University of Strathclyde, Glasgow, UK

Deep Dive 3: Off-Grid Energy Business Models and Data

Rural Energy Access through Social Enterprise and Decentralisation
Project Closing Dissemination Event
Blantyre, April 2024

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https://ease.eee.strath.ac.uk/

Overview

- Minigrid business models and financing – *Aran Eales, University of Strathclyde*
- Energy Hub Business models - Damien Frame*, University of Strathclyde*
- Minigrid data – *Aran Eales, University of Strathclyde*
- Questions and discussions

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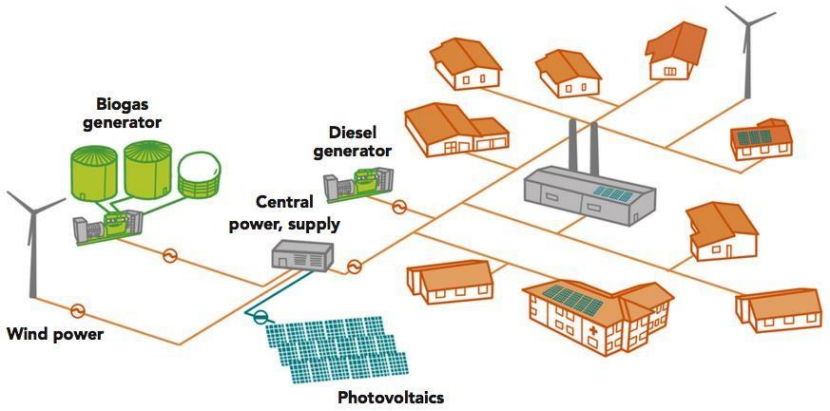
Minigrid business models and financing

Aran Eales, University of Strathclyde

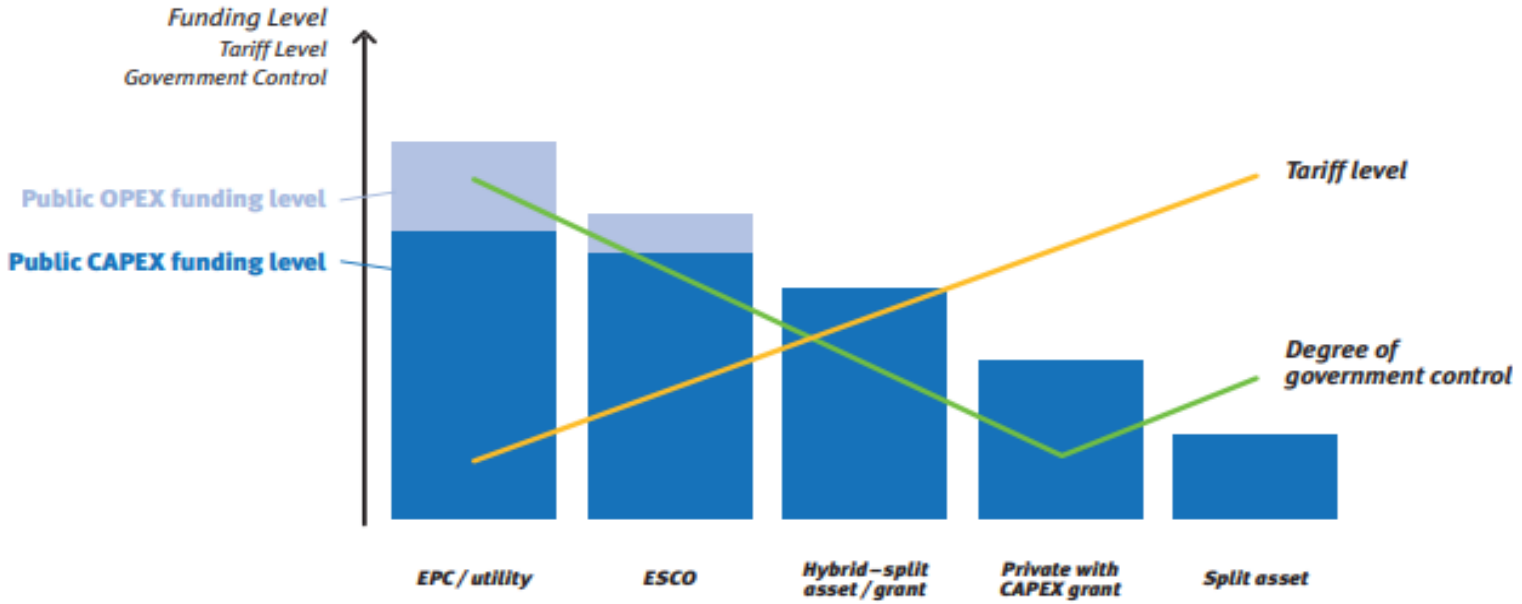
Types of business models: determining factors

- **How are mini-grids developed (procured)?**
  - Centralised (planning) versus decentralised (unsolicited)
- **Who finances the project? Who owns the assets?**
  - Government versus private
- **Who operates the mini-grid?**
  - Government (utility) vs private
- **How are revenues set?**
  - Tariffs: uniform or cost-covering
- **Different actors for different parts of the value chain?**
  - E.g. Private generation and public distribution and retail



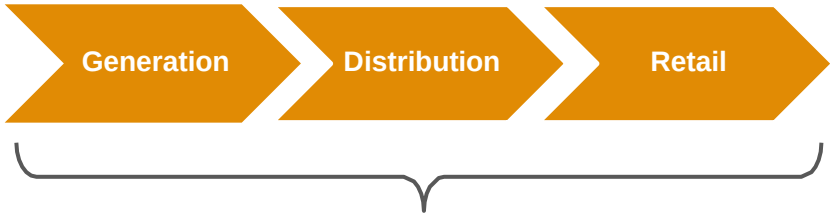
Types of mini-grid business models

- Public (Utility)
- Energy Service Company (ESCO):
- Private (unregulated vs regulated)
- Hybrid models (PPPs, split assets, O&M contracts, etc.)
- Community/customer-based



Private mini-grids

- Private entity plans, builds, manages and operates the mini-grid
- Funding from grants, private equity and commercial loans
- PROs:
  - Private financing to leverage public funding
  - Better suited for small sites (<50kW)
- CONs:
  - Hard for governments to accept (high tariffs, low tier of access)
  - Rely on favourable regulatory environment
  - Still unclear what happens when grid arrives



~100% private funding, ownership and O&M&M

Photo: Rafiki Power

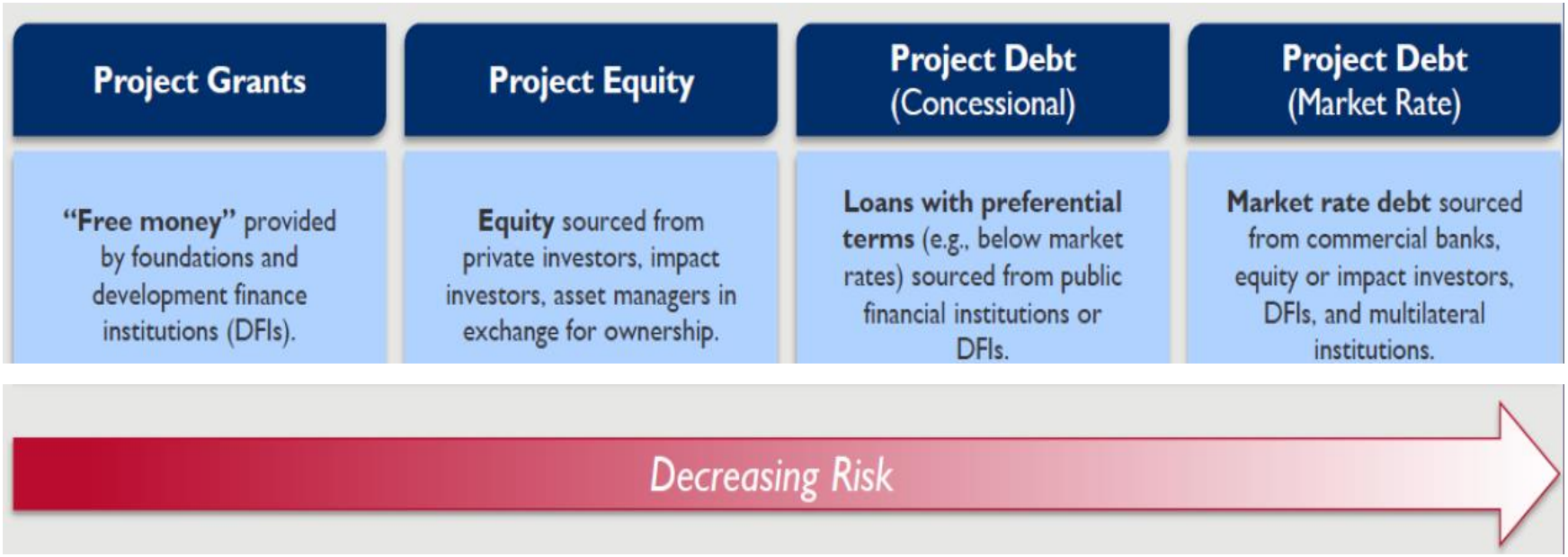
EASE approach: Social Enterprise

- "Pure" private model is more commercially driven,
  - Private financing presents opportunity to accelerate deployment (with a viable business model)
  - Is a purely financial bottom line best for rural communities?
  - Danger of seeing poverty alleviation as a 'market', high tariffs make communities poorer
- Social enterprise approach sets social impact as primary goal
  - Still needs a sustainable financial model
  - Puts more emphasis on community engagement, reaching last mile
  - Ensures affordable tariffs
  - Higher reliance on donor grants and subsidies

Types of Capital for Project Level Financing

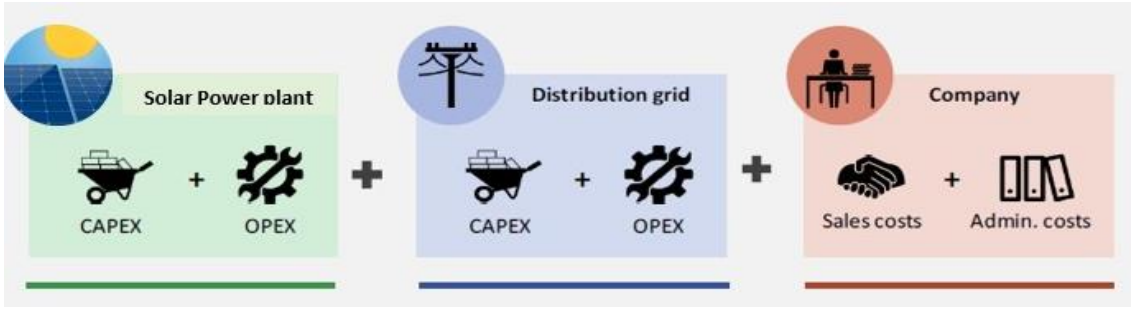
World Bank estimates that connecting 490 million people by 2030 will require 217,000 mini-grids and cost about **US$127 billion.**

where does the money come from?



Financial sustainability and investment case requires a clear understanding of costs and revenue

Costs



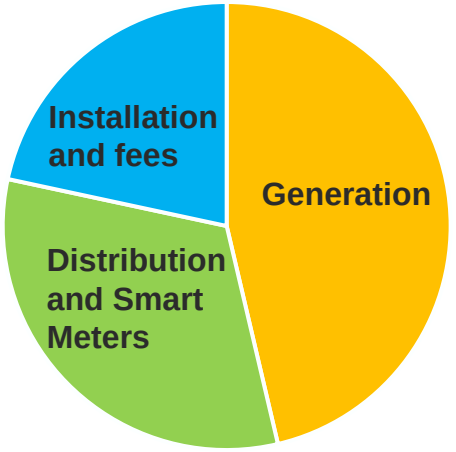
Revenue

Prove financial sustainability → Gain investment → Scale minigrids

Costs of installing and operating (currently) high

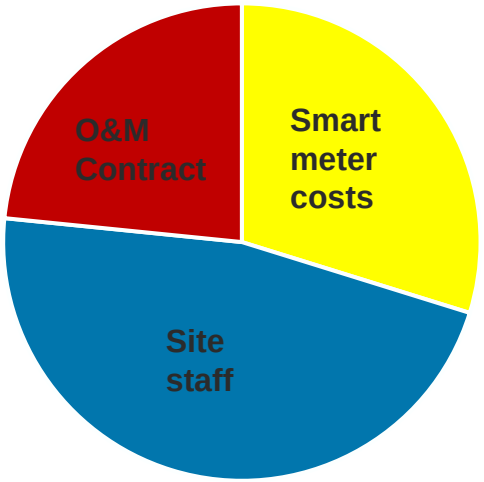
CAPEX:

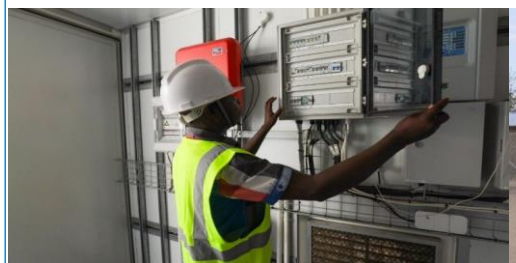
- per customer: USD 1,700-2,000
- per kW: USD 8,000–10,000
- Global costs of PV and batteries reducing
- Economies of scale reduce costs – bulk purchasing



OPEX:

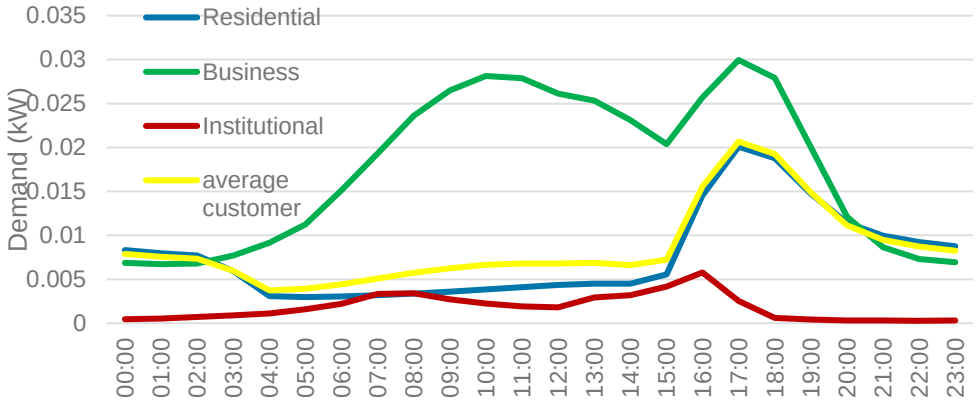
- per customer: USD 4.27 per month
- Efficiencies achieved through operating a portfolio
- Use of smart meters and remote monitoring reduces costs



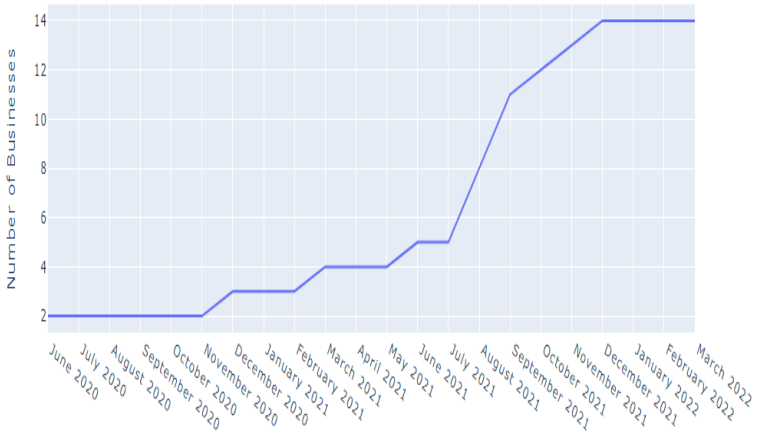


Demand is significantly higher than expected

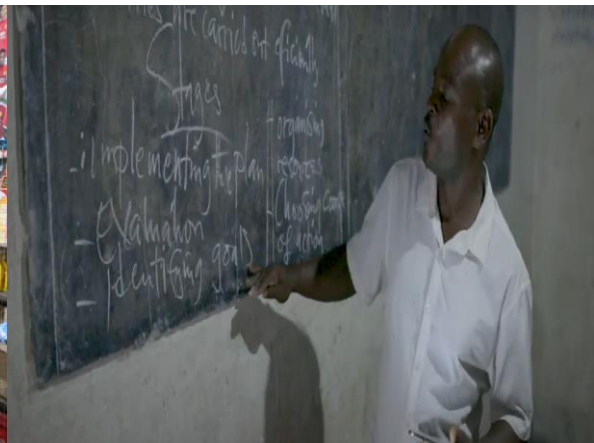
Average customer segment load profiles



Number of businesses

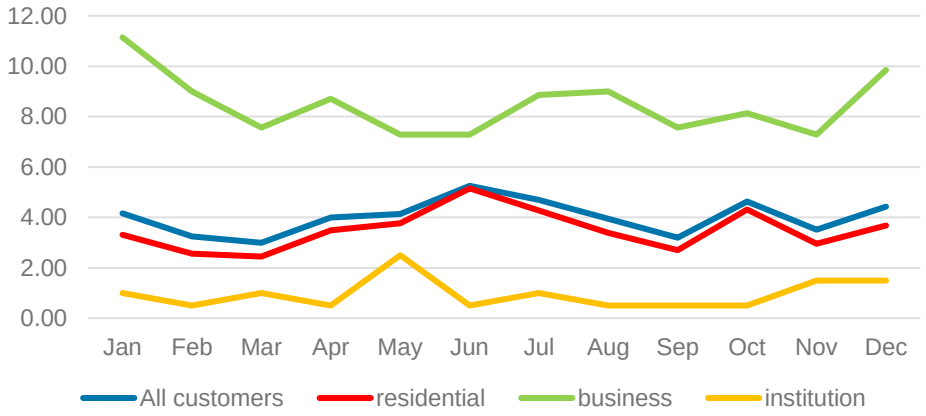


- Load growth ~10% per year
- Exponential increase in new businesses
- Generation systems need to be expanded
- Daytime Productive Uses of Energy key to increasing revenue



Strong evidence of willingness to pay

Business ARPU	$8.48/m
Residential ARPU	$3.89/m
Mean ARPU	$5.43/m



Monthly Average Revenue per User (ARPU) (USD)

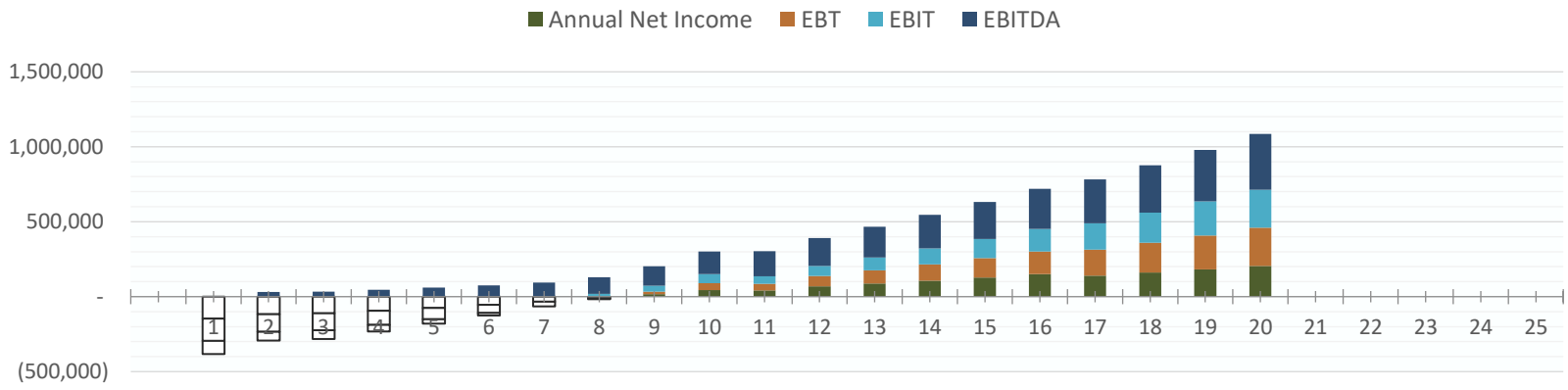
- Average Revenue Per User comparable to other minigrids in SSA
- Revenue covers site-based costs, with small contribution to business overheads
- Majority of revenue comes from a few customers

Donor capital is needed to provide a return on investment for a portfolio of minigrids

- 100% donor funded CAPEX allows for financial sustainability
- A modelled 10 site portfolio offers a small positive return on investment and covers all business costs for sustainable operation
- Return on investment increases with size and number of sites

CAPEX grant	IRR*	Payback
50%	5%	16 years
65%	7.93%	14 year
80%	13.2%	9 years

Income Statement for modelled portfolio



**Utilising data from 2 minigrids in 2021 – more data now available for updated calculations*

Conclusions

- Minigrids will play a big part in achieving SDG7 targets in Malawi
- Clear evidence of demand and willingness to pay for energy in rural areas
- Costs will reduce as the industry expands
- Increase revenue through promoting daytime Productive Uses
- Donor CAPEX is required in the short term
- Data will inform the nascent sector to reduce risk

A strong investment case for minigrids in Malawi is on its way

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Energy Hub business models

Edgar Bayani, Community Energy Malawi

University of Strathclyde Engineering

University of Strathclyde, Glasgow, UK

Minigrid data

Aran Eales, University of Strathclyde

Data Collection Frameworks

EASE real time data is publicly available:
https://malawi-microgrids.herokuapp.com/

Smart metering

Real-time data on: revenue generation, customer segregated demand, payment frequencies, connection status, uptime and more.

steamaco

Remote Monitoring

Track functionality and performance of microgrid generation systems, provide technical assistance for system operators by making it easier to conduct maintenance tasks in remote areas.

SUNNY PORTAL powered by ennexOS

Surveys

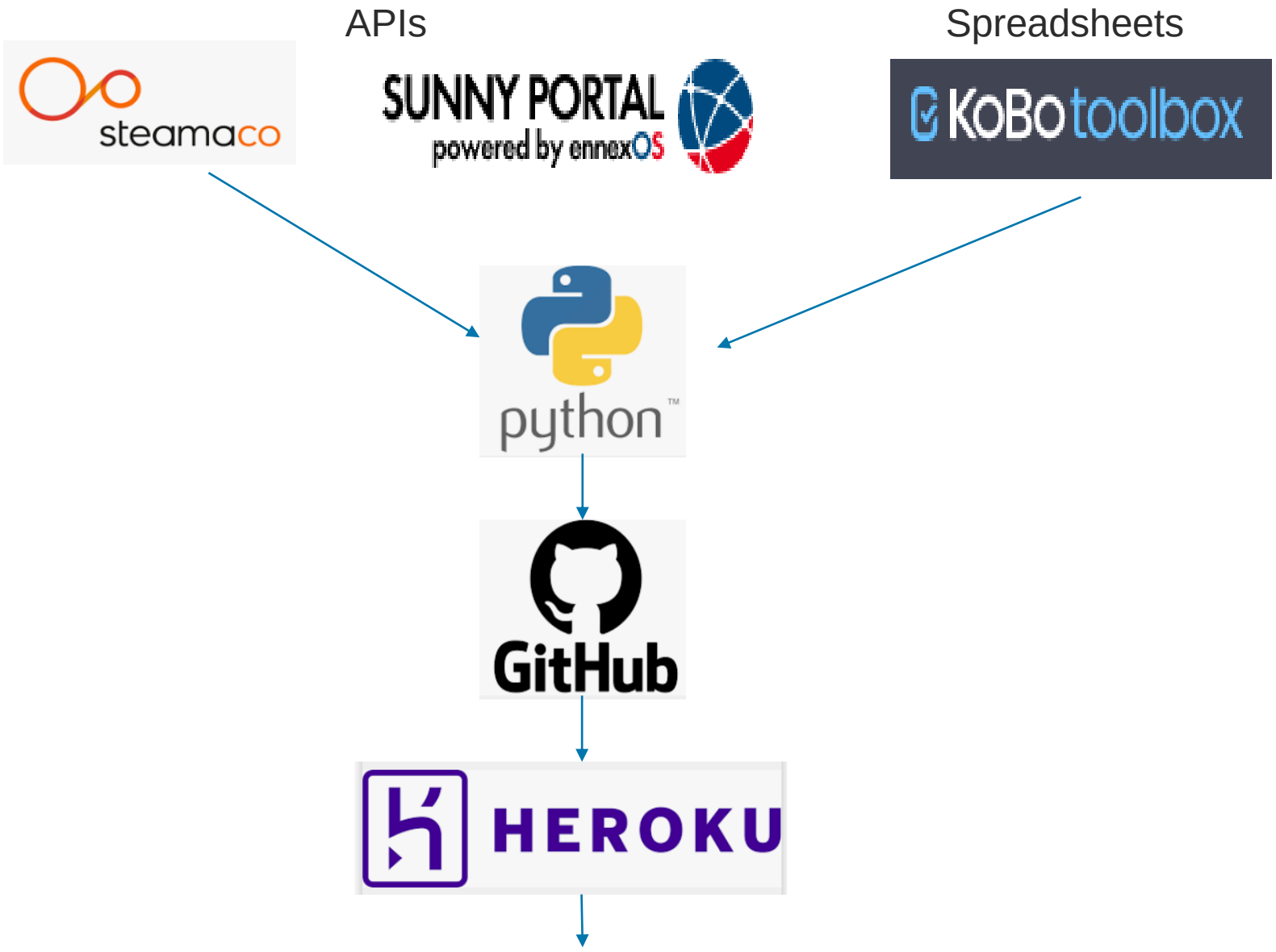
Precise qualitative and quantitative data collected from the community to gain insight on how electricity is being used and the social impact it has on the community

KoBo toolbox

Data analysis informs:

- **Technical design and operation**: Load profiles, component sizing, maintenance
- **Business models**: Tariff setting and financial planning
- **Investors and donors:** economic performance and impact
- **Policy:** rural electrification strategies, regulatory guidance

Data Visualisation platform



Data Key Performance Indicators

Technical

- System outages
- Generation
- Battery health
- Customer Segment Demand
- Utilisation Rate

Economic

- Sales revenue
- Cost per connection
- Cost per kW
- Total cost of power

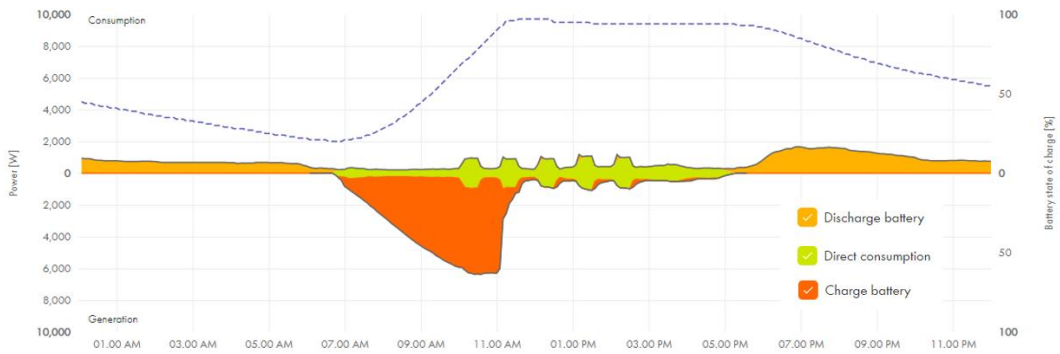
Social Impact

- Energy Access (SDG7)
- Health, Education and Communication (SDG 3,4,9)
- Employment and Finance (SDG 8)
- Female Empowerment (SDG 10)
- Tariff and Service (SDG 9)

Understanding performance and impact of microgrids informs recommendations for technical and business design, policy and research

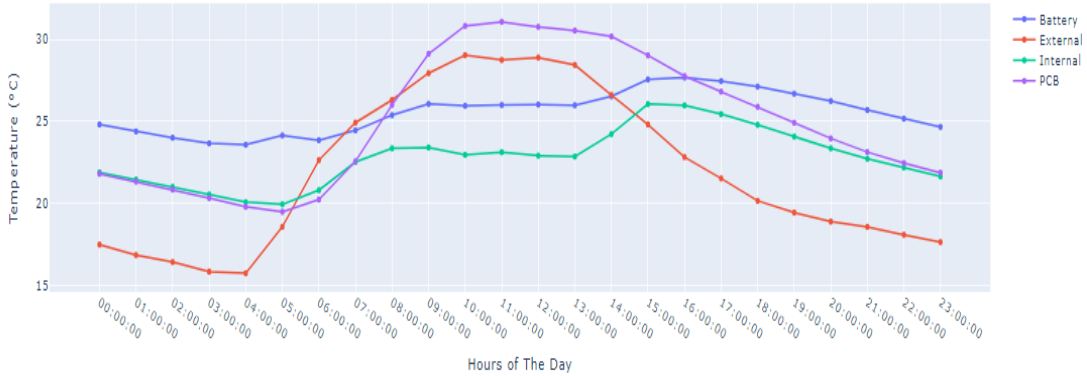
Battery state of charge and temperature

Figure 1 Typical daily energy flow for batteries



- Fully charged by mid morning – spare daytime generation capacity
- Maximum discharge by 6am – no storage capacity for more night-time loads

Figure 2: Daily temperature logging



- High temperatures decrease battery life
- Automate AC cooling and plan ahead for end of life

Communication uptime

Figure 3: Daily communication uptime 2021

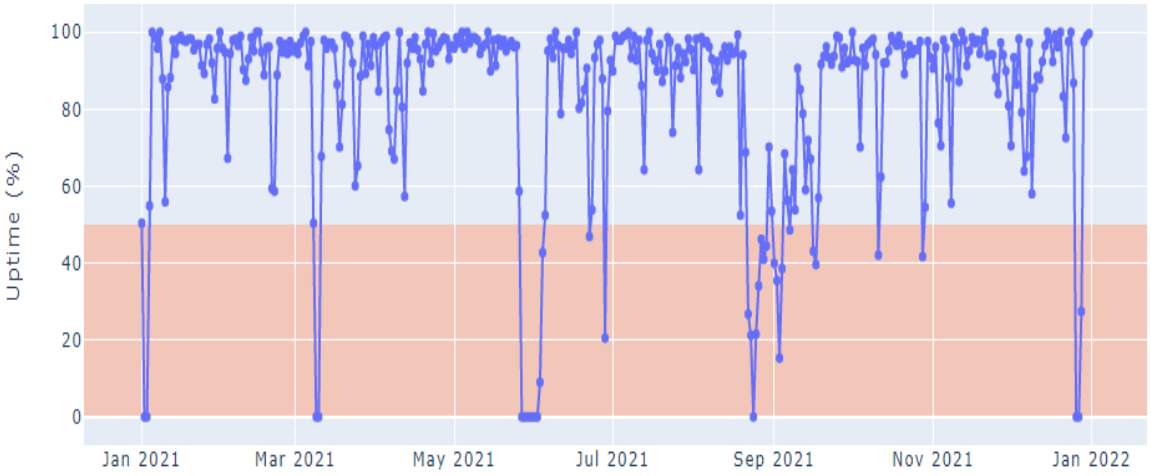
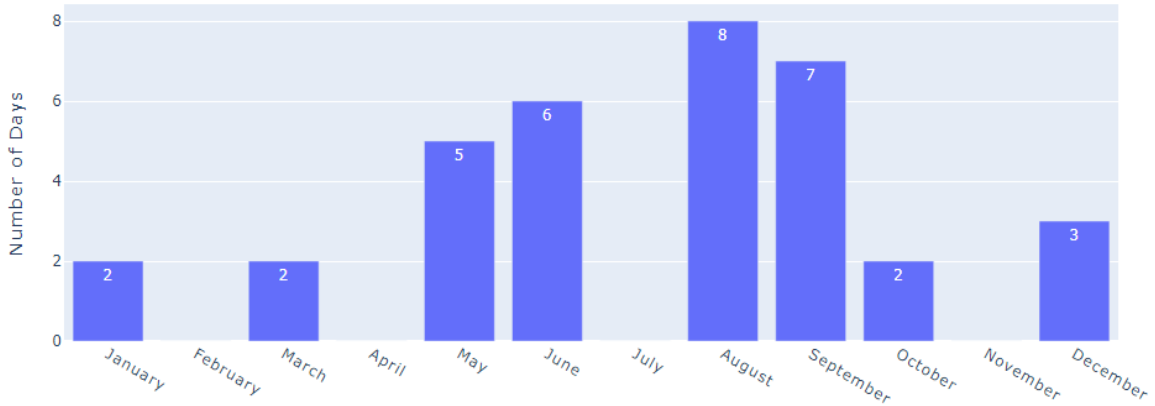


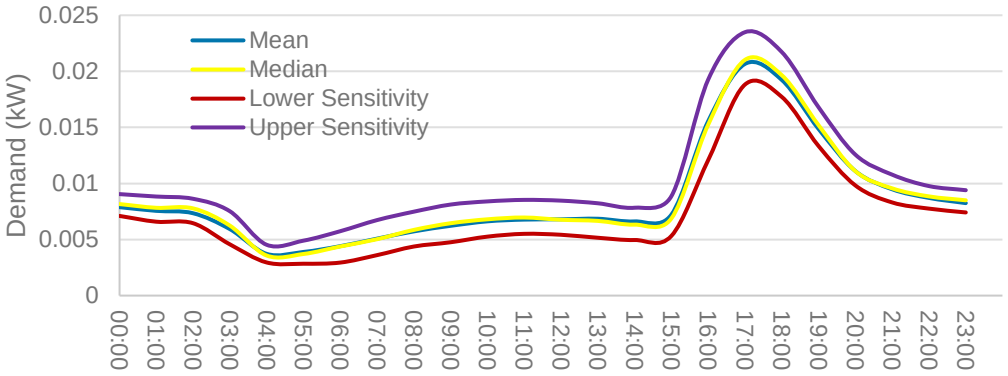
Figure 4: Number of days of outages per month 2021



- Significant issues from SteamaCo comms
- Impact on revenue and customer satisfaction
- Average response time: 2.8 days (since improved)

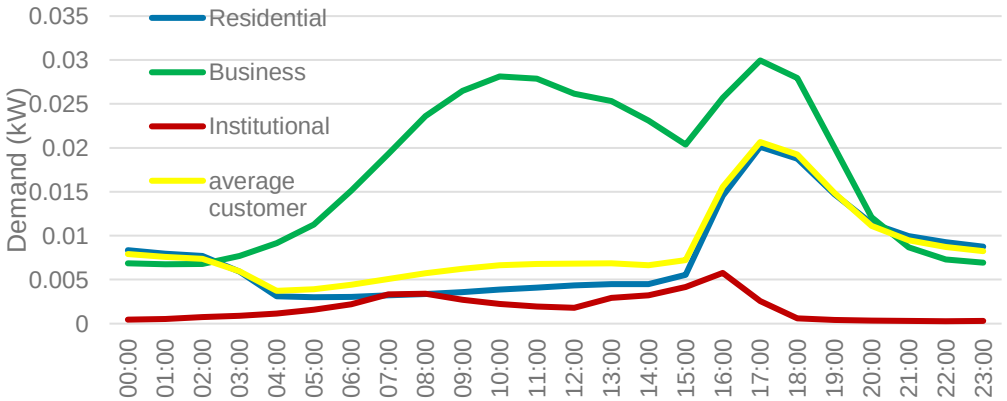
Demand

Figure 5: Total microgrid load profile



- High evening peak – mostly residential customers
- Business customers are highest energy users
- 8760 spreadsheet available for download – valuable for system design

Figure 6: Average customer segment load profiles



Revenue

Figure 7: Total microgrid monthly revenue (USD)

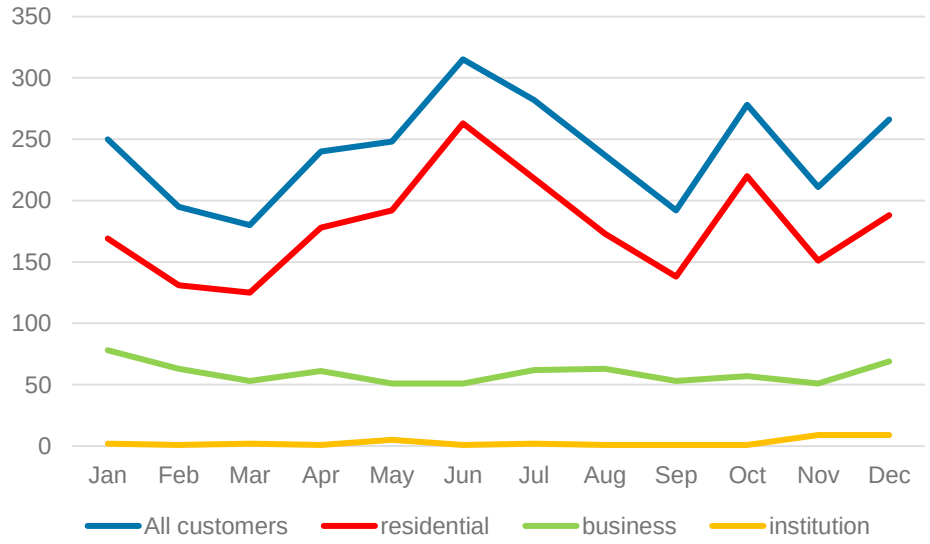
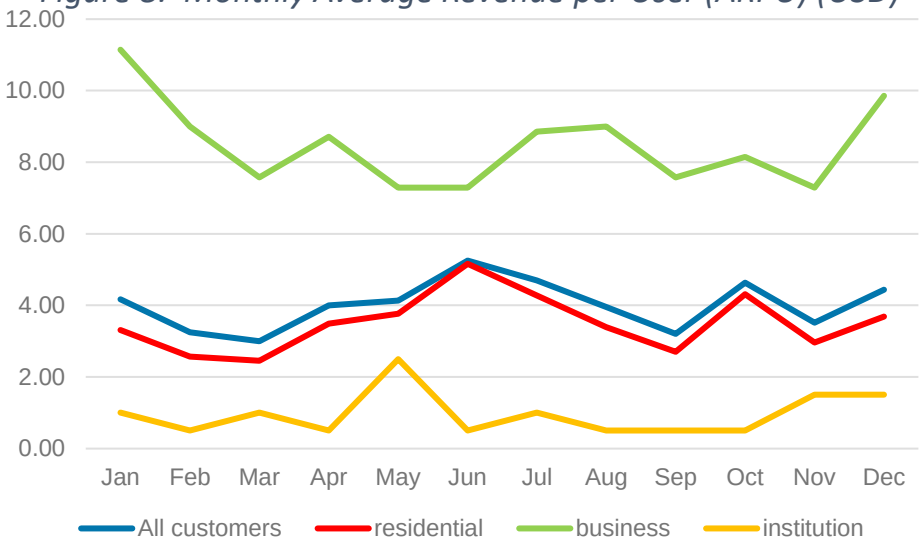


Figure 8: Monthly Average Revenue per User (ARPU) (USD)



- Seasonal income based on rice growing harvests
- Mean ARPU for 2021: 5.43 USD/m
- Businesses ARPU (USD 8.48) more than double residential (USD 3.89) - increase revenue through promoting daytime PUE
- Revenue matches site based OPEX, wider business costs not fully covered
- Revenue analysis informs ongoing tariff setting and business modelling for scale up

Current developments and next steps

Using data to inform technical design and business modelling

Build an investment case through risk reduction

Demand data disaggregated for PUE businesses

E.g grocery, barber shops, welding

Technical integration of new PUE

Available capacity both energy and power

API access is slow – store data on a local database

e.g. Amazon Web Service

More data and collaboration

Expand to more sites

Code is open source

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Questions and Discussion