University of Southampton

Energy for Development

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The **Energy for Development (e4D) programme** implements rural electrification projects as learning entities to support universal energy access with both technological and people-centric innovations.

In 2022, e4D delivered **Kenya's first community scale mini grid connectivity to the national grid** in Kitonyoni, Makueni County.

March 2022

e4D mini grids supply electricity 24/7 to businesses, health centres, schools, places of worship & households. Some projects are co-operatives, managed by elected members of the local communities. Others are operated by local electricity utilities with system performance remotely monitored by the e4D team in the UK.

Kenya

The 13.5 kWp Kitonyoni project in Makueni County was the first PV-battery mini-grid installed in Kenya by e4D in 2012. This project has been upgraded to three phase and connected to the utility grid in 2022. Two other PV-battery mini-grids were installed in 2015 in Oloika (13.5 kWp) and Shompole (8.4 kWp) in the south of the country's Rift Valley near Lake Magadi. REREC in Kenya provide assistance and maintenance of the projects.

Uganda

Two identical PV-battery mini-grids of 13.5 kWp capacity were deployed in 2015 in Kyenjojo, western Uganda, installed in the villages of Kyamugarura and Kanyegaramire. These projects were jointly funded by the e4D programme and the Rural Electrification Agency (REA), Uganda. These projects are being upgraded to 56 kWp PV, converted to 3-phase. There are plans to interconnect these two mini grids. REA provide assistance and maintenance of the projects.

Cameroon

A mini-grid was installed in Bambouti, as a joint effort with the University of Southampton students. The project serves the local health centre and provides a 'solar power hub' for the villagers.

Kitonyoni mini-grid plant room 2022. Inset thermal image of inverters for performance analysis

Maintenance work at Kitonyoni mini-grid distribution network, 2021

Mini-grid Projects

The e4D mini-grid delivery model is based on these key activities:

Engagement of stakeholders from the outset
Needs assessment, at the start and ongoing throughout project
Quality of installation ensured through inspection and monitoring
Upgrading of plants to cope with demand growth using energy innovations
In-country supply chain and technical support
Regular monitoring to support operation, maintenance and project expansion
Enterprise: co-operative business model, with micro-financing.

Community engagement , Kitonyoni, 2021

Comment on health impact of mini-grid:
"Previously I needed assistance using a kerosene lamp or I would hold a torch or mobile phone in my mouth to see what I am doing during a night consultation. Now I can work and perform deliveries 24 hours a day alone if needed. Thanks to e4D".
Mercy Twili, Kitonyoni Health Centre Chief Nurse

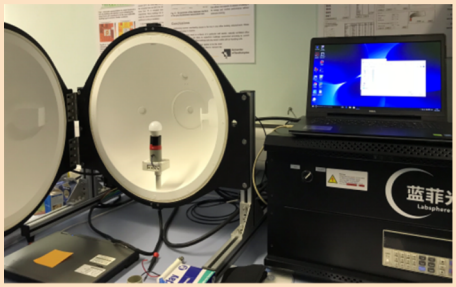
Kitonyoni Health Centre

The Energy & Climate Change Division undertakes research and development in many fields of energy covering all renewables and energy efficiency in buildings (energy.soton.ac.uk). In addition to mini-grid research, other key areas of energy access are addressed. Laboratory facilities include luminous efficiency, battery and appliance performance testing and small PV module and component characterization.

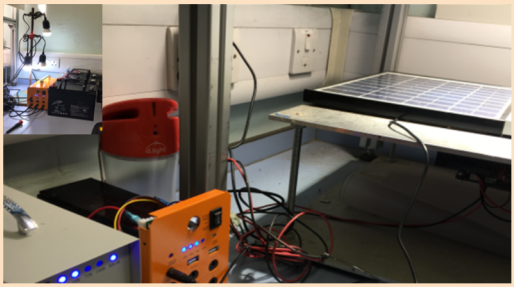
Optimised solar home systems (SHS)

Low cost graduated PAYG solar home systems

Research and development to combine generation and demand side optimisation leading to a robust and economically viable SHS solution. Experimental testing schedules to replicate the real world operation of appliance performance supplied through optimised renewable energy power generation systems.



Facilities for testing of luminous efficiency of LED light bulbs.



Testing and simulation of solar home systems including appliances, battery, charge controller etc.

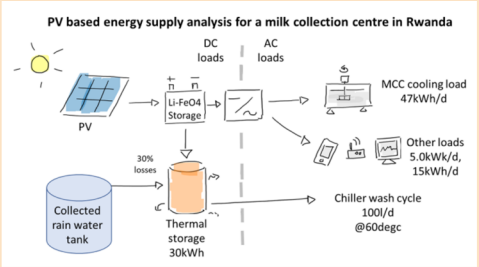
Off-grid DC appliances testing

Laboratory based DC appliances (refrigerator, television, LED light bulbs, cooling fan, batteries etc.) testing by replicating field conditions.

Power consumption study of a DC Television and LED bulbs.

A 50W DC refrigerator on test in an environmental chamber

Research and Capacity Building



PV based electricity supply modelling for a milk collection centre in Rwanda to be used as energy hub. This includes water storage, hot water storage as well as electricity for the local community.

Capacity-building in the Philippines

DC / AC mini grids

Efficient energy services solutions through mini grids

- Appropriate system design of AC mini grids to support electricity access.
- Unlocking the promise of high efficiency & low maintenance DC mini grids for electricity access.
- Spatial planning for mini grids.

Capacity building

Capacity building in research & development related to energy access and energy efficiency

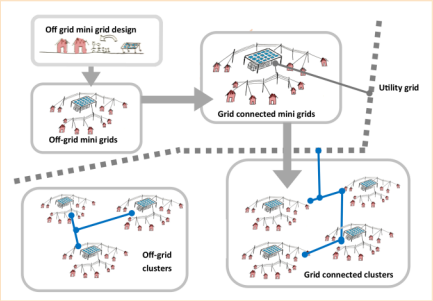
- Mini grid system design and performance analysis.
- Energy efficiency in buildings.
- Country-wide and regional geospatial analysis supporting energy studies at regional, city and village scales. (GIS, EnergyPlus®, HOMER® and others).

Students on field visit to Kitonyoni mini-grid

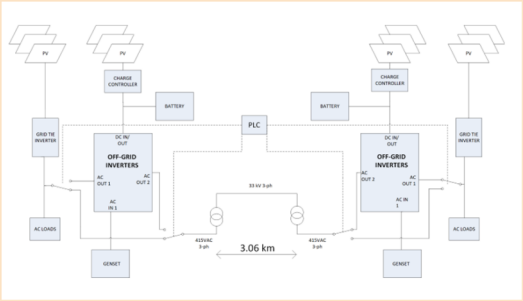
FORTIS UNUM (Stronger As One): Innovations in Mini Grids and their Networks

Fortis Unum builds on the extensive experience of the e4D team in the areas of energy access, mini grids and networks. This collaborative research team with partners from Kenya and Uganda (Kenya Power, Jomo Kenyatta University and Kyambogo University) is studying off-grid mini-grids and networks, in terms of their ability to:

- Work individually as isolated mini-grids.
- Work collaboratively with each other in a small network cluster in order to improve overall resilience.
- Work with utility grid at the following modes: individually and in clusters, to enhance supply security and resilience during outages, as part of the national grid.



Conceptual outline of Fortis Unum project, with off-grid isolated, clustered and grid-connected mini-grids



Single-line diagram of proposed clustering of two off-grid mini-grids in Uganda

Fortis Unum research was structured to test and model mini grid systems and their network configurations to enable African households to thrive through optimised, flexible and upgradable mini-grid networks.

Key understanding and learning gained:

- Potential to cluster mini-grids to form wider networks with greater stability and lower Levelized Cost of Electricity (LCOE).
- Utilisation of highly stable mini-grids to support the near end line of the utility network.
- Understanding the intermittent islanding operation of mini-grid networks.
- Demand side management approaches related to consumption profiles and mini grid network stability.

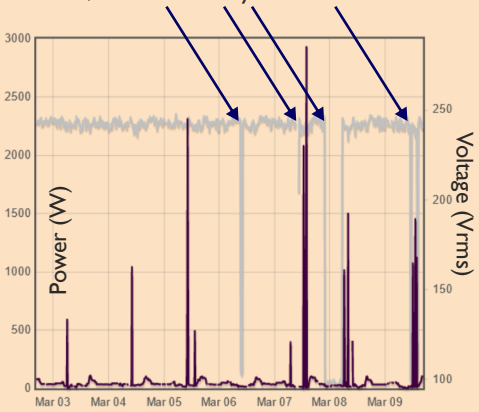
Mini-grids clustered or connected to the national grid

Kitonyoni grid connected mini-grid: (a) 3-phase plant room, (b) grid interconnection cabinet, (c) transformer connected to mini-grid circuit (LV) and transmission line from substation (MV)

Monitoring and data analysis

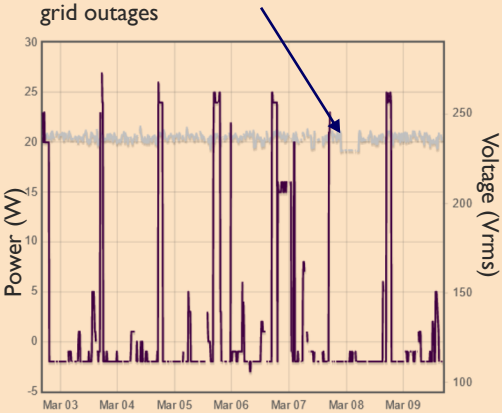
Monitoring systems to provide diagnostics such as comparison of power supply of Kitonyoni mini-grid vs utility grid. Ongoing monitoring through Open Energy Monitor of parameters and devices to capture real power and voltage:

On the main grid, frequent outages occur, business activity is curtailed



Welding shop, currently connected to the main grid

On the mini-grid, the inverters maintain the voltage at normal levels during main grid outages



Homestead, connected to mini-grid

Utility grid stability and monitoring at the low-voltage (LV) side of grid transformer linking to the mini-grid. This monitoring offers in-depth learning for future mini-grid projects.

Monitoring of LV feeders at Kitonyoni

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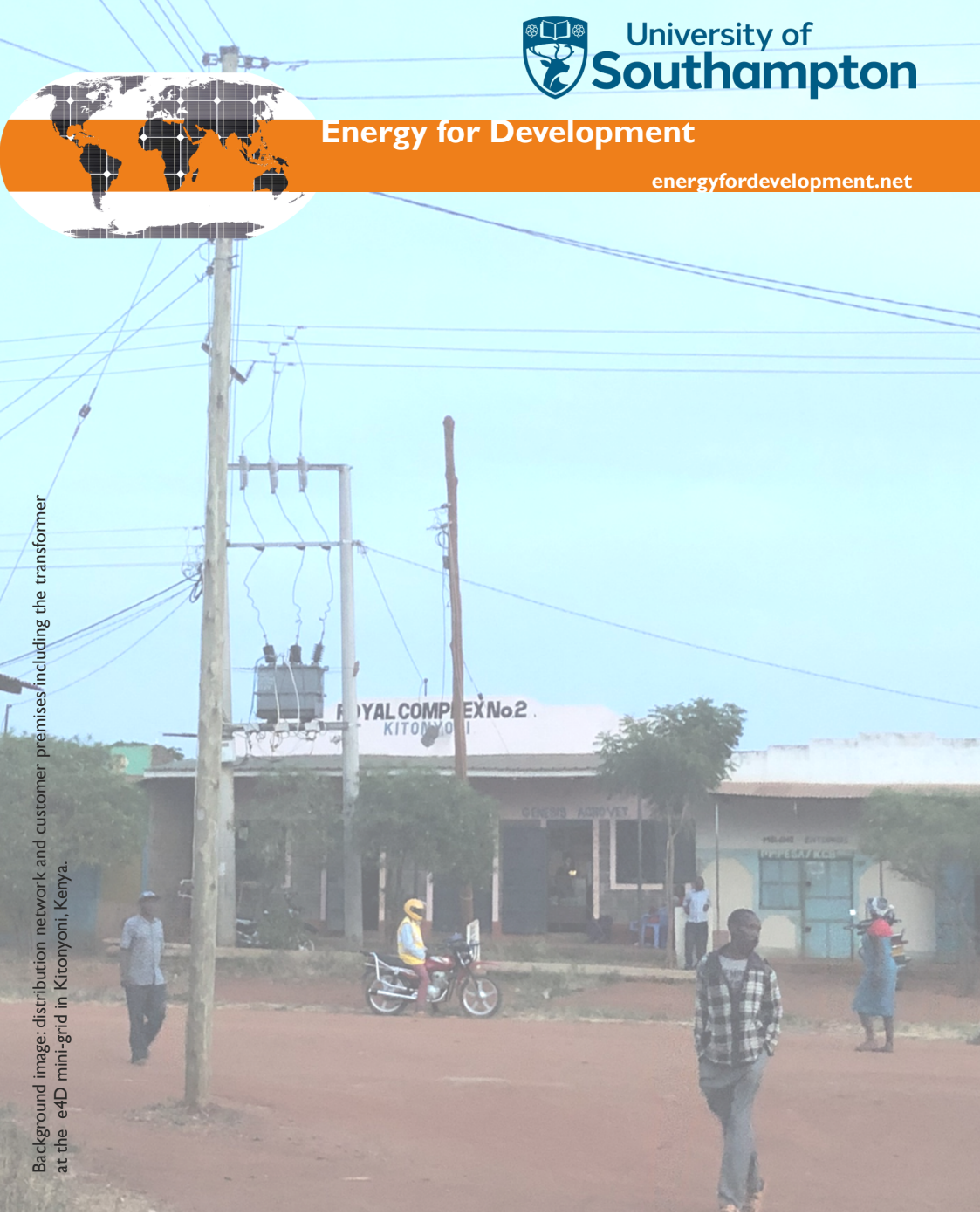

Background image: distribution network and customer premises including the transformer at the e4D mini-grid in Kitonyoni, Kenya.

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