Renewable Energy Solutions for Rural Zambia
Workshop Report
University of Zambia, Lusaka, Zambia

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https://www.smithschool.ox.ac.uk/research/rise-renewable-energy-innovation-scale
Abbreviations and Acronyms

ERC - Energy Research Centre
SEC - Solar Energy Centre
SSEE - Smith School of Enterprise and the Environment
RISE - Renewable Innovation and Scalable Electrification
GCRF - Global Challenges Research Fund
UNZA - University of Zambia
UCT - University of Cape Town
CBU - Copperbelt University
KNU - Kwame Nkrumah University
MU - Mulungushi University
NSTC - National Science and Technology Council
EERG - Energy and Environment Research Group
ZESCO - Zambia Electricity Supply Corporation Limited
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Introduction

An Interdisciplinary Workshop on Renewable Energy Solutions for Rural Zambia was held on November 5th, 2019 at the University of Zambia. This workshop was jointly organized by the Solar Energy Centre (SEC) in the Department of Physics, University of Zambia in collaboration with the Energy Research Centre (ERC), University of Cape Town and the Smith School of Enterprise and Environment (SSEE), University of Oxford (UK).

The theme of the workshop “Rural electrification in Zambia - Interdisciplinary research approaches & findings” reflected on interdisciplinary research approaches focusing on the question of how to enhance the low levels of access to electricity in rural areas of Zambia and across sub-Saharan Africa. In rural Zambia, this figure stood at about 5%. Sparse population, long distances, high poverty levels, low affordability, and low consumption/loads were some of the challenges attributed to impediment of efforts towards the provision of rural electrification in a sustainable manner. The workshop was attended by 46 stakeholders including senior academics, research staff, students from six Universities, external partners from the media as well as private and public sector organisations and a representative from the Zambian National Science and Technology Council (NSTC). It aimed at converging academics with different areas of specialisation with a view to sharing ideas, research methodologies and findings on rural electrification in Zambia.

The six universities represented were:

- University of Zambia (UNZA),
- University of Cape Town (UCT),
- University of Oxford (OxU),
- Copperbelt University (CBU),
- Mulungushi University (MU),
- Kwame Nkrumah University (KNU).

The workshop was officiated by the Acting Vice Chancellor of the University of Zambia, Dr. Michael MULENGA (The substantive Dean, School of Engineering).

Acknowledgements

The workshop was organized under the Renewable Innovation and Scalable Electrification (RISE) project. Authors would like to thank the Economic and Social Research Council (ESRC) of UK for the financial support through the Global Challenges Research Fund (GCRF).
Opening Speech

The importance of research in sustainable electrification in Zambia

Dr. Michael MULENGA
Acting Vice Chancellor, University of Zambia

The scientific and industrial revolution of past centuries has led to higher standards of living in many countries. However, our life styles, growing population and industrialization are upsetting the natural balance of the earth and damaging its life support systems and leading, in part, to global climate change. The use of renewable sources of energy, including solar, wind, biogas, hydro, tidal and geothermal technologies, in place of fossil fuels has emerged as the most powerful way to mitigate climate change.

In Zambia, hydroelectric power remains the dominant form of renewable energy. The country’s population has increased, resulting in increased energy demands. The low-rainfall patterns have resulted in continued national electric energy deficit. Scheduled power outages, which last up to 15hrs per day, have had negative impacts on homes, business and the economy at large. The inadequate electricity supply has resulted in an increase in the demand for charcoal at household levels. This in turn has resulted in an increased level of deforestation in various parts of the country. It is necessary to have a convergence of academics with different specialisations for purposes of sharing ideas, research methodologies and findings on rural electrification in Zambia. This should involve managing the Earth’s resources without depleting them for good – a concept referred to as “sustainable development”.

This workshop involves participants from the (i) University of Zambia, (ii) University of Oxford, (iii) University of Cape Town, (iv) Copperbelt University, (v) Mulungushi University and (vi) Kwame Nkrumah University.

It is my hope that this interdisciplinary academic workshop (involving staff and a few students) will allow for a synthesis of ideas with a view to contributing towards the development of good country policies, entrepreneurial savvy and behavioural changes.

Finally, it is my hope that this kind of collaborative workshops will continue for the betterment of the renewable energy sector in Zambia, and the continent at large.
1. The research partnership on rural electrification in Zambia: background and objectives

Professor Prem JAIN (UNESCO Chair in Renewable Energy and Environment Solar Energy centre, Department of Physics, University of Zambia, Lusaka, Zambia)

Access to electricity is the backbone for economic and social development. There is a dismally low rate (5-10%) of electrification in rural Zambia, a problem that exists in most African countries. Over 600m people in Africa (mostly in rural areas) have no access to electricity. The United Nations Sustainable Development Goal 7 (UN SDG 7) targets by 2030, to have affordable and clean energy, universal access to affordable, reliable and modern energy services. In pursuing SDG 7, Zambia’s strategy is to enhance energy access, especially in rural areas, to diversify its energy mix in a bid to reduce on green-house gas emissions as well as moving away from the dependency on hydro-power generated energy alone. With regard to rural electrification, governments and utilities have neither the resources nor surplus energy to extend the grid over long distances to remote areas. Off-grid energy systems are emerging as a viable option.

The Department of Physics at UNZA has been involved in solar energy and climate change for close to four decades. The Solar Energy Centre (SEC) which is mainly focused on providing a comprehensive range of support services to the emerging solar industry was launched on 22 November 2018. The SEC has established ties with the Smith School of Enterprise and the Environment (SSEE) at the University of Oxford, UK. The process was driven by Prof Prem Jain (UNZA) and Dr Susann Stritzke (OxU) as it was recognized that Rural Electrification, a global issue and a common thread, requires an interdisciplinary approach.

Following this collaboration, a Memorandum of Understanding (MoU) between the Solar Energy Centre, UNZA and Oxford University Smith School of Enterprise and the Environment was signed on 3rd September 2019.

The main goal of the collaboration is to develop interdisciplinary strategies for rural electrification in Zambia through solar energy specifically through the research project ‘RISE’ at SSEE in collaboration with the University of Cape Town (UCT). The three central goals of the workshop as an element of project RISE where the presentation of research findings on rural electrification, the discussion of interdisciplinary research approaches and the exchange between academics with different specialisations to share ideas, research methodologies and findings on rural electrification in Zambia.
2. Overview: The ‘RISE’ Project

Dr. Amos MADHLOPA (University of Cape Town, South Africa)

An international research team, led by Dr Aoife Brophy Haney from SSEE and Saïd Business School, was awarded funding from the Global Challenges Research Fund (GCRF) to investigate innovative solutions for promoting energy access in sub-Saharan Africa (SSA), through the Renewable, Innovative and Scalable Electrification (RISE) project from 1st September 2018 to 29th February 2020.

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced by the UK Government in late 2015 to support cutting-edge research that addresses the challenges faced by developing countries. GCRF forms part of the UK’s Official Development Assistance (ODA) commitment, which is monitored by the Organisation for Economic Cooperation and Development (OECD).

The interdisciplinary research project aims to design integrated, actionable and transferable development strategies for the local renewable energy sector in sub-Saharan Africa. The research pursues three mutually reinforcing areas of inquiry: suitable business models for a competitive local renewable electrification industry; optimal institutional arrangements to facilitate the development of the industry; and enabling community involvement, especially in rural areas. Two contrasting national case studies, Uganda and Zambia, form the basis of the project.

Sub-Saharan Africa is the most energy-deprived region in the world, with more than two-thirds of the population lacking access to electricity. Energy poverty is especially acute in rural areas, while high prices, unreliable supply, and slow adoption of renewable sources are persistent problems even for those with access to electricity. Thus, none of the three criteria for equal energy access — affordability, reliability and sustainability — as defined by the UN Sustainable Development Goals (SDGs) is yet close to being fulfilled. Energy poverty has impaired sub-Saharan Africa’s economic development for decades, yet these challenges will only worsen as the continent’s rural population growth outpaces capacity growth.

Given the sheer size of the African continent and low rates of urbanisation, large-scale electrical grids are both impractical and prohibitively expensive. Meanwhile, rapidly falling system costs have made renewable off-grid solutions the cheapest clean option in many remote areas. To date, however, three main issues have prevented sustainable electrification: difficulties in attracting international investment to small-scale renewables; inconsistent and often opaque regulatory and institutional frameworks; and a failure to include local communities, i.e. customers, in planning.

The project aims to understand how these three broad factors are interrelated and is deeply committed to delivering impact beyond academia. Key stakeholder groups from government, business, and civil society will be involved throughout all stages of the project. Integral to the success of the project will be translating the research findings into actionable development plans, including new renewable energy business models, financing and revenue schemes, and policy recommendations.
3. Energy access in rural Zambia: the community perspective

Dr. Bothwell BATIDZIRAI (University of Cape Town, South Africa)

This presentation focussed on findings of the RISE project Community engagement study with a view to sharing five key messages derived from undertaking the study in communities in Zambia and Uganda. The study undertook a novel community survey over a sample of 1016 respondents and elicited community views, perspectives, preferences, opinion on community electrification needs, interaction of community members with energy service providers as well as involvement in electrification planning and implementation. We identified 5 key messages as follows.

Key finding 2: There is tremendous unmet demand for electricity-enabled cooling, cooking and productive use, but severe challenges remain to unlock it

Challenges around electrification in communities, N=963

First, energy is key to improving the quality of life in rural Uganda and Zambia, but is not seen as a top-priority purchase. This is because there are other priority purchases such as education which imply limited ability to pay for modern energy services despite a high willingness to pay for electricity (~86%). There is recognition that electricity can transform lives and acknowledged by 90% of electrified respondents. Second, there is tremendous unmet demand for electricity-enabled cooling, cooking and productive use, but severe challenges remain to unlock it. Current main electricity uses are lighting, charging devices, and entertainment met by small systems. Current solutions are either far-away and often unreliable grid electricity or small-sized solar systems - often inadequate to meet community energy needs. The key challenge to access is the high electricity tariffs (~60%). However,
97% of respondents are willing to pay for electricity for productive uses across sectors. Other key community challenges with electrification include poor system reliability, limited access options, insufficient capacity to meet needs, poor service, technical problems, etc.

Third, potential for more productive use of energy exist across all income-generating activities, especially agricultural, small-scale industry, retail and services sectors. Currently only 15% use electricity for some form income-generating activity. It makes financial sense to use electricity for productive use at current tariffs as the value-add of 1 kWh can exceed 1 USD for different small businesses, especially in large untapped potential and strong desire to provide cooling services, hairdressing, sewing, cooking in restaurants, welding and gadget repairing. Fourth, despite various information channels that exist, end-users are not yet well-informed enough about their energy choices and face numerous challenges when interacting with energy businesses. Lack of information and knowledge is a key challenge of community interaction with energy providers and this is attributed to inadequate outreach and visibility by service providers and key energy institutions. Only 50% of respondents are aware of energy service providers operating in their localities and only 43% are satisfied with energy services. This highlights the importance of relationship building and communication between any new potential energy provider and the target community.

Fifth, communities desire greater inclusion in energy-related decision making using adequate and case-specific points of contact. Current community involvement in electrification projects is 30% but there is a high desire for stronger involvement in energy project processes. There is no one-size-fits-all for community engagement as there are no clear preferences on involvement methods. Community leaders and skilled community members can play a key role in facilitating the flow of information, and in mobilising resources. Thus there is need to identify individual community desires, to ensure adequate involvement through the relevant means. Communities could consider pro-active approaches of communicating their needs and initiating local level solutions following e.g. the Ghana community initiated electrification model. Links between the private sector, public institutions and communities need to be strengthened to support inclusive development. Also links between public sector and communities could benefit from enhanced community engagement, the inclusion of local representatives and the flow of information in both directions.

Sam SICHILALU and Esther T. AKINLABI (Department of Mechanical Engineering Science, Faculty of Engineering and the Built Environment, University of Johannesburg)

Energy scarcity has become a global challenge in the midst of climate change effects. In most African nations, there are rapid policy transformation with the help of donor funding that encourages diversification of its energy resources and development of distributed energy systems. These funding are mostly dedicated to renewable energy sector financing under matching grants or co-financing. This donor aid comes with an already packaged capacity building funding costed from the donor’s perspective rather than African. Therefore, this perspective mismatch in capacity building costings has led to massive developmental failures of renewable energy infrastructure, critical shortage of skilled human capital and system sustainability challenges.

The current financing model of renewable energy development is expected to continue registering failure projects in achieving energy-as-enabler for rural/urban development unless the capacity building financing model proposed in this paper is implemented. This paper empathizes capacity building as the key to success to the implementation of any renewable energy project whether on/o grid system. The proposed model provides realistic model of funding capacity building in all energy development and realities on the ground.
5. Challenges of solar energy utilisation in Zambia: a case study of Kitwe, Zambia

Prospery C. SIMPEMBA, Dickson CHEMBE and Inutu KATOTI (Copperbelt University, Zambia)

Zambia is currently facing a critical power deficit largely due to low rainfall and because of her dependence on hydroelectricity. Many Zambians have felt the impact of this power deficit and are looking for alternative energy sources for relief. We present here results of a case study of solar energy utilization in Kitwe, highlighting the opportunities and challenges in the application of this energy source.

It is evident that power stations in Zambia are reaching their lifespan and urgent need of replacement or retrofitting. Zambians recognise existing energy challenges, the need to diversify the energy mix and to tap into solar energy for lighting, water heating and small appliances.

Despite Zambia enjoying enough solar irradiancy, solar power utilisation has not received the much needed attention. In Kitwe, CEC has already implemented a 1MW solar power plant. Another 40 MW solar power plant has been constructed in Garneton area, Kitwe.

There are also some minigrid systems linked to milling. The common solar application in the area are home lighting, water pumping (Saro Agro supplies system), powering small electrical appliances (TVs, radios, phones, shaving machines, etc), water heating and drying. There are various brands of solar systems on the market.
Unlike hydro, utilisation of solar energy is not affected by droughts. There is also a desire for people to utilise solar technologies due to heavy load shedding in the country. There is need for appropriate policies to be in place to attract locals to participate in solar energy projects. Also research funding is required to study local materials for local production of solar panels.

### Hindrances of solar implementation

1. Lack of Technical Information - specifications, registered suppliers, installers etc.
2. Lack of favourable policies such as Feed-In-Tariffs (FITs), Renewable Portfolio Standards (RPS), Renewable Energy Certificates (RECs)
   - 2.1 Low-cost, long term financing
   - 2.2 Banks lacking loan facilities to finance solar systems
   - 2.3 Majority population cannot access personal loans
   - 2.4 Failure to implement existing policies
     - National Energy Policy – e.g.
3. Prohibitive initial costs for low income communities
4. Lack of skilled manpower in solar technology
5. Lack of local solar manufacturing industries and reliable services

### Recommendations

- Research on local materials for production of low cost solar panels (Requires funding)
- Training institution to intensify training of technical people in solar fields
- Energy sector and Universities to develop favourable policies to enhance independent power Producers (IPPs) and general utilisation of solar energy
- Create deliberate incentives for financing solar energy systems (that includes manufacturing locally)
6. Business models and institutional frameworks for successful electrification – findings & research approaches

Dr Susann STRITZKE, Dr Philipp TROTTER (Smith School of Enterprise and the Environment, University of Oxford, UK)

Energy access in rural Uganda and Zambia: mapping the challenges from the institutional and business perspectives

In many rural areas across SSA, renewable off-grid solutions are the cheapest and cleanest electrification option due to their abundance and rapidly falling system. At the same time, the rural electrification strategy for Zambia has shifted from a government-driven to a private sector-driven approach but off-grid energy businesses struggle to be financially viable, dramatically limiting their potential scale. Many complex and interrelated challenges on community-level such as low- and variable-income structures, reliance on traditional farming methods and low resilience to exogenic effects such as droughts negatively impact the long-term sustainability of off-grid solutions.

The profit of electrification
- Big investments require profitably and stable markets:
  - Large-scale electrification projects
  - Industrial and urban electrification
  - Growing economies, served by multi-national businesses

The problem of electrification
- Over 80% of unelectrified people in ACP countries live in rural areas:
  - Small-scale projects
  - Rural customers with weaker purchasing power
  - Economic challenges and limited local business development
  - Off-grid projects are expensive and economically risky

THE BIGGEST PROBLEM ISN’T WHERE THE PROFIT IS

In our research, we are finding that in order to address this challenge, mini-grid developers are designing innovative business models that go beyond delivering energy. Rather, their mission identifies them as integrated community developers who want to achieve energy-enabled development rather than mere energy access, viewing energy as nothing more and nothing less than a catalyst for development. They aim to increase revenues from not only selling kWhs but from
selling electricity-enabled productive goods and services. This increases the per-kWh value-add of the mini-grid and allows to cross-subsidise energy access in households, schools and health centres. The key learning lessons that can be derived from our research in the business model workstream are:

- To meet Uganda’s and Zambia’s goals, the off-grid market requires innovation
- The regulatory environment has a crucial influence on the business perspectives of off-grid developers.
- Policy needs to promote business model innovation – not hinder it
- A "Big Pull" approach as a solution to the frequently cited chicken-and-egg problem of electricity demand and economic development
- Innovative off-grid companies operationalise the “Big Pull” paradigm by re-defining their business models: the ‘Integrated Developer’ approach
- The ID business model is distinct from the current three existing business model types in the off-grid energy space, namely: Standard Retail (SR), Consumer Finance Retail (CFR), and Micro Utility (MU)

Research on the institutional perspective of sustainable electrification in Uganda and Zambia has revealed some gaps between rural electrification targets and underlying strategies to achieve these targets and a stakeholder mapping exercise has illustrated, that the involvement of local representatives in the national energy planning- and policy-making processes is yet very limited. The research findings for the institutional workstream of project RISE with regard to Zambia can be summarised as follows:

- Private sector & donor-driven programs can enhance no. of connections, but the picture is uneven with regard to productive use & regional distribution – government-driven strategic plans can complement private sector initiatives
- Greater coherence & integration of on- and off-grid planning can push rural electrification
- The clear definition of mandates and roles together with the development of integrated implementation plans can enhance the effective execution of national energy strategies
- Effective monitoring and evaluation can provide important learning lessons
- More community involvement in energy policy-making can lead to electrification approaches that capture the needs of the consumers
- Greater regulatory certainty for grid-encroachment reduces financial risks for MG developers
- Foreign Donors have increased their focus on off-grid solutions, enhancing coordinated efforts can reduce transaction costs and duplications of approaches
- Ministries of Energy and their affiliated agencies dedicated to rural electrification could take the driver’s seat in creating an integrated energy strategy
Assessing appropriate institutional and business models for successful electrification in SSA – research approaches

The research approach for the institutional analysis was comprised of four steps:

1. Formulation of the central research questions;
2. Development of the specific research approach was developed and based on an extensive literature review including selection of a deductive approach based on theoretical approaches of measuring and determining good governance;
3. Empirical research process including a Qualitative Document Analysis (QDA), a stakeholder mapping exercise and the design of semi-structured, qualitative stakeholder questionnaires.

The research of the business model workstream followed an inductive approach because there is little theory to explain the types of developments that are currently taking place in SSA related to business models for off-grid energy systems and these developments can indicate more general trends about business development in SSA particularly if it is possible to abstract general findings from specific observations. This meant that the overall aim of the research process at the beginning was to understand general developments in the RE markets or which types of companies were active.

During the research processes in both workstreams, the following challenges occurred, which were mitigated through a set of specific measures:

- Adapting research approach and at the same time staying focused: Initial focus on Zambia and Uganda but expanded interviews to other countries as the role of policy context emerged
- Iteration between data and theory: Because the process did not start with clear theoretical predictions, it was essential to keep an open mind and a clear process for going back and forth without getting too lost
- Deciding when to stop: It’s often difficult to know when the process has reached “theoretical saturation” – will one more interview or even one more country case help?
- Design of Questionnaires – Comprehensiveness vs Length: 3 Interview rounds – adjustment of questionnaires to findings and the research process necessary
- A broad range of stakeholders and views: remain critical, check facts, don't accept common knowledge.
7. Community level assessments: conducting community energy engagement and needs assessments

Dr. Bothwell BATIDZIRAI, (University of Cape Town, South Africa)

This presentation focussed on the experiences and lessons learnt during the RISE project Community engagement workstream with a view to sharing important highlights from methodology applied and outcomes derived from undertaking the study in communities in Zambia and Uganda. It focussed on three issues (a) Content of the community engagement (including research questions, questionnaire design, ethics, data management, etc.) (b) Process (of community engagement including how the survey was executed) (c) Outcomes (i.e. findings and impacts).

The community engagement study implemented a novel community survey to elicit views, perspectives, preferences, opinion on community electrification needs, interaction of community members with energy service providers as well as involvement in electrification planning and implementation. Our sample included both electrified and unelectrified households, businesses/entrepreneurs, and community leaders. This was designed to achieve gender, income and regional balance for a sample of 1016 respondents. The key research overarching question was: How can communities engage with and contribute to the development of sustainable electrification, especially in rural areas?

![Diagram of 7 Types of Response Bias in Surveys](image)

Nick Prins, 2019 [www.getfeedback.com](http://www.getfeedback.com)
The questionnaire design was done collectively by the RISE project team members, combining the three workstreams including business and institutional workstreams. This was to allow for integrated solutions to emerge from the community feedback. However, this resulted in a very long questionnaire—106 questions which contributed to fatigue during the interview. Translating the questionnaire into regional languages was also time consuming and requires expert quality control to ensure the sense is not lost. We used mainly structured questions to enable efficient questioning with a few open-ended questions to capture variety of answers. We avoided ranking questions, as these were considered difficult and time consuming, even though ranking would have been useful to show priority of needs and perceptions. Our pre-survey work included extensive literature review to identify gaps and framing assessment (including MIT Lab resources - which is a good resource for similar type of surveys). It was clear that deriving integrated solutions brings complexity but some improvements can be made, e.g. the questionnaire could be shortened to improve survey execution, questionnaire could be split by type of respondent and we could focus more on fewer but critical research questions. A shorter questionnaire with more open ended questions could provide wider variety of answers. We included relevant Ethics and data management code of conduct but we observed that Ethics are misunderstood by non-academic players. Thus there is need to educate other parties involved in the survey of the academic obligations to ethics e.g. offering gifts, protection of data, anonymising data to protect respondents, etc.

For executing the survey, we worked with partners embedded in communities as this allowed easier setting up of process, get support and navigating the protocol laden local community interactions. While enumerators can be trained – and it is important to tailor the training to the calibre of enumerators enrolled, there is however need for very professional enumerators – who can make split moment judgement to retain accuracy of responses. This avoids mechanical enumeration where illogical answers are captured without due diligence. Lower level enumerators require more targeted guidance. Training of such enumerators should be followed by a pilot for quality control and further refinement of training. During survey execution, there is need for continuous quality check on delivered questionnaires – to correct recurring common errors. Although this is still difficult in many rural parts of Africa, where there is connectivity, the use of mobile apps that upload completed questionnaires immediately can be useful.

There is also great need for managing expectations during process, as this feeds into responses and need careful communication. It is difficult to check how effective this communication is and how much bias is eliminated in the process.

For the analysis, we used the statistical software – Stata – to perform data analysis. Our results are contained at the moment as descriptive statistics in a Practitioner’s report. Further econometric analysis has been done and will lead to at least two scientific publications. The results are also expected to feed into business models and policy/institutional strategies in the region. The assumption is that our findings will be representative and can be extrapolated to other regions and SSA countries. This study is also expected to have made impacts in terms of capacity building and awareness in communities.
8. Community Level Assessments: Energy needs assessments for women in selected districts of Zambia

Progress H. NYANGA, Douty CHIBAMBA (The Department of Geography and Environmental Studies, University of Zambia)

This presentation is an outcome of a study supported by the Non-Governmental Gender Coordinating Council (NGOGCC). The study shows that women and children in the project sites are highly exposed to the health risks that come with heavy reliance on biomass energy for cooking and fossil fuel, particularly kerosene, for lighting. Thus, this assessment report provides empirical evidence for the need for actors such as Non-Governmental Gender Coordinating Council (NGOCC) to recruit, train and support women entrepreneurs to sell clean energy products in the selected project sites in order to increase access to clean energy technologies. This will reduce the health risks that women and girls are exposed to when using biomass sources of energy. This effort will also make a contribution towards attaining SDG7 which is calling for access to clean and renewable energy for all.

### Business Opportunities

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Willingness to pay (ZMW)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro power</td>
<td>200.2</td>
<td>68</td>
</tr>
<tr>
<td>Solar</td>
<td>267.5</td>
<td>82</td>
</tr>
<tr>
<td>Biogas</td>
<td>99.2</td>
<td>6</td>
</tr>
<tr>
<td>Geothermal</td>
<td>154.6</td>
<td>3</td>
</tr>
<tr>
<td>Wind</td>
<td>108.3</td>
<td>4</td>
</tr>
<tr>
<td>Natural gas</td>
<td>217.8</td>
<td>6</td>
</tr>
<tr>
<td>Woodfuel</td>
<td>160.4</td>
<td>8</td>
</tr>
<tr>
<td>Charcoal</td>
<td>88.3</td>
<td>24</td>
</tr>
<tr>
<td>Fossil fuel</td>
<td>122.7</td>
<td>25</td>
</tr>
<tr>
<td>Candle</td>
<td>53.8</td>
<td>21</td>
</tr>
<tr>
<td>Battery</td>
<td>116.2</td>
<td>46</td>
</tr>
</tbody>
</table>

- Implies simple cheap technologies
- Low annual income levels-
  - 4,200 ZMW/central region
  - 1,300 ZMW/northern region
- Paradox
  - Low income yet desire high quality/durability
  - Vulnerability/poverty trap
- Affordability than Availability

It is thus recommended that both state and non-state actors should promote the supply and commercialization, at community level, of affordable energy saving cookstoves and solar technologies for lighting. There is need to promote animal husbandry and bio digesters as affordable options for clean energy technologies for cooking. Sensitization of rural communities on the use of movable assets as collateral and lobbying with the private sector to pilot the actualization of the movable property Act (collateral registry) to overcome the limitations of access to credit by rural households is critical for success.
9. Technical planning: system sizing and protection of resilient standalone solar power plant—considerations for community projects planning to meet end user needs

Sebastian NAMUKOLO, Ackim ZULU (University of Zambia)

Off-grid solar-PV supply could be the path for achieving modern energy access in rural areas of Sub Saharan Africa, significantly moving the rural population toward the target of the 7th Sustainable Development Goal. Energy from the PV plants has the desirable attributes of being clean and affordable. Despite these desirable attributes, off-grid PV plants are also prone and susceptible to lightning effects in operation, this situation particularly accentuated in Sub Saharan Africa where there is high lightning activity. To redress this, the general principles of lightning protection are invoked in the design of the PV power supply to stave off the negative effects resulting from the plant being struck by lightning.

![Diagram of Lightning Protection for Off-Grid PV System]

This presentation discusses energy access using off-grid PV systems and proposes a design approach which makes the PV plant to be more resilient in lightning-prone regions. Five subsystems of lightning protection in PV-powered plants, which may be selectively applied depending on the results of the risk assessment, are adopted. This proposed approach is expected to reduce outages and downtime of the PV power plant.
10. Interactive session 1: Key questions and interdisciplinary approaches to address electrification challenges

Session Chair: Prof. Reccab O. MANYALA (Department of Physics, School of Natural Sciences, University of Zambia)

A significant part of the morning session was devoted to interactive group discussions for the participants to share experiences around a number of pertinent questions linked to the previous session (findings and methodologies). The participants were separated into five groups. A time frame of one hour was allocated for individual group discussions aimed at framing key electrification research questions and needs. A summary of key questions are given in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Community Needs Assessment Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  For what purpose(s) is energy used in communities?</td>
</tr>
<tr>
<td>2  What are the domestic and economic energy needs?</td>
</tr>
<tr>
<td>3  How do we prioritize investment to meet the energy needs of urban and rural areas?</td>
</tr>
<tr>
<td>4  What energy sources are used by communities?</td>
</tr>
<tr>
<td>5  What are the major barriers energy access and how can we overcome them?</td>
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<tr>
<td>6  How much money does the community spending on energy?</td>
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<td>7  What is the affordability of energy solutions (i.e. financial strategies) for communities in term of willingness to pay?</td>
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<tr>
<td>8  What is the level of awareness on energy solutions, cost implication and financial viabilities of different energy sources?</td>
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<tr>
<td>9  How can we enhance the coordination and collaboration between policy makers and the implementers?</td>
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<tr>
<td>10 What is the most economically viable approach to rural electrification between solar home system and mini grids?</td>
</tr>
<tr>
<td>11 Is it viable to manufacture and/or assemble components (invertors, solar panels, batteries, etc.) solar energy systems locally?</td>
</tr>
<tr>
<td>12 What non-financial assets can be used in exchange for energy usage and management? How can they be measured?</td>
</tr>
<tr>
<td>13 Which operational and financial models can be developed out of a system that uses non-financial assets for energy access?</td>
</tr>
<tr>
<td>14 What skills development training are required for communities?</td>
</tr>
<tr>
<td>15 Does the provision/access of electricity lead to social, economical and sustainable development?</td>
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<tr>
<td>16 How effective is the current sensitization on using Liquid Petroleum Gas (LPG) as compared to Hydro Electric Power?</td>
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<tr>
<td>17 What studies have been conducted on the effect of lightening on solar installations in view of the fact that Zambia is prone to lightning?</td>
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<tr>
<td>18 How can we further improve the efficiency of solar panels?</td>
</tr>
<tr>
<td>19 What affordable solutions are available for maximizing energy storage?</td>
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<tr>
<td>20 Can we produce a wind map for sub-Saharan Africa?</td>
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<tr>
<td>21 How can renewable energy be used as a productive tool for wealth creation?</td>
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</table>
From the group discussions, the participants examined the various questions in Table 1 and discussed extensively solutions to creating an enabling environment for upscaling rural electrification. Some of the recommendations and pre-conditions for achieving sustainable electrification include the following:

1. **Conducting Feasibility Studies;**, i.e.  
   - Properly identify specific target groups of potential rural market;  
   - Demonstrate the uses of available systems to communities;  
   - Carry out tailored needs assessment to specific communities (a one-size-fits-all approach cannot be effective);  
   - Investigate the viability - as well as legal and historical implications - of geothermal power considering that Zambia has about 86 geo-geysers from the rift valley systems  
   - Develop strategies and structures for generating funding for energy projects and capacity building

2. **Policy and regulatory framework**
3. **Revisit the policy frameworks;**
4. **Develop and implement policies to support independent power producers;**
5. **Long-term plan thinking**

6. **Technical considerations**  
   - Identify appropriate energy sources for various energy demands  
   - Identify best practices for energy storage systems  
   - Capacity building of local technicians to enhance sustainability of installed community energy systems

7. **Cultural profiling**  
   - Assess perceptions on energy technologies  
   - Explore community belief systems and how they impact technology adoption  
   - Develop appropriate advocacy (i.e. social engineering, demystification of energy solutions)  
   - Develop knowledge management and mentoring mechanisms (i.e. sustainability in knowledge management)

8. **Innovative energy delivery models**  
   - Encourage productive energy uses  
   - Possibility of “pay as you go” approach  
   - Involve local people in planning, design and implementation of electrification schemes  
   - Electrify for service (e.g. electrification of clinics and schools)  
   - Electrify for domestic and small scale business enterprises (such as refrigeration, lighting and entertainment units (e.g. TV and radio) as well as energy for light industrial activities such as welding, hummer mills, etc.)
9. Public Private Partnerships
   ▪ Provide conducive environment for private sector operations, including regulation
   ▪ Provide government subsidies as trade-off for efficiency to enable affordability by local communities
   ▪ Develop innovative pricing to suite local contexts
   ▪ Develop flexible pricing system that’s suits the rural markets

10. Monitoring and evaluation
    ▪ Evaluate private sector initiatives to ensure sustained technology uptake
    ▪ Evaluate public sector initiatives to monitor and revisit e.g. usage of its subsidy, effect of policy measures
11. Plenary discussion & consolidation – Making an impact on rural electrification, contribution of research and interdisciplinary collaboration

The final session of the workshop was a plenary discussion on how academics can contribute to making an impact on rural electrification through research and interdisciplinary collaboration. The discussion was framed around the following three issues:

(i) Identifying barriers that inhibit the adoption and diffusion of renewable energy among local communities in Zambia
(ii) Challenges that affect performance or viability of solar energy technologies
(iii) Way forward

Participants shared a range of insights and experiences on development challenges facing the rural electrification sector. Highlights of the discussions are summarised below:

- There was general consensus that access to efficient and sustainable energy services leads to a better quality of life for local communities. However, many people in rural areas still live with unreliable or expensive power which poses a key barrier to economic development as communities and public facilities remain without access to energy. Health clinics, for instance, are not able to deliver high quality of services, schools do not function effectively while local business are equally adversely affected.

- There is need to develop appropriate short term and long-term measures to accelerate the adoption of electricity services. Options include tariff rationalisation to encourage efficiency and investment in electricity supply. Tariffs would need to take into account the paying capacity of especially the rural poor.

- For mini grids, the biggest challenges are poor policies, inadequate regulations, lack of planning and lack of financing for off-grid entrepreneurs, and limited affordability for poorer households. It was noted that before the electricity crisis, the government of Zambia had K22 million which could have been invested in solar energy. However, such investments are not made as decisions in the electricity sector appear to be politically motivated. Thus, investment decisions in the sector need to be grounded on long term planning and feasibility studies. It was recommended that improvements in electricity supply could be achieved if ZESCO is freed from political interference.

- It was also noted that after the introduction of pre-paid meters, ZESCO was making profit. But the money was channelled to other uses.

- Distributed solar systems that feed into the grid could make an impact on electricity supplies in Zambia. An example was given that if each household generates 3kW of solar power, then on average, 300 000 households can feed in 600 kW power to the grid. However, the main challenge in Zambia is that ZESCO would not allow the customers to connect to grid as this can collapse the grid system. But with innovative solutions and modern technologies available, now is the time to be hopeful to introduce microsimulation at ZESCO. The country has many experts from...
institutions like UNZA, who can do microsimulation at ZESCO, and assist in resolving some of the capacity shortages. ZESCO can also introduce net metering on a larger scale.

- Innovative business models, such as pay-as-you-go offer great opportunities for private sector-driven off-grid electrification, as long as countries can create the right investment environment.
- Another intervention is to allow electricity provider (ZESCO) to supply solar panels, solar inverters and installation to people at a subsidized rate, thereby accelerating the uptake of renewable energy technologies.
## 12. Appendix - Workshop agenda

### Registration and Opening Session

<table>
<thead>
<tr>
<th>Event</th>
<th>Speaker/Details</th>
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<tbody>
<tr>
<td>Arrival and registration of participants</td>
<td>Secretariat, Solar Energy Centre (SEC), UNZA</td>
</tr>
<tr>
<td>Introductions</td>
<td>Nchimunya MWINGA, Director of Programme</td>
</tr>
<tr>
<td>Workshop Background and objectives</td>
<td>Prem JAIN, Solar Energy Centre, Department of Physics, UNZA</td>
</tr>
<tr>
<td>The RISE Project</td>
<td>Amos MADHLOPA, University of Cape Town, SA</td>
</tr>
<tr>
<td>Introductory remarks</td>
<td>The Dean, School of Natural Sciences, UNZA</td>
</tr>
<tr>
<td>Opening Speech</td>
<td>The Vice Chancellor, UNZA</td>
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### Session 1: Framing the key electrification challenges

**Session Chair: Dr. Progress NYANGA**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Speaker/Details</th>
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<tbody>
<tr>
<td>Energy access in rural Zambia: the community perspective</td>
<td>Bothwell BATIDZIRAI, University of Cape Town</td>
</tr>
<tr>
<td>Energy access in rural Zambia: institutional and business perspectives</td>
<td>Susann STRITZKE, Smith School of Enterprise and the Environment, University of Oxford, UK.</td>
</tr>
<tr>
<td>Capacity building – experiences in economics of renewable energy development</td>
<td>Sam SICHLALU, Department of Electrical and Electronics, School of Engineering, UNZA.</td>
</tr>
<tr>
<td>Challenges for the sustainable operation of a solar mini-grid – experiences and lessons learnt from Mpanta solar mini-grid</td>
<td>Prem JAIN, Solar Energy Centre, Department of Physics, UNZA.</td>
</tr>
<tr>
<td>Challenges for the sustainable operation of a solar mini-grid – experiences and lessons learnt from Kitwe</td>
<td>Prosperity SIMPEMBA, Department of Physics, School of Mathematics &amp; Natural Sciences, Copperbelt University, Kitwe, Zambia.</td>
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</table>

### Session 2: Key questions and interdisciplinary approaches to address electrification challenges

**Session Chair: Prof Reccab O. MANYALA**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Group</th>
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<tbody>
<tr>
<td>Group exercises - Framing the key electrification research questions and needs: What are the central research questions? What approaches can be used to achieve more effective and efficient electrification in SSA?</td>
<td>All</td>
</tr>
<tr>
<td>Group report back and discussions</td>
<td>All</td>
</tr>
<tr>
<td>Community level assessments: Energy needs assessment for women in selected districts of Zambia</td>
<td>Progress NYANGA and Douty CHIBAMBA, Department of Geographical and Environmental Sciences, UNZA.</td>
</tr>
<tr>
<td>Community level assessments: Conducting community energy engagement and needs assessments</td>
<td>Bothwell BATIDZIRAI, University of Cape Town</td>
</tr>
<tr>
<td>Technical planning: System sizing &amp; protection of resilient standalone solar power plant – considerations for community projects planning to meet end user needs</td>
<td>Sebastian NAMUKOLO, Department of Electrical and Electronics, UNZA</td>
</tr>
<tr>
<td>Institutional frameworks and Business Models: Assessing appropriate institutional and business models for successful electrification in SSA</td>
<td>Susann STRITZKE, Smith School of Enterprise and the Environment, University of Oxford, UK</td>
</tr>
<tr>
<td>Group Discussions – How to undertake interdisciplinary research and include all (social, technical, economic, policy, regulatory, institutional and business development) important aspects to achieve successful electrification in Zambia</td>
<td>All</td>
</tr>
</tbody>
</table>

**Session 3: Way Forward – Research and Capacity Needs**

**Session Chair: Dr. Amos MADHLOPA**

| Group report back | All |
| How to publish in top international journals | Philipp Trotter, Smith School of Enterprise and the Environment, University of Oxford, UK |
| Plenary discussion & consolidation – *Making an impact on rural electrification, contribution of research and interdisciplinary collaboration* | All |
| Closing remarks | HEAD, Department of Physics, School of Natural Sciences, UNZA |