The EASE Project

Accelerating Off-grid Energy Access in Malawi

An EASE Project Webinar

13th October 2022

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

Webinar Overview

Time	Description	Speaker
13.00	Introductions	Kelvin Tembo
13.05	District Energy Officer Experiences	Louis Yona
13.15	DEO Impact and Recommendations	Damien Frame
13.25	Solar Microgrid Experiences	Elizabeth Banda
13.35	Microgrid Performance and Impact	Aran Eales
13.45	Remote Monitoring	Million Mafuta
13.55	Panel Discussion/Q and A	Kelvin Tembo (Chair)
14.25	Closing Remarks	Kelvin Tembo

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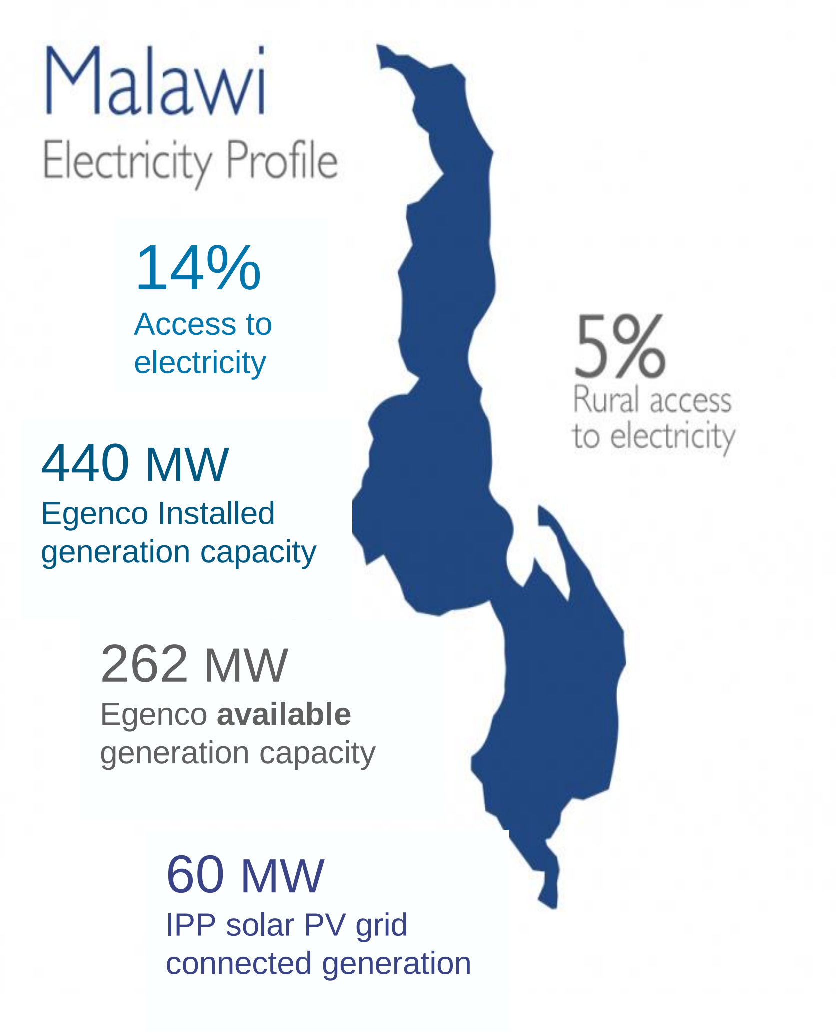
Energy Access in Malawi

- Access to national electricity grid in Malawi is currently just 14%
- 13.6 million people live off-grid in Malawi
- 99% of household energy is supplied by biomass. 32% reduction in forest cover in less than 40 years
- Lighting needs served by candles and non-rechargeable batteries.



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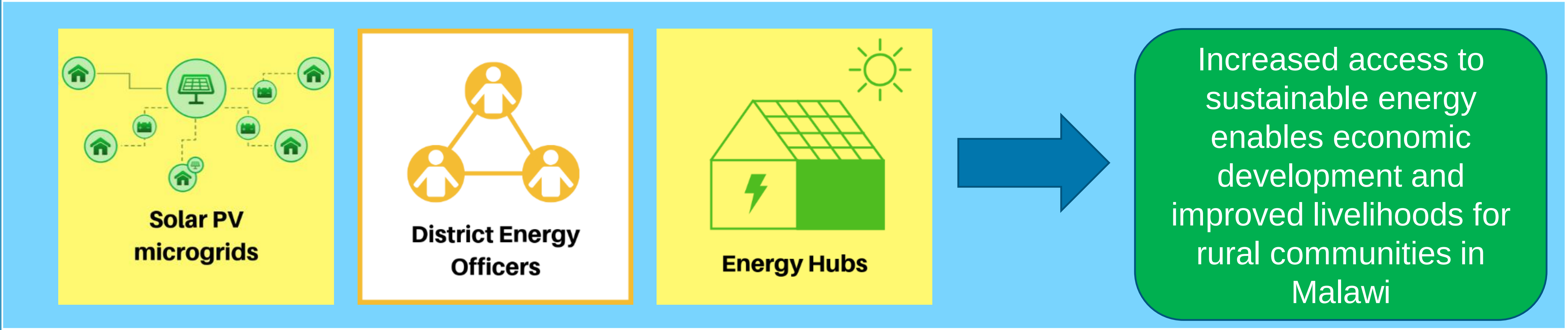
Rural Energy Access through Social Enterprise and Decentralisation (EASE)



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washted – Centre for Water, Sanitation, Health & Appropriate Technology Development

Scottish Government – Riaghaltas na h-Alba

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District Energy Officers

Programme Activities and Experiences

Louis Yona

Decentralisation in Malawi

- Since 1998, government has gradually devolved some of its functions to the district councils
- Education, Agriculture, Forestry, Environment, Water and Public Works have officers at the district level
- Energy has remained centralised – leaving a gap to adequately reflect on and plan energy issues in the local government structures

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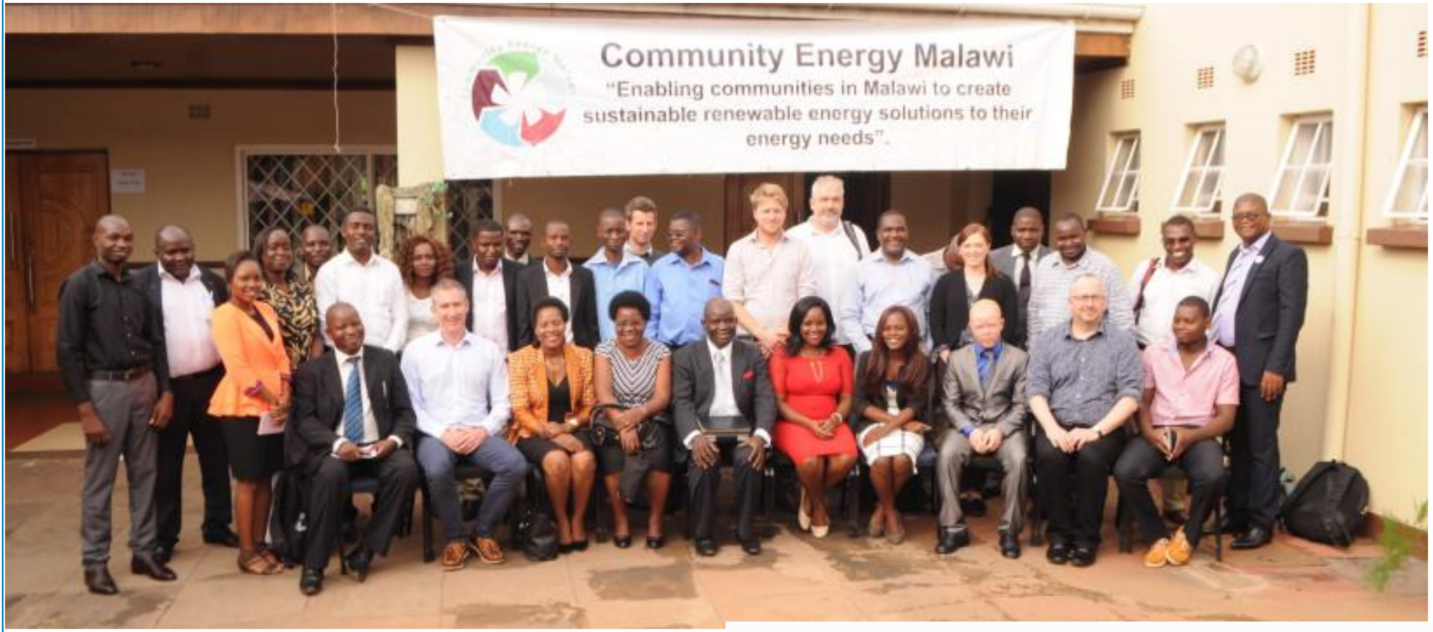
Developing the DEO Concept



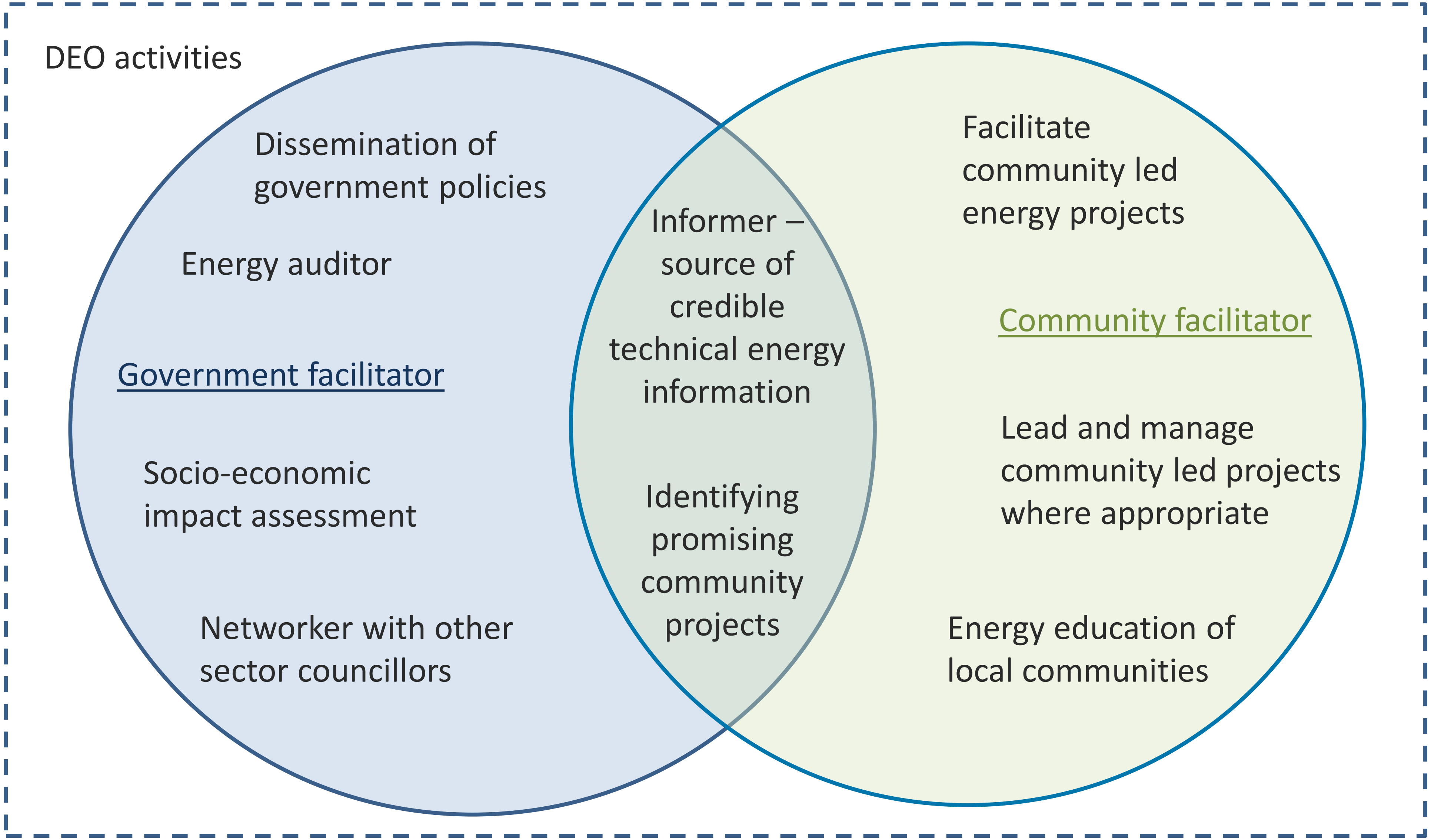
Original Article | Open Access | Published: 05 May 2020

Decentralization: the key to accelerating access to distributed energy services in sub-Saharan Africa?

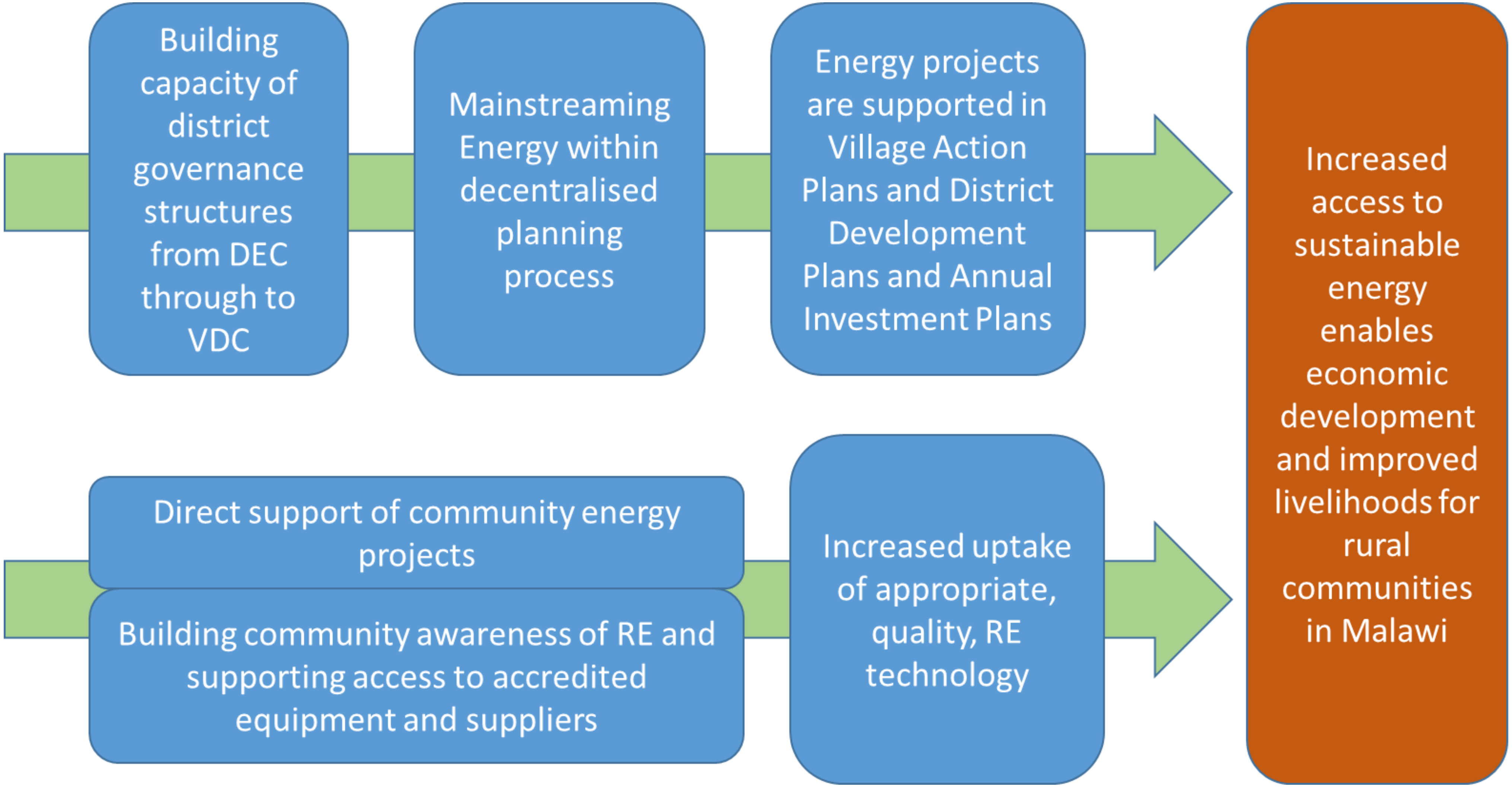
Collen Zalengera, Long Seng To, Richard Sieff, Alison Mohr, Aran Eales, Jon Cloke, Hannah Buckland, Ed Brown, Richard Blanchard & Simon Batchelor

Journal of Environmental Studies and Sciences **10**, 270–289 (2020) | Cite this article

Developing the DEO Concept



EASE DEO Activities



VDC Baselining

- Baseline survey of VDCs in Dedza and Balaka in 2019, assessing the energy access situation in the districts
- High level findings In-line with national energy access statistics, grid electricity access is very low, lighting is mostly provided by torches and lanterns, and energy for cooking is primarily from firewood
- In Balaka, 124 VDCs were surveyed. When asked if energy had been identified as a priority for the VDC, 44 indicated yes, 80 indicated no
- In Dedza, 123 VDCs were surveyed. When asked if energy had been identified as a priority for the VDC, 27 indicated yes, 96 indicated no

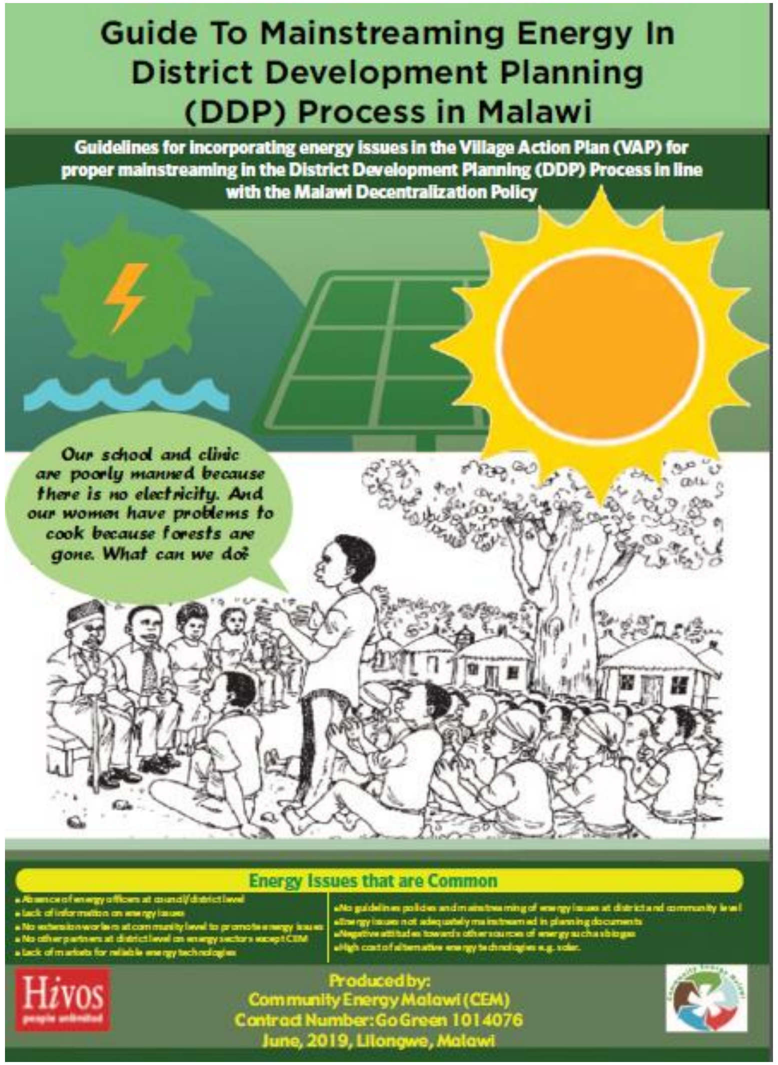
District Development Plan (DDP) Reviews

- At the commencement of EASE in 2018, Dedza had a DDP that was valid from 2013-2018. However, it was not until 2020 that a new DDP (covering the period 2017-2022) was officially published. In Balaka, the current DDP runs from 2017-2022.
- The CEM DEOs organized review workshops in each district to analyse the DDP documents and assess the level of energy mainstreaming. The workshops took a consultative meeting format that involved District Council secretariat representatives.

Key Learning – Incumbent DDPs did not address energy access, even though energy projects were highlighted as a development priority at VDC level. The most recent DDP in Dedza was developed after DEO support became available and shows a step change in the mainstreaming of energy within the planning process.

Training of Frontline Extension Workers

- Extension workers are the frontline officers that interface with community members at the grassroots, covering development priority areas such as agriculture, health, education, water, forestry, community development and more.
- Integral to Village Action Planning, feeding into DDPs
- 170 extension workers and Area Civic Education Coordinators trained during EASE
- Bespoke training package developed - based on existing guidelines for local development planning and renewable energy toolkits developed previously by CEM



Training of Frontline Extension Workers

Opportunities	Challenges
Energy access is a priority issue - strong interest/demand from communities	Proliferation of poor quality products has created distrust of RE in some communities
Active NGO programmes on PSP, cookstoves, and irrigation in the district provide rapid route to impact once communities have been made aware	RE products are viewed as very expensive, particularly as size of system increases.
After sensitization, more communities felt empowered to develop proposals on energy projects	Knowledge and cost barriers, combined with lack of access to reliable suppliers, prevents progress for larger, more complex projects (e.g. school, health center).
Extension workers felt empowered to discuss energy in most recent VAP process	Limited knowledge base – desire for more training and support
Extending reach of singular District Energy Officer to many communities	Extension workers require resources for additional travel and community engagements
	Integrating energy into reporting frameworks to track progress of energy projects

Training of Local Technicians

- Local technical capacity for installation, operation and maintenance of solar PV systems is a long-standing sustainability challenge
- The CEM DEOs trained 20 local technicians to provide technical support under DEO oversight
- Training covered design, installation and maintenance of solar PV systems
- In addition to improving the local capacity to maintain already existing renewable energy equipment, the technicians help identify renewable energy infrastructure needing support through the process of energyscaping.

Training of Local Technicians

Opportunities	Challenges
Energy access is a priority issue - strong interest/demand from communities	Quality RE products are often unaffordable for rural community members
Low levels of electrification of education and health institutions – high potential impact of RE installation	Lack of budget (or will to prioritize energy) from health and education budget managers
Installed capacity of many solar PV systems in need of minor maintenance and repairs at education and health institutions – high potential impact with low CAPEX requirement	Obtaining buy-in and collaboration from local education and health institution managers
Local technical capacity allows rapid support for community issues – avoiding delays and cost of bringing external support	Limits on technical knowledge and capacity of technicians – DEO oversight and support creates a constraint/bottleneck
Positive gender messaging by training female technicians	Truly empowering female technicians with the confidence to fully participate in historically male dominated role

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Capacity Building with Key District Stakeholders

- Tailored presentations targeting District Council Directorates, NGOs and private sector players in Dedza and Balaka (200+ attendees across all workshops)
- Sensitise participants on Renewable Energy Technologies
- Discussions on cross-cutting nature of energy to their different sectors, building on SDGs as over-arching development policy and demonstrate how Goal 7 on energy directly impacts the other goals
- Case studies from Malawi and outside to illustrate how energy has helped to transform communities or inspire holistic development

Renewable Energy Standards Awareness

- Substandard renewable energy equipment that fails to comply with recognised national or international standards has become an increasing problem in Malawi in recent years and information gaps have prevented the empowerment of communities to recognise and refuse substandard products
- The CEM DEOs organized 4 awareness campaigns (2 in each district), collaborating with MERA and MBS to bring information to the community level

Renewable Energy Standards Awareness

Key Learning

- Renewable Energy standards booklets are technical, in English, and are not available for free, communities have no capacity to access – DEOs can help provide more accessible messaging.
- MERA and MBA operate at national level with little local representation – DEOs can effectively support sensitization at a local level.
- Consumer rights on demanding evidence of regulatory and standards compliance, along with minimum guarantees are not widely known – DEOs can effectively support local dissemination of this knowledge.
- MBS aim to reduce proliferation of substandard RE products through market spot checks and audits – DEOs can support and facilitate efforts to ensure standards compliance.

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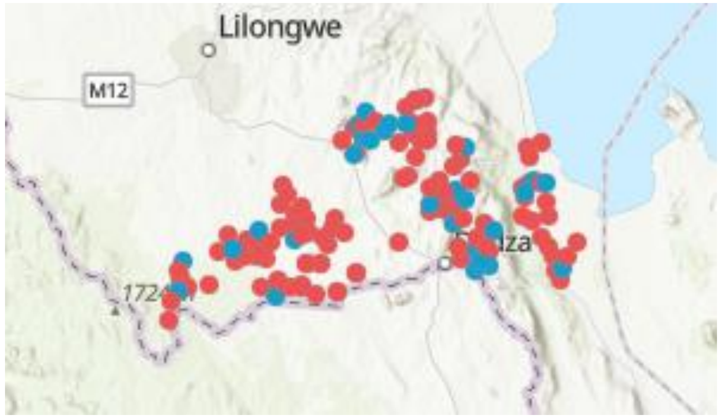
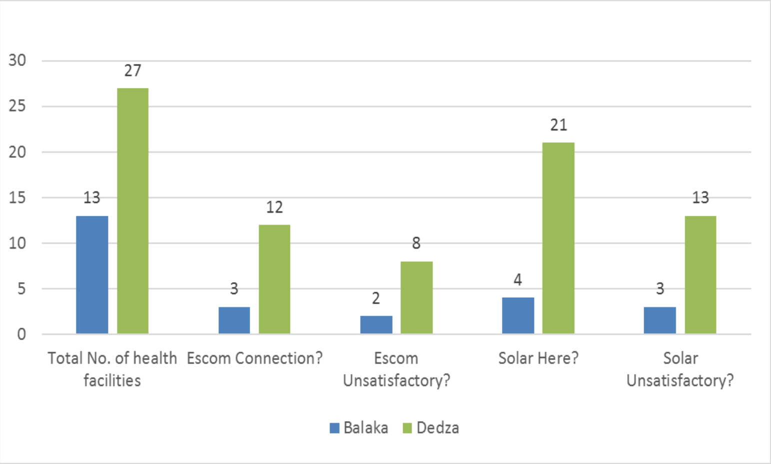
District Energy Officers

Data, Impact and Policy Reflections

Damien Frame





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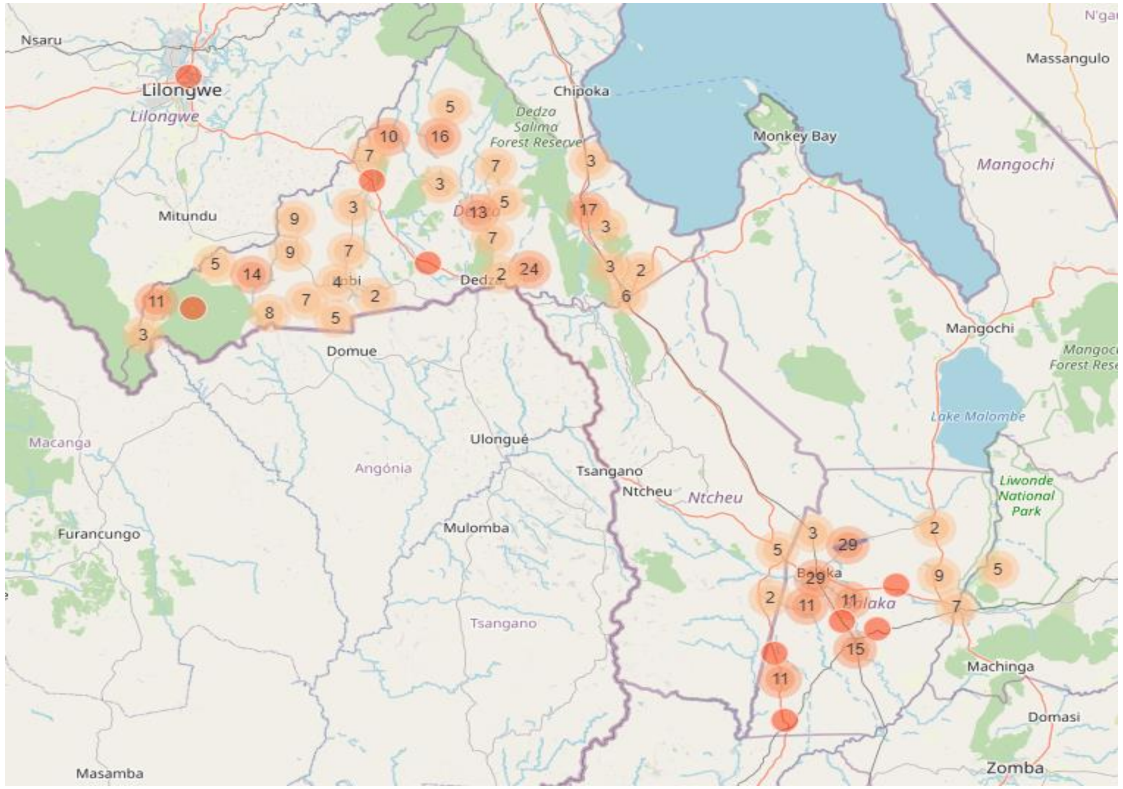
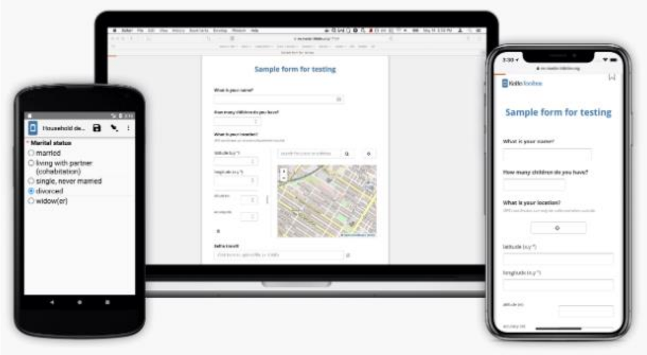
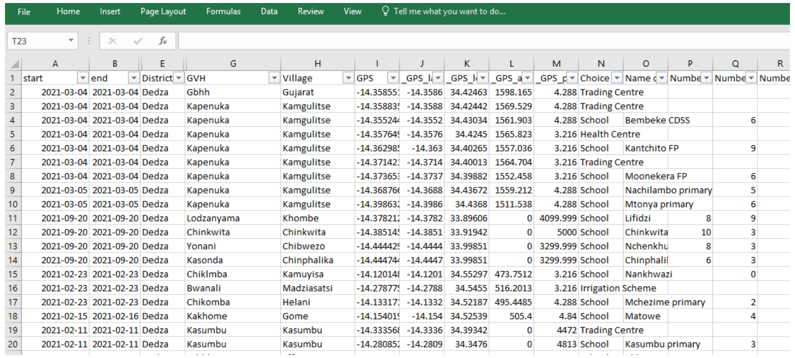
Energyscaping







	A	B	E	G	H	I	J	K	L	M	N	O	P	Q	R
1	start	end	District	GVH	Village	GPS	_GPS_l	_GPS_l	_GPS_a	_GPS_p	Choice	Name (	Numbe	Numbe	Numbe
2	2021-03-04	2021-03-04	Dedza	Gbhh	Gujarat	-14.35855	-14.3586	34.42463	1598.165	4.288	Trading Centre				
3	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.35883	-14.3588	34.42442	1569.529	4.288	Trading Centre				
4	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.35524	-14.3552	34.43034	1561.903	4.288	School	Bembeke CDSS		6	
5	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.35764	-14.3576	34.4245	1565.823	3.216	Health Centre				
6	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.36298	-14.363	34.40265	1557.036	3.216	School	Kantchito FP		9	
7	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.37142	-14.3714	34.40013	1564.704	3.216	Trading Centre				
8	2021-03-04	2021-03-04	Dedza	Kapenuka	Kamgulitse	-14.37365	-14.3737	34.39882	1552.458	3.216	School	Moonekera FP		6	
9	2021-03-05	2021-03-05	Dedza	Kapenuka	Kamgulitse	-14.36876	-14.3688	34.43672	1559.212	4.288	School	Nachilambo primary		5	
10	2021-03-05	2021-03-05	Dedza	Kapenuka	Kamgulitse	-14.39863	-14.3986	34.4368	1511.538	4.288	School	Mtonya primary		6	
11	2021-09-20	2021-09-20	Dedza	Lodzanyama	Khombe	-14.37821	-14.3782	33.89606	0	4099.999	School	Lifidzi	8	9	
12	2021-09-20	2021-09-20	Dedza	Chinkwita	Chinkwita	-14.38514	-14.3851	33.91942	0	5000	School	Chinkwita	10	3	
13	2021-09-20	2021-09-20	Dedza	Yonani	Chibwezo	-14.44442	-14.4444	33.99851	0	3299.999	School	Nchenkhu	8	3	
14	2021-09-20	2021-09-20	Dedza	Kasonda	Chinphalika	-14.44474	-14.4447	33.99851	0	3299.999	School	Chinphalil	6	3	
15	2021-02-23	2021-02-23	Dedza	Chiklmba	Kamuyisa	-14.12014	-14.1201	34.55297	473.7512	3.216	School	Nankhwazi		0	
16	2021-02-23	2021-02-23	Dedza	Bwanali	Madziasatsi	-14.27877	-14.2788	34.5455	516.2013	3.216	Irrigation Scheme				
17	2021-02-23	2021-02-23	Dedza	Chikomba	Helani	-14.13317	-14.1332	34.52187	495.4485	4.288	School	Mchezime primary		2	
18	2021-02-15	2021-02-16	Dedza	Kakhome	Gome	-14.15401	-14.154	34.52539	505.4	4.84	School	Matowe		4	
19	2021-02-11	2021-02-11	Dedza	Kasumbu	Kasumbu	-14.33356	-14.3336	34.39342	0	4472	Trading Centre				
20	2021-02-11	2021-02-11	Dedza	Kasumbu	Kasumbu	-14.28085	-14.2809	34.3476	0	4813	School	Kasumbu primary		3	

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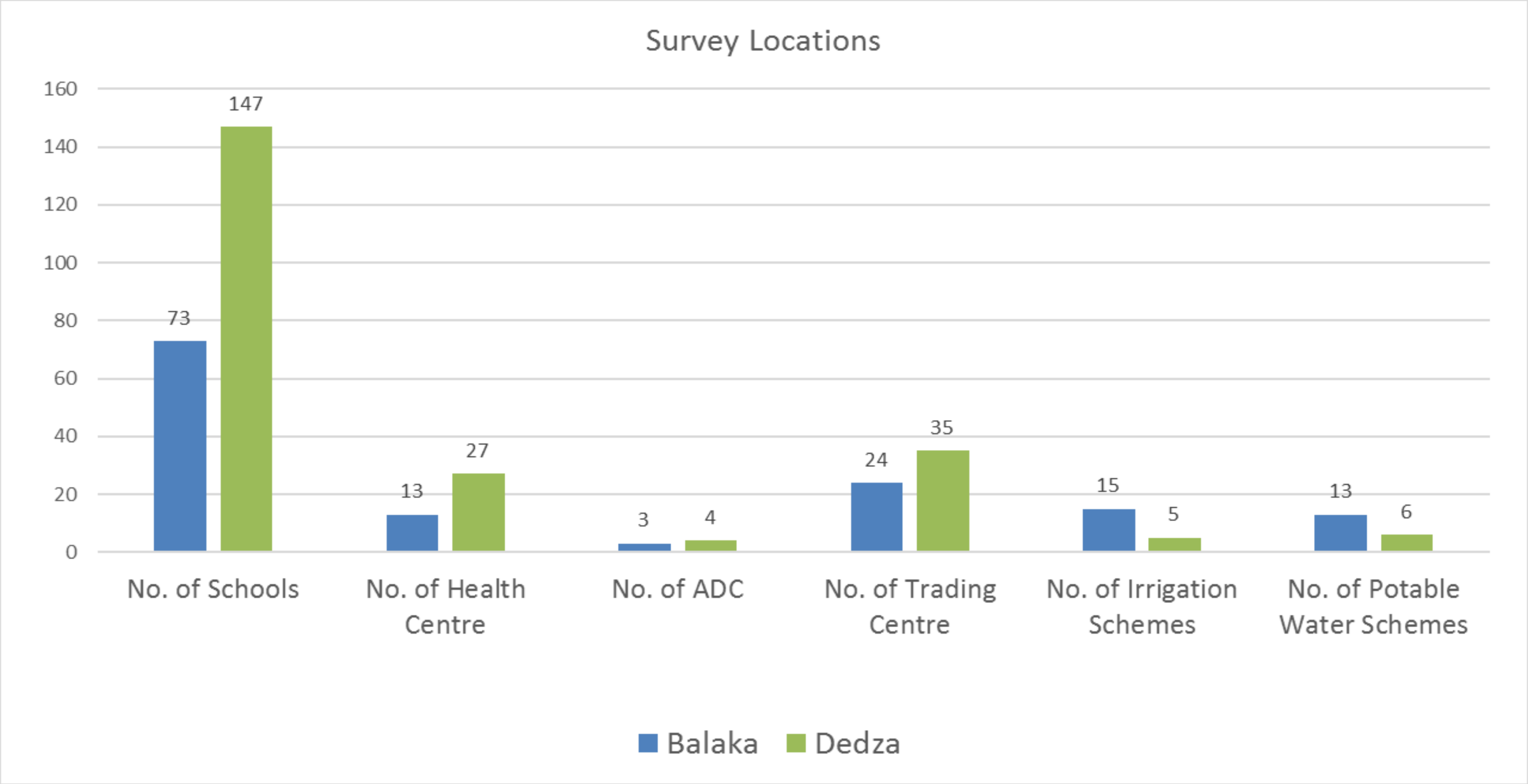
Energyscaping



Of the 368 surveys completed so far, 224 were conducted in Dedza and 141 were conducted in Balaka. A majority of the locations surveyed were schools

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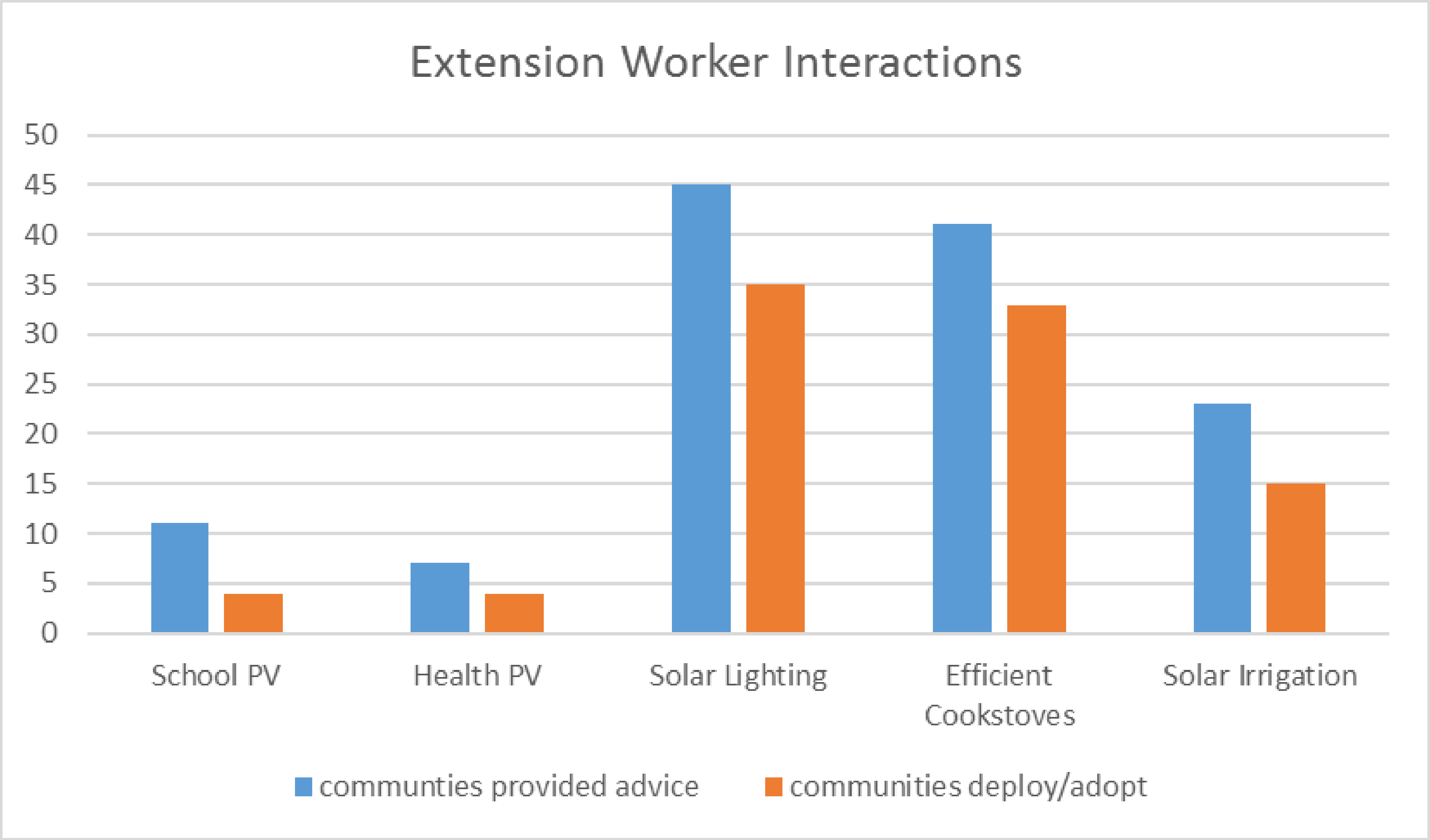
Impact - Trained Extension Workers



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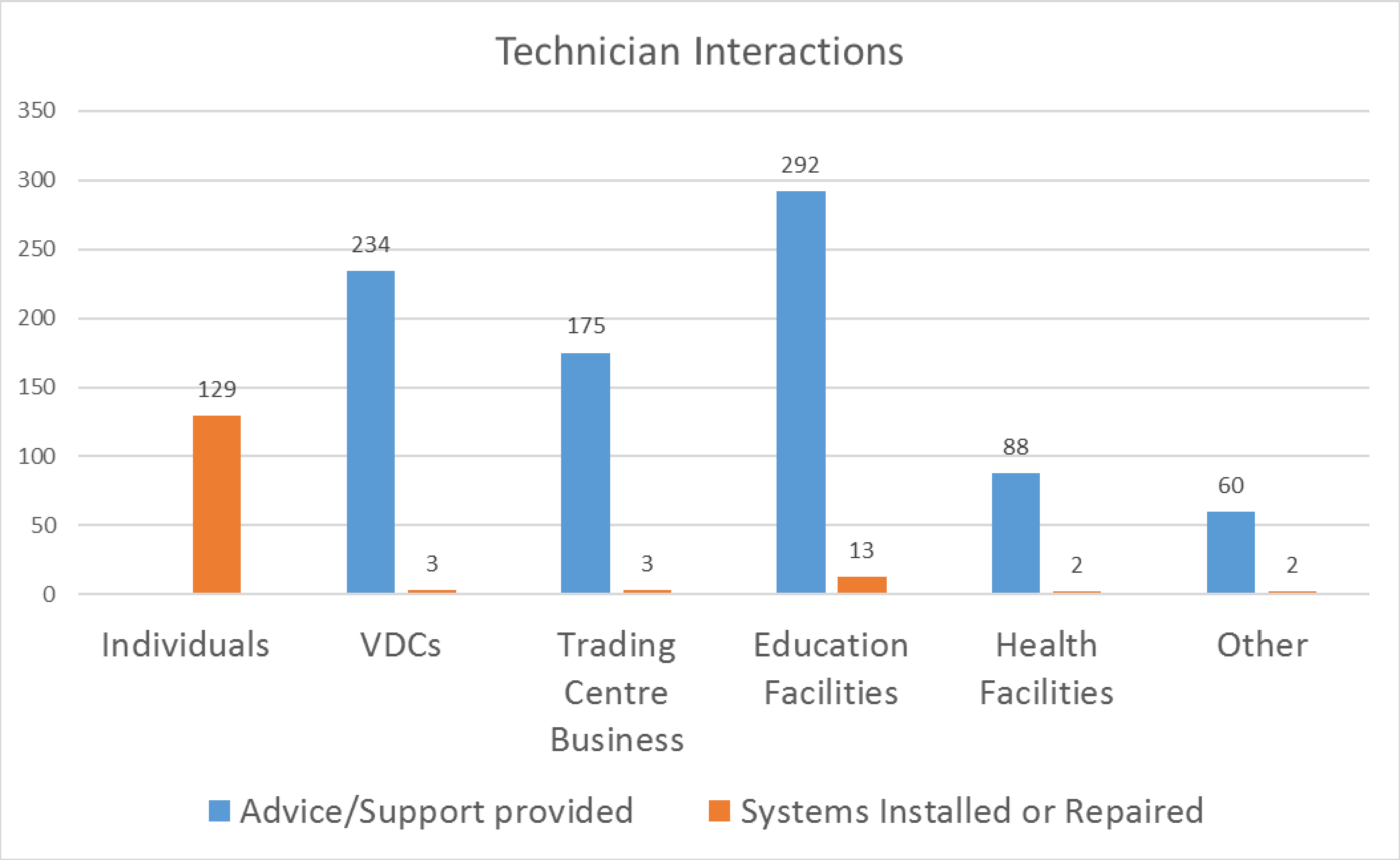
Impact – Local Technicians



Policy Reflections

Implementing the current policy commitment to DEOs can deliver clear benefits; however, effectiveness is dependent on level of resourcing, stakeholder buy-in and access to RE development funding:

- Mainstreaming energy in the local planning process
- Supporting communities to identify and develop energy projects
- Obtaining and sharing datasets to support local and national planning and energy access tracking
- Building local technical capacity to improve sustainability and overcome barriers of access to renewable energy
- Growing local awareness of renewable energy product standards and associated consumer rights

Thank You!

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Experiences from operating solar microgrids in Malawi

Elizabeth Banda

13th October 2022

United Purpose

Beyond aid

Overview

- Update on United Purpose activities under EASE:
  - Second microgrid installation
- Experiences of Operating Mthembanji Microgrid
  - Technical
  - Economic
  - Social Impact
- Community engagement
- Next steps for scaling up

Update on EASE Kudembe microgrid

- Second (and final) EASE Microgrid
- Installations finalised and commissioned in September 2022
- Same tariffs and site agent set up as Mthembanji
- Currency devaluations and inflation offered challenges, causing frequent changes in component prices and necessitating frequent budget revisions.

Number of customers	50
PV Generation	10.92 kW
Battery technology	48V, Lithium Ion Batteries
Battery manufacturer	BYD
Battery Capacity	20 kWh
Inverter manufacturer	SMA, Germany
Battery Inverter	8 kVA
PV Inverter	12 kVA
Smart Meters	Steamaco
Generation and distribution system supplier	BNG Electrical (Lilongwe)

Kudembe: First "Built in Malawi" microgrid

- Locally assembled generation system housed in a shipping container
- Some components (PV modules and batteries etc) sourced from South Africa, most locally purchased
- Builds local capacity and stimulates local value chain

Mthembanji Experiences - Overview

System Overview

Installed 2020 – 2 years of operation

60 connections, 364 people served directly

12kW PV, 19kWh lithium ion Batteries, 240V Distribution grid

Operations

Site agents for customer interaction and taking tariff payments

UP field staff weekly visits

Technical support from UoS

Maintenance contract with BNG – quarterly visits

Business planning

Data collection and analysis

Ongoing business and financial modelling for social enterprise approach to scaling up microgrids in Malawi

Mthembanji Experiences – Technical

- SMA inverters and Tesvolt batteries performed well - generally low maintenance apart from regular cleaning of panels
- Remote monitoring by UoS
- Frequent problems with Steamaco smart meters
- Distribution lines damaged from tree cutting

Mthembanji Experiences – Economic

- Payments taken through site agent and logged by smart meters – no revenue loss
- Tariffs negotiated with customers, initially high but reduced with a significant daytime discount
- Operational costs include site agent salaries, data and SaaS fees for smart meters and maintenance contract
- Call out fees for smart meter repairs have been reduced through training of local staff for troubleshooting

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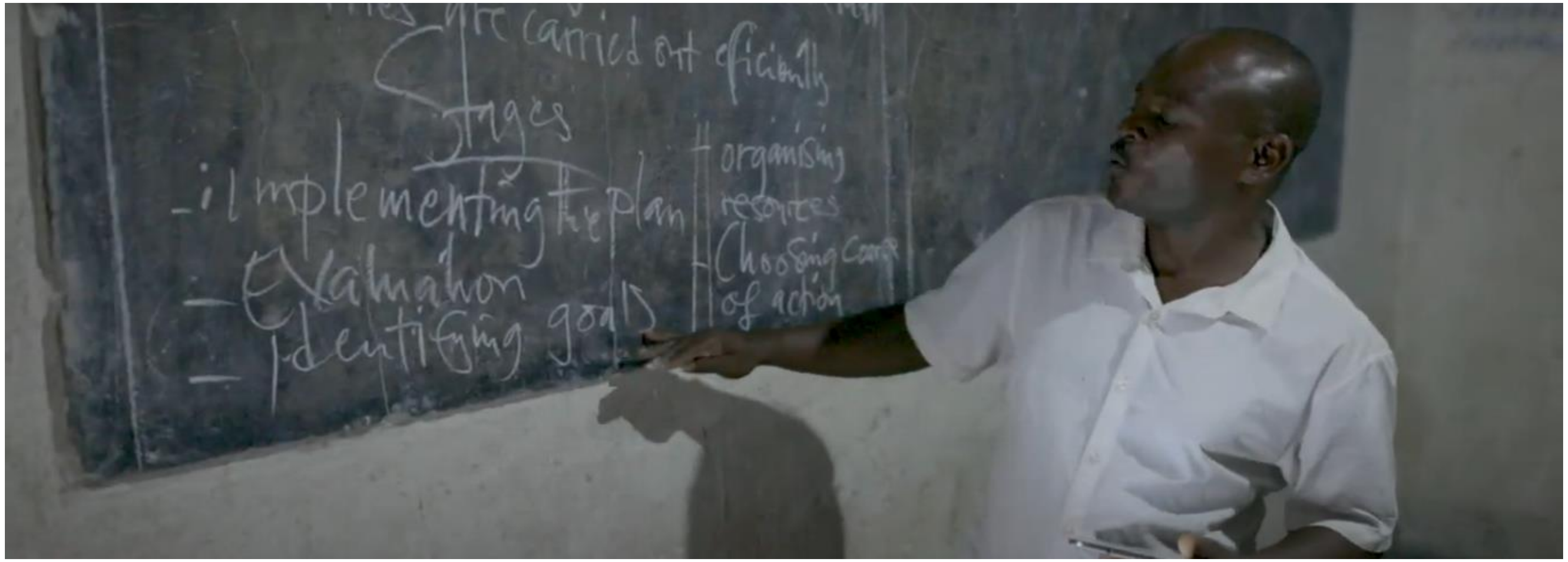
Mthembanji Experiences – Social Impact

- “Customer Journey” enumerator surveys conducted every 6 months
- Primary school offers evening classes, and children are spending additional time studying at home after dark.
- Educational tablets introduced to school trough Turing Trust
- Number of primary school pupils making it to secondary school has increased from 7 to 38
- Access to news and health information has improved



Mthembanji Experiences – Social Impact

- New businesses have started up including:
  - video shows, grocery shops with fridges, computer cafés, cold soft drinks, salons and barbershops
  - total of 20 new businesses to date
- All businesses have reported an increase in income, suggesting local economic development
- Positive gender impacts, with women reporting positive impacts on
  - amount of free time,
  - independence and decision making,
  - respect within the community and household,
  - security in the home

Mthembanji Experiences – Community Engagement

United Purpose Beyond aid

- Community training and capacity building a key focus of EASE
- Two-way dialogue between community and microgrid operator to ensure:
  - expectations are managed
  - complaints and feedback are heard
  - Customer service is improved
- Facilitated through customer contracts, site agents, regular visits from field agents, and specific targeted community trainings.
- Vandalism in 2022 – awareness raising and prevented further occurrences
- Tariff negotiations ongoing
- Ongoing training on electrical safety

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Next Steps - Kuyatsa

EASE strategy to transition to a social enterprise approach for deploying microgrids

Kuyatsa has been registered for ownership of microgrids to be transferred

Kuyatsa will offer reliable and affordable energy to rural communities through sustainable solar microgrids, focus on agricultural PUE as anchor loads

Analysis of data and experiences from EASE to inform Business modelling for scale up

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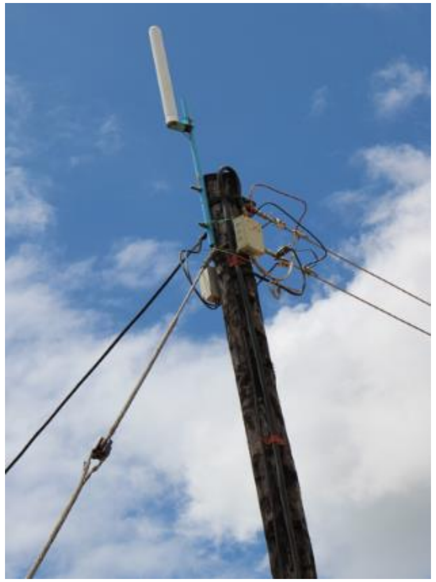
Understanding Microgrid Performance and Impact

Aran Eales, University of Strathclyde

EASE Learning Webinar

October 2022

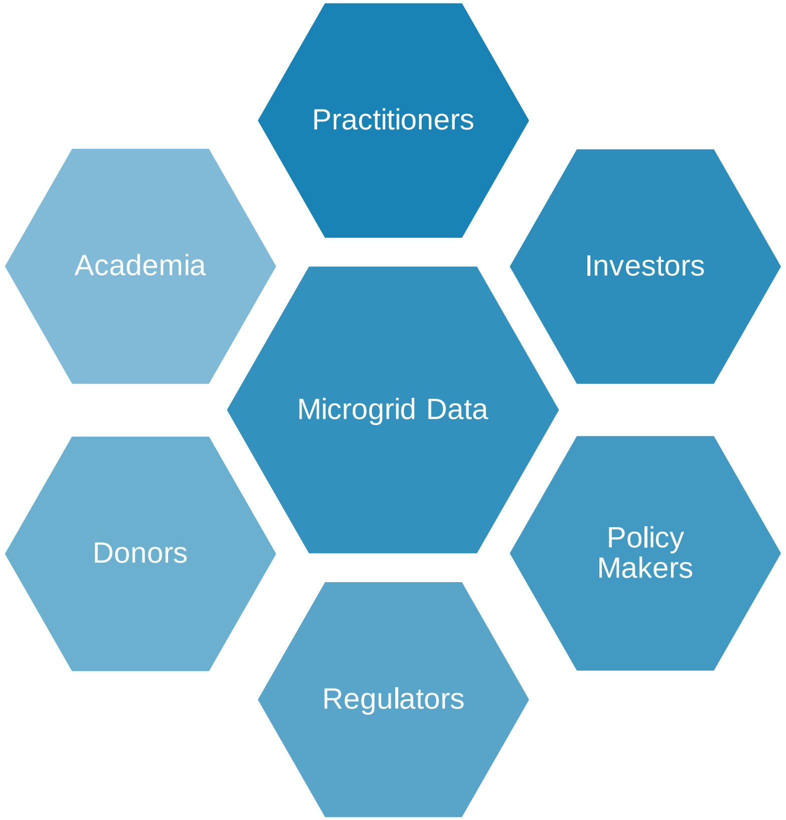
University of Strathclyde Engineering



Overview

- Importance of microgrid data collection and analysis
- Data collection frameworks
- Insight from Mthembanji
    - Technical
    - Economic
    - Social Impact
- Recommendations and research agendas

Performance monitoring of microgrids has benefits for multiple stakeholders



- Microgrids are the lowest cost electrification pathway for 37% of population in Malawi[1], but:
  - Currently a nascent sector
  - No proven or bankable business models
  - High uncertainty, high risk
- Data analysis informs:
  - **Technical design and operation**: Load profiles, sizing of components, maintenance procedures
  - **Business models**: Tariff setting and financial planning
  - **Investors and donors:** economic performance and impact
  - **Policy:** rural electrification strategies, regulatory guidance

[1] Eales A, et al. Assessing the market for solar photovoltaic (PV) microgrids in Malawi. Hapres Journal Sustainability Research. 2020 Jan 7

Data Collection Frameworks

Smart metering

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

Remote Monitoring

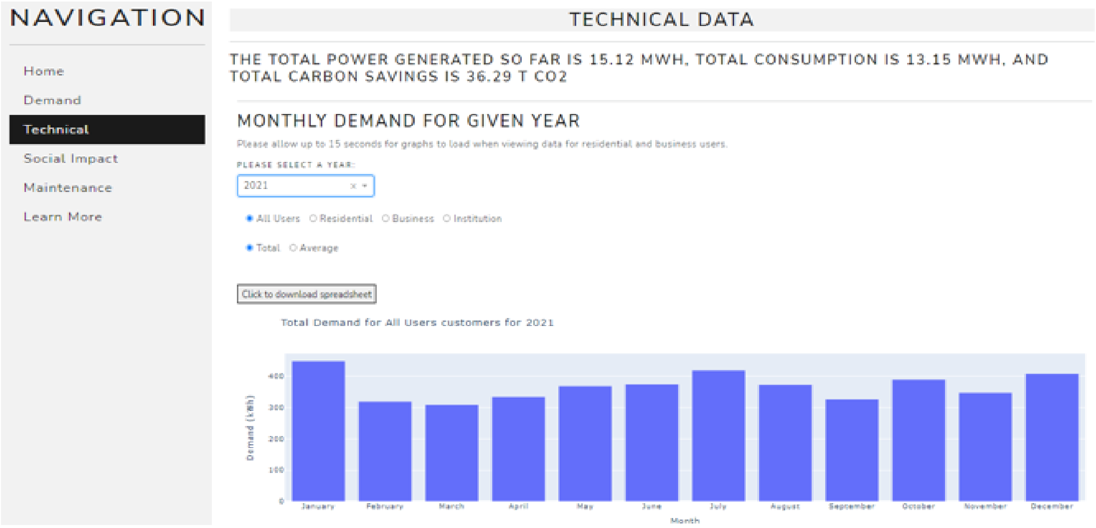
Track functionality and performance of microgrid generation systems, provide technical assistance for system operators by making it easier to conduct maintenance tasks in remote areas.

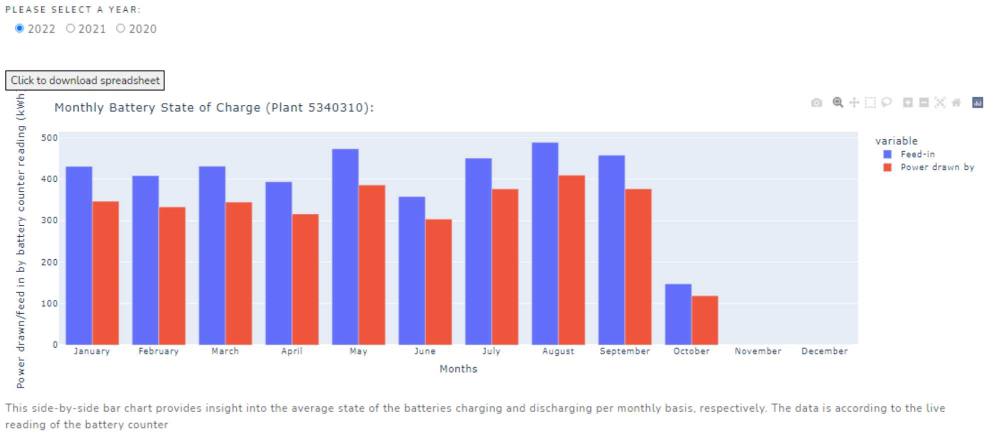
Surveys

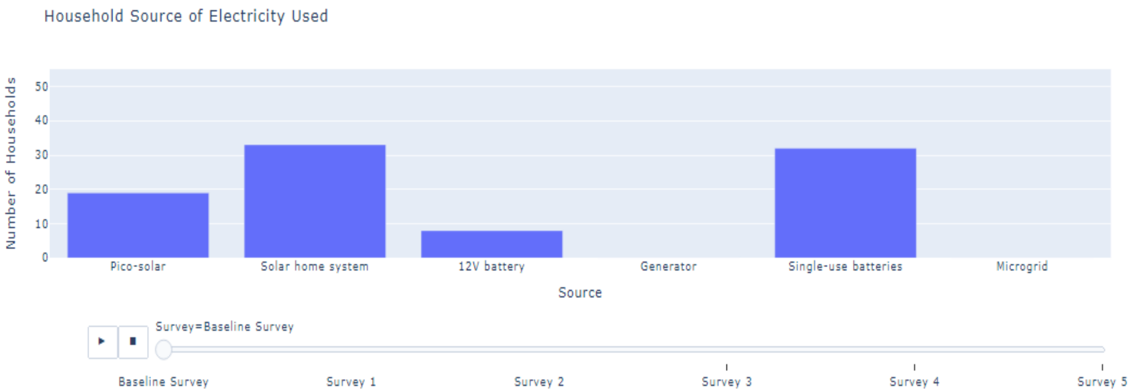
Precise qualitative and quantitative data collected from the community to gain insight on how electricity is being used and the social impact it has on the community

EASE data visualisation tool

- Free and open access to inform sector
- Real time API access
- Technical, economic and social impact Indicators
- Spreadsheet download
- Work in progress – currently for Mthembanji, Kudembe to be included







http://ease-microgrid.herokuapp.com/

Battery state of charge and temperature

Figure 1 Typical daily energy flow for batteries

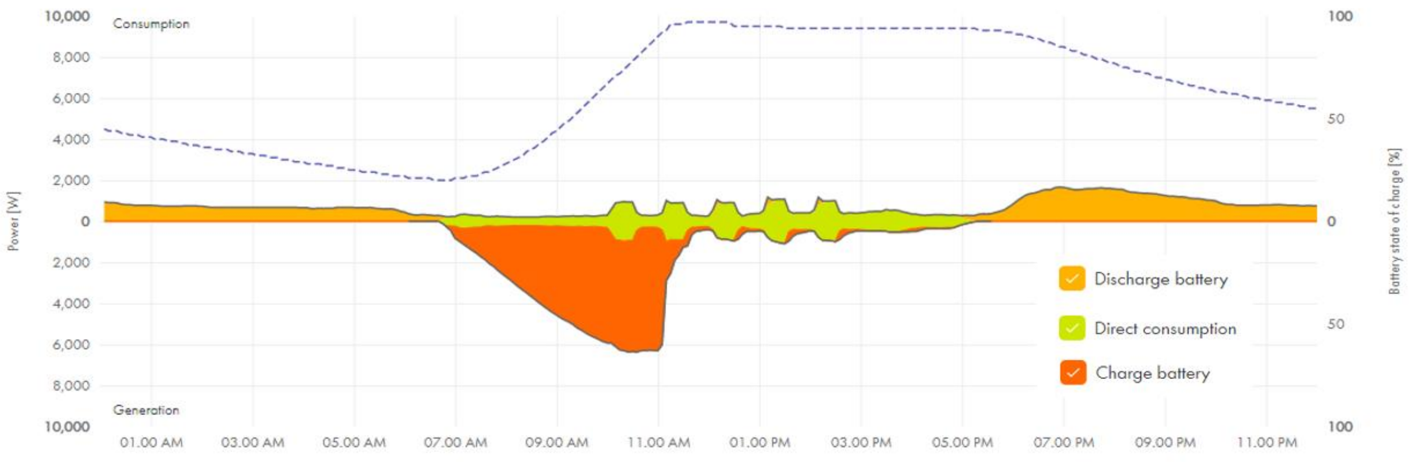
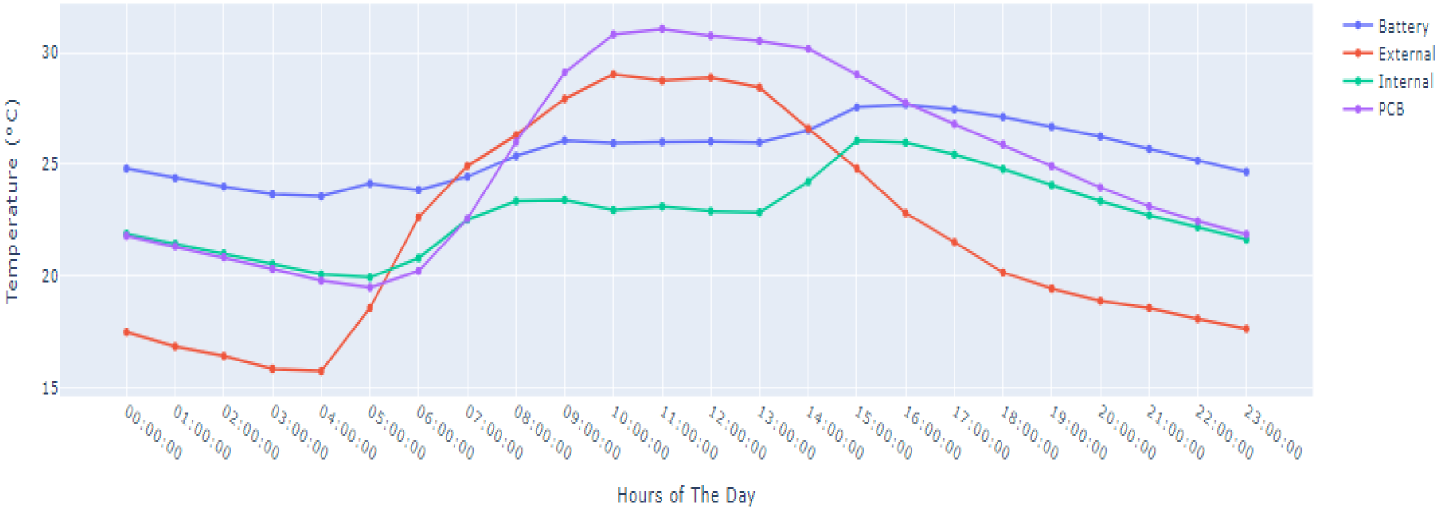


Figure 2: Daily temperature logging



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

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

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Communication uptime

Figure 3: Daily communication uptime 2021

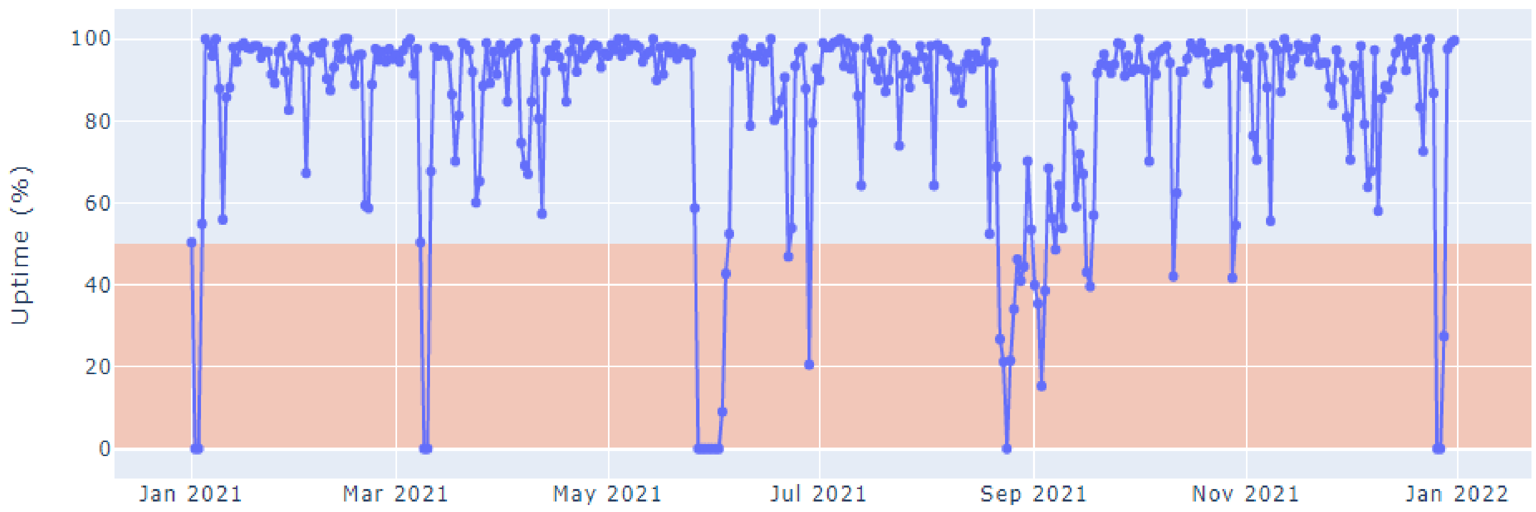
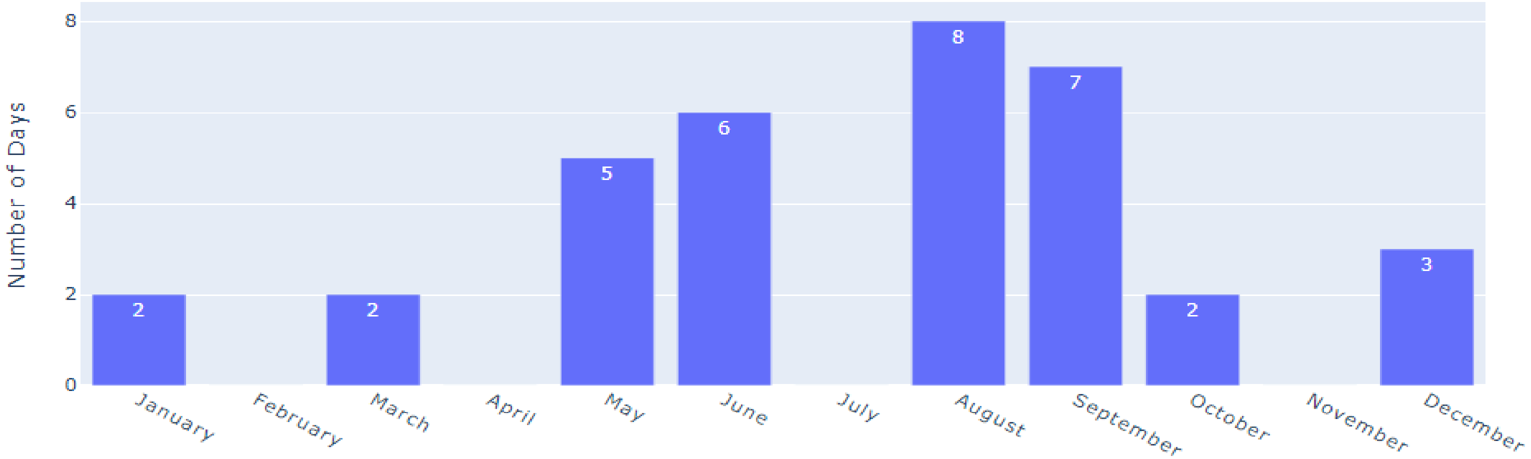
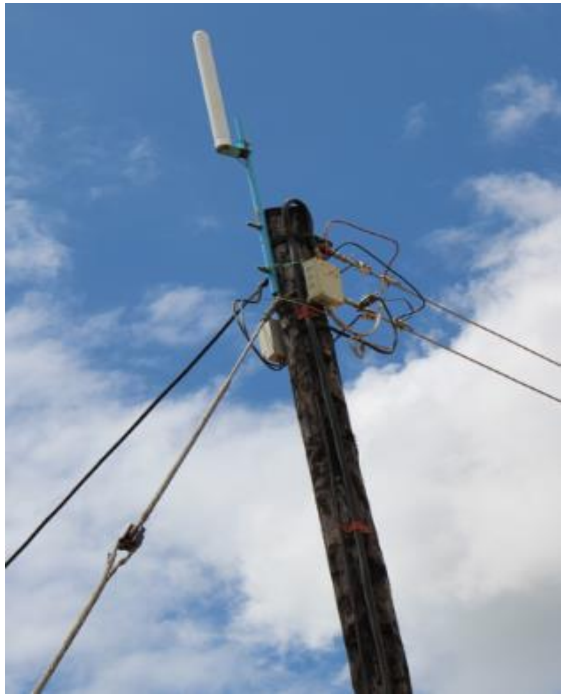


Figure 4: Number of days of outages per month 2021





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

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Demand

Figure 5: Total microgrid load profile

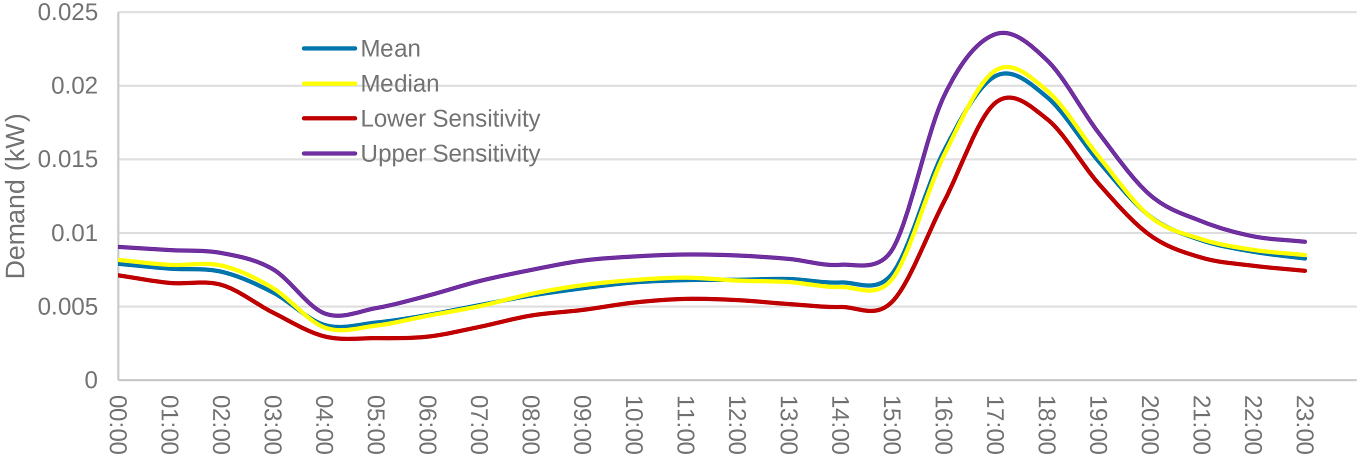
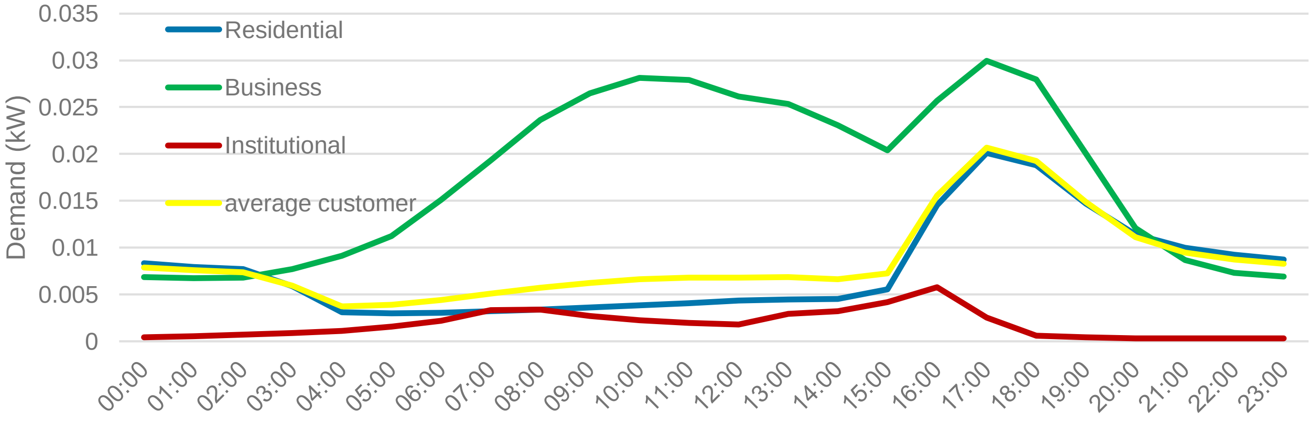


Figure 6: Average customer segment load profiles



- High evening peak – mostly residential customers
- Business customers are highest energy users
- Seasonal demand corresponds to harvest seasons
- 8760 spreadsheet available for download – valuable for system design

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Revenue

Figure 7: Total microgrid monthly revenue (USD)

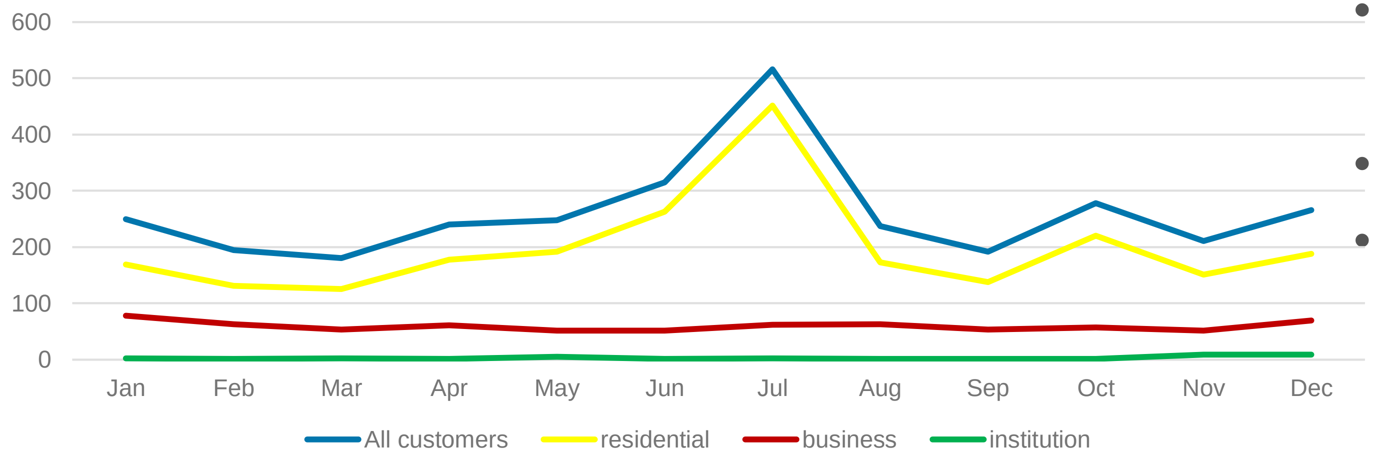
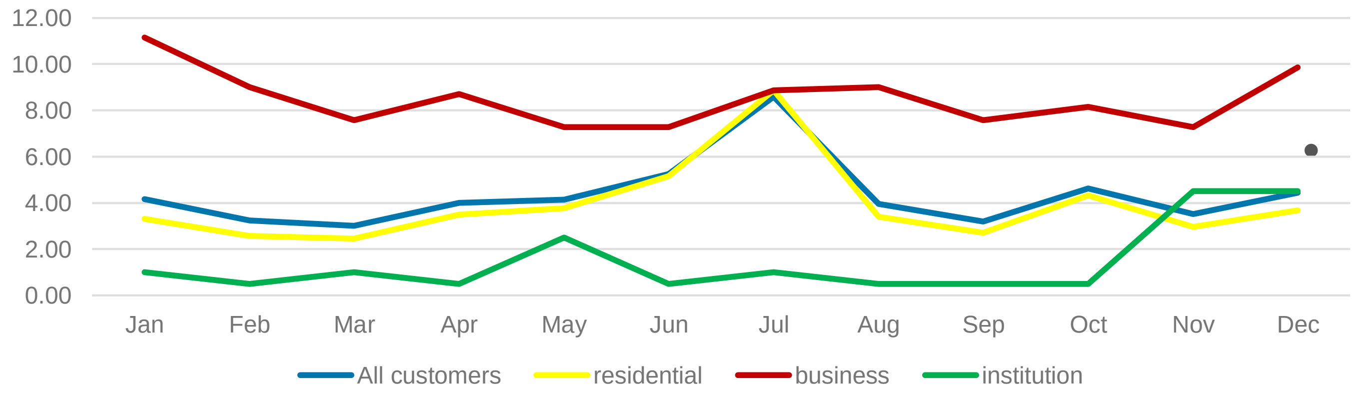


Figure 8: Monthly Average Revenue per User (ARPU) (USD)



- 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

Social Impact

KPI Themes
- Demographics
- Energy Access
- Health, Education and Communication
- Employment, Finance and PUE
- Female Empowerment
- Tariff and Service

Figure 9: Satisfaction with energy access

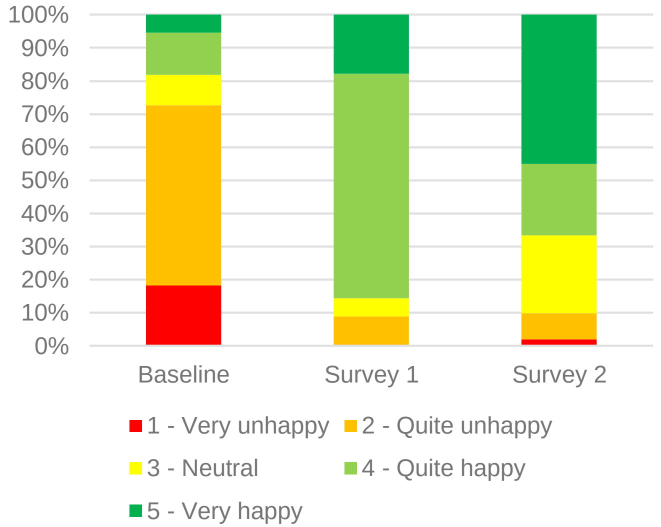


Figure 10: Number of businesses

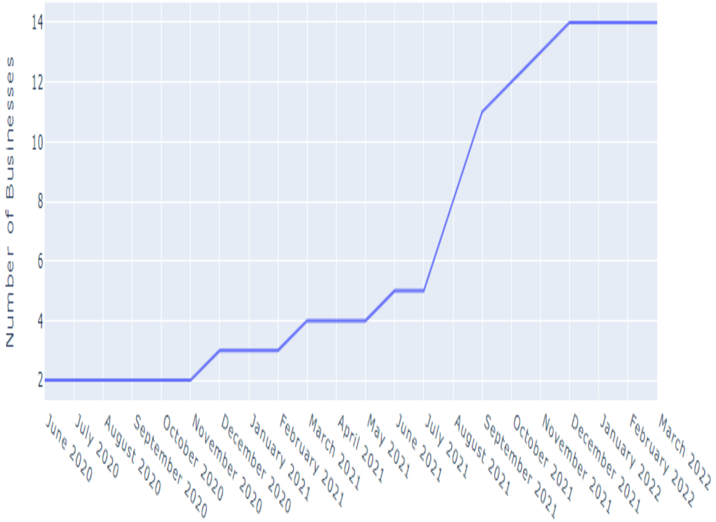


Figure 11: Use of Energy devices

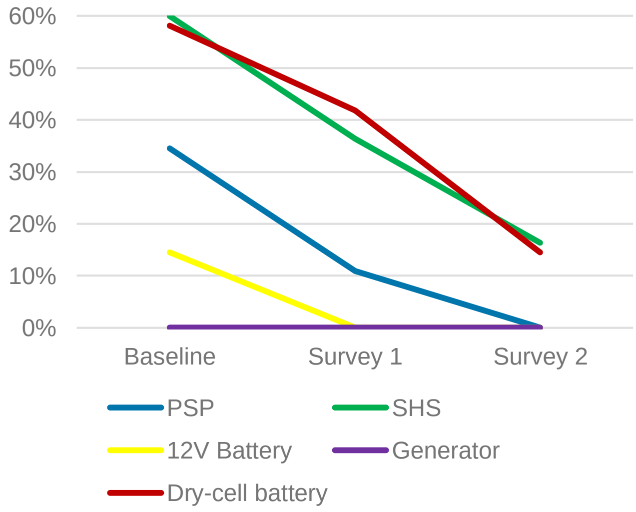
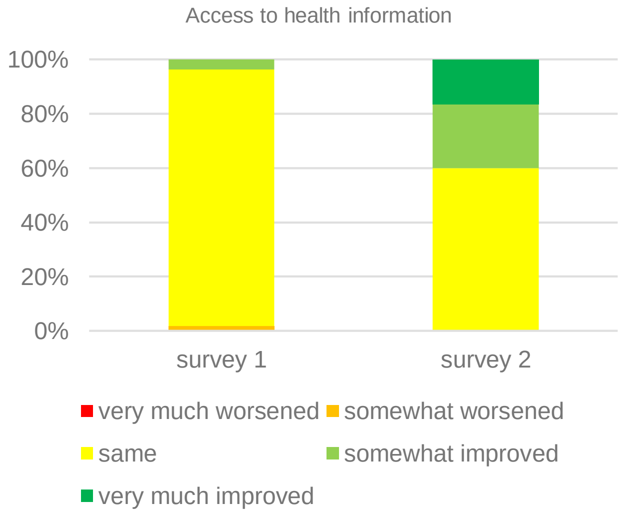


Figure 12: Access to health information



Recommendations

For policy makers:

- Implement smart subsidies: reduce tariffs and improve financials;
- Designate space for microgrids in rural electrification planning;
- Remove barriers from VAT and FOREX;
- Invest in research and capacity building.

For microgrid developers:

- Invest in data monitoring and analysis – and share data;
- Seek collaboration and partnerships with multiple development players;
- Improve financial sustainability through innovative business modelling;
- Set aside resources for community engagement and measuring social impact

Research Agendas

Techno-economic business modelling	Performance monitoring through data acquisition and analysis	Understanding demand
Spatial planning	Asset management	Distribution grid design and optimisation
Interconnecting microgrids	Productive Use	Social Impact

Summary

- Solar microgrids have significant potential to reduce energy poverty and contribute to SDG7 targets in Malawi
- Data will inform the nascent sector to reduce risk and boost investment
- Tools available: remote monitoring, smart meters and surveys
- Collaboration between government, practitioners, academia needed to accelerate deployment

University of Strathclyde
Engineering

The EASE Project

Remote monitoring and data analysis:
Estimating the potential energy yield from solar PV power microgrids

Webinar Theme
Accelerating Off-grid Energy Access in Malawi: Lessons from Piloting District Energy Officers and Deploying Solar Microgrids

Date
13th October, 2022

Million Mafuta

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Outline

- Introduction
- Methodology
- Results and discussion
- Conclusion and future work

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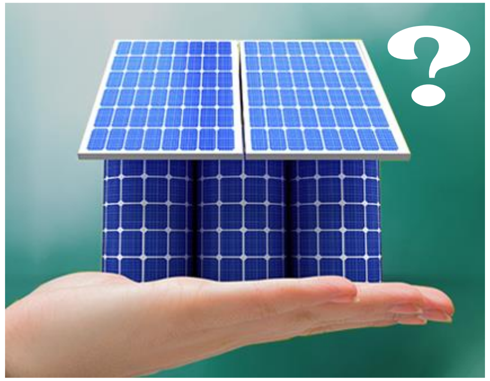
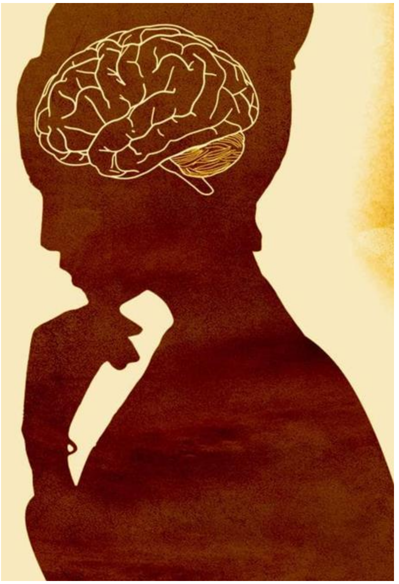
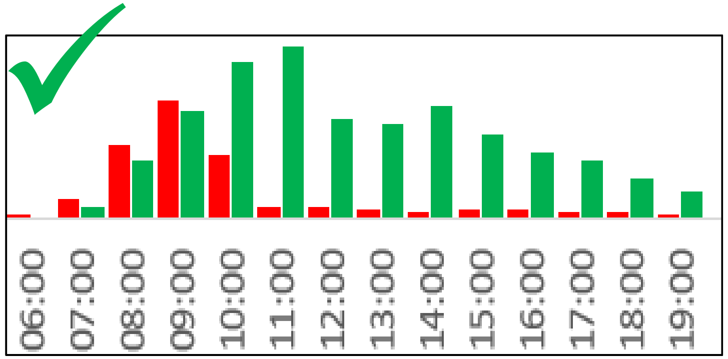
Introduction





Microgrid operator



Energy yield forecasting

Introduction

- Is it possible to estimate/forecast potential energy yield?

Modern inverters integrate IoT technologies

- Record actual energy produced, and not potential yield

Amount of recorded energy depends on:

- Weather conditions, and
- Dynamic load (and storage)

Difficult to capture potential yield

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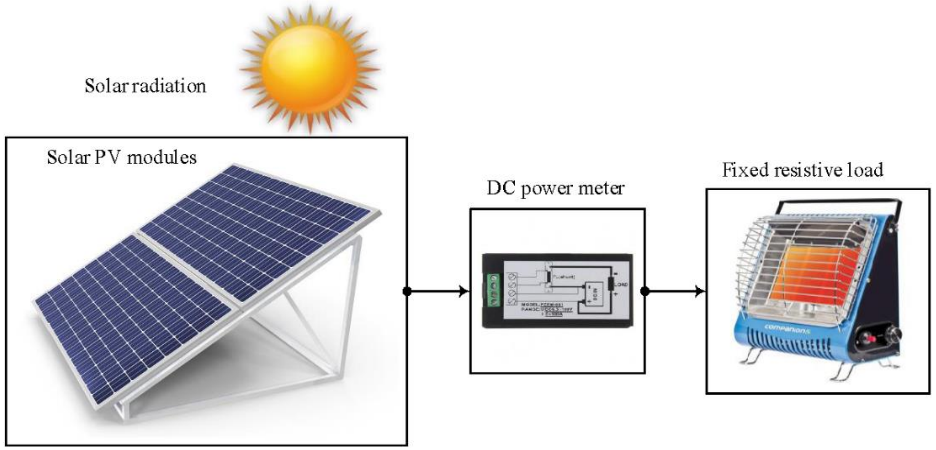
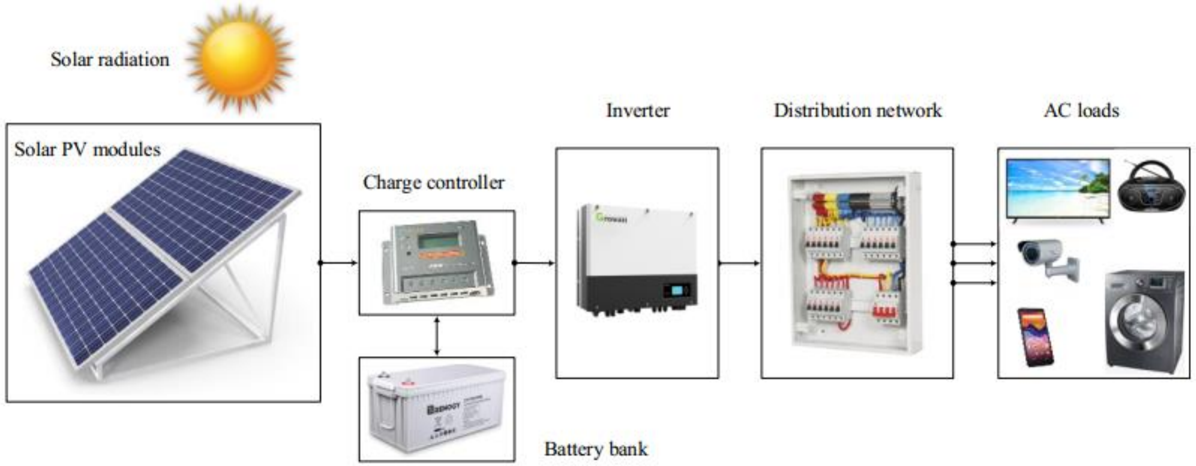
Methodology

Control treatment (CT) plant with flexible load

- Unlimited power consumption – allow capturing total potential energy
- Assist in assessing influential weather parameters



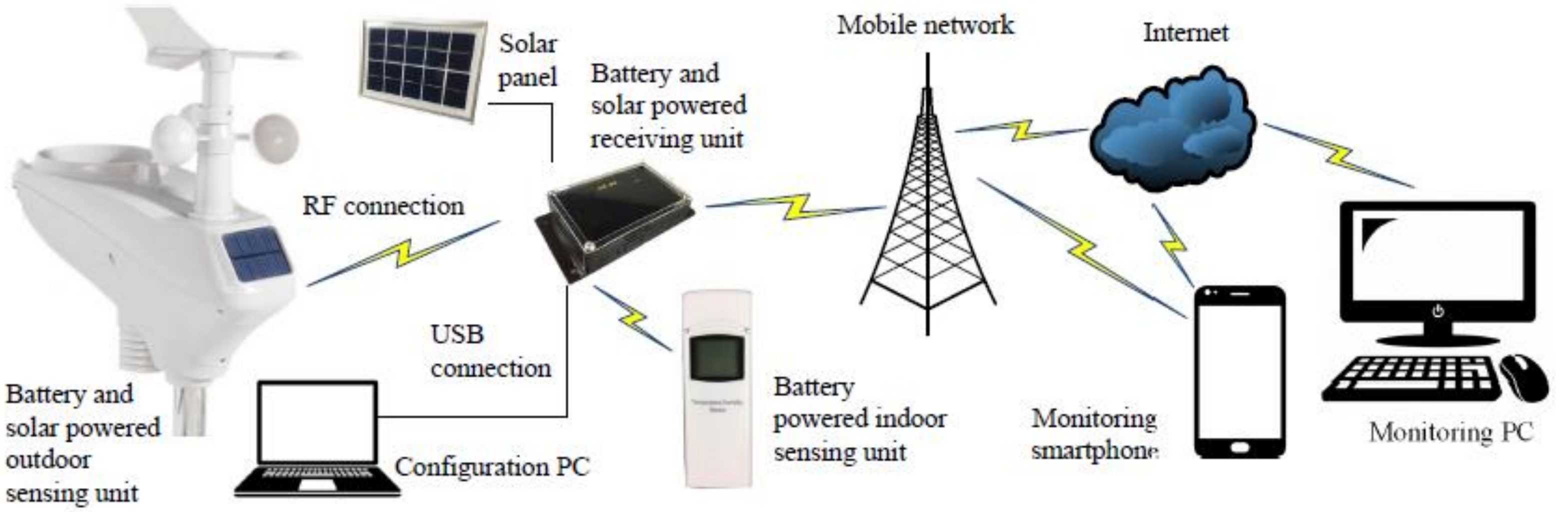
Control Treatment (CT) solar PV plant – 120Wp



Practical solar PV microgrid – 12kWp

Methodology

- Configured and installed an IoT-based weather station
- Remotely captured weather parameters
- Performed correlation analysis



- Built and trained linear regression model
- Statistically compared actual and potential energy yields

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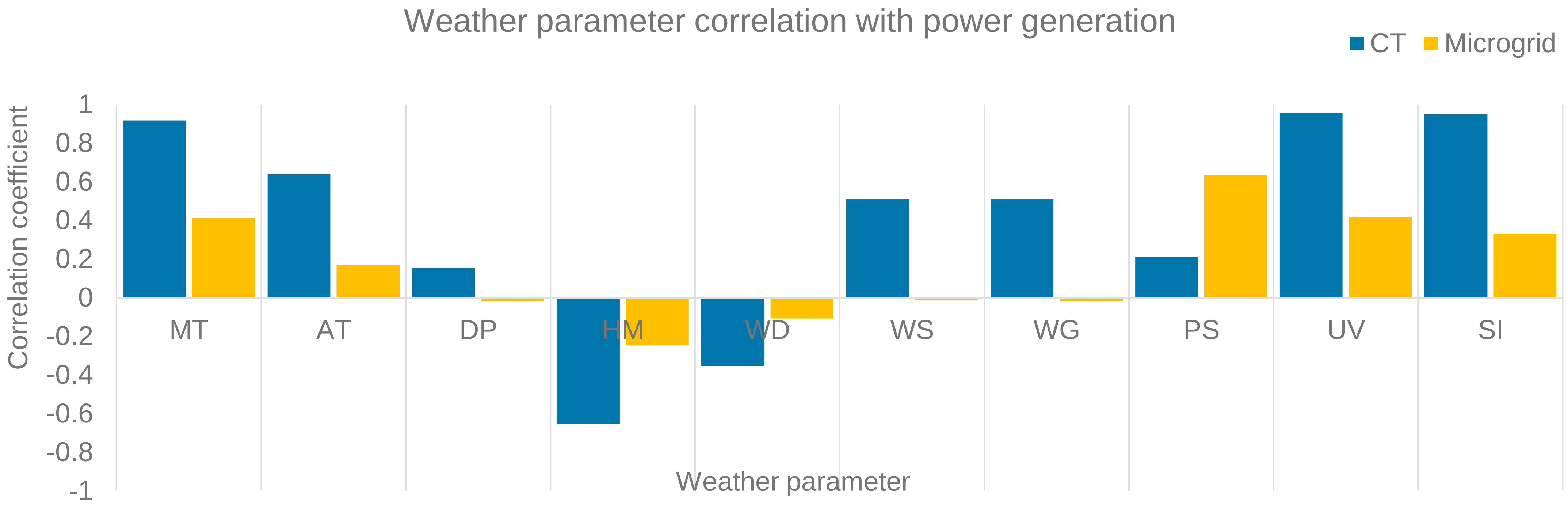
Results – Influential weather parameters



MT, UV, and SI – most influential

- Also correlate with Microgrid generation but only in the morning

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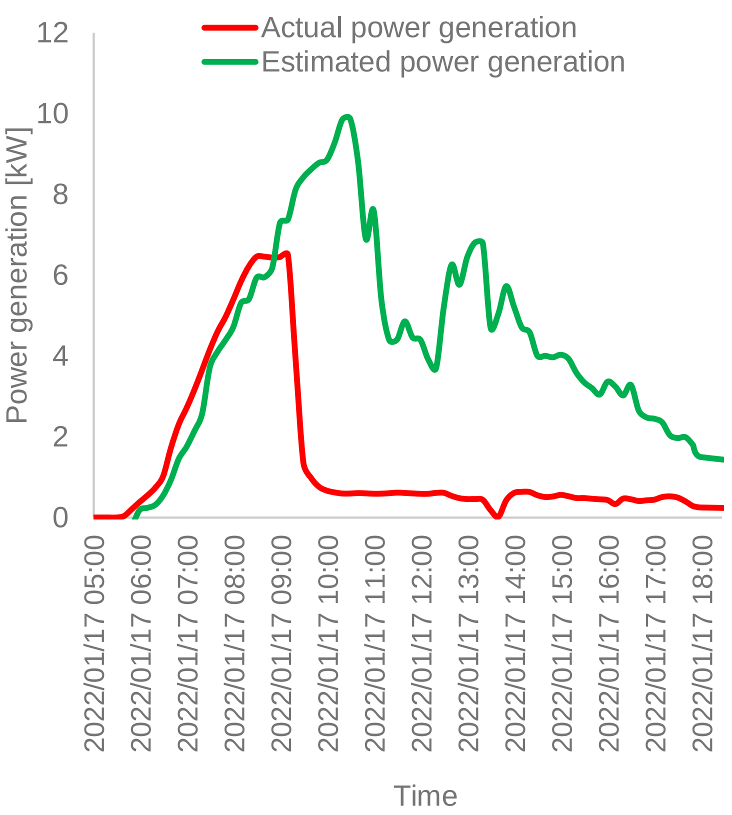
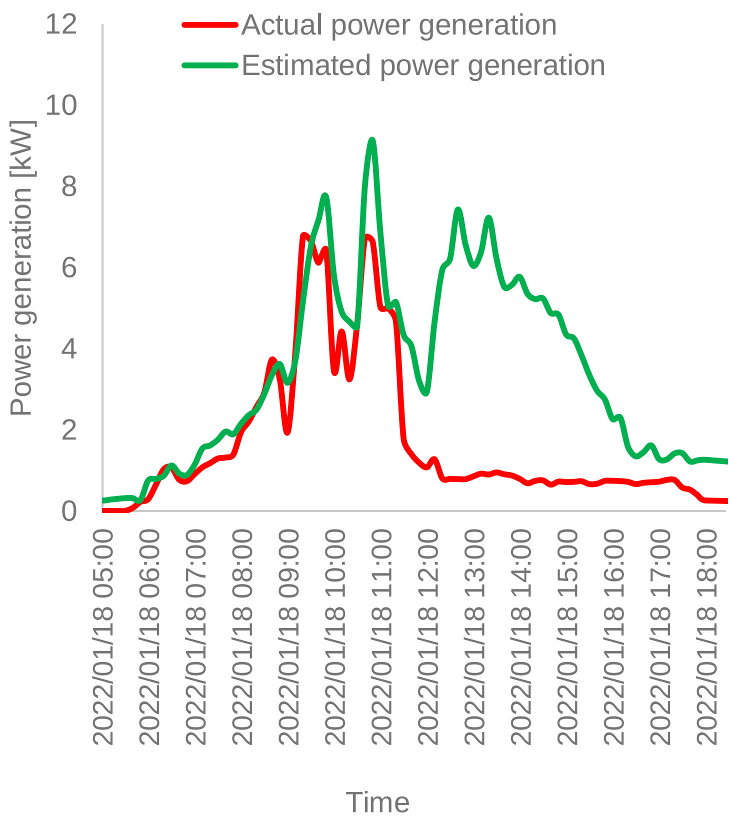
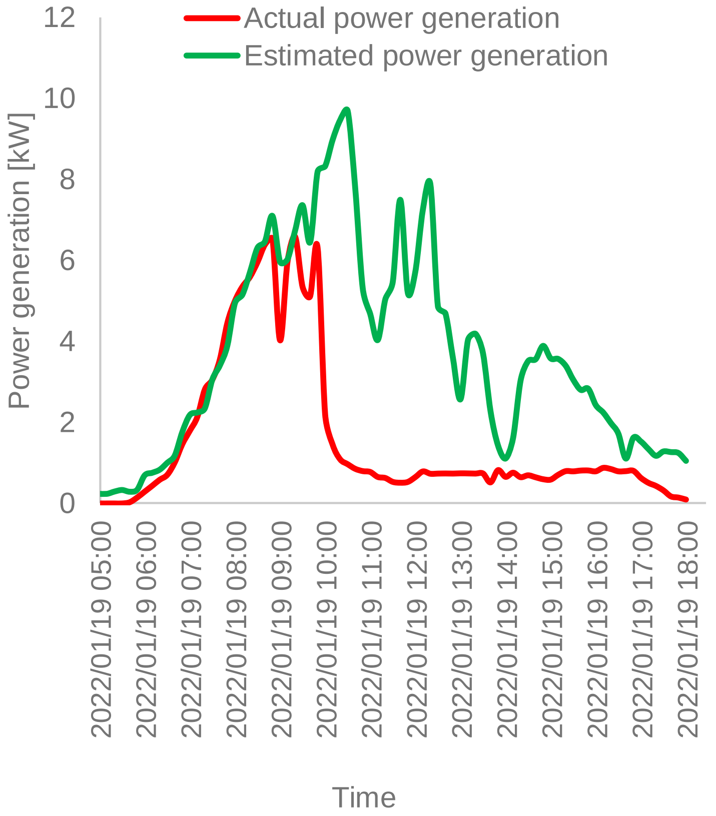
Results – Prediction model performance

- Linear regression model with accuracy of 94.7% based on R^2
  - Input features: MT, UV, and SI
  - Target output: morning microgrid power generation
- Estimate full-day microgrid power generation







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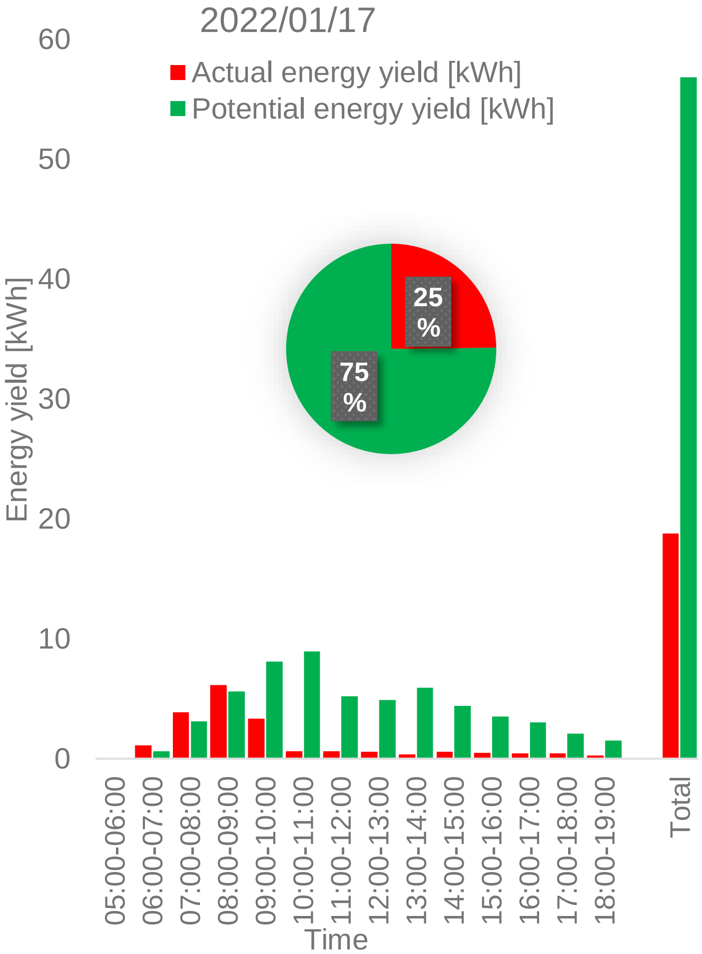
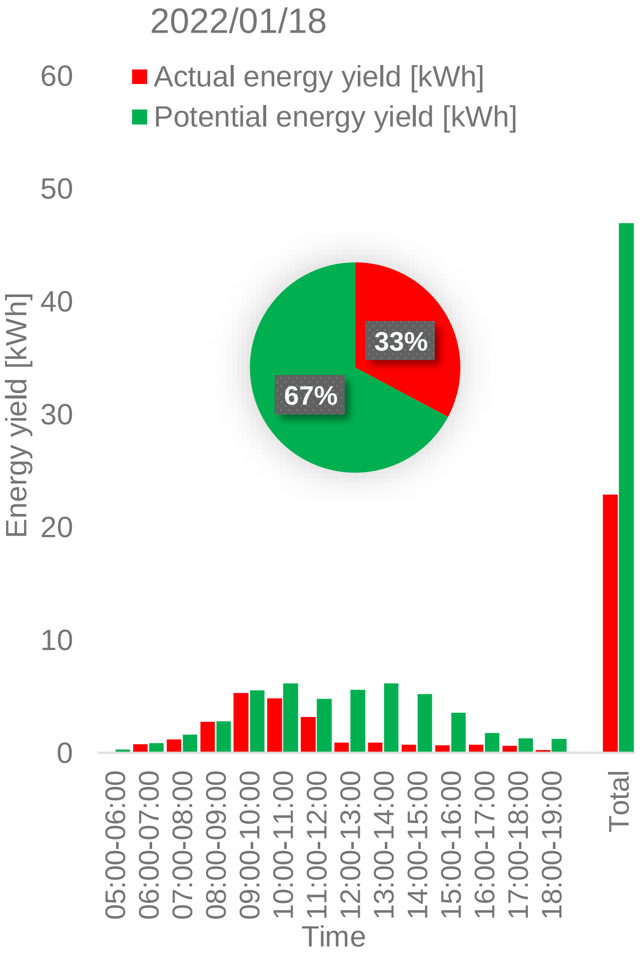
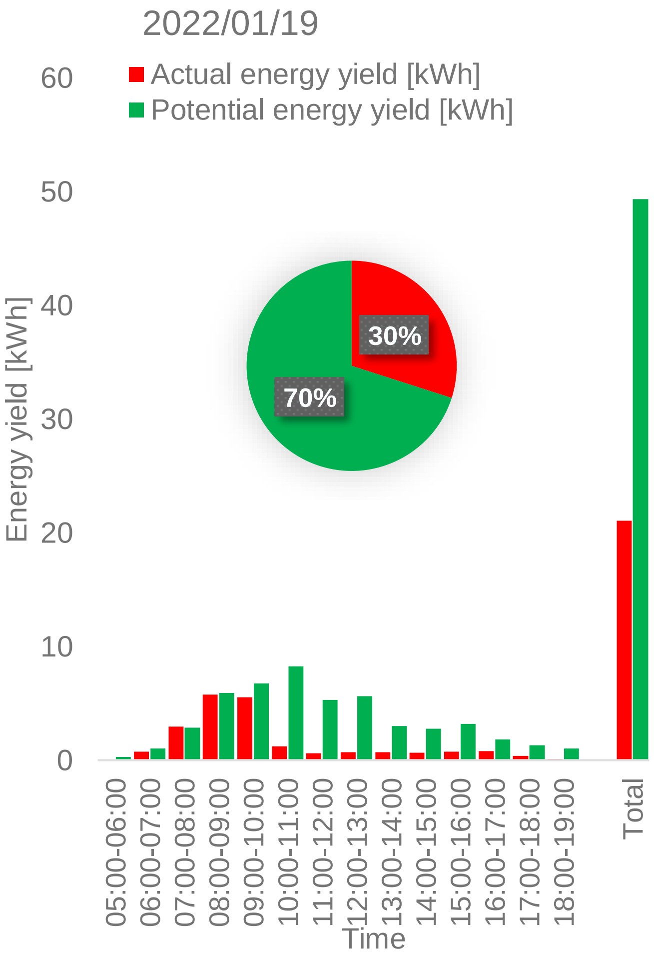
Results – Potential energy yield estimation

Hourly and daily potential/actual energy yield data







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Results & Discussion – Potential energy yield estimation

- Benefits of energy yield estimation/forecasting
  - Excess energy dispatch to non-fixed loads – economic resilience
  - Load profile shifting – technical resilience

Conclusion and future work

- Possible to harvest more energy from off-grid solar PV plants using
  - Flexible load configuration
  - Remote monitoring technology
- Future work - develop more robust day-ahead forecasting algorithms
- Contribute to technical and economic resilience of microgrids

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THANK YOU

mmafuta@mubas.ac.mw

The EASE Project

Accelerating Off-grid Energy Access in Malawi

Panel Discussion and Q&A

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

Closing Remarks

Policy briefs coming soon:

- Detailed reports with recommendations to inform the energy access sector in Malawi
    - Deploying Solar Microgrids
    - DEO Experiences

Check out the EASE blog for updates:

- https://ease.eee.strath.ac.uk/blog/
- Presentations and recording of this webinar to be available

Further EASE events planned for next year:

- In person – Lilongwe or Blantyre - TBC
- Online event
- Provisionally March 2023