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Appliance Financing 1.0 Innovation Insight

Offering household appliances on credit did not significantly increase mini-grid revenues

April 2021

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Disclaimer and acknowledgements

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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:

Household appliances did not significantly increase consumption. Income generating machinery are necessary

Household appliances did not significantly increase mini-grid revenues. The Lab has moved its focus to scaling financing programs for income generating machinery

We present evidence supporting two headline findings with major implications for the future of appliance financing programs:

1. Offering household appliances to customers on set financing terms had no significant impact on mini-grid consumption and revenues. Among appliance users on sites in East Africa and Nigeria, ACPU fell 3% and 13% respectively, and ARPU fell by 13% and 22%
2. Income generating machinery show the highest potential for increasing consumption. In East Africa, for example, a grain miller introduced to the mini-grid consumes ~50x more energy than the median residential user

Note these findings are based on the balance of evidence from the Lab's testing. Other permutations of financing terms, markets, sample size, appliances, etc may result in different outcomes e.g., if financiers had run the program instead of mini-grid developers.

The Lab has moved its focus to scaling financing programs for income generating machinery:

1. Developing income generating machinery: the Appliance Financing 2.0 prototype resulted in an electric grain mill that was 4x more energy efficient than alternatives. The Lab is building on that success to develop agricultural machinery with local (e.g., Agsol) and international manufacturers
2. Developing supply chains: in the Appliance Financing 3.0 prototype, the Lab partnered with an international appliance supplier Asaga who imported energy efficient agricultural machinery from China for developers to sell to their customers. The Lab is now working with other specialists (e.g., CLASP) to identify and procure the best energy efficient machinery.
3. Securing financing to launch at scale: in Appliance Financing 3.0, the Lab partnered with NoMAP to develop a financing facility with MFIs in Nigeria. The Lab is now building on this by partnering with new financiers (e.g., Nithio)

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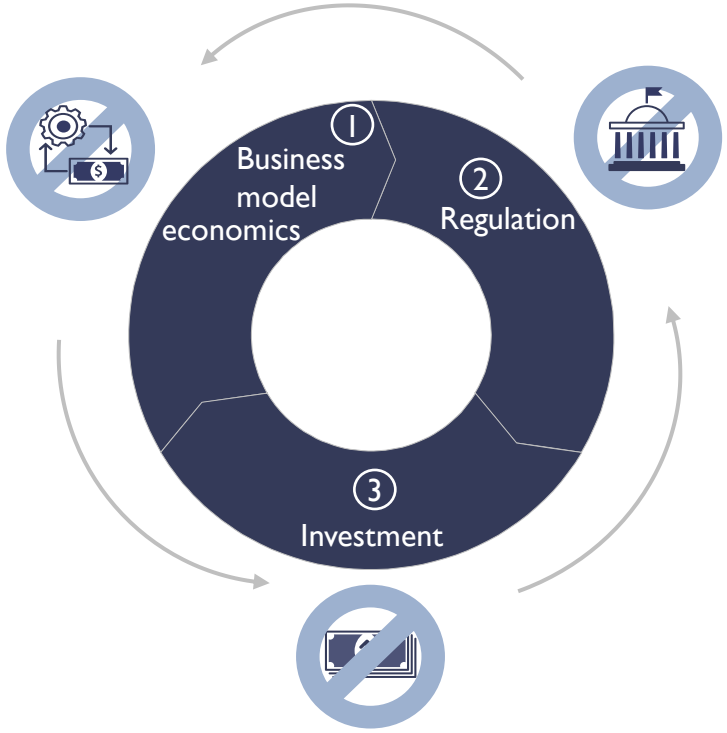
The Innovation Lab:

The Innovation Lab tests innovations to improve the mini-grid business model

The Innovation 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

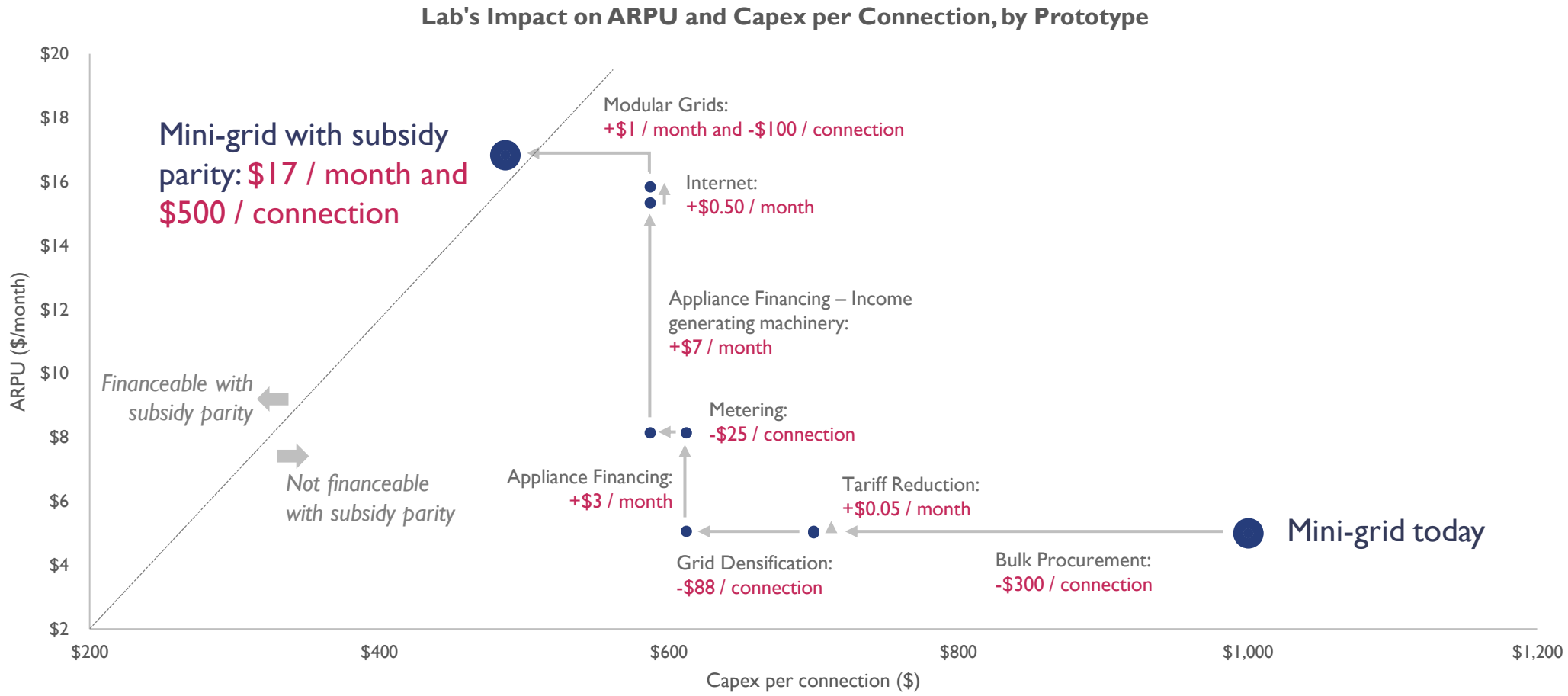
…to bring the Modern Energy Minimum to 260M Africans

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

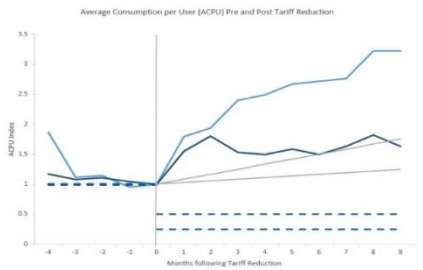


Notes: Modular Grids consists of two distinct innovations (Increasing Capacity and Extending Reach). A grid would, however, only be eligible for one of the two innovations at any given time.
The Connecting Beyond the Meter innovation is excluded from this graph as it delivers the combined impact of Appliance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

The Lab's *Innovation Insight* series provides early, actionable business intelligence on results from its 10 innovations tested in rural Africa; this publication focuses on Appliance Financing

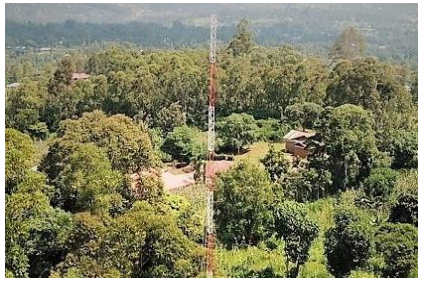
1
Financing programs for household and income generating machinery

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

In our first Appliance Financing *Innovation Insight*, published August 2019, we reported results 11 months after selling 663 appliances on credit in East Africa and Nigeria

We found that rural customers are use- and credit- constrained, and are ready to consume more power given access to appliances:

1. Offering appliances on credit has an immediate and strong effect on rural customers' consumption, with median monthly consumption among all customers increasing by up to 52% in the first five months following appliance delivery.
2. Mini-grid developers can raise revenues by implementing appliance financing schemes – revenues rose by 18% in East Africa, and 25% in Nigeria.
3. Rural customers principally purchased household appliances and as a result there was no significant shift to daytime consumption.

All the Lab's publications can be found on our website: https://www.crossboundary.com/labs/our-research/

This *Innovation Insight* brings more data to develop these findings, incorporating:

13 more months of hourly consumption and revenue data

67 more appliances

New analysis on loan repayment for appliance suppliers and financiers to act on

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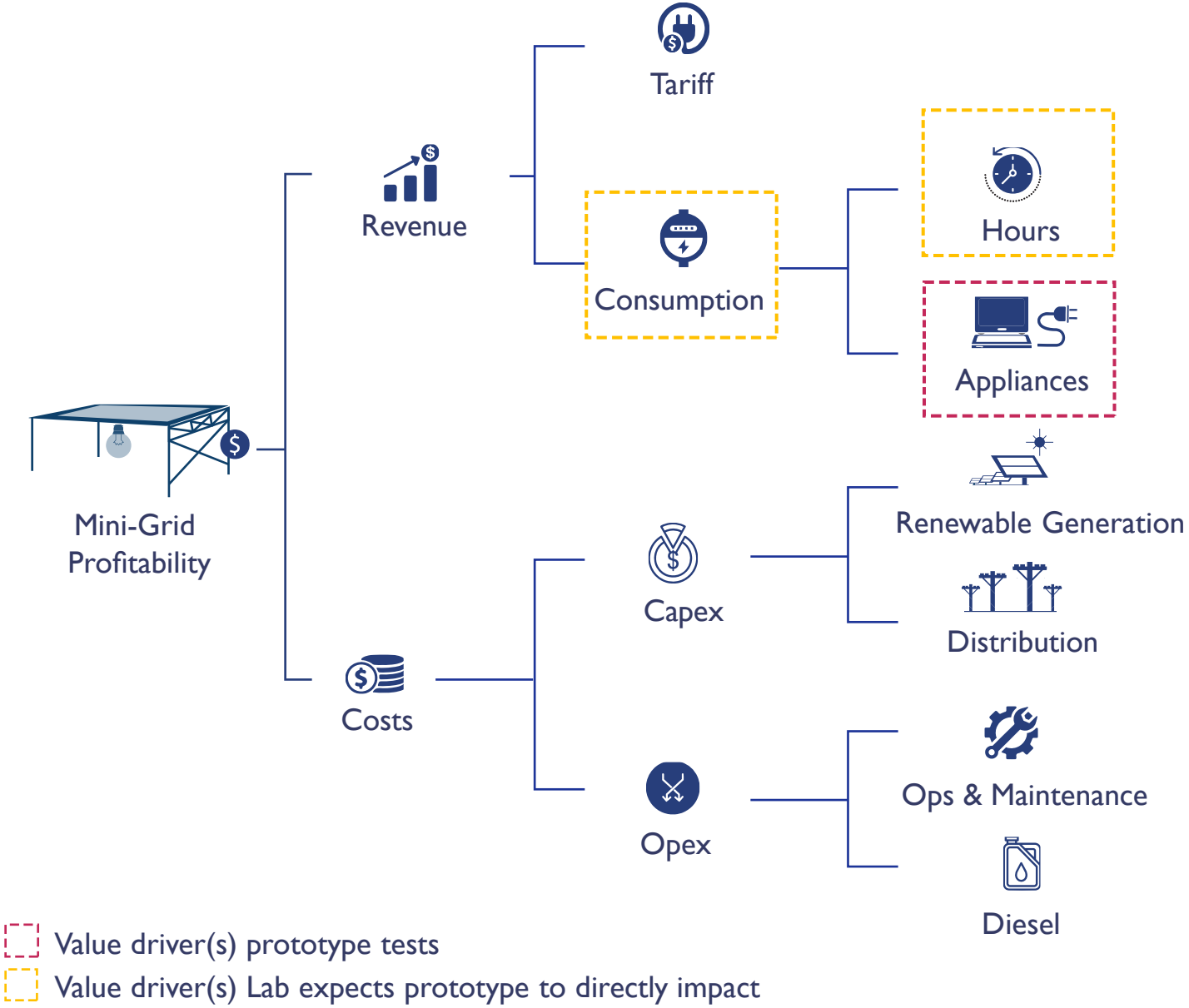
Why we're doing this:

Appliances drive customer consumption, and therefore mini-grid revenues

Appliances are a major driver of how much energy customers consume, and how much revenue developers earn.

The Lab expects offering customers appliances on credit will increase electricity consumption, both because customers can use energy in new ways, and they have a reason to use energy for longer.



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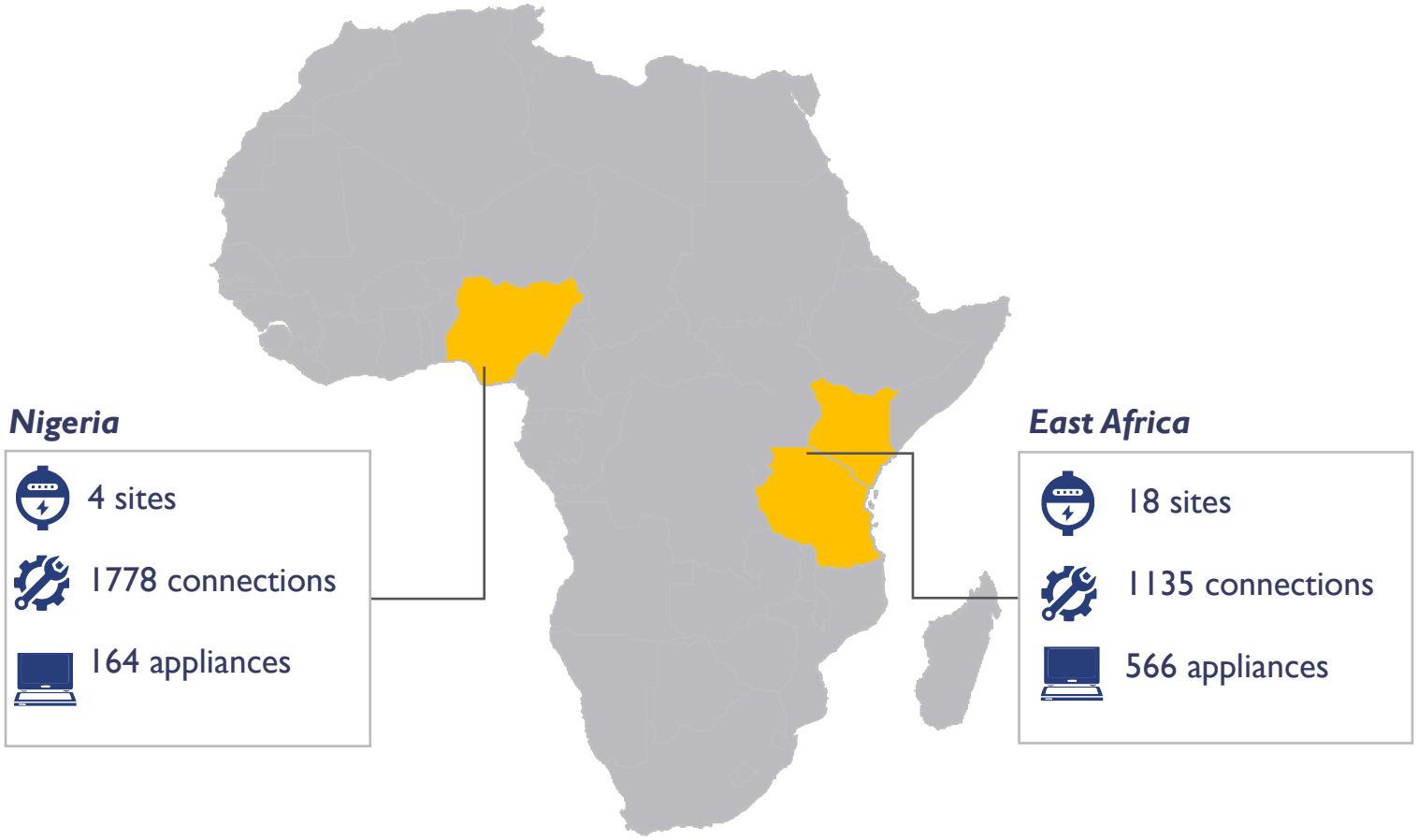
How we're doing it:

The Lab funded developers to offer customers appliances on credit in East Africa and Nigeria

The Lab funded developers to offer customers 730 appliances on credit across 22 sites in Kenya, Tanzania and Nigeria



Appliance selection was developer-led

- Developers chose appliance offerings according to customer demand, the mini-grid's ability to sustain the load, and feasibility of procurement and distribution
- Accordingly, appliance offerings varied by site

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-month loan term, with a 20% upfront deposit and a 2.55% monthly interest rate[1]

1. Due to particular circumstances, some developers made minor adaptations to these terms.

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What we're seeing:

Consumption and revenue levels of appliance purchasers did not increase in East Africa or Nigeria

The Lab had 5 hypotheses on how we expect the prototype to impact the mini-grid business model

1. Average revenue per user (ARPU) will be 30% higher after one year
2. Consumption will shift to increased daytime usage, with a 10 percentage point increase in the proportion of electricity consumed during daylight hours
3. Historically higher-user customers will exhibit the highest repayment rates
4. Of all appliances, TVs will have the highest uptake rate among customers
5. Fridge and freezer purchasers will exhibit the largest absolute increase in consumption

Note: A sixth hypothesis, which addresses the prototype's social impact, will be included in the final publication for this prototype. Customer surveys are conducted to collect customer-level data on spending, employment, and energy use, among other demographic and socioeconomic metrics.

Note: Axes marked by month reflect totals at the end of each month; axes marked by day reflect totals at the end of each day; axes marked by hour reflect totals at the end of each hour. We aggregate and report revenues using the mean, as average revenue per user (ARPU) is the metric most commonly used by mini-grid developers to evaluate revenues. We aggregate and report consumption using the median to provide a different perspective of the data. Sites experiencing sustained system outages or sizeable tariff changes were excluded from the analysis.

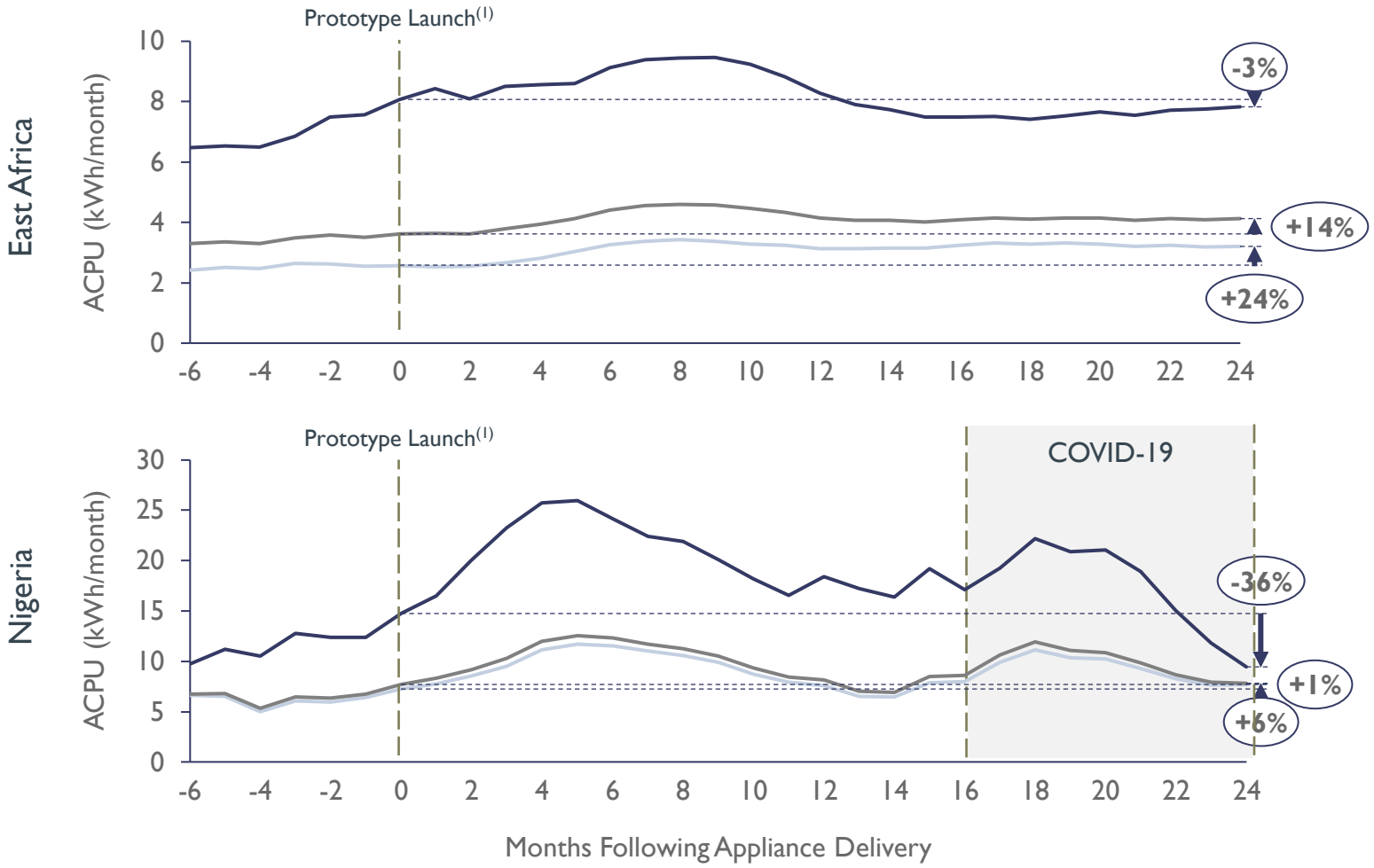
Hypothesis 1

Average revenue per user (ARPU) among all customers will be 30% higher after one year.

What we expected

Offering customers appliances will increase the number of customers using energy to power those appliances, and thus increase overall consumption. This will lead to a 30% increase in revenues for mini-grid developers.

Average Monthly Consumption per User (ACPU) Pre and Post Appliance Delivery



Note: Prototypes launched between Feb – Mar 2018, COVID-19 only affected Nigeria as prototype was launched there after East Africa
Source: Smart meter data from Sparkmeter and SteamaCo

What we're seeing

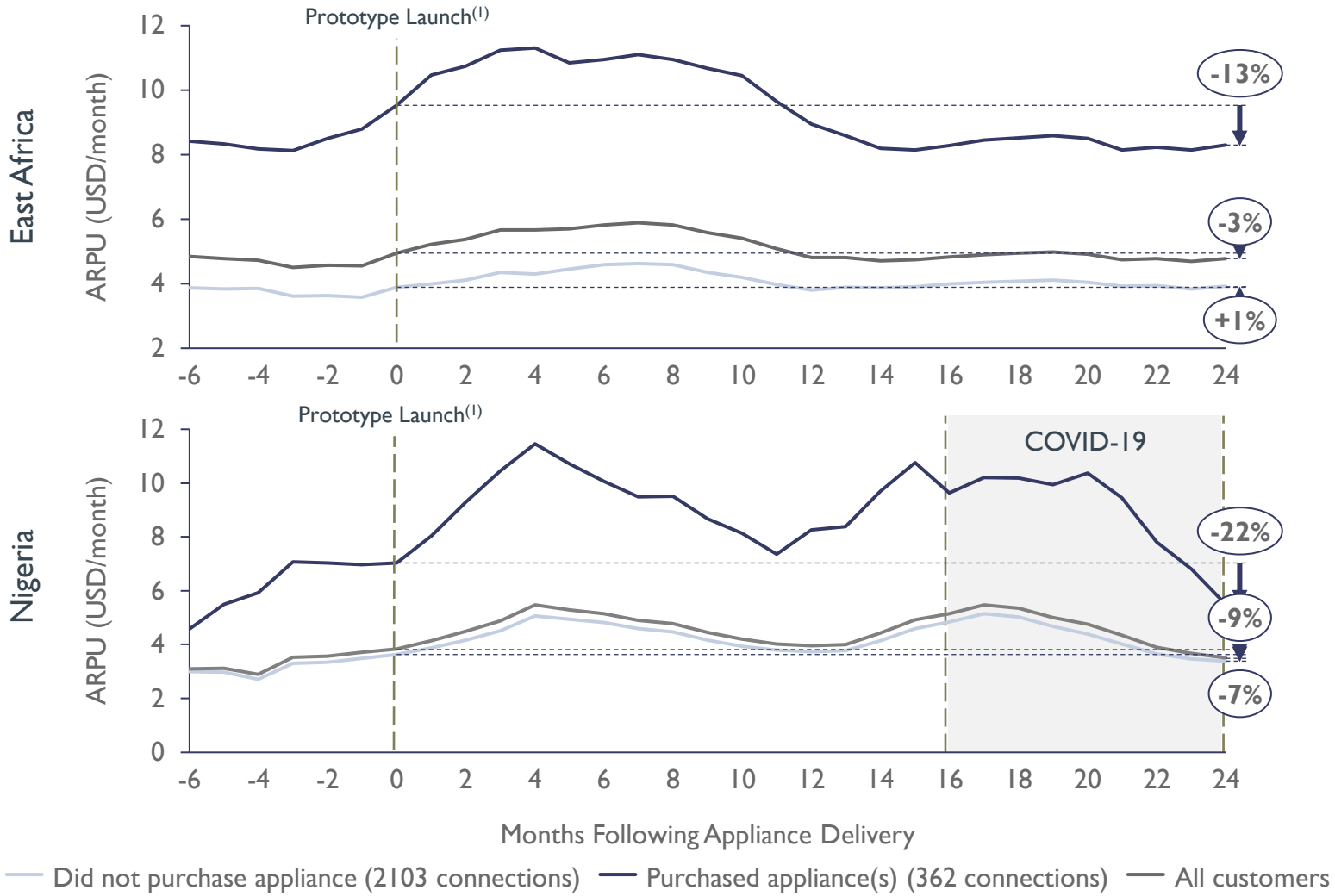
In East Africa, consumption increased 14% but it was driven by customers who did not purchase appliances who grew ACPU by 24%. By the end of the period, customers who purchased appliances ACPU fell slightly by 3%.

In Nigeria, consumption dropped 36% for appliance purchasers, while overall site consumption remained stable.

What it means

Appliances did not increase consumption. Appliance purchasers were already among the highest consumers prior to the launch of the prototype, however, they did not use appliances as expected and further increase consumption.
The reduction was more pronounced in Nigeria, potentially due to the economic downturn induced by the COVID-19 lockdown.

Average Monthly Revenue per User (ARPU) Pre and Post Appliance Delivery



Note: Prototypes launched between Feb – Mar 2018, COVID-19 only affected Nigeria as prototype was launched there after East Africa
Source: Smart meter data from Sparkmeter and SteamaCo

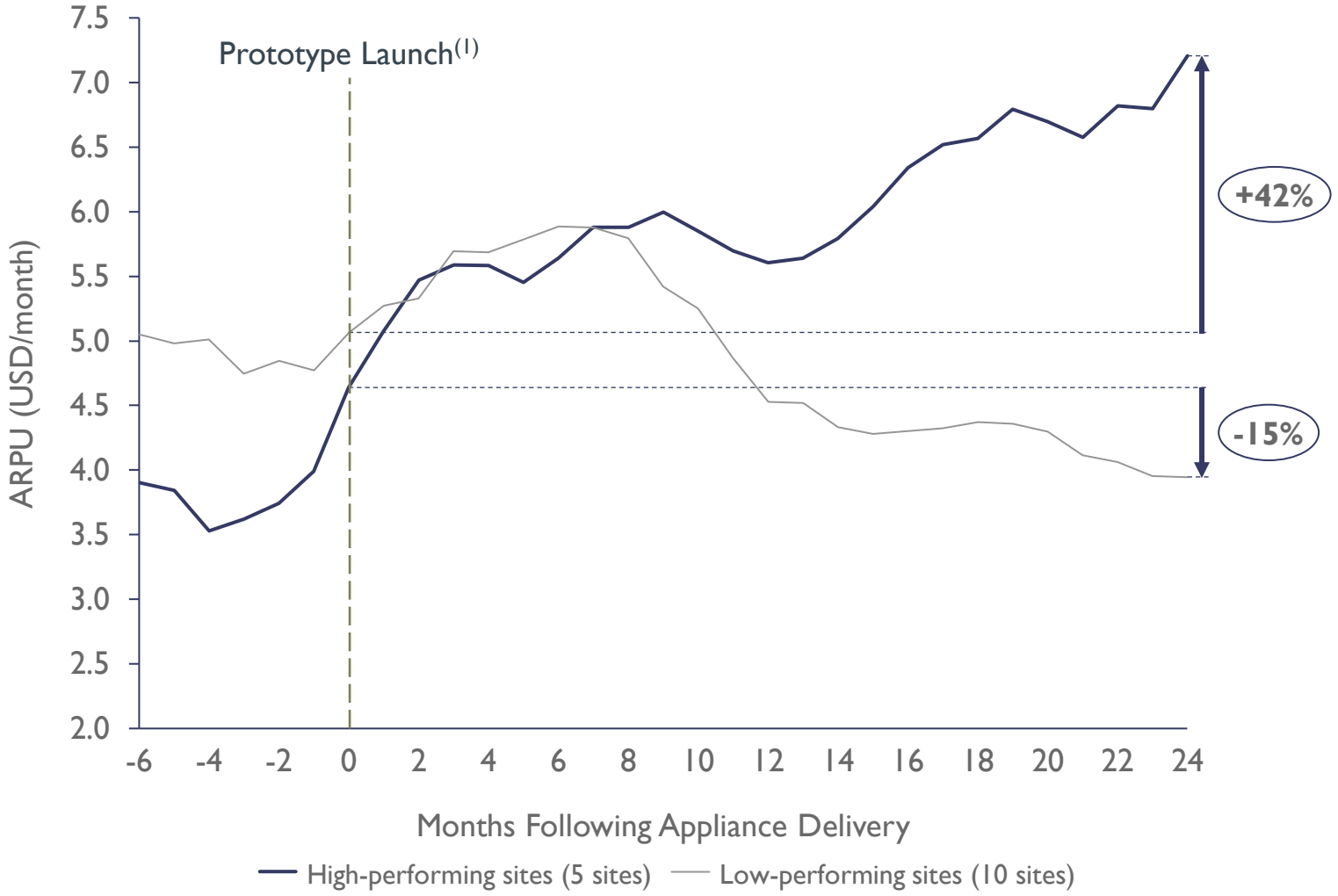
What we're seeing

There was a decline in ARPU from all customers despite slight increases in ACPU. In East Africa, ARPU fell by 13% for appliance purchasers, while overall ARPU remained stable - decreasing only 3% from baseline. In Nigeria, ARPU from all customers declined 9%

What it means

In both East Africa and Nigeria, appliance purchasers experienced a decline in ARPU. Surveys show that customers are not using appliances as expected due to their inability to cover the increasing energy bill. Furthermore, the ARPU decline of 9% on Nigerian sites vs 1% ACPU growth is likely due to the marginal shift to daylight hours where tariffs are generally cheaper. This decline was likely further exacerbated by the COVID-19 pandemic.

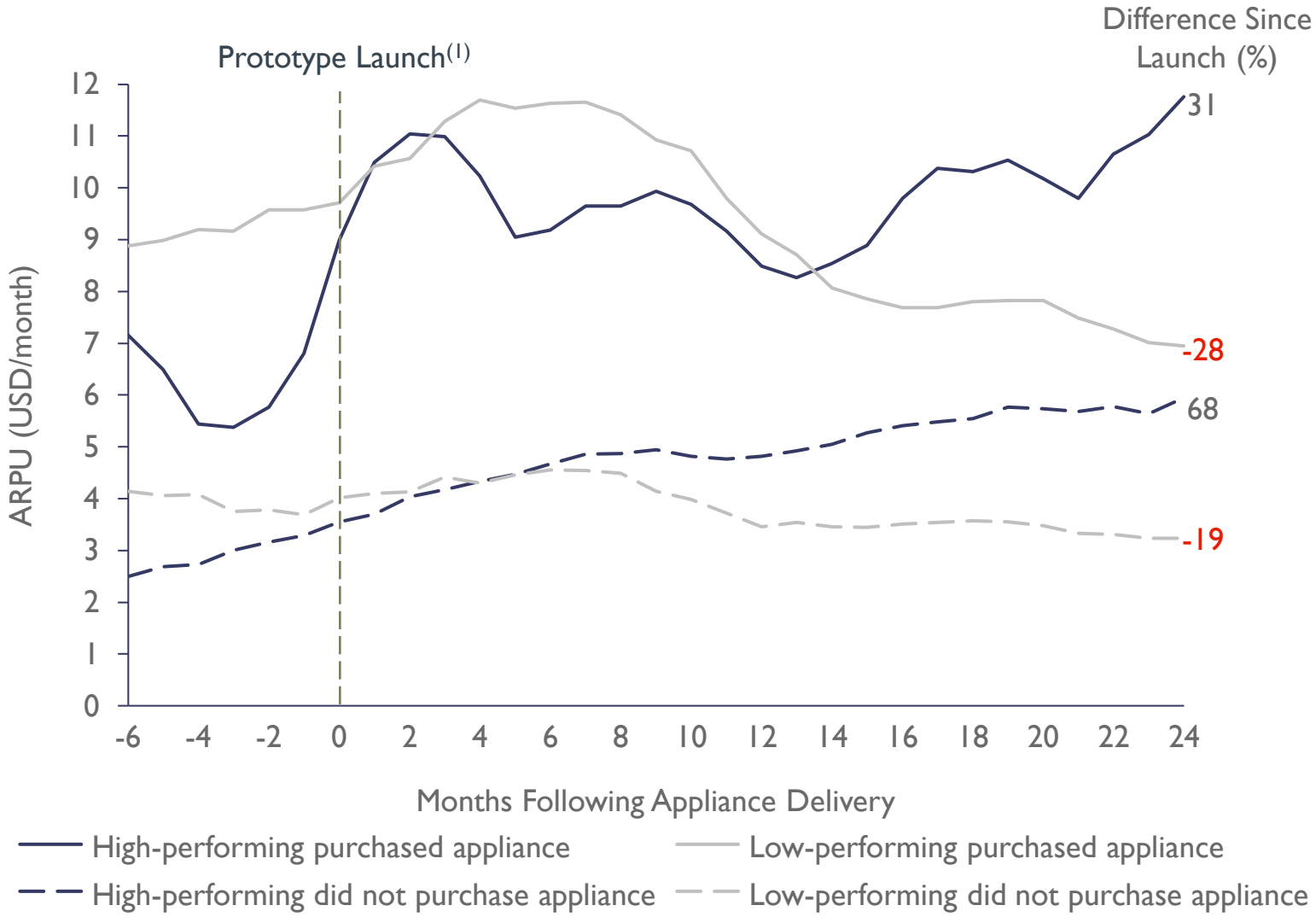
Average Monthly Revenue per User (ARPU) Pre and Post Appliance Delivery East Africa deep-dive



Note: Prototypes were launched between Feb – Mar 2018
Source: Customer smart meters

While average revenues fell, strong revenue growth is possible on high-performing sites…

Average Monthly Revenue per User (ARPU) Pre and Post Appliance Delivery
East Africa deep-dive



Note: Prototypes were launched between Feb – Mar 2018
Source: Customer smart meters

…but household appliances do not seem to be driving that growth.

The control group and appliance finance customers follow similar trends.

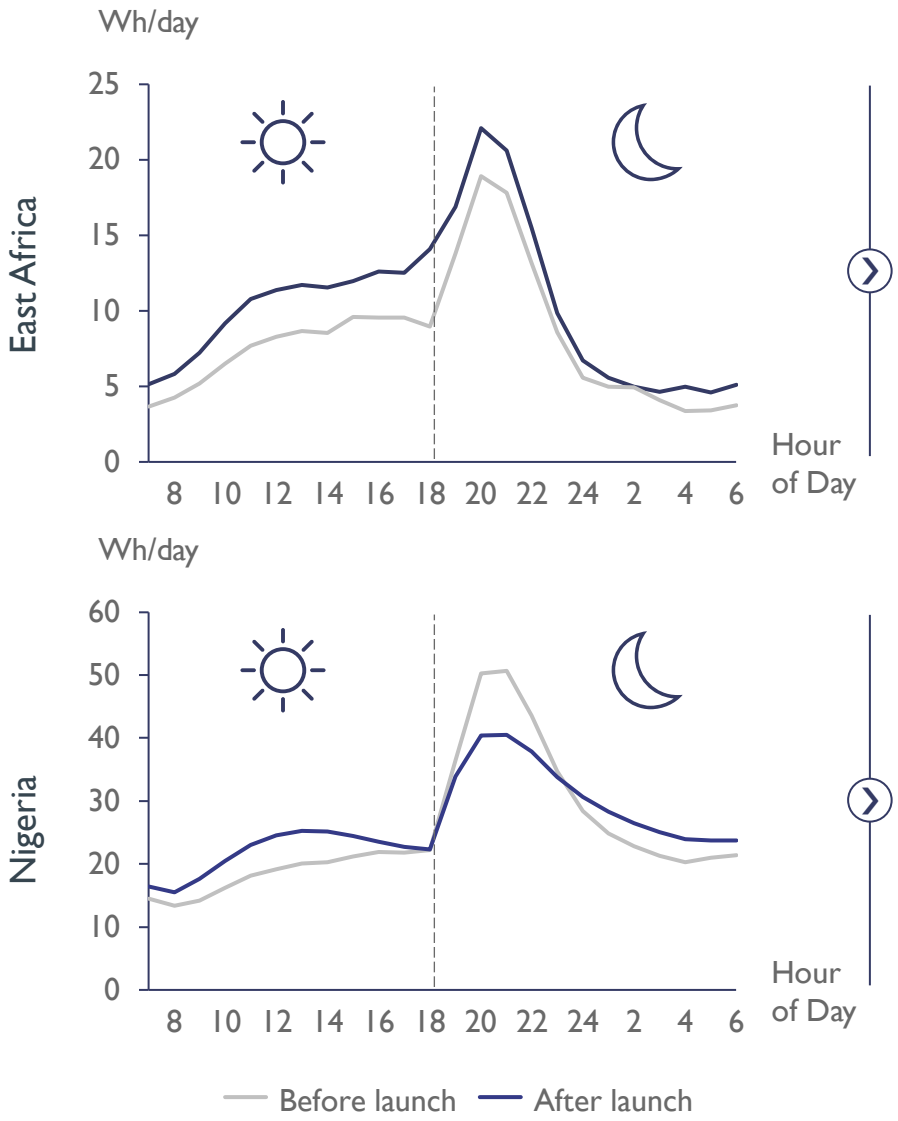
Hypothesis 2

Consumption will shift to increased daytime usage, with a 10 percentage point increase in the proportion of electricity consumed during daylight hours.

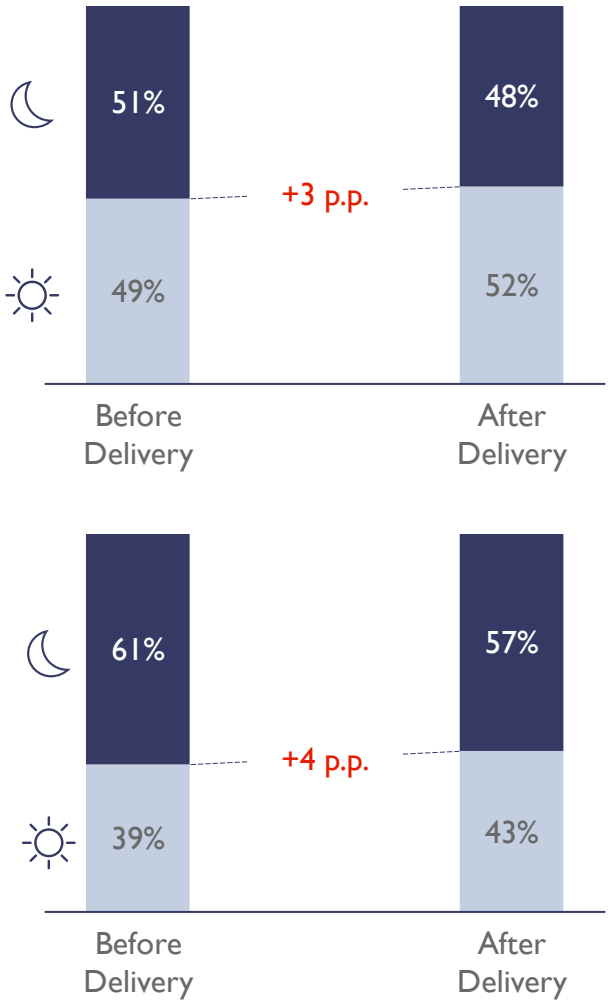
What we expected

Offering customers appliances will increase the number of customers using energy to power those appliances, and thus increase overall consumption. We expected this increase in consumption to be concentrated during daylight hours (6am-6pm) owing to customers buying high-consuming income generating machinery.

ACPU by Time of Day



Total nighttime vs. Daytime Consumption



Source: Smart meter data from Sparkmeter and SteamaCo

What we're seeing

Offering household appliances on credit only marginally shifts consumption to daylight hours, when solar mini-grids supply least-cost energy

What it means

Customers use household appliances during the evening and thus do not shift consumption to match the grid's hours of generation. Offering appliances primarily used during the day, such as income generating machinery, may be an effective way of aligning consumption with the hours of generation, allowing developers minimize the number of batteries the grid requires to store energy and thereby minimizing costs

Hypothesis 3

Historically higher-use customers will exhibit the highest repayment rates.

What we expected

Customers who can afford to run their appliances for longer have more disposable income, and are more likely to repay their loans on time.

Expected Loss by Consumption Group

(Total Loan Not Repaid / Total Loan)

1. Customers are grouped into bands based on their monthly energy consumption

Note: Repayment period had elapsed in both countries prior to start of COVID-19 pandemic. Mini-grid customers are customers for life. As such, even if the payment becomes dormant, developers can continue collecting for years after during the ordinary course of business

Source: Smart meter data from Sparkmeter and SteamaCo; Benchmarks from: Boiyo Kibet et al: Effect of Selected Factors on Non-performing Agricultural Loans in Commercial Banks in Kenya, Business Daily Africa, CGAP, Nairametrics, Techcrunch

What we're seeing

High energy consuming customers across both regions had better than average repayment rates, thus reducing overall loss given default.

What it means

Appliance financing programs targeted at high energy consuming customers can decrease loss given default and improve the attractiveness of these programs to developers.

High repayment rates in Agriculture in both East Africa and Nigeria are promising for agricultural income generating machinery.

Hypothesis 4

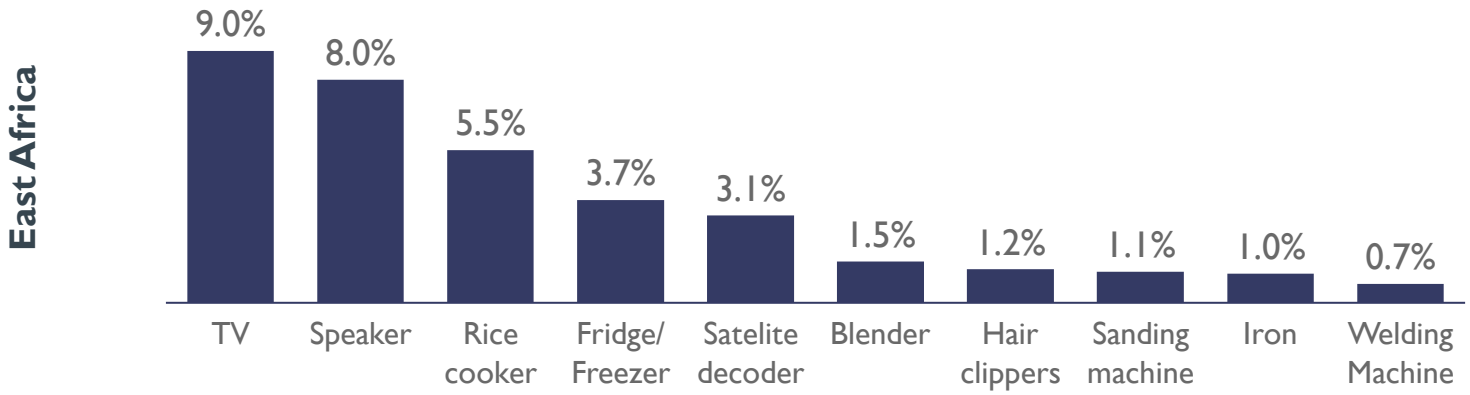
Of all appliances, TVs will have the highest uptake rate among customers.

What we expected

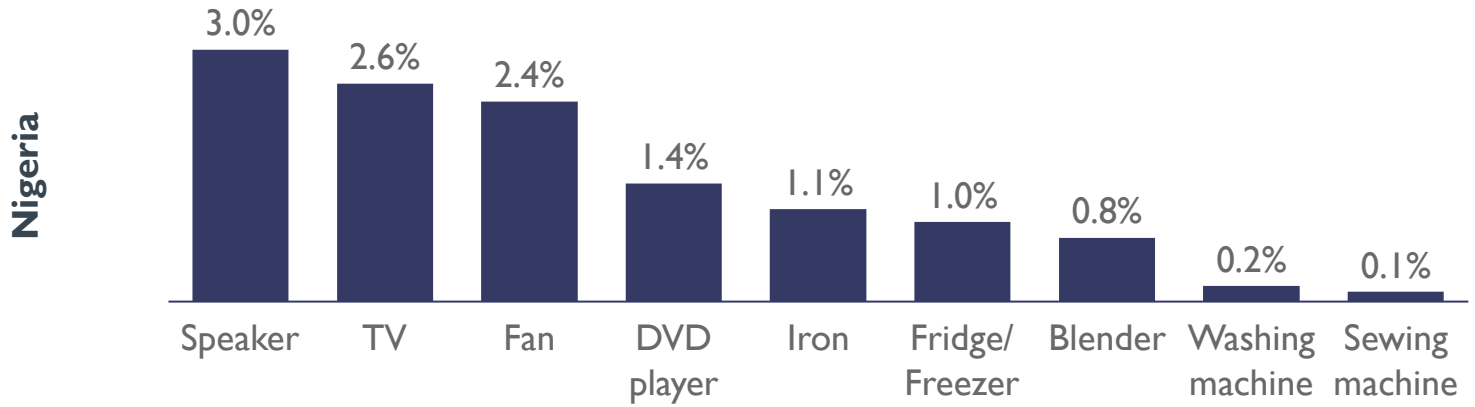
TVs will be the most popular appliance among customers, because of their price and entertainment value.

Appliance Uptake Rate by Appliance

# purchased	194	156	3	76	61	26	19	4	10	4
# offered	2155	1959	55	2072	1959	1778	1599	363	957	592



# purchased	19	24	22	13	9	6	4	1	1
# offered	623	910	910	910	803	623	516	516	803



Note: Uptake rate is calculated as # purchased divided by # offered

What we're seeing

TVs were the most purchased appliance in both East Africa (194) and Nigeria (24). In East Africa, nearly one in ten customers given the opportunity to purchase a TV did so. In both geographies, speakers proved similarly popular in terms of uptake rate, though slightly fewer were sold overall.

What it means

Offering entertainment products such as TVs, speakers, DVD players, and satellite decoders may improve customer uptake and minimize program costs by streamlining offerings. However, while these appliances may improve the quality of life of owners, they do not increase consumption on the mini-grid

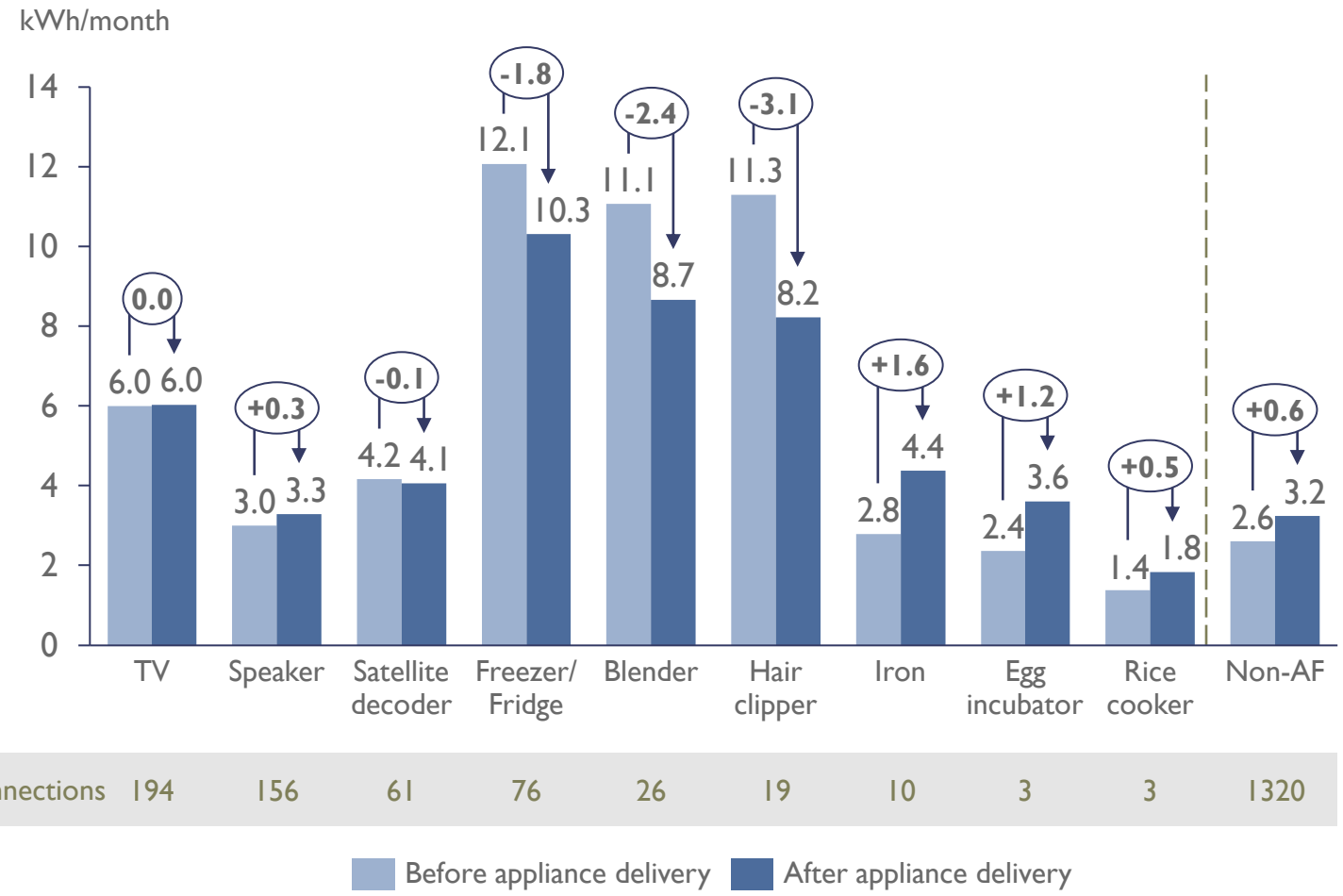
Hypothesis 5

Fridge and freezer purchasers will exhibit the largest absolute increase in consumption.

What we expected

Fridges and freezers use more energy than other appliances offered because they must have a continual supply of power to run and consume much more power per hour. Moreover, customers who can afford to purchase fridges and freezers are likely to have greater disposable incomes and are thus able to increase their consumption the most.

Average Consumption per User (ACPU) Change by Appliance
East Africa



Note: Showing median monthly consumption of months -6-0 (Pre-Appliance Financing) and months 18-24 (Post-Appliance Financing) since launch prototype
Source: Smart meter data from Sparkmeter and SteamaCo

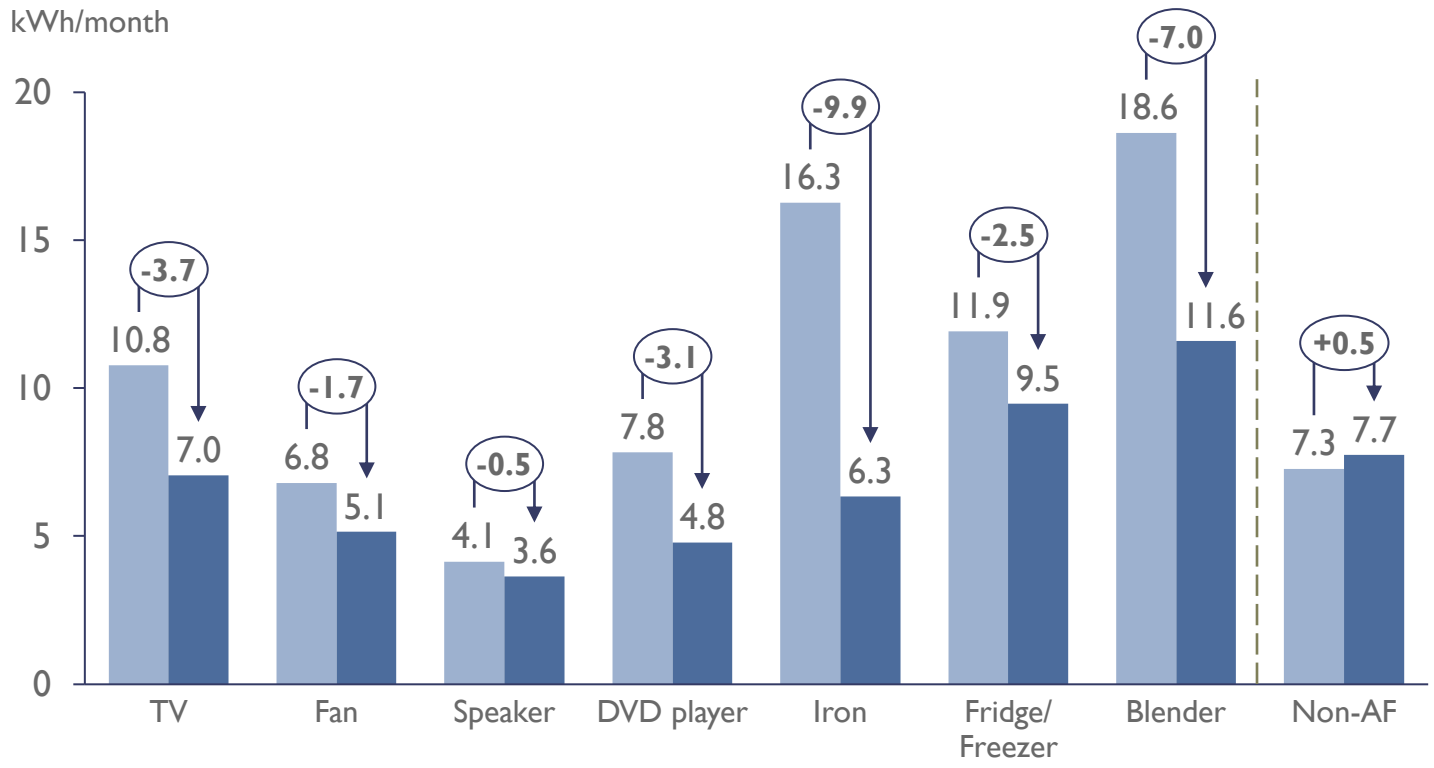
What we're seeing

In East Africa, high consuming appliance users (freezer/fridge, blender, hair clipper) reduced their consumption by an average of ~2.1kWh/month, while lower consuming appliance users increased consumption by an average of ~0.2kWh/month

What it means

Users of high consuming appliances found it difficult to maintain consumption levels likely due to the impact of additional appliances on their limited income.

Average Consumption per User (ACPU) Change by Appliance
Nigeria



# connections	24	22	19	13	9	6	4	183

Before appliance delivery After appliance delivery

Note: Showing median monthly consumption of months -6-0 (Pre-Appliance Financing) and months 18-24 (Post-Appliance Financing) since launch prototype
Source: Smart meter data from Sparkmeter and SteamaCo

What we're seeing

In Nigeria, high consuming appliance users (freezer/fridge, blender, iron, TV) reduced their consumption by an average of ~5.1kWh/month, with lower consuming appliance users also reducing consumption by an average of ~1.6kWh/month

What it means

Users of high consuming appliances found it difficult to maintain consumption levels likely due to the impact of additional appliances on their limited income. In Nigeria, this effect was likely further exacerbated by the negative economic impact of the COVID-19 pandemic. At least 35% of appliance purchasers reported having a much worse financial situation during the pandemic. As one customer put it, "we can't afford paying for TV electricity since COVID. I need money to attend [to] other needs"

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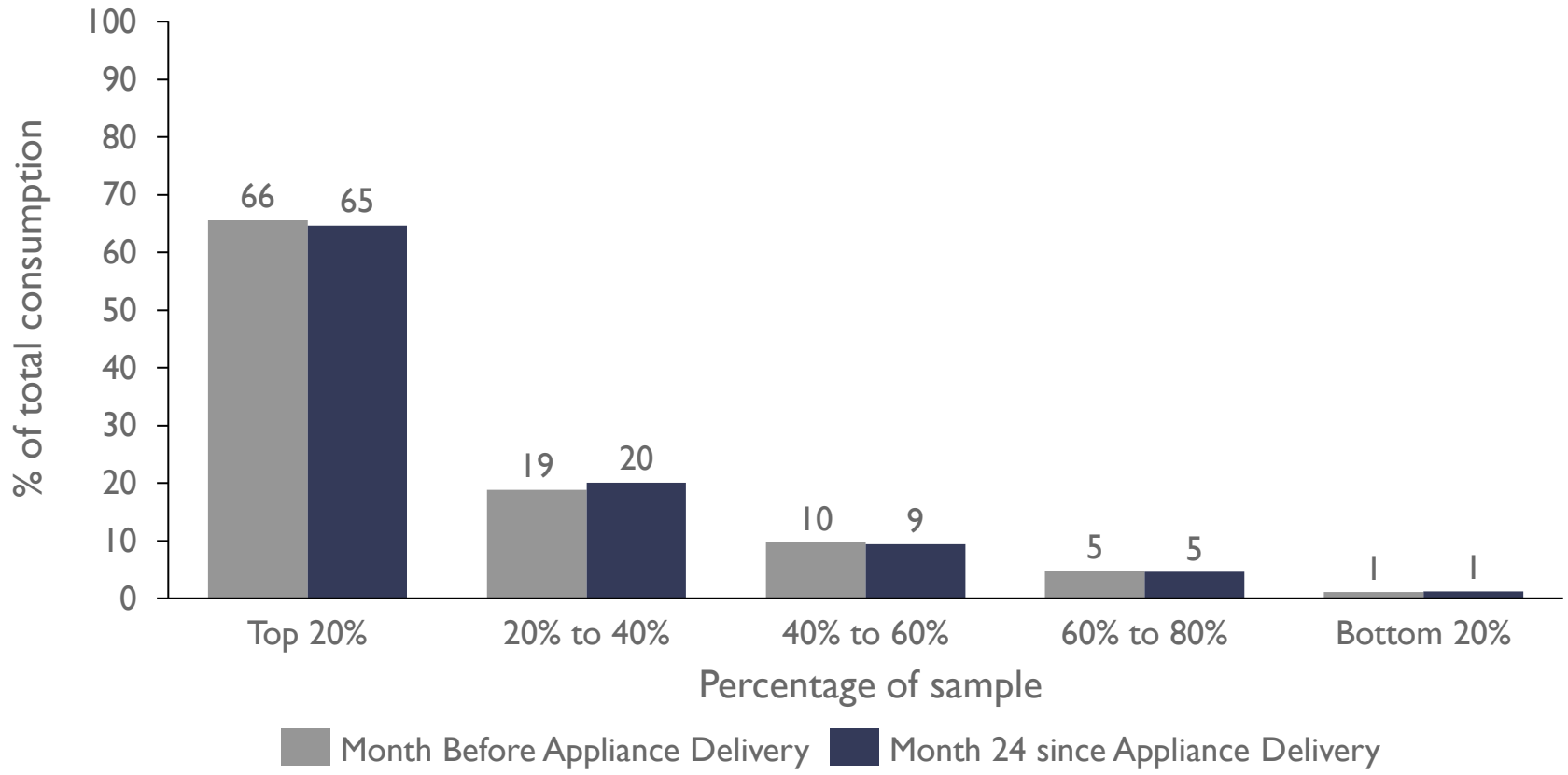
What we're going to do about it:

The Lab is scaling appliance financing programs that focus on income generating machinery

The mini-grid business model is heavily dependent on the top customers. The top 20% of mini-grid customers account for ~65% of electricity consumption.

Consumption Distribution Pre and Post Appliance Delivery
East Africa



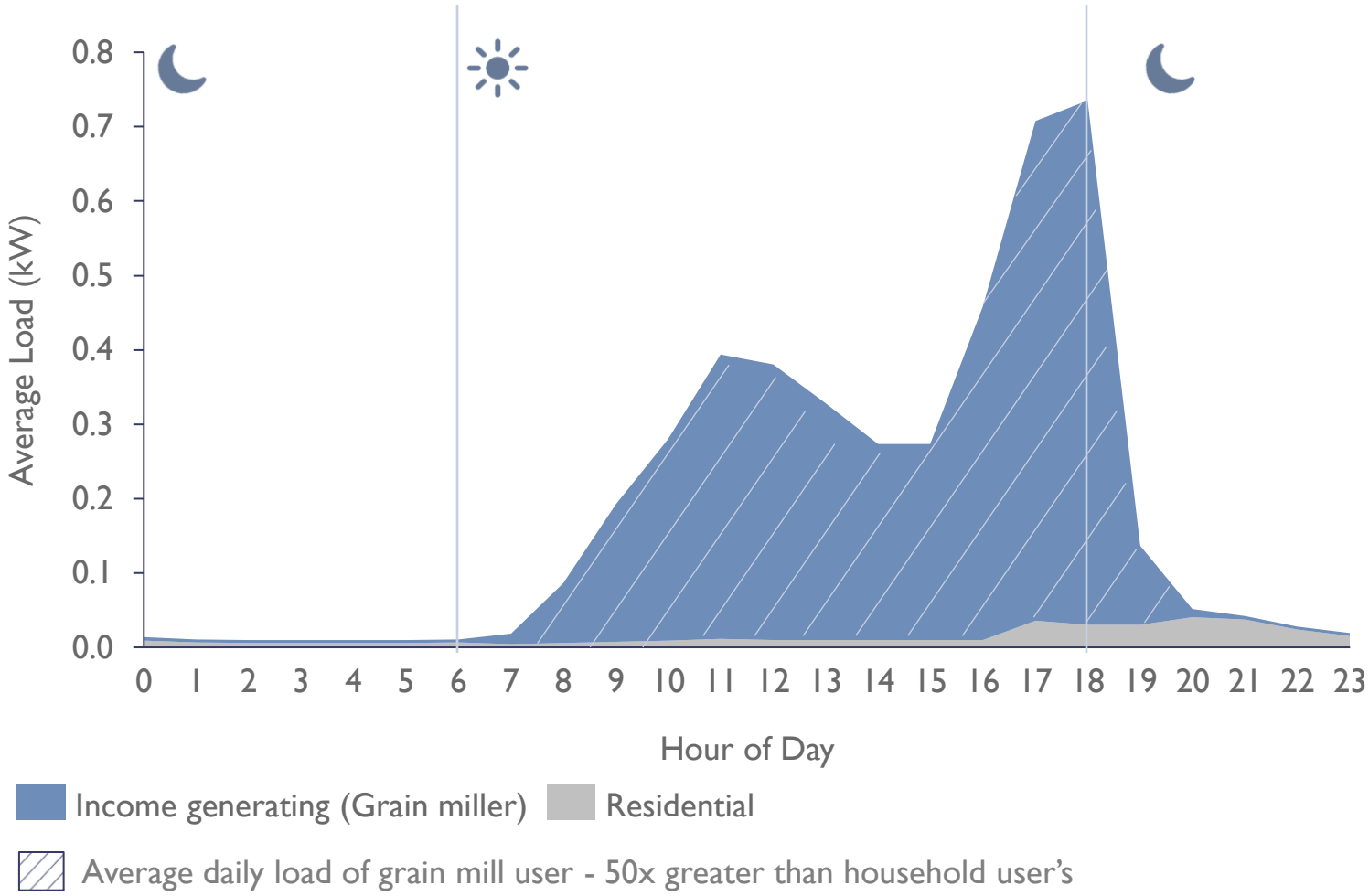
Household appliances did not change the consumption profile.

Appliance financing users were already among the highest consumers prior to the launch of the prototype, and while they maintained their consumption levels, the increases in consumption by non appliance financing users didn't alter the consumption distribution.

Notes: 1. Prototypes were launched between Feb – Mar 2018
Source: Smart meter data from Sparkmeter and SteamaCo

To grow those top users, we must focus on agricultural income generating machinery. For example, grain millers consume ~50x more energy than the median residential user

Daily load profile: Income generating and residential customer
East Africa



Source: Smart meter data from Sparkmeter and SteamaCo

However, solar-powered agricultural machinery that can compete with diesel doesn't exist, at scale, in any market

Diesel mills dominate the rural off-grid market in Africa as they are cheaper and faster than local solar mills…

Metric	Diesel mill	Solar powered electric mill[1]
Price ($)	1,000	2,000
Energy Spend ($/kg)	0.02	0.02 – 0.06[4]
Power rating (kW)	7.5 – 20	2.2
Throughput (kg/hr)	200	60

…and solar mills sourced internationally require substantive modifications to work in local markets

As part of the Lab's testing, PowerGen[2] and other local partners had to modify the electric mills to work in Tanzania:

- Installed larger pulleys to increase throughput
- Added a switch to run the mill's rice huller and maize grinder separately, to improve efficiency
- Replaced 1.5 mm sieves with 0.8 mm sieves to produce fine quality flour suitable to local preference
- Installed soft starters to minimize surge in power draw

The resulting mills had a 50% higher throughput of 90 kg/hr, but this is still less than the target throughput of 200 kg/hr for diesel mills

"Solar powered agro-processing units do not currently match diesel units in terms of performance at any scale" – IFC[3]

1. Mills from China Source Impacting, before changes. 2. In partnership with Factor[e], Agsol and SIDA; 3. IFC PULSE Report (2019); 4. Calculates at tariff of $0.5/kWh to $1.5/kWh

To get energy-efficient, solar-powered agricultural machinery to market at scale, we need three building blocks

1. High-performing machinery

Solar-powered agricultural machinery that outperforms diesel on cost and output in rural settings

2. Effective supply chains

Supply chains for the machinery to get to local markets (if sourced internationally), and supply chains from urban distribution centres to rural sites

3. Financing for appliances

Financing for the machinery for either customers or solar mini-grid system operators

The Lab is building the evidence base for appliance financing programs, focused on income generating machinery, across Africa and working with partners to scale it

	Key activities	What the lab is doing
1	**Developing income generating machinery**	• Providing data, analysis, and funding to global, regional, and local manufacturers to design mills and other agricultural income generating machinery that work for mini-grid developers, customers, and appliance operators in rural Africa • Working with funders and appliance aggregators such as CLASP to design and implement incentives for achieving set performance metrics, such as prizes • Coordinating with local and regional suppliers, such as Agsol, and international players, such as Siemens, to develop, customize, and test energy-efficient agricultural income generating machinery
2	**Developing supply chains**	• Introducing international and regional suppliers to existing local supply chains currently supporting distribution of diesel-powered machinery • Expanding local supply chains to serve international and regional suppliers by connecting suppliers with local distributors or other required partners • Partnering with CLASP & Nithio to aggregate demand on appliance procurement platform to optimize procurement and delivery from international and regional suppliers
3	**Securing financing and launching at scale**	• Providing financiers, such as Nithio and local MFIs, with the data-backed business case they need to provide financing for off-grid PU agricultural machinery • Establishing commercial contracts for developers or customers to contract with MFIs or other financiers, in line with the Lab's current work with NOMAP testing financing from local MFIs to support appliance financing programs across Nigeria

Partners

Developers
- Nayo Technology
- Rift Valley Energy
- PowerCorner
- Husk Power
- ARC Power
- Nal Offgrid
- PowerGen
- Powerhive
- Havenhill
- RVE.SOL
- SteamaCo
- Rubitec
- ACOB
- A4&T
- GVE

Donors
- Shell Foundation
- Rockefeller Foundation
- DOEN Foundation

Government Agencies
- Zambia Rural Electrification Agency
- Nigeria Rural Electrification Agency
- Ministries of Agriculture
- Ministries of Finance

Implementing Partners
- Factor[e]
- Odyssey
- Nithio
- CLASP
- NoMAP

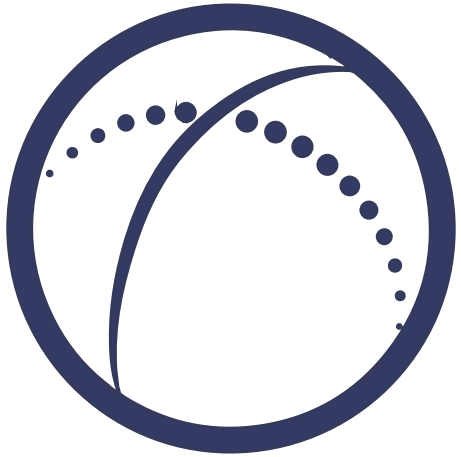
Machinery Suppliers
- Energy Excell
- Global Icetec
- Agsol
- Siemens

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

Shell Foundation | NoMAP Nigeria Off-Grid Market Acceleration Program | clasp | REA RURAL ELECTRIFICATION AGENCY ENERGY=EMPOWERMENT=EFFICIENCY

The ROCKEFELLER FOUNDATION | Nithio | AFRICAN DEVELOPMENT BANK GROUP | POWER AFRICA A U.S. GOVERNMENT-LED PARTNERSHIP

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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