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# Mini-grid Innovation Lab

LCEDN 7<sup>th</sup> annual conference

2018

PRIVILEGED AND CONFIDENTIAL

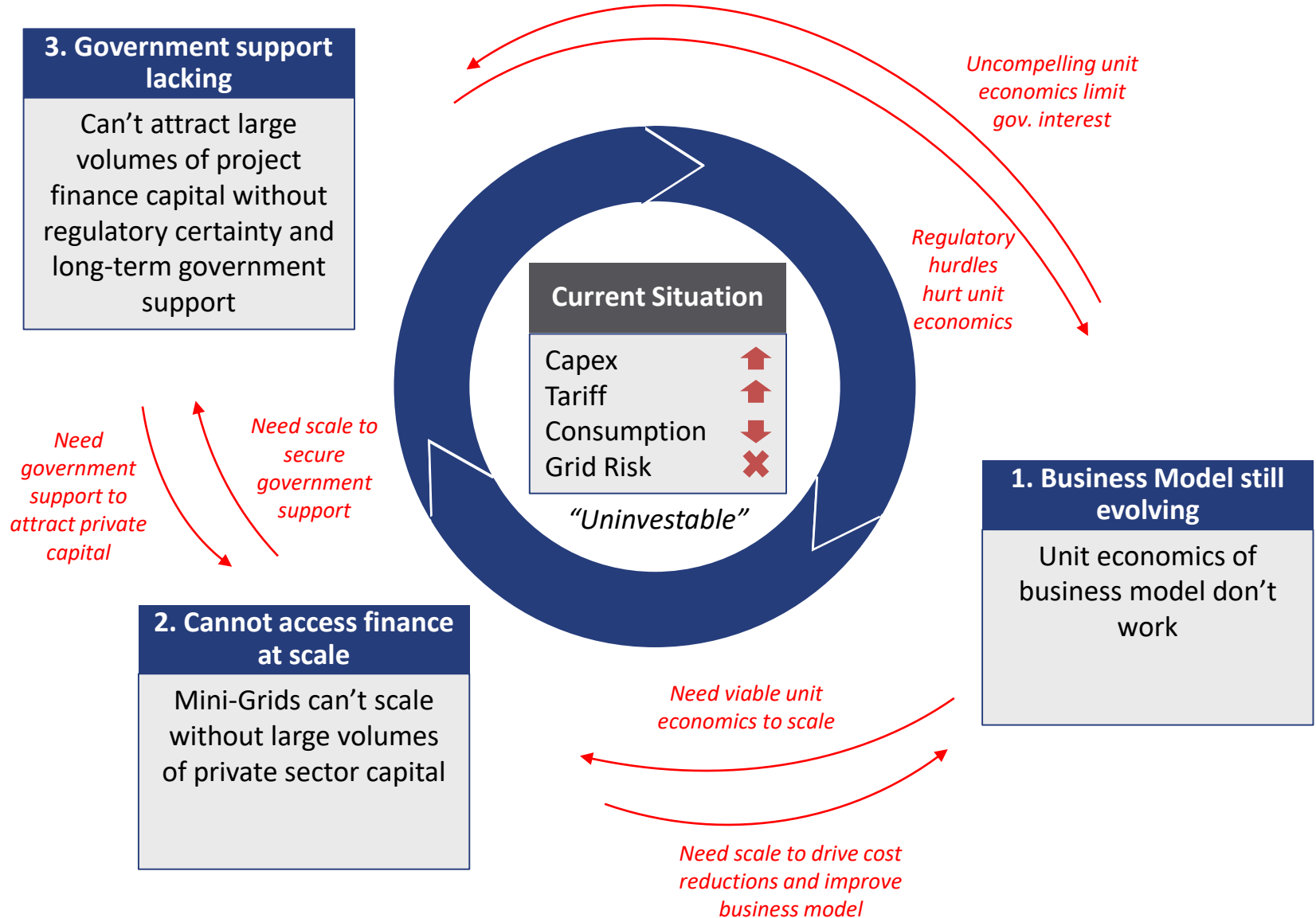


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**The Mini-Grid Innovation Lab exists to improve the capability of mini-grids to provide Africans with electricity**

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# Mini-grids are currently stuck in a 'doom loop': need (i) improved unit economics, (ii) finance to scale and (iii) government support to thrive





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**The Lab is a pooled R&D fund for developers to test new ideas and to build the evidence base for mini-grids in Africa**

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# The Lab's objective is to improve energy access provided by mini-grids in Africa, underpinned by more granular performance measures

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## Mini-Grid Innovation lab performance measures

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<b>Objective</b>	<b>Improve the capability of mini-grids to provide Africans with electricity</b>		
<b>Outcomes</b>	<b>Increase consumption per person</b>	<b>Reduce costs to operate</b>	<b>Increase number of consumers</b>
<b>Outputs (end of 2018)</b>	<ul style="list-style-type: none"><li>• <b>Test 4 prototypes in 2-3 countries</b></li><li>• <b>Developers adopt and scale up 1-2 innovations</b></li><li>• <b>Source additional funding for scale-up</b></li></ul>		

## The Lab is different in 3 ways:

It is developer led, grounded in data and relies on iterative field testing

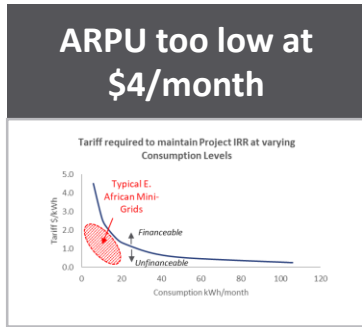
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1. **Developer led** – we work with developers to understand their innovation priorities and implement prototypes with them that they think will have the most impact
2. **Data driven** – we collect data on everything we do to understand how a prototype will affect a business's bottom line and the impact it could have at scale
3. **Iterative testing** – great ideas often collide hard with reality when implemented. We iterate the approach during field testing to ensure the best chance of success

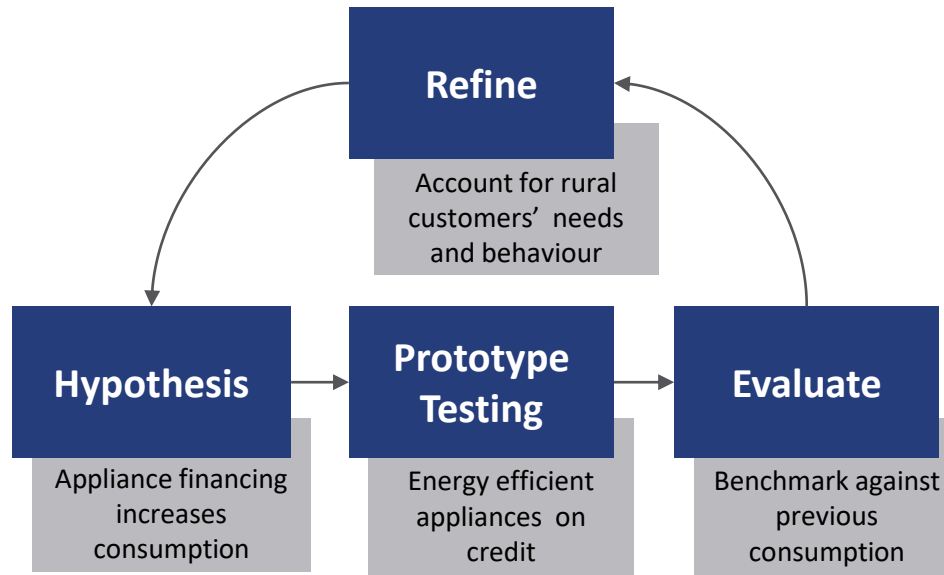


# We have launched an innovation lab to improve the business model through a developer-centred, iterated prototyping process

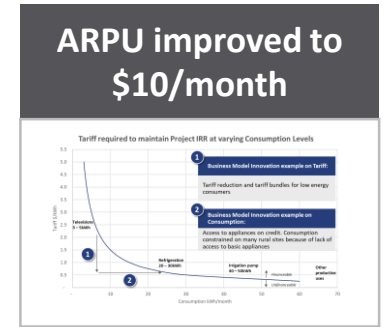
Developers identify gap in business model



Innovation Lab runs iterative process to test and refine solution to business model gap



Developers implement solution



## Lab Stakeholders

**Innovation Lab**

**CROSSBOUNDARY**  
+ E4I and partners

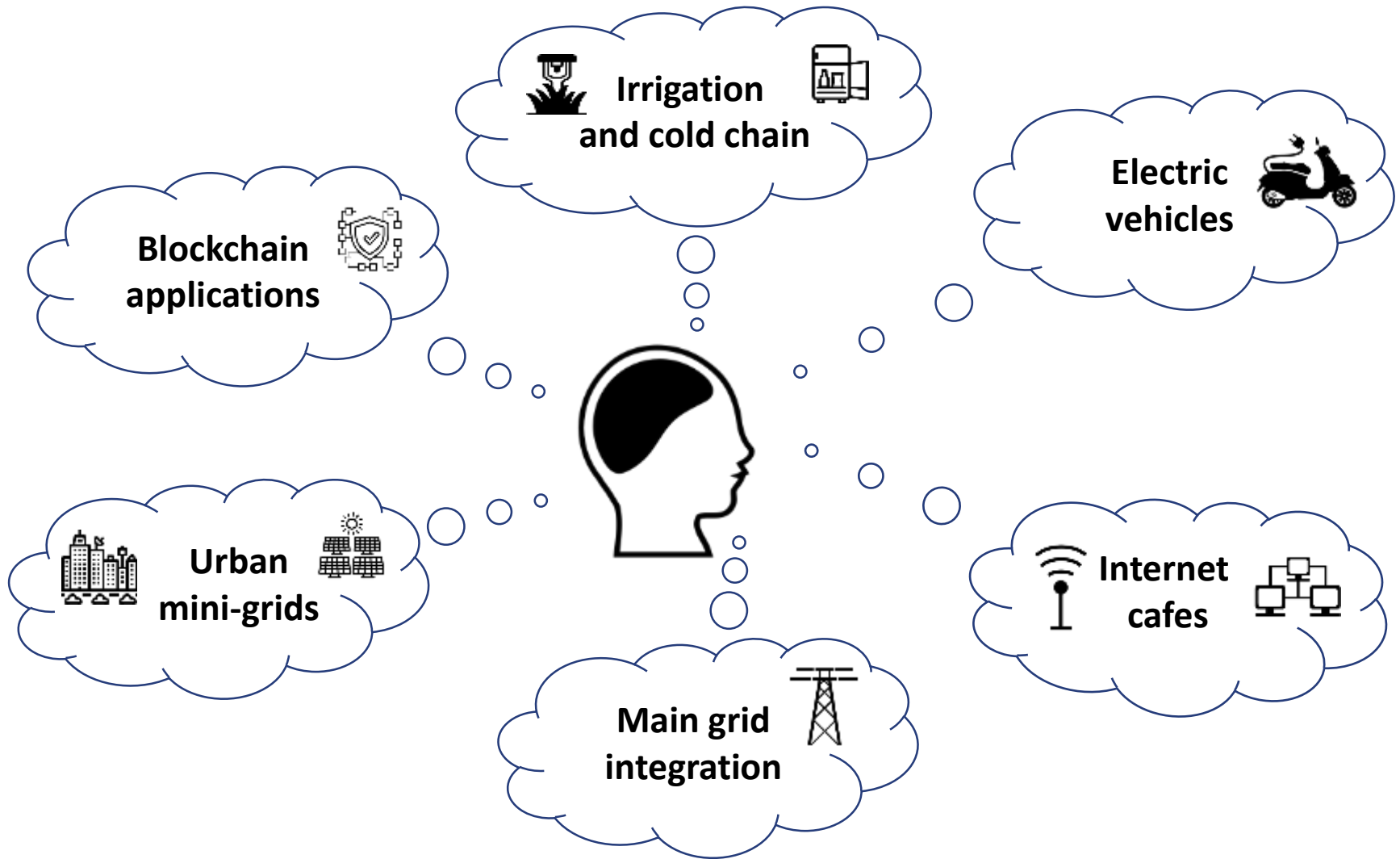
**Donors**

**The ROCKEFELLER FOUNDATION**  
+ others

**Developers**

# The Lab will test innovative ideas that improve mini-grids economics and demonstrate new ways of delivering power to people

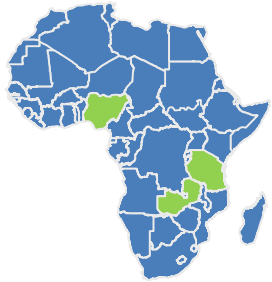
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# The Lab delivers unparalleled access to data on mini-grid customers and consumption patterns, that will be carefully managed

Numerous developers across several countries



- 3 countries
- 5+ developers already involved

Customer profiles across multiple sites



- 2,000+ customers
- 15+ sites
- More data to come with further prototypes

Thousands of data points per customer

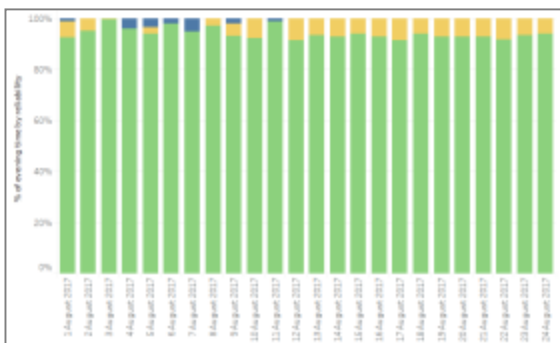
A screenshot of a data table with multiple columns and rows. The columns include 'SiteID', 'CustomerID', 'Date', 'Consumption', 'Voltage', 'Current', and 'Power'. The rows contain numerical data for various sites and customers, representing thousands of data points per customer.

- Hourly or quarter-hourly consumption, voltage, current measurements per customer

We already have 20 million+ data points before starting any prototypes

# The Lab will use its data base of tens of millions of data points to publish ground breaking research pieces on rural electrification and mini-grids' role

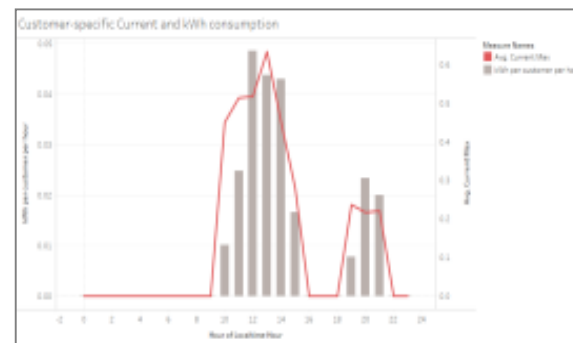
Power quality at mini-grid sites is high (2% down-time on average)



Satellite imagery reveals high consumption concentration around main roads



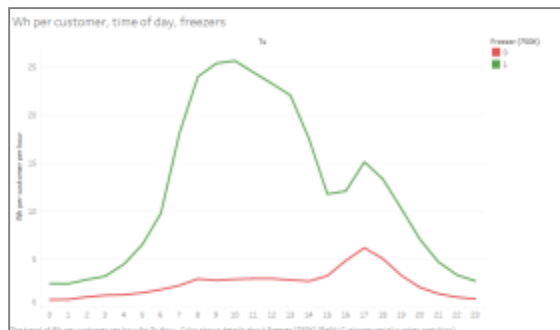
Appliance types can be identified through customer-level current and voltage profiles



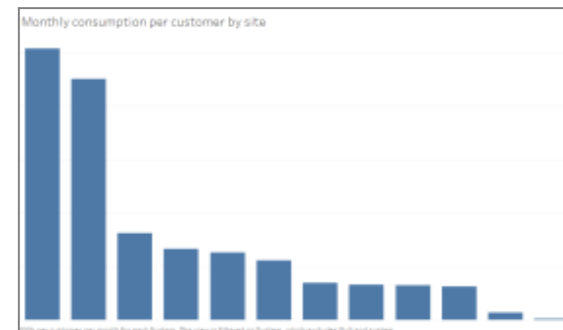
Appliance ownership significantly increases consumption



Productive appliances could align electricity demand with generation



Site benchmarking can highlight strengths to replicate across other locations



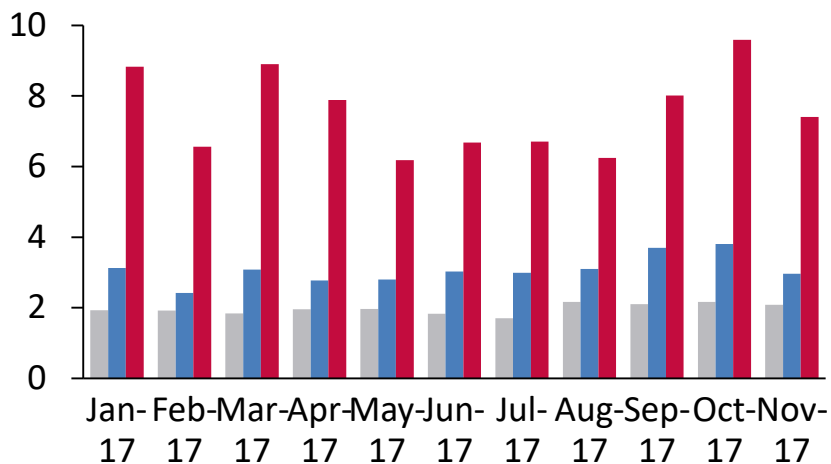
**CrossBoundary is using Big Data analytics to drive understanding of rural mini-grids and their customers previously not possible**

# Sector evidence base: Freezer owners have 200-300% higher consumption vs. 50% for TVs, and their demand profile is cheaper to serve

## Energy consumption by freezer owners is 300% higher; TVs only 50% higher

Average monthly consumption by type of appliance owned, 2017

kWh per month

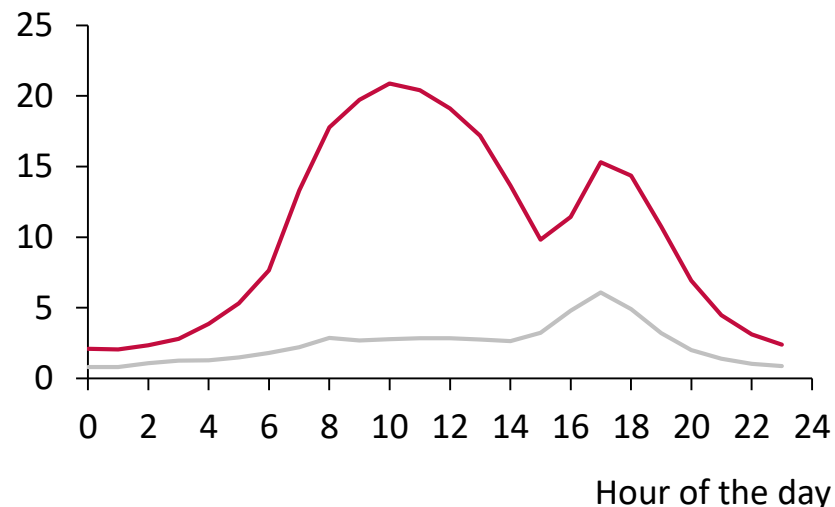


- Neither appliance owner
- TV owner
- Freezer owner

## Freezer users' load profile cheaper to serve as it aligns with generation time

Average consumption by hour of day per customer by appliance ownership, 2017

Wh



- Does not have freezer
- Has freezer

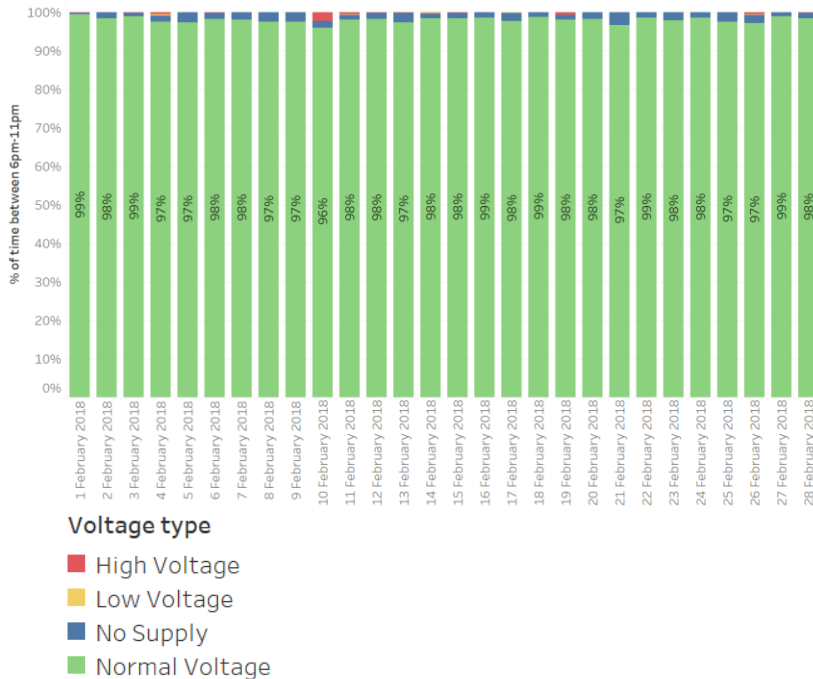
**Freezers are 2-3x more expensive than TVs but 4-6x more profitable for mini-grids and should be a higher focus for operator leasing**

Source: Developer data, 2017 (smart meter and customer appliance purchases)

# Sector evidence base: Private sector rural mini-grids can provide better quality power than parts of the public sector run main grid

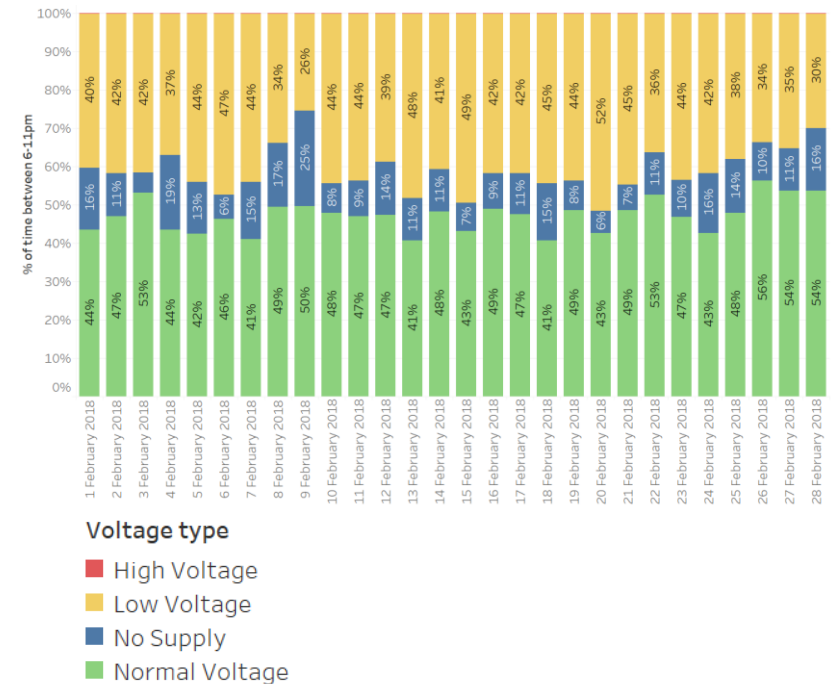
## Sample rural mini-grids have 98% normal voltage on average

% of evening hours, average across all customers, February 2018 Powergen 9 site sample



## City connection in Tanzania has 46% normal voltage range on average

% of evening hours, February 2018 20 site sample

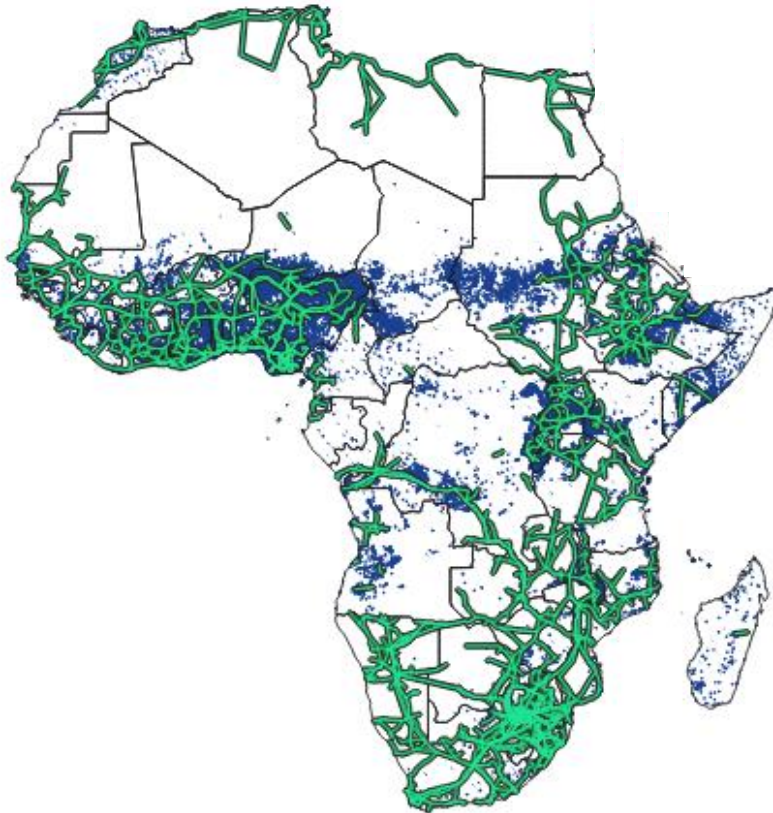


**Average downtime across Africa is 6% per year, and only 42% of grid connected rural customers say they have electricity most or all of the time**

Source: ESMI Kenya KPLC outages by location, 2017-8; Developer smart-meter voltage data 2017; Africa Energy Outlook 2014, duration of energy outages; Afrobarometer 2016 Off-grid or 'off-on'. Evening hours are 5pm-11pm. Outage in developer sample is any time voltage drops below 50V on average for an hour, and the whole hour is counted as an outage for that household – a conservative estimate. Outages in KPLC sample are done on a minute-by-minute basis

# Sector evidence base: We can show mini-grids are the most cost-effective means of electrifying *at least 100 million people*, based on *today's costs*




## Mini-grid and main grid addressable zones African continent, 2015



100m best served by mini-grids

210m best served by grid extension

### Legend

- Existing + Planned HV grid line 
- Grid addressable zones  
(25km HV line buffer) 
- Mini-grid addressable zones 

**Note:** Zones in Algeria, Libya, Tunisia, and Egypt have been excluded from total potential given high electrification rates (99%+)

Source: Electrification for Under Grid households in Rural Kenya, Kenneth Lee et al 2016; Africa's Pulse, April 2017, volume 15, World Bank; World Bank African Transmission and Distribution lines 2017; WorldPop 2015 population density map, Africa, UN adjusted, International Energy Agency Africa Energy Outlook 2014

# Prototype testing: The Lab has already deployed two prototypes, with several more in the pipeline for 2018

## Appliance finance

- The Lab is testing whether offering appliances to customers on credit will increase consumption and grow mini-grid revenues more than the associated costs
- Over 500 appliances have been sold across 20 participating sites with 4 developers in East Africa
- 6 Nigerian developers are eager to deploy a similar prototype

## Tariff subsidy

- The Lab is testing whether rural customers use more electricity if the price is lower, or if other factors are preventing them from using more power
- Tariff subsidy is launching on 2 sites in Tanzania
- 3 other developers are interested in launching this prototype
- The prototype will provide an evidence base to governments and donors about the impact of a tariff subsidy and how it can be structured

## Selected prototype pipeline

- **Metering:** testing and evaluating the performance vs. cost of smart meter providers
- **Grid integration:** testing the technical, legal and economic feasibility of integrating existing mini-grids with main grid infrastructure as it extends
- **Wi-fi:** testing whether offering wi-fi services increases revenues significantly
- **Extension capex reduction:** testing whether a modular solution can be used to profitably extend capacity at site (or be used for initial generation capacity)