



Study Design: Internet 2.0 Fiber
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Executive Summary

This study tests whether offering internet services alongside electricity is a profitable service addition for mini-grid developers. Internet is a key electricity-enabled service which allows rural communities to access new technologies, information, and opportunities to improve community members' livelihoods. Internet delivered via fiber optic cable directly to customers' homes presents a promising approach to delivering high-speed, reliable internet using infrastructure which can be built concurrently with a mini-grid. Offering internet services not only spurs the beneficial use of electricity, thereby increasing demand within communities, but it also allows mini-grid developers to diversify their sources of revenue.

The primary objective of the study is:

1. Determine what impact offering internet services has on (1) the economics of mini-grids, (2) the economics of the project, (3) mini-grid operators' revenue base, (4) customer uptake of internet services, and (5) experienced internet usage and speeds.

The study targets customers of currently operating mini-grids in Africa. The study will be conducted on site(s) where the community is newly connected to the internet via fiber optic cables connected directly to customers' homes. On some sites, the community may have previously had access to the internet via a village-wide Wi-Fi network. Fiber internet services will be offered to all current and potential customers at selected site(s).

The study will assess the impact of offering internet services alongside electricity on five principal matters: (1) grid economics, (2) project economics, (3) revenue base, (4) customer uptake of internet services, and (5) quality of internet services. IRR and ARPU will be used to analyze the impact on grid economics; IRR will be used to analyze the impact on project economics. The revenue base will be assessed by measuring the number of unique customers across both customer sets (electricity and internet), while payment for internet services among existing electricity customers will be used to evaluate customer uptake of internet services. Finally, quality of internet services will be considered by measuring the true speeds experienced by customers and customer-reported satisfaction scores. Control grids will be used to compare changes observed at treatment grids.

The study will be delivered by the Operator, with support from technical advisors and other third parties as necessary. This study will involve Poa Internet, an Internet Service Provider (ISP). Poa Internet will be responsible for providing and monitoring the internet service.

The Study Partners will provide funding for the study, collect all relevant data, and analyze the results as they pertain to each hypothesis. The results will be made publicly available on an anonymized, aggregated basis. The study is expected to run over a two-year period, beginning April 2020.

Study Partners

The following table outlines the role of each partner involved in the study.

Partner	Role
Funder	<ul style="list-style-type: none"> • Provides funding • Offers strategic oversight for the study
CrossBoundary (CB)	<ul style="list-style-type: none"> • Manages all aspects of project • Leads study design • Leads data collection, including surveying, and data cleaning • Leads analysis and communication of study results
Energy4Impact (E4I)	<ul style="list-style-type: none"> • Disburses and monitors funds provided to Operator • Supports analysis and communication of study results
Operator	<ul style="list-style-type: none"> • Provides insight into study design • Operates the mini-grids involved in the study and leads site implementation of study • Supplies data to CrossBoundary and other partners for analysis
Other partners	<p>Academic institutions:</p> <ul style="list-style-type: none"> • Supports study design • Supports analysis and communication of study results <p>Poa Internet and other third parties (as identified):</p> <ul style="list-style-type: none"> • Supports Operator in site implementation of study

Introduction

Mini-grids are emerging as a viable technology to accelerate access to electricity in Sub-Saharan Africa. However, for mini-grids to become sustainable and scalable commercially, profitability must improve. This study seeks to improve grid economics by answering the question: can developers increase customer consumption, and thus revenue, by offering internet services alongside electricity?

Electricity is an enabler—a way for communities to access new technologies and opportunities that improve the livelihoods of their members—and internet is a key electricity-enabled service. Internet access allows rural communities to more easily and quickly engage with the world. It allows rural farmers to access weather reports, young entrepreneurs to learn how to run their businesses, and community members to supplement their income through task-based work. Access to the internet creates and expands opportunities for rural communities.

Most forms of internet access, whether using electricity via ethernet cables, light via fiber optic cables, or radio waves via a Wi-Fi network, rely on electricity. Offering internet services not only spurs the beneficial use of electricity, thereby increasing demand within communities, but it also allows mini-grid developers to diversify their sources of revenue. Internet is a compelling business line to add to a mini-grid project and one the mini-grid operator can potentially manage directly, thus improving overall grid returns.

Building the infrastructure needed for a rural community to access the internet remains costly. Constructing a Wi-Fi network connected to the local internet service provider (ISP) through point-to-point and point-to-multi-point radios is one low-cost option previously tested. However, because all users of a wireless network share bandwidth, as the number of users grows, the speed of service falls. Additionally, wireless signals weaken with distance. Even with Wi-Fi hotspots scattered throughout the community, it can be difficult for customers to receive strong and reliable signals in their homes, where 85% of internet access occurs globally. Internet provided via satellite, another method previously tested, is privy to similar challenges. These technologies may suffice to get internet to site, but relying on these technologies to distribute internet within the site is problematic.

This iteration of the prototype tests a new way of distributing internet to members of a community. Laying fiber optic cable to connect households to the internet solves the strength and reliability issues inherent in Wi-Fi connections. Assuming all potential customers can be reached by cable, fiber optic presents a promising alternative solution to delivering high-speed, reliable internet to a rural community. If the cable can be laid at the time the mini-grid is built, it may be more cost-effective than currently understood.

This study, therefore, seeks to:

1. Determine what impact offering internet services has on (1) the economics of mini-grids, (2) the economics of the project, (3) mini-grid operators' revenue base, (4) customer uptake of internet services, and (5) experienced internet usage and speeds.

The study targets customers of currently operating mini-grids in Africa. The study will be conducted on site(s) where the community is newly connected to the internet via fiber optic cables connected directly to customers' homes. On some sites, the community may have previously had access to the internet via a village-wide Wi-Fi network. Fiber internet services will be offered to all current and potential customers at selected site(s).

Experimental Design

Hypotheses

The following table details the hypotheses the study will test and how each will be measured. See *Annex 2* for hypotheses focused on customer wellbeing that all studies will consistently test. **Treatment sites** are defined as sites connected to internet services; **control sites** are defined as sites not connected to internet services.

Hypothesis	Metric	Source
<i>Grid Economics</i>		
1. ARPU at treatment sites will be 10% higher than at control sites after two years. <ul style="list-style-type: none"> a. Fiber and Wi-Fi internet revenue will increase ARPU at treatment sites by 4% and 1%, respectively, after two years. b. Increased consumption will increase ARPU at treatment sites by 5% after two years. 	<ul style="list-style-type: none"> • ARPU 	<ul style="list-style-type: none"> • CB financial model
<i>Project Economics</i>		
2. Project (internet-only) IRR will be 20% after two years.	<ul style="list-style-type: none"> • IRR 	<ul style="list-style-type: none"> • Developer data
<i>Uptake of Internet Services</i>		
3. 20% of customers at treatment sites will purchase fiber internet services by the end of one year, with 35% of customers purchasing either fiber or Wi-Fi internet by the end of two years.	<ul style="list-style-type: none"> • # of customers paying for fiber or Wi-Fi services as % of total customers 	<ul style="list-style-type: none"> • Developer data
<i>Quality of Internet Services</i>		
4. At any given time, at least 97% of fiber internet customers receive the speed for which they are paying.	<ul style="list-style-type: none"> • # of fiber internet customers receiving correct speed as % of total fiber internet customers 	<ul style="list-style-type: none"> • Network management data • In-person spot check data
5. Fiber internet customers are sufficiently satisfied with the load times, latency, and stability of the service they receive.	<ul style="list-style-type: none"> • Median of customer-reported fiber internet service satisfaction scores 	<ul style="list-style-type: none"> • Survey data

At the end of the study, CrossBoundary will report how the observed changes in revenues and costs would impact IRR at a typical mini-grid.

Site and Participant Selection

Treatment sites will be chosen according to where the Operator has current operations and installing a fiber optic network is feasible. Control sites will be chosen to resemble treatment

sites as closely as possible, based on population, geography, profile and use of customers, and tariff structure.

All sites are eligible to serve as treatment sites; however, priority will be given to those sites meeting the following criteria:

- At least 100 customers
- At least six months of customer consumption and billing data
- Capability to automatically measure customer consumption and payment
- Topology allowing for backhaul installation in a direct line, or where backhaul is already installed
- Reasonably high population density
- Customers sufficiently wealthy to afford internet services

See *Annex 3* for Operator-specific site selection information.

Participants are those households who choose to purchase internet services. All households considered members of the community or village will be given the opportunity to purchase internet services.

Duration

The study is expected to run two years, starting as soon as possible upon the signing of the Operator Agreement. The projected timeline of the study is April 2020 – April 2022. Early results will be analyzed after three months and quarterly thereafter.

The study's duration may be adjusted following initial results or any unforeseen circumstances.

Prototype-Specific Design Decisions

Internet Pricing

Fiber internet will be offered as a premium option alongside the Wi-Fi internet options already available. This will ensure basic access is available to a large group of customers with premium options available for those with a higher ability and willingness to pay. Options may vary according to usage and/or speed allowances. Pricing should be based on the following inputs:

- Wholesale hardware cost
- Wholesale mbps cost
- Operator contention ratio
- Benchmarking to local telecoms' data rates

Prices should be set to reflect commercial standards.

Customer Awareness

Given a limited familiarity with the internet among target participants, it's important the study shows customers the benefits and impact of fiber internet access delivered directly to the home. This may take the form of a village baraza or more traditional marketing materials.

See *Annex 3* for Operator-specific design information.

Budget and Disbursement of Funds

The Operator is responsible for providing a budget that accurately reflects the cost of running the study in excess of standard operations. See *Annex 3* for Operator-specific budget information.

Prior to receiving funds, the Operator must submit the following:

- Approved budget
- Signed Operator Agreement (consisting of the Grant Agreement and Study Design)
- Historical remote monitoring data, as available
- Site economic data

Funding of [budget] to support the study will be disbursed by Energy4Impact to the Operator in a single payment upon the study's launch.

The Operator is required to maintain a record of all costs incurred in implementing and running the study and must provide receipts reflecting the totality of costs to Energy4Impact. The Operator agrees to use funds solely for the purposes of the study.

Energy4Impact is responsible for monitoring the use of funds for the purposes agreed with the Funder.

Implementation

Operator

The Operator is responsible for operating all sites involved in the study and implementing the prototype on selected treatment sites as agreed to in this Study Design. This involves but is not limited to the following:

- Installing (or overseeing the installation of) all equipment required to connect study participants to internet services provided by the ISP
- Selling internet subscriptions to customers
- Communicating all relevant information to study participants

The Operator will lead in engaging all third parties involved in the study and is responsible for thoroughly researching and proposing all third party collaborations. The Operator is also

responsible for identifying and procuring any licenses or other regulatory approval required to implement the prototype. See *Annex 3* for Operator-specific implementation information.

The Operator agrees to inform CrossBoundary of any occurrences that may affect electricity consumption or other study results, and identify customers affected by such interventions (e.g. changes in tariff or meter numbers). The Operator additionally agrees to disclose any other information pertinent to the study (e.g. GIS data).

Third Parties

This study will involve one third party: (1) Poa Internet. Poa Internet is responsible for providing and monitoring internet services to all study participants.

See *Annex 3* for Operator-specific third-party information.

Licenses and Other Regulatory Approval

No licenses are required to implement this study, apart from the standard licenses required to operate mini-grids in [country].

Data Collection

All data shared through execution of the study is protected by a direct Non-Disclosure Agreement with Energy4Impact, who in turn holds a Non-Disclosure Agreement with CrossBoundary. Data will only be shared with partners approved by the Operator as outlined in the Non-Disclosure Agreement on an aggregated and anonymized basis to protect customer information.

Through participation in this study, the Operator agrees to share three types of data: (1) remote monitoring and customer data, (2) prototype-specific data, and (3) site economic data. Additionally, the Operator agrees to allow CrossBoundary to collect survey data. The following table details the data the Operator is required to share, or allow CrossBoundary to collect, as part of the study.

Data Type	Metric	Unit	Frequency
(1) Remote Monitoring & Customer Data	Customer consumption	kWh	Twelve months' historical (<i>as available</i>), prior to disbursement of funds + monthly for duration of study

Data Type	Metric	Unit	Frequency
	Customer electricity payment	Local currency	Twelve months' historical (<i>as available</i>), prior to disbursement of funds + monthly for duration of study
	Meter numbers with customer information	Various	Once, prior to disbursement of funds
(2) Prototype-Specific Data	Monthly customer internet payment	Local currency	Monthly for duration of study
	Project IRR	%	Quarterly for duration of study
	Number of customers paying for fiber internet services	#	Quarterly for duration of study
	Number of customers paying for Wi-Fi internet services	#	Quarterly for duration of study
	Number of fiber internet customers receiving correct speed	#	Quarterly for duration of study
(3) Site Economic Data	As shown in Annex 1	Various	Once, prior to disbursement of funds
(4) Survey Data	Various demographic, socioeconomic, and user experience data	Various	Twice, prior to the prototype's launch and following the prototype's end

(1) Remote Monitoring and Customer Data

To evaluate the study's success, the Operator will share electricity consumption and payment data alongside smart meter numbers for all customers on control and treatment sites. This should take the form of raw smart meter data exhibiting the highest resolution available (e.g. individual payment records on a fifteen minute to hourly basis).

Historical consumption and payment data for the twelve months prior to the prototype's launch must be provided upon signing of the Operator Agreement, before disbursement of funds. In the case this data does not exist (e.g. a site involved in the study is newly constructed or yet to be built), the Operator will provide historical data for as many months prior to the

prototype's launch as is available. Following the prototype's launch, consumption and payment data must be shared on a monthly basis for the duration of the study.

The Operator will share all consumption and payment data with CrossBoundary through the Lab's data platform, managed by Odyssey Energy Solutions, via API integration with the smart meter account. Should this not be feasible, the Operator will share all data as otherwise agreed to by both parties.

Additionally, to facilitate data analysis and survey conduction, the Operator will share a list of all meter numbers with customer name, customer ID, connection date, phone number, site, and site geographic coordinates. This information must be provided upon signing of the Operator Agreement, before disbursement of funds and may be uploaded to Odyssey.

(2) Prototype-Specific Data

Any prototype-specific data required to evaluate the study's success must be shared for control and treatment sites on a regular basis for the duration of the study. Data that will remain constant over time need only be shared once at the outset of the study. All customer-level data should be tagged by smart meter number. See the previous table for a schedule of the required prototype-specific data.

The Operator will share all data with CrossBoundary by uploading files to Odyssey.

(3) Site Economic Data

To assess the study's impact on mini-grid site economics, the Operator will share required site economic data for control and treatment sites. This data will be used to quantify the prototype's effects on Operator revenues, costs, and other important economic drivers.

Site economic data must be provided upon signing of the Operator Agreement, before disbursement of funds. The data should be shared by Operator's completion of the Excel table shown in *Annex 1*, which may be uploaded to Odyssey

(4) Survey Data

Surveys will be conducted to collect demographic, socioeconomic, and user experience data of study participants at control and treatment sites. Two surveys will be administered over the course of the study: (1) a baseline survey deployed prior to the prototype's launch and (2) an endline survey deployed following the prototype's end.

The surveys will measure asset ownership, current spending patterns, and current energy use patterns, among other metrics. This data will be analyzed to understand the prototype's impact on the socioeconomic status and well-being of participants.

The following table details the survey schedule for this prototype.

Survey	Audience	Format Administered
Baseline	Control and treatment sites, sample survey	Phone / In person
Endline	Control and treatment sites, sample survey	Phone / In person

CrossBoundary will deploy the surveys through Ipsos with funding from the Innovation Lab budget. The schedule, audience, and format of surveys may change given any updates to Lab funding or study needs (i.e. sample size).

Risks

The following table outlines the risks involved in the study.

Risk	Description	Probability	Mitigation
Low sign-up rates	Inability to pay or limited familiarity with the internet results in low interest	Low	<ul style="list-style-type: none"> • Increase marketing activities, offer a promotional sign-up special, or extend the tenor of the device loan program
Competition from telcos	Larger telcos like Airtel or Safaricom begin to offer data services	Low	<ul style="list-style-type: none"> • Focus on unlimited offering • Sell devices to customers separate from internet services
Technical solution insufficient	Wireless solution as designed doesn't work as expected given site topology	High	<ul style="list-style-type: none"> • Conduct a technical test with actual equipment on site before installing the formal POC

Analysis and Evaluation

Full analysis and evaluation of the study's results will be performed by the Study Partners.

Analysis

Study Partners will thoroughly evaluate each hypothesis against the metrics outlined in this Study Design, both periodically throughout the study and at the study's end. Partners will, additionally, monitor and analyze the prototype's effects on customer behavior as well as its social and economic impact on treatment communities.

CrossBoundary will analyze to what extent the prototype improves the mini-grid business model and quantify the benefit or cost to developers of incorporating the prototype into their standard operations. CrossBoundary will do this by applying observed changes in revenues and costs to its proprietary financial model. The resulting impact on project IRRs and cash flows will be evaluated under different scenarios. CrossBoundary will also assess the impact of the prototype on customers' wellbeing and economic opportunities. CrossBoundary will then recommend improvements to the prototype's design and implementation, to be incorporated into a later study or taken up directly by developers.

Dissemination of Results

Regularly throughout the study, CrossBoundary will publish a brief report, or *Innovation Insight*, capturing the study's results against each hypothesis in an anonymized and aggregated form. At the end of the study, CrossBoundary will publish a complete report capturing the study's final results as well as the Lab's recommendations on scaling, further testing, or discarding of the prototype. For each report, all developers involved in the Lab will be given time to review the report for completeness and accuracy ahead of the report being published. The reports will be made publicly available and shared with stakeholders engaged in CrossBoundary's work, including but not limited to mini-grid operators, donors, investors, and government agencies. Findings may also be disseminated through sector events, such as conferences and workshops. Other Study Partners may publish anonymized and aggregated study results in peer-reviewed academic journals.

Annex 2: Customer Wellbeing (Social Impact) Hypotheses

Hypothesis	Metric	Source
<p>1. <i>Income generation & employment</i> Customers at treatment sites will report an increase in income generation compared to customers at control sites, exhibiting:</p> <ul style="list-style-type: none"> a. a 10% increase in the proportion of households operating businesses within the compound; b. a 10% increase in the proportion of households using electricity to generate income; c. a 10% increase in spending of disposable income; d. a 10% decrease in the proportion of households for whom subsistence farming or casual labor is the primary source of income, or who report they are unemployed. 	<ul style="list-style-type: none"> • Proportion of households operating businesses within the compound • Proportion of households using electricity to generate an income • Weekly airtime expenditure • Proportion of households who report that their primary source of income is subsistence farming, casual employment or that they are unemployed 	<ul style="list-style-type: none"> • Lab survey data
<p>2. <i>Education</i> Customers at treatment sites will report an increase in education investment among school-age children compared to customers at control sites, with customers reporting:</p> <ul style="list-style-type: none"> a. a 25% increase in the number of hours spent on school work per child in school; b. a 5% increase in expenditure on school fees; c. a 3% increase in the proportion of school-age children who regularly attend school. 	<ul style="list-style-type: none"> • Hours spent on schoolwork per child in school • School fee expenditure • Proportion of school-age children who regularly attend school 	<ul style="list-style-type: none"> • Lab survey data
<p>3. <i>Sources of energy</i> Customers at treatment sites will switch away from unclean, unsafe, and expensive energy sources for household use compared to customers at control sites, with customers reporting a 10% reduction in expenditure on non-mini-grid energy sources.</p>	<ul style="list-style-type: none"> • Expenditure on non-mini-grid energy sources 	<ul style="list-style-type: none"> • Lab survey data

Hypothesis	Metric	Source
<p>4. <i>Customer well-being</i> Customers at treatment sites will derive greater well-being from their mini-grid service, with customers reporting greater satisfaction with their mini-grid service compared to customers at control sites, and access to electricity as having a more positive effect on their life.</p>	<ul style="list-style-type: none"> • Customer-reported score on satisfaction with mini-grid service • Customer-reported score on impact of having electricity on life 	<ul style="list-style-type: none"> • Lab survey data
<p>5. <i>Health</i> Customers at treatment sites will report fewer energy-related health complaints compared to customers at control sites, with: a. 10% fewer customers reporting any kerosene accidents in the household in the last year; b. 10% fewer customers reporting any respiratory illness in the household in the last year.</p>	<ul style="list-style-type: none"> • Proportion of households experiencing kerosene accidents • Proportion of households experiencing respiratory illnesses 	<ul style="list-style-type: none"> • Lab survey data
<p>6. <i>Female empowerment</i> Customers at treatment sites will report an increase in female empowerment compared to households at control sites, with 5% more households at treatment sites reporting that a female household member is either fully or partly involved in decisions on household expenses.</p>	<ul style="list-style-type: none"> • Proportion of households where a female household member is fully or partly in household expenditure decisions 	<ul style="list-style-type: none"> • Lab survey data
<p>7. <i>Access to financial services</i> Customers at treatment sites will report more access to financial services compared to customers at control sites, with 5% more households using financial services from formal institutions (commercial banks, SACCOs, MFIs, NGOs).</p>	<ul style="list-style-type: none"> • Proportion of customers who use financial services from formal institutions 	<ul style="list-style-type: none"> • Lab survey data

Annex 3: Operator-Specific Information

Site Selection

The following sites have been selected for execution of the study with [developer] in [country].

Site	Study Purpose	Households	Current Connections	Additional Information

More sites may be added to the study pending initial results and Lab budget.

Budget

The following budget has been agreed to for execution of the study with [developer] in [country].

Implementation Plan

The following implementation plan has been agreed to for execution of the study with [developer] in [country].

Technical Design

The following details the technical design of the study with [developer] in [country].

Options and Pricing

Billing

Backhaul

Fiber Optic Network