on mini-grid profitability



Notes: 1. Estimated total addressable market is 9 fridges per site
Assumptions: Five fridges/freezers deployed on the mini-grid, 200 households per community, 10% of customers are businesses, 42% of businesses need fridges/freezers, Profitability is calculated as the increase in the IRR of the mini-grid (from a benchmark IRR of 7%) due to increased consumption from fridges/freezers
Source: Smart meter data from Sparkmeter, SteamaCo and Calinmeter; Developer interviews

Cold storage is a viable business model in rural areas due to the lack of fridges in most households. However, the addressable market[1] is small as it is limited to businesses.

On average, each group of five fridges deployed on the mini-grid will increase its profitability by 6%.

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What's next:

The Lab is partnering with ESMAP and other partners to make electric grain mills competitive with diesel

The Lab has 9 hypotheses on how this prototype impacts the mini-grid business model. We will address these in our next publication.

1. Average Revenue Per User (ARPU) at treatment sites will be 10% higher than at control sites (after adjusting for baseline ARPU differential between sites)
2. Consumption will shift to increased daytime usage, with a 25% increase in consumption during daylight hours on treatment sites vs control sites, and a 5 percentage-point increase in the proportion of electricity consumed during daylight hours
3. The additional revenue from increased consumption and interest payments on appliances will cover the total costs to the operator of managing the program
4. The total cost of using Angaza technology to manage loan repayments will be less than the total cost of managing loan repayments without using Angaza technology
5. Historically higher-user customers will exhibit the highest repayment rates
6. Solar mini-grids can sustain the load and meet the technical requirements of common income generating machines
7. Appliances procured through the program will be sufficiently well-suited to the mini-grid market that developers sell 90% of their inventory within one month
8. After two years, increased revenue or avoided expenditure resulting from use of the appliance will be greater than the cost of purchasing and operating the appliance
9. For customers who previously used diesel-powered appliances, it is equally or more profitable to use the electric appliances purchased through the program as compared to appliances powered by diesel

The Lab is continuing its work developing the building blocks to get energy-efficient, electric-powered income generating machines to market at scale

Building blocks	Description	The challenge	The Lab's work
 1. High-performing machines	Electric-powered agricultural machines that outperform diesel on cost and output in rural settings.	"Solar powered agro-processing units do not currently match diesel units in terms of performance at any scale" – IFC PULSE report (2019)	▪ Providing data, analysis, and funding to manufacturers to design mills and other agricultural income generating machines that work in rural Africa ▪ Working with funders and appliance aggregators to design and implement incentives for achieving set performance metrics
 2. Effective supply chains	Supply chains for the machines to get from international to local markets, and supply chains from urban distribution centres to rural sites.	High performing electric-powered machines are not being distributed to rural areas due to supply chain challenges.	▪ Introducing international and regional suppliers to existing local supply chains currently supporting distribution of diesel-powered machines ▪ Creating linkages with Indian and Chinese suppliers tackling the same challenges in Asia
 3. Financing for appliances	Financing for the machines for either customers or mini-grid operators.	Rural mini-grid customers cannot afford to buy the machines outright and mini-grid developers do not have the expertise to structure financing facilities in-house.	▪ Providing financiers with the data-backed business case they need to provide financing for off-grid income generating machines ▪ Establishing commercial contracts for developers or customers to contract with MFIs or other financiers

The Lab is pursuing partnerships with industry stakeholders to scale appliance financing schemes across the continent

THE WORLD BANK
IBRD • IDA

Kenya Power

- Developing options for an appliance finance & distribution pilot to make high-quality demand-stimulating appliances affordable to KPLC customers

ESMAP
Energy Sector Management Assistance Program

- Setting up a task force consisting of key industry stakeholders (such as developers, machine manufacturers/suppliers, financing companies and government agencies) to conduct road-shows to scale agricultural income generating machines, starting with Ethiopia

clasp

- Supporting CLASP to pilot an appliance financing procurement platform, in partnership with Nithio, to bulk purchase income generating machines and help developers get best-in-class machines at good rates and to enable end-users to access finance

Other industry stakeholders continue to build on these findings to drive mini-grid business model viability through income generating appliance financing schemes

Shell Foundation

Nithio

POWER AFRICA
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Nigeria Off-Grid Market Acceleration Program

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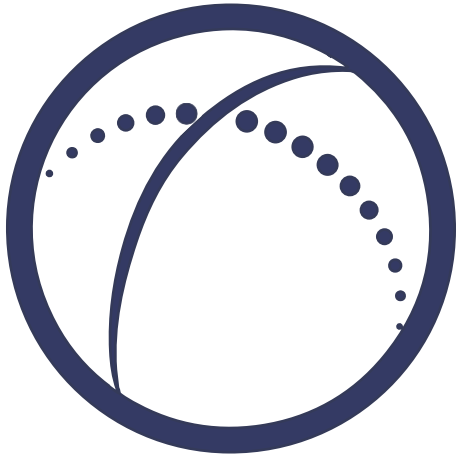
IF YOU ARE DESIGNING OR RUNNING AN APPLIANCE FINANCING SCHEME FOR MINI-GRID CUSTOMERS, PLEASE REACH OUT TO MINIGRIDSLABS@CROSSBOUNDARY.COM.



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