Promoting Economic Development through Sustainable Energy

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Overview

- Context: Energy Access and Development
- Energy Access in Malawi
- Energy Delivery Models
    - District Energy Officers
    - Solar Microgrids
    - Productive Uses of Energy
- Modern Energy Cooking Systems
- Next Steps
- Discussion

Sustainable energy powers education and health systems, new businesses in previously unserved communities, jobs, manufacturing and industrialization, and water storage and food security.

"Energy is the **golden thread** that connects economic growth, increased social equity, and an environment that allows the world to thrive."

– Former UN Secretary-General Ban Ki-moon

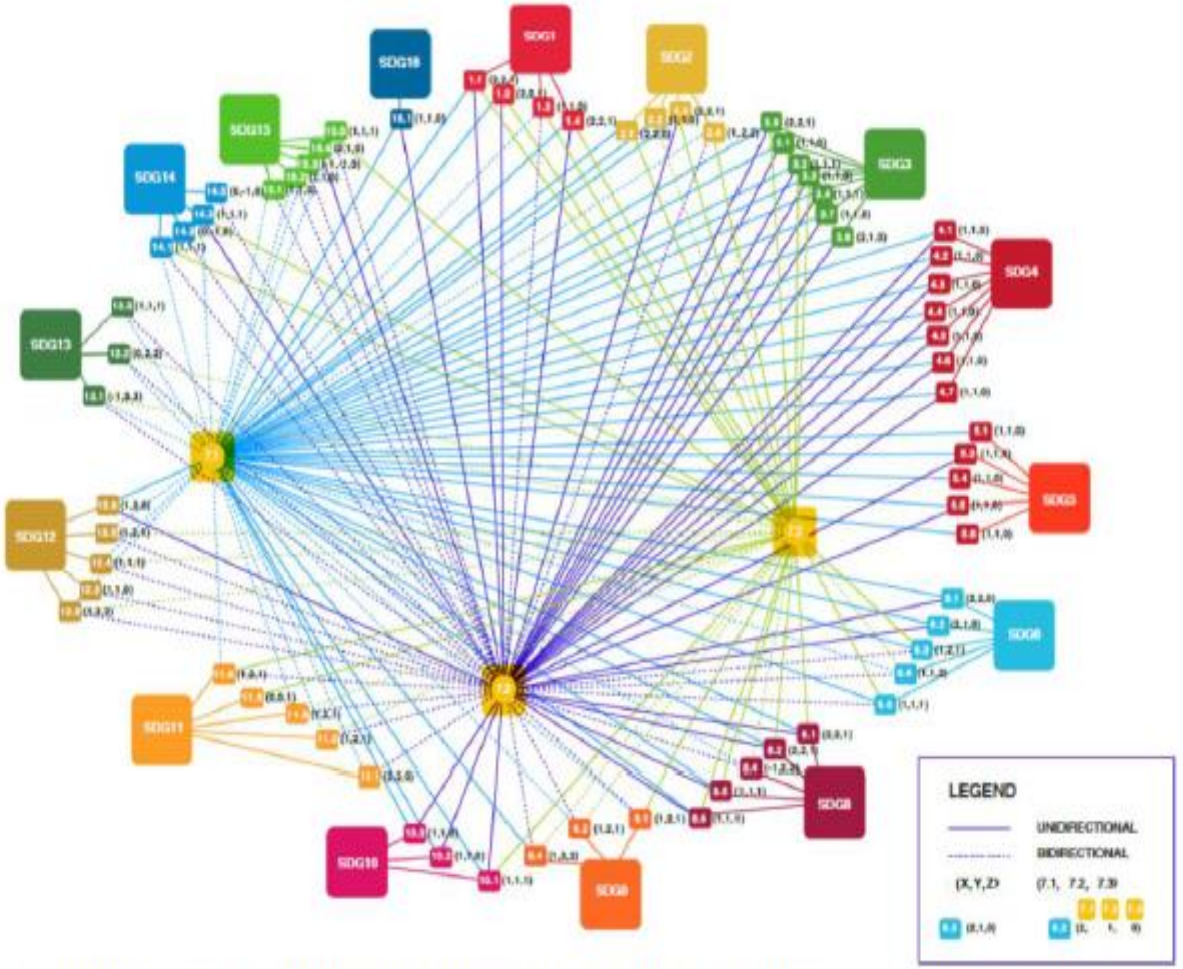
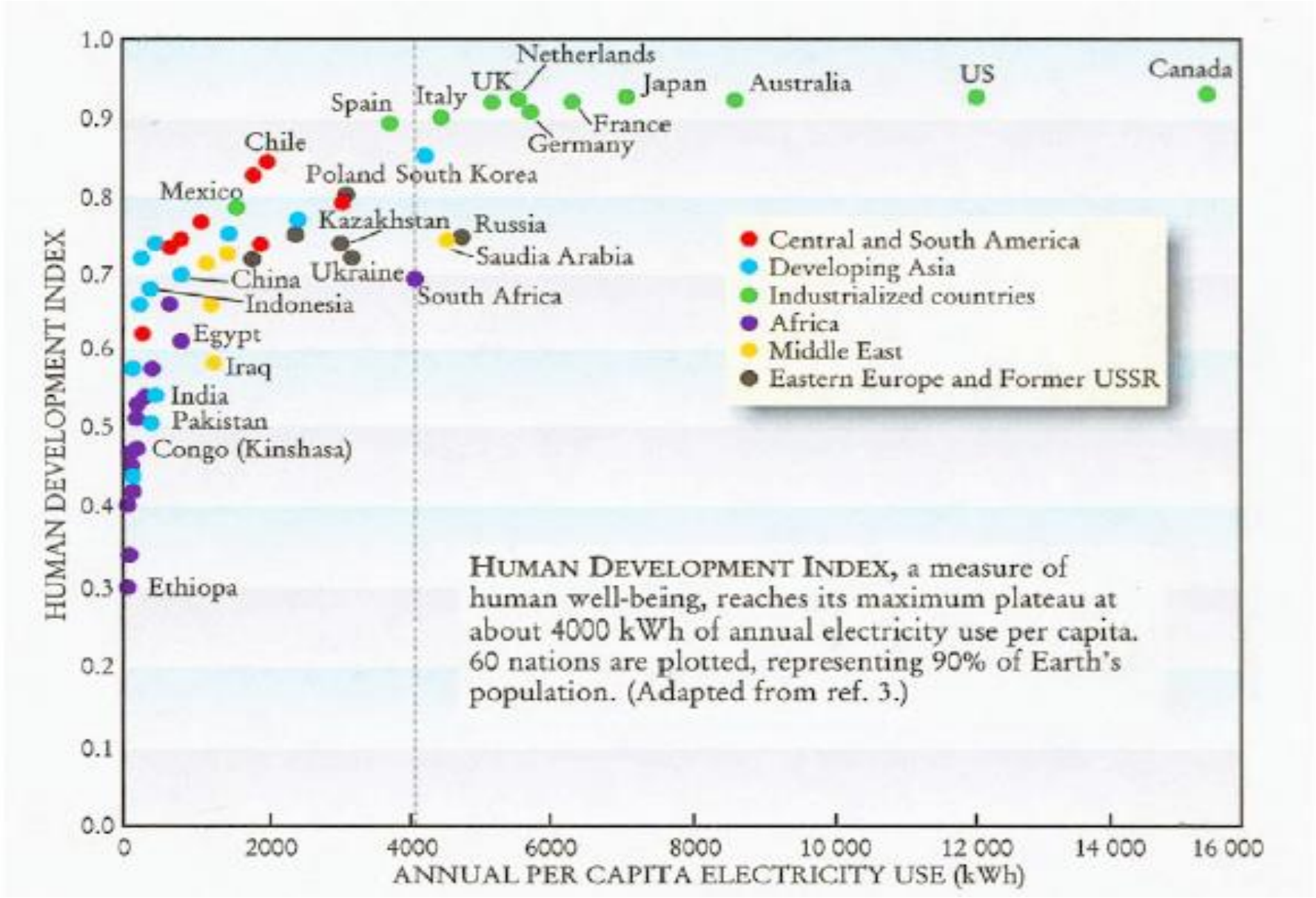


Figure from *"SDG 7 as an enabling factor for sustainable development: the role of technology innovation in the electricity sector"*, Alloisio et al

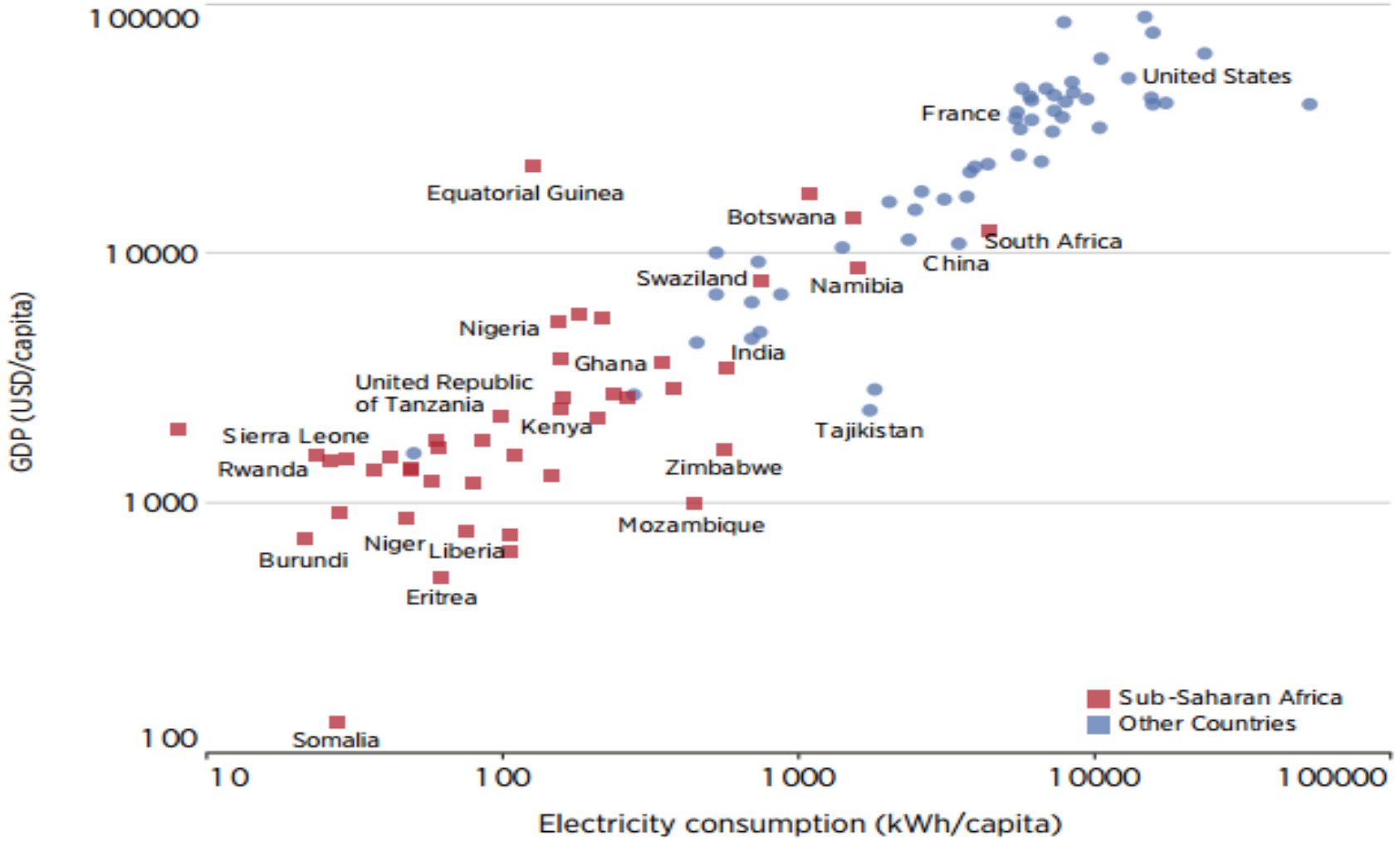
Human Development Index and Access to Energy



Benka (Physics Today), 2002

Energy Access and GDP

Relationship between electricity consumption and GDP, 2012

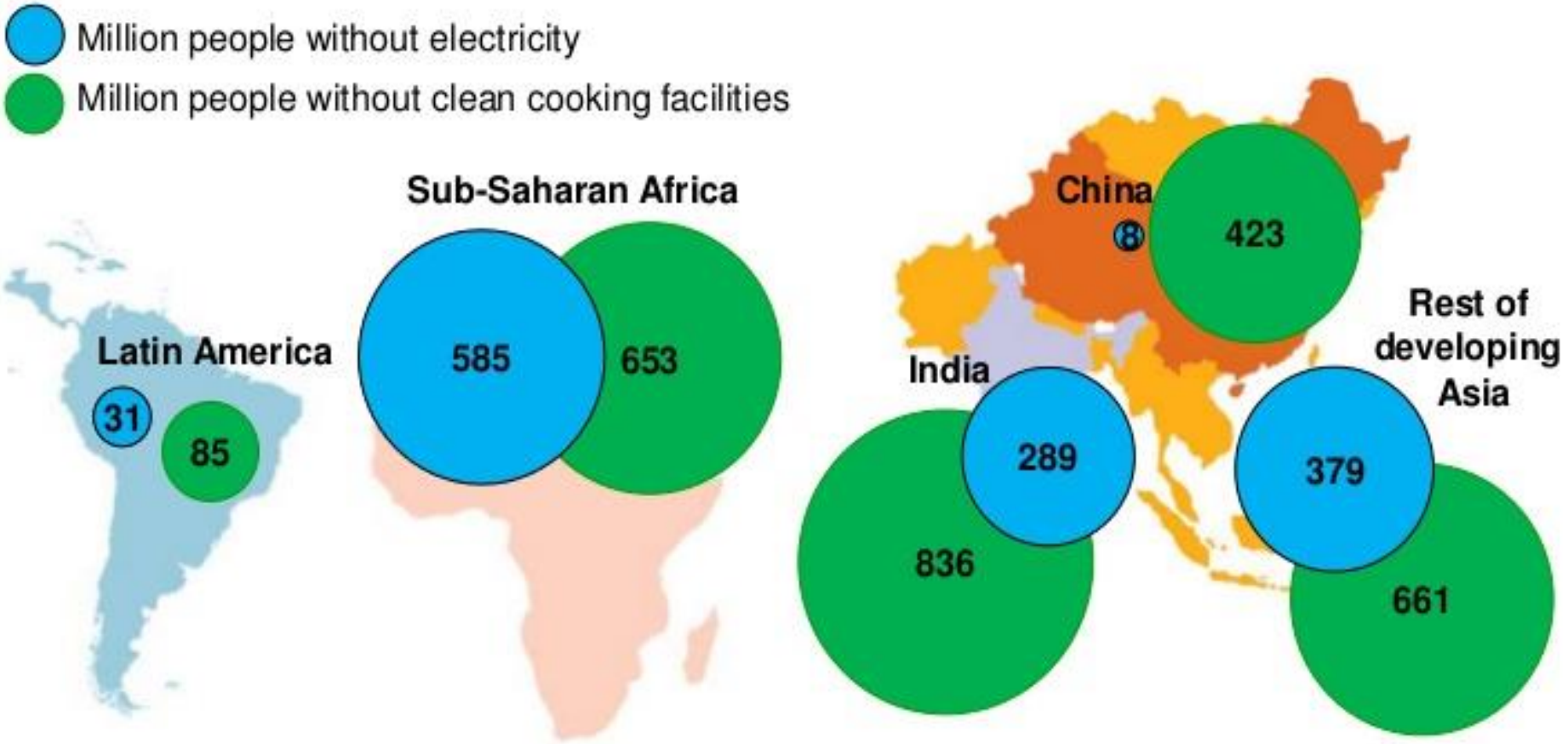


Source: US CIA, 2016 and World Bank, 2015a

Note: A logarithmic scale was used on both axes of the figure.

IRENA, 2016

Energy poverty by region



Over 1 billion people without access to electricity

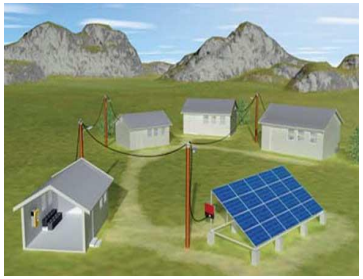
POOR PEOPLE'S ENERGY OUTLOOK, 2019

Energy Access Levels

Candles/ Kerosene

Pico Solar Products

Solar Home Systems



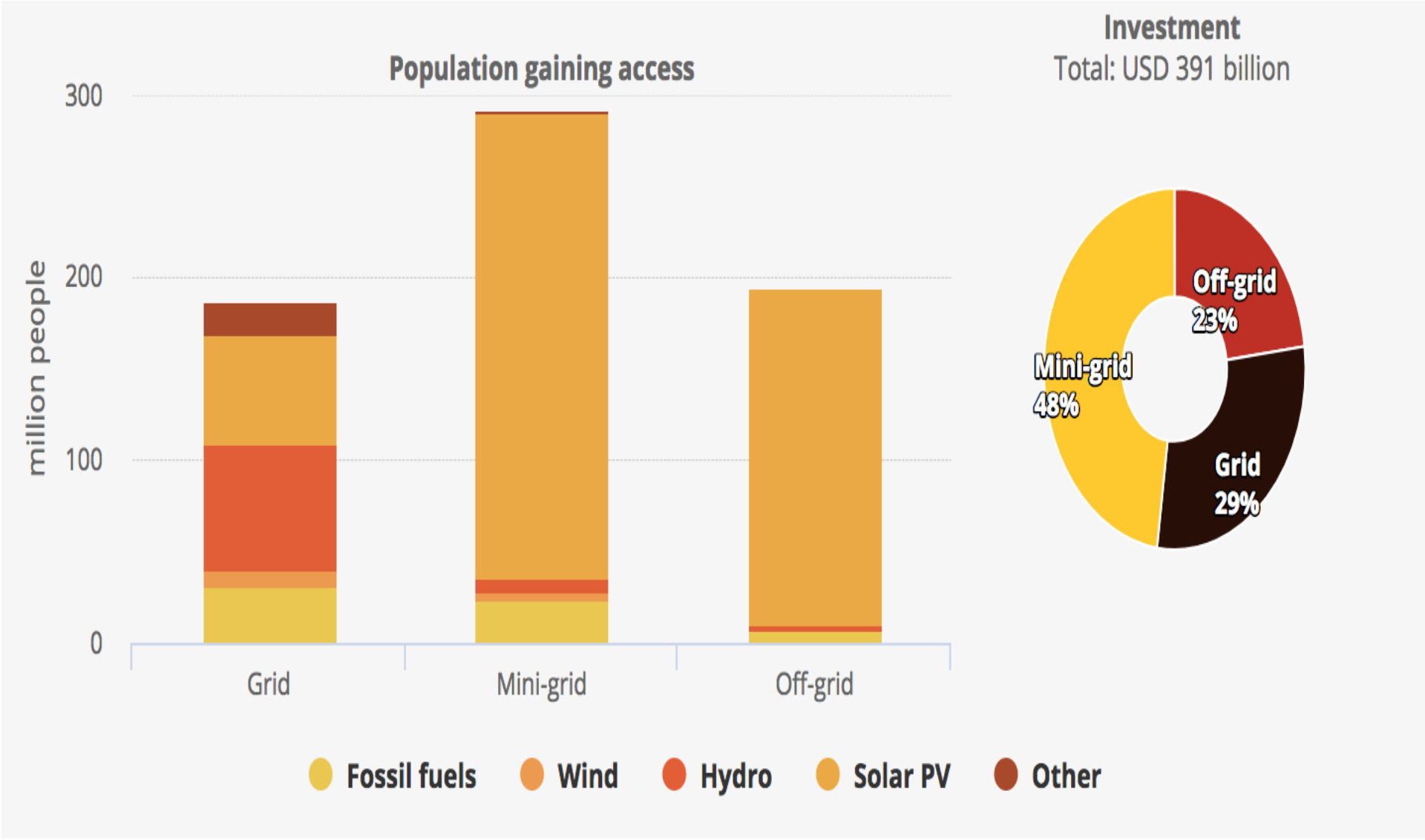
Minigrids

National Grid

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	No electricity	1-50W	50-500W	500-2000W	>2000W	
Duration	<4hrs	4-8hrs		8-16hrs	16-22hrs	>22hrs
Reliability	Unscheduled outages				No unscheduled outages	
Quality	Low quality			Good quality		
Affordability	Not affordable			Affordable		
Legality	Not legal			Legal		
Health & Safety	Not convenient				Convenient	

Source: ESMAP: A New Multi-Tier Approach to Measuring Energy Access, 2014

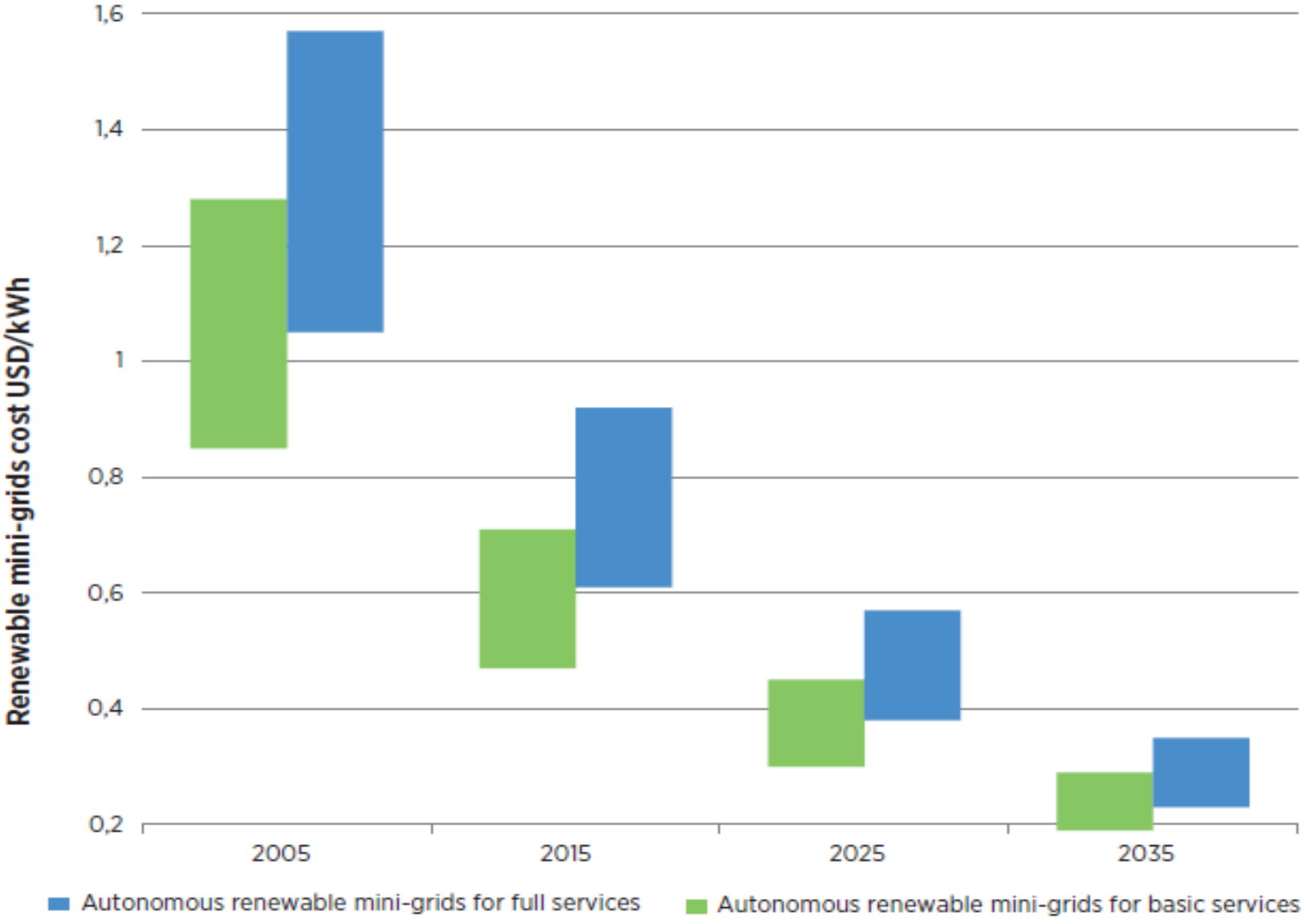
Providing Electricity to All by 2030



Energy Access Outlook 2017, IEA

Enabling Technology Innovation

Unsubsidised cost ranges for renewable mini-grids from 2005 to 2035 for a 100% renewable energy community system

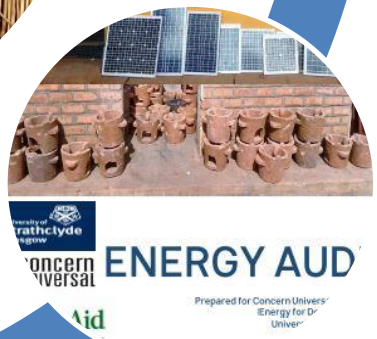


Energy access is not just a technical challenge

Ecosystem: a complex network or interconnected system.

Research and Innovation

Capacity Building



Consultancy

- Small core group of researchers (3 or 4 members)
  - Work on renewable energy projects (mainly in Malawi)
    - (some other countries in Sub-Saharan Africa and beyond)

- Work mainly around sustainable off-grid energy access:
  - Energy projects and research with local partners (inc. advocacy, implementation)

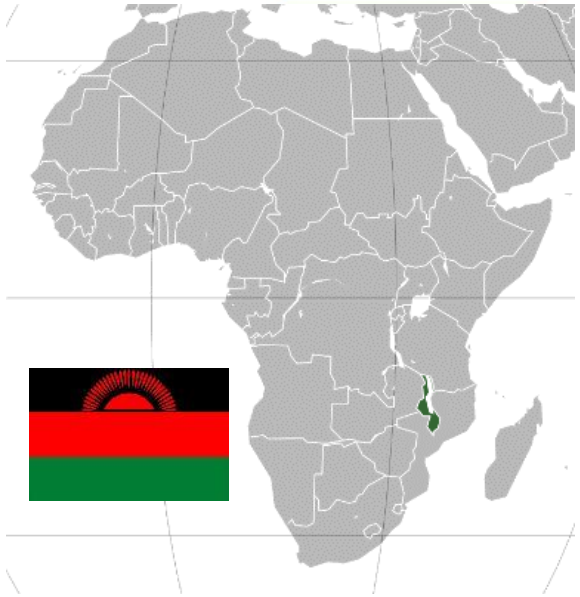
- Key partner is Community Energy Malawi (Malawian-run social enterprise which UoS helped to found approx. 10 years ago)
  - Also United Purpose and Malawi's universities (Mzuzu, Polytechnic and Washted)

…Welcome to Malawi

University of Strathclyde Engineering

Energy access in Malawi

- Malawi is one of the poorest countries in the world
  - Largely agrarian population living in rural areas: 83%
- Access to electricity is low: 11%
  - As little as 1% in rural areas (46% urban)
- Most household energy use is biomass for cooking:
  - charcoal (urban and peri-urban)
  - firewood (rural)
- Severe deforestation problem
  - Largely from rural charcoal production for urban cooking
  - All forest reserves may be depleted within the next 10 years
  - Also contributes to crop loss and droughts
- Lighting is largely from non-rechargeable batteries and candles



<u>Overall figures (United Nations):</u>

Population: 18.6 million

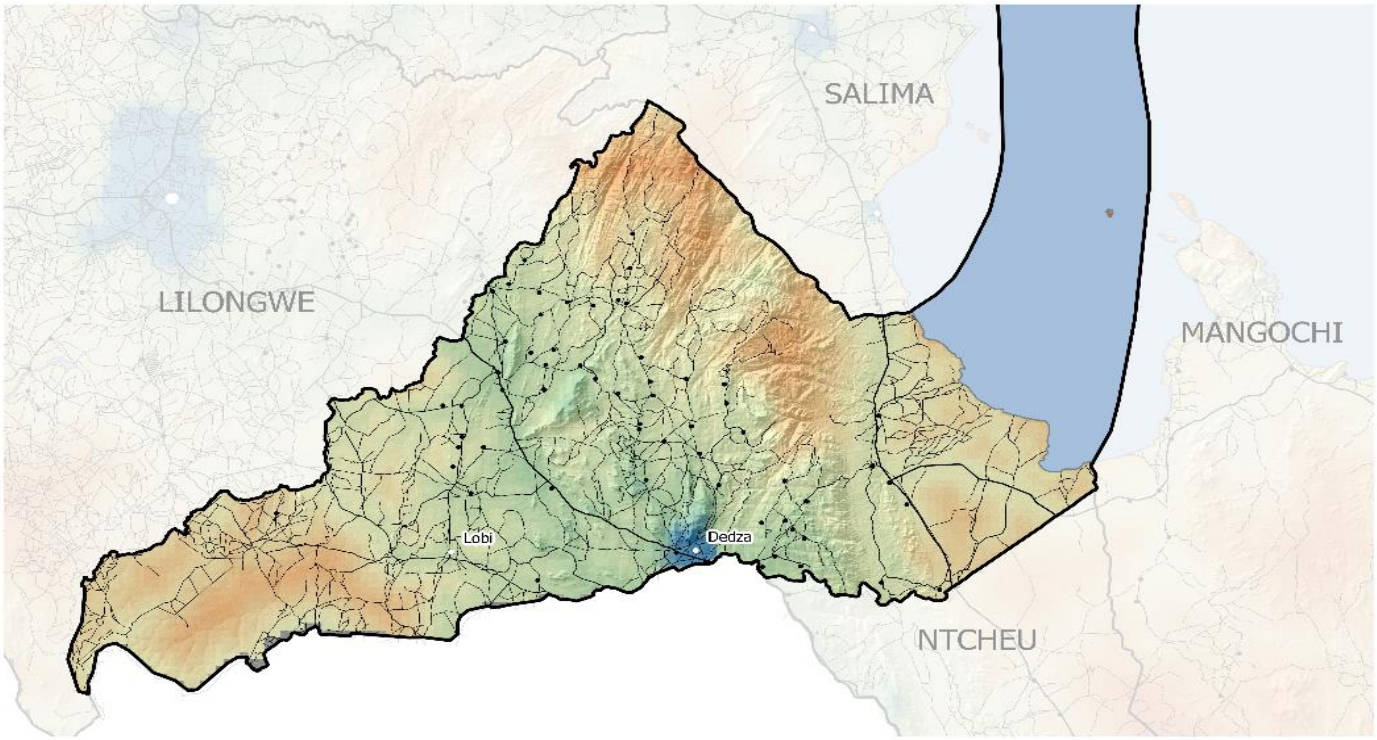
GDP rank: 146/192 (UN)

GDP per capita rank: 191/192 (UN)

HDI rank: 172/189 (UN)

Snapshot: Dedza District

Poverty Levels in Dedza

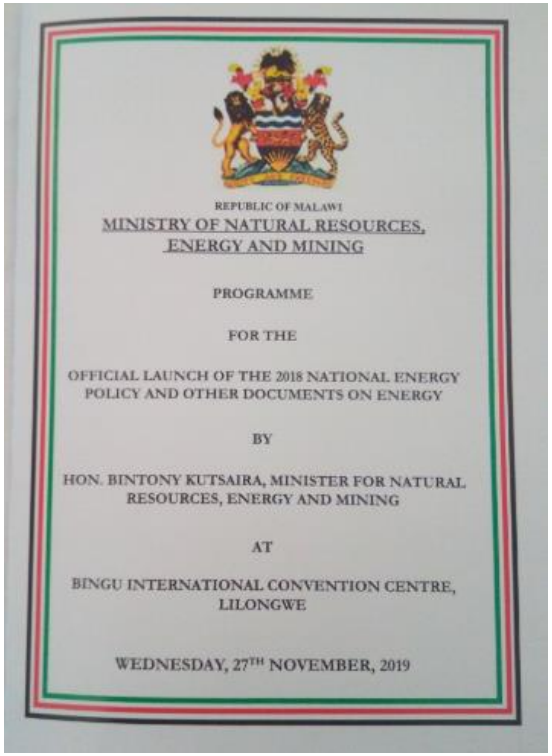


- Poverty levels range between 70% - 99% of the population living under $2/day
- Low life expectancy (45.4 yrs) and very high fertility rate (5.8 children).
- Main challenges affecting communities in Dedza include lack of capital to start businesses, drinking water, infrastructure, and availability/affordability of agricultural inputs.

Electricity in Malawi

- Electricity generation capacity: 439 MW
  - European country with similar population: 26,620 MW (Netherlands)
- Demand is far higher than supply, hence frequent blackouts
- Supply (as much as 98%) comes from hydroelectric generation (Shire river fed by Lake Malawi)
  - Inconsistent rainfall reduces already insufficient generation capacity (sometimes to as little as 50%)
- Slowly increasing presence of solar
  - Difficulties with sub-standard products
  - Cost and longevity of batteries

- Since 2000, Malawi's government has devolved powers to district councils/councillors
  - District Officers for: Health, Education, Agriculture etc
- Energy has remained a centrally governed sector focussed almost exclusively on extension of the grid
  - Progress has been slow
  - Generation capacity is not keeping up with population growth
  - Grid extension often politicised
- New National Energy Policy and Renewable Energy Strategy
  - Recognising the need to diversify electricity strategy
  - Loosening of government grip on energy production (IPPs)
  - Understanding the importance of energy within district planning and creation of District Energy Officers
    - More about this later…



REPUBLIC OF MALAWI

MINISTRY OF NATURAL RESOURCES, ENERGY AND MINING

PROGRAMME

FOR THE

OFFICIAL LAUNCH OF THE 2018 NATIONAL ENERGY POLICY AND OTHER DOCUMENTS ON ENERGY

BY

HON. BINTONY KUTSAIRA, MINISTER FOR NATURAL RESOURCES, ENERGY AND MINING

AT

BINGU INTERNATIONAL CONVENTION CENTRE, LILONGWE

WEDNESDAY, 27TH NOVEMBER, 2019

E4D Past projects in Malawi

- **2008 – 2015: CRED -> MREAP**

(Community Rural Electrification and Development) -> (Malawi Renewable Energy Acceleration Programme)

  - Community energy systems - 50+ solar systems in schools and health posts
  - Capacity building - energy committees, training, policy support
  - Distribution of solar products

- **2015 – 2018: SOGERV** (Sustainable Off-Grid Electrification of Rural Villages)
  - Community energy supply businesses established (kiosks)
  - Business model research and development towards appropriate delivery models
  - Continued study of the social impacts of electricity access and sustainability of services

- **Lessons learned**
  - Energy access positively impacts rural communities in Malawi
  - There is a desire and market for energy products of all sizes in rural areas but up-front cost is a significant barrier to systems beyond those which are small and low powered
  - Engagement, training and ownership within communities is essential to providing energy
  - Implementing delivery models which lead to sustained energy services beyond donor-funding for capital and maintenance are a key challenges which need further study


CAMP LAKE
50 miles
2018
CHIPPEWA TRIATHLON

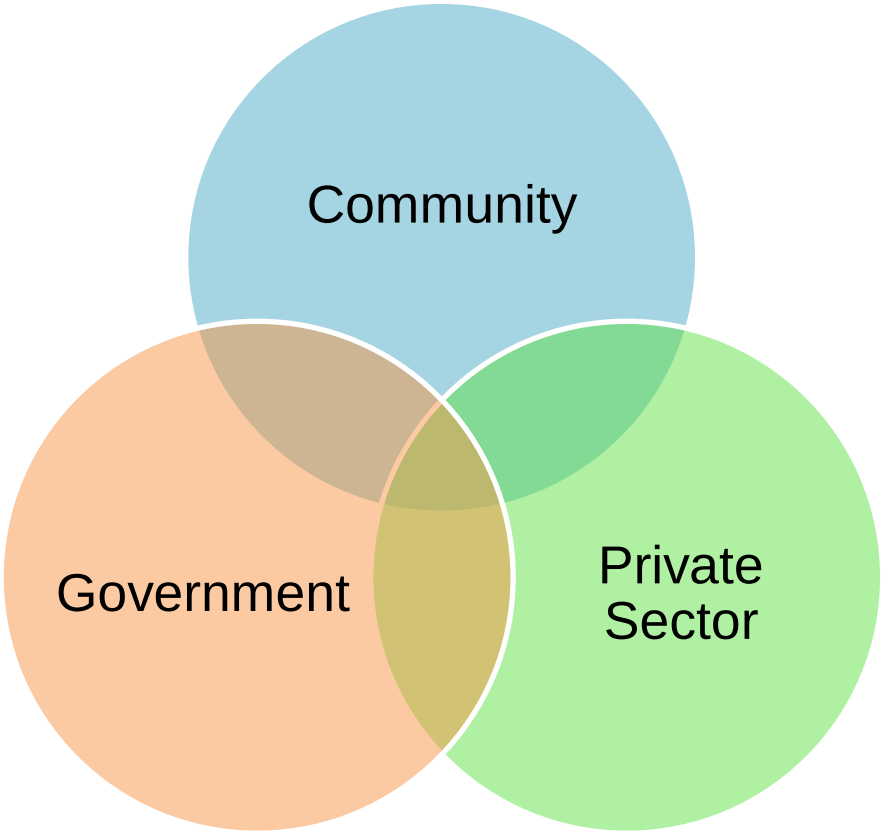

WALLET

Energy Delivery Models

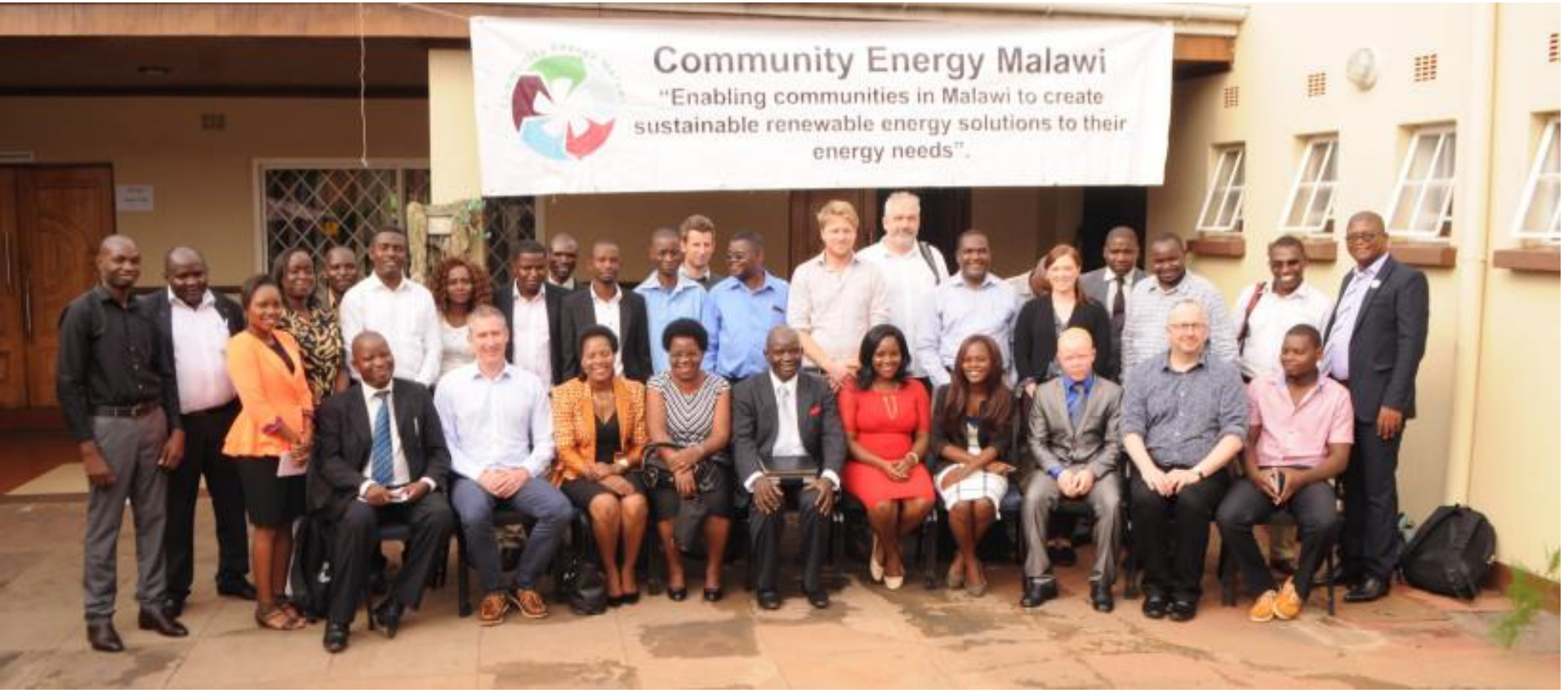
University of Strathclyde Engineering

"The concept of the 'energy delivery model' has emerged to describe a core set of activities and actors that constitute an energy service required to make energy infrastructure sustainable "

B. Garside and S. Wykes, "The energy delivery model toolkit," 2017.

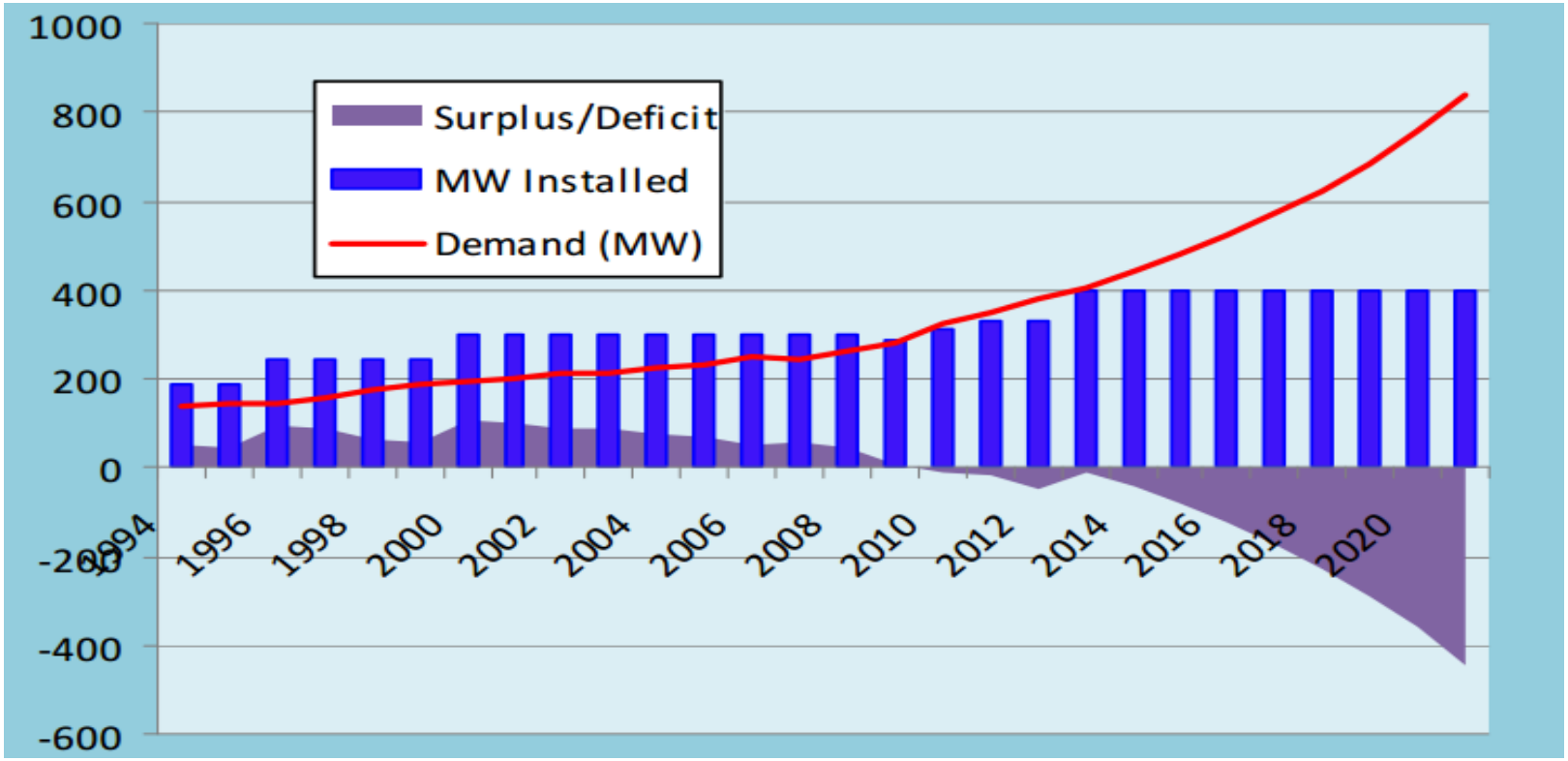


Government Case Study: Piloting District Energy Officers with CEM



Government of Malawi Rural Electrification Strategy

- Primary focus on grid extension
- Energy demand exceeds supply, with deficit expected to increase exponentially



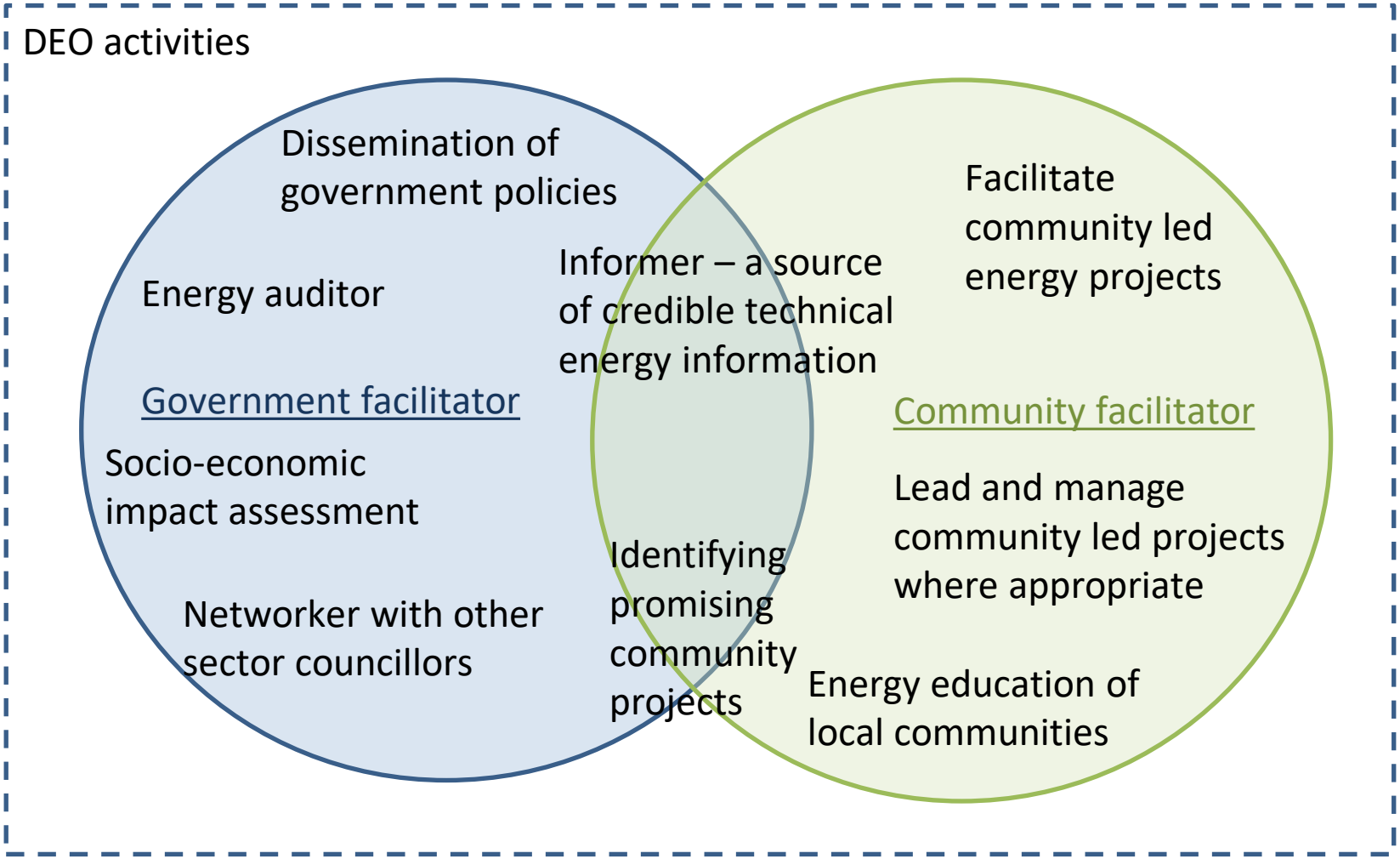
- Community-based decentralised energy projects now a key development priority of the Government of Malawi energy policies

Energy Policy in Malawi

- Energy policy in Malawi has evolved significantly in recent years, culminating in the recent formal launch of a new National Energy Policy and the Malawi Renewable Energy Strategy
- Both documents recognise the need to think beyond grid connections, embracing the abundant renewable resources and integrating energy to the decentralised planning process
- In parallel with this policy evolution Community Energy Malawi have been advocating for decentralisation of energy policy implementation

District Energy Officers (DEO)

- The Government of Malawi implementing a DEO role to support energy sector decentralisation
- Expected in all 28 Malawi districts by 2022



Piloting District Energy Officers

Background

- DEO pilot in 2 districts 2017 - 2022
- Community Energy Malawi and University of Strathclyde, funded by Scottish Government

COMMUNITY ENERGY MALAWI

Scottish Government
Riaghaltas na h-Alba
gov.scot

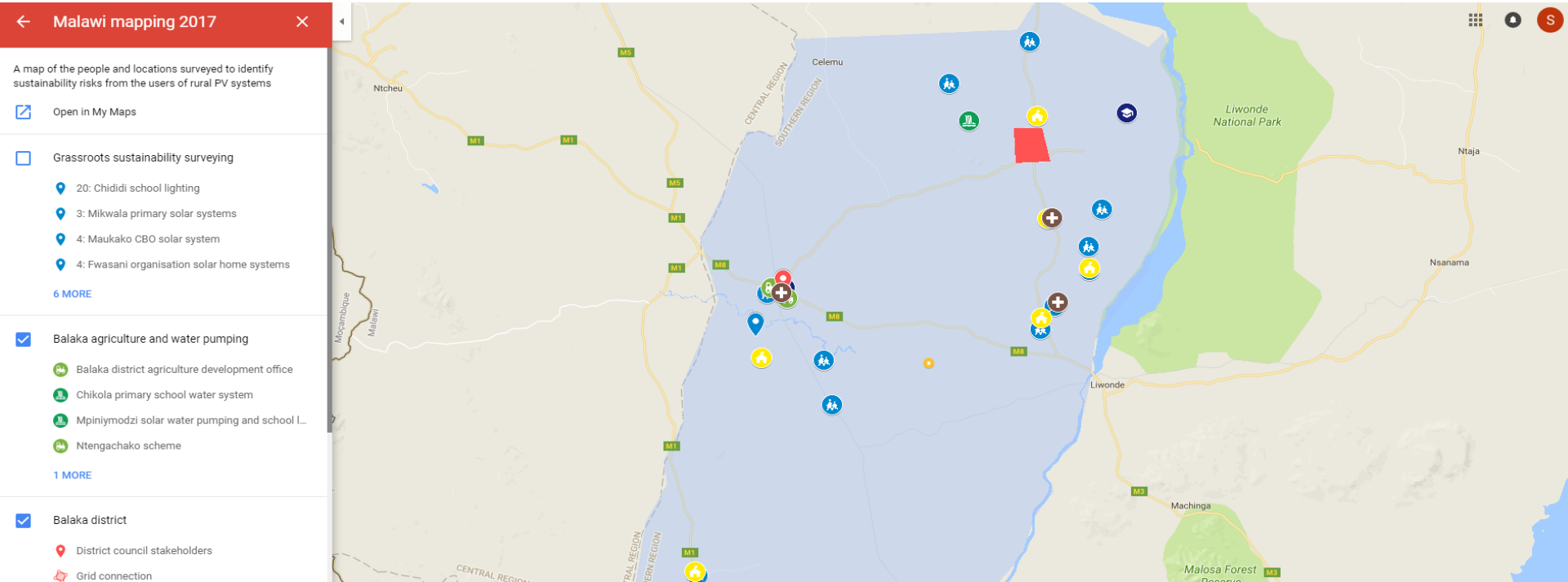
Key Activities

- Work with the existing district structure and extension workers to advice on energy issues
- Targeted district training for high impact energy information dissemination
- Record challenges faced by the communities on energy issues
- Identify, support and develop promising community energy projects

Piloting DEO: Energyscaping

Mapping existing and potential energy projects and demand

- The use of mobile data collection effective way to capture and ‘heat map’ district energy activity
- Targeting information dissemination to local and national government decision makers and allowing tracking of SDG7 progress.



Piloting DEO: Increased Awareness

- Evidence that ‘energy awareness’ of community members and decision makers at the district level has significantly increased when compared to the pre-DEO era.

- Increase in knowledge has unveiled a proliferation of sub-standard energy products in local markets, leading to calls for more regulations and standards for energy product quality control.

Private Sector Case Study: Solar PV Microgrid

What is a Solar PV Microgrid?

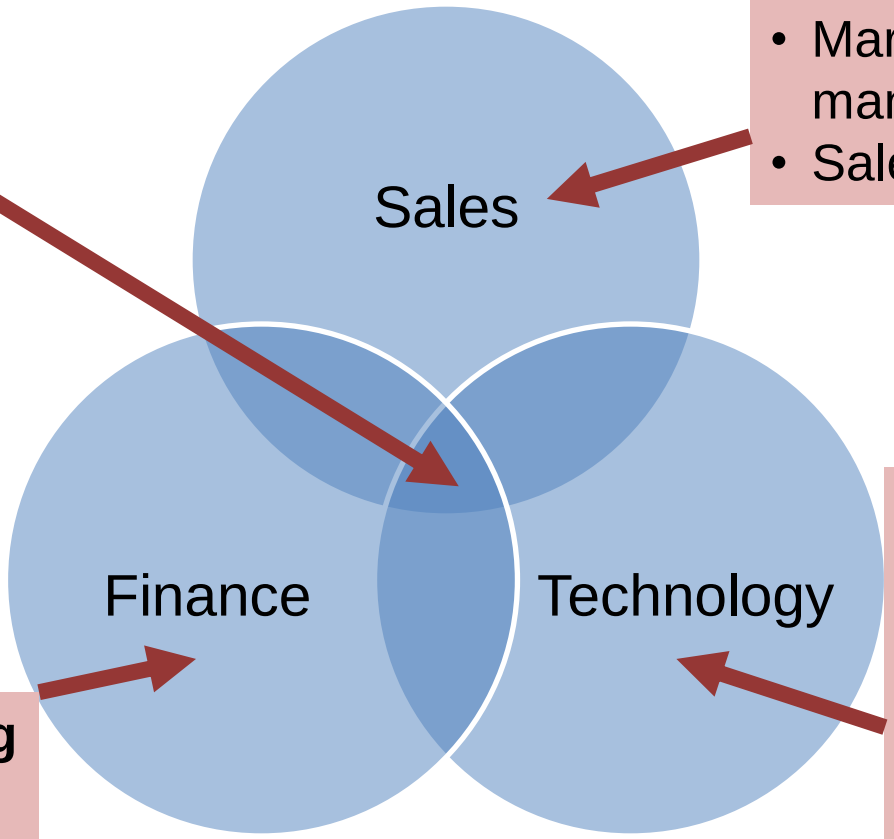
"Mini-grids, microgrids and nanogrids, are defined as a set of electricity generators and energy storage systems interconnected to a distribution network supplying electricity to a localised group of customers"

IEEE, 2018

Key Aspects of a Mini-grid Business Model

Education
- Sensitivity and Awareness
- Productive use
- Capacity building

Marketing of Power
- Tariff design
- Marketing management
- Sales and Billing

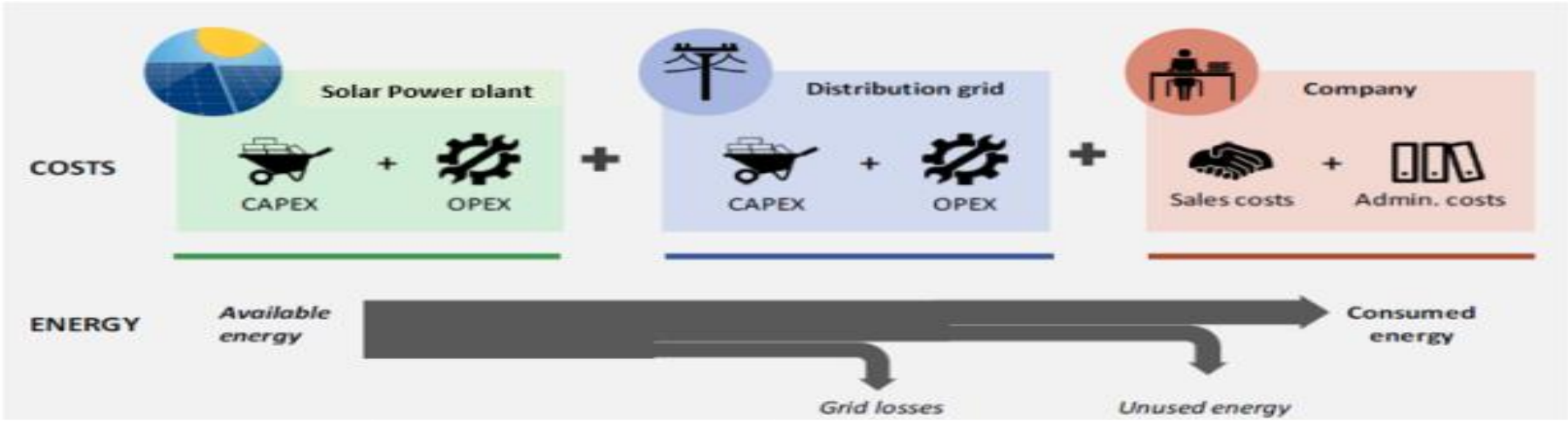


Financial Controlling
- Accounting
- Budgeting
- Cost/result controlling

Production of Power
- Operation management
- Maintenance and repair
- Procurement (parts, fuel)

Successful minigrid schemes taking into account local economic, social and environmental conditions

Tariff Setting and Ability to Pay



	Small Grid (2.5kWp)	Medium Grid (4.5kWp)	Large Grid (10kWp)
CAPEX per customer	$895	$976	$1,208
Annual OPEX	$2,060	$3,863	$6,215
Initial Cost Reflective Tariff	$2.03/kWh	$1.56/kWh	$1.22/kWh

Description of indicator	USD
Household monthly energy spend (from surveys)	$5.11
Monthly spend on dry cell batteries plus phone charging	$3.12
"What would you be willing to pay per month for lighting and phone charging in your house?" 15% subtracted	$6.77

Business Canvas

Key Partners
- United Purpose
- University of Strathclyde
- Malawian government
- Suppliers
- Local community leaders
- Donors / impact investors
- Universities

Key Activities
- Providing electricity for domestic and businesses
- Maintaining electrical system
- Monitoring and evaluation: energy use, cash flow, and social impact

Key Resources

Physical
- Microgrid generation and distribution, metering, tools, equipment, transport

Intellectual & Technical
- System design, installation, monitoring and maintenance

Human
- Management, technicians, partners:

Financial
- Capital funding for equipment and installation

Value Proposition
- Safe, affordable and secure source of energy for the local population
- Sustainably provide access to modern energy products and services
- Increased productivity of local businesses
- Create jobs and reduce poverty
- Local economic development
- Improve health at household level
- Business development support and training

Customer Relationships
- Customer sensitisation
- PUE training
- Locally employed site technician and vendor

Channels
- Establish distribution channels through Rural Energy System
- Direct marketing
- Website
- Communication with maintenance workers and managers on the ground

Customer Segments

Household
- Low Income
- High Income

Businesses
- Barbershop and Phone Charging
- Grocery shops with and without refrigeration
- Video Show

Cost Structure
- Capital Expenditure: development and instalment costs
- Operation, maintenance and metering costs
- Vehicles and transport
- Wages / salaries, training
- Insurance, Licensing, accountancy, legal, marketing

Revenue Streams
- Fees for electricity service delivery
- Connection fees
- Sales of products and technologies
- Funding for CAPEX

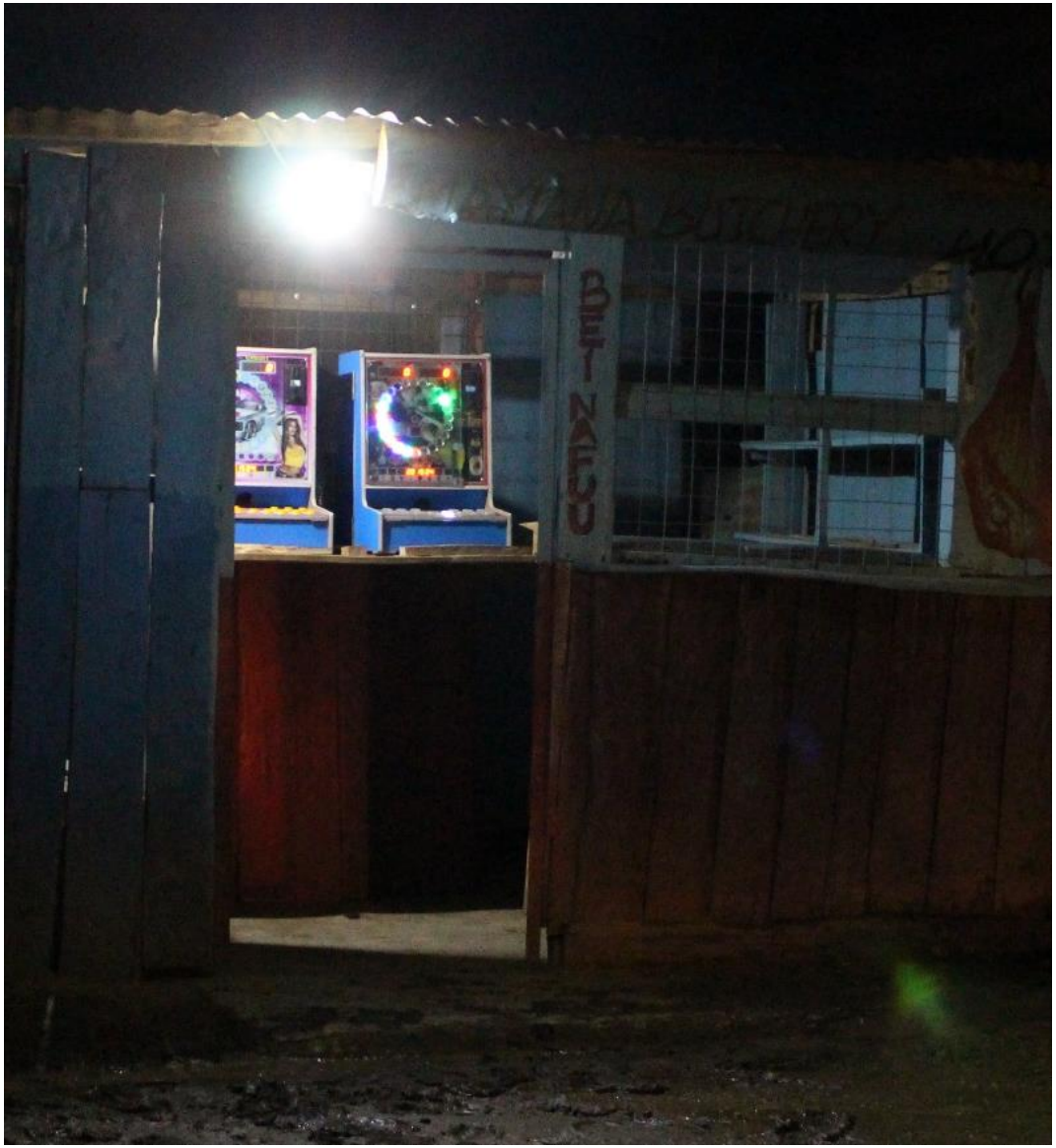
What is a Social Enterprise?

Social enterprises are businesses that:

- Have a clear social and/or environmental mission
- Generate the majority of their income through trade
- Reinvest the majority of their profits
- Are autonomous of the state
- Are majority controlled in the interests of the social mission
- Are accountable and transparent

Social Enterprise UK, 2019

Electricity changes lives…



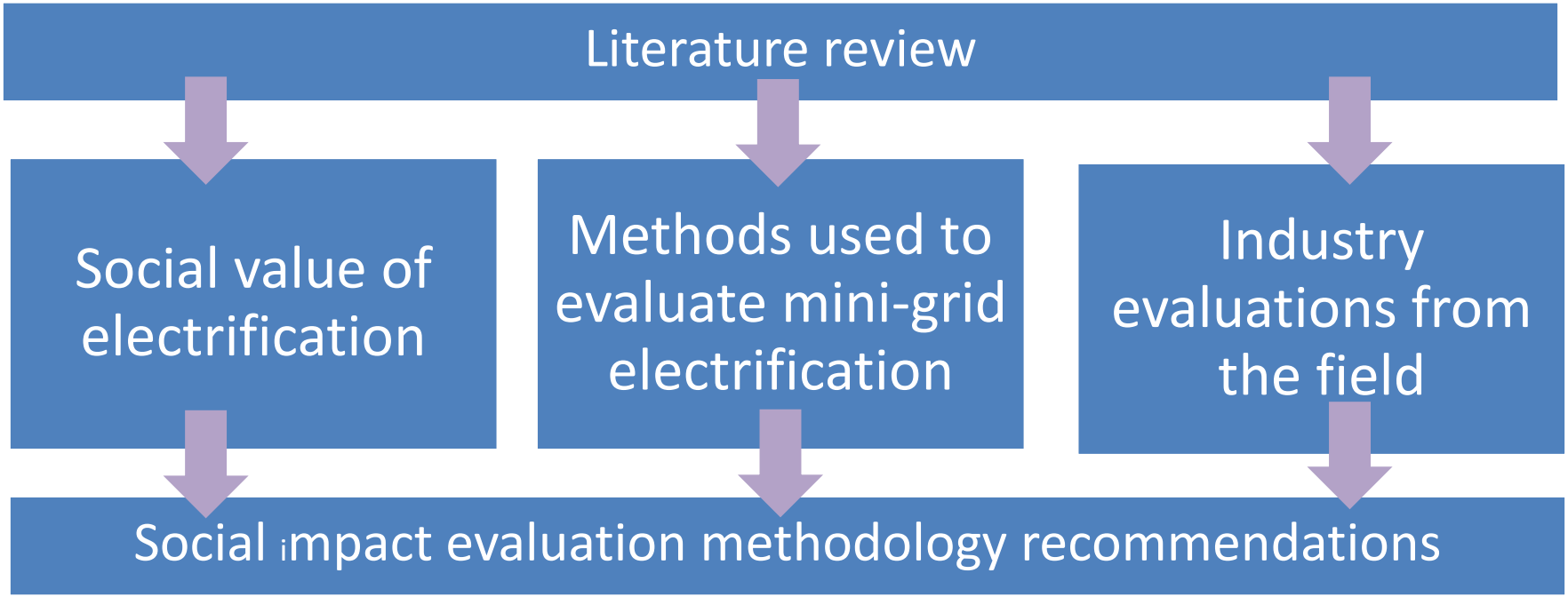
A reliable microgrid customer in East Africa

Social Impacts of Minigrids

- SE4All and SDGs: Energy Access for All
  - How is electricity used?
  - What is the impact and development outcomes?

- Lack of understanding of the real social impacts of mini-grids on the community they serve, due in part to the cost of collecting data.

- Identified need to quantify the holistic impact of mini-grids within context of SDGs, particularly with regards to anticipated impacts at design stage.



Longitudinal Impact Evaluation of Rural Electrification in Africa (LIEREA)

University of Strathclyde Engineering

Partners:

MZUZU UNIVERSITY
SELF RELIANCE SERVICE PERFECTION

Strathmore University
Energy Research Centre

KCRC
Kigali Collaborative Research Center

Outputs:

- **A robust research proposal** for conducting a longitudinal study of electrification impact in Malawi, Kenya, and Rwanda, ready for submission to GCRF and other large funding opportunities.
- **A network of energy experts** built and enhanced for partner research institutes, sharing current research and fostering new ideas and frameworks for collaboration in the energy impact space.
- **Capacity building and knowledge exchange** developed, specifically on multi-disciplinary bid development, research methods for impact evaluation, and building strong evidence bases.

Case Study: Productive Uses of Energy

- "Agricultural, commercial and industrial activities involving energy services as a direct input to the production of goods or provision of services."
  - Range of scales - shop lighting systems/phone charging up to agricultural processes
  - Not limited to renewable energy, some use diesel energy, minigrid energy and others
- Objective – to maximise impact of energy access and address financial sustainability challenges
- UoS implemented 8 pilot PUE systems in a rural area of Malawi – partnered by CEM
  - 4 shop lighting, 1 barbershop, 1 TV show, 1 refrigeration and 1 irrigation

Shop lighting in cafe

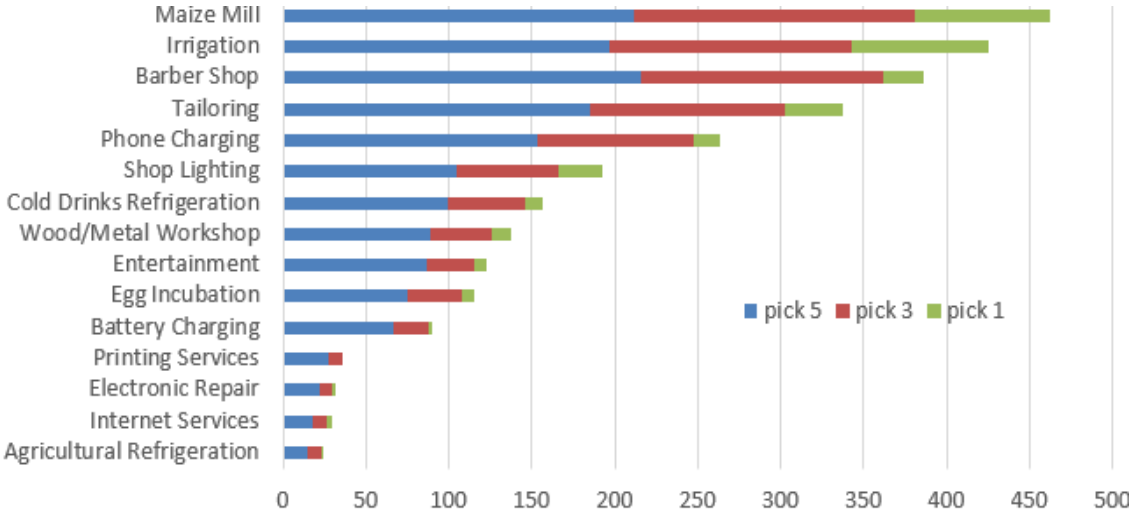
Barbershop and phone charging business

PUE - methodology

Feasibility Studies – Dedza District 2017-18

- CAPEX, OPEX, Income, Load profiles
- Socio-economic data
- Ability and willingness to pay
- Local need and desirability of businesses

→ Pilot projects → Recommendations



Popularity of different potential PUE systems

Interview with local resident

Pay As You Go Business Energy (PAYG-BE)

- Initial financial models created to spread system cost over a 18-36 month period
  - Systems comprised of solar panel, battery and electrical components
- Businesses agreed to repayment terms through written contracts
- Repayments collected via mobile money
- Electricity use and income/expenditure data collected to inform CEM business strategy

Product	Deposit	Loan Amount	Monthly Payment	Term (months)
Refrigeration	$63	$2,414	$49	36
Barber & Phone Charging	$21	$605	$34	18
Shop Lighting	$13	$227	$13	18
Irrigation	$56	$2,268	$63	36
TV show	$42	$1,837	$49	36

PUE – findings

- Successfully collected repayments from 6/8 customers
  - All shop lighting systems completely paid off (lower system cost)
  - Refrigeration and barbershop continue to make regular payments and are around 50% paid off
  - Mobile money is a useful tool for managing repayment collection remotely but field visits still needed
- Difficulties faced with irrigation and TV show system owners
  - Irrigation – seasonality of agricultural income lead to an unwillingness to make repayments
  - TV show – abuse of the system lead to poor performance and failure of components
- To be a viable business, over 100 small systems of this type would need to be deployed
  - Fewer larger systems may be more viable (e.g. agricultural uses – maize milling, egg incubation, large scale cold storage) – **to be the subject of future research pilots**
- Other issues are access to local finance for up-front capital and spread of sub-standard products

Village location and PUE system owner's shop (yellow – left image) and owner with refrigeration unit (right)

- “rapidly accelerate the transition from biomass to clean cooking on a global scale”

- 5 year project funded by DFID
  - Global scope with budget of over $60 million

- Involves several UK universities, and is multidisciplinary
  - For example, engineers, geographers, anthropologists, and economists

- Mainly involves trying to increase the market of efficient, electric cooking devices (eCook) and LPG

- Malawi is a priority country largely due to deforestation risk mentioned earlier

- Market assessment activities have sought to define the state of cooking in Malawi and provide a foundation for future activities
  - Surveys, cooking diaries, focus groups and interviews with a range of stakeholders

- Initial findings
  - The use of modern cooking fuels is almost non-existent in Malawi
    - Unreliable grid electricity
    - Myths around LPG
    - Up-front costs too high for many
  - Policy is lacking to encourage uptake
  - Work needed to discover the viability of low-powered cooking devices which are more suitable for battery-powered use (off and on-grid)

Next Steps

- Rural Energy Access through Social Enterprise and Decentralisation (EASE)
  - £1.3m Scottish Government Funded Rural Electrification Project
- Microgrid Social Enterprise
  - Installation and setting up a business
- Productive Uses of Energy
  - Research and strategies for scale up
- Energy Policy Advocacy
  - District Energy Officers
- Modern Energy Cooking Systems
  - Pilot projects in Malawi

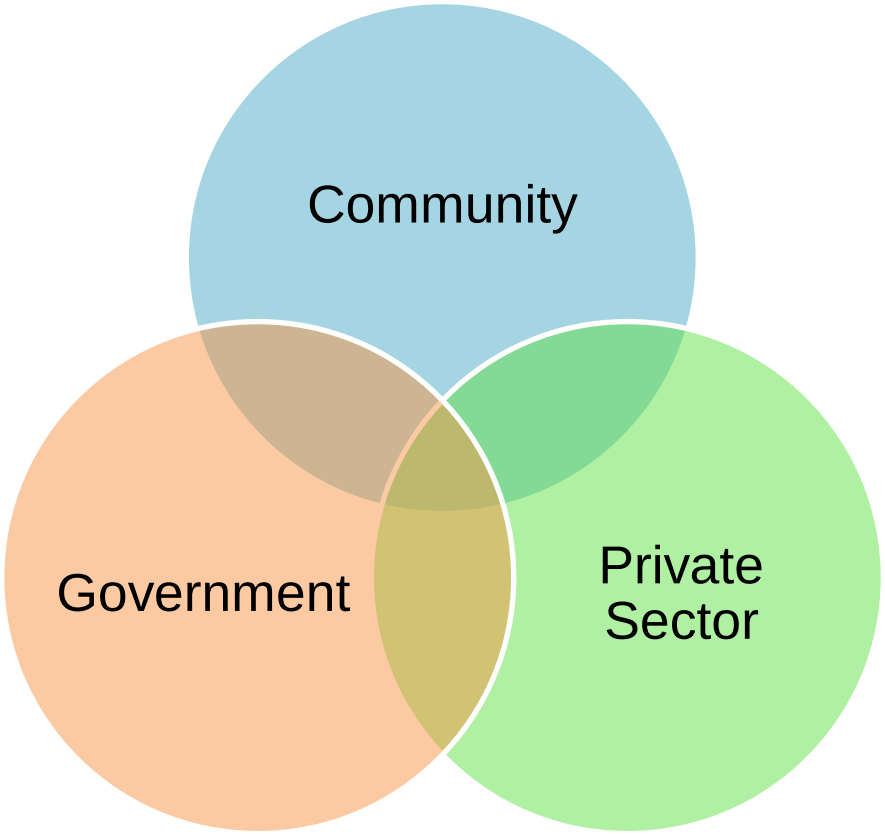
- Research and Knowledge Exchange towards sustainable universal energy access

Summary

- Lack of sustainable energy access reduces community resilience and is a barrier to economic development
- Case study data has highlighted where progress is being made and where key challenges lie:
  - Effective government energy policy needs efficient mechanisms for implementation
  - Sustainability of energy systems requires robust economic planning
  - Technical innovation aids and accelerates energy interventions
- Multifaceted challenges present a wealth of opportunities for multidisciplinary research

University of
Strathclyde
Glasgow

Discussion



What role does each of the above have in promoting and implementing sustainable energy access in developing countries?