BOOK OF ABSTRACTS

Editors

Niklas Hayek, Africa-EU Renewable Energy Cooperation Programme (RECP)

Benjamin Freischlad, Africa-EU Renewable Energy Cooperation Programme (RECP)

Thrie Energy Collective

Dr. Thimothy Thamae, National University of Lesotho

Dr Mekbib Sissay Bekele, National University of Lesotho

Table of Contents

Chapter 1: Energy Socioeconomics (RERIS)

Smart grids in the European Union: Assessing energy security, regulation & social and ethical considerations. Possible synergies with Africa

Prof. Dr. Rafael Leal-Arcas*

Queen Mary University of London

The purpose of this article is to provide an analysis of smart grids in the European Union (EU) as a way forward to reach de-centralized sustainable energy. It does so by assessing the energy security, regulatory, as well as social and ethical aspects of smart grids in the EU. The article represents a significant milestone in the up-scaling of the various aspects of smart-grid technology across the EU. This article deals with smart-grids deployment and their impact on energy security with a view to a stronger role of prosumers in the energy market. It also analyzes smart grids regulation; specifically, it examines the existing legal frameworks that impact smart grids in the EU. It outlines existing EU Directives and assesses the level of implementation of these Directives in various EU Member States. The article also assesses the extent to which the existing legal frameworks facilitate the development of smart grids and proposes areas of further regulatory consideration. The article then explores the social and ethical dimension of smart grids in the context of the collaborative economy, the circular economy, and digital technology, including cyber-security and data-management issues.

Keywords: Smart grids; Prosumers; Sustainability; Energy security; Demand response; Electricity storage; Collaborative economy; Circular economy; Cyber security; Data protection

Corresponding author: Rafael Leal-Arcas;
r.leal-arcas@qmul.ac.uk
+44-20 7882 8071

Optimising Europe's efforts to support Africa' electrification

Simone Tagliapietra*

Fondazione Eni Enrico Mattei, Milan, Italy

Electrification is one of sub-Saharan Africa (SSA) most dramatic socio-economic challenges. Less than a third of the regional population has access to electricity, and around 600,000 premature deaths are annually registered as a consequence of household air pollution resulting from the utilization of polluting fuels for cooking and lighting.

SOLVING this ISSUE is a fundamental prerequisite to unleash SSA economic potential. Given the order of magnitude of the challenge, only a joint effort of SSA countries and of international public and private players could contribute to its solution.

SSA countries should be the first to move. They should reform the governance of their energy sectors, in particular by reforming the generally-inefficient state-owned electricity utilities, and by phasing-out market-distorting energy subsidies schemes. Without such reforms, international investments will never scale-up across SSA.

International PUBLIC AND PRIVATE players have a key role in facilitating SSA energy transformation, particularly as far as the electrification of rural areas – where three-fifth of SSA population lives – is concerned. International public support is particularly key for crowding-in international private investors, most notably via innovative public-private partnership schemes.

China and the U.S. are already widely engaged on SSA electrification. China has substantially invested into SSA's large-scale electricity projects, while the U.S. have put in place a comprehensive initiative – Power Africa – aimed at scaling-up electrification, particularly in rural areas, through public-private partnership projects.

Europe has, instead, created a myriad of fragmented initiatives on SSA electrification, limiting potential leverage in crowding-in private investments and in stimulating SSA countries' energy sector reforms. This sub-optimal situation should be reversed, by coordinating European institutions' and Member States' initiatives for SSA electrification through a unique platform, such the 'EU Electrify Africa Hotspot' proposed by this paper.

Keywords: Africa, energy access, electricity, investments

Corresponding author: Simone Tagliapietra
simone.tagliapietra@feem.it
0032465683788

A thermo-economic model for objective solar collector choice and sizing of a solar water heating system

Hove. T*

**Department of Mechanical Engineering, University of Zimbabwe*
P.O Box MP 167, Mount Pleasant, Harare, Zimbabwe

In this paper, a thermo-economic model is developed for the computation of suitable metrics that can aid in choosing the most cost-effective collector to use in a solar water heating system and to determine the optimal sizing of the solar water heater components once the choice collector has been picked. An approach to calculating the energy-per-dollar is introduced and used for comparing cost-effectiveness of different solar collectors. For the determination of the optimal sizing of the solar water heating system, the Net Present Value of Solar Savings was used as the objective function. Ten (10) different models of liquid solar thermal collectors, which are rated under the OG-100 collector certification program of the Solar Ratings & Certification Corporation (SRCC), were first ranked according to the energy-per-dollar criterion. By making the Net Present Value of Solar Savings the objective function to maximize, the optimal area of the choice-collector to be used in the solar water heating system was then determined using the thermo-economic model. The required hot water storage volume decreases exponentially as the deployed collector area increases while the solar fraction increases, with diminishing marginal rate, as it approaches unity solar fraction. By the energy-per-dollar criterion, one collector model of the flat plate technology was ranked as best among its competitors at the study site in Zimbabwe, when applied for heating water to 50^{o}C. The optimal size of this collector model to deploy in the solar water heating system at the location is 17 m^2 per m^3 of daily hot water demand; with a hot water storage volume of 910 l/m^3; at an optimal solar fraction of 91%. The energy-per-dollar as used in this study is an objective criterion to select from among different solar collector models for deployment at specific sites and for a specified temperature of application.

Keywords: Energy-per-dollar; Thermo-economic model; Collector selection; Optimal sizing; Diminishing marginal returns; SRCC-rated

Corresponding author: Tawanda Hove
tawandahv2@yahoo.co.uk
+263779731907

A qualitative analysis of renewable sources of energy used and policies in Lesotho

T.C. Ramoeletsi* and Matandare B.

Limkokwing University of Creative Technology, Lesotho

African Union member states are confronted with a lot of challenges in their quest to implement the United Nations Sustainable Goals. One of the major challenges is lack of access to affordable and reliable energy. Power consumption per capita in sub-Saharan Africa is the lowest of all the continents. It is currently estimated at 181 Kilowatts per annum, paling significantly in comparison to 6,500 Kilowatts per annum in Europe and 13,000 Kilowatts per annum in United States[1]. Energy is a catalyst of development and at the core of modern life. Lack of access to modern energy services has adverse effects on social and economic developments. Socioeconomic factors such as high energy tariffs, unaffordable energy infrastructure and disperse population deny a majority of the continent population access to modern energy. Africa has a lot of energy resources including both fossil fuel and renewable resources. The latter offers unique opportunities to provide affordable and sustainable energy to a larger population.

This paper discusses energy socioeconomics impacts on communities with special attention to Lesotho. It evaluates how access to renewable energy is affected by economics factors. About 30.2% of household in Lesotho have access to electricity, concentrated mainly in urban areas. The government has set a goal of increasing the electrification rate to 35% of households by 2015 and 40% by 2020[2]. However the most stumbling block is the financial budget necessary to expand to disperse rural areas. While this can be mitigated by taking advantage of carbon credits, there is potential, and there are plans to establish wind farms and to expand the current hydropower capacity from 72 Megawatts generated by'Muela Hydropower plant.

Keywords: Energy, renewable energy, Sustainability, socioeconomic impacts, policies

Corresponding author: Mr. T.C. Ramoeletsi
tramoeletsi@gmail.com
+266 6301658

[1]African Development Bank (The new Deal on Energy for Africa) - 2017
[2]Lesotho Electricity and Water Authority 2012/2013 annual report

Renewable Energy Law and Policy in Ghana: A Legal Analysis of the Support Schemes under the Regulatory Framework and Some Lessons from the EU Experience

Nana Asare Obeng-Darko*

UEF Law School and the Center for Climate Change, Energy and Environmental Law (CCEEL),
University of Eastern Finland.

Renewable energy sources (RES) in Ghana are readily available and abundant. Due to issues of climate change at both national and global levels, lack of access to energy services and the recurring shortages in electricity supply plaguing the country, the Ghanaian government recognised the necessity for developing its renewable energy (RE) potential at the turn of the 21st century. The realisation to develop its RE potential is to enable Ghana to generate electricity from its abundant RES to support economic, environmental and social developments in the country. To this goal, the Ghanaian government established a Strategic National Energy Plan (SNEP) to achieve 10% penetration of renewable energy sources (RES) into the country's energy mix by the year 2020. The Government also established a National Energy Plan (NEP) to achieve a 100% nationwide access to electricity by 2020. In line with both the SNEP and NEP, the country in 2011, adopted its Renewable Energy Act, 2011 (RE Act) with the objective of providing for the development, management and utilisation of renewable energy sources for the production of heat and power in an efficient and environmentally sustainable manner. This study examines whether the support schemes provided under the RE Act creates the necessary legal and regulatory environment for achieving those objectives. This paper will argue that, for the Ghanaian RE Act to create the enabling environment it would have to establish vibrant and tangible support mechanisms that will address the issue of lack of investment into the RE sector of the country. The support systems established under the RE Act must also provide long-term stability to enable return on investment for investors. It will further suggests some policy and regulatory improvements by highlighting some regulatory issues from the EU experience.

Keywords: Renewable energy policy, renewable energy sources, regulatory framework, support schemes, investment

Corresponding author: Nana Asare Obeng-Darko
nana.asare.obeng-darko@uef.fi

Solar PV training kit, a novel community outreach programme in Kenya

Robinson Juma Musembi*, Sebastian Waita, Alex Ogacho, Justus Simiyu, Julius Mwabora, Bernard Aduda

Department of Physics, University of Nairobi, P.O. Box 30197-00100 Nairobi, KENYA

In order to address the perennial problem of lack of knowledge on solar pv systems and sizing during installation, the Solar Energy Group (SEG) of the Department of Physics, University of Nairobi has developed a novel solar PV training kit as part of its community outreach program. The kit consists of two solar modules (different sizes), wooden block board, one deep cycle battery, charge controller, dc-ac inverter and various wiring components. The outreach program entails teaching majority non-physicist or anyone interested in doing DIY PV installation on the basic theory of photovoltaics systems, wiring, pv mounting and configurations, storage of batteries, power conditioning, pv appliances, maintenance and commissioning.

This is a novel idea which is benefitting the community in a number of ways, example, mobile charging in rural area, lighting for homes and schools, hospitals and shopping centres and the people are appreciating science. The outreach program has become very popular within the region; the trainees come from as far as DR Congo, Ethiopia, Uganda and Tanzania.

Keywords: PV modules, installation, training, novel kit

Corresponding Author: Robinson Juma Musembi
musembirj@uonbi.ac.ke

Energy system planning models for cities: On the limits of existent modeling tools and a new approach for models tailored to the needs of developing countries

Aminata Fall*

Energy Economics Group - Vienna University of Technology, Saarplatz 2, 1190 Vienna (Austria)

The community of nations has resolved to ambitious targets for development in 2015, by adopting sustainable development goals, including on energy access (SDG-7) and livability of cities (SDG- 11). When related to the concept of development, the energy sector is one among a number of other sectors such as health. However, its cross-cutting nature and the nexus it forms with other sectors make dynamics in the energy system impact, in a broader perspective, development targets.

Models are the most used instruments for description and analysis of a system. Connolly et al. (2009) identified sixty height computer based energy modeling tools, including MARKAL and MESSAGE. We tried make use of these tools in our research context, the city of Dakar in Senegal, considering three filter-steps based on the following criteria:

1) Experience of use in a developing country returns 40 models (Urban et al., 2007).
2) Focus on energy and electricity and exclude models which entirely focus on climate change and its impacts or address economic issues such as energy markets returns 12 models (Urban et al., 2007).
3) Possibility to scale down from national to subnational level returns 0 model.

This paper documents reasons why existent energy models cannot be used for planning the energy system of an emergent city in a developing country. It also proposes a new approach for designing a tool that is tailored to the needs of a city like Dakar, using as methodology a combination of multi-criteria decision making analysis and mechanism design. The analysis shows the new methodology is applicable and returns more accurate results in terms of scientific validity, and potentially has an experimental validity that is yet to be confirmed in the field.

Keywords: Energy sustainability; Developing country; Cities; Complex systems; Models

Corresponding author: Aminata Fall
amissfall@gmail.com
+43 (0) 664 37 39 631

Status of Rooftop PV Generation in South Africa

N. Mararakanye*, K. Kritzinger and N. S. Mamphweli

Centre for Renewable and Sustainable Energy Studies, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa

There has been a worldwide rise in the installations of rooftop photovoltaic (PV) systems over the past few years and this trend is now also being seen in South Africa. These systems are installed on residential-, commercial- and industrial- rooftops at a cost of the property owners. As of March 2016, the estimated privately owned rooftop PV capacity in South Africa amounted to ~159MW. This is a rise from just 50-70MW in 2015. This increase is primarily due to the declining cost of PV technology, rising electricity prices and the abundance of sunshine in most parts of the country. It remains to be seen if the installations of rooftop PV systems will continue to rise in South Africa. International experience has shown that a high uptake of rooftop PV is not only fuelled by the three factors mentioned above, but also by policies, financial incentives, metering arrangements, regulations and successful business models. The question now arises whether the conditions in South Africa are such that it will continue to encourage property owners to install these systems and also whether there are constraints that can limit further development of rooftop PV in the country.

This paper presents a comprehensive review on the current status of rooftop PV generation in South Africa and compares this to countries that already have a high uptake of rooftop PV installations. Thereafter, the major constraints that can impede the further development of rooftop PV in South Africa will be identified.

Keywords: Rooftop PV; tariffs; metering; grid-tied; low voltage network

Corresponding author: N. Mararakanye
ndamulelo@sun.ac.za
+27 21 808 9474

Impacts of electrification under the perspective of the Multi-Tier-Framework in Southern Tanzania

Annika Groth*

Interdisciplinary Institute for Environmental-, Social- and Human Studies
Department Energy and Environmental Management
Europa Universität Flensburg, Germany

Off-grid areas in many African countries do not necessarily lack access to electricity. In the last decade, energy technologies based on solar power achieved higher penetration rates, also in rural areas of Sub-Saharan Africa. This "pre-grid-electrification status" needs to be reflected in research on rural electrification and its impacts on socio-economic conditions. Nevertheless, many studies in the field still focus on the effects of having or not having access to grid-electricity. Taking into account the Multi- Tier- Framework (MTF) by the World Bank electricity access is no longer a binary metric. This study strives to fill this gap and compares households in villages that are electrified by a hydro power based and main grid-connected mini-grid system with households in villages having no connection to grid-electricity but access to solar powered electricity in the Southern Tanzanian Region.

In the focus of this paper are mean lighting and lumen hours per day consumed per household in grid-electrified and not yet grid-electrified areas. Lighting is one of the most important intermediary outcomes of electricity through which households can benefit in many fields. In contrast to absolute hours of lighting consumed per day, lumen hours can be seen as an indicator of quality of lighting, one of the criteria in the Multi-Tier Approach.

Propensity Score Matching Method is applied to identify treatment and control group. As has been expected, lighting and lumen hours consumed by households in grid-connected areas are significantly higher. However, the analysis underlines the importance of interconnected systems supporting the reliability of electricity access, which is also acknowledged in the MTF and crucial for productive uses. Additionally, fertile ground for further research is identified.

Keywords: Interconnected energy systems; Electricity access; Multi-tier framework; Propensity score matching; Sub- Saharan Africa

Corresponding author: Annika Groth
annika.groth@uni-flensburg.de

Capacitating the core: introducing social performance to the renewable energy sector in Africa

Holle Linnea Wlokas* and Paul Kapelus[1]

*Stellenbosch University, Center for Complex Systems in Transition
[1] Synergy Global Consulting

Depending on technology type, scale and location, renewable energy projects can have a range of positive and negative economic, environmental and social impacts. Impacts of all kinds require relationship management involving government, communities and companies. Social performance is the professional response and offering in this context.

Social performance essentially deals with all the different ways a company and its operations contribute positively or negatively to the communities and societies in which they operate, and how these contributions and impacts are managed or optimised. Within this context, social performance is a critically important business tool to ensure a company's positioning in the local economy is sound, which directly relates to an effective risk mitigation and reputation management.

What are the critical social performance issues that renewable energy companies should anticipate, consider and plan towards when determining a business strategy throughout construction and operation of renewable energy plants? Building upon decades of experience in the extractives industries, it is possible to not only identify the current issues that require immediate attention but also the emerging external and internal factors that are going to be both exerting pressure on and driving a renewable energy company's relationship with its stakeholders.

This paper develops a comprehensive response to this question by outlining three agendas, which are to be advanced within academia, private sector and civil society. All three contributions are critical to the implementation of a just and deep energy transition on the continent.

Keywords: Renewable energy; Social performance, Energy Transition, Just transition

Corresponding author: Holle Linnea Wlokas
holle@sun.ac.za
+27 79 936 1157

Market Segmentation of Rural Electricity Consumers for Mini-Grid Business Development in Tanzania *(Poster)*

Lee, C. J. *

E.ON Off Grid Solutions Gmbh Völklinger Straße 4, 40219 Düsseldorf

The research explores the daily lives of electricity consumers in rural Tanzania, examines the characteristics of low-income consumers, and illustrates their consumption and growth potential. Rural, low-income consumers are often considered as a homogeneous market. However, the research hypothesized that there exists a great variety within rural communities and requires further market segmentation for mini-grid operators to tap the electricity consumption potential in its rural customers.

Through extensive data collection across eight villages with over 600 households, which are connected to solar-powered mini-grid electricity by E.ON Off Grid Solutions (EOGS), the study first plotted a Pareto distribution of rural electricity consumption and found a large disparity among EOGS's rural consumers. It then conducted an analysis of 16 variables in relation to electricity consumption, covering a wide array of characteristics of rural consumers, from assets ownership, occupation, living condition to expenditures. The results show that housing condition, connection purpose and mobile money expenditure have strong implication on electricity consumption level.

Based on the selected criteria, the research further develops a market segmentation methodology for rural electricity consumers, as an attempt to better understand a relatively new and unexplored market. Through understanding the specific needs, challenges, spending and saving pattern, and electricity consumption behaviour of each customer group, mini-grid businesses can then tailor their value propositions that unleash the most consumption and growth potential of the rural electricity consumers.

Keywords: mini-grid; rural consumers; electricity consumption

Corresponding author: Daniel Becker
chih-jung.lee@rafikipower.com
+255 (0) 657 496 669
+33 (0)7 81 87 82 29

Work-in-progress journey towards cost-reflective electricity tariffs in Lesotho *(Poster)*

M. Mpholo [1,*], T. Jardine[2], D. Eager [2], C. Migues [3], R. Thamae [1] and T. Molapo [1]

[1,*]*Energy Research Centre (ERC), National University of Lesotho, Roma 180, Lesotho.*
[2] *Energy Market & Regulatory Consultants (EMRC), Energy Market and Regulatory Consultants, Suite 216, Conference House, 152 Morrison Street, Edinburgh, EH3 8EB.*
[3] *Market & Regulatory Consultants (MRC), General Moscardó, 32, 28020 Madrid, Spain.*

Energy Market & Regulatory Consultants in collaboration with researchers from the Energy Research Centre (ERC) of the National University of Lesotho are carrying out a Cost of Service Study and Design of Economic Cost Reflective Tariffs on behalf of the Lesotho Electricity and Water Authority. The paper will share the results of the on-going 9 months study due for completion in January 2018. Lesotho is looking into implementing cost-reflective tariffs for electricity with the aim of promoting efficiency of the electricity industry and thereby reducing costs, to the benefit of the customers. The work includes a review of the regulatory model that best fits the Lesotho situation - a number of approaches are being looked at including the Rate of Return (ROR) regulation and the Incentive Based Regulation (IBR). The optimal model will be determined from the results of the following analyses: demand forecast, development programs and the financial performance of the utility. Transitioning to cost reflective policy often leads to steep increases in electricity prices. This will be a challenge in Lesotho where the average consumption per household has decreased by over 60% between 2001 and 2016 (2,951 kWh/year to 1,157 kWh/year). This demonstrates that the bulk of the large number of new connections have been to poor households, so there is a need to balance efficiency with social stability, access, affordability and fairness. Hence there may be a need to introduce a lifeline tariff. The results from the various components of the study will be presented, showing how they were used to come up with the ultimate model, and how the model could realistically be phased. The results will be useful to a number of African countries who are planning to follow this route.

Keywords: Cost Reflective Tariff; Life line tariff; Demand forecast; Tariff determination

Corresponding Author: Moeketsi Mpholo
mi.mpholo@nul.ls
+266 5221 3529

Stalemate or Priority: An Examination into the Energy Question in Zimbabwe *(Poster)*

Nyamadzawo L*

Department of Rural and Urban Planning, University of Zimbabwe
P O MP 167 Mt Pleasant, Harare; Zimbabwe

Zimbabwe currently faces an amalgamation of energy access and availability challenges across all sectors of the economy. The paper seeks to advance the debate that Zimbabwe could do well in the energy sector should it rethink its economy, technology, policy and scale of operation and influence. This comes as a result of paucity of a scholarly debate and practical implementation on the situation and prospects on the multiple alternatives available for the energy sector. It is not clear, in practical terms, whether this issue is a matter of politicization, neglect or indecision on the part of the state not to utilize the many resources that the energy sector has – natural gas, geothermal power, coal, nuclear, hydro-power, solar, to mention these few. By way of documentary analysis including official, scholarly articles and media reports, the paper observes that with informed decision making, systems thinking and prioritization, the energy sector is poised to make the country a useful hub and user of the multi-packaged energy resource. The paper furthermore highlights the opportunities that Zimbabwe can harness to further advance the adoption of renewable energy both at household and National Level. It recommends that developing this sector requires a multi-stakeholder approach which also helps in ensuring advancement in multi-dimensionality to the whole debate including pro-poor strategies and targeting, climate change, economic performance and essential infrastructure development and maintenance.

Keywords: Energy Question; Priority; Stalemate; Economy; Policy

Corresponding Author: Nyamadzawo L
nyamadzawo.lisa@gmail.com
+263776695757

Using a Multi-Criteria Decision-Making Approach to Evaluate Sustainability of Renewable Energy Generation Sources in Uganda

(Poster)

Bamutura C* and Braig K. F[1]

**Pan African University Institute of Water and Energy Science (Including Climate Change), PAUWES,*
B.P. 119, Pole Chetouane, Tlemcen 1300, Algeria
[1]*University of Basel, Petersplaptz 1, Postfach 4001 Basel, Switzerland*

There are increasing concerns on utilization of Renewable Energy (RE) resources. This results from perceived economic, technical, environmental and socio-political risks in the deployment of RE systems which negatively impacts their suitability and sustainability for energy generation. Uganda in particular has hydro power potential of about 2,200 MW, solar energy potential of about 200 MW, bioenergy potential of 1650 MW, geothermal energy of 450 MW, and wind speeds ranging between 3-5 m/s and yet still grapples with low energy access for her citizens. This research assesses the various generation sources in Uganda based on a multi criteria decision making approach to determine the most suitable energy generation resource alternative. This is done by utilizing Analytical Hierarchy Approach (AHP) which utilizes a pairwise comparison of the criteria in relation to the goal, sub criteria in respect to the parent criteria and finally the energy generation sources to the set criteria to rank RE generation sources in order of priority. The evaluation of the RE sources with respect to the goal of prioritization of energy generation sources based on four key criteria i.e. economic, technical, environmental and social political criteria revealed priorities as hydro, solar, wind, geothermal and biomass with weights of 27.0%, 22.1%, 15.9%, 14.2 % and 8.1% respectively. The assessment further revealed that operation and maintenance cost, technological maturity, emission reduction and job creation are important sub-criteria with respect to the main criteria with weights of 36%, 38.3%, 73.1% and 73.1% respectively. Based on these priorities evaluated using this approach, relevant information is provided to inform decision makers on what should be prioritized, enables investors in renewable energy to choose the most suitable alternatives to invest in, as well as financiers to make decisions on financing RE projects

Keywords: Renewable Energy; Sustainability; Multi-Criteria; Decision Making; Prioritization.

Corresponding Author: Bamutura C
c.bamutura@gmail.com
+213542219518
+256774516178

Multi-Feed Biomass Gasifier Project: Promoting good human and environmental health and food production *(Poster)*

Akolgo G. A.*[1], Essandoh E. O.[1], Atta-Darkwa T.[1], Anafo D. [2], Bart-Plange A. [3] , Kemausour F. [3], Maia C.M. B. F. [4]

[1, *]*Department of Mechanical and Manufacturing Engineering , University of Energy and Natural Resources, P. O. 214, Sunyani, Ghana*
[2] *Department of Environmental Management, University of Energy and Natural Resources, P. O. 214, Sunyani, Ghana*
[3] *Department of Agricultural Engineering , Kwame Nkrumah University of Science and Technology, Kumasi, Ghana*
[4] *Embrapa Forestry Estrada da Ribeira km111, 83411-000 Colombo-PR,Brazil*

Across Africa, a lot people cook over open fires or with solid fuels. Cooking this way emits small particles and carbon monoxide, which can be harmful to women and children who spend a lot of time in the kitchens. The cookstoves are also inefficient and slow in cooking, which further increase deforestation and climate change. The agricultural soil in Africa are also increasingly losing fertility and becoming acidic due to continuous cropping. This study conducted through a project funded by Agricultural Innovation MKTPlace designed a multi-feed biomass gasifier (MFBG) cookstove, which has a dual function of cooking and producing biochar. The MFBG was tested for its thermal efficiency, cooking time and fuel consumption using the water boiling and kitchen performance tests protocols as recommended by Global Alliance of Clean Cookstoves. The biochar produced from the gasifier was tested in maize and cabbage farms at three levels of application rates. The MFBG has an efficiency of 42.4% and reduces emissions by 80% as compared to open fire. Kitchen Performance tests revealed that the MFBG cooks banku in 11.5 minutes and rice in 18.5 minutes whilst the gyapa – the reference stove - cooks banku in 42 minutes and rice 33 minutes. Field tests of biochar revealed that plots with biochar were less acidic and had higher organic carbons and exchangeable cations. This caused an increase in the yield of the cabbage and maize in plots that biochar was applied. Its strengths (project addresses a serious problem and simple device design) and opportunities (possible government investments, international agency funding, products' commercialization, afforestation tool) were found to far outway its weakness and threats. We are now working in a next-steps proposal regarding biochar validation and MFBG improvement.

Keywords: MKTPace; Biomass Gasifier; Biochar; Cookstove; Fuel Use.

Corresponding Author: Gilbert Akolgo
gilbert.akolgo@uenr.edu.gh
+233-240125425
0209143907

Chapter 2: Decentralized Renewable and Household Energy Solutions (RERIS)

Integrating a Solar PV System with a Household based backup Generator for Hybrid Swarm Electrification in sub-Saharan Africa: case study of Nigeria

Muceka R* and Kebir N[1]

**Pan African University Institute of Water and Energy Sciences (Including Climate Change), B.P.119, Pôle Chetouane, Tlemcen 13000, Algeria*
[1]MicroEnergy International
Potsdamer Str. 143, 10783 Berlin, Germany

Today most of the electrification grids in sub-Saharan Africa (SSA) are found in the urban areas. However, these grids experience erratic and frequent power outages for long hours, on average 4.6 hours in the whole of SSA. Due to this problem, many of the African population rely on unclean options like backup diesel/petrol generators for lighting, phone charging and other electrical appliances. In Nigeria, millions of people own power generators. These generators are not only noisy but the fuel they use are also costly and result in greenhouse gas emissions like carbon dioxide. In order to optimize fuel consumption and gradually reduce use of backup generators while increasing share of renewables, a strategy is proposed in this paper to interconnect the existing backup infrastructure to form a bottom-up swarm electrification grid with step by step integration of alternative storages and renewable energy sources. In the swarm-grid excess energy can be generated, sold among grid participants and even at later stage to the national grid. This study focused on the integration of a solar PV system to the existing individual backup generators for the household and the retail shop end users. Out of three systems designed, and the hybrid system is found to be the most suitable system for the household user with fuel savings of 39%, excess energy of 27% and reduced cost of backup electricity by 34%. For the retail shop, the hybrid system is also found as the most suitable system with fuel cost savings of 53%, excess energy generation of 28% and reduced cost of backup electricity by 45%. The study found that integration of a solar PV system has a high potential to reduce fuel costs for the backup generator end users and could contribute to a hybrid swarm electrification approach.

Keywords: National Grid; Stand-alone System; Swarm grid; Renewable Energy; Excess Energy

Corresponding author: Rolex Muceka
mckrolex@gmail.com
+256779204081

Baseline Assessment for the Smooth Operation of Solar Mini Grid Facility in Umon Island and Bagana Community in Southern Nigeria

Uyigue E.*, Uyigue P. O. and Iyalekhue O.

Community Research and Development Centre,
No. 2, Michika Street, Off Ahmadu Bello Way
Garki Area 11, Abuja Nigeria.
www.credcent.org

Umon Island and neighboring Bagana Community are located in southern Nigeria and both have a population of about 5000 people. The two communities are both surrounded by water and are not connected to the national electricity grid. The Nigeria Energy Support Programme (NESP) of the GIZ and the European Union, in collaboration with the Community Research and Development Centre (CREDC) is supporting the implementation of 50 kW Solar Mini Grid Facility to serve the two communities. To ensure the smooth operation of the Facility, the CREDC embarked on a survey to determine the average electricity needs of end-users and assess community's willingness and ability to pay for electricity. Method of data collection include interview with key informants, questionnaire administration, review of existing literature and direct observation. There is a total of 253 houses in both communities and 181 potential customers. The inhabitants of both communities were already familiar with electricity as 80% of the houses generate their electricity using privately-owned generators. The average peak load was calculated to be 0.887kW per households while 48.8% of the total electricity demand is used for lighting due to the dominant use of incandescent light bulbs; a total of 96% of respondents use incandescent light bulbs. The electricity used for lighting could be reduced to 8% if all end-users replace their incandescent lamps with LEDs. A total of 94% of end-users have expressed their willingness to connect to the Facility, while 93% have express their willingness to pay for electricity from the Facility. Over 76% of households already pay as much as N15,000 ($50) and above monthly to generate electricity from privately-owned generators. As elicited from the study, the current paper enumerates the strategies that will employed by the Operator to ensure the smooth operation of the Facility.

Keywords: Umon Island; Nigeria; Facility; Mini grid; Solar

Corresponding author: Etiosa Uyigue
etiosa@credcentre.org
+2348028978877

Energy Efficiency Optimization of Biochar Cook Stoves through Computational Simulation

Getachew Shunki Tibba*, A. Venkata Ramayya[1], Emanuela Colombo[2]

**Mettu University, Ethiopia*
[1] *Jimma University, Ethiopia*
[2] *Politecnico di Milano, Italy*

Biochar cook stoves have high potential of solving socio-economic and environmental problems of community living in rural areas like south-west part of Ethiopia where there is large biomass resource polluting the environment. Technically, these stoves have two purposes: 1. Energy generation (energy conversion) and 2. Biochar production. The stoves can be best in either energy generation or Biochar production but not both. This work aims at optimizing the stoves for maximizing energy generation efficiency. The problem is shape and size optimization, with energy efficiency as objective function, of stoves that use saw dust, coffee husk, brewery waste and Qat residue as feed stocks using computational fluid dynamics (CFD) simulation to generate alternative solutions. The optimization is conducted for Anila and Elsa Biochar cook stoves. The optimization results show energy efficiency improvement up to 10 percent of the optimal stoves compared to classical ones.

Keywords: Biochar; Cook Stoves; Optimization; Energy; Efficiency; CFD

Corresponding author: Getachew Shunki Tibba
getachew.shunki@meu.edu.et
+251911386973

Plasma gasification of biomass using nitrogen plasma reactor to produce synthesis gas for small scale-communities

R. F. Muvhiiwa*, B. Sempuga[1], D. Hildebrandt[1], X. Lu[1], J. van der Walt[2]

*, 1 *Materials and Process Synthesis, College of Science, Engineering and Technology, University of South Africa (UNISA), c/o Christiaan de Wet & Pioneer Avenue, Florida Campus 1710, Johannesburg, South Africa.*

[2] *South African Nuclear Energy Corporation SOC Limited. Elias Motsoaledi Street Extension (Church Street West) R104 Pelindaba, Brits 0240, South Africa*

The most common set of problems encountered when using biomass-to-energy (BTE) processes relate to tar formation and product gas composition. However, using plasma technology to convert biomass provides a solution, because it unlocks more energy than can be achieved by other BTE systems by using a heat supply derived from electricity. The research presented in this paper focuses on the conversion of biomass to chemical energy (in gaseous form) with the aid of the electrical energy supplied by a water-cooled, nitrogen plasma torch. The authors conducted a series of experiments in a pyrolysis set up in which wood pellets were converted to syngas in a small-scale laboratory nitrogen plasma torch reactor, with a maximum power supply of 15 kW. The efficiency of the process was measured in terms of the carbon conversion to all product gases, which changed from 43 to 77 %, at temperatures ranging from 400 ^{0}C to 1000 ^{0}C respectively. The combined carbon monoxide and hydrogen (syngas) mole concentration in the produced gas was 86 % at 1:1 ratio for all temperatures studied. Syngas yield increased with increase in temperature. The overall biomass conversion obtained increased from 46 % to 82 % for the temperatures 400 ^{0}C to 1000 ^{0}C respectively, with the balance comprising carbon-rich solid residue and liquid. This tells us that plasma gasification can be a viable method for converting industrial and agricultural biomass into energy and small-scale systems have potential to help produce energy in communities.

Keywords: Plasma; Gasification; Biomass; Syngas; Renewable energy

Corresponding author: Ralph Muvhiiwa
muvhirf@unisa.ac.za
+27 11 670 9386

Storage as the weak link of the biomass supply chain

Dumfort S.*, Kirchmair C.[1], Floerl K.[1], Larch C.[2]

**Department of Environmental, Process & Energy Engineering, MCI Management Center Innsbruck, Innsbruck, A-6020*
[1]Bioenergie Tirol, Innsbruck, A-6020
[2]Syneco-tec GmbH, Absam, A-6067

Biomass such as wood, straw or agricultural wastes is a worldwide abundant resource offering high potential for a decantralized energy production and supply which is especially interesting for rural areas. However, substance and energy loss caused by microbial degradation is one major reason for high feedstock costs. As a consequence of the microbial activity and further exothermic processes, heat is produced inside stored piles, leading to temperatures >200 °C, causing partial pyrolysis and self-ignition. This work investigates the degradation process of spruce forest residues in order to generate a better knowledge about underlying processes and possible counteractions.

Therefore, the microbial metabolic activity has been described in dependency on the temperature, moisture content (MC), pH as well as the woodchip quality by respirometric tests. Additionally, temperature and gas measurements have been conducted in woodchip piles of commercial size.

Respirometric tests revealed the microbial activity over time showing a maximum within the first few days of storage. This corresponds to the measurements at woodchip stocks. This initial activity is responsible for the very high temperatures inside the woodchip piles reaching up to 80 °C within the first week. The moisture content is a key factor during wood degradation. No microbial activity could be verified for a MC<20 %. A moisture content of 46 % led to a monthly dry matter loss of 5.4 %. Also the pH plays an important role. Raising the pH from 7.5 to 9.0 by adding calcium carbonate reduced the monthly dry matter loss from 3.3 % to 1.8 % per month. Further investigations have to be conducted to clarify underlying mechanism and countermeasures. This issue does not only apply for woodchips but also for other biomass products that need to be stored over a period of time.

Keywords: Biomass, Dry matter loss, Self-ignition, Storage; Woodchips

Corresponding author: Sabrina Dumfort
Sabrina.dumfort@mci.edu
+43 512 2070-3251

Minigrid electricity service based on renewable generation for isolated or rural areas: sizing criteria, management and sustainability models, and case studies in Africa and Europe

Arranz-Piera, P*, Velo, E[1], Kemausuor, F[2]

[*, 1] *UPC Technical University of Catalonia. Diagonal, 647,Barcelona 08028, Spain*
[2]*Department of Agricultural and Biosystems Engineering, College of Engineering, Kwame Nkrumah University of Science and Technology, Ghana*

Clean mini-grids (distributed energy generation and distribution systems based on renewable sources) are already a technological and operational reality worldwide, totally mature and able to supply grid-equivalent electricity services, particularly in rural and peri-urban areas with low population and remote from the national transmission grid.

In rural or isolated locations, the traditional extension of national electricity networks is technically and financially inefficient because of a combination of factors: (i) high investment costs, (ii) deficient grid supply (brown-outs, blackouts), (iii) long construction times, (iv) mid and long term increases of fossil fuels prices, (v) the recognition of the environmental benefit of renewable energy technologies, among other challenges to connect remote areas (e.g. submarine connections to islands, or security related aspects in areas with conflicts).

Properly designed and financed mini-grids, operated under an appropriate service scheme, are a suitable alternative to traditional electrification programmes, perfectly ready to be rolled out by public and private developers and accepted by customers and electricity sector actors in general.

This paper analyses the four (4) key components that conform sustainable electricity services from mini-grids (Social Development, Technical Reliability, Organisational Empowerment and Financial Viability), and describes case studies from existing mini-grids in Europe and Africa.

The recommended steps for financial analysis are: Twenty-year Life cycle and Annual flow of costs and revenues; discounted cash flow analysis (i.e. considering a discount rate); Cost breakdown by typology: (i) Capital (ii) fixed M&O&M (iii) Fuel; consideration of several technology options, and calculation of the specific costs breakdown for each of them (levelised cost US$/kWh, costs per connection).

Keywords: Rural electrification, Sustainability, Electricity services, mini-grids.

Corresponding author: Pol Arranz-Piera
pol.arranz.piera@upc.edu
+34 637975662

Parametric sensitivity in sunflower oil ethanolysis using Shea nut shell based catalyst

Aristide Dejean* [1, 2], Igor W.K. Ouedraogo[1], Sylvie Mouras [2], Jeremy Valette[2] and Joel Blin[1, 2]

[1] *Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), Laboratoire Biomasse Energie et Biocarburants (LBEB), Rue de la Science, 01 BP 594, Ouagadougou 01, Burkina Faso*
[2] *CIRAD, UPR BioWooEB, F-34398 Montpellier, France*

The present work reports the production of ethanolic biodiesel with a carbon based catalyst. Shea (*Vitellaria paradoxa*) nut shells (SNS) were used as raw material to prepare carbon based catalyst by chemical activation with potassium hydroxide (KOH). The catalysts were characterized by XRD, EDX, SEM, ICP/OES and FTIR. The influence of ethanolysis reaction parameters including reaction temperature, reaction time, catalyst loading, ethanol to oil molar ratio and reaction stirring speed were investigated to identify the optimal conditions. With the optimal and highly stable catalyst prepared at a pyrolysis temperature of around 650 °C, 120 min pyrolysis residence time and a KOH to SNS ratio of 14 wt%, a conversion yield of 98% was obtained using the following transesterification conditions: 30 °C reaction temperature, 30 min reaction time, a 12:1 ethanol to oil molar ratio, catalyst loading of 10 wt% (oil weight basis) and a stirring speed of 650 rpm. The catalytic activity was linked to the development of active species of K_2CO_3. The catalyst lost activity when water was present in the ethanol, conversion yield decreased to respectively 86% and 72% at 2% and 5% ethanol water content. Catalyst recyclability and stability were investigated. The catalyst was used 3 times and catalyst activity was still 75.7% at the third run after regeneration of the catalyst by thermal treatment.

Keywords: Biodiesel; Shea nut shell; Carbon based catalyst; Ethanolysis; Parametric sensitivity.

Corresponding author: Aristide Dejean
daristide5@hotmail.com
+22664531044

Promoting rural electrification in Sub-Saharan Africa: Least-cost modeling of decentralized energy-water-food systems

J. Winklmaier*, S. Bazan[1], T. Hamacher[1]

*, [1] *Chair of Renewable and Sustainable Energy Systems, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany*

Two major obstacles for economic development in Sub-Saharan Africa (SSA) are limited purchase power and insufficient access to affordable and reliable electricity, especially in rural areas. The outstanding solar potential in SSA enables significantly cheaper levelized costs of electricity for decentral solar systems compared to the commonly used diesel generators. Yet, the limited purchase power in SSA impedes rural electrification by solar systems due to their high investment costs.

Decentralized Energy-Water-Food systems have the potential to solve this problem. Using solar-powered water pumps, rural communities can supply water for drinking and irrigation. Thereby, agriculture does not depend on rainfall solely and can be done all over the year, which leads to increasing productivity. The increased crop production reduces the community´s expenses for nutrition and enables profit by sales, which in turn enables a payback of the initial investment costs of the solar system. The increased amount of biomass waste enables economically feasible small-scale biogas production. The biogas can be used for cooking and for electricity production by biogas motors. These motors can supply private, social or small commercial loads, which enhance the local productivity even more.

To identify the least-cost system design, the linear optimization model *urbs* was adapted. *urbs* was developed for energy system modeling, yet its sector coupling feature allows to add processes like water pumps and commodities such as biogas. The available amount of ground water is implemented based on GIS data and the possible types of crops are restricted based on soil data and agricultural habits in the respective region.

The modelling results shall support local governments and entrepreneurs in their decision making. A Zimbabwean community recently started to implement an energy-water-food system according to the results of the model, which has already improved the living quality of the local population significantly.

Keywords: Decentralized renewable energy solutions; Energy-water-food systems; Biogas; Least-cost modeling; Economic development

Corresponding author: Johannes Winklmaier
Johannes.Winklmaier@tum.de
+49 179 9757475

Assessment of decentralized hybrid mini-grids in Sub-Saharan Africa: Market analysis, Least-cost modelling, and Job creation analysis

A. Okunlola*, E. Osamudiame[1], H. Zaheer[2], J.Winklmaier[3]

** Institute of Advanced Sustainability Studies, Berliner Strasse 130, 14467 Potsdam, Germany*

[1]*ILF BERATENDE INGENIEURE GmbH, Werner-Eckert-Strasse 7, 81829 Munich, Germany*

[2] *Power and Technology Research LLC, Firkenweg 5, 85774 Unterföhring, Germany*

[3]*Chair of Renewable and Sustainable Energy Systems, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany*

With a growing impetus to meet energy demands through decentralized hybrid mini-grids in rural and semi-urban locations in Sub-Saharan Africa (SSA), the need to accurately assess the market drivers, policy requirements, and job creation impacts of this energy system typology within this region cannot be ignored. This work provides a techno-economic impact analysis of decentralized hybrid energy systems in selected locations in SSA.

To optimally satisfy an electricity demand time series for a year and minimize all cost components amortized over a period of 20 years, a least-cost modelling approach and tool; *urbs* is applied. Applying Employment Factors methodology to the system sizing results obtained from *urbs*, the direct jobs created across the value chain is determined for each region. The backward linkage economy-wide-jobs created is further estimated by Leontief Inverse Input – Output table model.Preliminary results obtained show that “Solar + Wind + Diesel + Battery” hybrid system (SWDB) had the lowest Levelized Cost of Electricity (LCOE), thus it provided the cheapest means of meeting the electricity demand in the modelled regions. However, the highest locally created direct and net employment impact in the model locations is provided by “Wind + Storage” (WS) system. Additionally, two major sectors: Manufacturing and Agriculture had the largest backward linkage jobs in the local economy for all decentralized hybrid systems analyzed. This occurs due to higher interlinkage between these sectors and productive energy use in the regions. Conversely, despite higher employment impacts obtained for WS, the cost and length of time needed for wind resource mapping and assessment served as a major bottleneck to WS systems market access in the regions. Sensitivity analysis results obtained further suggest that by de-risking macro-economic factors such as: Discount rates and Inflation, improved market access for decentralized renewable energy mini-grids can be realized in Sub–Saharan Africa.

Keywords: Decentralized hybrid energy systems; Electricity access; Job creation; Employment Impact; Least-cost energy system modelling

Corresponding Author: Ayodeji Okunlola
ayodeji.okunlola@iass-potsdam.de

Development of a methodology to assess the lifespan of Pico PV systems

Neeraj Joshi*
Carl von Ossietzky Universität Oldenburg, Carl von Ossietzky Str. 9 – 11, D-26111 Oldenburg, Germany

In the Rural electrification domain, Pico PV systems are playing a key role in increasing electricity access. Most of the energy access programs funded by Donors and managed by Development organizations are implemented using Pico PV to provide affordable & clean energy to users at the base of the pyramid. However, there is a big information gap on the lifespan of these systems, currently assumed equal to the warranty years of the product sold by supplier, that is 2 years. However, the real lifespan of these devices can be longer or shorter than the warranty period. To investigate this issue in a comprehensive manner, and estimate the real lifespan of the Pico PV devices, the project is developing a methodology and testing it in Kenya, which off late has witnessed a rapid growth in off-grid electrification by implementing Pico PV solutions.

The intended outcomes are:

a) Estimation of lifespan including deviation calculations from assumed lifespan (2 years warranty) of Pico PV systems sold in Kenya.
b) Analyzing the concept of lifespan from user point of view and when does the lifespan of a Pico PV device ends.
c) Identification of the factors that contribute to lifespan of Pico PV devices (e.g. social such as user behavior, total usage time, etc.) but also technical (in case of failure, which parts break down first).

Currently, the field studies are undergoing in Kenya and the project will finish by November 2017.

Keywords: Pico PV; Lifespan; Methodology; Warranty; User

Corresponding author: Neeraj Joshi
neerajalok@gmail.com
+49-157-78686245

Developing a Low Cost Real-Time SMS Feedback Tool for Off-grid Household Electricity Consumption *(Poster)*

Tonny Kukeera*[,2], Setu Pelz[2,3], Sebastian Groh[4] , Noara Kebir[2]

**Pan African University Institute of Water and Energy Sciences (Including Climate Change) – B.P. 119, Pole Chetouane 13000 Tlemcen – Algeria*
[2]MicroEnergy International GmbH Potsdamer Str. 143 – 10783 Berlin, Germany
[3]Department of Energy and Environmental Management, Europa-Universität Flensburg, Germany
[4]North South University, Dhaka, Bangladesh – School of Business and Economics

With national grid access standing at levels as low as 1 out of 20 in Burundi, Liberia and other African countries, off-grid energy systems are proving themselves to be a reliable technology towards a solution for many of Sub-Saharan Africa's (SSA) energy access problems. Investments in the off-grid industry have grown 15-fold since 2012 to $276 million in 2015 with Pay-As-You-Go companies taking over 87% of the investments. It is estimated that 1 in 3 off-grid households globally will use off-grid solar by 2020, however, the off-grid system still suffers from problems, the main ones being capacity limitation, and ensuring energy efficiency (EE) amidst operation and maintenance/user errors, a topic that in the past has often been overlooked. EE is a very critical part of energy systems because by boosting the efficiency of production, storage and distribution processes, it frees up currently wasted energy resources and boosts the battery lifespan. Therefore, in the move to ensure sustainable and equitable energy access, EE is an indispensable part that cannot be ignored in developing economies. In this study, a low cost real-time SMS tool that informs off-grid households of their electricity consumption through short text messages on their phones is developed. By informing users of their energy consumption, it is anticipated that energy awareness is enhanced thereby influencing users' behaviors and hence promoting EE. Besides awareness, majority of energy users often lack sufficient knowledge and skills to reduce their energy consumption. The tool provides timely feedback about consumption through simple and understandable text messages. The algorithm collects data from the three main parts of the solar system i.e. power generation, storage and consumption. The paper demonstrates that it is possible to avail consumption information timely to off-grid households and this could be used to improve EE.

Keywords: Energy Efficiency; Off-grid Energy; SMS; Feedback; Pay-AS-You-Go

Corresponding author: Tonny Kukeera
tonnykukeera@gmail.com
+213 552 600 105

Energy decentralization in Rwanda *(Poster)*

D. Nshimiyimana* and A. Khellaf[2]

**PAUWES Institute, Panafrican University, Pole de Chetouane, Tlemcen, Algeria.*
[2]Centre de Développement des Energies Renouvelables, BP62, Bouzareah, Algiers, Algeria.

Energy has been described as the 'missing' Millennium Development Goal (MDG), the catalyst without which other goals such as health, education and gender equality cannot be achieved. Rwanda has significant renewable energy resources. Despite those resources, Rwanda electrification rate is still very low at only 23% and most of remote and rural areas are not connected to the grid network due to the insufficient power production and high capital cost for grid network extension. It was reported that by the end of 2015 the installed electric power was at 177.2MW and the energy consumption from modern energy was dominated by hydro with 137.5MW followed by 28.5MW of thermal and 11.15MW coming from solar. Compared to the renewable energy resources that the country is endowed with, this value has to improve. In order to achieve the sustainable energy for all, the use of renewable energy and energy decentralization are considered as the most cost-effective ways that will facilitate the population for having access to energy. As it is mostly known that households are the main consumers of energy and within the pressing challenges of rapid energy demand, increased pollution and need to integrate renewable energy sources into the existing grid; energy decentralization has become an ever important solution. By gradually changing the energy distribution method, decentralization may evolve by means of resources and strategies but its fundamental objective which is mainly to satisfy the side demands will not change.

The paper presents the Rwanda renewable energy potential. It gives a clear view on the energy demands side and goes ahead discussing on the decentralization of different modern energy technologies.

Keywords: Renewable energy; Households; Decentralization; Energy technology; Sustainable energy

Corresponding author: Nshimiyimana Devotha
n.dedevota@gmail.com
+250 783 814 308

Scales of rural photovoltaics – considerations assisting deployment

(Poster)

Erik O. Ahlgren*

Department of Space, Earth and Environmental Sciences,
Chalmers University of Technology, 412 96 Göteborg, Sweden

Photovoltaics (PV) is often claimed not to provide the necessary power output required for rural village electrification when the electricity provision concerns not only households but also businesses, so-called productive use. It is, however, the hypotheses of this study that a closer inspection of demand load curves of the various village demands will show that the cost-effectiveness of PV could be greatly improved by addressing system optimisation over temporal and spatial scales.

For small, isolated systems supply-demand interactions grow in importance due to limitations is redundancy. Since PV has its major comparative advantages in off-grid power supply and often is deployed in small, decentralized applications the supply-demand interactions are of large importance for successful PV deployment. Thus, knowledge of the electricity demand is a key to PV deployment success.

The study is based on a comparison of load curves and interview-based data on demand development in already electrified villages in rural Tanzania. Two types of temporal scales are addressed, the short-term variations of the demand during the day, and the long-term development of demand with time after electrification. The spatial scales involve the step-wise process of connection of the various loads until a partial or full mini-grid is evolving.

The results show that there are large differences in terms of load curve characteristics between the different demand categories and, thus, that there are considerable possible benefits from a partial or full connection of the various demands. This, in turn, is linked to important possible cost-efficiency improvements, and results in the possibility of productive use electrification by PV. It also has implications for the PV-battery design balancing.

Keywords: Photovoltaics; rural electrification; demand load curves; system optimisation

Corresponding author: Erik O. Ahlgren
erik.ahlgren@chalmers.se
+46 73 079 4214

Development of a pilot passive solar distillation plant for *Dan-Jirima* community health post, Kano-Nigeria *(Poster)*

Adamu, A. A[1], Adeyemi, K.O.[2]* and Hassan, S. I[3].

[1]*Department of Mechanical Engineering, Bayero University, Kano, Nigeria,*
[2]**Department of Mechanical Engineering, University of Abuja, Nigeria;*
[3]*National Agency for Science and Engineering Infrastructure Abuja, Nigeria.*

Many rural communities in Nigeria including the Dan-Jirima community in Kumbotso LGA of Kano state, lack access to clean portable water and mostly depend on sources that are largely unhygienic, including flowing or stagnant bodies of water and wells. Some of these rural communities host primary health posts whose operations are often impeded by a lack of clean water for sterilization and other clinical uses as well as for consumption by both staff and patients. One most promising way to address the problem of lack of access to clean water for these health posts is the establishment of water distillers, using solar energy as the renewable energy source. A solar still plant was designed and constructed to meet the water requirements of a rural health post in Kano, Nigeria. The plant, consisting of four identical units, each incorporated with a porous cloth wick material and blackened gravel for thermal storage, was test-run using river and well water as sources of unpurified water at basin depths of 20 mm, 30 mm and 40 mm. The total daily distillate yield were 7.40 liters/m2/day, 6.75 liters/m2/day, and 5.71 liters/m2/day for respective depths of basin water for the river water, while for the well water, the corresponding values were 6.96 liters/m2/day, 6.17 liters/m2/day, and 5.62 liters/m2/day. The mean efficiencies were 32.1% when river water was used and 25.8% when well water was used, thus bringing the overall efficiency of the plant to 28.9%. Further, it was noted that significant distillate production above 1 liter/hour began at 11:30 hour, at basin water temperatures above 55 ºC and at an average solar radiation of 850 W/m2 for the river water and 890 W/m2 for the well water. Lastly, the continued accumulation of distillate above 1 liter/hour at the mean basin water temperature of 55ºC even after peak period hour and even with declining solar radiation was attributable to the use of storage media in the still, which gives out the needed heat when the solar radiation declined. It is recommended that a thorough economic analysis of the still plant be undertaken in order to further reveal the attractiveness of the project for further improvement and implementation by stakeholders, as well as a bacteriological and mineralogical test of the distillate, so as to enable steps to be taken to restore, if necessary, vital minerals, that may have been lost in the course of distillation.

Keywords: Distillate; Transmissivity; Latent heat; Thermal storage; Solar radiation.

Corresponding Author: Kafayat Adeyemi
Kafayat.adeyemi@uniabuja.edu.ng
+2348067156254

Comparison of Power Conversion Techniques for Rural Electrification
(Poster)

A. Mohapatra*, A. K. Seppälä[1]

[1] *Chair of Renewable and Sustainable Energy Systems, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany*

Over a billion people worldwide have no access to electricity, which effectively hinders their economic and social development. The problem is most apparent in rural and developing regions where extending the national power grid is neither easy nor economically feasible. The majority of these areas are situated in sub-Saharan Africa and Southeast Asia.

Providing access to reliable, affordable and sustainable energy would help lift communities out of poverty, and mitigate environmental impacts of future economic development. Small off-grid systems have the potential to do so by supplying communities with flexible energy solutions, but due to the variability of renewable energy sources, efficient power conversion systems are a necessity. However, cost reductions are still needed in such systems to make them feasible in low-income scenarios, and to ensure the systems will easily be extended in the future.

This study focuses on comparing existing power conversion techniques in small off-grid systems in rural and developing areas, and will exhaustively discuss the advantages and drawbacks of traditional methods, such as transformers, and more modern technologies that utilise power electronics components. In the latter case, a distinction is made between high-tech and possibly self-made, low-cost solutions. Moreover, various system architectures and DC/AC power distribution shall be considered. The main emphasis is given to finding an optimal method in terms of cost and efficiency.

The aim of the study is to show the potential of low-cost conversion technologies in low-power off-grids for the promotion of rural electrification in low-income regions. This objective is reached by means of a literature review and cost analysis of the most prevalent power conversion strategies.

Keywords: Rural electrification, Power conversion, Off-grid, Sustainable development, Power electronics

Corresponding author: Anurag Mohapatra
Anurag.Mohapatra@tum.de
+49 152 58436614

Chapter 3: Power Generation, Distribution and Transmission (RERIS)

Prospects For Electricity Generation From The Wind Potential Of Zamala In Cameroon

Kazet Y. M.* and Mouangue R.[1]

*Department of GEEA, PAI, ENSAI, University of Ngaoundere, Cameroon.
[1] Depart. of Energy Engineering, UIT, Po Box 455, Ngaoundere, Cameroon

Promoting sustainable development and combating climate change have become integral aspects of energy planning, analysis and policy making in many countries. Zamala is a village of about 500 people, around the town of Maroua in the Far North Region of Cameroon. The lack of electricity is a brake on the well-being of this population and this limits the growth of their economic activity which is mainly based on agriculture and cattle farming. In this study, we have investigated the possibility to consider a small wind farm as a decentralised household energy solution. For this purpose, different kinds of data have been collected about climate, topography, and wind. The Observed Wind Climate of the meteorological station has been made. The Wind Atlas has been calculated, especially in the high wind resource areas. Also, a wind resource map has been drawn in order to select the best site for the wind power plant. From our assessment, the mean wind speed is 4.5 m/s and the power density is 101 W/m2; this result illustrates the strong potential of our site. Annual Energy Production of our hypothetical wind farm consisting of six Nordex wind turbines has been computed using the WAsP software. The computed Annual Energy Production is 16,330 MWh which represents the annual electricity consumption of more than 5,000 people. The additional energy production could be connected to the electricity grid of Maroua. We are expecting that with the Africa - EU research collaborations, the involvement of public and private investors, this project could come true and hence solve the problem faced by the people living in that rural area.

Keywords: Wind energy; Resource assessment; Wind farm; Electricity generation,

Corresponding author: Myrin Kazet
myrin_kz@yahoo.fr
+237 699 99 44 78

Printing Powder-based Photovoltaic Modules. An appropriate technology to make African countries energy-self sufficient

Meissner, D.*

Department of Materials and Environmental Technology,
Tallinn University of Technology, Ehitajate tee 5, 19086 Tallinn, Estonia,
and crystalsol GmbH, Am Kanal 27. 1110 Wien, Austria

The prices for solar electricity have dropped constantly since several decades already reaching the level of consumer costs in most countries of the world today and will decrease further.

Thereby photovoltaics will enable all countries to electrify energy supply in decentralized and sustainable ways, if the necessary technology can also be produced within the country. Crystalsol has developed a technology allowing the production of photovoltaic modules based on standard printing of stable semiconductor powders, which can easily be shipped from powder production facilities anywhere in the world. Thereby every country can become largely self-sufficient in terms of energy supply and with falling costs provide electricity for very low costs even in remote areas.

In this talk after an introductory part underlining the key importance of energy supply for a sustainable development and discussing the past and future of solar electricity prices, crystalsol´s technology will be explained. It will be demonstrated how this technology will empower basically all countries to not only use solar energy for extremely low costs, but also to produce the necessary devices in their own control largely avoiding further exploitation by developed countries.

Keywords: Solar Energy, Sustainability, Self-sufficiency, Photovoltaics, Printing

Corresponding author: Dieter Meissener
dieter.meissner@ttu.ee

Feasibility study of linear Fresnel solar thermal power plant in Algeria

Hani Beltagy*[1], Sofiane Mihoub[2], Noureddine Said[3] and Hamid Ajdad[4]

[1]*Hydrogen Energy Applications Laboratory (LApEH), Mechanical Engineering Department, University of Blida, Algeria*
[2]*Research Unit of Materials and Renewable Energies (URMER), Abou Bakr Belkaid University, Tlemcen, Algeria*
[3]*Renewable Energy Development Center (EPST/CDER), Bouzareah, Algiers, Algeria*
[4]*Renewable Energy Team, Department of Energy, Ecole Nationale Sup_erieure d'Arts et Métiers, Moulay Ismail University, Meknes, Morocco*

Because of clean renewable electric power technologies is the human's future, a great number of thermal solar power plants with different configurations are being considered for deployment in different locations in Algeria. It is necessary to study the operating performance of the concentrator solar power plant located in typical sites of Algeria, in this work for reference of the feasibility study of this technology in Algeria, it is essential that the plant designs will be optimized for each specific location. The aim of this work is to describe the characteristics of a Fresnel solar power plant at different areas of Algeria Sahara. These areas have been chosen for comparison by shifting the plant to different locations; namely Hassi R'mel, Tamanrasset, Beni-Abbes, and El Oued. A specification has been developed in which plant characteristics namely: direct Normal Irradiance (DNI), solar field surface, block number, have been defined. The block surface, block panels' number, absorber surface, and finally thermal power losses in the absorber have been defined also. The calculation results have been depicted for each site. Indeed, the calculation of performance varies from a site to another with DNI mean values of 788.4W/m^2, 698.7W/m^2, 671.7W/m^2, and 636W/m^2, respectively for Tamanrasset, Beni-Abbes, El Oued and Hassi R'mel sites. The surface of solar field, block number, absorber surface and power loss have been also evaluated for the same sites.

Keywords: solar energy; solar concentrator mirrors; Fresnel solar thermal power plants; performance; thermoelectric plants

Corresponding Author: Hani Beltagy
hani.beltagy@gmail.com
+213 551464592

Aspen simulation of Hybrid Concentrated Solar Power - Biomass Integrated Gasification Combined Cycle Process *(Poster)*

Shahid H Ansari[1], Xinying Liu[1,*], Maria Fernandez-Torres[1,2]

[1]Material and Process Synthesis Engineering, University of South Africa, Private Bag X6, Florida, Johannesburg, South Africa, 1710.
[2]Department of Chemical Engineering, University of Alicante, Apdo 99, Alicante, Spain

Biomass integrated gasification combined cycle has been used for power production from biomass. It is a process where biomass is partially combusted in a gasification unit to produce synthetic gas, which is combusted in a synthetic fired generation unit to produce electricity. The excess heat from gasification and synthetic fired generation is then passed to a steam cycle. This process results in improved thermal efficiency compared to direct biomass combustion, and less pollutants as the impurities in the synthetic gas can be removed before sent to the synthetic gas fired generation unit. The biomass gasification process is endothermic and normally operated at very high temperature. The heat and temperature needed for the biomass gasification is normally provided by combustion of biomass, inside the gasification unit or externally. This results a higher carbon dioxide emission. Concentrated solar power (CSP), which is a renewable energy resource collected from a solar collector and stored at high temperature, has potential to be used to provide energy for biomass gasification. The application of CSP can reduce the carbon dioxide emission. In this study, an Aspen simulation was conducted to simulate the hybrid CSP-IGCC process. Biomass gasification process with internal combustion and external combustion were both simulated in Aspen using thermodynamic equilibrium model. The option of co-production of bio-char from a carbonizer was also studied. It is found that the heat storage temperature from CSP system needed for the hybrid CSP-IGCC process is feasible with current CSP technology. The energy efficiency of the hybrid CSP-IGCC process is higher than biomass IGCC process only as well as CSP.

Keywords: Biomass; Integrated Gasification Combined Cycle; Concentrated Solar Power; Hybrid CSP-IGCC; Bio-Char

Corresponding author: Xinying Liu
xyliu.wits@gmail.com
+27722868656

Chapter 4: Energy Research, Innovation, Education and Entrepreneurship (RERIS)

Entrepreneurship as a Leverage for Innovative Energy Technologies in Africa: An Investigation of the Entrepreneurial Framework in Zimbabwe

H. Ben Charrada*; J. Winklmaier[1]

** TUM Entrepreneurship Research Institute, Technical University of Munich*
Lichtenbergstrasse 6, 85748 Garching, Germany
[1] Chair of Renewable and Sustainable Energy Systems, Technical University of Munich,
Lichtenbergstrasse 4a, 85748 Garching, Germany

The development of decentralized energy technologies is expected to keep creating new market opportunities in energy supply in the African countries, which still face challenges in secring a clean and safe energy access for its population (Silvia Escudero, Josephine Zana 2017). These market opportunities can be targets for entrepreneurs, whose role is to discover arbitrage opportunities in the market such as unmet needs and/or undervalued resources (Levie, Autio 2008; Kirzner 1997). African entrepreneurs can play hence a crucial role in the market development of innovative energy systems in Africa.

However, the economic and institutional framework in many African countries differs considerably from the framework in renowned entrepreneurial developed countries and may constitute a challenge for African entrepreneurs. This study aims to examine the entrepreneurial framework within an African economy, in order to point out the challenges and chances for the African entrepreneur. A systematic approach based on the GEM conceptual model (Reynolds et al. 2005) is assumed to investigate the interactions of the entrepreneurs with the whole entrepreneurial framework. For the entrepreneurs, the motivation, skills and attitudes are pointed out and analyzed. On the other side, the entrepreneurial framework is fragmented into its different constituents, where the role of each is analyzed according to its role and influence. A mapping of the whole ecosystem comprising roles and interactions is then deduced. Moreover, the role of entrepreneurial innovation through technology is investigated. Additionally, the gender issue in entrepreneurship is observed. Based on this overview, recommendations for further enabling of entrepreneurial activity in the African markets are concluded especially in terms on entrepreneurial and technical training. The observed case study in this work is the entrepreneurial ecosystem in Zimbabwe. The findings are based on a qualitative research based on interviews with entrepreneurs and experts in Harare.

Keywords: Entrepreneurship; Entrepreneurial framework; Entrepreneurial ecosystem; Africa; Technological innovation

Corresponding author: Hajer Ben Charrada
hajer.ben-charrada@tum.de
+49 157 51897895

Promotion of energy research, innovation and entrepreneurship by bilateral and international projects between Tunisian research center and private/public European institutions

M. Barbouchea*, R. Chtourou, H. Ezzaouia, A. Guizani, S. Ben Mabrouk and B. Bessais

Research and technologies center of energy CRTEn, HammamLif 2050, Tunisia

Bilateral and international projects present a very important framework for cooperation between research and industrial institutions from European and African countries. In this paper, we present some success stories of research and technologies center of energy (CRTEn) in Tunisia with these projects.

In the framework of seventh Framework Program for research and technological development 'FP7', a desalination plant operating by photovoltaic and wind energy was installed in CRTEn. The electricity produced by the hybrid system is also injected into the grid through a robust and smart installation with performance supervision system. In the same framework, CRTEn was a partner in international project called ETRERA aiming to knowledge transfer on fuel cells technology. In this context, PEMFC membranes were synthesized and test station was developed. The success of this project made the extension of African-European cooperation possible in the framework of 'Horizon2020'. Consequently, CRTEn was selected as a partner in the energy consortium 'ETRERA2020' with more than 8 partners from Europe and North Africa. In this context, many activities were carried out like workshops organization, visits of CRTEn's engineers to industrial companies in Europe, and training courses on patenting and intellectual property to develop the entrepreneurship of CRTEn staff and bridge the gap between research and innovation. On another hand, in the framework of Italian-Tunisian bilateral cooperation project, 15KW photovoltaic field was installed in both CRTEn and Valderice municipality in Italy. Using smart inverters, produced electricity can be injected to grid or directly supply an off-grid network inside CRTEn. Also, the cooperation between CRTEn and Turkish research center allowed to synthesize high efficiency solar cells in clean room using silicon carbide as passivating layers.

Projects presented above allowed to setup decentralized and grid connected renewable energy, to face financial problems and to promote energy research, innovation and entrepreneurship within CRTEn.

Keywords: African-European cooperation; Photovoltaic system; Fuel cell; Innovation; Entrepreneurship

Corresponding Author: M. Barbouchea
mohamed.barbouche@crten.rnrt.tn

The Status of Large-Scale Solar Thermal Systems for Industrial Applications in South Africa and the Promotion of Solar Thermal Research at CRSES, Stellenbosch University

Buckley A.I*, Mamphweli S. and Kritzinger K

Stellenbosch University, Centre for Renewable and Sustainable Energy Studies, Private Bag X1, Matieland, 7602, South Africa

The study aims at presenting recent key findings and field experiences in the field while promoting the solar thermal (ST) research and projects done by the Centre for Renewable and Sustainable Energy Studies (CRSES). The study builds on the work done by Joubert et al. (2016), entitled “Large-scale solar water heating in South Africa: Status, barriers and recommendations” by discussing the updated large-scale ST database of CRSES. This is aimed at providing an overview of the current status of large-scale ST installations in South Africa. This database includes information such as the year of installation, provincial location, type of application, beneficiary industry and specific ST technology used. During 2016, CRSES was contracted to conduct a feasibility study, draft the technical specifications and provide technical advisory services for the tender evaluation process of a leather tannery located in the Western Cape, South Africa. This feasibility study identified that a 500 m2 collector area would be able to supply a total of 531 MWh/year of thermal energy, covering 61% of the company’s annual heat demand and saving the company a total of 68 m3 of HFO annually. The total system cost is estimated at R 2 350 000 and presents a payback period of 7 years with a project IRR of 31%. The project was released on tender and a total of 9 proposals were received. This study presents the key findings related to technical aspects and financial outcomes of this feasibility study and provides a detailed system and component costing comparison, based on tender proposals, with the costs based on those shown by Joubert et al. (2016) for the Cape Brewing Company (CBC) Solar Thermal project, done under CRSES. The study also presents the data and key findings of the monitoring systems installed at two of the Soltrain solar water heating (SWH) demonstration systems in the Western Cape over the past year. Furthermore, it presents means in which this monitoring data, as well as data from SWH systems planned to be equipped with monitoring devices, can be used for the validation of decentralised ST system modelling and simulations, allowing more accurate research outputs and feasibility studies from within CRSES, related to the field.

Keywords: Solar thermal, Database, Soltrain monitoring data, CRSES, Tannery ST project

Corresponding author: Angelo Ian Buckley
buckley@sun.ac.za
+27 21 808 4251

De-Colonising Power Supply in Cameroon: A Community Entrepreneurship Approach

Atembe Roland*

Department of Strategic Management, Marketing and Tourism
School of Management, University of Innsbruck
Karl-Rahner-Platz 3, 6020 Innsbruck, Austria

Energy is an indispensable resource for promoting economic activities and the enhancement of human welfare. This realisation underpins extensive research works in the field of energy and the environment in order to address socio economic issues such as poverty, income disparity, energy availability, accessibility and affordability within communities. But in sub-Sahara Africa, two in every three people significantly suffers from access to electricity. This is due to dysfunctional energy governance of the colonial hydro power systems and structures. Extensive studies advocate for decentralized energy systems and technologies in providing access to electricity; as well as associated investment requirements such as the grid energy paradigm. Nevertheless, previous studies on grid energy have predominantly focused on individual and groups ownership. Far too little attention has been paid to community investment and management of the energy systems. This research draws on the social capital and resilience theory, to critically examine the perceptions and reactions of community members towards investment and governance of energy supply in Cameroon. The qualitative case study approach was utilised. The in-depth interview technique was used to collect data from the South West Region of Cameroon. Findings reveal that communities were very anxious and willing to invest in the energy system. Evidence indicates that collective action of informal financial institutions can form the basis for community investment in energy thereby employing social cultural management systems. The study argues that there is a need for holistic resilience in the entire energy process from decision making, financing ownership, management and control using the bottom top approach. The study concludes that local community involvement is significantly needed to manage sustainable energy supply system in Cameroon. It also shows how community involvement model has been operationalized in other sectors.

Keywords: Energy; Electricity Supply; Sustainable Energy System; Community; Entrepreneurship; Cameroon

Corresponding Author: Roland Atembe
Roland.Atembe@student.uibk.ac.at
roatembe@gmail.com
0043 6606566805

Cost-Efficient and Simple Hands-On Experiments for Education in Renewable Energy Systems *(Poster)*

A. Mohapatra*, J. Krell[1], S. Baur[2]

*, [2] Chair of Renewable and Sustainable Energy Systems, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany
[1] Chair of Vocational Education, TUM School of Education, Technical University of Munich, Marsstraße 20, 80335 Munich, Germany

Active learning and practice-oriented teaching stimulates the student abilities and improves their performance significantly in comparison to traditional lectures. However, most practical lessons in renewable energy are restricted to demonstration sessions run by an instructor handling expensive equipment or limited field trips where students observe the plants at a distance. The unidirectional lecturing and lack of hands-on exposure further alienates the students and makes renewable technology seem mysterious. The writers propose a hands-on education framework suitable for university and high school students which explains a vast majority of photovoltaic (PV) and wind energy concepts through simple experiments using low-cost equipment for classrooms of up to 30 students. Proposed experiments cover PV and wind power equipment, installation, functionality, controllers, dependency on physical factors, and storage sizing along with basics of electrical engineering required to understand a decentralized grid structure. Students are divided into groups of five to encourage collective learning and team-work. The teachers introduce the core principles through a short lecture like presentation at the beginning of the lesson. The cohesion of the sub-tasks ensures that the students remain motivated throughout the course. Students are expected to analyze the results using computer tools (e.g. free spreadsheet processors) which further the active learning process. These individual sessions are followed by a student project addressing a real world scenario, such as a proposal for a new PV and storage installation in a neighbourhood building, which will require the students to bring together aspects from the experiment modules. This methodology has been successfully implemented in Rupert Mayer High School, Makonde, Zimbabwe in a workshop organized by TU Munich for 22 high school students. A university-level version of the same course is created by deepening the curriculum and by using advanced data visualization, sensors for feedback measurement and Raspberry-Pi for data logging and analysis.

Keywords: Renewable energy education; Active learning; Hands-on education; Low-cost equipment; Group work

Corresponding author: Anurag Mohapatra
Anurag.Mohapatra@tum.de
+49 152 58436614

Decentralized Energy-Water- Food systems in Africa: Space Analysis, Least-cost modelling of sack farming and establishment of renewable energy technologies in the Diepsloot slums of Johannesburg, South Africa *(Poster)*

T. Klöffel*, M. Beyers[1], K. Rajadurai [2], M. Mabaso[3], J. Bhanye[4], J. Winklmaier[5]

*, [1]*Department of Civil, Geo and Environmental Engineering, Technical University of Munich, Arcisstr. 21, 80333 Munich, Germany*
[2]*Division of Resource Management, TUM School of Life Sciences Weihenstephan Technical University of Munich, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany*
[3]*Department of Industrial Engineering, Stellenbosch University, RSA*
[4]*Center for Applied Social Sciences (CASS), University of Zimbabwe, Zimbabwe*
[5]*Munich School of Engineering, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany*
[1, 2, 3, 4, 5] *TUM Summer School on Energy, Water and Food Technologies in Africa*

UNICEF projects South Africa to have a staggering 80% of the population living in urban areas by 2050. Poor urban planning and unavailability of affordable low cost housing will force the underprivileged population to overcrowded slums. Thus, creating a sustainable solution incorporating energy-water-food nexus to aid these sectors of population will become a defining impetus of modern societies. Analysis of past rainfall and climate trends in Diepsloot show that it is an ideal location for urban farming. Due to lack of land, sack farming, in which farmers plant crops into the sides and tops of large sacks filled with soil, bears potential for such agricultural practice. Apart from the aforementioned, rainwater harvesting, a passive cooling system for vegetables shall be introduced, which uses natural evaporative cooling instead of electricity compared to a fridge. In addition , a community center marketplace will be established. Powered by solar energy mainly for lightning. Furthermore, it is envisaged to be a place of inspiration and demonstration for decentralized solar systems. Respective trainings on this subject and subsequent realization can be conducted in cooperation with on-site NGOs like Dell Learning Lab. Through crowd funding, partnerships with governmental agencies and the city of Johannesburg and a monthly subscription fee of 60 ZAR, we plan to provide two sacks per household, ad hoc training and support, and access to a nursery within the marketplace. The project hopes to run a pilot cycle in any accessible section of informal Diepsloot, with initially 100 families as participants. Pessimistic cost analysis of the 2-year pilot cycle results in a return on investment of $800, which can be used in subsequent cycles. The long term goal of the project is to create a marketplace of social interaction and a feeling of community belonging for an otherwise disregarded faction of society.

Keywords: Urban Farming, Renewable Energy, WEF Nexus, Diepsloot, Local Entrepreneurship.

Corresponding author: Tobias Klöffel
tobias.kloeffel@tum.de
+49 176 57956708

Chapter 5: Energy Resource Mapping and Planning (RERIS)

An application of the Multilayer Perceptron: Estimation of Global Solar Radiation and the Establishment of Solar Radiation Maps of Togo

K.A. Amou*, T. T. E. Boroze, S. Ouro- Djobo, K. Sagna, Y.O. Azouma, M.Banna and K. Napo

Solar Energy Laboratory, Department of Physics, Faculty of Sciences, University of Lomé, Lomé, Togo

This paper presents a new neural network approach for the generation of synthetic monthly radiation data for nine localities in Togo. Because of the fact that, classical methods can't allowed us to obtain solar irradiation of other localities, the MLP method (Multi-Layer Perceptron) and the backpropagation of the gradient were used to involve a network of neurons in order to determine the relation between solar irradiation of Togo and the parameters which are the average temperature, the relative humidity and the latitude of the place. The neural model employed is the well-known Multi-Layer Perceptron (MLP) paradigm, in feedback architecture, using a record of historical values for the supervised network training. The method is based on the MLP ability to extract, from a sufficiently general training set, the existing relationships between variables whose interdependence is unknown a priori. Simulation results are compared to the measured values for the three towns where solar irradiation is measured in Togo. The results show that the generated values are of the real values. The method has been developed using data values from Lomé, Atakpamé and Mango, and is generalized to generate data of any location for the establishment of solar maps. Indeed, the proposed methodology is of general applicability to the estimation of highly complex temporal series.This work is devoted to the determination of the solar irradiation in Togo which resolves the problem of weak of data of solar irradiation in Togo.

Keywords: estimation; neural model; multi-layer Perceptron (MLP); solar radiation maps

Corresponding Author: K. A. Amou
mapkamou@yahoo.fr
00228 90197874

Remote sensing techniques for village identification: Improved electrification planning for Zambia

Catherina Cader*, Alin Radu, Paul Bertheau and Philipp Blechinger

Reiner Lemoine Institut, Rudower Chaussee 12, 12489 Berlin

Access to energy remains a challenge in many regions of Africa. In Zambia, approximately only 28% of the total population of 17 million has access to electricity, with even lower access rates of 5% in rural areas. One of the first challenges in providing these regions with reliable electricity is identifying the location of small settlements that still lack access to electricity. Systematic electrification planning requires in detail information about the current extent of electrification and the spatial location and distribution of villages and households without access. If this is available, transparent planning mechanisms can assess different electrification options such as stand-alone systems, mini-grids or grid extension. This paper aims at detecting a sample of Zambian villages without electricity through remote sensing techniques. These techniques involve applying various machine learning algorithms to classify medium resolution Sentinel 2 multispectral imagery. This method provides quick and accurate results on large areas with minimum costs, since many satellite imagery providers offer their products for free, as well as a significant amount of open source satellite image processing software exists. Exploring the existing classification algorithms and finding the best fit for the detection of built up areas in each region are the main challenges that we are addressing. As a final product we aim to identify the location, spatial extension and number of people of rural settlements in the research area. Combining this with night light and infrastructure data will reveal the level of energy access of each settlement. These results will support official bodies such as the Rural Electrification Authority (REA) as well as private project developers with an entrepreneurial interest in the region. Thereby, this knowledge enables improved legal and regulatory decisions as well as increased private sector participation.

Keywords: Remote sensing; Village detection; Spatial planning; Energy access; Zambia

Corresponding author: Catherina Cader
catherina.cader@rl-institut.de
+49 3012 0843 40

Analysis of Solar Radiation Models and Three-Dimensional Modelling Of Irradiance

Sendegeya, A*[1] and Chiguvare, Z[2]

*,[1]*Muteesa-1 Royal University*
[2] *University of Namibia*

Modelling and simulation of solar energy systems require reliable and comprehensive solar radiation data and models. Solar PV systems, in particular, require hourly solar radiation models. The intermittent nature of solar radiation, and the uncorrelated behaviour of solar resource availability to the energy use, makes techno-economic planning, designing and operation assessment of solar energy conversion systems challenging. The paper explores and analyses different modelling techniques for predicting hourly solar data. The models are based on the assumption of clear sky without any cloud cover, and are compared and validated using measured data from a site in Namibia. The models analysed have unique similarities and differences. The Collares-Pereira and Rabl model (CPR) closely mimics daily variations. The results are presented as two- and three-dimensional graphs depicting seasonal variations in solar radiation. In order to show variations in radiation seasonally, daily and regionally (using latitude), three-dimension graphs are presented. This type of modelling can easily be adopted by researchers, academics and planners, to have a clear understanding of the variations in solar radiations. For planning purposes modelling of solar radiation can be used to carry out preliminary studies especially in areas with limited access to reliable solar radiation data.

Keywords: Solar Radiation; Modelling; Simulation; Three-dimension

Corresponding Author: Al-Mas Sendegeya
asendegeya@gmail.com
+256703242390

Sizing and performance prediction of solar-powered pump-pipe systems using empirical solar radiation and pump characteristic data as applied in Zimbabwe *(Poster)*

T. Hove* and E Mungofa

Department of Mechanical Engineering, University of Zimbabwe
P.O. Box MP 167, Mount Pleasant, Harare, Zimbabwe

Solar powered systems have a natural synergy with most water pumping applications, since the demand for water rises at the same time when there is more solar radiation available for solar pumping output. In this paper a comprehensive method for sizing and performance prediction of a photovoltaic (PV) solar-powered pump-pipe system is proposed. The sizing and performance prediction methodology utilizes empirical data of the solar pump performance simultaneously with solar radiation and ambient temperature data, resulting in the prediction of the time-step response of solar pump-pipe system flow output to changing solar radiation level. Empirical functions of flow rate versus solar power are derived for different pumping main pipe diameters. The combination of pump, pipe diameter and PV array size which results in the least unit cost of pumping is selected as the optimal design of the solar pumping system. This kind of approach to solar pumping system design is recommended since it yields significantly different and more accurate sizing and performance prediction of the solar pumping system than the commonly used simple approach which does not account for the fact that total dynamic head varies as the solar irradiance (PV power) varies.

Keywords: Solar pump-pipe design, variable total dynamic head, flow-power functions, unit cost of pumping

Corresponding author: Tawanda Hove
tawandahv2@yahoo.co.uk
+263779731907

Design and Construction of a Low-Cost Meteorological Station *(Poster)*

A. Mohapatra*, N. Betz[1], M. Hussak1, S. Baur[1]

[1] *Chair of Renewable and Sustainable Energy Systems, Technical University of Munich, Lichtenbergstrasse 4a, 85748 Garching, Germany*

Africa's immense solar, wind and hydro power offer a huge potential for the deployment of renewable energy systems. The physical location of the solar, wind and hydro plants is an important factor for the sustainable success of renewable energy generation. For optimal project siting, meteorological data collection and analysis is required. Existing meteorological stations are very expensive and are often not suitable for the deployment in remote areas, which therefore lack location-specific data. This project aims to develop a low-cost meteorological station especially designed for the deployment in remote areas.

The station's design is based on a Raspberry Pi system with the appropriate measurement technologies. The developed station provides reliable measurements for long-term acquisition of meteorological information, including wind speed, temperature, rainfall and solar radiation. The self-sufficient station is powered by an external solar cell in combination with acid batteries. Furthermore, the station is connected to the internet via a UMTS stick and automatically sends data to a central FTP server. This data is then published on an internet site, where it can be further analyzed. The equipment prototype was site tested in Zimbabwe and Nepal. The findings from these installations were implemented as hardware and software updates enabling the current version to be used in remote locations in development countries.

Workshops and construction manuals will be provided without costs to enable students, researchers, and companies in Africa to rebuild the station at different locations. The low price for the materials and the possibility for local manufacturing with the open source idea are the important points for the sustainability of the project. The project's vision is to establish a wide station network, which can help to determine Africa's renewable energy potential and the optimal locations for renewable energy systems.

Keywords: Renewable energy; Data acquisition; Meteorological station; Low-cost; Local manufacturing

Corresponding author: Anurag Mohapatra
Anurag.Mohapatra@tum.de
+49 152 58436614

Chapter 6: Entrepreneurship and Information Technology (NULISTICE)

Solar Trees for Outdoor and Household Energy Access and Wi-Fi hotspots

Nyamadzawo Lisa*

Solvus Zimbabwe: Green Spaces The TechVillage National University of Science and Technology, P.O Box AC 939 Ascot, Bulawayo Zimbabwe

Green Spaces is a project that seeks to revamp public places and outdoors such as parks, public sitting areas, bus termini, swimming pool areas and University Campuses by providing off-grid solar energy solutions. It aims at making outdoor living a place of preference through providing a comfortable and pleasurable environment by assembling solar trees. These are tree shaped structures with solar panels at the top and wooden poles as the supporting material. Solar Tree Technology saves space harvests large amounts of energy due to its positioning (Bio mimicry of trees) and is also aesthetically appealing. These solar trees which use renewable solar energy will provide energy ports and Wi-Fi for its users. A user can be able to use the Wi-Fi hotspot and at the same time recharge their devices at a very low cost. The project addresses urban blight, energy access and connectivity. With rapid move towards digitalization, electronic device usage has increased too, however limited to indoors and very expensive to use. When solar trees are erected in public spaces, these areas become Wi-Fi hotspots and energy harvesting areas for indoor use as well; revamping public spaces. More people will become connected to the internet and also be able to recharge their devices cheaply. The prospective location of this project will be in Urban Areas such as Bulawayo, Harare and Gweru. Due to its nature, the project timeline will be ongoing. Production will be as per demand. The market for the solar trees is Diversified and Multisided. Comprising of local authorities, public institutions; such as schools and universities; property owners, companies with extensive outdoor spaces, hotels, lodges, function venues, private homeowners and Individuals.

Keywords: Solar Tree; Outdoor Off-Grid; Wi-Fi; Bio Mimicry.

Corresponding author: Nyamadzawo Lisa
nyamadzawo.lisa@gmail.com
+263776695757

Public-Private Partnerships and the Case of the Solar Water Heater Industry

Xavier Lemaire*

University College London – Energy Institute, Central House, 14 Upper Woburn Place, London WC1H 0NN

Solar water heaters (SWHs) are considered as a mature technology which can easily be manufactured locally, but their dissemination remains marginal in most African countries. Some African countries like South Africa, Tunisia or Zimbabwe have nevertheless disseminated on a large scale solar water heaters with various successes. They could provide important energy services not only just for households, but also for the hospitality sector or the health sector and for small industries in urban areas. Their large-scale dissemination could be part of an energy demand-side management programme. Up-front costs are still a barrier and specific financial and institutional mechanisms need to be in place. The research project called Sustainable Thermal Energy Services Partnerships (STEPs) – an international project funded by the Department for International Development between the University College London – Energy Institute and several consulting companies in the Global South – has examined how public-private partnerships could be established to expand thermal energy services, solar water heaters being one of the technology surveyed by this project. This policy-oriented project has notably studied a number of cases and drawn guidelines for entrepreneurs and policy-makers on which combination of policy, regulatory and institutional elements could make a successful model to create a sustainable market. This paper presents some findings of this four-year research project. After a reminder of what benefits can be expected from the replacement of electric water heaters by solar water heaters, it synthetizes the experience of different countries where SWHs have been successfully disseminated and others where less successful programmes have been implemented: it particularly focuses on fee-for-services programmes - inspired from experiences from decentralised generation with solar systems - where SWHs are not sold as a product but as a thermal energy service.

Keywords: Solar water heating; Fee-for-services; Public-private partnerships; Thermal energy services; Energy Demand-Side Management.

Corresponding author: Xavier Lemaire
x.lemaire@ucl.ac.uk
+44 (0)20 7679 9242

Problems of engineering entrepreneurship in Africa: A design optimisation example in solar-thermal engineering

Kanyarusoke Kant. E.*, Magoda C. M. and Makhomo S.

Mechanical Engineering Department, Cape Peninsula University of Technology, P.O. Box 1906 Bellville – Cape Town

Sub-Sahara Africa is beset with many engineering challenges. This, on the positive side, creates opportunities for entrepreneurs to start engineering businesses in the region. But there are many problems to be overcome. This paper first reviews them, drawing on secondary and primary sources. It then focuses on one specific one: that of designing products for low income markets in situations of limited supplies of suitable raw materials and manufacturing processes. An example of designing low cost solar water heating systems for the region by the authors is presented. Potential Market analyses for different countries in the region are done based on recorded research and governments/world bank social-economic data. Arising out of these, an engineering design and manufacturing model is formulated and solved for minimum total engineering costing in each market segment. Results indicate two major segmentation bases: Domestic and Commercial. Each of these is further differentiated according to location: i.e. whether in the equatorial belt or in the subtropical and temperate regions. Location also leads to distinction between pure solar-syphon and auxiliary power augmented systems. The domestic groups of markets are additionally sub-segmented into starter, middle and large systems. We illustrate the optimal designs of these latter systems. Based on the assumption that consumer sale price is twice the engineering cost, we show that the optimal systems can be between 20 and 30% less costly to the consumer than technically equivalent ones currently on the South African market. It is therefore concluded that the de-novo design approach is appropriate for the region and it is recommended that governments and development partners should seek to support similar design entrepreneur efforts to overcome Africa's engineering challenges.

Keywords: Africa; Design optimisation; Engineering; Entrepreneurship; Solar-thermal.

Corresponding author: Kanyarusoke Kant
kanyarusokek@cput.ac.za
(27)78 436 8347

Mathematical Assessment of Global Solar Radiation in Sub-Saharan Africa's Tropical Regions: Case of Cameroon and Senegal

Edouard Mboumboue* [1,2], D. Njomo[1], M. L. Ndiaye[2], P. A. N'diaye[2]

[1]Environmental Energy Technologies Laboratory (E.E.T.L)/Department of Physics/Faculty of Science/University of Yaoundé 1/ P.O. Box 812 Yaoundé-Cameroon
[2]Centre International de Formation et de Recherche en Energie Solaire (C.I.F.R.E.S), E.S.P : BP 5085, Dakar-Fann, Sénégal

Renewable sources of energy acquire growing importance due to enormous consumption and exhaustion of fossil fuel. Renewable energy is abundant, free, sustainable and clean. However, for the efficient functioning and better performance of renewables' devices, the information of solar radiation and its components at particular location in the ground is very essential for designing the solar energy systems. In developing countries like ours, the number of observing stations is inadequate and direct measuring is not always available. Therefore, the need for empirical relations becomes effective alternatives to estimate global solar radiation for places where measurements are not carried out and for places where measurement records are not available. In this paper, we study the Hargreaves & Samani model in order to estimate the solar distribution in four sites in Cameroon and Senegal, and then we discuss about its performance. The proposed model was simulated using Matlab software environment. According to the simulation results, the model was found good for Dakar site (in Senegal) and acceptable for Garoua and Yaounde sites (in Cameroon) respectively with a coefficient of determination of 0.9826; 0.8202 and 0.8144. In contrast, this model is not adapted for Gandon site in Senegal (R2=0.2903). In the meantime, the mean yearly radiation received are respectively, 6.6 kwh.m-2.d-1 for Yaounde, 8.2 kwh.m-2.d-1 for Garoua, 5.3 kwh.m-2.d-1 for Dakar and 10.5 kwh.m-2.d-1 for Gandon. Taking into account the foregoing, we can say that this model is suitable for sites where only air temperature data are available and whose latitude is less than 15° North of the Equator.

Keywords: Developing countries; Hargreaves & Samani Model; Matlab Software; Performance Assessment; Renewable Energies.

Corresponding author: Edouard Mboumboue
edomboue@gmail.com
(+237) 656 19 23 12

De-Colonising Power Supply in Cameroon: A Community Entrepreneurship Approach

Atembe Roland*

Department of Strategic Management, Marketing and Tourism, School of Management, University of Innsbruck, Karl-Rahner-Platz 3, 6020 Innsbruck, Austria

Energy is an indispensable resource for promoting economic activities and the enhancement of human welfare. This realisation underpins extensive research works in the field of energy and the environment in order to address socio economic issues such as poverty, income disparity, energy availability, accessibility and affordability within communities. But in sub-Sahara Africa, two in every three people significantly suffers from access to electricity. This is due to dysfunctional energy governance of the colonial hydro power systems and structures. Extensive studies advocate for decentralized energy systems and technologies in providing access to electricity; as well as associated investment requirements such as the grid energy paradigm. Nevertheless, previous studies on grid energy have predominantly focused on individual and groups ownership. Far too little attention has been paid to community investment and management of the energy systems. This research draws on the social capital and resilience theory, to critically examine the perceptions and reactions of community members towards investment and governance of energy supply in Cameroon. The qualitative case study approach was utilised. The in-depth interview technique was used to collect data from the South West Region of Cameroon. Findings reveal that communities were very anxious and willing to invest in the energy system. Evidence indicates that collective action of informal financial institutions can form the basis for community investment in energy thereby employing social cultural management systems. The study argues that there is a need for holistic resilience in the entire energy process from decision making, financing ownership, management and control using the bottom top approach. The study concludes that local community involvement is significantly needed to manage sustainable energy supply system in Cameroon. It also shows how community involvement model has been operationalized in other sectors.

Keywords: Energy; Electricity Supply; Sustainable Energy System; Community; Entrepreneurship; Cameroon.

Corresponding author: Atembe Roland
Roland.Atembe@student.uibk.ac.at
+43 660 656 6805

Design and Optimization of Solar PV and Diesel Generator Hybrid Power System for Remote Telecommunication Base Transceiver Stations in Nigeria

Babalola Samuel. O *[1]; Kana M.G.Z [2]

[1] *Pan African University Institute of Water and Energy Sciences (including climate change), Algeria*
[2]*Kwara State University, Malete, Nigeria*

Due to the creeping growth of mobile telecommunication subscribers in cities and a compulsory demand for telecommunication network in remote locations, Nigerian mobile network operators (MNOs) have begun to look for potential customers in previously unreached locations. Unfortunately, they are confronted with the prohibitive cost of powering remote off-grid base transceiver stations (BTS) with diesel generators and its associated environmental impacts. Nigeria is a country with huge potential for solar energy due to its closeness to the equator, but this resource has remained untapped for telecommunication sites despite its important benefits. Therefore, this study investigates the possibility of using a hybridized solar photovoltaic (PV)/diesel generator (DG) system (with battery) as a reliable, economical and environmentally suitable power source for off-grid micro BTS in the Nigerian rural areas. In this work, HOMER (Hybrid Optimization Model for Electric Renewable) simulation tool was used to model an off-grid solar PV/DG/battery hybrid power system for a telecommunication site located in Nigeria, while the performance of this system is examined under six different annual average solar radiation values which represents selected rural locations for the BTS across the geopolitical zones in Nigeria. The focal point of this work is to study the effects of varying annual average solar radiations on the optimal system configurations (OSC). To achieve this, three key aspects of the possible OSC were examined, namely; (i) energy output, (ii) economic implication (net present cost), and (iii) environmental impact (carbon emissions). The results showed the possibility of having at least 87% of Nigeria's remote BTS load demand from solar PV system. It also showed important benefit for mobile network operators in terms of a reduced cost based on a 47.3% drop in the net present cost and a reduced carbon emission from 1,652 kg to 45 kg compared with a conventional diesel/battery system.

Keywords: Base station: Mobile network: Optimal system configuration.

Corresponding author: Babalola Samuel
babalola_sammie@yahoo.com
+234 806 662 3161

Language, Science and Translation within a Socio-Developmental Context in Lesotho

Mosisili Sebotsa*

National University of Lesotho, Roma 180, Lesotho

In the world of industrialisation and mass production, technological designers invent ideas and products to satisfy human needs while in various technical domains specialists communicate in unison as they employ a well-established European technical jargon intelligible only to the initiated. However, in the African context, due to absence of cultural equivalence and differing educational backgrounds, highly technological concepts are not always easy to communicate to the ultimate consumer, the common man. This is exacerbated by the fact that vernacular languages are not always used at all levels of education to teach scientific and technological studies and the fact that existing scientific terminology is not sufficiently employed by the local scientific community. In Lesotho, this situation has demarcated and established a visible diametrical polarity between the specialist and the consumer (the common person), between the literate and the illiterate. The present study endeavours to show how language and terminology development is a sine quoi non in attaining social development in a predominantly monolingual and monocultural society. It strives to demonstrate how use of English as the only medium of instruction at all levels of education limits the development of Sesotho in techno-scientific terminology. It tries to manifest how, to a measurable extent, this practice impairs capacity building initiatives among semi-literate and illiterate consumers and how it frustrates efforts undertaken to attain collaboration and community participation in the overall development of the country. It further proposes a mechanism of how the development of science and technology can be accomplished concomitantly with the creation of terminology used to refer to scientific concepts in Sesotho. Lastly, it encourages collaboration among linguists, technical translators and scientists with the aim to attempts a usable but precise Sesotho techno-scientific lexicon in various scientific fields.

Keywords: Language, Translation; Techno-scientific terminology; Cultural equivalence; Creation of scientific terminology.

Corresponding author: Mosisili Sebotsa

Standardization and Characterization of Composed Basotho bread prepared in rural and urban areas according to the culinary practices of Basotho

Pulane Nkhabutlane[a,*] Gerrie E. du Rand[a], Henriett L. de Kock[c]

[a]Department of Consumer Science, National University of Lesotho, P.O. Roma 180, Lesotho.
[c]Department of Food Science, University of Pretoria, Private Bag x20, Hatfield 0028 Pretoria, South Africa

Bread forms an important part of Basotho diet. Lesotho, is experiencing difficulties with changes in food habits due to introduction of modern foods brought by westernization and urbanization. Literature on culinary practices related to traditional bread in Lesotho is very limited. The study was conducted to document culinary practices regarding bread in Lesotho. Mixed methodology using both qualitative and quantitative techniques was employed. A total of 253 female respondents from 5 districts of Lesotho completed a questionnaire on knowledge, preparation and consumption frequency. Recipes for 10 traditional Basotho breads prepared from wheat, maize and sorghum were obtained from focus group sessions. Breads were standardized and profiled using descriptive sensory evaluation. Flour particle sizes, sourdough properties, colour, volume and texture of the breads were characterised. The type of cereal and milling properties of the flour used has major effects on the physical and sensory properties of the bread. Wheat + maize composed breads have lighter colour and are sweeter compared to wheat + sorghum composed breads. Both wheat + sorghum and maize + wheat breads are characterised by low volume, denser crumb, heavy, chewy, dry, fibrous, brittle texture and more complex, strong flavours and aroma. The knowledge on the culinary practices and sensory characteristics from this study could be considered when promoting health, nutritional activities and sustainable food security in Lesotho. Further research is needed to improve the characteristics of wheat + sorghum composed breads and wheat + maize composed breads in order to encourage their acceptability to the younger generation.

Keywords: Basotho diet, Bread flour, Maize, wheat, Lesotho

Corresponding author: Pulane Nkhabutlane
pn111@hotmail.com

The role of TVET in Promoting Universal Education and Economic Productivity from Renewable Energy Resources *(Poster)*

Mokopanela Kekeletso. A*

Lerotholi Polytechnic, School of Engineering and Technology, Department of Electrical Engineering, P.O. Box 16, Maseru 100, Lesotho

Human life is supported by the use and consumption of natural resources. The most significant resources are energy, water, air, and land which are the fundamental needs for all forms of live. Other resources are materials and forests that human beings use to build shelter for living purposes for their families to protect themselves from harsh weather conditions of the seasons and provide comfortable living conditions. Industries and households, all consume resources through cooking, drinking, heating, bathing and on transportation. Energy and water are very important basic inputs for human survival and welfare. This implies that most of the SUSTAINABLE DEVELOPMENT GOALS, if not all, would be achieved if African nations have enough energy to make use of. In this paper the author discusses practices which can be adopted by vocational and training institutes in an effort to diversify teaching and training that would reach the masses. Different instructional methods are proposed that would enable education that encompasses people from all spheres of life to comply with universal education. The emphasis on this paper will be on the teaching and training of solar thermal energy applications that are important in improving the quality of life for rural communities as well as to enhance economic productivity.

Keywords: Solar thermal energy; Training; Universal education; Informal education, Economic development

Corresponding author: Mokopanela Kekeletso
mokopanelak@ymail.com
00266-58845324

The Basotho Cultural shift; what dress had to do with it *(Poster)*

Papali Maqalika-Mokobori*

National University of Lesotho, Roma 180, Lesotho

One of the characteristics of culture is that it evolves, Basotho culture evolved notably through rites of entry, significant ceremonies, daily living and approach to others. These affect the local dress and the study focused on the evolution of culture and the role played by dress, simply put; how dress contributed or was affected by the shift. Mostly secondary data were used most original cultural practices are no longer valued therefore not practiced. The evolution of culture is inevitable affecting several attributes of social fabric. The intellectual environment also influences dress notably, and could have contributed to the cultural dress turned-around. The museum curator and some purposely sampled senior citizens with occasional snowballing were interviewed. Data were subjected to content analysis. Interestingly even the young adults believed that culture had meaning and was valued with good intentions. A prominent scenario in most responses was the mourning gown type, period and limitations of a widow with interesting reasoning given. It was concluded that since culture is imparted through socialisation, most Basotho women spending most of their time at work and busy with other issues like careers, church and societies; there is little time left for socialisation with children and this contributes towards culture shift. In addition acculturation contributed massively to the value system of Basotho. Because of the type of mind-set Basotho have now: It is recommended that cultural days be observed in schools including the multi-racial ones, and media to assist in this information transmission.

Keywords: Intellectual-environment; Textile; Basotho; Culture; Cultural Dress; Values; Socialisation; Acculturation; Rites-of-Entry; Ceremonies and Religion.

Corresponding author: Papali Maqalika-Mokobori
papali2020@gmail.com
+27 730841581 / +266 59187279

National Scale-up Program for Ethanol and Ethanol Cook Stoves Supply in Ethiopia *(Poster)*

Michael Tesema*

Ministry of Mines Petroleum and Natural Gas,
D. Getaneh, Gaia Association.

Like most Sub Saharan countries, a marked feature of Ethiopia's energy sector the high dependence on biomass (firewood, charcoal and crop residues). Approximately 89% of the total final energy consumption was derived from bio-energy. Firewood and charcoal combined 74% percent, agricultural residues for 15% percent. Petroleum and electricity play a less important role in the national energy supply system. Ethanol fuel offers substantial opportunities for substitution of solid biomass and kerosene consumption in Ethiopia. The development of Ethiopia's bio-ethanol sub-sector has been hampered by a combination of factors including poor institutional framework and lack of a comprehensive study on the economics of ethanol for cooking as well as on the technical and economic viability of small-scale ethanol production. In order to address these challenges, has been initiated the present "National Scale-up Program for Ethanol and ethanol Cook Stoves supply in Ethiopia." The objective is to contribute to the development of the bio-ethanol sub-sector in Ethiopia. The study is expected to improve energy access, enhance the contribution of bio-ethanol towards income and employment generation/diversification in the rural areas, and contribute towards a low carbon energy path in Ethiopia. To this end, have been reviewed relevant policies, strategies and programmes towards the energy and health issues. The updated energy policy is generally supportive of the development and utilization of ethanol fuel for cooking. However, there remain gaps in policy implementation. The limitations observed are not in the policies and strategies, per se, but rather gaps in policy implementation. The study recommends that the future of ethanol fuel in Ethiopia will greatly depend on government support. The motivations behind the government support for ethanol are environmental, energy independence, and rural development. The recommendations below are for effective marketing and wide spread use of ethanol as a household cooking fuel.

Keywords: Household Energy; Biofuel; Ethanol; Cook stoves; Indoor pollution; Michael

Corresponding author: Michael Tesema
michaelgessese@gmail.com
251-118684832 / 251-118684831/251-116675562/
Fax; 251-116463364 / 215-116463426

Techno-economic Feasibility of Wind-Solar Hybrid Systems for Rural Electrication of Sioure village in Sahel *(Poster)*

Nogoye Diaw[1]*, Lamine Thiaw1, Thi Thi Soe[2], Swathi.A[3], Prasun Kumar Das[3], G.Giridhar[3]

[1]*Renewable Energy Laboratory, Polytechnic Higher School in Dakar/ Cheikh Anta Diop's University, Senegal*
[2]*Renewable Energy Research Department, Dept. of Research and Innovation, Myanmar*
[3]*Solar Radiation Resource Assessment, National Institute of Wind Energy, India*

This paper focused on techno-economic feasibility analysis of Sioure village to develop wind solar hybrid model by using HOMER (Hybrid Optimization Model for Electric Renewables) software. Sahel is part of African continent and which regroups nine countries namely Senegal, Gambia, Mali, Mauritania, Niger, Nigeria, Cameroon, Chad and Burkina Faso. It has enormous solar and wind potential. Solar and wind are one of the most promising renewable energy in Sahel. The case study area, Sioure, is one of the villages in Sahel. Sioure village locates in 16° 27′ 23.98″ N latitude and 14° 8′ 50.98″ W longitude (North of Senegal). It is a remote village dependent on agriculture, livestock and fisheries, with no grid extension. This village has enormous potential in terms of production of renewable energy to bridge a gap for electricity supply. From NASA record, the monthly average solar radiation data 5.87 kWh/m²/day and wind data (4.4m/s) can be the generation source for village electrification case. The wind solar hybrid system is an alternative to supply the production of electricity. From hybrid model simulation, the cost of energy is about 0.1879$/kWh when the total net present cost is about 588,566 $. The system has no greenhouse gas emission. While the selling price of Electricity is considered in 0.20$ (120 FCFA), the simulation result is more economical system to design integrated system with minimum total net present cost and cost of electricity. Therefore, this wind solar hybrid model design can able to be the single most favored option for dealing with electricity supply in the study area not only economically but also environmentally.

Keywords: Sahel; Hybrid model; Solar; Wind; Greenhouse gas.

Corresponding author: Nogoye Diaw
nogoyediaw@gmail.com
+221778005837 Fax: +221338255594

Chapter 7: Environment and Natural Resource Management (NULISTICE)

Modelling drought recurrence intervals from theoretical probability distribution and SPI: Semonkong, Lesotho

Bernard Moeketsi Hlalele*, Dusan Sakulski

University of the Free State: Disaster Management Training and Education Centre for Africa (DiMTEC), P.O Box 339, Bloemfontein, 9301, South Africa

Drought events are major natural hazards that occur in various climate regimes with significant agricultural, environmental and socio-economic adverse impacts. These hazards are insidious, obstinate and slow-onset with creeping nature that lead to drought disasters mostly in agriculture dependent communities. In this study, the recurrence intervals of drought were studied from theoretical probability distribution and Standardised Precipitation Index (SPI) at Semonkong station in Lesotho. Firstly the spring (Sep, Oct and Nov) monthly precipitation data obtained from Lesotho Meteorological Services, was tested for outliers and homogeneity (2 tailed p-value = 0.286) for quality control purposes. Secondly, Mann Kendall trend test and probability distribution fitting were both determined by XLSTAT software. No significant trend was revealed. A normal probability distribution fitted well to the data using a Kolmogorov-Smirnov test (p-value = 0.869) with a risk of 86,9% of rejecting the null hypothesis. DrinC software was then used to compute drought monitoring parameters at three months' time scale (SPI-3) as shown in equation 1. The normal distribution parameters were then inputted in INSTAT software to determine exceedance probabilities and corresponding precipitation values. All precipitation values exhibited by INSTAT were matched with their SPI values. Given the focus of the current study, both recurrence intervals in years and non-exceedance probabilities were determined. The results showed that the study area is highly likely to experience moderate, severe and extreme or more drought events in 3.33, 5 and 10 years respectively at any given period. This is really a short period that these events will occur at any given year, therefore, the study recommends that authorities, Government, participating private and NGO's put livelihood diversification measures in place given that over 80% of Lesotho population's livelihood depends on rain-fed-agriculture.

Keywords: Recurrence interval; drought; Standardised Precipitation Index; Semonkong; drought modelling

Corresponding author: Bernard Moeketsi Hlalele
hlalele.moeketsi@gmail.com

Co-Determination of Heavy Metals, Lead, Cadmium, Mercury and Zinc in Water Samples by Anodic Stripping on Bismuth-Modified Electrodes

Kabelo Makara and Mantoa Sekota*

National University of Lesotho, Department of Chemistry and Chemical Technology, P.O. Roma 180, Maseru, Lesotho

The main objectives of this research were to study the toxicity of heavy metals in the environment and develop an inexpensive, effective and highly sensitive electrode for co-determination of the chosen four heavy metals: lead, cadmium, zinc and mercury in water samples using anodic stripping voltammetry. Glassy carbon and carbon paste working electrodes were modified with bismuth for better performance. Glassy carbon working electrode was modified by plating a bismuth film onto its surface while carbon paste electrode modification on the other hand involved mixing of graphite and nujol oil and then using the mixture for electrode fabrication. For better comparison, operational parameters such as deposition time, bismuth concentration, type of electrolyte and electrolyte concentration were optimized so as to establish which electrode would yield better results in the co-determination of heavy metals using square wave voltammetry. The electrolytes 0.1 M HCl, 0.01 M sulphuric acid and 0.1 M acetate buffer were compared in the optimization of electrolytes. Peaks of highest height were obtained when using 0.1 M HCl hence it was found to be the most appropriate electrolyte and was therefore optimized for concentration. In the optimization of deposition/ pre-concentration time, deposition time was varied from 30 to 150 seconds where 120 seconds was found to give highest peaks and hence optimum. Bismuth concentration was found to be directly proportional to the response although increase in bismuth concentration also leads to potential shift to more negative values.

Keywords: anodic stripping voltammetry, Glassy carbon electrode, carbon paste electrode

Corresponding author: Mantoa Sekota
msekota@yahoo.com
(+266) 52213501 or (+266) 53188246

Producing Sustainable Clean Energy and Ensuring Sanitation through Blackwater Management

Aiyuk Sunny. Khants'i B[1]., Moeti T.

Department of Environmental Health, National University of Lesotho

This study determined the Chemical Oxygen Demand removal efficiencies of two Continuously Stirred Tank Reactors (CSTRs) from blackwater under anaerobic conditions, in order to generate sustainable clean energy. Two CSTRs were operated for a period of 100 days where they digested blackwater with cow dung acting as inoculum in reactor I (RI) and blackwater alone in reactor II (RII) that served as control set-up. They were both investigated at the hydraulic retention time (HRT) of 1.57 days or approximately 38 hours. RI had a maximum efficiency of 81% with biogas production of 1250mL and RII had a maximum efficiency of 65% with biogas production of 1030mL during the experimental period. This research points to the double advantage of using waste to produce clean renewable energy in the form of biogas. It also ensures removing the waste from the environment, thereby improving sanitation. How about the by-product that is released as sludge? What has somebody to do with that? Similar research should be conducted in order to meet sustainable development goals, particularly by ensuring availability and sustainable management of water and provision of adequate sanitation for all.

Keywords: Anaerobic digestion; CSTR; Blackwater; Renewable energy; Sanitation

Mineral Production, Processing and Associated Environmental Issues in sub-Saharan Africa

M. Nete* and W. Purcell

Department of Chemistry, University of the Free State, Bloemfontein, South Africa

Minerals are an important commodity and major contributor to the economies of some African countries. For example, in 2005 Zambia produced 19% Co, South Africa 89% platinum group metals, 23% vanadium while the sub-Saharan Africa (SSA) region accounted for 40% of diamonds, 20% of bauxite and 20% of rutile of the global supply. However, it is important to note that to date the mineral resources in the region have been insufficiently surveyed. Despite the mining potential and the resultant economic benefits many SSA countries still face many challenges to fully benefit from these resources due to different factors such as unstable political environments, labour unrests and sporadic power cuts in many of the countries. The aim of this work was to review mining activities in some SSA countries as well as the environmental issues associated with such mining practices. Additionally, the study gives some examples of hydrometallurgical separation of Ti and Fe in Lesotho ilmenite sample. The mineral was dissolved using a fusion digestion method and phosphate as fluxing agent. Analytical results indicate that the mineral contained 22.5(7)% Ti, 0.75(2)% Mn, 68(3)% Fe and a significant amount of V.

Keywords: Minerals, Sub-Saharan Africa, Environment

Corresponding author: M. Nete
netem@ufs.ac.za

Bioenergy for Africa- the Quest for Energy Independence and Food Security

Mekbib S.B.*[1]; George M.J.[2], Marake M.V.[3]

[1]*Department of Biology and Biotechnology*
[2]*Department of Chemistry and Chemical Technology*
[3]*Department of Soil Science,*
National University of Lesotho, P. O. Roma 180, Lesotho, Southern Africa

Energy is vital to sustain life activities and stability of the environment. However, dependence on fossil fuel besides creating crisis to the environment, it hugely affects human values. The deepening crisis in energy and food security in many Least Developing Countries of Africa is worsening due to poor economic conditions, crop and livestock disease epidemics, and the high incidence and impacts of HIV and other associated tropical diseases. A recent estimate indicated that more than 700 million people in the region are vulnerable to food insecurity and energy crisis. Renewable energy sources are viable options to halt the damaging effects of fossil fuel to the environment and society. Africa has great potential in biomass resources that can be used as biofuel and bio fertilizer for sustainable development in this bio-energy arena. Emergency responses that focused on food aid to reduce sufferings do not provide long-term development solutions to Africa. Underutilized or poorly administered biomass resources of Africa has to be utilized and it is a requirement to introduced advanced adoptable technologies to nations and device a workable policy to support such initiatives towards implementation of the clean energy practices for household and community purposes. Besides energy security, this would leverage a wide range of income generation to the family and communities to support their livelihood. The role of biomass technologies with other renewable energy practices has not yet been fully exploited. The Africa-EU partnership is highly mandatory to mobilize resources to create cleaner, much affordable and sustainable renewable energy sources for energy and food security in Africa.

Keywords: Renewable energy; Bioenergy; DRE system; SSPS system; Low carbon energy; Waste management; Biogenic electricity and economy.

Corresponding author: S.B Mekbib
sbmekbib7@gmail.com/ sbmekbib@nul.ls
+266 63242329

An Assessment of Health Risk of Toxic Cyanobacteria in Drinking Water in the Nyanza Gulf Water, Lake Victoria Kenya

Lilian Kwamboka[1] Abongo, B. Omondi[1, 2] and Itayama Tomoaki[3]

[1]Maseno University, School of Public Health and Community Development
Private Bag, Maseno.
[2]National University of Lesotho, Faculty of Science and Technology, P.O Roma 180, Lesotho
[3]Graduate School of Engineering, Nagasaki University, Nagasaki, Japan

Cyanobacteria are single-celled algae that thrive in warm and nutrient rich water bodies such as ponds, rivers and lakes. They occupy varied niches and can produce scums and blooms. Cyanobacteria can produce different kinds of toxins. There are more than 90 variants of cyanotoxins and microcystin is the most studied. Microcystin mostly affects the liver. Epidemiological studies in China and Serbia have shown an association between cyanotoxins and occurrence of Primary Liver Cancer. The World Health Organisation has set a guideline value of 1µg/L for microcystins for drinking water sources and a Tolerable Daily Intake of 0.04 µg/kgbw/day. Cyanobacteria are found in Lake Victoria, which is an important source of drinking water for the riparian communities, thus posing a danger to human health. This is as a result of eutrophication that has taken place in the last three decades in Lake Victoria increasing the levels of cyanobacteria and cyanotoxins in the Nyanza Gulf. However, the health risk from exposure to toxic cyanobacteria in the Nyanza Gulf water, remains unknown. As such, the objective of this study was to assess the health risk of toxic cyanobacteria to the riparian communities in the Nyanza Gulf. The specific objectives were to determine the concentration of microcystins, characterize and quantify microcystins and evaluate the health risk of microcystins in household and Lake Victoria water for Nyanza Gulf residents. In a longitudinal study, both quantitative and experimental approaches were adopted. The targeted sample size was 127 water samples from 6 beaches and an equal number from 30% of 422 households from the beaches. Water samples were collected from the community water collection points within the beaches along Lake Victoria and the households once a month for six months. Cyanobacterial levels were determined using an enzyme assay method (PP2A) and microcystin strains were measured and identified by High Performance Liquid Chromatography (HPLC). Statistical association between daily intake of microcystin and microcystin concentration in source and household water, treatment methods of household water were analyzed using logistic regression analysis. Eutrophication was observed in the Nyanza gulf and as a result, cyanobacteria which release cyanotoxins in the lake water especially during the wet seasons have flourished. Concentration of cyanobacterial toxins was over the WHO limit. MC-RR is the most abundant cyanotoxins followed by MC-YR and Mc-LR is the least abundant in the Nyanza Gulf. There is a health risk posed by cyanotoxins to the residents of the Nyanza gulf who use the lake water for drinking. This information will provide an insight into the quality of Lake Victoria water for drinking and will form a basis for making recommendations for water treatment to local residents.

Keywords: Health Risk; Toxic Cyanobacteria and Drinking Water.

Corresponding author: Dr. Abong'o Benard Omondi,
Cell: +266 51953606
E-mail: melfelis@gmail.com

Conceptualising the effectiveness of mitigation in post project - approval: translating theory into practice- case study of Zimbabwe platinum mines

Patrick Gwimbi1*

**Department of Environmental Health, National University of Lesotho, P.O. Roma 180, Lesotho*

Mitigation is a recognised component of environmental impact assessment (EIA) and its effectiveness has become the primary means by which EIA effectiveness is judged in post project approval. However, project proponents have often been accused of acting as if the environmental impact statement (EIS) is an end in itself, rather than an action-forcing tool for implementing measures to avoid, minimize or control potential impacts stemming from project development activities in post project approval. The practices of mitigation implementation and follow-up have been questioned as they are seldom practiced in post project approval. This paper conceptualizes and evaluates the effectiveness of mitigation in EIA through a framework lens integrating EIS; translation of its proposed mitigation measures into planning and EIA follow-ups obligations in practice. A case study focusing on a multinational platinum mining and smelting company operating along the Great Dyke in Zimbabwe is used to illustrate the framework. The case study was selected based on it having an EIA study carried out on it and being subjected to environmental planning and monitoring control. Documentary analysis, questionnaire survey and field observations were conducted. The quality of the project's EIS was reviewed using the amended Lee and Colley (1992) EIS quality review package. Those proposed mitigation measures translated into project EMPs and followed up as shown in environmental monitoring reports were documented and assessed. Questionnaire on perceived health risks from platinum smelting activities were administered on environmental managers and 40 purposively sampled residents. With respect to the quality of EIS, 52% of proposed mitigation measures were deemed of satisfactory quality to influence decision making. Deficiencies on baseline data and analysed impacts contributed to unsatisfactory grading of mitigation measures. Implementation and EIA follow-up of mitigation measures were executed to adhere to EIA procedures driven by legal regulations. Thirty-two (80%) of the forty respondents perceived exposure to SO2 emissions as adverse and the cause of their illnesses, with coughing, nasal congestion and shortness of breath the most frequently self-reported symptoms. The need to incorporate and enforce substantive mitigation measures in EISs and community participation in post EIA monitoring are proposed. Additionally, rigorous follow-ups are necessary to ensure the effectiveness of implemented mitigation measures.

Keywords: Environmental Impact Assessment (EIA), Environmental Impact Statement (EIS), Mitigation, Effectiveness, Great Dyke of Zimbabwe.

Corresponding author: Patrick Gwimbi
E-Mail: pgwimbi@yahoo.com

Modelling the Rate of Initiation and Retention on Isoniazid Preventive Therapy in a High HIV/TB Burden Setting of Lesotho

Eltony Mugomeri[1*], Dedré Olivier [2] and Wilhelmiena M.J van den Heever [2]

[1]Department of Pharmacy, Faculty of Health Sciences, National University of Lesotho, Roma Campus, Maseru 180, Lesotho;

[2]Department of Health Sciences, Central University of Technology, Bloemfontein, South Africa

Tuberculosis (TB) remains a major public health problem, particularly in people living with HIV (PLHIV). Yet, efforts to reduce TB incidence using isoniazid preventive therapy (IPT) have been curtailed by poor uptake of this intervention. This study modelled the rate of IPT initiation in the sub-Saharan country of Lesotho, which has one of the highest TB incidences worldwide. Time to IPT initiation in randomly sampled medical records of PLHIV was modelled using Cox's proportional hazards regression. Differences in the periods of enrollment into HIV care were controlled for by considering 2011, the year when IPT was launched, as the base year for follow up and stratifying the medical records into the 2004-2010 cohort (before the launch of IPT) and the 2011-2016 cohort (after the launch). Out of 2,955 patients included in the final analysis, 68.8% had received IPT by the study exit time. The overall rate of IPT initiation was 20.6 per 100 person-years, with 135 (6.6%) defaults. Compared to the 2004-2010 cohort, the 2011-2016 had a significantly ($p<0.05$) higher rate of initiation (15.8 versus 27.0 per 100 person-years, respectively). Age group, district category and duration of ART emerged as the most significant predictors of IPT initiation, while district category and gender significantly predicted IPT defaulting. These findings indicate a sluggish rate of implementation of a key health intervention for TB in PLHIV. Significant factors associated with disparities in the initiation and defaulting of IPT in this study are important for policy review.

Keywords: Cox's proportional hazards function; isoniazid preventive therapy; tuberculosis; uptake of health interventions

Corresponding author: Eltony Mugomeri
E-Mail: emugomeri@yahoo.com

A Study to Establish the Effects of Traditional Medicines in Pregnant Women in Lesotho

Gertrude Mothibe[1*], Nomalima Tshabalala.[2]

[1]Lecturer, National University of Lesotho;

[2]Pharmacist, EGPAF, Lesotho

Some pregnant women in Lesotho do not attend antenatal care services but use traditional medicines for their pregnancy related medical needs. Some attend the services but use the medication from the clinics simultaneously with traditional medicines. Although traditional medicines are natural, the safety, pharmacological effects and potential drug interactions of these products is not established and they may potentially harm both the mothers and unborn babies. The aim of this study was to establish the effects of traditional medicines in pregnant women for purposes of educating the public, traditional doctors and health professionals. Interviewees were 20 pregnant women, 100 mothers, 10 health professionals (midwives) and 3 traditional healers, from around the above mentioned places that were willing to participate. Results showed that 14% (n=120) of the women interviewed used traditional medicines, either during the current or past pregnancies. 88% (n=17) of the women who used the traditional medicines reported that the medicines had worked very well for them. 100% of the women who took part in the study knew about antenatal care services that are provided at clinics and thought it was important to attend them. 48% (n=120) women reported that they had refused recommendations from relatives and parents to use traditional medicines during their medicines. Midwives reported negative effects of precipitate labour with women who use pitsa, and positive effects of induction of labour and the shortened labour time. Traditional healers reported that pitsa helps prevent miscarriages and shortens labour when the time has come for the baby to be born. With these results, the researches recommend a laboratory based analysis of the traditional medicines used in pregnancy, for the purpose of clinically ascertaining the effects of these medicines on mother and child.

Keywords: traditional medicine, pregnant women, anti-natal clinic, labour, trimester

Corresponding author: Gertrude Mothibe

E-Mail: gn.mothibe@nul.ls

Optimization of the Photovoltaic Off-grid System for the Production of the Electricity at Nkoteng in Yaounde *(Poster)*

Aloyem kaze C.V*[1]; M. Mbeutoum[2] and R. Tchinda[3]

[1]*Department of Electrical and Power Engineering, University of Bamenda, P.O. Box 39 Bamenda*
[2]*Department of Physique, University of Yaoundé I, P. O. Box 812 Yaounde*
[3]*IUT-FV Bandjoun, University of Dschang, P.O. Box 134 Bandjoun*

Electricity is essential to plan any social and economic development. Nowadays, several systems developed for the production of electricity include photovoltaic systems where the price on the market has decreased seriously. Optimization is therefore an elaborate method for obtaining better efficiency. It is in this light that an installation on an isolated site has been set up in the neighborhood of the city of Nkoteng in Yaoundé-Cameroon having a total load of 3161 Watts. The optimization criteria are based on a threshold of economic viability; an environmental impact threshold, the return on investment and a threshold of service render the consumer. Each of these criteria being associated with a desirability index "DOI" giving the related satisfaction rate. We then performed an aggregation based on the weighted geometric means of the "DOI" to obtain the global objective function "OF" which gives us the overall satisfaction rate. Thus, to meet the energy requirements of the loads of this system, the optimal combination obtained is 18 PV modules of 90Wp and 2 batteries of 150Ah with an overall satisfaction rate of 87.48% and an initial investment cost of 1 890 000 FCFA (2 885€).

Keywords: Off-Grid; Desirability index; Global objective function; Environmental impact; Photovoltaic

Corresponding author: Aloyem Kaze
kazealoyem@yahoo.fr

Public-Private Partnership investment to enhance sustainable renewable energies in Rwanda *(Poster)*

Kazungu Jules[1], A. Munezero[1] and T. Nsengiyumva[2]

[1]Regional Research Centre for Integrated Development (RCID)
[2]Rwanda Agricultural Board (RAB)/Rwanda.

Rwanda has considerable opportunities for energy energies from methane gas, biogas, solar and peat deposits. Rwanda's Vision 2020 emphasizes the need for economic growth, private investment and economic transformation supported by a reliable and affordable energy supply as a key factor for the development process. The growth of the industry in Rwanda is being led by the private sector involving a range of different renewable energies. The question remains to know the extent the role of public private partnership institutions contributes to the variation being upwards or downwards of the access to sustainable energy in Rwanda. Therefore, this paper sought to contribute by highlighting the main achievements and challenges of ensure sustainable renewable energies, deriving the lessons that can be learned from the MDGs as a means of promoting sustainable development. The paper assesses the role of Public and Private sector investment in a growing renewable energy market in Rwanda. In additional, the paper examines the types of public and private institutions that require capacity building support, including institutions responsible for system-level coordination, dissemination and innovation in renewable energies. The findings from this paper will help official agricultural policies, ministerial and rural development agencies for scaling up and/or out the approach of renewable energies in Rwanda. In view of the results obtained in this study, effort among the priorities, the government of Rwanda needs to keep its efforts on the reduction of the impact of the increasing population on its environment and innovative funding systems are required to effectively supply renewable energies for all Rwandans.

Keywords: Rwanda, renewable energies, institutions, public private partnership, sustainable development.

Corresponding author: rcidcentre@gmail.com
(+250)788589224

Determinants of Livelihood Outcome Differentials Among Urban Youth in Nairobi, Kenya *(Poster)*

Njuguna, Christine*, Ngige, L., Ogola, L. and Wainaina, J.

Kenyatta University, Nairobi, Kenya.

Youth are faced by challenges of unemployment, underemployment and working poverty which influence their livelihood outcomes. These challenges facing youth have drawn global attention. Youth livelihood outcomes (YLO) are important factors in the development of sustainable community livelihoods in Kenya. The purpose of the study was to determine the predictors of urban youth livelihood outcomes in Nairobi, Kenya. Specifically, the study sought to establish the relationship between individual attributes of youth and youth livelihood outcomes, to determine the relationship between household characteristics of youth and youth livelihood outcomes, to explore the influence of typology of livelihood strategies on youth livelihood outcomes, to analyze the influence of youth focused interventions on youth livelihood outcomes and to establish important predictors of youth livelihood outcomes. The study was guided by the General Systems Theory by Bertalanffy (1968) and the Department for International Development (DFID) livelihoods framework (1999). A survey was conducted on 206 youths randomly selected from Kamukunji Sub-County in Nairobi County. Respondents included eleven development actors targeting youth. Findings indicated that there was a relationship among individual attributes, household characteristics and youth focused interventions with youth livelihood outcomes. Moreover, youth who pursued entrepreneurship as a livelihood strategy did not significantly attain higher livelihood outcomes relative to those who pursued other strategies. Various implications for policy and formulating appropriate intervention programs to enhance youth livelihood outcomes are established.

Keywords: Households; Entrepreneurship; Predictors; Livelihood outcomes

Corresponding Author: Christine Njugune
njuguna.christine@ku.ac.ke
(254) 020 8710901/12 Cisco 4128/9.

A Review of Some Best Practices in the Energy Sector with Policy Options for Uganda

Rugumayo, A.I.*

Ndejje University, P.O.Box 7088, Kampala, Uganda

This paper provides a background to the energy sector in Uganda and includes the institutional framework the role of private investment, financing options and key issues facing the sector. The review includes energy access in rural areas, energy services, the energy transition ladder, the ability to pay for energy services and the energy trilemma. It looks at renewable energy; policies for the poor, sustainable development goals (SDGs), off grid and grid connected systems and biomass energy. It then discusses financing mechanisms, which include microfinance facilities, a green economy and decoupling and the private sector, market incentives, tax measures and financing mechanisms, renewable energy institutions, research and development. The next section deals with the rural electrification and covers privatisation, successful programmes and appropriate technologies for low cost grid electrification. It also discusses value chain analysis in energy markets, gender and rural electrification planning. This is followed by a section on power generation, which covers hydropower, nuclear energy, geothermal energy, waste to energy, solar energy and biogas energy. The next section deals with energy efficiency and conservation and includes the SDGs; measurement and verification, the successful programmes; energy efficient technologies; nationally appropriate mitigation actions; technologies and energy savings; technical standards; energy efficiency in buildings; industrial energy efficiency, energy efficient public procurement and energy and health. The next section is on oil and gas and deals with the policies, the financing and revenue management; the legal and institutional framework; local content and capacity development; technology; research and development and awareness creation. Finally, policy recommendations are made for the sub sectors of renewable energy; rural electrification; power generation; energy efficiency and conservation and oil and gas.

Keywords: Energy access; renewable energy; rural electrification; power generation; energy efficiency

Corresponding author: A Rugumayo
airugumayo@gmail.com
25 6772428763

National action plan for reducing maternal mortality in Lesotho

Mmelia Mashea Mabitle*

**Department of Nursing and Midwifery, Faculty of Health Sciences, National University of Lesotho, P. O. Roma, 180, Lesotho, Southern Africa*

Lesotho has been suffering negative trends of escalating maternal mortality ratio since 2004. Currently the country is at 1024/100 000 live births (LDHS 2014).This is a bad reflection of a country with about 2.2million people (World Population Prospects 2017). The objectives of this study was to identify the possible gaps that could have contributed to the increasing mortalities and develop strategies that will reduce this problem. Assessment of all facility and community based maternal deaths were analysed using MaMMAS software covering the deaths which occurred between 2010 and 2016.The office of the secretariat was trained on the use of the software (MaMMAS) to analyze all the reported maternal deaths. The causes of maternal deaths were classified using the ICD-10 coding system. The first Maternal death report was released and shared with stakeholders in 2010. The verbal autopsy tool was designed and disseminated to all primary health facilities to report the maternal deaths occurring at community level. There is great improvement in the reporting of cases. Following the recommendations made, there is decline in reported maternal deaths since 2010. Improved maternal health is the core business of all birth attendants in all countries.

Keywords: Maternal health, Lesotho, Public health, Mortality rate, Primary health facility

Corresponding author: Mmelia Mashea Mabitle
masheam@yahoo.com

Wastewater Stabilization Pond Technology: Effectiveness and Efficiency at the Ratjomose Sewage Treatment Plant, Maseru, Lesotho

Aiyuk, S.E.[1]*, Molomo R.N[1]., George, A.M.[1]

[1]*Department of Environmental Health, National University of Lesotho, PO Roma 180, Lesotho*

The performance of wastewater stabilization ponds at the Ratjomose sewage treatment plant, in Maseru, was evaluated in removing Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS) and total phosphorus from wastewater. Grab samples of wastewater from the influents and effluents of facultative ponds (F1 and F2) and maturation ponds (M1 and M2), were analysed according to standard analytical procedures for water analysis. Results showed no removal efficiency of BOD, TSS and total phosphorus in almost all of the stabilization ponds, both in trials 1 and 2. Temperature was measured at sampling point, and temperatures ranged from 20 to 28℃ . Removal efficiencies of these ponds were thought to be affected by inadequate maintenance and introduction of detergents into the ponds by people living around the treatment plant. The plant thus needs better management and an upgrading, to ensure the protection of the environment and public health.

Keywords: Wastewater; Wastewater stabilization ponds; Efficiency; Upgrading

Corresponding author: Aiyuk Sunny
E-Mail: se.aiyuk@nul.ls
Tel: +266 22340 601
Cell: +26659450338

Spatio-temporal Climate Change Risk Assessment: Mangaung Metropolitan Municipality, South Africa *(Poster)*

Bernard Moeketsi* and Dusan Sakulski

University of the Free State: Disaster Management Training and Education Centre for Africa
P.O Box 339, Bloemfontein 9301, South Africa

Scientists have warned about global warming, resulting in climate change risks such as droughts. In 2015, the Free State provincial government declared a state of drought risk disaster which was extended into 2016. The current study aimed to (i) assess the climate change risk on annual and seasonal temporal scales over all areas of the Mangaung Metropolitan Municipality, (ii) determine most-at-risk areas and (iii) advise government authorities /risk disaster management stakeholders about disaster risk reduction projects aimed at resilience and capacity building against adverse effects of climate risk disasters. Ten climate change vulnerability variables were collected from Stats SA, census, 2011. The study applied principal component analysis to determine the key variables that give rise to the existing vulnerability conditions in the study area. A 43 year long time series data set (1973-2016) was also collected from an online source for RDI computation. The results show that some of the main underlying variables behind high vulnerability in this municipality are; number of people with no income, the young (0-14) and the elderly (65+), as identified by principal component analysis. The main towns seem to be less vulnerable compared to the rest of the other areas under study. The most vulnerable areas are in the outskirts of Thaba Nchu. Furthermore, climatic hazard analysis using RDI showed constant hazard severity and probability over a 43 year long time series data set on annual basis. To further assess climate change, RDI was computed on seasonal time scales which also showed no significant differences in both severity and probability. Due to the fact that the study used only one station over Mangaung Metropolitan Municipality to assess climate change conditions, the risk assessment analysis differences were influenced by differences in the vulnerability levels. High risk levels are therefore in the rural areas. The study recommends that the government and all relevant stakeholders set up income generating projects through which young people will not necessarily seek jobs in urban areas and help afford higher education costs.

Keywords: climate change risk: disaster; reconnaissance drought index; spatio-temporal, vulnerability.

Corresponding author: Bernard Moeketsi
hlalele.moeketsi@gmail.com
+27 736985797

Performance Evaluation of Grid Connected Solar pv in the Tropical Conditions - a case study of Karume Institute of Science and Technology, Zanzibar *(Poster)*

Mohammed Haji M.* and Thomas Kivevele

The Nelson Mandela African Institution of Science and Technology, Tanzania

Solar photovoltaic (SPV) is one of the renewable energies expected to contribute a significant portion of the future energy needs in Tanzania. Due to the importance of the solar energy for generating electricity, the grid connected solar photovoltaic (SPV) power plants are also increasing worldwide. In Tanzania attempts carried out to connect solar PV in national grid power system like at Karume Institute of Science and Technology (KIST) in Zanzibar. In this study, the normalised performance parameters of the solar PV- grid connected (75.63 kWp) for the year 2016 was investigated. The impact of the distance from the roof surface, light intensity and angle of inclination on energy output of solar panel were also studied. The results demonstrated that, the efficiency increased from 0.0131 to 0.0185 for the panel placed at 10cm to 20cm from the rooftop, respectively due to sufficient distance from the roof surface enabling enough natural ventilation of the panel. Thus, the best performance were observed when the panels were placed at 20cm to 25cm from the roof surface, with an angle of inclination between 20° to 30° and light intensity when aluminium foil inclined at an angle of 45°. The total energy generated during this period was found to be 5059.303kWh and the PV module efficiency, inverter efficiency and performance ratio were found to be 13.15%, 85.46% and 0.85 respectively. Therefore, there is a need to recheck most of solar installations in Tanzania with regard to distance between panel and the roof surface and angle of inclination for the purpose of improving the efficiency.
.

Keywords: Performance Evaluation, grid, PV, solar, tropical

Evaluation of Animal Manure as a Feedstock for the Production of Biogas in Comparison with Sewage Water Microalgae

Matlosa Tebello.[1], George M.J.[2]; Mekbib S. B.[1]*

1Department of Biology and Biotechnology
[2]Department of Chemistry and Chemical Technology,
Faculty of Science and Technology, National University of Lesotho,
P. O Roma 180, Maseru, Lesotho

The use of fossil fuels as energy sources have impacted the environment and economy negatively as they are the major sources of carbon emission to the environment. It is therefore important to find cheap and clean sources of energy options to protect the environment. In this study, the use of animal manure: cattle and chicken drops were assessed in comparison with microalgae as sources of feedstock for the production of flammable biogas. Semi quantitative and qualitative data analyses were carried out to evaluate the biogas produced from these feedstock sources. The biogas from chicken manure was not flammable indicating the presence of high concentration of carbon dioxide compared to other feedstock sources. High quality of biogas was produced when microalgae was digested by the cellulose degrading microorganisms. However, the initiation of the decomposition process and production of gas took a little longer time compared to the chicken and cattle manure. Though, the chicken drops shown high volume of CO2 production, the mix of feed stock with other carbon sources such as microalgae to maintain the C:N balance, would enhance the decomposition process faster to produce a flammable biogas.

Keywords: Biogas, Chicken drops, Methane, Cattle manure, Microbial decomposition, Microalgae

Corresponding author: S.B Mekbib
sbmekbib7@gmail.com/sbmekbib@nul.ls
+266 63242329

The VIP Latrine in Lesotho: Addressing Technical Flaws from the Qachas'nek District Experience

Aiyuk Sunny*

Department of Environmental Health, Faculty of Health Sciences, National University of Lesotho

Developing countries face a dilemma regarding the provision of adequate sanitation, especially for the poor, who constitute by far a greater proportion of the population. This is particularly so in rural and peri-urban areas, where sanitation is far from optimal, exposing communities to a plethora of communicable and other diseases, thus compromising public health and safety. In Lesotho, measures to address issues of sanitation, in the midst of general scarcity, have led to the adoption of the cost-effective Ventilated Improved Pit (VIP) latrine, a technology used by over 80% of the population. This is especially so because Lesotho is one of the poorest countries in the world and is faced with abject scarcity of manpower and financial means for construction and maintenance of complex sanitary modern fixtures. There is, therefore, tremendous need to develop cheap reliable technologies that can handle basic sanitation issues adequately. Therefore, the VIP latrine, a technology that proliferates in the country, comes to light. However, this system, commonplace as it is, is bedevilled by technical flaws that largely compromise its adequacy, leading to this intervention that was made in the Qachas' Nek District, one of the Districts of the country, by addressing technological drawbacks inherent in their design and construction, especially as this is the case with other parts of the country. Such intervention will help educate the communities and improve sanitation drives in the country.

Keywords: Sanitation; VIP latrine; Technology; Community intervention

An exploration of how communities in Lesotho can benefit through Katse and Mohale dams in agriculture *(Poster)*

Mukurunge Tawanda[1]*, Matandare B[2] and Mukurunge E[3].

[1]*Faculty of Communication Media and Broadcast*
[2]*Faculty of Business and Globalization, Limkokwing University of Creative Technology*
[3]*Lesotho Campus and Paray School of Nursing, Thaba Tseka, Lesotho*

The government of Lesotho, in partnership with the Republic of South Africa, invested in the construction of Katse and Mohale dams in the 1980s but since then there is no evidence of these two bodies of water contributing towards agricultural production in Lesotho. The primary business for the construction of these two dams is to supply South Africa with water but Lesotho can tap into this venture and cost effectively utilize the water for agricultural purposes especially through the drip irrigation kind of agriculture. This study therefore seeks to explore the potential presented by the existence of the two dams in Lesotho for boosting agricultural production and establish Lesotho as an independent producer of its own food to feed the nation and boost industry at the same time. Using quantitative and qualitative methods of data gathering, presentation and analysis, this study will seek to establish the efforts by the responsible authorities in Lesotho to boost agriculture production in order to establish a solid agricultural base through irrigation schemes from the two dams.

Keywords: Agriculture, Dams, Irrigation, Ministry of agriculture, Lesotho Highlands Development Authority.

Corresponding author: Mukurunge Tawanda
tawanda75mukurunge@gmail.com
(00266) 56043037

Exploring the Potential of Rural Development Through Harnessing Solar Energy in Lesotho *(Poster)*

Mukurunge, Tawanda[1]*., Matandare, B[2]. and Mukurunge, E[3].

[1]Faculty of Communication Media and Broadcast,
[2]Faculty of Business and Globalization,
Limkokwing University of Creative Technology, Maseru Campus
[3]Paray School of Nursing, Thaba Tseka, Lesotho

The harnessing of solar energy in Lesotho can have benefits for rural communities in agriculture, household as well as industrial use. This source of energy is readily available in the country and it is a clean source that does not produce any emissions dangerous to the climate and users as compared to paraffin and gas when used in households for cooking and heating households. Solar power is also very ideal for use by rural communities in Lesotho considering that gas and paraffin are expensive for the poor who resort to the use of firewood which is a very scarce commodity in the Lesotho countryside. Utilizing the abundant energy from the sun can make efforts of forestation a success as newly planted trees will not be harvested by desperate communities for firewood and this can help mitigate the dangers paused by the absence of trees to both the climate and the environment. Using both quantitative and qualitative methods of data gathering, presentation and analysis, this study will interview the ministries responsible for energy, agriculture and rural development as well as the rural communities to establish their views on the best way forward regarding the subject matter

Keywords: Solar energy, Emissions, Forestation, Mitigation, Ministry of Energy.

Corresponding author: Mukurunge Tawanda
tawanda75mukurunge@gmail.com
(00266) 56043037

Chapter 8: Material Science and Nano-Technology (NULISTICE)

Desulphurization of Diesel Fuels using Metal Oxide Loaded Activated Charcoal and Alumina

Liberty Mguni L.[1,2], Thulisile Nkomzwayo[1], Yali Yao,*[1], Xinying Liu[1] , Diane Hildebrandt[1] and David Glasser[1]

[1]Material and Process Synthesis (MaPS), Florida campus, University of South Africa, Johannesburg, South Africa,
[2]Department of Chemical Engineering, National University of Science and Technology, PO Box AC 939, Ascot, Bulawayo, Zimbabwe

Desulphurization of diesel fuels is crucial for producing clean fuels, as sulphur is the source of acid rain, can poison emission control catalysts and exacerbate corrosion. Although new, stringent environmental regulations have succeeded in reducing the sulphur level of diesel produced locally, diesel fuel from Africa has a considerably higher sulphur content than those produced in the developed countries. It is therefore necessary to develop a new and efficient technology to produce low-sulphur fuels in Africa. Among these, adsorption is considered to be one of the most promising processes. Sulphur compounds prefer to interact with intermediate or soft Lewis acid sites. In this work intermediate Lewis metal oxides (MO) acids were loaded on activated carbon (AC) and alumina (Al2O3) to desulphurise diesel using adsorption process. The following metal oxides were used: Co2O3, NiO, CuO and ZnO. A group of experiments have been conducted in our laboratory on ways to remove the sulphur components from both model fuels and commercial diesel fuels with metal oxide loaded activated charcoal and alumina. The effects of adsorbents on sulphur removal was investigated. For carbon loaded metal oxides, NiO showed the highest activity when using both model diesel and conventional diesel. The activity of alumina and alumina supported metal oxides was approximately 4 times less than of activated carbon for model diesel desulphurisation. A huge difference was also observed in activity between treating model diesel and conventional diesel. This big difference i.e the lower activity when treating conventional diesel is due to competitive adsorption between sulphur compounds in diesel and some compounds with similar chemical structures . Although there is a huge difference in activity when adsorbing model diesel and conventional diesel, the trends were generally maintained suggesting that the use of model diesel is not a bad technique of screening adsorbents.

Keywords: Desulphurisation; Diesel; Metal oxides; Activated carbon; Alumina

Corresponding author: Yali Yao
yaoy@unisa.ac.za

Optical and Electrical Characterization of Ni-doped CdS Thin Films Prepared by Chemical Bath Deposition

Sheilah Bisach*, F. W. Nyongesa, R. J. Musembi and B. O. Aduda

Department of physics, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya

In this study, the effect of doping on electrical and optical properties of CdS thin films prepared by Chemical Bath deposition technique has been investigated. The un-doped and Nickel-doped cadmium sulphide thin films were prepared by Chemical Bath deposition from aqueous solution of hydrated cadmium chloride (CdCl2.21/2H2O) and thiourea (CH4N2S) respectively. Nickel (II) Chloride (NiCl2.6H2O) was used as a dopant and Triethanolamine (TEA) as a complexing agent while ammonia solution was used as the pH regulator. Thin films with varying Cadmium/Nickel percentage weight ratios (0%, 15%, 25% and 45%) were deposited on fluorine doped Tin oxide (FTO) glass substrates. The effect of Nickel concentration and annealing temperatures on the optical, electrical and structural properties of the deposited films was investigated. X-ray diffraction (XRD) analysis revealed that the un-doped and Ni-doped CdS thin films were polycrystalline with hexagonal structure. All films were found to be transparent while the transmittance in the visible region (400nm-700nm) varied between 40% and 60%, depending on the dopant concentration and the annealing temperature. The band gaps of Ni -doped CdS decreased with increased annealing temperature up to 250°C. The band gap increased with Nickel concentration and the band gaps (Eg) for the films prepared varies from 2.006 to 4.005 eV.

Keywords: Cadmium Sulphide; Doping; Chemical bath deposition.

Corresponding author: Sheilah Bisach
sheilah.bisach@gmail.com
+254 713 163783

Synthesis and Characterization of Copper Oxide nanoparticles and their Application as Electrode Modifiers

Hailemicheal Alemu[1], Lineo F. Maxakaza[1] and Himanshu Narayan [2]*

[1]Department of Chemistry & Chemical Technology
[2]Department of Physics & Electronics
National University of Lesotho, Roma 180, Lesotho.

Nano-sized copper oxide (CuO) powder was synthesized through the method of wet chemical precipitation from Cu(NO3)2. The nanoparticles were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), particle size analyzer and Fourier transform infra-red spectroscopy (FTIR). Two most prominent peaks in XRD profile, around 2□ = 35.9° and 39.2°, which are combinations of double-reflections {(002) and (-111)} and {(111) and (200)}, respectively, are characteristics of monoclinic CuO. The unit cell parameters determined from the analysis of XRD data were: a = 4.6927, b = 3.4283 and c = 5.137 Å, with □ = □ = 90□ and □ = 99.546□. SEM pictures showed uniform distribution of ice-glass like crystalline particles, which are made up of smaller particles. Crystallite size estimation from XRD data using Debye-Scherrer formula produced average size of 34 nm for the nanoparticles. However, the particle size analyzer measured the average grain-size as 86 nm. Clearly, each grain of the nano-sized CuO seemed to be made up of roughly 16 crystallites. FTIR results showed expected peaks corresponding to Cu-O stretching. Further, the electrocatalytic efficiencies of CuO nanoparticles as carbon paste electrode (CPE) modifier were investigated for the electrochemical oxidation of ascorbic acid, hydrazine, glucose and potassium Ferrocyanide, using different voltammetric methods. The results showed marked improvement of detection efficiency with respect to the first three compounds but only marginal enhancement in the case of potassium ferrocyanide.

Keywords: Copper oxide; Nanoparticles; Voltammetry; Carbon paste electrode modifier

Corresponding author: Himanshu Narayan
h.narayan@nul.ls

Surface Modified Polyvinylidene Fluoride Membranes for Potential Use in Membrane Distillation

L.N.Nthunyaa[1], A.R.Verliefdeb[2], B.B. Mambaa , S.D. Mhlangaa*

[1]Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa, Florida, 1709, Johannesburg, South Africa.
[2]Particle and Interfacial Technology Research Unit, Faculty of Bioscience Engineering, Ghent University, Coupure Links 653, B-9000 Gent, Belgium

Membrane distillation (MD) is a membrane-based technology that presents a possibility to counteract challenges associated with pressure driven membranes at high separation efficiencies. MD membranes are affected by their wettability and fouling. Wetting of the membrane pores is elevated by the hydrophilic characteristic of the membrane; while fouling is mostly induced by the hydrophobic-hydrophobic interaction of pollutants and the surface of the hydrophobic membranes, hence block the pores of the membranes. These properties are not desirable. As such, a carefully designed PVDF MD membrane composed of a super-hydrophobic modified backbone and a super-hydrophilic thin layer has been developed to concurrently overcome these challenges. The membranes were characterized using contact angle measurements to confirm the hydrophobicity/hydrophilicity. SEM and SAXS were used to study the morphology and pore distribution on the surface of the membrane. The ultimate goal is to develop membrane materials that will be used for brackish/saline water purification in affected communities in South Africa.

Keywords: Membrane distillation membranes; Fabrication; Modification; Energy efficiency.

Corresponding author: S.D Mhangaa
mhlansd@unisa.ac.za
+27 11 471 2104

Raman Spectroscopy and Imaging of Bernal-stacked Bilayer Graphene Synthesized on Copper Foil by Chemical Vapour Deposition: Growth Dependence on Temperature

Mopeli Fabiane[1,2]*, M.J. Madito[1], A. Bello[1], and N. Manyala[1]

[1]University of Pretoria, Department of Physics, Institute of Applied Materials, SARChI Chair in Carbon Technology and Materials, Pretoria 0028, South Africa
[2]National University of Lesotho, Department of Physics and Electronics, P.O. Roma, Lesotho

We report on the effect of temperature on the growth of bilayer graphene on a copper foil under atmospheric pressure chemical vapor deposition (AP-CVD). Before characterization of the AP-CVD bilayer graphene, a high-quality graphene flake was obtained from the Kish bulk graphite by micro-mechanical exfoliation and characterized using Raman spectroscopy and imaging. The Raman data of the exfoliated, high-quality graphene flake shows monolayer and bilayer graphene and was compared to the Raman data of AP-CVD graphene. Raman spectroscopy of AP-CVD graphene shows bilayer films that exhibit predominantly Bernal stacking with an I2D/IG ratio of ~1. At low growth temperature (~780 °C), Raman disorder-related peak intensity in the AP-CVD graphene is high and decreases with an increase in growth temperature to the lowest disorder intensity at ~973 °C. The AP-CVD graphene is uniform at low growth temperatures (~780 °C) with a high disorder and becomes non-uniform at high growth temperatures (~867–973 °C) with a very low disorder as bilayer graphene evolve to form islands with an average lateral size of <10 µm. Competition between carbon adatoms supply through dehydrogenation of the CHx species, mobility and desorption rate of the carbon-adatom species for nucleation of the bilayer graphene as a function of temperature is elucidated. This study provides further insight into the growth mechanisms of bilayer graphene by AP-CVD on Cu.

Keywords: Graphene, AP-CVD, Copper foil, Bernal-stacked bilayer, exfoliated grapheme.

Corresponding author: Mopeli Fabiane
fabianemop@gmail.com
+266 59002990

Multiwall Carbon nanotubes Ag-Pt composite Electrochemical Sensor for Nevirapine – Antiviral drug

Okumu F.O. and Matoetoe M.C.*

Department of Chemistry, Cape Peninsula University of Technology, Tennant Street, P.O. Box 652. Cape Town, South Africa.

Nevirapine is a component of first-line antiretroviral therapy for reduction of vertical transmission and prevention of mother to child in Sub-Saharan Africa. Preference of this drug is due to its low cost, good long term tolerability and high efficacy. However, resistance occurs rapidly if sub-therapeutic drug levels occur. Therefore, a need to pursue this drug detection is vital in adherence monitoring. This work describes fabrication of a MWCNT/Ag-Pt bimetallic nanoparticles (NPs) sensor for Nevirapine using glassy carbon electrode (GCE) as a substrate. Optimum platform and voltammetry techniques for the transduction / electro-oxidation of Nevirapine (NVP) was found to be MWCNT/Ag-Pt NPs (3:1 ratio) film on GCE and Differential pulse voltammetry (DPV) respectively. The platform showed better signal stability, excellent electro-catalytic activity for the oxidation of NVP under optimal experimental conditions of 0.01 mol L^{-1} NaOH solution, pulse amplitude of 25 mV, initial potential of 0.20 V and a scan rate of 20 mV s^{-1}. The oxidation peak (0.555 V) height of NVP was linear in NVP concentration range of 0.76 to 4.6 µM with a detection limit of 0.021 µM. Cyclic Voltammetry (CV) was used to investigate the electrochemical properties of the platform based on Laviron's equation. The apparent charge transfer rate constant (ks) and electron transfer coefficient (α) between NVP and MWCNT/Ag-Pt NPs 3:1/GCE were calculated as 0.884 s^{-1} and 0.31 respectively. The diffusion coefficient involved in the electro-oxidation of NVP was determined as 5.205 x 10-10 cm^2 s^{-1} with the NVP electro-oxidation mechanism found to be a 2-electron transfer process. The sensor was applied in detection of NVP content in commercial tablets, milk and human urine. The sensor method is simple, fast and highly sensitivity. The sensor knowledge provides a basis for development of low cost robust Nevirapine drug adherence monitoring system.

Keywords: Electrochemical, Bimetallic, Nanoparticles, Nevirapine, Silver, Platinum.

Corresponding author: M.C Matoetoe
lellangm@gmail.com
+27 012 4603163

Pore Size Enhancement in TiO_2 Thin Films and its Effects on Dye Sensitized Solar Cells *(Poster)*

Domtau Dinfa Luka. [1,2]*, Simiyu J. [2], Ayieta E.O. [2], Mwabora J. M. [3]

[1]*Department of Physics, University of Jos, P.M.B. 2084, Jos, Nigeria*
[2]*Department of Physics, University of Nairobi, P.O. Box 30197-00100, Nairobi, Kenya*

Light harvesting efficiency in dye sensitized solar cell is currently enhanced by the employment of an additional TiO_2 scattering layer hence increasing the overall film thickness. This has limitations on effective charge transport especially in dense electrolyte media due to the increased film thickness. The additional film layer further reduces light intensity on the adsorbed dye hence decreasing photocurrent generation. Therefore, there is still the challenge of light scattering optimization versus charge transport and photocurrent generation. In addition, though TiO_2 is a relatively cheap material, the addition of TiO_2 layer raises the production cost of the dye sensitized solar cell effectively and rendering it not cost effective. In this study, carbon black was employed to create artificial pores in TiO_2 thin films to enhance light harvesting and hence photocurrent generation. TiO_2 films deposited by screen printing method had 0, 1.0, 1.5, 2.0 and 3.0 wt% carbon black. On annealing of the films at 500^{o}C in air for 30 minutes, carbon black decomposed leaving behind voids. Transmittance, reflectance and absorbance spectra of the films determined by a UV-Vis-NIR show that transmittance decreased as the carbon black concentration increased. On the other hand, both reflectance and absorbance increased with increase in carbon black concentration. Micrograph images obtained from both Scanning Electron Microscope (SEM) and Atomic Force Microscope (AFM) show that the pore size of the films increased as the carbon black concentration increased. Furthermore, the XRD results of these films show that the TiO_2 are anatase and without any carbon contamination. Conductivity of the films determined using a four point probe was found to decrease with increase in pore size due to decrease in electrical contacts among the TiO_2 molecules. The values 384.61, 352.11, 103.41, 52.41 and 35.29 Siemen's cm^{-1} were determined for 0, 1.0, 1.5, 2.0 and 3.0, respectively. Current-Voltage (*I-V*) characteristics of the cell fabricated with different pore sizes were determined using a solar cell simulator at 100 mW/cm^2 illumination. The results show that photocurrent generated by these cells increased from 6.1 mA/cm^2 to a maximum value of 9.9 mA/cm^2 as the wt % carbon black increased from 0 wt% to 1.5 wt %, respectively. Beyond 1.5 wt%, photocurrent begun to drop until it got to its minimum value of 4.7 mA/cm^2 at 3.0 wt%. The overall efficiencies for 0, 1.0, 1.5, 2.0 and 3.0 wt% were found to be 2.3, 2.6, 4.3, 2.4 and 1.4 %, respectively. The result shows an improvement in the photovoltaic performance of DSSC as a result of the artificial voids created. However, beyond the optimum concentration of 1.5 wt%, the cell performance begun to decline. This approach greatly enhanced the current density of the cells and consequently the overall conversion efficiency significantly.

Keywords: Pore size; Thin films; TiO_2 and Dye-sensitized

Corresponding author: Domtau Dinfa Luka
domtaudinfa@gmail.com
+491781772110

Modelling of Thermal Expansion Coefficient and Specific Heat of Nano-materials

M. Singh [1]

[1]*Department of Physics and Electronics, National University of Lesotho, Roma 180, Lesotho*

Surface to volume ratio is negligible for the bulk materials but as the size of materials tends to nanorange, number of surface atoms increases and the surface of the nanomaterials becomes quite active. Free surface atoms feels different environment than their bulk counterparts. The energy linked with these atoms will be different from their bulk materials. The excess energy associated with these surface atoms is defined as the surface free energy. At nano scale surface area to volume ratio increases and it becomes significant. As a result, the surface energy increases in multiplication. On considering the surface effect, a simple model is discussed to study the size dependence of thermal expansion coefficient and specific heat of Ag and Ni nano sized solids with different shapes like nanofilm, nanowire and nanosphere . Thermal expansion coefficient for nano-sized crystal is reported as .Where, d is the diameter of the atom and D is the diameter of the nano sized particles. Here, is shape factor which is defined by ratio of surface area of non-spherical nanosolid to the surface area of nanosphere. It is predicted that the thermal expansion increases with decrease in particle size. It is realized that the particle shape can influence the thermal expansion of nanoparticles and this effect on the thermal expansion becomes larger with decreasing of particle size. On the same ground, I extended this model to analyse the specific heat of the nanomaterials. It is reported that the specific heat increases as particle size decreases. Our theoretical predictions agree fairly well with the available experimental and simulation results for nanosized particles in different shapes.

Keywords: Nanosphere, Particle shape, Nanofilm, Nanosolid, Nano materials

Corresponding author: M. Singh
Email: m.singh@nul.ls

Energy Efficient Membrane Separation Technology for Production of Potable Water *(Poster)*

Masheane Monaheng.L [1.,2]*, Verliefde A.R.D.[2], Mhlanga S.D.[1]

[1]Nanotechnology and Water Sustainability Research Unit, College of Science, Engineering and Technology, University of South Africa, Florida, 1709, Johannesburg, South Africa.
[2]Particle and Interfacial Technology Research Unit, Faculty of Bioscience Engineering, Ghent University, Coupure Links 653, B-9000 Gent, Belgium

Due to the growing concern over the availability of water research is currently focused on a more efficient and economical ways of obtaining clean and potable water and maintaining the quality if freshwater sources . The purification of alternative water sources by membrane separation has become a well-established water treatment technology recently. Membrane-based separation processes such as microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), electromembranes, reverse osmosis (RO) membranes utilize selective permeability to achieve separation of various mixtures under a significant driving force (pressure difference, concentration gradient, temperature difference and electric potential). A stand-alone solar-driven membrane system has been developed. This has a production capacity of 0.26±0.08 L/hr with more than 98% rejection for most of the pollutants.

Keywords: Membrane, potable water, purification.

Corresponding author: Masheane Monaheng
mashleon@gmail.com
(+2711) 471 2104.

Eco-Friendly Synthesis of Zinc Oxide Nanoparticles for Rayon Fibre

(Poster)

Amrita Singh[1], Brijesh Gaud[1], Himanshu Narayan[2], Rinkesh Kurkure[3], Sandesh Jaybhaye[*1]

[1]Nanotech Research Lab, Department of Chemistry, Birla College, Kalyan (M.S.), India
[2]Department of Physics and Electronics, National University of Lesotho, Roma, Lesotho
[3]Terna College of Engineering, Nerul, Mumbai (M.S.), India

Nanotechnology concerns with the development of experimental processes for the synthesis of nanoparticles of different sizes, shapes and controlled disparity. This provides an efficient control over many of the physical and chemical properties with various potential applications including pharmaceuticals and medicine. Various methods have been employed to improve the size and property of the Zinc oxide (ZnO) nano particles (NPs) so as to enhance the performance of ZnO NPs based material. Biological methods for nanoparticle synthesis using microorganisms, enzymes, and plants or plant extracts have been suggested as possible eco-friendly alternatives. In this work, ZnO NPs have been synthesized by Bio-Reduction of Zinc Nitrate in plant extract and study the effect of concentration of Zinc Nitrate on size of synthesized ZnO NPs. FT-IR spectra absorption peak at 418 cm-1 indicated characteristic absorption bands of ZnO. UV-Vis absorption wavelength at 372 nm showed a typical spectrum for ZnO. The SEM image shows that ZnO NPs prepared in this study are spherical in shape with smooth surface have size of minimum 16-36 nm. The better results with regard to antibacterial efficacy of ZnO NPs after different washing cycles whereas nanoparticles with a size of 16 nm show improved optical appearance.

Keywords: Zinc oxide Nanoparticle, Bio-Reduction, FT-IR Spectroscopy, Antimicrobial activity, Rayon Fibre

Corresponding Author: Sandesh Jaybhaye
jaysandesh@gmail.com
(+91) 9869566808
0251-2230054

Green Synthesis of Zinc Oxide Nanoparticles using Neem (*Azadirachta indica* L.) **Plant Extract** *(Poster)*

Himanshu Narayan*

**Department of Physics and Electronics, National University of Lesotho*

A number of methods have been employed to synthesize zinc oxide (ZnO) nanoparticles (NPs) with improved properties. Biological methods for NPs synthesis using microorganisms, enzymes, and plants or plant extracts have been suggested as possible green and eco-friendly alternatives. We report the synthesis of ZnO NPs through bio-reduction of zinc nitrate in neem (Azadirachta indica) plant extract. Samples were characterized by X-ray Diffraction (XRD) analysis, FT-IR spectroscopy. UV-Vis absorption, Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM). XRD analysis confirmed the hexagonal wurtzite phase of ZnO with unit-cell parameters: a = b = 3.249 Å, c = 5.206 Å. Debye-Scherrer crystallite size was estimated to be around 16 nm. FT-IR spectra absorption peak at 418 cm-1 was attributed to the characteristic absorption of ZnO. UV-Vis absorption wavelength at 372 nm also showed a typical spectrum for ZnO. The SEM image showed spherical ZnO NPs smooth surface morphology and size ranging between 16 to 36 nm, which was confirmed through AFM pictures also.

Keywords: Medicinal plants, Biological methods, Bio-reduction, X-ray diffraction, Christal formation

Corresponding Author: Himanshu Narayan
E-mail: h.narayan@nul.ls

Chapter 9: Agriculture and Climate Change (NULISTICE)

The Impact of Climate Changes on Food Security in Lesotho: Challenges and Opportunities

Matandare Blessing., Ramoeletsi T.C., Mukurunge T.

Limkokwing University of Creative Technology, Lesotho

Agriculture is the backbone of many economies in the world and many households in Lesotho are dependent on this sector for survival. For the past decade, this sector has faced a lot of challenges including severe droughts. The country imports most of its food from the Republic of South Africa thus contributing to the growth of the economy of South Africa. The National Strategic Development Plans (I & II) have selected agriculture as one of the priority sectors that should contribute to ensuring the national goals such as creating employment and economic growth are achieved. This paper will employ qualitative analysis by reviewing the policies regarding food security and interviewing the major stakeholders in the Ministry of Agriculture and Food Security to see the challenges and opportunities available for this sector.

Keywords: Agriculture, Food security, Policy, Challenges, Opportunities

Corresponding author: Blessing Matandare
bmatandare@gmail.com
+266 63016586

Production and Utilization of Conserved Barley and Oat grass as Fodder for Merino Sheep

Mosebi Poloko.E.*, Ntakatsane M.P., Matebesi-Ranthimo P. A and Makata R.

Department of Animal Science, Faculty of Agriculture, National University of Lesotho, P. O. Roma 180 Lesotho

Barley (Hordeum vulgare) and Oat (Avena sativa) are cultivated cereal forages adapted to dry season conditions. Conserved cereal forages provide nutritious fodder for sheep in winter and spring months. The objective of this study was to evaluate nutritional composition of conserved barley and oat and assess performance of merino sheep fed conserved fodder. The experiment was conducted from February to December 2017, in a complete randomized block design with three replications. Treatments consisted of two conserved forages barley and oats. Six Merino sheep ewes (Body weight = 25±3.25kg) were given 300g in separate feeders daily. Conserved forage were analysed for nutritional composition represented by dry matter, crude protein, neutral detergent fibre (NDF) and acid detergent fibre (ADF). Body weight gain was measured for merino sheep performance. Dry matter and crude protein of conserved oat forage was significantly higher than that of conserved barley forage. Neutral detergent fiber and acid detergent fiber were lower in conserved oat compared to conserved barley. The body weight gain values obtained by sheep fed oats were higher than those fed barley. The results of this study indicate that conserved oat forage had an impact on nutritional composition and body weight gain of merino sheep.

Keywords: barley; oats; merino sheep; nutritional composition; body weight gain

Corresponding author: Poloko Mosebi
pe.mosebi@nul.ls
(00266) 56700610

Prevalence of lice in Merino sheep: Case of Roma valley in Maseru District

Matebesi-Ranthimo, P.M.A.*, Taole, T. and Mosebi, P.

Department of Animal Science, Faculty of Agriculture, National University of Lesotho, P.O. Roma 180, Lesotho

External parasites negatively affect Merino sheep with a direct effect on wool production and quality general health of Merino sheep. Prevalence of Lice downgrades wool quality as the parasites pupae built-up on the wool there-by giving the wool dirty appearance. Heavy infestations can also cause anaemia in lambs and reduce productivity in adult Merino sheep. Therefore, the objective of the study was to determine the prevalence of lice of Merino sheep in Roma valley in Maseru district. The study was conducted in the form of survey where structured questionnaires was administered to 60 farmers in the individual interviews. Purposive sampling procedure was use to select responded for the current study. Data was analyzed using statistical package for social scientists (SPSS) version 20.0. Descriptive statistics was used to present findings in the form of tables and chards. There was prevalence of lice in Roma valley as indicated by 80% of the respondents. The results illustrated that lice infect both rams and ewes. However, adults are more infested than young sheep as indicated by 72% of the respondents. Farmers control Lice with both commercial and traditional medicine with application done upon exhibition of clinical signs and/or presence of Lice. Good husbandry practices including proper feeding methods, housing and best treatment and control methods lead to lice eradication and prevention.

Keywords: External parasites; prevalence; Merino sheep

Corresponding author: PMA Matebesi-Ranthimo
pmatebesi@gmail.com
(00266) 58756737

Comparison between Liming and Manure Application on Phosphorus Retention in Selected Benchmark Soils of Lesotho

Mpela T'sepo., Molete, S.F.*, Raseepho, T., Sekaleli, M., Mohale, N. & Maduna, L.

The National University of Lesotho, P.O. Roma 180, Lesotho.

Acidity is often a limiting factor in cropping soils. Some soils are acidic by nature whereas other soils have become acidic as a result of mismanagement. Usually the weathered clayey soils are acidic to strongly acidic and their fertility is limited mainly by low CEC, low base saturation, and high phosphorus sorption capacity, all of which are attributed to acidic nature of the soils. Apparently, phosphorus sorption (retention) capacity is regarded a serious soil fertility problem in most benchmark soil series of Lesotho. The high sorbing soils retain 70 – 80 % or more of P applied in fertilizers. These are mainly the clayey soils (clay loam to clay), with pH ranging from slightly acid, pH(water) 6.2 – 6.5 (Fusi and Thabana) to very acidic, pH(water) 5.0 – 5.1 (Machache and Sefikeng). It was presumed that controlling soil pH through liming or building a pool of humus by adding manure to the soil could solve the problem of phosphorus retention. Building a pool of humus was based on the notion that humus in a way reduces phosphorus retention. In order to achieve this, two parallel experiments were conducted in which the four high sorbing soils were treated with lime at 0, 40, 80 and 120 % of the respective soil lime requirement in one study, and with animal manure applied at 0, 5 and 10 % of the equivalent weight of the used soil in another study. In each case, incubation period of 42 days was allowed, followed by application of phosphorus fertilizer at a single level of 400 kg P/ha, and another 42 days incubation period. The soil tests analyses showed increase in pH in all soils as a function of lime but varying responses from manure application. Both lime and manure reduced fertilizer efficiency, increasing phosphorus retention.

Keywords: Lesotho benchmark soils; Soil fertility management; Phosphorus retention; Manure application; Liming

Corresponding Author: SF Molete
sf.molete@nul.ls
+266 2234 0601 (Office)

Evaluation of Microalgae Sludge as Biofertiliser for Growth of Maize under Greenhouse Trials

Mammati Kombi.[1].; George M.J.[2]; Mekbib S. B.[1*]

[1]Department of Biology and Biotechnology, [2]Department of Chemistry and Chemical Technology,
Faculty of Science and Technology, National University of Lesotho,
P. O Roma 180, Maseru, Lesotho

The importance of microalgae is justified by its nutrition content especially the presence of carbohydrates, lipids and proteins which make it useful in a wide array of applications including biogas production. In the present study, microalgae sludge was obtained by two formulations in biogas production as digested with cellulose degrading microorganisms (CD) and the other without CD. The microalgae sludge was then used as a bio-fertiliser for growing maize on acidic and neutral soil in comparison with the application of organic (cattle and chicken manure) and NPK at 2:6:1 proportion. Results prevailed that microalgae sludge + CD increased maize growth in both acidic and neutral soils by more than 100% and 15% of increase, respectively. Microalgae sludge + CD also effected the maize biomass more than the positive control in both soils, suggesting the effectiveness of microalgae sludge + CD in improving growth of maize. The use of microalgae sludge as a biofertiliser from the anaerobic digester is known to be free of pathogenic coliforms to be applied directly as liquid or dry formulations.

Keywords: Microalgae sludge, Cellulose degrading microorganisms, Biofertiliser, Acidic soil, Maize biomass

Corresponding Author: Sissay Mekbib
E-Mail: sbmekbib7@gmail.com
Tel: +266 63242329

The Effects of Climate Change on Food Security *(Poster)*

Amile Terlumun*

Department of physics, Benue State University Makurdi, Nigeria

Climate Change has a lot of implications on food security which encompasses food availability, food accessibility, food stability and food utilization. This paper examines how agricultural food systems and food processing technology is predominantly dependent on the use of non-renewable energy sources and the combustion of fossil fuels for energy exploration produce gases such as carbon dioxide, carbon monoxide and sulphur dioxide which causes serious environmental degradation and contribute to an acceleration of climate change on which the base of food lies. The paper gives insight on some effects of climate change on agriculture and food production directly with mean global temperatures at a random increase since the last decade mainly due to the accumulation of greenhouse gases in the atmosphere as a result of combustion of fossil fuels which cause global warming, erratic rainfall patterns and changes in agro-ecological conditions. The work highlights how renewable energy technology can be integrated into our agricultural systems with solar photovoltaic energy being the most readily available and easy to harness and some of its potentials of utilization and applications in agriculture which can reduce food postharvest losses and enhance food security being discussed in the work. Finally the paper highlights how existing global assessments of climate change and food security have only been able to focus on the impacts on food availability and access to food, without quantification of the likely important climate change effects on food safety and vulnerability (stability).

Keywords: Climate change, Greenhouse gases, Food Security, Solar photovoltaic Energy, postharvest loss

Corresponding author: Amile Terlumun
amilet47@gmail.com
+2347032512436

Using Temperate Annual Grasses for Rabbit Production *(Poster)*

Mosebi, P.E.*, Ntakatsane M.P., Matebesi-Ranthimo P. A and Nyane, T.

Department of Animal Science, Faculty of Agriculture, National University of Lesotho, P. O. Roma 180 Lesotho

Temperate annuals are important for forage production in winter and spring seasons. They decrease dependence on stored forages such as hay. They also decrease expenses of purchased feed by providing fodder in winter months. Temperate annuals are used primarily as an energy and protein source in animal diets. However, little information exists regarding the influence of temperate annual grasses on rabbit productivity. The present study was planned to evaluate nutrient content and forage yield of various temperate annual grasses, feed intake and body weight of rabbits. The trial was carried out in the National University of Lesotho Experimental Farm during winter and spring seasons in 2017. The treatments comprised of two temperate forages; oats and barley in completely randomized design. There were three replications of each treatment. Twelve crossbred rabbits (Flemish giant/New Zealand white) aged between 4and 8 weeks and with a mean live weight of 1.1±1.5 kg were housed in individual cages. The rabbits were given 90g of forage in separate feeders in the morning. The forage diets were given ad libitum. The values of dry matter (DM) and crude protein (CP) were higher in barley samples while values of neutral detergent fibre (NDF), acid detergent fibre (ADF) were lower than those of oats samples. Feed intake was higher for rabbits fed barley than oats fodder. There was an improved weight gains on rabbits fed barley compared to oats. The results obtained in this study suggested barley being highly nutritious hence improved live weight gain of rabbits. Therefore barley could be used as source of forage for rabbits.

Keywords: barley; oats; rabbits; nutrient content; body weight

Corresponding author: P.E Mosebi
pe.mosebi@nul.ls
(00266) 56700610

Prevalence of Gastrointestinal Parasites of Goats in Different Agro-ecological Zones of Maseru District in Lesotho *(Poster)*

Molapo Setsumi[1], Matebesi-Ranthimo, P.M.A.* [1], Phoofolo, M. [2], Phalatsi, M.[2] and Moea, L.[1]

[1]Department of Animal Science, Faculty of Agriculture,
[2]Department of Biology, Faculty of Science and Technology,
National University of Lesotho, P.O. Roma 180 Lesotho

The study on the prevalence of gastrointestinal parasites of goats was carried out for six months from July to December 2016 in different agro-ecological zones of Maseru. Randomly nine farmers from three zones with a total of 180 goats were identified for sampling. Faecal samples were collected from the rectum of each goat and Macmaster technique was used. Month, sex, age and agro-ecological zone influenced patterns of gastrointestinal infections. The higher coccidia infections were observed in July. Young animals were more susceptible to parasitic infections than adults. Male goats were more susceptible than females. Animals in the highlands were heavily infected with coccidia as compared to those in the foothills and lowlands. The nematode prevalence rates recorded in lowlands were higher than that of foothills and mountains.

Keywords: gastrointestinal parasite; goats; Agro-ecological zone

Corresponding author: P.M.A Matebesi- Ranthimo
pmatebesi@gmail.com
(00266) 58756737

Evaluating Prevalence of Gastrointestinal Parasites of Merino Sheep in Quthing District of Lesotho *(Poster)*

Molapo Setsumi[1], Matebesi-Ranthimo, P.M.A.* [1], Phoofolo, M. [2], Phalatsi, M.[2] and Moea, L.[1]

[1]Department of Animal Science, Faculty of Agriculture,
[2]Department of Biology, Faculty of Science and Technology,
National University of Lesotho, P.O. Roma 180 Lesotho

The objective of the study was to evaluate the prevalence of gastrointestinal parasites and how they are affected by month, age, sex, and agro-ecological zones. The study was conducted in three agro-ecological zones of Quthing which are the Mountains, Foothills and the Lowlands from July to December 2016. A total of 180 sheep (60 from each agro-ecological zone) were examined monthly with the sample collected directly from the rectum of the tagged sheep. Animals in the foothills were more affected by the gastro-intestinal parasites. The months of October, November and December had higher nematode prevalence. Coccidia was more prevalent in July, August and September. Age had an effect on the prevalence of coccidian in sheep. Both males and females were similarly affected by nematodes and coccidia. Therefore, it is recommended that agro-ecological zone, age, sex and time of the year should be taken into consideration when treating gastrointestinal parasites.

Keywords: gastrointestinal parasite; sheep; Agro-ecological zone

Corresponding author: P.M.A Matebesi- Ranthimo
pmatebesi@gmail.com
(00266) 58756737

Optimization of Agricultural Production through Soil Testing at Community Levels *(Poster)*

Ntsapi 'Mathuso.J*

Faculty of Agriculture, Department of Soil Science, National University of Lesotho

As a concerned soil scientist, I have noticed the poor quantity of Agricultural production even when the soil is costly amended. Money that could have benefit in or invested in other projects and infrastructure development is wasted on fertilizers. Public and private sectors may assist in lab materials that test fertility of the soil in respect to targeted crop. Poor Agricultural production is due to failure of soil to supply required nutrients to a certain plant not that they are unavailable but because plant nutrient requirement differ according to varieties and types. Agriculture is the backbone of the country stabilizing food security hence it is important to invest in it. Soil and plant tests and analysis would benefit in increased production and saving costs. Agriculturalists, soil scientists and environmentalist would also be employed in order to disseminate innovative techniques like conservation Agriculture that are environmentally smart at the same time increasing production on scares land.

Keywords:

Corresponding author: Ntsapi Mathuso
ntsapi201400427@gmail.com
+26657711178 Fax: (+266)22340000

Effect of Liming on Retention of Applied Phosphorus in Selected Benchmark Soils of Lesotho *(Poster)*

Molete Sebolelo, F.*, Raseepho, T., Sekaleli, M., Mohale, N., Maduna, L. & Mpela, T.

The National University of Lesotho, P.O. Roma 180, Lesotho.

High phosphorus retention coupled with low pH in agricultural soils pose a serious threat to crop production in most countries. These two problems, inclusively, account for a much high failure of most soils to respond to fertilizer application and/or a need to apply too much fertilizer with limited returns. Thus, limiting the potential of agricultural productivity as well as economic development in any country. Lesotho is not an exception in this case. The previous studies showed that seven (7) out of the eleven (11) benchmark soil series of Lesotho retain significant proportions of phosphorus. The percentage of P retained from a single application point of 400 kg P/ha, in the order of 22 to 83 %, has been recorded. Four (4) of these soil series, viz. Thabana, Fusi, Machache and Sefikeng, characterized by clayey texture (clay loam to clay) and pH ranging from slightly acid or near neutral (pH(water) 6.2 – 6.5) to very acidic pH (pH(water) 5.0 – 5.1), retained between 69 and 83 % of applied P, hence classified as soils with high phosphorus retention capacity. The current study investigated the subsequent effect of liming for control of pH on P retention in those four high phosphorus retaining soils. The soils were treated with lime at 0, 40, 80 and 120 % of their respective lime requirement, and incubated for 42 days. Thereafter, they were given P fertilizer at a single application rate of 400 kg P/ha, and incubated again for another 42 days. Laboratory soil test results from this study showed increase in pH in all soils as a function of liming. However, phosphorus retention also increased with lime application rate. Explanations to this behaviour are provided in the paper. Correlation between pH and P retention was determined.

Keywords: Single point application rate; Lesotho benchmark soils; Phosphorus retention; Incubation studies; Liming

Corresponding author: Sebolelo Molete
sf.molete@nul.ls
+266 2234 0601 Fax: +266 2234 0000

Microbial Biomass and Characterization of Bacterial Community of Wetlands Soils *(Poster)*

Mapeshoane Botle. E[1]*, M. Nketu[1], M. 'Mota[1] & L. Maduna[2]

[1] *Department of Soil Science & Resource Conservation*
[2]*Department of Statistics*
National University of Lesotho, P.O. Box Roma 180, Lesotho
[3] *Ministry of water, Department of Water Affairs Maseru 100, Lesotho*

Microbially-mediated biogeochemical processes such as organic matter decomposition and biomass turnover lead to increases and decrease in the content of microbial biomass, moreover, fluctuations in the size of the microbial biomass pool can be considered as an indicator of peat degradation and functions of the wetland. The study was conducted to evaluate variability in microbial biomass and characterise bacteria species of peat at different depth in the Khalong la Lithunya Wetland, Lesotho. The results revealed that the soil microbial biomass (fungi and bacteria) of peat decrease with depth. The bacterial biomass mean was found to be 3.91*104 per gram of soil with standard error of mean being 1.29*108 per gram of soil while the fungal biomass mean was 1.83*109 per gram of soil with standard error of mean being 6.77*107 per gram of soil. The most identified bacterial species were Photobacterium damselae, Aeromonas schubertii, Aeromonas molluscorum, Aeromonas bivalvium, Aeromonas salmonicida and Aliivibrio fischeri. The study resulted in isolation of soil bacteria belonging to known groups suggesting that the used methods extended the range of culturability among soil bacteria in this will help to elucidate their roles in soil.

Keywords: Microbial, Biomass, bacterial, decomposition

Corresponding author: Botle Mapeshoane
be.mapeshoane@nul.ls

Screening of Common Bean Cultivars (*Phaseolus vulgaris* L.) for Drought Tolerance *(Poster)*

Rephe Moliehi A.*, Matsie M.S. and Morojele M.E.

National University of Lesotho, Faculty of Agriculture, P.O. Roma. 180. Lesotho.

Drought is increasingly becoming a serious challenge reducing common bean productivity in Lesotho. A study was conducted in Lesotho with the object of (1) verifying the differences among common bean cultivars in response to induced water deficit stress, (2) evaluating common bean cultivars against different concentration levels of Polyethylene glycol which induces drought stress in germinating seed and seedling growth and (3) identifying cultivars of common beans tolerant to drought stress and rank top performing accordingly. Complete Randomized Design with three replications and 28 treatments were employed in the laboratory experiment. Treatments were seeds of common bean cultivars obtained from Department of Agricultural Research in Maseru, Lesotho and four different concentrations of PEG-6000. Parameters measured were germination percentage, germination stress index, plumule length, radicle length, plumule fresh and dry weight and radicle fresh and dry weight. Significant differences ($P<0.01$) among cultivars of common beans in relation to induced procedure of determining drought tolerance as described by Michel and Kaufiman (1973) was followed. Data generated from the experiment were subjected to ANOVA using Genstat Version 14. Mean separation was done using LSD. The results revealed that differences exist among bean cultivars. Different concentrations of PEG created highly significant ($P<0.01$) different environments for common bean cultivars. Interactions of common beans and PEG concentration created highly significant different ($P<0.01$) environments in which seed germinated and seedlings grew. Kranskop and Small white haricots cultivars obtained highest values in five drought stress indices out of eight measured, followed by CAP 2000, Mkuzi, Nordak, RS7 and DBS 840 cultivars with highest values in four drought stress indices, lastly followed by PAN 148, PAN 9213 and DBS 310 in three drought stress indices.

Keywords: Common bean, Anova, Drought tolerance, PEG, Lesotho.

Corresponding author: Moliehi Rephe
moliehirephe@gmail.com
+266 57551322

Screening of Maize Cultivars Grown in Lesotho for Drought Tolerance

(Poster)

Matsie Mateboho Selina*, Rephe M.A and Morojele M.E.

The University of Lesotho, Faculty of Agriculture, Department of Crop Science, P.O.Roma. 180. Lesotho

Drought is a natural phenomenon that affects maize growth, development and ultimately yield, necessitating mitigation strategies. A study was conducted in Lesotho with the aim of (1) verifying the differences among maize cultivars in response to induced water deficit stress, (2) evaluating maize cultivars against different concentration levels of Polyethylene glycol which induces drought stress in germinating seed and seedling growth and (3) identifying cultivars of maize tolerant to drought stress. Complete Randomized Design with three replications and 22 treatments were employed in the laboratory experiment. Twenty-two different accessions of maize were collected from Department of Agricultural Research in Maseru, Lesotho, were evaluated for their genetic potential to drought tolerance at seedling stage. Water stress was induced by non-ionic water soluble polymer polyethylene glycol (PEG) of molecular weight 6000 using the procedure which was described by Michel and Kaufiman (1973). After ten days, data were collected on plumule length, radicle length, coleoptile length, radicle fresh weight, plumule fresh weight, coleoptile fresh weight, radicle dry weight, plumule dry weight and coleoptile dry weight. Analysis of variance was performed using Genstat recovery Version 14 to establish the difference among treatments. The results showed significant differences ($P<0.05$ and $P<0.01$) among the accessions, PEG-6000 concentrations and their interactions for evaluated seedling traits suggesting a great amount of variability for drought tolerance in maize cultivars. The maize cultivars which outperformed the others in terms of drought tolerance were CAP 9019, SNK 2778, DKC 78-27, PAN3MO1 and Natal.

Keywords: Drought tolerance; Maize cultivars; PEG-6000; Lesotho; Analysis of variance.

Corresponding author: Selina Mateboho Matsie
matebohomatsie@gmail.com
+266 57096152

Growth of Elephant Grass (*Pennisetum purpureum*) as Influenced by Application Fertilization and Organic Amendment *(Poster)*

Molise T. P. and M. M. S. Sekoli*

National University of Lesotho, P. O. Roma 180

The study was conducted at the National University of Lesotho during 2015 – 2016 to evaluate the effect of nitrogen fertilizer and Bokashi on the growth and development of elephant grass under rain fed conditions. A factorial design was used to transplant the root slips of elephant grass in 5m x 5m plots of four replicates, where treatments were allocated in randomized complete block design. Two levels of Lime Ammonium Nitrate (LAN), 0 and 180 kg ha-1 as well as two levels of organic amendment (Bokashi) at 0 and 2t ha-1 were applied as top dressing two weeks after transplanting. The growth characteristics: plant height (cm), tiller number, stem diameter (cm), total fresh weight (kg), and dry weight (g) were measured during two harvesting intervals. Data was subjected to Analysis of Variance at 5% significance level and separation of means was done through Least Significant level. The treatment with a combination of Bokashi at 2t ha-1 and 180 kg ha-1 LAN fertilizer significantly increased stem diameter fresh and dry weight during the first harvest. During the second harvest, the treatment with a combination of Bokashi at 2t ha-1 and 180 kg ha-1 LAN fertilizer significantly increased plant height, tiller number, stem diameter and fresh weight. During both harvest times, the control which had neither Bokashi nor fertilizer had the lowest values of the measured variables.

Keywords: Elephant grass; Bokashi; Fertilizer; Growth characteristics; Lesotho.

Corresponding author: M.M.S Sekoli
mms.sekoli@nul.ls
+266 22 340 601 Fax +266 22 340 000

Chapter 10: Biotechnology and Food Safety (NULISTICE)

Assessing the Economic Viability and Practical Application of Organic Photovoltaics in Africa

Nwadiaru Ogechi Vivian*

Department of Energy Engineering,
Pan African University Institute of Water and Energy Science (Including Climate Change),
Tlemcen, Algeria

The rise in the global population is constantly putting pressure on the available energy resources leading to an excessive exploitation of conventional energy resources such as fossil fuels. The use of fossil fuels has led to several health challenges and environmental issues, this has therefore informed the decision to switch to renewable energy resources. Solar PV technology has carved a niche for itself as a low cost option for providing electricity even to the most inaccessible areas; however convention technologies are relatively limited in their application due to their rigid nature and difficult manufacturing steps. This has created an opportunity for research into materials that can be easily fabricated and used for their photovoltaic effect, hence the recent interest in the field of organic photovoltaics. Organic photovoltaic (OPV) research has gained momentum since the discovery of conducting polymers and holds a promise for a low cost alternative to conventional PV technologies for providing access to electricity. The challenge currently facing the commercialization of this technology is the very modest efficiencies and lifetimes currently achieved. Efficiencies as high as 13.1% have been obtained with these devices and cost estimates place them at $50 - $100/m2 at a lifetime of 5years and an average modular efficiency of 5%. Considering these modest values for lifetime and efficiency it is important to access possible new market frontiers in the African context where the use of this technology could be viable and economical for availing electricity. In this work the potential of OPV for use in Africa is evaluated and possible niche applications are recommended.

Keywords: Organic Photovoltaics; Conducting Polymers; Lifetime; Efficiency.

Corresponding author: Vivian Ogechi Nwadiaru
nwadiaruo@gmail.com
+213557049590

Lesotho Medicinal Plants of the Asteraceae Family: A Review of the Ethnobotany, Chemistry and Conservation Status

Mohale B. Mabaleha[1, 2] * and Susan L. Bonnet[2]

[1]Department of Chemistry, Faculty of Science and Technology, National University of Lesotho
[2]Department of Chemistry, Faculty of Natural and Agricultural Sciences, University of the Free State

Plants have and continue to play a pivotal role in the wellbeing of humankind, either in the form of food, fuel, medicine or shelter. Several plant species from a diverse range of families are used in Lesotho for medicinal purposes. For example, Dicoma anomala (hloenya) is used to treat breast cancer while Aster bakerianus (phoa) is effective against sexually transmitted infections (STIs), particularly syphilis1. While ethnobotanical information about most of Lesotho medicinal plants is well documented (albeit out-dated sources), the scientific validation and conservation status of these plants remain subjects of concern. In spite of their important role in healthcare and as a source of livelihood, medicinal plants in Lesotho are faced with ever-increasing threats. Exponential growth in trade of some of these plants, coupled with socio-economic factors lead to unsustainable and uncontrolled harvesting. The family, Asteraceae provides an arguably significant number of Lesotho plant species used in traditional medicine. This study provides an in depth account of the ethnobotany, chemistry and conservation status of selected medicinal plant species of the family, Asteraceae that are commonly used in Lesotho traditional medicine and cited most in the literature. According to the literature, the ethnobotanical information for the sampled species is satisfactorily preserved. The reported medicinal uses cover a wide range of ailments from circulatory, gastrointestinal, respiratory, reproductive, pain relief, digestive and other non-classified sicknesses. Flavonoids, terpenes, chalcones, phenolic compounds and coumarins are some of the characteristic metabolites of this family. The observed biological activities are in agreement with the reported metabolites, and they include antioxidants, antimalarials, purgatives and narcotic analgesics. This study has found that the ethnobotanical knowledge of Lesotho medicinal plants of the family, Asteraceae has been adequately covered. However, gaps still exist in the isolation of active ingredients (compounds) and elucidation of their mechanisms of action.

Keywords: Medicinal, Plants, Lesotho, Asteraceae.

Corresponding author: Mohale Mabelea
mmabaleha@yahoo.com

Screening and Extraction of Essential Oils from Different Indigenous Non-food Plants for Detergent Production

Thabiso Letseka and Mosotho J. George*

Department of Chemistry and Chemical Technology,
National University of Lesotho, P.O. Roma 180, Lesotho – Southern Africa

In this study, an alternative plant oil is investigated for substitution of pine oil which is the most expensive ingredient in pine gel detergent. Firstly a headspace sampling technique known as BID-SDME was optimized for the initial screening for presence of essential oils in the plants as to compare their profiles with that of the commercial pine oil. The parameters optimized were as follows: use of 1 µL heptadecane with 0.5 µL of an air-bubble as an extraction solvent, 55 °C sampling temperature, 15 minutes sampling time and 1500 µL sample volume. Following the screening of the potential plants, oil was extracted from different locally growing non-food plants using a modified steam distillation for comparison of oil content. Of the screened plants, Tagetes minuta known locally as either monkhane or lechuchutha resulted in the highest yield of 0.83 -1.35 % while sewage algae and pine leaves resulted in yields of 0.28 - 0.44 and 0.54 - 0.97 % (v/m) respectively. Tagetes minuta oil was then used for detergent preparation. However, the detergent could not set the same way as the pine gel counterpart and displayed higher CMC (0.002219 mol/L) compared to that of the pine gel 0.001691 mol/L demonstrating a somewhat lower detergency. Despite these challenges, T. minuta still demonstrate a potential that will lead to improved profit margin should the optimization be carried out further.

Keywords: Pine gel detergent, headspace sampling, BID-SDME, Tagetes minuta oil, Critical Micelle Concentration.

Corresponding author: Mosotho George
jm.george@nul.ls
+266 5221 3502

Physicochemical and Microbiological Quality Assessment of Different Brands of Bottled Water, Maseru, Lesotho

Molefe Khothalang. E.[1], Mosotho G.J.[2] and Mekbib S. B.[1]*

[1]Department of Biology and Biotechnology,
[2]Department of Chemistry and Chemical Technology,
Faculty of Science and Technology, National University of Lesotho,
P. O Roma 180, Maseru, Lesotho

Water is vital for life. However, it also serves as the commonest route of transmission of a number of infectious diseases. “Standard Methods for the examination of water and wastewater” were followed to analyze most of the physicochemical and microbiological characteristics of the water samples. The different brands of bottled water samples didn’t show significant variation in their physicochemical characteristics compared to unbottled water. Instead, significant variation was observed in their microbiological analyses in that 50% of the total samples were heavily contaminated with faecal Coliforms (E. coli), while the other 50% of the water samples were heavily contaminated with opportunistic microorganisms (Staphylococcus aureus), which indicates poor hygienic water bottling practices. It is therefore highly recommended that all bottled water companies should fulfill the basic water quality standards given by WHO before marketing the water for public consumption.

Keywords: Physicochemical; Microbiological; Quality assessment; Bottled water; Lesotho; Coliforms

Corresponding author: S.B Mekbib
sbmekbib7@gmail.com / sbmekbib@nul.ls
+26663242329

Deploying Novel Forms of Nisin to Control Listeria monocytogenes in Food Industry

Lekatsa Teboho*

Department of Nutrition, Faculty of Health Sciences,
National University of Lesotho, Roma 180, Maseru, Lesotho

There is growing consumer awareness of the link between diet and health. Consumers are more concerned about the synthetic chemicals used as preservatives in food now-a-days, and there is resulting trend towards less processed food. These untreated foods can harbour dangerous pathogens which can multiply under refrigeration and without oxygen. Lantibiotics are post-translationally modified antimicrobial peptides, of which nisin A is the most extensively studied example. Nisin is a natural, toxicologically safe, antibacterial food preservative. Here we address this issue by assessing the ability of nisin A and nisin V to control Listeria monocytogenes EGDe in two commercially available milk products. The efficacy of the nisin peptides in chocolate milk resulted in significant reduction (over 1 log) in listerial numbers for nisin V after 24 hrs. In cottage cheese, after 48 and 72 hours no listerial cells were detected in the nisin V containing cottage cheese sample while low cell numbers (7 X 102) were detected in the nisin A samples This analysis revealed that nisin V was more effective than Nisin A with respect to being used as anti-Listeria food preservative. Further studies will be essential to find the optimum pH and sodium chloride conditions to control Listeria in particular target food products.

Keywords: Nisin, anti-microbial activity, Listeria monocytogenes, natural preservative, Lanibiotics

Corresponding author: Lekatsa Teboho

Use of Soil Microbiota for Stability and Functionality of Mine Waste

(Poster)

Pheko Relebohile. J[1]*, B. E. Mapeshoane[1], S. B. Mekbib[2], M. V. Marake[1], S. F. Molete[1] P. A. Molumeli[1] & T. Nkheloane[1]

[1]Department of Soil Science & Resource Conservation
[2]Department of Statistics
National University of Lesotho, P.O. Box Roma 180, Lesotho
[3] Ministry of water, Department of Water Affairs Maseru 100, Lesotho

The direct impacts of mining activity on land surfaces are usually severe, with the likelihood of the destruction of biodiversity of the natural ecosystems through the removal of natural soils and overburden with mine waste. Soil biota is useful as quality and health indicators of soil and one of the sensitive biological markers useful to identify the disturbance and damage of ecosystem. Several fungal and bacterial species, popularly called as Phosphate Solubilizing Microorganisms (PSMs) assist plants in mobilization of insoluble forms of phosphate, while others degrade cellulosic material. The study was carried out to isolate, characterize PSMs and Cellulose Degrading Microorganisms (CDMs) and assess their impact on microbial activity of Letšeng Diamond Mine (LDM) waste. Screening of PSM and CDM were isolated from soil samples were collected from 30 cm depth top soil at LDM. Microbial biomass of four classes of mine waste (fine and coarse kimberlite tailings, fine and coarse basalt waste rock) was determined by dilution method. Microbial activity greenhouse experiment was layout of four classes of mine waste inoculated with isolated PMS and CDMs treatment combinations respiration was determined at the interval of 5 days. The average bacterial biomass ranged from $5.10*10^5$ per gram of fine tailings to $1.38*10^6$ per gram of coarse waste rock. The average fungal biomass was 9.10*105 per gram of tailings to $6.77*10^7$ per gram of coarse waste rock. Respiration measure Carbon dioxide absorbed after 5 days of inoculation ranged 0.8385 g kg^{-1} from fine tailing to 1.0576 g kg^{-1} from waste rock. Basalt waste rock has more microbial biomass and more carbon emitted from it than kimberlite tailings, hence such material can be easily stabilised and be functionally active to rehabilitate the mine site.

Keywords: Cellulose degrading; Nitrogen fixing; kimberlite; Letseng Diamond; Bioremediation.

Corresponding author: Pheko Relebohile
relebohilepheko2@gmail.com

Bacteriological properties of commercially available fermented sorghum beverages (Motoho) against selected spoilage microorganisms in Maseru *(Poster)*

Teboho Lekatsa[1], *Mothibe Kebitsamang Joseph[1], `Mamakase Sello[1] and Puseletso Lekhema[1]

[1]*Department of Nutrition, Faculty of Health Sciences, National University of Lesotho, Roma 180, Maseru, Lesotho*

The fermented sorghum beverage (Motoho) is one of the famous traditional beverages found in the markets of Lesotho. It is readily consumed by the entire families including babies in Lesotho therefore its safety is of paramount importance. The objective of the study was to assess the microbiological, physical and chemical characteristics of Motoho against potential spoilage strains of Escherichia coli and Staphylococcus aureus which cause Foodborne Illnesses. The unfermented sorghum beverage (Lesheleshele) was used as a control. Selected commercially available samples of fermented and unfermented sorghum beverages were inoculated with Escherichia coli ATTC-25922 and Staphylococcus aureus ATCC Baa-1026 respectively. Samples were incubated at room temperature, 4°C and 8°C and the presence of bacteria was tested at every 3 hrs. Fermented sorghum porridge showed to have some inhibitory properties against E. coli and Staph aureus at different incubation temperatures. The findings also showed that there is a significant difference in sugar content and pH of products from different manufacturers. More studies are still needed for the large scale production to set standards in producing healthier and safe beverages.

Keywords: Motoho, Bacteriological properties, spoilage microorganisms and Lesotho

Corresponding author: Mothibe Kebitsamang Joseph
kebitsamangmothibe@yahoo.com