CROSSBOUNDARY

Achieving universal electrification in Africa

The role of private sector mini-grids

May 2019

Private sector mini-grids have a transformational role to play in electrifying Africa. The sector is ready to scale, but needs support now

1. **Universal rural electrification is worthwhile, but requires subsidy**

2. **Mini-grids are the best mechanism of rural electrification for at least 100 million people in Africa**

   Things we know:

   i. For these 100 million people, mini-grids are the most cost effective means of providing electricity

   Things we believe:

   ii. Mini-grids and grid will integrate to form the grid of the future. This is not a dead-end

   iii. Mini-grids facilitate private utilities who will serve customers better

CROSSBOUNDARY

Universal rural electrification is worthwhile but requires public subsidy

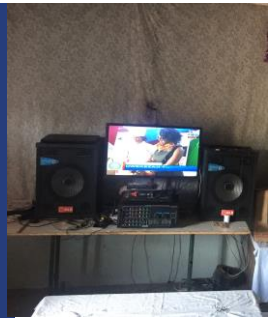
Why electrification? Because people should not live in poverty, and electrification can address both the symptoms and the causes of poverty

Why are we supporting rural electrification?

Rural electrification…

Because we believe no one should live in poverty, and rural electrification is part of the solution

1. …alleviates symptoms of poverty by improving quality of life and…



2. …drives local economic development, increasing incomes

The link between electrification and quality of life is well established. The link between electrification and economic development is not

Source: Photos from CrossBoundary site visits to India, Tanzania, and Kenya 2017

The fundamental challenge of universal rural electrification is that rural customers cannot afford the cost to connect them

Cost to connect and service rural customers

>

Revenues from rural customers

This gap is not unique to Africa. It's generic to the history of rural electrification in every single country

Rural electrification therefore requires subsidy, direct or indirectly

Direct subsidy

Funded from **the tax base**, directly disbursed by government agencies directly to support rural connections

OR

Indirect subsidy

Funded by **higher paying utility customers**, utility uses profits to cover costs of servicing unprofitable rural connections

Light for All, Brazil

Funding provided from federal and state governments budgets

Queensland, Australia

Urban consumers cross-subsidise rural consumers by **$561m every year, $800 per consumer**

Under either mechanism, wealthy tax payers / energy consumers subsidise poorer rural consumers

But, we've done this before. 2.5 billion rural people enjoy electricity today due to subsidy programs…

The United States under Roosevelt in the 1930s

- Roosevelt established the Rural Electrification Administration (REA) in 1935.
- In its first 5 years, the REA provided over $227 million in **government subsidized loans** ($3.6 billion in today's dollars) to connect rural famers

By 1953, more than 90 percent of U.S. farms had electricity

Post-apartheid South Africa in the late 1990s

- In the late 1990s, the government decided to fund the capital cost of the electrification program entirely through fiscus, through the National Electrification Fund.
- From 2001, this covered the **entire cost of the capital connection**

Access to electricity increased from 35% of households in 1990 to 84% in 2011

Lula's Brazil in the early 2000s

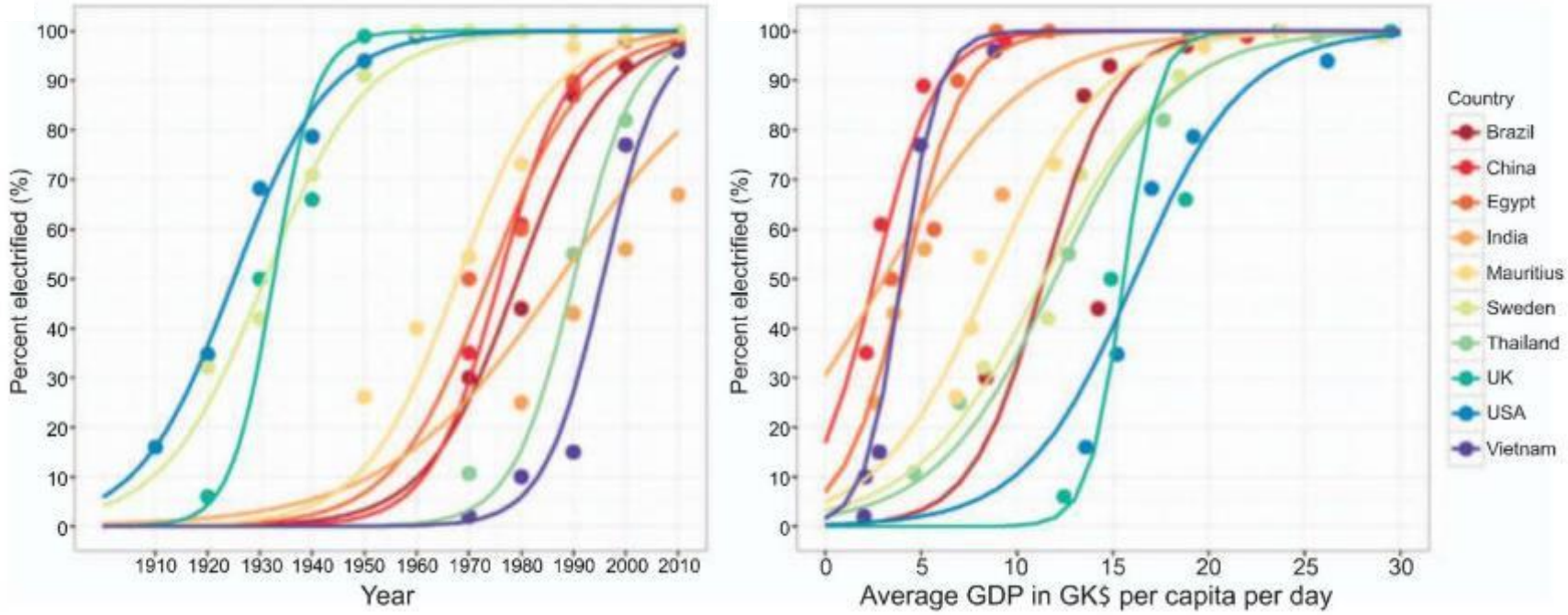
- One of Lula's first initiatives on becoming President was to launch Brazil's Luz para Todos (Light for All) program in 2003
- **85% of capital costs for expanding rural connections** were covered by federal and state governments

After 10 years of intervention, more than 15 million connected by the LfA program

Source: World Bank data, https://www.electric.coop/our-organization/history/ , StatsSa 2012

…and rapid universal electrification progress can be achieved in low-income countries

Electrification develops rapidly along an S-curve against both time and GDP $/capita[1]



- Unsurprisingly, supporting mass electrification with government support strongly correlated to GDP per capita
- Early achievers, like the UK and USA, **started electrification at around $15/capita/day**[1] when electricity access was about 20%.
- More recently, China and Vietnam started the electrification process when **average income was less than $5/capita/day**[1].

Challenge for Sub-Saharan African nations is illustrated by countries like Tanzania, which currently has electrification rate of 16% and GDP per capita of just over $2/day

Source: Energy access and living standards: some observations on recent trends, 2017. Note: 1. GDP/capita given in international (or Geary–Khamis) dollars. International dollars have the same purchasing power parity that the U.S. dollar had in the United States at a given point in time – 1990 in the graph above.

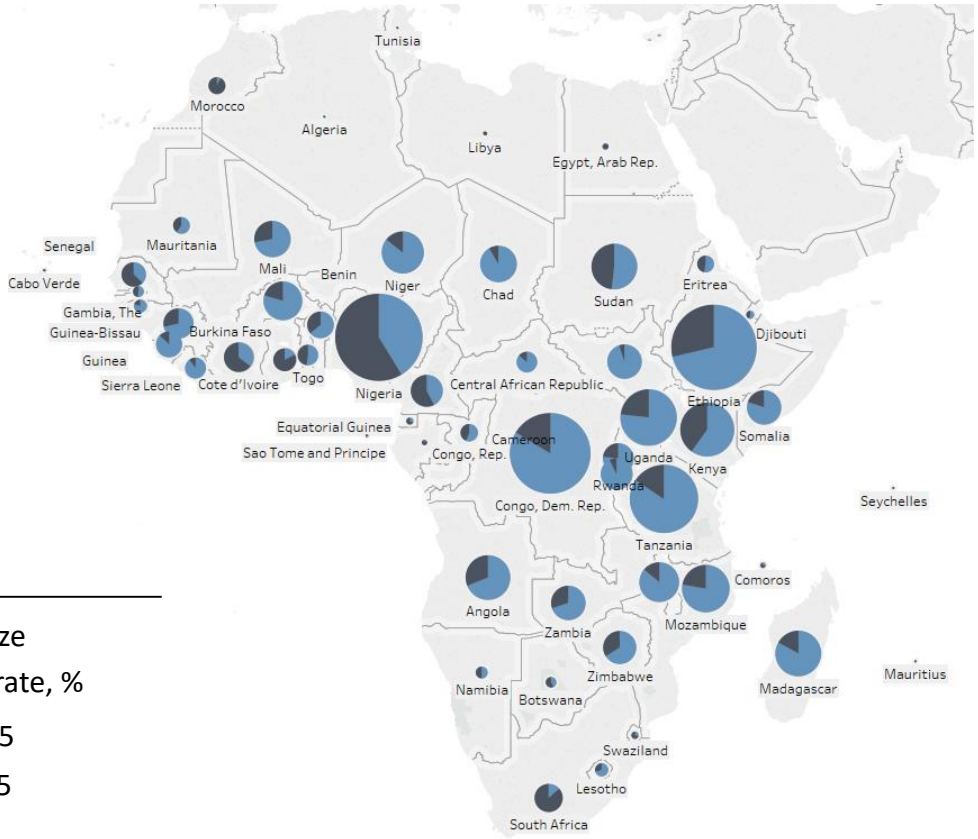
CROSSBOUNDARY

Mini-grids are the best mechanism to electrify 100 million people in Africa:

i.	Mini-grids are most cost effective for 100 million Africans	FACT
ii.	Mini-grids and grid will integrate to form the grid of the future	
iii.	Private sector can support mini-grid customers most effectively	

Based on World Bank data, CrossBoundary estimates 618m people in Africa lack electricity

Most of Sub-Saharan Africa has low electrification rates, with largest potential markets in Nigeria, Ethiopia, Kenya, DRC and Tanzania



618m people are not connected to the grid

Legend

Size scale: Off-grid market size

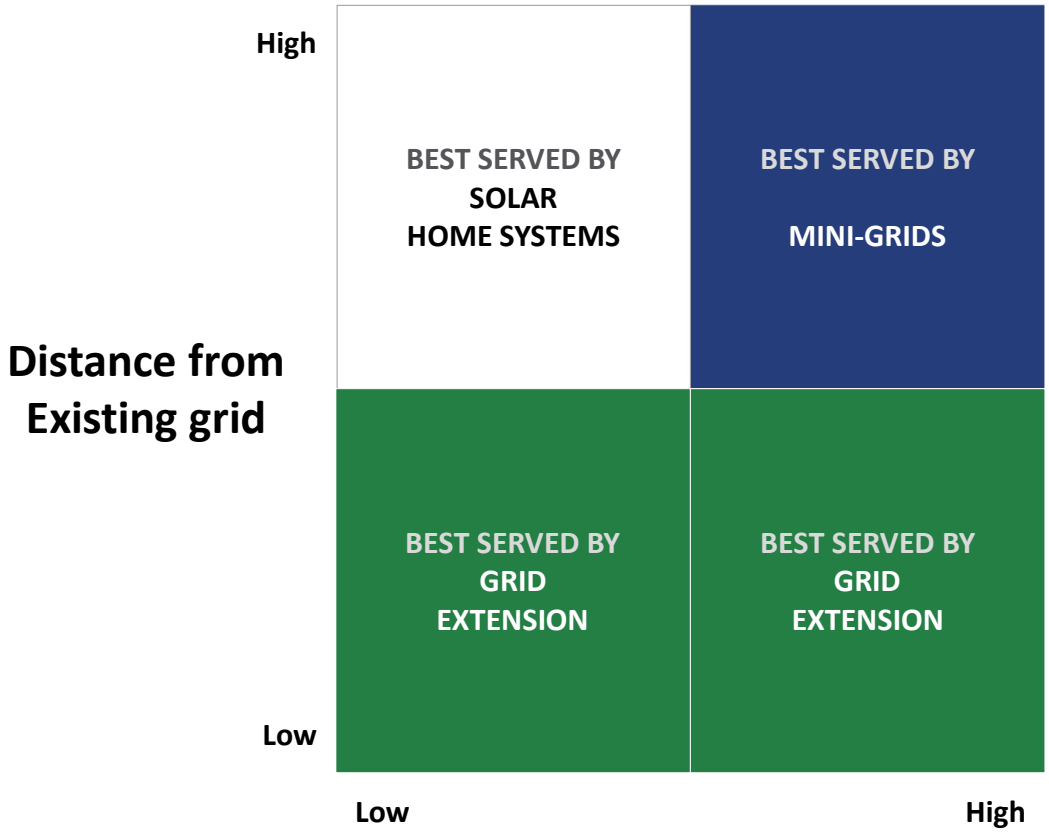
Colour scale: electrification rate, %

- Off-grid population, 2015
- On-grid population, 2015

Note: World Bank 2014 off-grid estimates are 616m non-electrified and 546m electrified, extrapolation was done to reduce discrepancy between 2015 population data used in CrossBoundary estimate. Extrapolation was based on historic percentage of new population electrified from 2012-14. If a country's electrified population decreased between 2012-14 in absolute terms, it was held constant for 2015

Source: World Bank population and electrification rate data, 2014; UNEP population data 2015 onwards

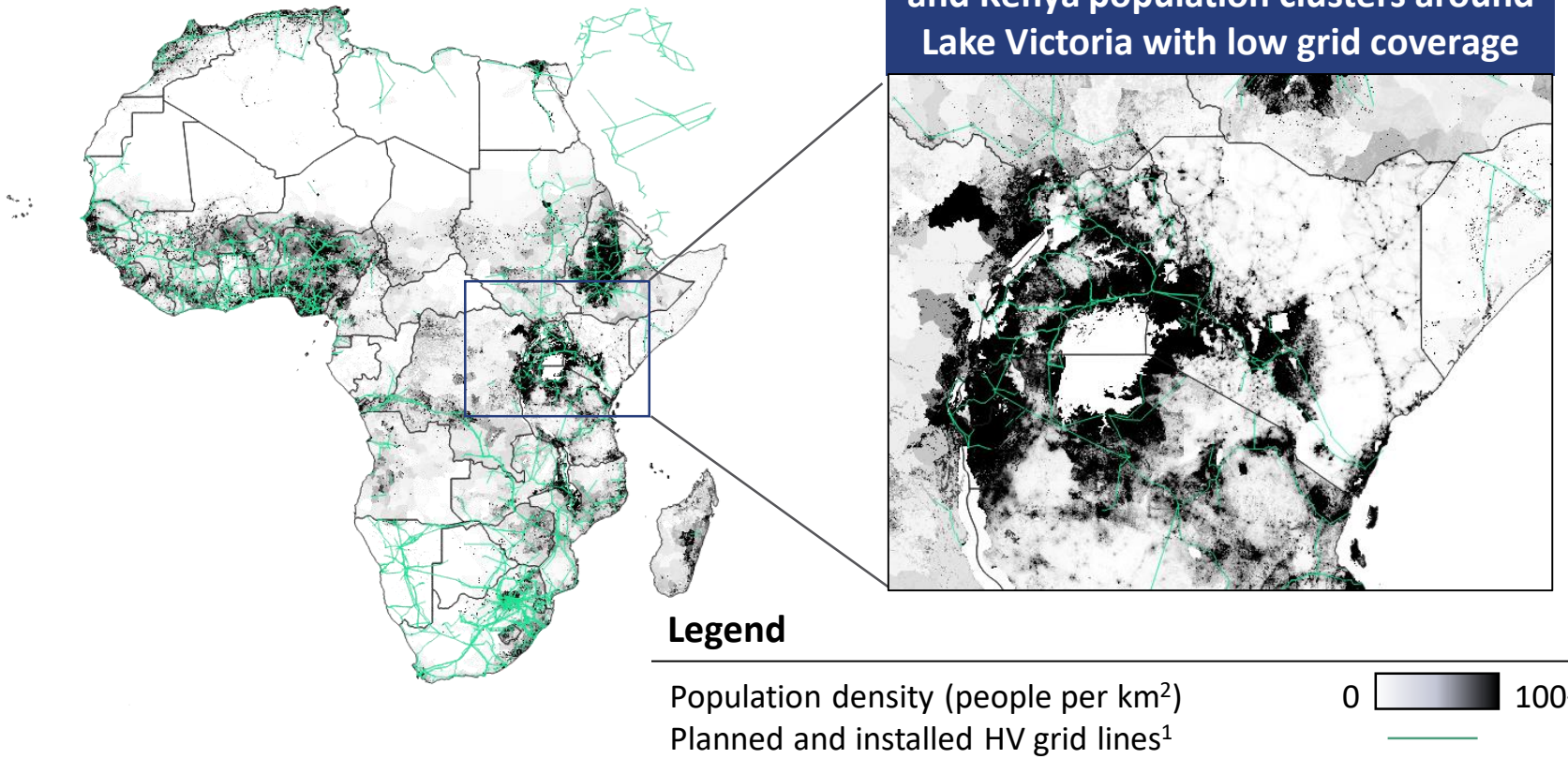
This 618m can be segmented by the most cost-effective means of electrification; (i) grid extension, (ii) Mini-Grids or (iii) SHS



But there is no broad consensus on how many people are in each box!

CrossBoundary has developed a 'big data' approach to estimate the size of the population *most cost-effectively served by mini-grids*

Analysis utilizes large datasets on existing and planned high voltage transmission line presence and population density: (i) World Bank grid map (2017) and (ii) population density by km^2 (2015)

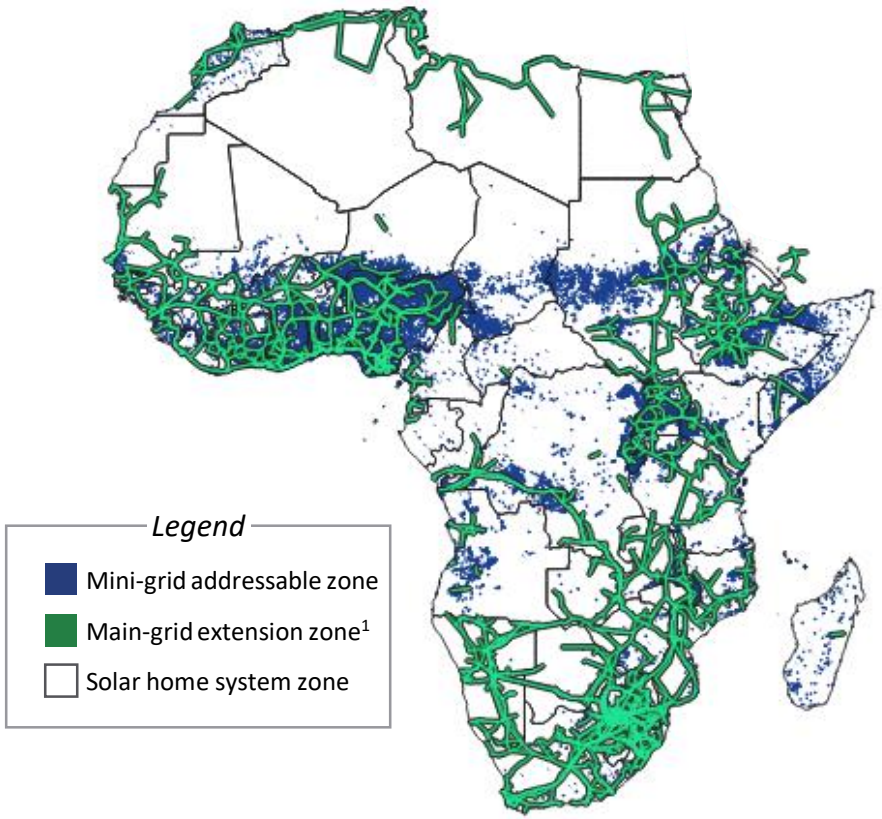


1. Equal or over 66 kV; includes planned and installed lines

Source: World Bank Electricity Transmission and Distribution Map, 2017; WorldPop population density per square kilometre, adjusted to UN 2015 population

Using this method, we can show mini-grids are the most cost-effective means of electrifying *at least* 100 million people, based on *today's* costs

Analysis of mini-grid and main-grid expansion addressable zones - African continent, 2015



100M best served by mini-grids

210M best served by grid extension

308M best served by SHS

1. 25km buffer from existing and planned HV grid lines

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

CROSSBOUNDARY

Mini-grids are the best mechanism to electrify 100 million people in Africa:

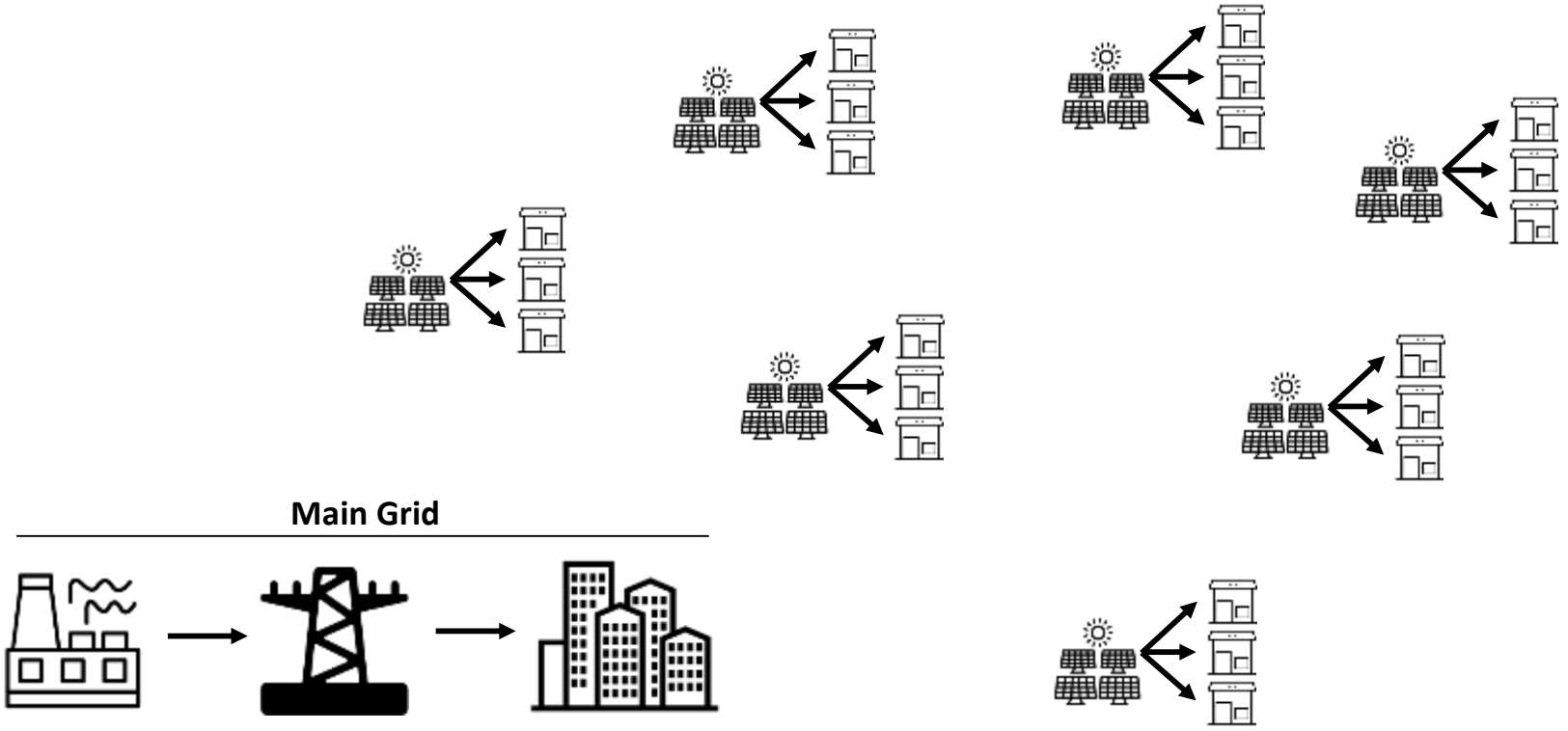
i. Mini-grids are most cost effective for 100 million Africans

ii. Mini-grids and grid will integrate to form the grid of the future **BELIEF**

iii. Private sector can support mini-grid customers most effectively

Mini-grid vs Main Grid is a false choice. Mini-grids are the main grid, just built with smarter technology and years ahead of schedule (1/3)

Initially mini-grids are autonomous, serving customers years before the main grid arrives…

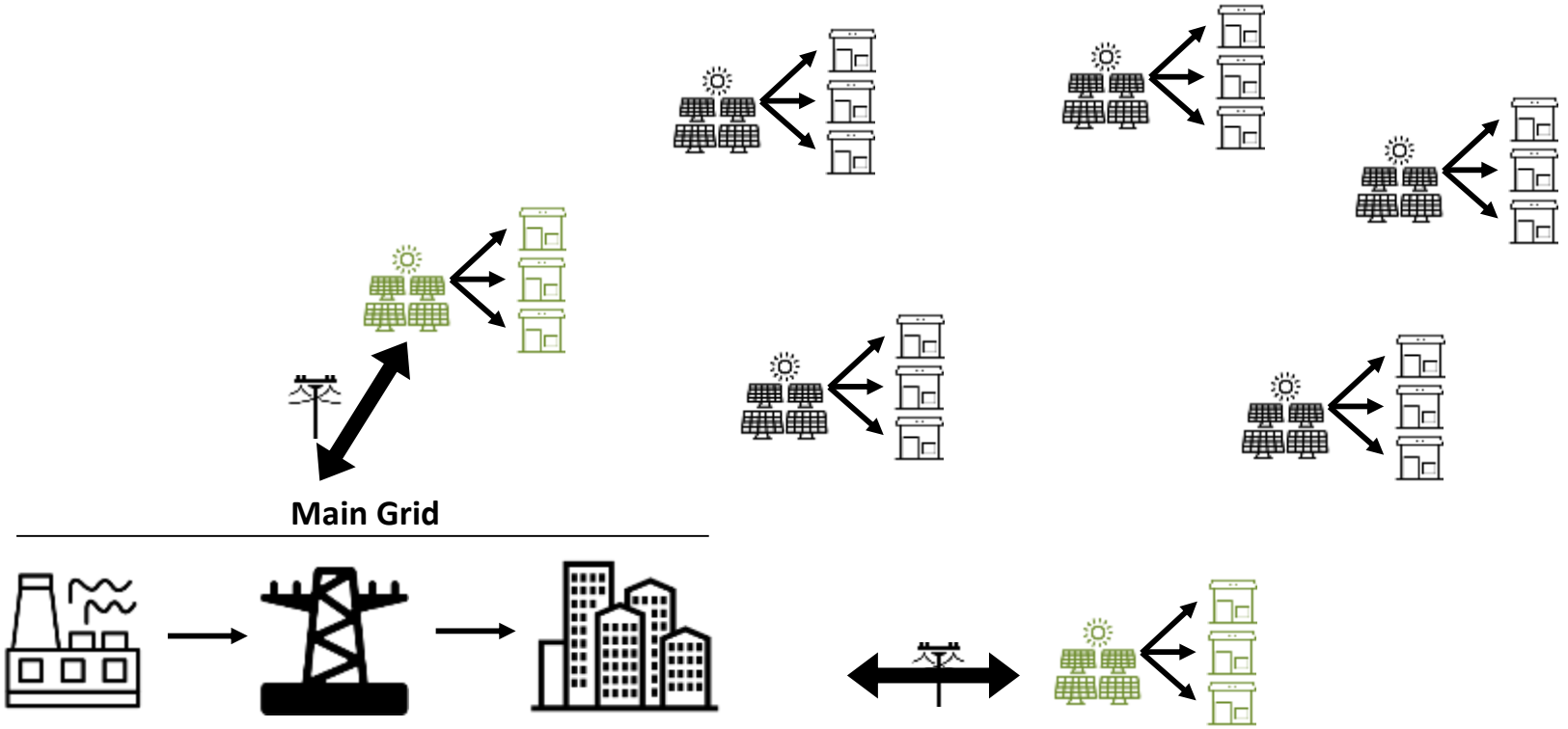


Energy Service Company (ESCO) builds last mile distribution networks for remote off-grid sites. Generation and storage are provided by solar and batteries. ESCO provides energy services to customers

Source: Graphic provided by PowerGen Renewable Energy

Mini-grid vs Main Grid is a false choice. Mini-grids are the main grid, just built with smarter technology and years ahead of schedule (2/3)

…as the main grid expands, it interconnects into mini-grid's existing distribution networks…

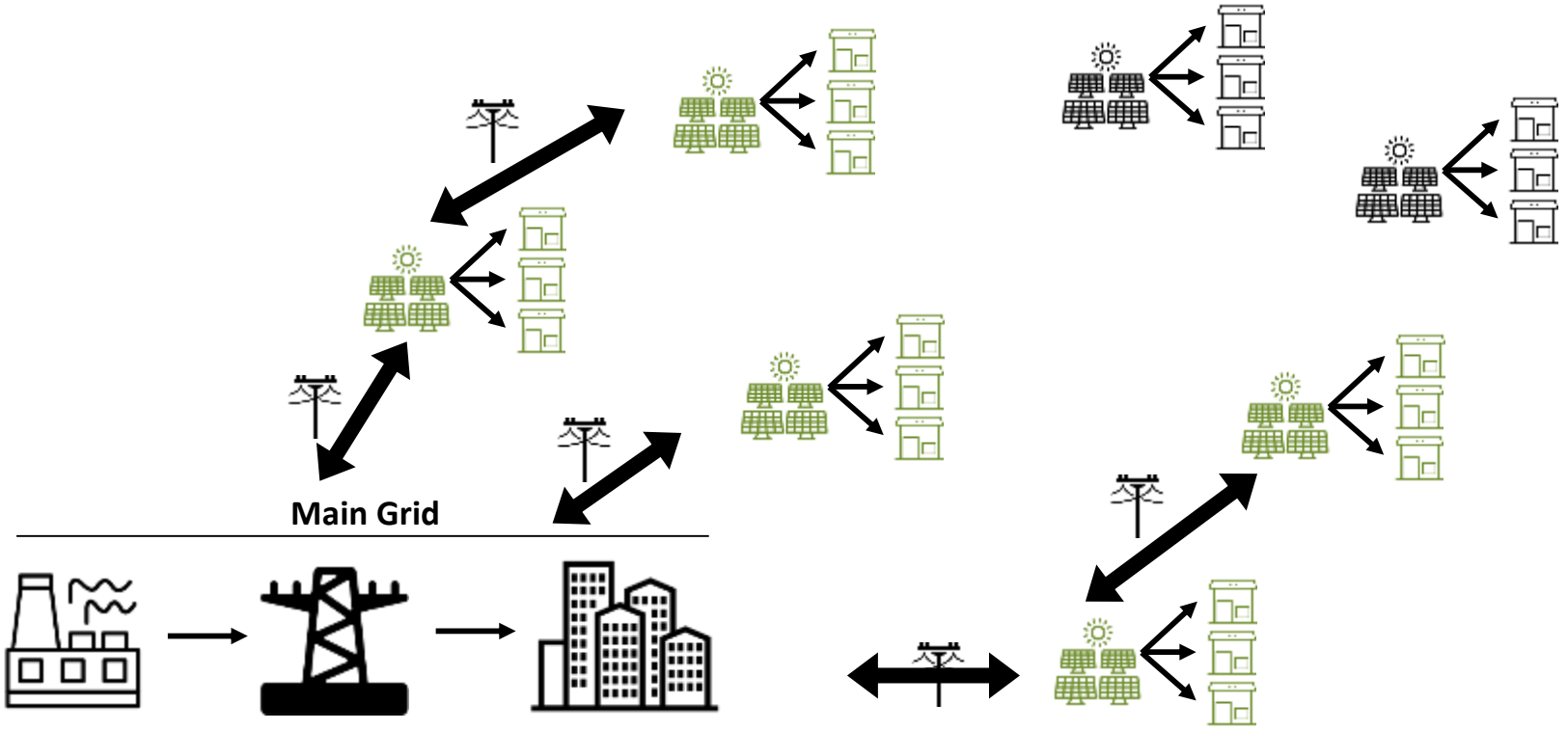


Main grid extensions arrive and connects into existing distribution network. Grid funders realise Capex saving as the last mile network is already built

Source: Graphic provided by PowerGen Renewable Energy

Mini-grid vs Main Grid is a false choice. Mini-grids are the main grid, just built with smarter technology and years ahead of schedule (3/3)

…forming a smart, flexible, and reliable grid made up of distributed generation and consumption



Building mini-grids is effectively building the grid from the outside in. Last-mile distribution networks have to be built for the main grid at some point – mini-grids just do it faster than main grid extension

Source: Graphic provided by PowerGen Renewable Energy

This is not a vision of the future. This is the history of rural electrification. Mini-grids have and always will be part of main grid expansion

Cambodia

- 250 privately owned and operated mini-grids
- Formerly isolated, **mini-grids are now connected to national grid** as 'small power distributors'
- Mini-grids serve 1M customers in Cambodia

7% of population still connected to mini-grid sites

China

- From 1978-1997, China connected 330M rural people to electricity
- Township Electrification Program used local renewable energy sources for mini-grids
- **Township mini-girds were connected to main grid**

Renewable energy complements main grid back-up supply

Australia

- Australian communities are building **mini-grids connected to main grid** to save on power bills
- Sites combine batteries, solar and diesel generators
- 2-way flow with main grid

Cleaner, cheaper power in rural communities

Source: Renew Economy, Australia's energy future 2015

CROSSBOUNDARY

Mini-grids are the best mechanism to electrify 100 million people in Africa:

i. **Mini-grids are most cost effective for 100 million Africans**

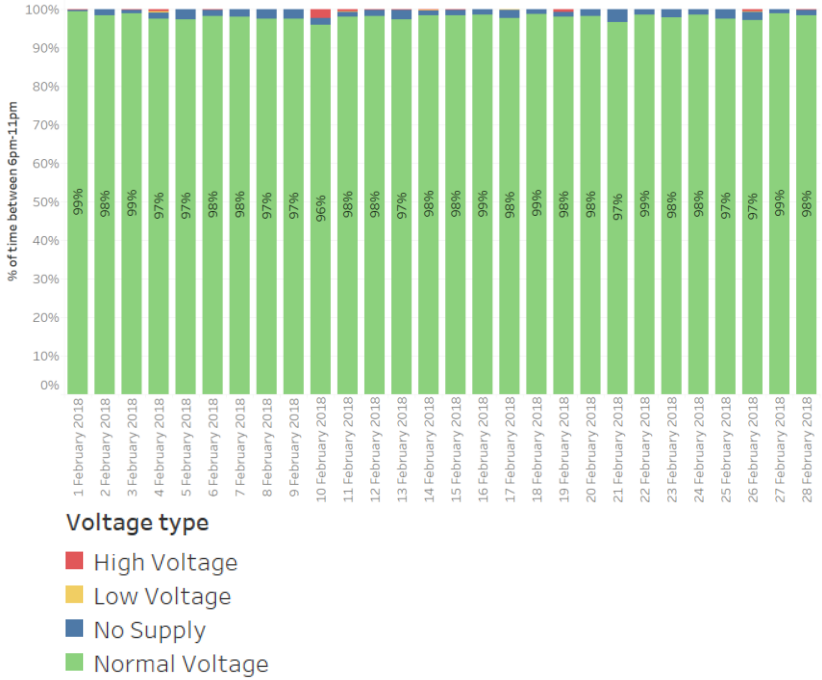
ii. **Mini-grids and grid will integrate to form the grid of the future**

iii. **Private sector can support mini-grid customers most effectively** BELIEF

Private sector rural mini-grids serving remote customers can provide better quality energy than many parts of the public sector run main grid

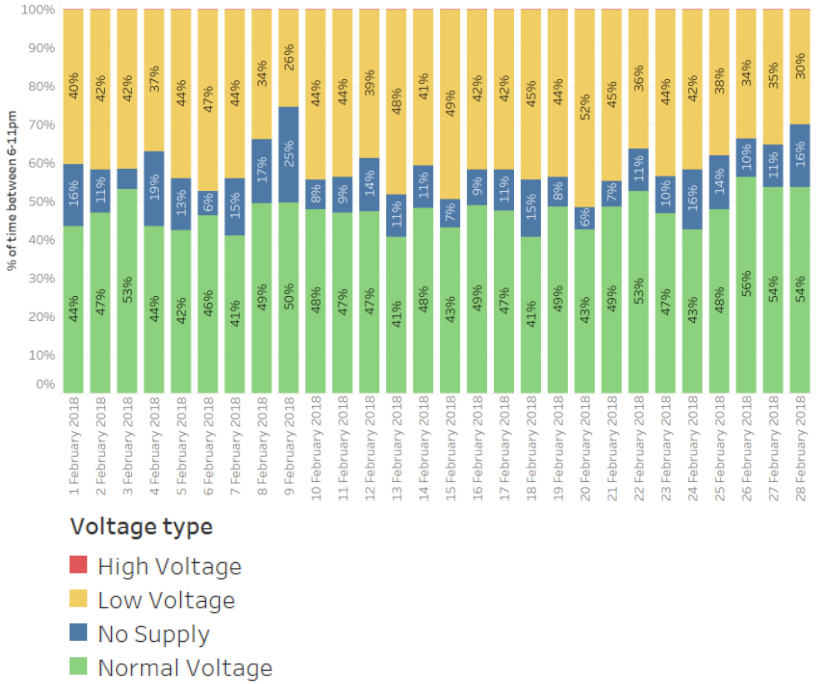
Sample rural mini-grids have 98% normal voltage on average

% 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



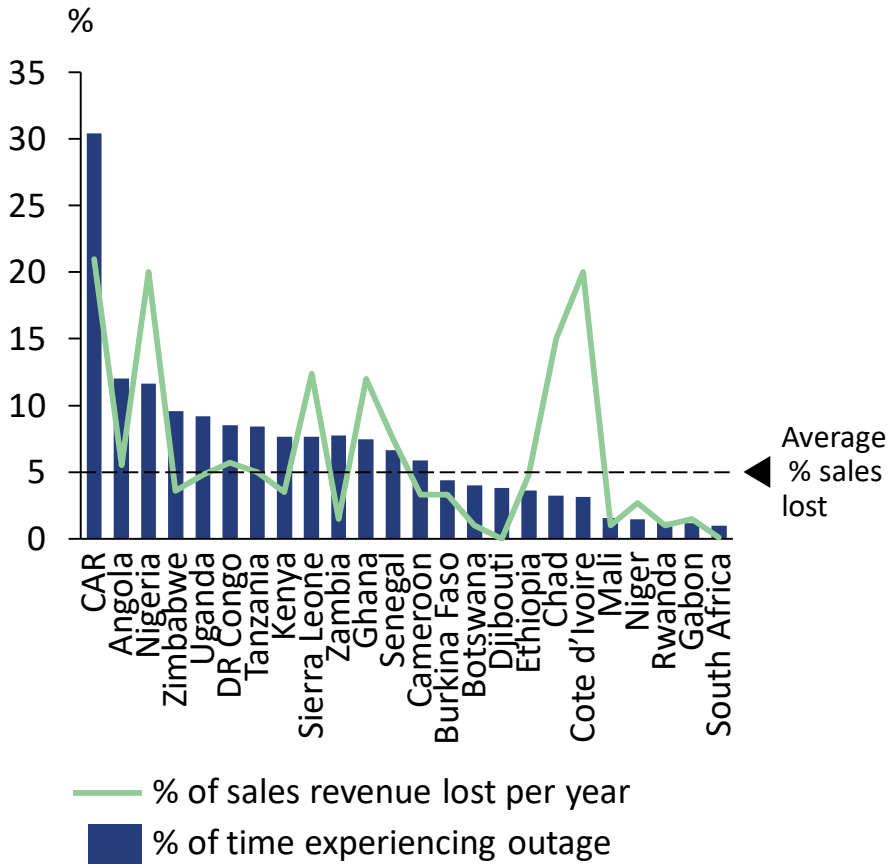
Average downtime across Africa is 6% per year, and only 42% of grid connected rural customers say they have electricity most or all of the time

Source: ESMI Tanzania TANESCO outages by location, 2017-8; Developer smart-meter voltage data 2017; Africa Energy Outlook 2014, duration of energy outages; Afrobarometer 2016 Off-grid'. 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 TANESCO sample are done on a minute-by-minute basis

And quality energy service is critical for income growth

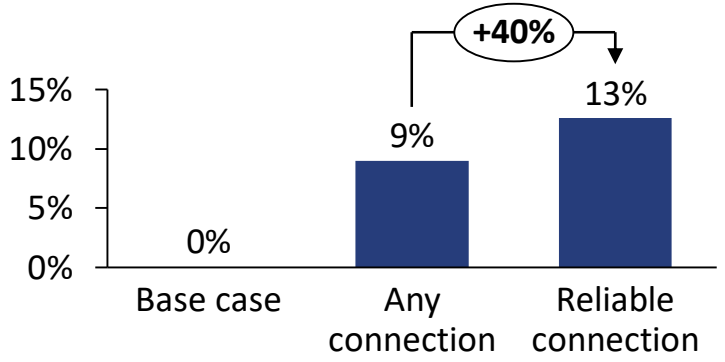
Power outages cost African businesses 5% of sales each year on average

Power outages and impact on business sales, 2014



India case: Increasing supply reliability tends to improve household income

% increase in income based on grid connectivity



- **Connecting to the grid** improves household incomes by **8-9%**
- **Connecting to reliable connections** (<6 hours downtime per day) increases income by **up to 13% (~40% premium** on 'standard' connections)
- Income improvements tend to come from wage/paid labour increases rather than from own businesses

Source: Africa Energy Outlook 2014, International Energy Agency; Impacts of reliable electricity supply: evidence from India, 2012

Private sector mini-grids have a transformational role to play in electrifying Africa. The sector is ready to scale

Thank you!