



International Solar Alliance Expert Training Course

PV Technology: Productive Use in Rural Environments

In partnership with the Clean Energy Solutions Center (CESC)

Carbon Trust

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This Training is an additional module under Module 4, and focuses on the issue of **Productive Use/Rural Environments**



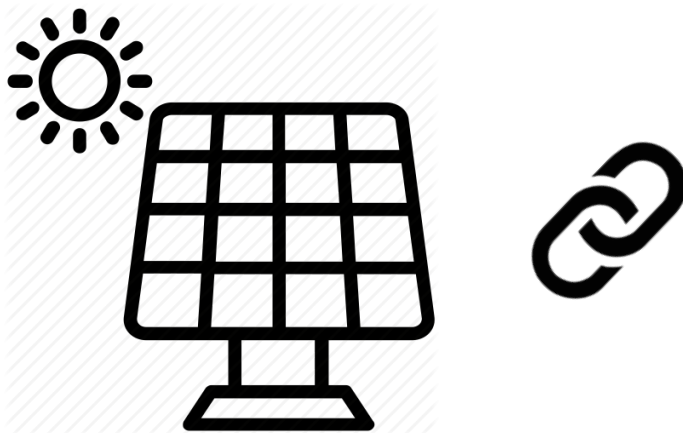
- 1. Introduction: Learning Objective**
- 2. Rural Environments: Status Quo**
- 3. Productive Energy Use (PEU) & PV Technology**
- 4. PV Technology & PEU Implementation Challenges & Opportunities**
- 5. Case Studies**
- 6. Conclusion**



1

Introduction: Learning Objective

- Understand the **application of PV technology** in the global rural electrification context and its **potential use in productive energy use** applications.

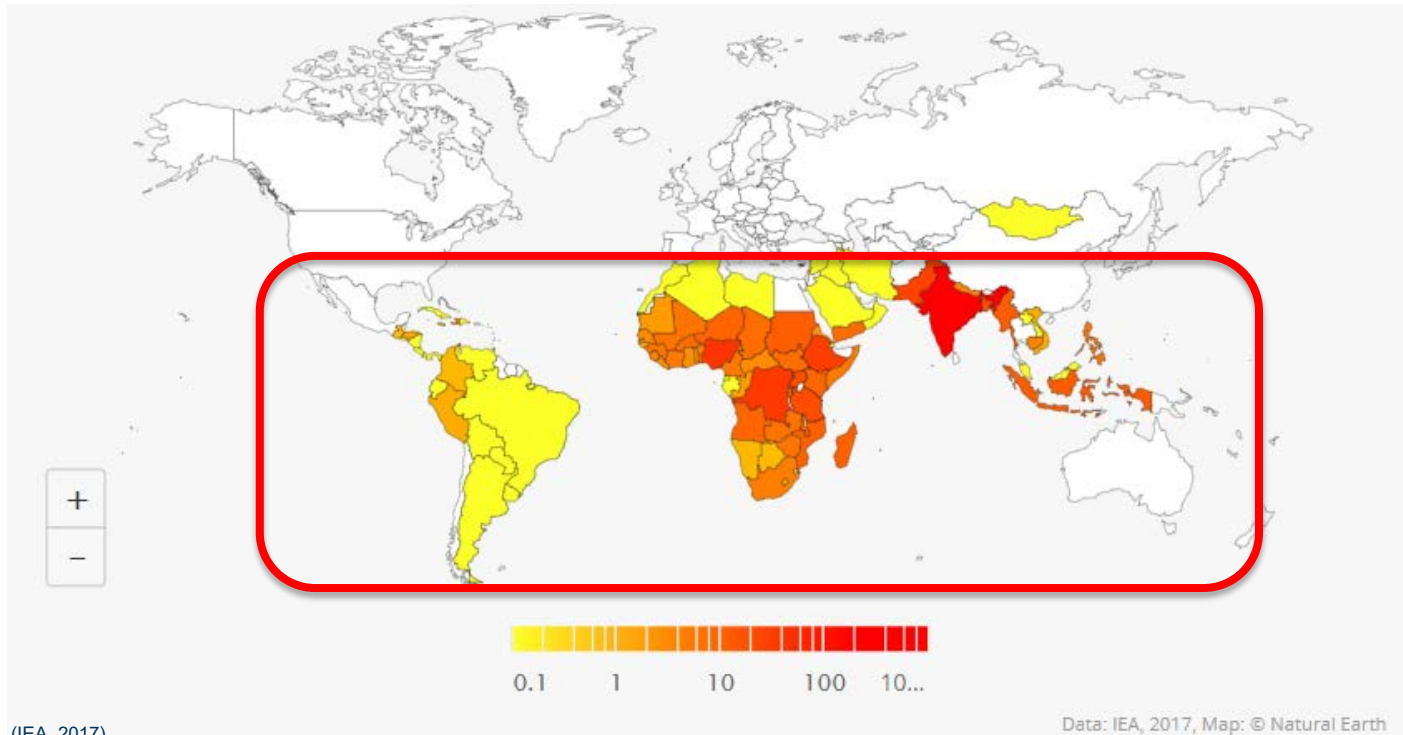


2

Rural Environments: Status Quo

Currently ca. 1 billion people are without access to electricity

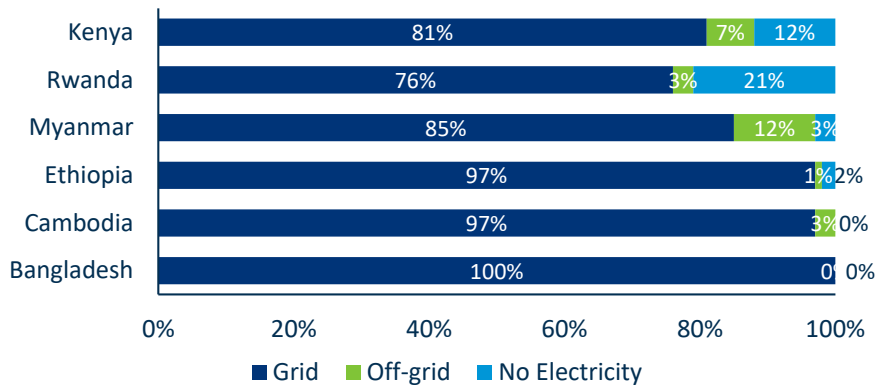
People without access to electricity, 2016 (millions)



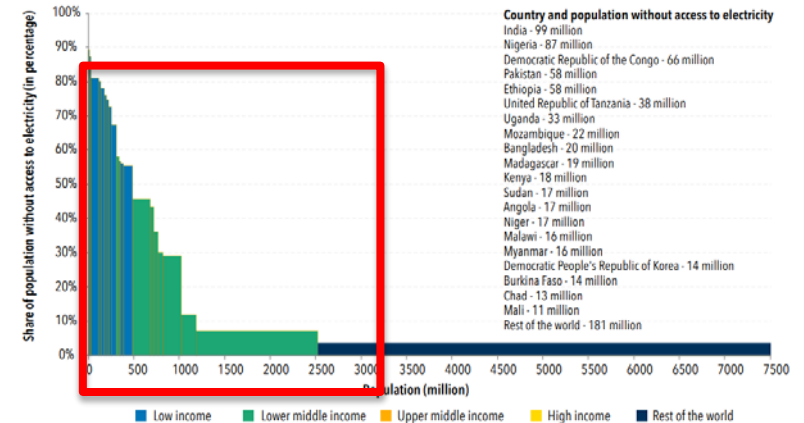
- Most of the population without access are from the global South
- A majority are from Africa & Asia

A significant portion of the unelectrified population reside in rural areas and are from the lower income bracket

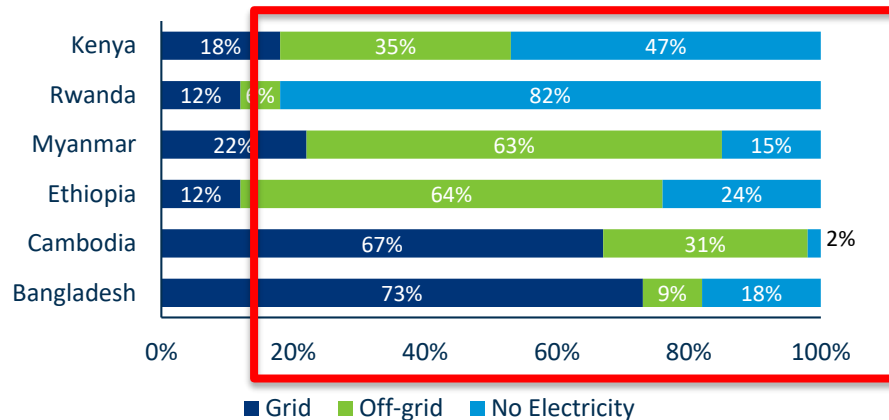
Urban population % electricity access, 2017



Share of the global population without access to electricity, top 20 access deficit & the Rest of the world, 2017



Rural population % electricity access, 2017



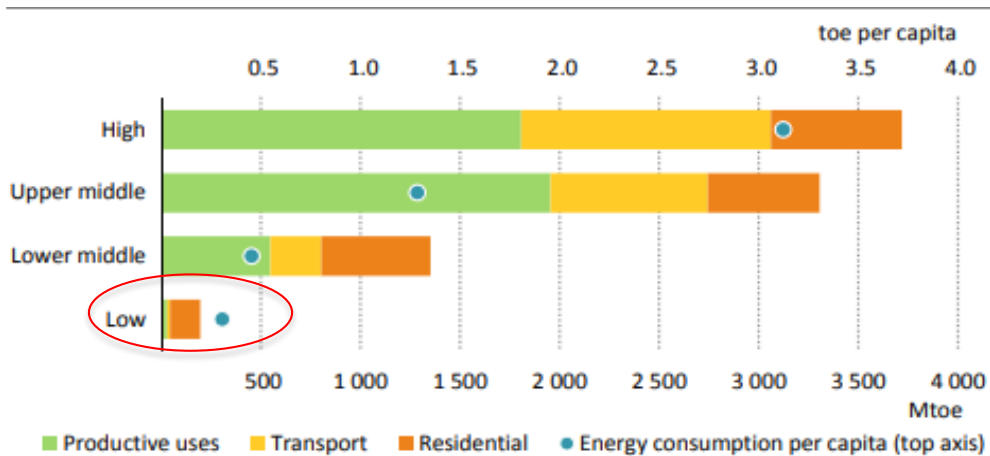
Source: World Bank.

- A comparison between % of populations having access to electricity shows that a larger % of people residing in rural areas have no access to electricity or are connected to off-grid electricity sources, when compared to urban areas.
- Further, it is evident from the figure above, that out of the top 20 electricity access deficit countries, a significant portion of the population without electricity are from **low to lower middle income bracket**.

Source: MTF, World Bank

Electricity in rural areas is primarily used for residential electrification purposes

Total final energy consumption by income group, 2016



Notes: Mtoe – million tonnes of oil equivalent; toe = tonne of oil equivalent. Productive uses include industry, services and agriculture

(IEA Energy Outlook, 2017)

- Uses:
 - Pico-solar systems
 - Solar Home Systems – lighting, solar home charging
 - Mini-grids
- These uses are mostly powered using PV technology
- Residential purposes are the major source of energy consumption because the technology is **affordable**, and business models have been developed to facilitate financing for low-income consumers.
- From the diagram, **higher income groups** are observed to **consume a significant amount of energy for productive energy use applications**

Productive Energy Use (PEU) creates opportunity for impactful rural development

Productive use activities for electricity access can be defined as “activities that create goods or services or that enhance income potential or value” (IEA, 2017).

PEU promotes socio-economic development by enabling and/or increasing income generation.



PEU can be differentiated from ‘consumptive use’ (i.e. the use of energy services such as household lighting, cooking and private entertainment), and the use of energy for ‘community services’ (such as health and education).

PEU can broadly be broken down into 3 main categories:

Primary Industries



Animal Husbandry: Milking machines
Estimated retail price range: 545 – 950 €



Solar Fences
Estimated retail price range: 62 – 120 €



Poultry farming: Egg incubation
Estimated retail price range: 250 – 688 €

Retail Prices Reference: (GIZ, 2016)

Light manufacturing activities are generally the most expensive category

Light Manufacturing Industries



Carpentry & Welding: Workshop tools
Estimated retail price range: 200 – 1000 €



Ice-making
Estimated retail price range: 1200 €



Grain milling
Estimated retail price range: 400 - 2900 €



Tailoring: Sewing machines
Estimated retail price range: 170 – 540 €

Retail Prices Reference: (GIZ, 2016)

Commercial and retail enterprises vary in scale and retail prices range

Commercial and Retail enterprises



Hair salon equipment – 20 – 300 €

Charging stations - 100 – 300 €



Solar water pumping

Estimated retail price range: 355 €



Freezers – 700 – 3500 €

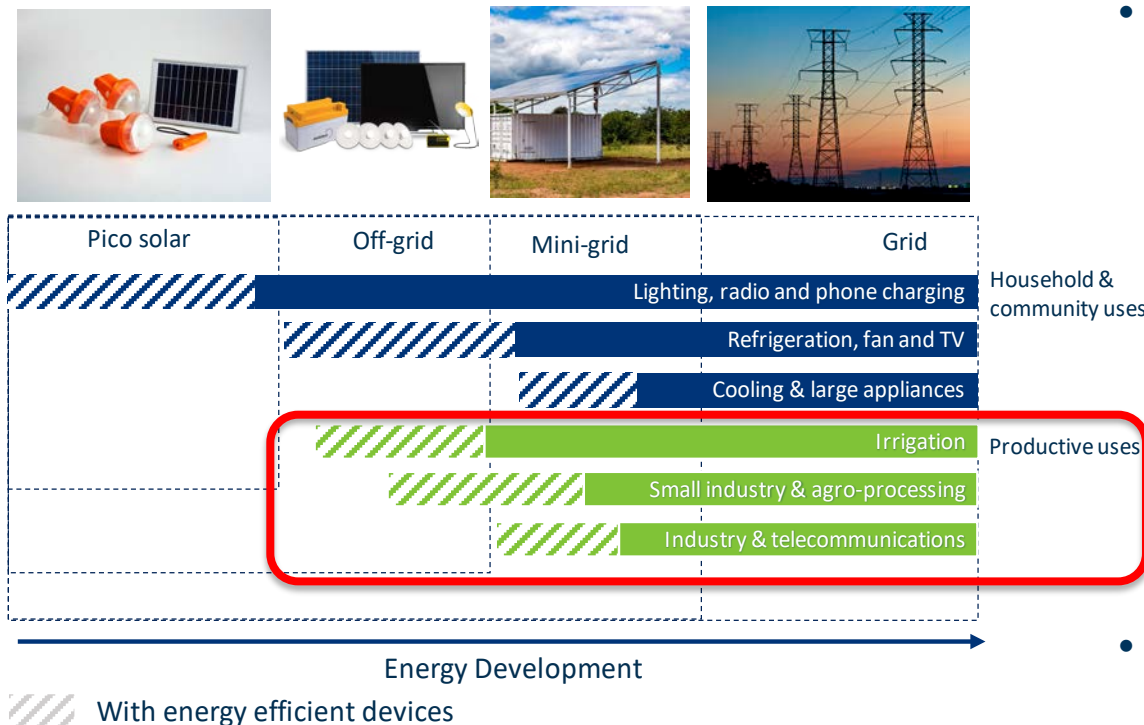
TV & radio – 10 – 150 €

Fans – 20 – 90 €

Retail Prices Reference: (GIZ, 2016)

PEUs in rural environments, for the most part, do not exist or are powered primarily by fossil fuels

From the chart, it can be seen that productive uses are currently **energy intensive**



- Further, for rural settings, renewable-powered mini-grids **have high upfront infrastructure and installation costs** and finding funding for mini-grids is challenging, as demand from residential use is too low to finance long-term sustainability of the grid.
- This makes access to productive energy uses in rural areas difficult.

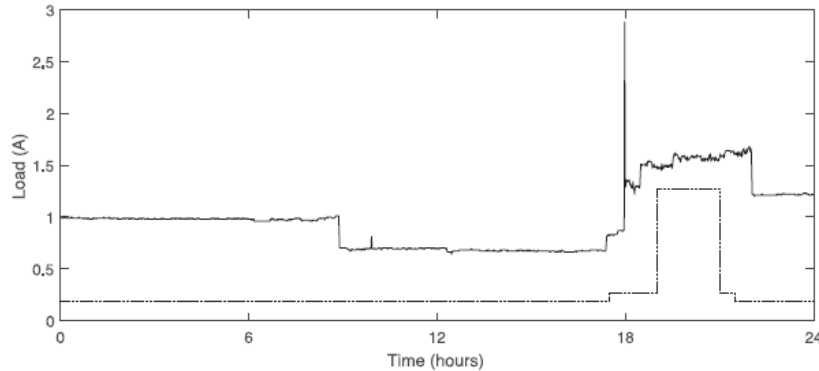
Retail Prices Reference: (IEA, 2017)

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Productive Energy Use (PEU) & PV Technology

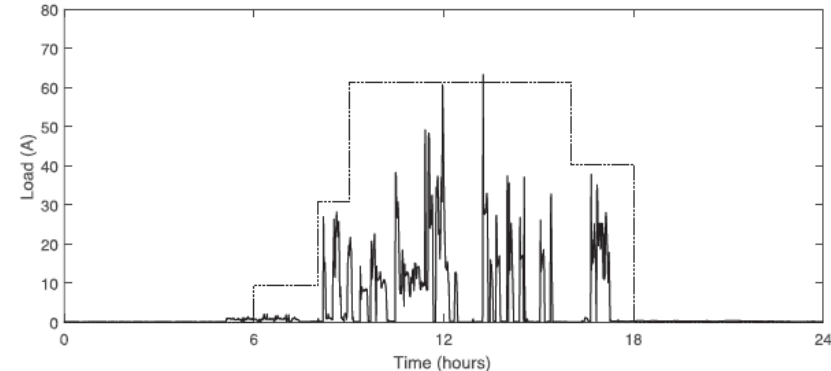
Productive energy use can support PV economics – day time load

Rural Household Load Profile



Hartvigsson & Ahlgren (2018, p192)

Rural Business Load Profile



Hartvigsson & Ahlgren (2018, p193)

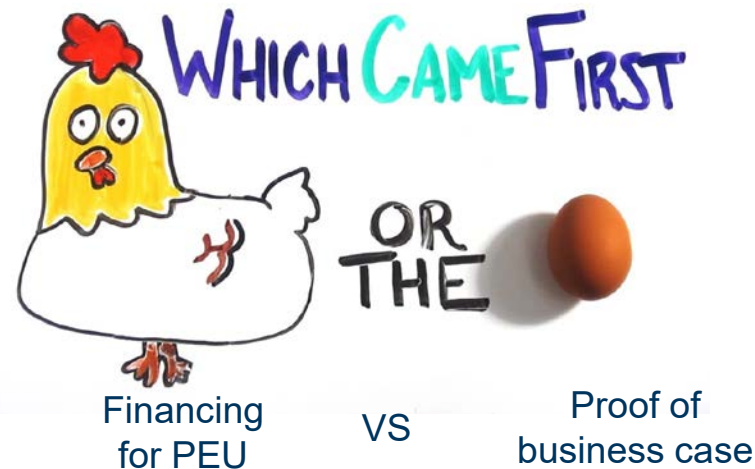
- With regard to energy use, residential demand is highest at night and productive uses are primarily carried out during the day
- High energy intensity of productive energy during the day and can increase revenues for project developers makes solar PV a good technical and economic fit

4

PV Technology & PEU Implementation Challenges

Access to finance is a major hindrance to implementation of PV based PEU technology

- **High tariffs and import duties** on appliances and equipment = **High upfront infrastructure and installation costs** for renewable mini-grids.
- **Proof of business case is required** to secure finance from investors
- With limited budgets for rural electrification, governments are attempting to bridge this investment gap with innovative public, private, and blended investment arrangements.



Lack of policy certainty makes it difficult for project developers to invest in PEU

At international level...

The United Nations has set a target to “ensure universal access to affordable, reliable and modern energy services” by 2030 under SDG 7, however it quantifies the indicator for this target as the “proportion of population with **access to electricity**” (United Nations, 2016), and **not the electricity-enabled services**.

7 AFFORDABLE AND CLEAN ENERGY

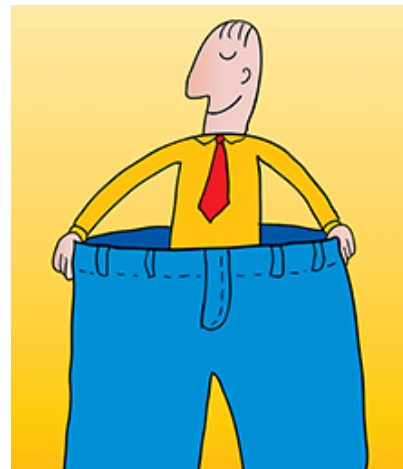


At national level...

There are no policies in place in most countries in the global south (to our knowledge), directed towards productive energy use, that have been developed to drive uptake in rural areas. Most are usually targeted towards electricity access.

Consequently, investors and project developers are reluctant to invest in productive energy uses

Matching of available standard PEU technology to different rural environments remains a challenge



- Brown outs for end-users if undersized
- Poor return on investments for developer and investors if oversized.

Developed standardised product, usually imported

+

Uncertain demand profiles in rural areas (especially newly electrified ones)



Poorly sized grid due to low level of certainty in demand



Lack of local supply chain to manufacture products



Lack of reliable data and replicable demand profiles



Energy users need access to secured affordable modern energy...

- to drive enterprises with higher productivity and improved margins...
- to realise opportunities for profit and growth...
- and contribute to local socio-economic development.

Possible Actions:

- Development of policies & regulation that provide a conducive environment for uptake of productive energy use technology
- Identification of opportunities for direct collaboration between energy users and developers to identify energy service solutions that meet both parties' needs



Energy developers need...

- secured increased overall and daytime demand...
- to improve operational economics...
- to achieve financial viability...
- and reach operational sustainability.

5

Case studies

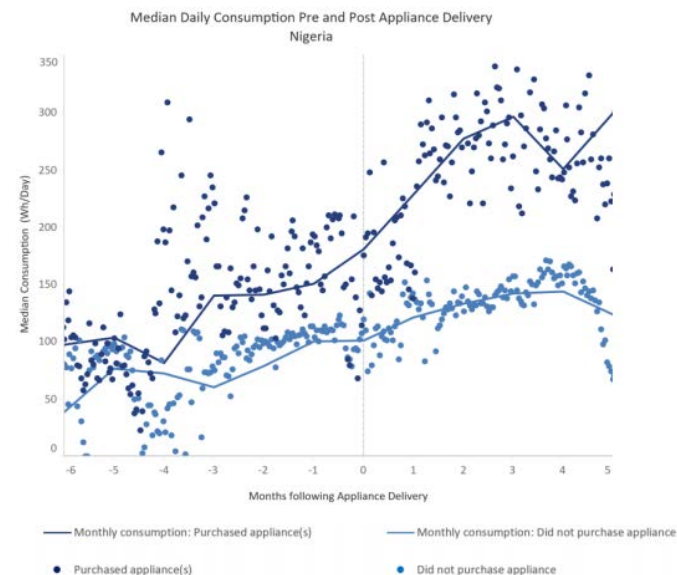
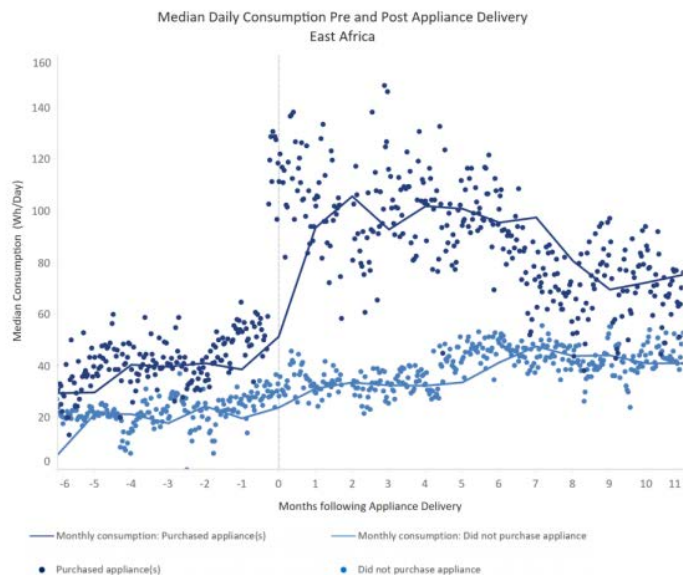
Case Study: The Mini-Grid Innovation Lab is exploring appliance financing to drive up mini-grid demand



Mini-grid Innovation Lab, 2018

- Project Developer: Mini-Grid Innovation Lab
- Date Implemented: 2018
- Project detail: Pilot project testing the impact of appliance financing – the lab helped seven mini-grid developers to sell 663 appliances on credit across 25 sites in East Africa and Nigeria
- **Success indicator**, mini-grid customers who purchased appliances nearly doubled their consumption and total grid revenues increased by 18% after eleven months

- **Challenge:** Overcoming the finance barrier to drive up electricity demand for mini-grids in rural environments
- **Solution:** The lab is funding developers to offer appliances to customers on credit
- The below graphs show the change in consumption of energy users who purchased appliances compared to those who did not in East Africa and Nigeria over 11 months.



Source: (Innovation Insight: Appliance Financing, 2019) (nextbillion.net, 2019)

Case study: Overcoming the demand uncertainty barrier through partnerships and value chain analysis



Mini grid on Ukara Island, Tanzania

- Project Developer: JUMEME
- Date Implemented: 2016
- Type & quantity of power: Modular 60 kWp solar plant, 33kVA diesel genset, and 240 kWh battery bank
- **Success indicator**, currently expanding to operate 11 similar mini-grids across the Lake Victoria.
- **Challenge**: Overcoming demand uncertainty for mini-grids through productive use
- **Solution**: Partnerships with SACCOS and non-profits in the region to understand demand and drive uptake
- **Partners**: **Energy 4 Impact and Excel Hort Consult analysed existing production, transportation, and production methods.**
 - For instance, Energy 4 Impact successfully partnered with diesel vendors to identify businesses that owned generators and approached entrepreneurs to make the switch to electricity



Further, JUMEME set up their own shop on the island to sell appliances and increase consumer education about technology

Source: (OCA Capital Advisors, 2017)

6

Conclusion

- PEU provides great opportunity for development in rural areas as it is source of income generation
- PEU can also support PV economics as most productive energy uses are carried out during the day
- There are major barriers in finance and policy that need to be overcome to enable uptake of productive energy use in rural areas

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