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# Innovation Insight

## Measuring the impact of reducing mini-grid tariffs on customer consumption and grid NPV

September 2020

# The Innovation Lab's work is made possible by the following funders:

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powerhive

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# Disclaimer and acknowledgements

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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AMDA

UMass Amherst

RIT
Rochester Institute of Technology

Duke UNIVERSITY

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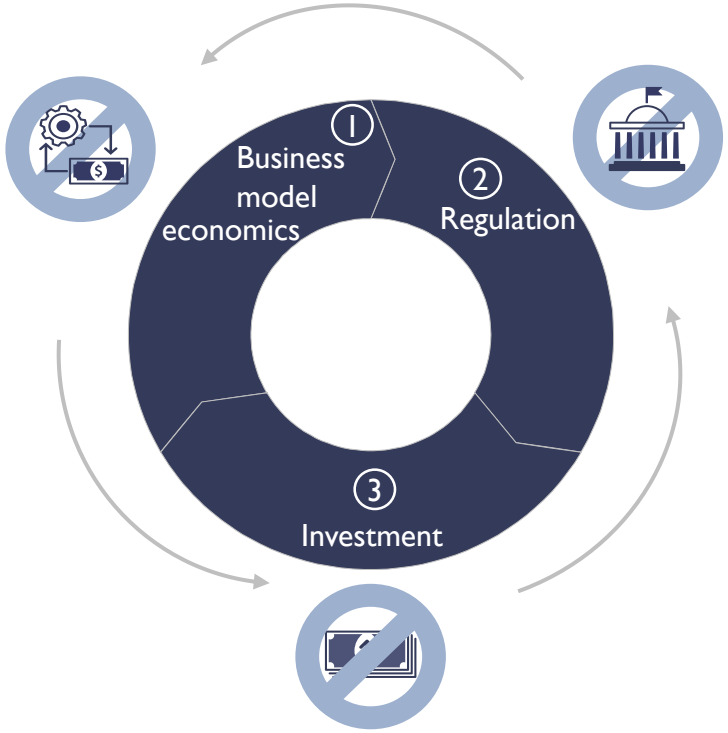
# The Innovation Lab:

## 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… → …to bring mini-grid power to 100M Africans

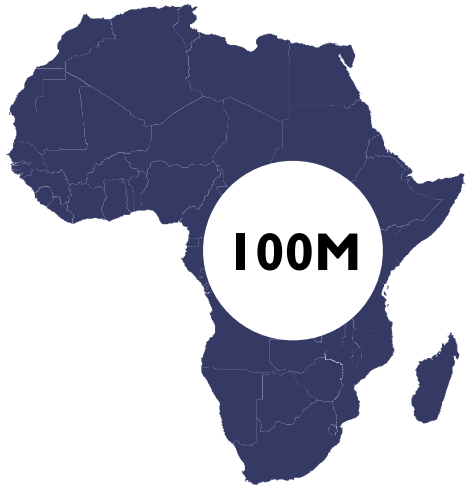



**The Lab directly improves the mini-grid business model by:**

1. Testing innovations and scaling those that are most effective

**The Lab indirectly addresses other barriers to mini-grids' scale by:**

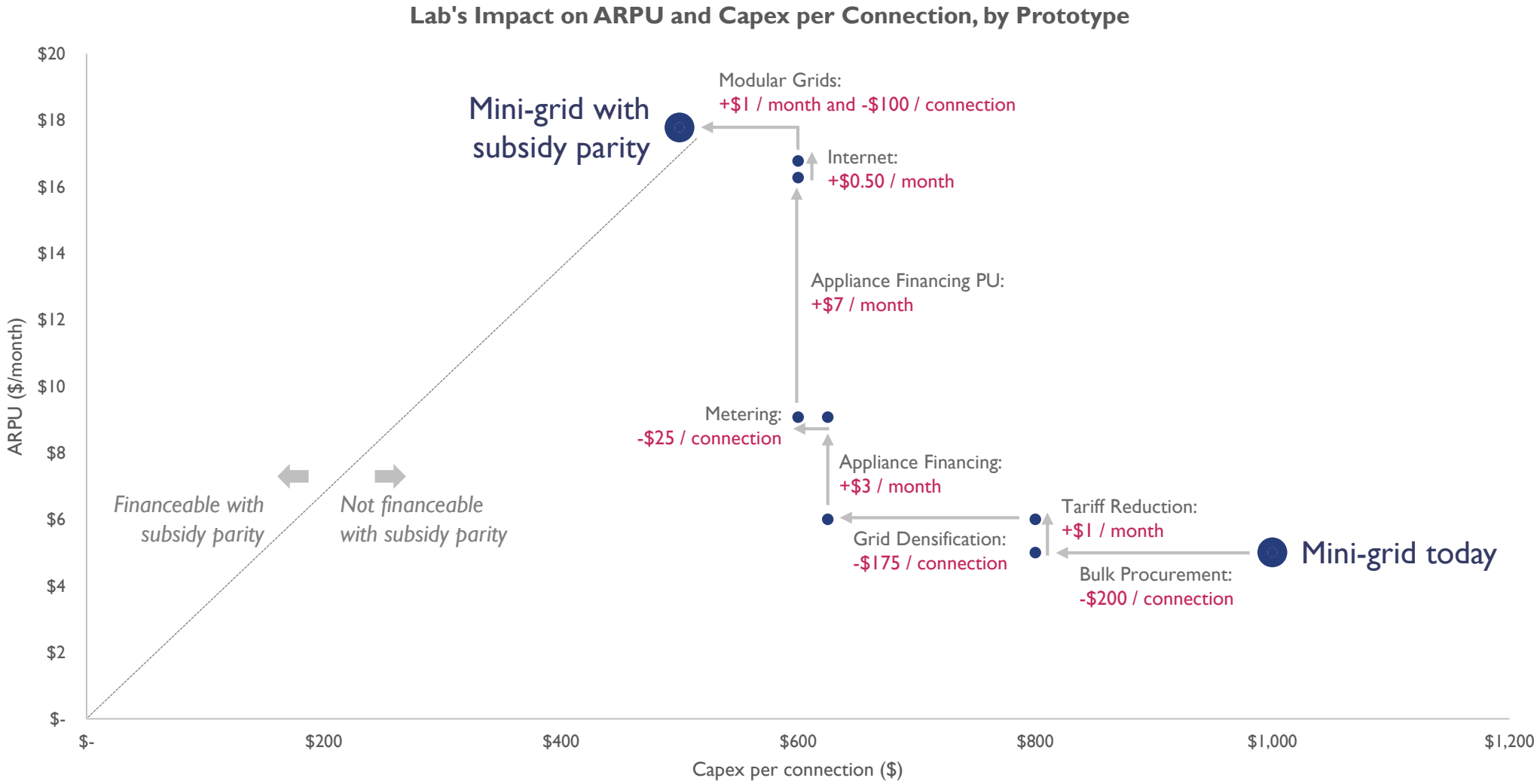
2. Convincing governments mini-grids are the least cost option to providing electricity to rural communities
3. Sharing evidence of successful innovations to attract investment to the mini-grid sector




Mini-grids provide least cost electricity for 100M Africans to power their homes and businesses

Note: For further information on the Lab, please visit our website.

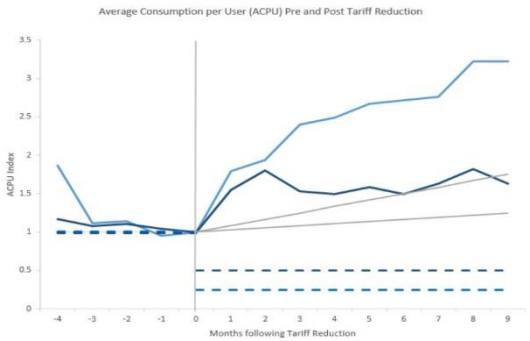
# The Lab has identified 8 innovations that together could reduce capex per connection from $1000 to $500 and increase ARPUs from $5 to $17.50 per month



# The Lab's *Innovation Insight* series provides early, actionable business intelligence on results from its 8 innovations field tested in rural Africa; this publication focuses on Tariff Reduction

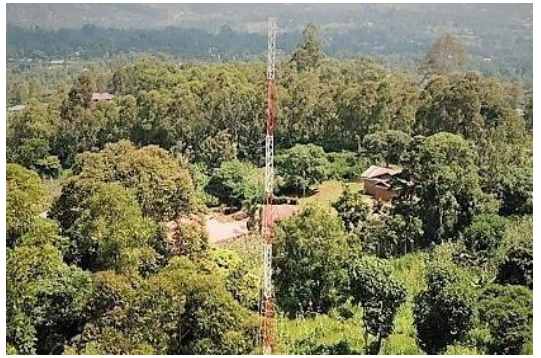
1 Financing programs for energy-efficient productive use appliances

2 Assessing the price sensitivity of rural customers




3 Competing with the arrival of the main grid

4 Providing internet services alongside electricity



5 Deploying larger, denser grids in anticipation of customer demand

6 Testing smart meter technologies

7 Negotiating lower equipment price through bulk procurement

8 Testing smart inverters and other modular technology

In our first Tariff Reduction *Innovation Insight*, published in May 2019, we reported results one year after reducing tariffs at two sites in Tanzania by 50% and 75%

We found that rural customers are extremely price sensitive, and are ready to consume much more power than they can afford at current tariffs:

1. Following the tariff cut, customers immediately consumed significantly more electricity. Customers are budget constrained.
2. For every $1 they saved on price, customers spent $0.93 on increasing their energy consumption. Therefore, after one year, developers' revenues had decreased by only 7% on average.

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

This *Innovation Insight* builds on those findings, incorporating:

A third, larger site, with 3x as many connections as the first sites

15 more months of data and 210 new connections under the prototype

New analysis for governments and donors to act on

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# Executive Summary:

## Mini-grids need less subsidy than the main grid to charge lower tariffs

# Mini-grids need less subsidy than the main grid to charge lower tariffs because mini-grid customers significantly increase their energy use at these lower prices

The Lab has been running the Tariff Reduction prototype since 2018 to test the impact of lower tariffs on customers, developers, and subsidies. At five sites across Tanzania, developers have cut tariffs for all customers by 50-75%, to on average $0.48/kWh[1].

We present evidence supporting two headline findings with major implications for developers, governments and donors:

1. Governments cannot mandate lower tariffs without seriously damaging the business case for mini-grid developers, and developers should not introduce them without financial support. The tariff reductions implemented under this prototype resulted in a decrease in average Net Present Value (NPV) of 13%, excluding subsidy payments.
2. Lower tariffs are a) so beneficial for customers that b) less subsidy is required than is typically provided to the main grid.
    a) Customers increased their consumption by 1.5-3x baseline levels after two years. The lowest consuming users increased their consumption by 5x, suggesting their low electricity use was due to budget constraints, not a lack of demand.
    b) This increase in consumption reduced the amount of lost revenue that subsidy needs to bridge. The subsidy required to maintain NPV appears to be far lower than the main grid. Main grid subsidies are difficult to identify, but the Lab's academic partners at UMass Amherst and Rochester Institute of Technology are publishing a paper that quantifies the implicit subsidy provided to the main grid in Kenya.

What's next for the Lab: The Lab is collaborating with AMDA and P4G to work with donors and regulators, gathering more data on the optimal tariff and subsidy in our target markets, and then developing tariff reduction programs at scale.

[1]This report focuses on results from the three longest-running sites, presenting data up to June 2020. These findings therefore precede the recent developments in Tanzania.

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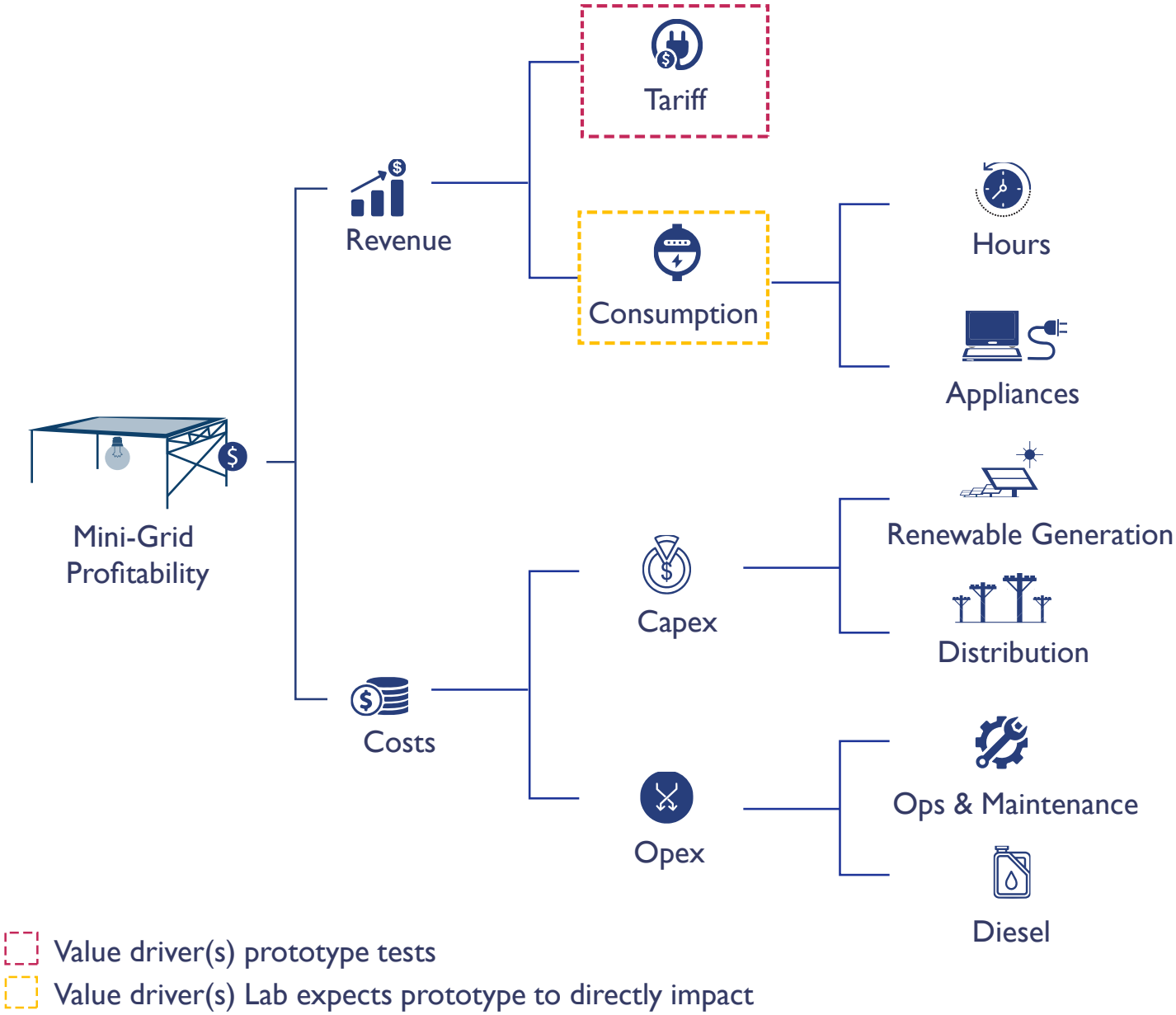
# Why we're doing this:

Tariffs are a key driver of the mini-grid business model

Tariff is a major driver of both mini-grid revenue, and how much energy customers can afford to consume

The Lab expects reducing the tariff will increase electricity consumption, either because customers can afford to use energy for longer (hours) or in new ways (appliances)



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# How we're doing it:

The Lab funded developers to reduce tariffs at five sites in Tanzania

# To test this prototype, the Lab is providing a 5-year subsidy that allows developers to reduce tariffs charged to customers, but not have a negative impact on project returns

| 1 | 2 | 3 |
|---|---|---|
| Before the prototype, developers charged customers a specific tariff per kWh of energy consumed | During the 5-year prototype, developers charge customers a fraction of the initial tariff, and the Lab subsidizes the difference | Following the prototype, developers continue to charge customers the lower tariff, and no longer receive a subsidy |
| Customer pays set tariff of $1.50 / kWh[1] | Customer pays reduced tariff of $0.50 / kWh + Lab pays the $1.00 / kWh difference | Customer pays reduced tariff of $0.50 / kWh |

## How we set the subsidy per kWh

We worked with each developer to determine the lowest average tariff they could charge customers for at least 20 years which ensures:

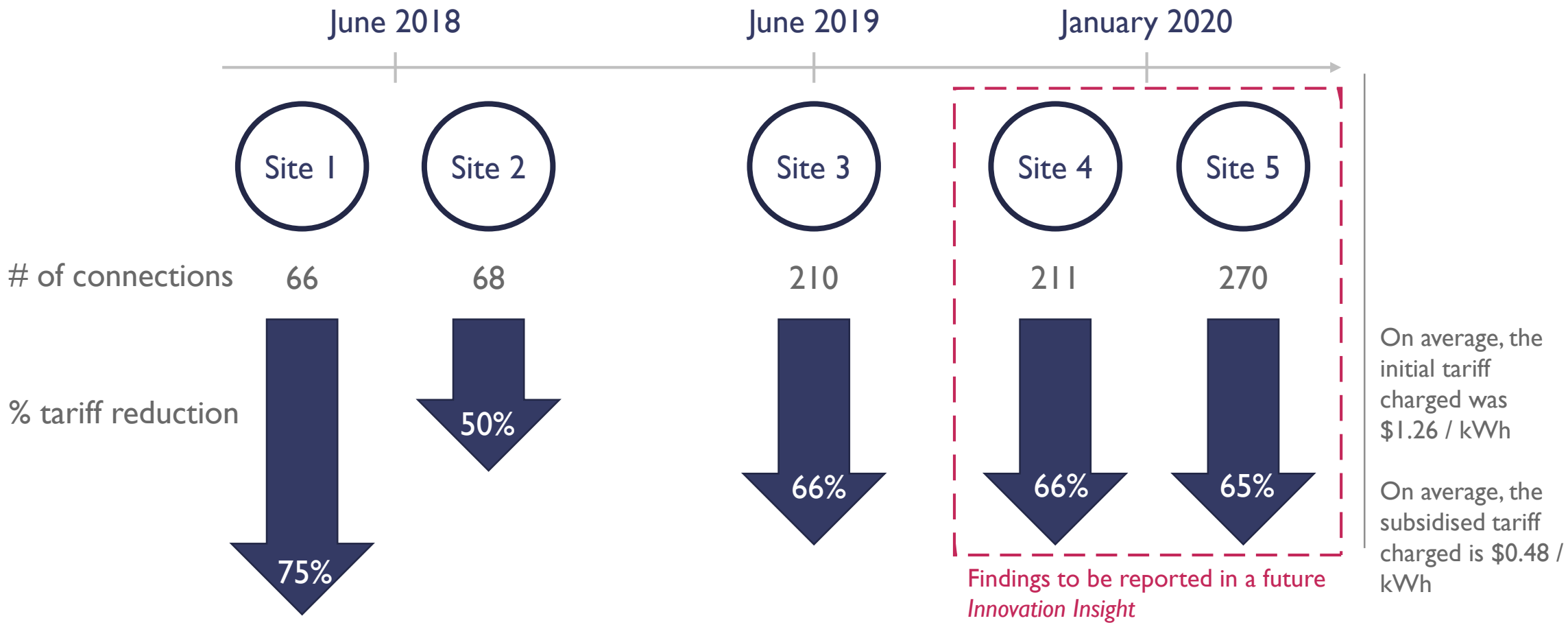
1. Projected revenues, including subsidy payments, are sufficient to cover operating costs, depreciation, and project return in the long-term.
2. The subsidy payments over the 5 years of the prototype, and expected revenue increases from higher consumption, will cover any additional capex or expansion necessary. The mini-grid can therefore run profitably after the subsidy expires at a tariff that only covers opex, thus preserving initial project net present value (NPV).

The total subsidy available for each site was capped.

**Customers' tariffs will not need to be increased following the completion of the prototype**

[1] Demonstrative numbers

# Starting in June 2018, the Lab began testing the impact of reducing tariffs by between 50% and 75% at five rural mini-grid sites in Tanzania




Note: Per the previous slide, the tariff reductions were chosen so the price change was significant enough to change customer behavior, while allowing mini-grid operators to recover enough of their costs to ensure the sustainability of their business model. Total subsidy was capped by site to, on average, $26,000.

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# What we're seeing:

Lowering tariffs has a smaller impact on NPV than expected

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

1. Mini-grids can maintain their project NPV at lower tariffs if provided with a 5-year tariff subsidy

2. Consumption will increase such that average revenue per user (ARPU), excluding subsidy payments, returns to baseline levels by year three

   Beyond year three, consumption will have increased to such a degree that revenues exceed baseline levels

3. Historically low-user customers will exhibit the largest percentage increase in consumption

4. The number of connections at treatment sites will be 10% greater after one year

Note: A fifth 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.

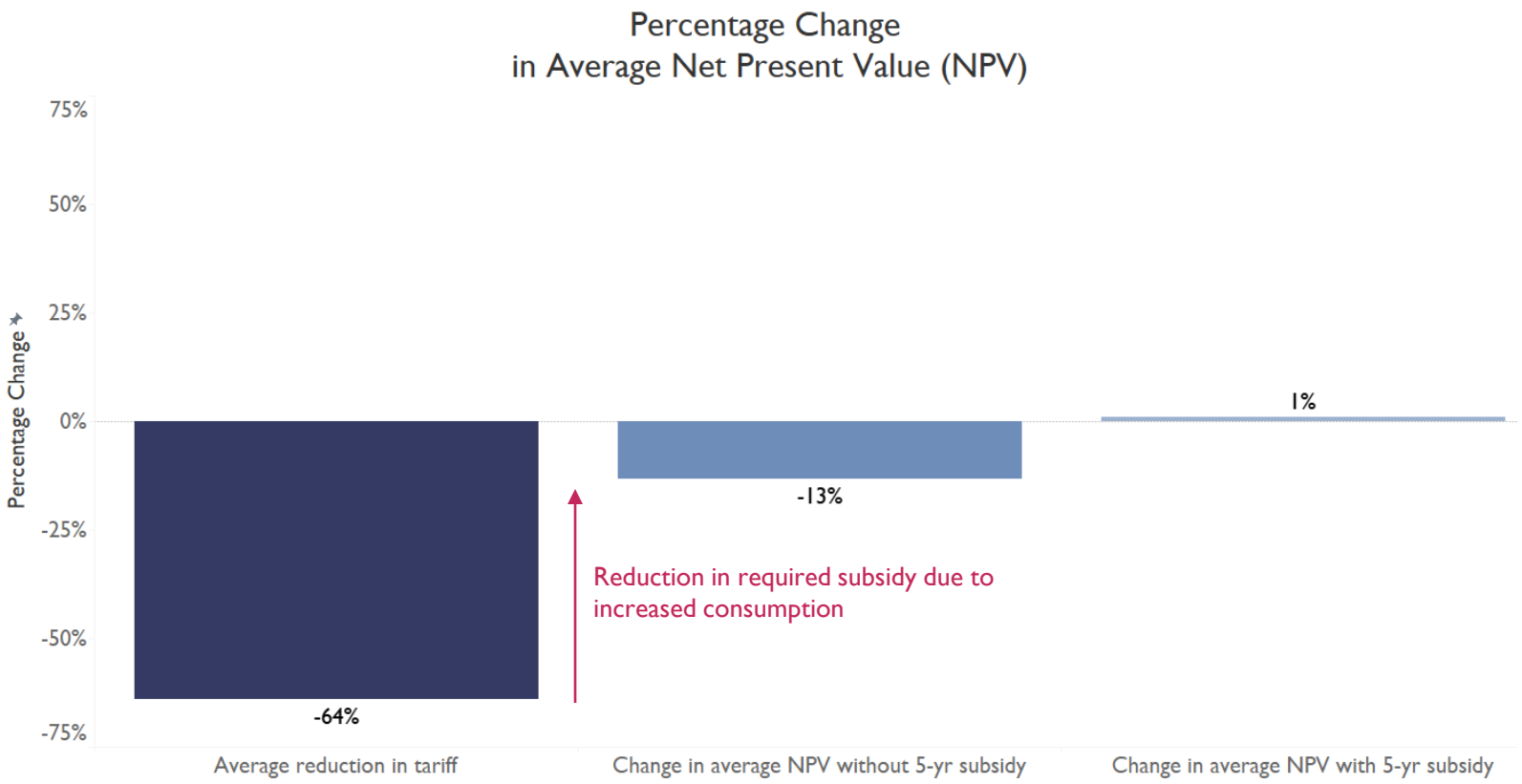
Note: Revenues are always shown excluding subsidy payments, ie. they include only electricity payments made by customers, unless otherwise stated. We display them as an average because average revenue per user (ARPU) is an important KPI for mini-grid developers. For each month, we show a rolling average of each metric, calculated over the preceding three months.

## Hypothesis 1

Mini-grids can maintain their project net present value (NPV) at lower tariffs if provided with a 5-year tariff subsidy

## What we expected

Subsidy payments over the 5 years of the prototype will cover any additional capex or expansion necessary. The grid can therefore run profitably after the subsidy expires at a tariff that only covers opex, thus preserving initial project net present value (NPV)




Note: The bars represent the change in average NPV across all three sites

## What we're seeing

Without a subsidy to offset the lost revenue per kWh, average project NPV is 13% lower across all sites following the tariff reduction. However, this is far lower than the average tariff reduction of 64% because consumption has increased beyond expectations.

## What it means

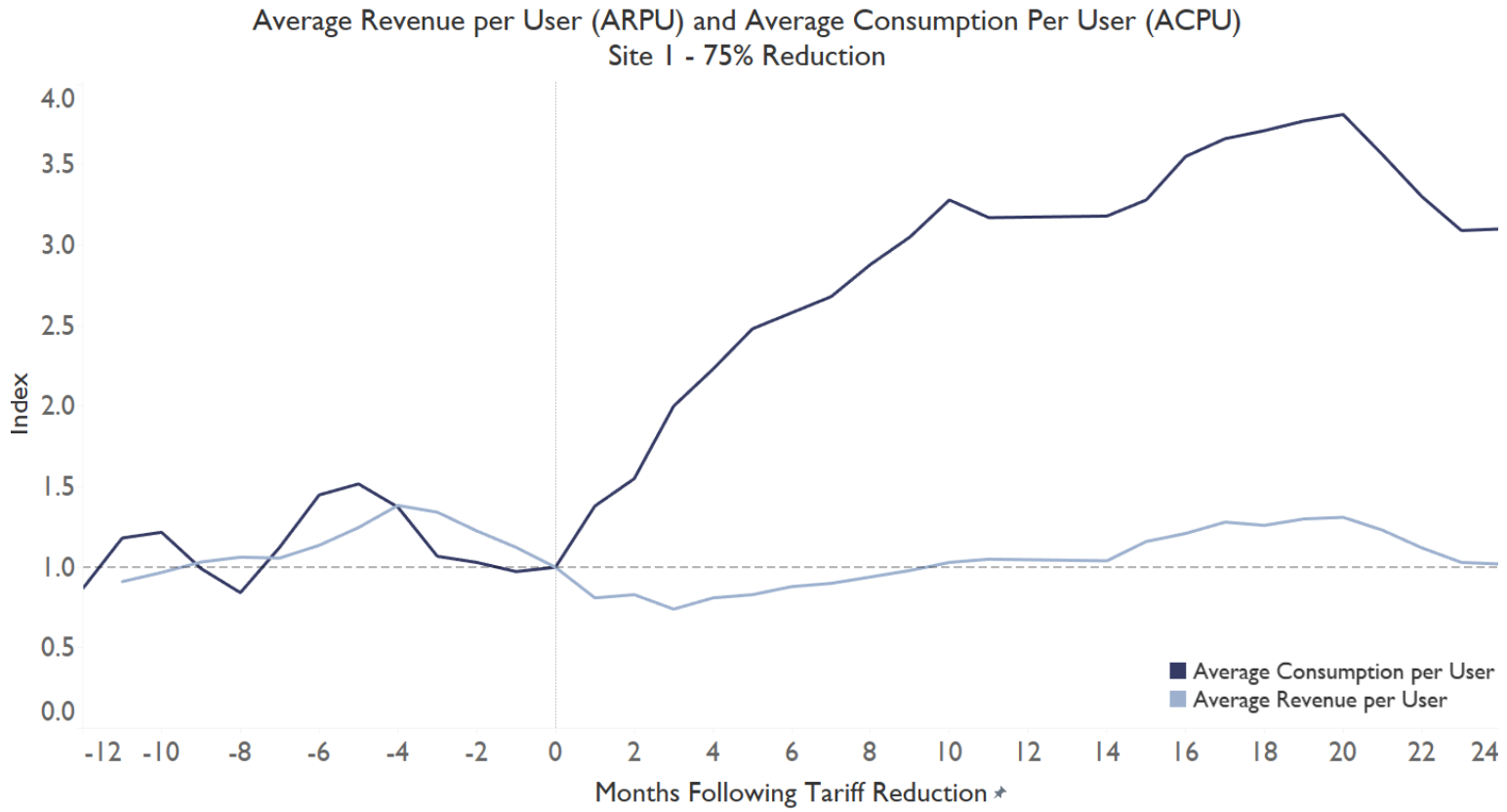
Reducing tariffs without providing a subsidy makes mini-grids financially unsustainable. However, lower tariffs generate so much additional consumption that less subsidy is needed than expected.

## Hypothesis 2

Consumption will increase such that average revenue per user (ARPU), excluding subsidy payments, returns to baseline levels by year three. Beyond year three, consumption will have increased to such a degree that revenues exceed baseline levels.

## What we expected

After reducing the tariff, revenues would fall considerably as consumption remained the same. Lower tariffs allow customers to use higher-energy appliances. Over five years, customers' energy budgets would increase either through new income streams enabled by appliances (e.g. selling cold drinks) or displaced spending on other uses (e.g. kerosene for lighting).




## About the site

66 initial connections

Low baseline consumption

- Site located in northern Tanzania
- Some customers purchased appliances such as TVs, subwoofers, and fridges following the tariff cut through a community member who facilitated sales from local vendors. The developer did not offer a financing program.

Note: Actual values immediately prior to tariff reduction indexed to 1

# Site 1
# 75% reduction in tariff

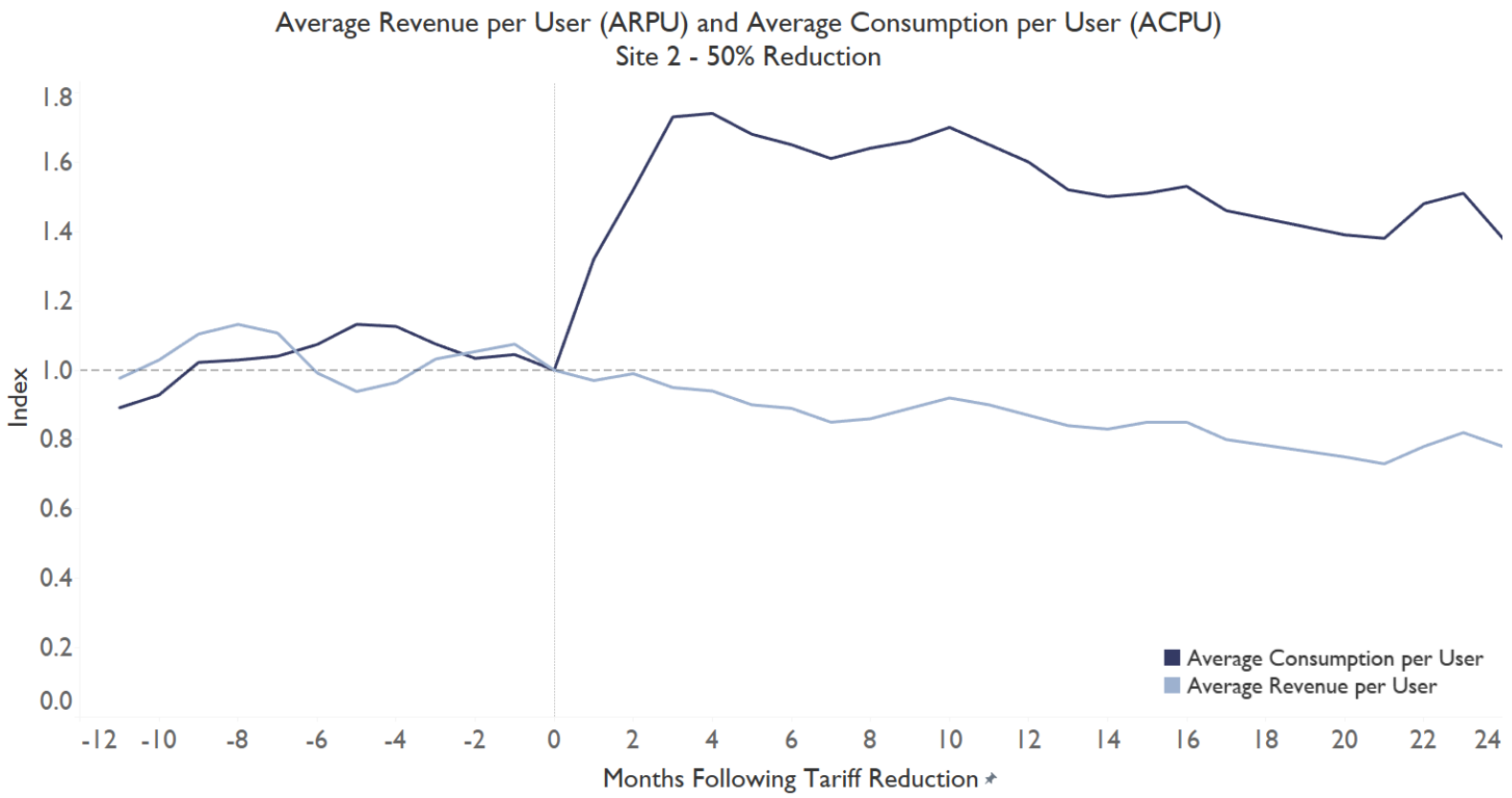
## What we're seeing

Customers dramatically increased their consumption following the tariff cut, and after two years ACPU is at 3x baseline levels. Revenues returned to baseline levels within a year.

## What it means

Sites with low consumption levels may be best suited for tariff reductions given the large potential gains.

Lower tariffs make appliances affordable for low income customers, unlocking pent-up demand for the services that electricity provides. The greatest impact will be seen if customers have access to appliances to take advantage of lower tariffs.




## About the site

- 68 initial connections
- High baseline consumption (8x Site I)

- Site located in Northern Tanzania
- Community has relatively strong economy centred around cattle rearing
- The developer has not implemented an appliance financing program at this site

Note: Actual values immediately prior to tariff reduction indexed to 1

# Site 2
# 50% reduction in tariff

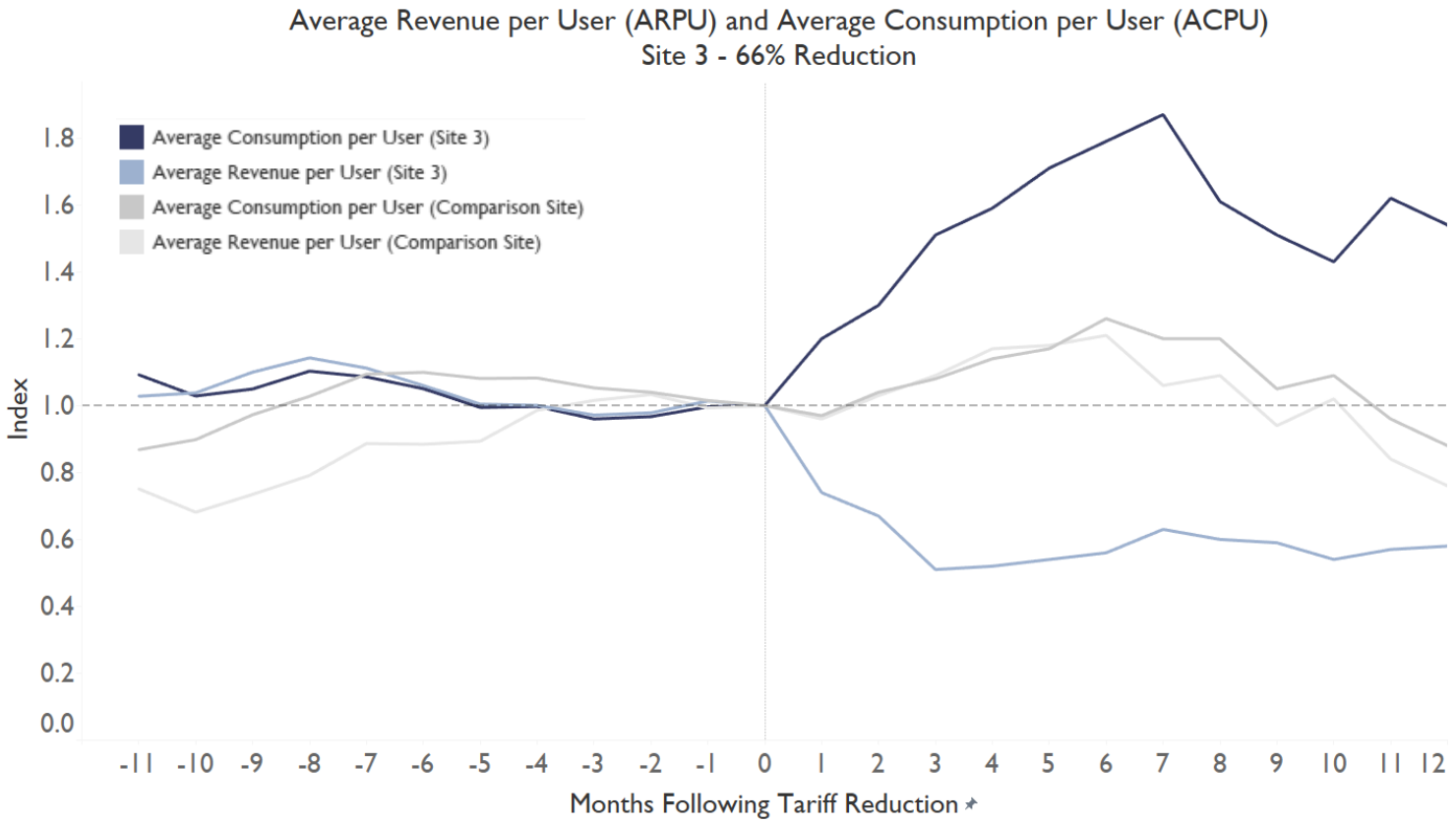
## What we're seeing

Customers immediately doubled their consumption, following the tariff cut, but after two years have reached a steady state of approximately 1.4x baseline levels. Revenues remain 20% lower than baseline levels.

Customers are using part of the tariff cut to increase consumption but also to reduce their overall spend on electricity.

## What it means

Customers do not sufficiently value the uses for electricity currently available to increase their energy expenditure. Encouraging customers to use appliances for productive use might be necessary to see revenues return to baseline levels.




## About the site

210 initial connections (Site 3)

273 initial connections (Comparison Site[1])

Typical baseline consumption levels

- Sites located in agricultural communities
- Income largely dependent on farming seasonality; customers typically have higher incomes in the four months of the year following the tariff cut
- The developer has not implemented an appliance financing program at this site

Note: Actual values immediately prior to tariff reduction indexed to 1

[1]Comparison Sites were introduced for all Lab prototypes launching from 2019 onwards. They are mini-grids selected for their similarity to the treatment sites, operated by the same developer in the same geography, where the prototype was not implemented.

# Site 3
# 66% reduction in tariff

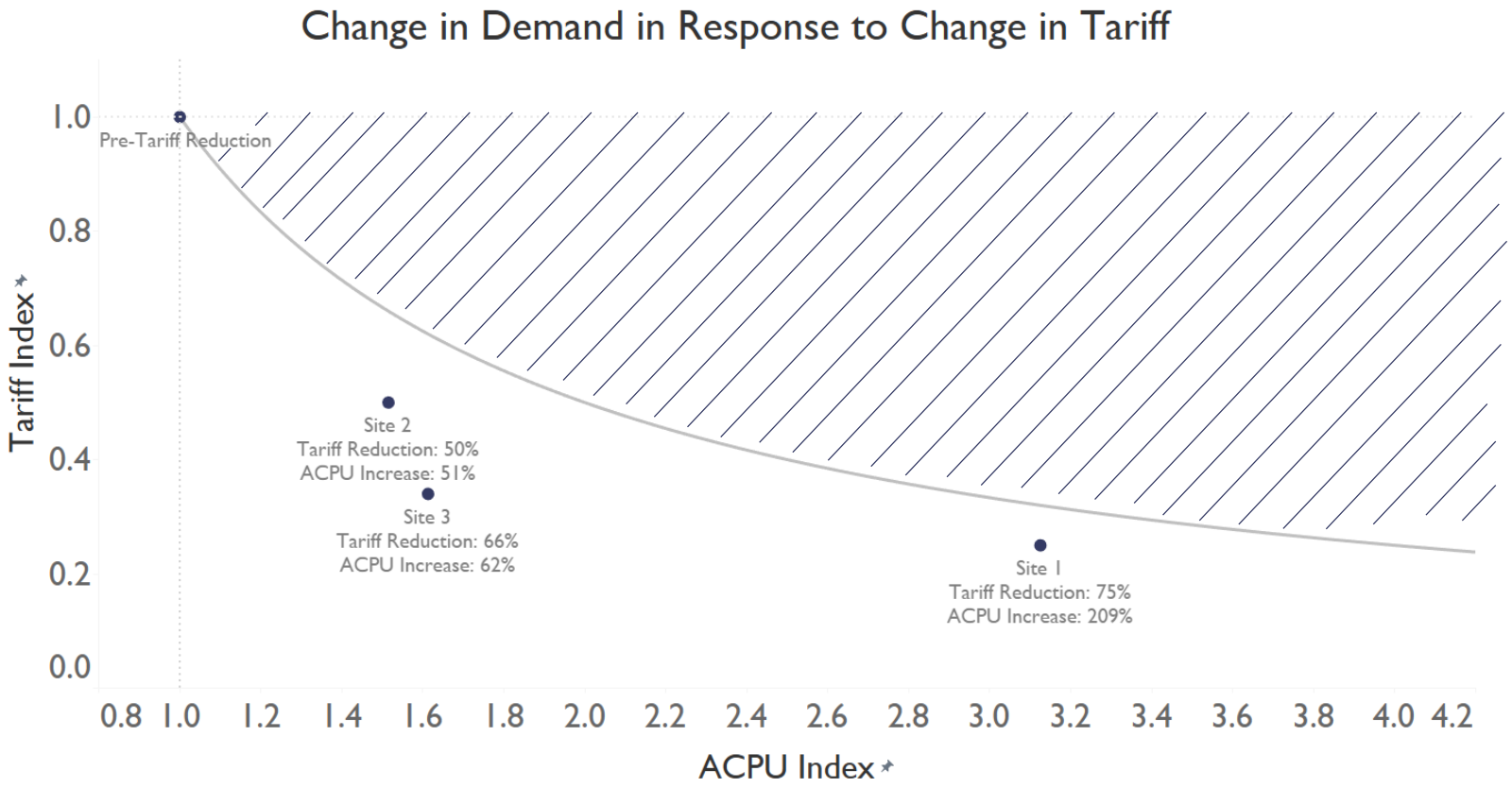
## What we're seeing

Immediately following the drop in tariff, customers used their seasonal gains in income to consume more electricity (peaking at 2x baseline levels), and have maintained higher levels (1.5x baseline) even in the low season.

This has led ARPU to reduce to a lesser degree than the tariff cut, settling at approximately 0.5x baseline levels. The increase in consumption seen at the Comparison Site had entirely reversed after one year.

## What it means

Customers' energy budgets are strongly linked to seasonality. They are ready to use more power when they can afford to do so.




The shaded area represents tariff and consumption combinations that generate increased revenues relative to baseline. Customers use every dollar they save, and more, to increase their consumption.

Note: Actual values immediately prior to tariff reduction indexed to 1

## What we're seeing

At two sites, (Sites 2 and 3) consumption increased roughly in proportion to the tariff reduction. For revenues to be higher than baseline levels after five years, customer consumption must increase further. At the third site, once customers could afford to consume more power, they were motivated to purchase appliances and consumption increased by a much greater degree, marking an increase in overall energy spend.

## What it means

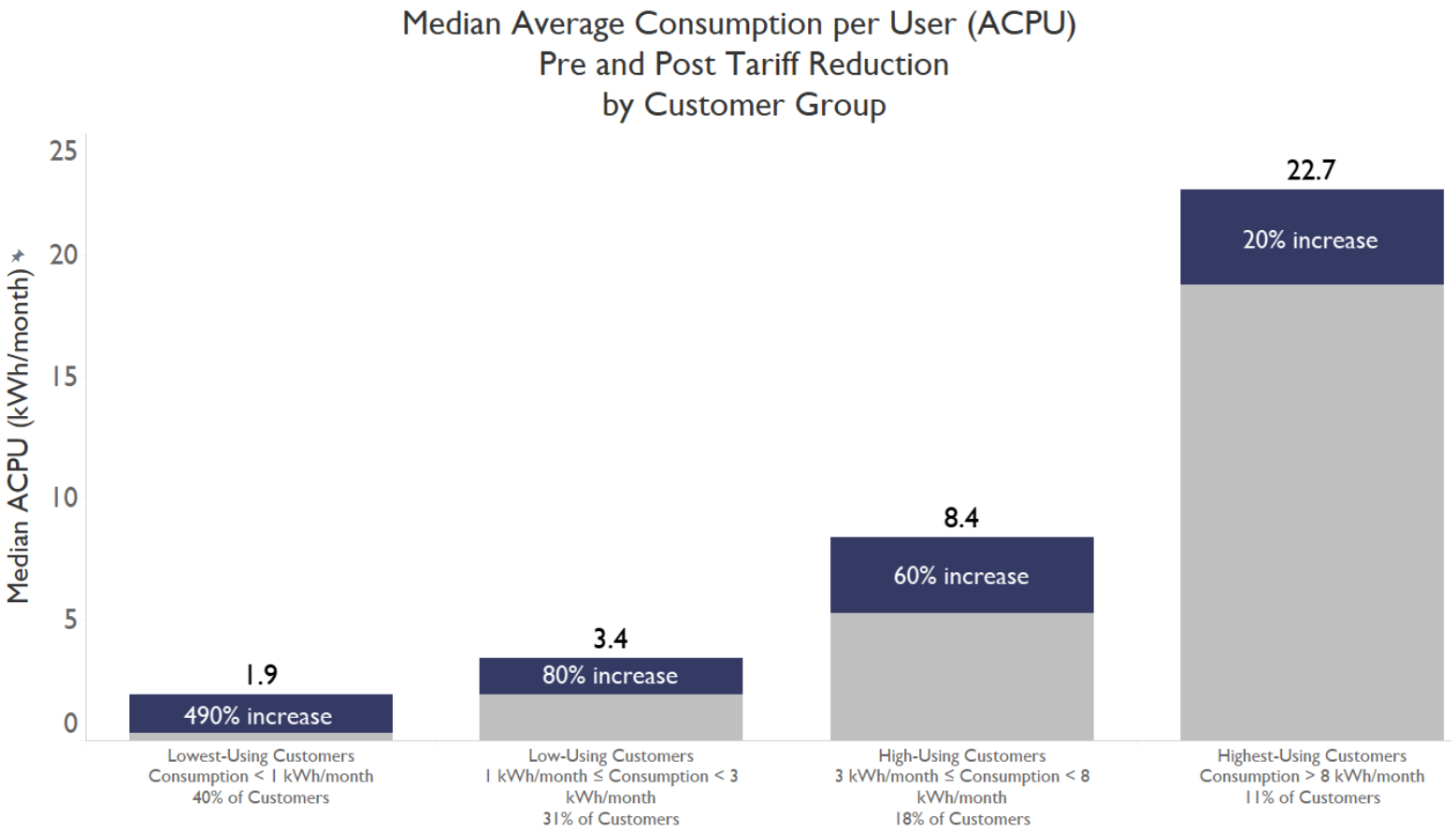
Customers at Sites 2 and 3 are not budget-constrained, but demand-constrained. Providing them with more uses for electricity, in the form of appliances, could boost their consumption and unlock the full impact of the tariff cut.

## Hypothesis 3

Historically low-user customers will exhibit the largest percentage increase in consumption

## What we expected

The historically lowest-using customers are the most price-sensitive, and thus most responsive to a tariff reduction




Note: The groups were defined according to known levels of electricity usage. 1 kWh per month translates to roughly two lights for three hours per day, 3 kWh per month to two lights and a TV for three hours per day, and 8 kWh per month to two lights and a TV for three hours per day, plus a fridge for nine hours per day for ten days per month.
Lowest-using customers increased consumption by approximately 1.5 kWh a month, the equivalent of adding two lights to a household for six hours per day. Highest-using customers increased consumption by approximately 3 kWh a month, the equivalent of using a TV for an additional three hours per day or adding four lights to the household for six hours per day.

## What we're seeing:

Low-using customers are the most price sensitive of all customer groups, and ready to use more power.

Customers who consumed more before the tariff reduction showed the greatest increase in consumption in absolute terms, but the smallest percentage increase.

## What it means

Tariff subsidies benefit all categories of mini-grid customers, but the greatest impact is felt by the lowest-using, and likely lowest-income, customers. This stands in contrast to many subsidy programs in the electricity sector which are "regressive in their distribution, favoring the nonpoor over the poor"[1]

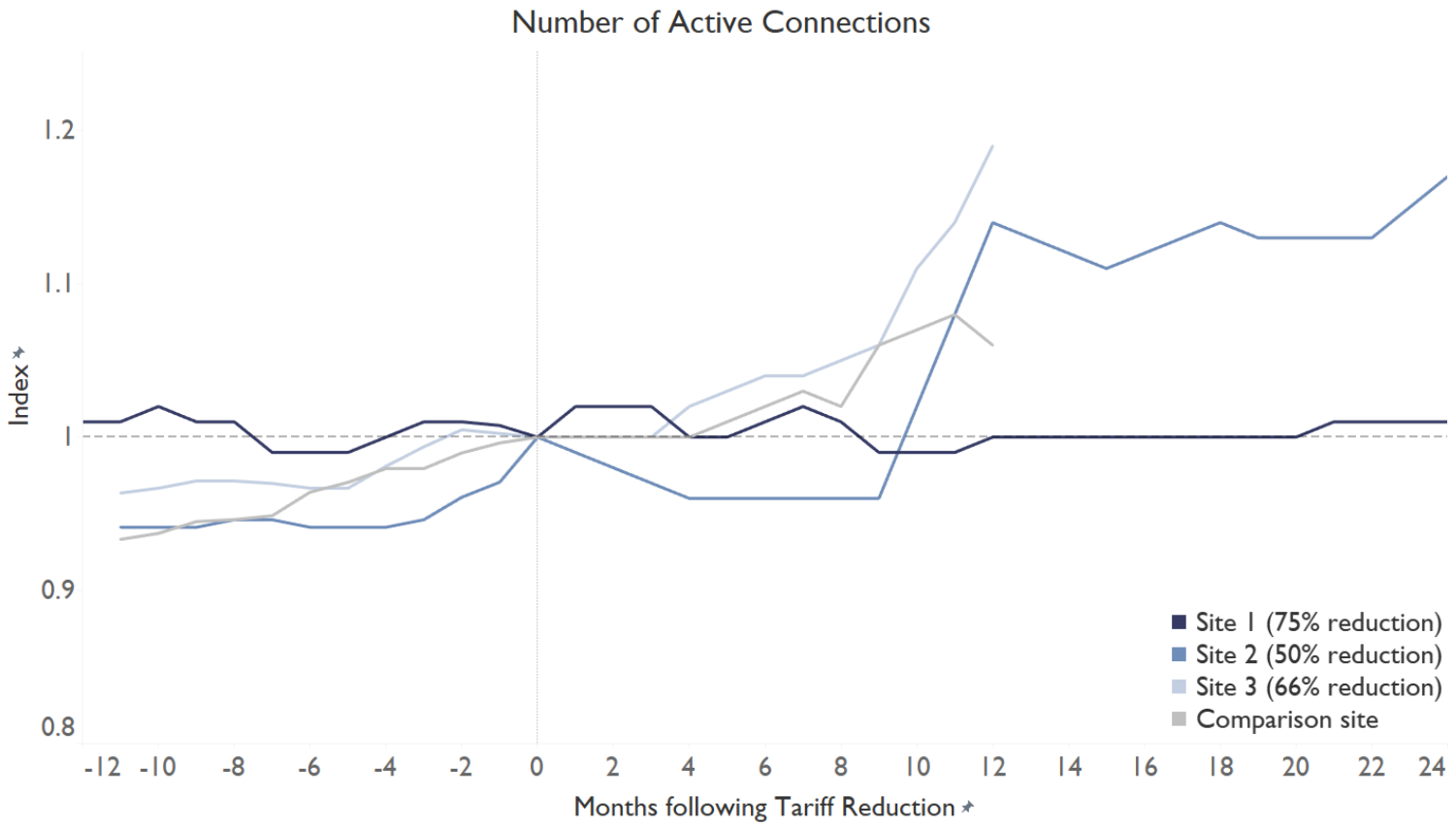
[1] *Water, Electricity, and the Poor: Who Benefits from Utility Subsidies?* K. Komives (2005)

## Hypothesis 4

The number of connections at treatment sites will be 10% greater after one year

## What we expected

Previously unconnected households and businesses connect to the mini-grid once electricity is made cheaper




## About the sites

At Site 1, the developer has received connection requests since the tariff cut, but made the decision not to add new customers at this site due to competing priorities

Note: Actual values immediately prior to tariff reduction indexed to 1.

## What we're seeing

At Sites 2 and 3, connections have increased more than expected: to 1.15x baseline levels compared to only 1.05x at the comparison site. At Site 1, there are few new customers.

## What it means

The decision to add new customers is driven by business considerations, not just new customer demand. At sites where demand is also close to generating capacity, serving new connections may also require additional investment in generating capacity that reduces overall project returns. Tariff subsidy programs will not necessarily lead to more connections at existing sites.

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# What we're going to do about it:

The Lab will work with advocacy experts and donors to scale up tariff subsidy programs across the continent

# The Lab will build the evidence base for scaling sustainable tariff reductions across Africa

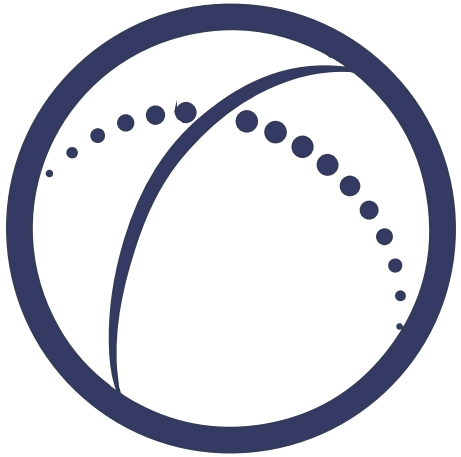
## The Lab will:

Fully analyze and incorporate data from the two new, additional sites in Tanzania testing the prototype, increasing the number of connections analyzed from 396 to 877

Partner with donors to trial tariff reduction programs in other countries, in particular where there is pressure on tariff levels

Determine the optimal tariff to unlock customer demand and increase revenues, and the tariff subsidy required to support that

Work with AMDA to establish a plan for subsidizing tariffs at all operating mini-grids sites within one country



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