

The EnPe Secretariat is proud to present a collection of abstracts from beneficiaries of the EnPe Programme (2013-2020). In this booklet you can read more about ongoing and completed research conducted by PhD students and postdoctoral researchers with funding from the EnPe Programme.

The research scope covered spans from biological, economic and technological issues to impacts on social issues, human rights and the environment in renewable and non-renewable energy resource development. Within renewable energy, the studies are mainly focused on solar, bioenergy and hydropower; while for non-renewables, studies focus on petroleum resources.

We expect that the readers will get acquainted with a broad suite of innovative research which has been supported by the EnPe programme within the energy sector. We hope that this may contribute to future energy research and strengthened development strategies in the participating countries.

We want to thank the students for their contributions and wish them all the best in their future endeavors.

The EnPe Secretariat

### Trondheim February 14. 2019



## Name

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Expected completion date

January 2020

#### Supervisor(s)

Ole J. Nydal, Cuthbert Kimambo & Joseph Kihedu

### Characterization of Three Phase Flow in Pipelines

# Background including justification or problem statement:

Multiphase flow models for oil and gas industry are very essential for the comprehension of behavior of flow under wide range of operating conditions and configurations. Experimental measurements are required to develop and validate flow models

Despite many efforts towards improvement of models, yet characterization of three phase flow appeared to be one of the key challenges. For example, Tanzania deep water offshore field development stimulates the need for more experimental data on three phase flow in inclined pipelines.

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Prediction of flowparameter such as pressure loss which is very essential parameter for design and operational strategies depend on correct prediction of flow patterns and liquid hold up. Liquid hold up is again very important to be correctly understood for controling liquid accummulation during the production of natural gas.

This work is based on experimental study of flow regimes and liquid loading in inclined pipelines. The data will be

used to test the performance of existing prediction models and as a basis to improve some of the flow models

#### Aim and objectives:

The aim is to characterize flow regimes and liquid loading in inclined three phase flow pipelines. While specific objectives of this research are as follows;

a) Mapping three phase oil water gas flow regimes in inclined pipes to clarify the effect of the second liquid phase on flow patterns transitions.
b) Characterisation of liquid loading in inclined pipelines.

c) Testing existing flow models' accuracy in prediction of three phase flow in inclined pipelines.

#### Short overview of methodology:

Experiments are carried on Multiphase Flow Laboratory at NTNU. The two test sections are involved; inclined six-meter length section and eighteen meters vertical section both having 60 cm internal diameter.

The rig is equipped with air, water and oil flow line with their flow meters, differential pressure meters and absolute pressure meter.

Flow regime is identified by two methods; observation with the aid of high quality camera and by analysis of capacitance probes signals.

Liquid holdup will be determined by quick closing valve technique.

All experiment start with two phase flow followed by three phase flow in order to mark the differences. **Results and/or findings:** The research is still in progress.

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Capacitance signals for slug with backflow at 14 degrees inclination, superficial water velocity of 0.02m/s and superficial air velocity of 0.1 m/s





Name Agnes Carol Kisanga

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Supervisor(s)

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# Diversity of Small Mammals Along the Gradient of Distance from Major Infrastructure in Mikumi National Park, Tanzania

Education background

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# Background including justification or problem statement:

The need for fast development in developing countries has led to establishment of public major infrastructure even in biodiversity rich protected areas.

In Tanzania, a number of infrastructure have been established in protected areas such as public road along the Serengeti, Katavi and Mikumi national parks (MNP).

In some protected areas like Mikumi which is a focus of this writing, there are four types of infrastructure, namely highway, pipeline, power lines and railway. Some of them were established prior to establishment of EIA, others without proper EIA due to the urgency of such projects leading to paucity of baseline data that could be used to assess their effects.

There is fair literature on effects of such infrastructure on biodiversity. Still, the literature show high representation from Europe and America focusing on large mammals in separate infrastructure type. Known Small Eulip

Conversely, there is limited representa-

tion of small mammals especially from the tropical Africa. Therefore, this study reports effects of the four linear infrastructure found in MNP on diversity of small mammals.

#### Aim and objectives:

To determine the effect of four linear infrastructure on diversity of small mammals

#### Short overview of methodology:

Small terrestrial mammals of the order Eulipotyphla and Rodentia were trapped during both wet (February-April) and seasons dry (July- September) in 2018 from three established plots along the three transect lines set perpendicular to each infrastructure.

The first three immediate plots in each transect were set immediately after the right of way (ROW) margin of the infrastructure, the intermediate and distant plots were set at 500m and 1000m away respectively.

The transects were set 2km apart and the plots had 100 m x 200 m size with two trap lines spaced around 50m. The trap lines had 10 Shermans® live traps placed 10m apart baited with fried sardines and groundnuts.

For places where two infrastructure share ROW example highway and pipeline we conducted additional sampling to assess the combined effect.

#### Results/findings:

In 10102 trap nights, we captured nine species of small mammals, Mastomys natalensis being the most abundant species. Shannon diversity was marginally high in dry than wet season. Diversity was significantly high along the railway in the dry season.

The power line and pipeline sites had relatively high animal abundance compared to the railway, road and combination of road and pipeline. In addition, the intermediate plot (500M) had significantly higher abundance than immediate and distant plots.

There were generally high number of female caught than males. The infrastructure had relative spatio-temporal effects on the abundance, diversity and sex of small mammals.

# Challenges and how these have been addressed:

 Limited time and fund to establish season's replications and to exhaust animal trapping.
 Insufficient funds to complete some research activities such as soil sample analysis



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Supervisor(s)

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### An Experimental Investigation of Silica Nanoparticles Assisted Water Flooding for Enhanced Oil Recovery

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Education background

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#### Abstract:

The era of "easy oil" production is ending, and it is necessary to develop new enhanced oil recovery (EOR) technologies to run the production economically.

Previous studies have shown that hydrophilic silica nanoparticles can improve water-flooding performance significantlv due to their small size (1-100 nm) and high surface area-to-volume ratio.

However, the major challenge is the development of the nanoparticle types capable of meeting the oil field screening conditions while providing the highest

oil recovery. In addition, a proper understanding of the underlying EOR mechanisms of the nanoparticles is needed.

This work provides results of cooperation between the nanoparticles manufacturer and the nanoparticles for EOR or "nano-EOR project" at Norwegian University of Science and Technology (NTNU).

Twenty-three different types of silica nanoparticles were developed targeting stability in water.

nanoparticles will improve the performance of the water injection in a specific oil reservoir.

The objective of this work was to evaluate the potential of the nanoparticles as additives to injection water for oil recovery applications.

The nanoparticles were prepared to 0.1 wt. % concentration in synthetic North Sea water. The crude oil was obtained from a field in the North Sea.

The main hypothesis is that the The following investigations were per-

formed to rapidly obtain enhanced oil recovery information of the nanoparticles and subsequent verification of their oil recovery performance on consolidated rocks:

1) The nanoparticles were injected from start (at initial water saturation) in a visual glass micromodel.

2) For the prominent silica nanoparticles, we evaluated oil recovery by conducting secondary core flooding experiments in water-wet Berea sandstone rocks

3) Supplementary measurements included interfacial tension. Amott-wettability and an analyze of differential pressure across the core to gain fundamental knowledge of oil recovery mechanisms of the nanoparticles.

Injection of nanoparticles through glass micromodel resulted in very high oil recoveries and small variations between the recoveries obtained with different nanoparticles samples.

The selected nanoparticles samples

showed promising oil recovery factors on Berea sandstone rocks. The secondary core flooding oil recoveries ranged from 44.4% to 55.7% of original oil in place (OOIP) compared to 39.7% of reference water flood and four nanoparticles were recommended for further investigations.

recovery of oil.

Supplementary studies showed that oil recovery is affected by a contribution of interfacial tension reduction and wettability. However, the increased differential pressure observed throughout the nanoparticle injection may support the occurrence of log jamming effect in the



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### Evaluation of Public Bus Accessibility for Sustainable Transport Planning: A Case of Kathmandu Valley

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# Background including justification or problem statement:

Growing demand for transport activities has raised numerous transport problems mainly traffic congestion, environmental and energy issues.

Efficient public bus services can be one of the sustainable solutions for meeting local transport demands. But the inefficient operation of public bus services has attracted tremendous numbers of private vehicles to ply in the road of Kathmandu valley worsening the situation.

The access to public bus and its efficient

operation is one of the key issues to reduce soaring vehicle numbers and for sustainability in transport.

The need for investment in improving access to good public bus services for the sustainable transport planning of the valley is a priority.

#### Aim and objectives:

To define accessibility of a ley.
 public transit system operating without
 strong regularity measures and access
 the status of public bus accessibility to provide input to the sustainable transport planners.

2) To analyze the impact of informal and unregulated transport system prevalent in most of the developing countries focusing mainly on energy and the environment point of views.

#### Short overview of methodology:

Quantitative and qualitative approaches were used to evaluate overall public transit accessibility in Kathmandu valley.

Quantitative data were collected from primary and secondary sources. Primary data were collected from a survey that includes frequency of service availability, the total number of stops, the time interval between stops, total travel time in transit lines and traffic count per hour in major stops.

The quantitative approach measures the existing public transit accessibility in Kathmandu valley. The spatial modeling tool was used to map the accessibility of public transit in Kathmandu valley.

The key findings from quantitative analysis highlight the importance of travel time in mode choice that led to qualitative analysis to understand the issues relating to the reduction in travel time and mode choice.

#### **Results or findings:**

The analysis of nearest distance to the bus stop from each ward of Kathmandu valley shows approximately 75% of the total valley population has a connection to the public bus stops within the catchment of 1000m at a walking speed of 3km/h in the terrain of Kathmandu valley. Most of the valley people thus owns an alternative mode of transport mostly motorcycle and car for their daily commute.

This has extensively increased the number of private vehicles that ply in Kathmandu valley in one hand and on the other hand, the poor performance of public bus service has made it less attractive modes. Chall

The tremendous increase in traffic in city-centric route shows the importance of good connecting roads to improve public bus accessibility for sustainable transport.

The result of the accessibility analysis shows the need of an integrated transport system for optimal operation of the bus service such that a significant reduction in energy and emission can be achieved without the need for huge investment.

Improved accessibility to public transit attracts more users towards it that plays a vital role in assessing the potential energy efficient transition. The geographical categorization provides the basis for the transport planners to plan and implement transport policies. Results can also be used to identify the area with poor accessibility so as to prioritize investments in transport planning.

# Challenges and how these have been adressed:

The lack of resources including poor data availability and access to the tool is one of the major challenges.

Field survey and secondary sources were relied upon for detail analysis.



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Supervisor(s)

Sudha Shrestha & Hans Skotte

### An Integration of Urban Landuse and Transport Planning for Energy Efficiency: A case study of Kathmandu Valley

# Background including justification or Valley. problem statement:

With rapid growing economies and population, there is an increasing trend of expansion of urban sprawl and auto-mobilization, within the cities of the Kathmandu Valley. With the rise in travel demand, transport energy is becoming a major concern for planners and policy makers.

#### Aim and objectives:

The aim of this research is to study travel behavior, urban landuse and transport system in relation to transport energy demand, in context of the Kathmandu

Short overview of methodology:

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Travel data of daily trips was collected from the household survey. Travel behavior of the workers and students was studied using statistical analysis to find the relationship between travel characteristics and socio-economic background, demographic factors.

Four key variables - gender, age and income and household vehicle ownership were related with mode choice and trip distance. Spatial analysis was done using Four Step Model (FSM) based on current travel behavior data. It was aimed to study the travel pattern in macro scale, whereby, the travel pattern of whole of the study was modelled.

#### **Results or findings:**

For mode choice of work trips, it shows that income group, gender, age-group, vehicle ownership, indeed are the persuading factors. For trip length of work trips, average trip length tends to increase with income level and average trip length of men is longer that of women. For educational trips, there is not much influence of socio-demographic factors on mode choice and trip length.

When analyzing travel behavior in relation to urban for the travel energy assessment, work trips are observed to vary more, spatially, than educational trips. Travel energy for work trips varies significantly with respect to distance from Central Business District (CBD), whereas population density and accessibility to public transport have little influence on travel energy.

From the spatial analysis using FSM, different factors associated with transport energy from the resulting travel pattern were studied. From the analysis, strategies to optimize energy usage were identified using scenario analysis.

Mode shift to public transport, distribution of work and educational facilities, in accordance to trip generation and shift to NMT, all plays an important role in minimizing transport energy.

#### Conclusion:

From this research, it can be concluded that travel behavior, urban form and urban mobility have a significant impact on transport energy.

This research can be viewed as the departure point for exploring travel energy and should help the policy makers to focus on the strategies to minimize urban transport energy consumption.



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### Analysis, Modeling and Evaluation of Service Provider Network Migration to Software Defined IPv6 Network

#### **Background:**

Internet Protocol version 6 (IPv6) & Software Defined Networking (SDN) are the new paradigms in networking operation and management. IPv6 is the next generation addressing mechanism invented to avoid the problem of address exhaustion, issues in routing and security, while SDN is the next generation networking management technology invented to efficient network management with flexibility and scalability. Both are the new technologies/standards not backward compatible and hence real time Network Migration is required. Because of «sustainability» being a ma-

jor issue, Network Migration is not an easy task for the service providers. It involves cost with respect to hardware, software applications & skilled human resources for which proper strategy has to be developed considering technology needs, customer demand, Capital Expenditure (CapEx), Operational Expenditure (OpEx) & from the perspectives of traffic engineering

#### Problem statement:

Service providers shall not be able to provide the service with the customer demand of new technologies immediately. Customer profiling and prioritization is required to provide the service as per the Service Level Agreement (SLA). Especially the Small and Medium Enterprises (SMEs) and fairly sustained internet/network service providers of the developing countries like Nepal feel challenges to migrate their current service network infrastructure into the next generation network technologies basically like IPv6 and Software Defined Networking due to limited cost, lack of trained human resources and lack of proper planning.

Hence, for the fairly sustained Service

Providers, It is the most important thing to evaluate the energy efficiency of newer networking technologies and estimate the cost incurs for total migration of network together with the guarantee of uninterrupted service for their future sustainability.

#### Major Research Questions:

l) What are the challenges, risks and strategies for joint migration of legacy network into new networking and management technologies like IPv6 and SDN?

2) What is the sustainable plan for real time migration to Software Defined IPv6 (SoDIP6) network considering Energy Efficiency and regulatory requirements with optimum cost?

3) What is the best migration cost estimation approach for joint migration to SoDIP6 network?

4) How efficient and sustainable the service provider SoDIP6 network with respect to energy efficiency?

#### Aim and objectives:

The major aim of this reserach is to design and develop cost effective, efficient and reliable networks migration planning for service provider legacy network migration to Software Defined IPv6(SoDIP6) Network. The objective(s) are as follows:

 Analyze the joint approach of SDN and IPv6 network migration

 Develop an intelligent approach for Service Provider Legacy Network Migration to SoDIP6 Network.
 Evaluate the energy efficiency of SoDIP6 network for service provider

challenges and h

sustainability.

#### Challenges and how these were adressed:

There are challenges to establish knowledge base system for migration cost estimation and data collection by survey from the service providers.

We are coordinating with relevant ISPs/ Telcos and cloud service providers of Nepal to obtain the current status of service provider network and their migration challenges.

#### **Results or findings:**

The research till date has the following results/findings: - Joint migration to SDN enabled IPv6 network reduces the overall migration cost as compared to individ-

ual migration and hence more sustainable for service providers.

- Energy efficiency of SoDIP6 network: there is significant reduction in energy consumption and CO2 emission leading to economic benefits to service providers. This is encouraging for all ICT stakeholders focus towards green computing by implementing SoDIP6 network.

#### Short overview of methodology:

Figure 1 conceptually presents the overall research framework. Primary data shall be collected from ISPs/ SMEs with questionnaire survey and the semi-structured interview regarding the status measurements of current networking equipment like device specifications, life, capacity etc. together with the economic aspects of the network operation and management like past trends on CapEx and OpEx, future deployment plan if any, human resource readiness etc. This assessment would be helpful to develop the trained data sets for adaptive neuro fuzzy inference system (ANFIS) and also helps to validate proposed model by identifying total cost of network device to manage, operate, maintain and migrate. It shall be requested to provide NMS data from service providers for research analytical purpose only in the routing domain of having at least five routers/switches in the Autonomous System (AS).

A Knowledge Base system will be established based on the data available to predict the device upgrades or replacement into SoDIP6 network. Set of data shall be generated from the simulated programming environment in the real time for massive testing and implementation of the proposed model.



Figure 1 Conceptual Research Framework



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#### Supervisor(s)

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### Reviewing Concepts and Practices of Ecovillage in Local and Regional Contexts in Case of Jhong, Lower Mustang, Nepal

Education background

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# Background including justification or problem statement:

With a top-down approach to define and implement sustainability issues and bottom-up strategies and implementations forwarding practical solutions, the sustainability debate illustrates the incoherence in the concept.

The problem exists in the interpretation of national/global policies of sustainability, into sustainable actions at grass root levels, for example, ecovillage (EV).

Even though sustainability is acknowledged on the highest political level, the focus tends to be on resolving issues with short focus, for example, EV, which often restrains the longevity of sustainability.

#### Short overview of methodology:

The methodological framework is based on system's perspective that attempts to see sustainability through dynamics of human-nature relationship at local and regional levels.

The research uses case studies to understand EV and analyse findings by comparing with EV literature. Method wise, the research uses observations, semi-structured interviews and secondary literature for information collection, verification and analysis.

The research assumes that the success of sustainability is only evident at the local level. The polices can only guide the performance of actions.

#### **Results or findings:**

The study on EV illustrates that EV develops various sustainable actions on resource management and develops the community organisation structure for generating and sharing knowledge. Practically, the cases of EV (Hurdal, I Schloss Tempelhof) also illustrate that the concept of EV needs to be integrated into mainstream development.

However, EV lacks on developing the community value that can across time. The major reason is its deviation from developing the cultural values based on the knowledge.

Many interventions are goal-oriented in terms of numerical achievement. On the other hand, the case of Jhong illustrates that the continuation of the sustainable initiatives is possible if they are institutionalised into the local values.

For this, the sustainability initiations (actions and policies) have to be contextualised in terms of local norms and regulations.

# Challenges and how these have been addressed:

The research faces theoretical and practical challenges.

Theoretically, the challenge is to find the right methodological framework that combines concepts and practices. On a conceptual level, all the goals are assigned categorically.

Practice wise, all the issues are interconnected and interdisciplinary.

Practically, the challenge is in achieving spatial and temporal connotations of sustainability. By spatial challenge, the PhD emphasises on how the abstract concept like sustainability can be interpreted in terms of communicable objects at a local level.

By temporal aspects, the PhD refers to a series of events and actions related to sustainability that continues across time.

The PhD assumes that the sustainability issues are conceptualised categorically without human values. PhD, Partly, this is solved in using social system theory, that understands a sustainability issue through human-nature-human relationships in a holistic manner.



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# Assessment of Energy Efficiency for Sustainable Neighborhood from Gender Perspective, A Case Of Kathmandu

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# Background including justification or problem statement:

Energy is a fundamental concern of transitional society shifting towards sustainability. The major aim of sustainability is to achieve clean and safe energy for all. Residential energy efficiency is a backbone strategy to resolve sustainability goals; considering indoor air pollution, fuel accessibility, affordability, and decision-making roles.

Most research shows that the improved and efficient technology are major factors to improve the welfare of individual and sustainable communities. Globally,

2.7 billion people, almost 40% of the world's population suffering from indoor air pollution due to the cooking fuel (IEA, 2010).

Nepal has experienced frequent household energy crises during the last two decades though it has tremendous potential of clean energy. Whereas the residential consumption accounts the highest energy (80%) which is relatively higher than the global average residential energy consumption (IEA, 2004; IEA, 2007). The haphazard urbanization is one of reason that has a great impact on the urban present situations resulting critical towards women and children.

Moreover, the limited women participation and gender blind policies have been hindering to achieve sustainability. Thus, the research emphasizes the women's proactive role in pursuing a low carbon path to contribute to a global initiative of energy efficiency for sustainable development.

#### Aim and objectives:

The major aim of the study is to identify the gender differences in the energy use/management on urban household from the historical analysis to envisage energy future. The objectives of research are to:

l) Identify the social, economic, and environmental context of energy consumption on the urban household of Kathmandu,

2) examine the factors influencing energy use;

3) to analyze the energy based sustainability and efficiency indicators of the neighborhood using a gender lens in an urban context.

#### Short overview of methodology:

The research design is focused on gender and energy projecting the energy culture framework and feminist perspective.

The methodology of the research is based on interpretive strategy, producing scientific accounts of social life on a transformational approach recognizing dimensions of diversity associated with power differences for a better society.

The research is constructed on mixed methods of qualitative and quantitative using questionnaire surveys, interviews, and direct observation of three layers of city analysis.

The data analysis is done on pattern matching, descriptive and correlation using SPSS.

#### **Results or findings:**

The results show that Kathmandu urban women still have drudgery of workload of home, working place, and child rearing activities however the energy has made easier their life in certain extent.

The role of women in saving energy and management of household energy from history to present society is still inevitable and undeniable. Thus, the role of women in energy should be realized on policy development.

It suggests gender-responsive interventions on energy policies and strategies with an identification of roles of different stakeholders can support to achieve sustainable development goals.

# Challenges and how these have been adressed:

The challenge in this research is definitely an issue of sustainability and gender, which is founded on dilemmas from history. Additionally, it is hard to get gender data of urban areas because urban people hardly have time for interaction and rarely opened to a stranger.

The survey and interviews were not easy -- however it had addressed developing trust by familiarizing the researcher on the neighborhood which took a lot of time and money.





#### Name

Caroline Aboda

#### Education background

PhD fellow(Mak), Post graduate certificate in Sustainable land Mgt & Restoration (UNU, Iceland), Mpil Development Geography (NTNU), Bachelor's Degree in Environmental Management (Mak)

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Social Vulnerability to Displacement and Resettlement due to Land Acquisition for Petroleum Development Activities in Uganda

# Background including justification or problem statement:

Globally, every year approximately 15 million people are forced to live their homes to give way for huge development projects such as dams, industries, and roads leaving them displaced, disempowered and homeless.

The Albertine region of Uganda where commercially viable deposits of oil and gas were discovered and confirmed (Kathman and Cannon, 2011) was undergoing several infrastructural development projects, notably road construc-

tion and refinery development (Ouma, 2014). Those development projects required large land potentially resulting into displacement and resettlement of local communities that increases social vulnerabilities (Cernea, 2006; Terminisk, 2011). This is amidst a scenario where most research on oil and gas issues in Africa and other developing countries had been skewed towards macro level 'resource curse' discourses (Hammond,2011; Obeng-Odoom, 2013; Olanya, 2015). Consequently, the resultant effects of displacement and resettlement particularly on asset and livelihoods of

individuals and households as a result of land acquisition for oil and gas exploration and development activities and how women and other socially vulnerable groups have been affected had not been given considerable attention. As a result establishing the susceptibility, extent and the likelihood of individuals, households and social groups within those communities becoming vulnerable was difficult.

Expected completion date

P. Byakagaba, F. Mugagga &

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#### Aim and objectives:

The overall objective of the study was to investigate how displacement and reset-

tlement has influenced social vulnerability in the Albertine region.

The specific objectives of the study were to;

1. Assess the socio-economic consequences of displacement and resettlement on household asset in Buseruka sub-county, Hoima District.

2. Assess household adaptive capacity and adaptation mechanisms to displacement and resettlement processes.

3. Determine the level of vulnerability to displacement and resettlement processes in Buseruka sub-county, Hoima District.

4. Suggest recommendations for revised policy on displacements and resettlement schemes.

#### Short overview of methodology:

A cross-sectional design that is exploratory and descriptive using both qualitative and quantitative approaches was employed. The quantitative approach included use of a questionnaire with closed and open ended questions to 187 heads of displaced households. The qualitative approaches included; Interviews and Focus Group Discussions with displaced households; cash compensated, households receiving land and /or house benefits, host households and socially vulnerable groups such as women and the elderly.

#### Results or findings:

Although the displaced communities have been exposed to numerous consequences, some households indicated that they had benefited while most felt that their livelihood situation had become less secure and more risk ridden for the future.

The negative consequences resulting from the displacement and resettlement on asset such as reduced access and altered land ownership, social disintegration, loss of income, food insecurity, poor health conditions and loss of access to safe water had deteriorated the living conditions of affected households. The consequences experienced also have a social profile where the male respondents with access to more and productive assets including larger land sizes, higher incomes and smaller household sizes reported to be affected more by the displacement on their households. But also vulnerable groups such as female, the elderly, those with low or no education levels were more risk prone than before the displacement. That implied both male and female respondents experienced the consequences of the displacement and resettlement.

Resettled households found it difficult to restore their livelihoods after relocation, partly due to insufficient compensation and a decline in the size of farm land. Overall adaptive capacity among men and women was low but also varied among the households in relocation areas. Men and women were both affected in terms of adaptive capacity, but the women's capacities in terms of access to livelihood assets: the social, natural. physical, financial, human, household activities, and the outcomes have been even more constrained by the displacement and resettlement. The livelihood outcomes of displaced households dropped a lot compared to before the relocation.

# Challenges and how these have been adressed:

• High expectations from local communities leading to unwillingness to participate in the research.

• Hostility of local communities in some villages due to fear that their land will be taken away again.

#### Solutions

Informed local people that I am a research student and the findings from the study would benefit them through the government and NGO's

The district and sub-county leaders were also informed about the ongoing research project within Buseruka and Hoima as a district.



People ruthlessly affected by land acquisition due to oil refinery development



Name Cleide Vieira

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Supervisor(s)

Milan Stanko & Curtis Whitson

### Modelling and Experimental Study on the Production of Gas Wells with Associated Liquid

#### Abstract:

Most gas wells at the beginning of production, the reservoir pressure is sufficiently high to achieve gas production rates that can transport any co-produced fluid to the surface.

The co-produced fluid can be free liquids flowing from the reservoir and/or condensate and water that drops out of the gas due to pressure and temperature reduction along the tubing. As the pressure in the reservoir goes down, the gas velocity drops as well as its capacity of lifting the liquid. When the critical gas velocity is reached the liquid starts flowing counter-current and starts accumulating in the bottom of the tubing. This condition typically starts occurring at the bottom of the well creating a backpressure against the formation resulting in a further reduction of gas production and premature abandonment of a gas well due to further accumulation of the liquid.

To counteract liquid loading and maintain production, deliquification methods are typically installed in wells. The operator must then have an accurate prediction of the onset of liquid loading to support the choice of the method to be used to prevent the well of abandonment.

Recent largest discoveries are offshore gas reservoirs and there deliquification methods to be used a limited to extend the life of the wells comparied to onshore, therefore, more accurate methods to predict the onset and evaluation of liquid loading are critical.

However, liquid loading behaviour and prediction of critical gas rate remain questionable. Several researchers have suggested different methods, correlations based on field and experimental data, equations from physical properties to determine when the liquid starts to accumulate in the well. Almost all these analyses indicated the existence of two physical models for liquid removal in gas wells:

1) the liquid is transported as droplets that entrained in the high velocity gas core and

2) the liquid is transported as film moving along the walls of the pipe.

The overall objective of the project is to improve the understanding of the liquid loading phenomena, particularly in deviated wells, systems with condensate and water in the liquid phase and to study the effect of viscosity.

This will hopefully contribute to improve current liquid loading onset criteria and modelling practices. The first part of the project will focus on performing an experimental study on the liquid loading phenomenon that often occurs in gas wells during their production lifetime.

For this, experimental tests will be carried out at the multiphase flow laboratory at EPT-NTNU where an inclined test section comprised of 6-m long, 60-mm ID transparent acrylic pipe is available. Test fluids in the system can be water, oil and air.

Experiments will focus primarily on determining accurately the critical gas lifting velocity for different system fluid systems as air-oil, air-water and air-oilwater, for a variety of flow rates and pipe inclinations.

The second part of the of the research will be focused on performing a numerical modelling study on the onset of liquid loading deposition in the well and its impact on the well flow performance. The numerical study will be performed comparing commercial software and several theoretical models available in the literature. Improvements to current models will be proposed and tested

based on the experimental results obtained.

The PhD research results will hopefully provide a better understanding of the liquid loading phenomenon including:

 Liquid deposition mechanism in the well when exposed at different conditions, such as, superficial gas and liquid velocities, pipe geometry and fluid properties;

2) Detailed and consistent description on the gas and liquid velocity ranges and relation for liquid accumulation in the well;

3) Applicability of the available model available to predict liquid loading at diverse conditions; and

4) A model for a transient hydraulic interaction between near-wellbore formation and well in liquid loading wells.





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Expected completion date

January, 2020

Supervisor(s) Trine Hyoslef-Eide

Somatic Embryogenesis of Physic Nut (Jatropha Curcas) for Mass Multiplication of Elite Trees for Renewable Energy – Physiological and Genetic Studies

Education background

Agronomical Engineering

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# Background including justification or problem statement:

Jatropha has been considered a very promising plant due to the high oil content. This oil is of great importance as it can be used directly by the farmers and house wives. When refined, it can be also used as a source of biofuel.

Furthermore, jatropha is a plant that is able to grow under very poor conditions of water and climate (arid lands) and it can be grown everywhere. Nevertheless, the propagation of this plant has become one of the biggest challenges, since traditional methods through seeds

reveals a great variability in the amount of seeds (yield) and oil produced by the plants. Sowing seeds away from the seed origin has given disappointments with regards to yield.

This problem have created great inconveniences to farmers, because the required yields have not been achieved with financial losses as a result.

#### Aim and objectives:

In order to minimize and overcome these difficulties, selection and mass propagation of superior plants (elite genotypes) has become one of the most reliable solutions.

To achieve mass propagation successfully, the technique of somatic embryogenesis (SE), an artificial seed process (cloning) through which a full plant is obtained from a somatic cell (a cell that is not a gamete cell) is studied.

A small clonal seed (somatic embryo) is obtained from a somatic cell, and then, germinated into a full plant. This plant is a true genetic copy of the mother plant.

This technique has been chosen due to its high amount of plants obtained per explant (small part of the plant) and its higher rate of success compared to other techniques used for the same purpose.

#### Short overview of methodology:

Several Jatropha curcas plants, from several locations around the world and at different maturity (age), have been used in this study.

Different explants (leaves and leaf petioles) cut in different ways: discs and stripes, thin cell layers (TCL) for the leaves, and discs (TCL) and small pieces for the petioles. These have been placed (inoculated) on two artificial growing nutrient media (Y3 and MS). These media secure the nutrients, amino acids, vitamins that the plants need to grow. Into these media, growth promoters or growth regulators have been added.

The most important growth regulators are plant hormones (auxins, cytokinins, among others), which control several aspects of growth and development. The petri dishes with medium and inoculated plant parts are in chambers, where the conditions of temperature, humidity and light can be controlled.

**Results or findings:** Somatic embryos have been developed. These embryos have been obtained using TCL of the leaf petioles and inoculated onto the medium Y3. The auxin 2,4-D and the cytokinin BAP have been used to induce the embryos.

It has been possible to develop these embryos from all the different genotypes studied, which is rare for somatic embryogenesis. The method is usually genotype dependent.



# Challenges and how these have been adressed:

One of the most difficult challenges have been finding the right conditions for the embryo to develop and thereafter, germinate. This is because the right growing medium, explant, concentration of hormones must be worked out.

This has been overcome step by step, by elaborating well planned experiments, where all the different variables and possible errors, can be covered.



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Expected comple

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### Study of Conjunctive Water Use Planning in Kankai Irrigation System of Nepal

# Background including justification or problem statement:

In order to meet the food requirements with a population expected to reach 9.8 billion in 2050, the agricultural sector is facing challenges to increase food production.

The issue become more critical due to urbanization, migration and industrialization, along with increases in production and consumption which have generated ever-increasing demands for freshwater resources.

The UN's Development Goal 2 targets

to double the agricultural productivity by 2030 to feed the growing population and ensure sustainable food production systems and implement resilient agricultural practices.

This is possible through supply management by developing new water resource projects or efficient water management of available water resources.

In this regard, the conjunctive use of water resources is being considered as an important water management practice to deal with increasing irrigation demand and inadequate surface supplies. Unplanned utilization of ground water and surface water for irrigation purpose triggers the need to address water management issues. The water that is available for irrigation is not utilized effectively to achieve maximum productivity in terms of crop production. So, it is important to optimize the available water resources to achieve maximum return.

Literature reviews indicate that difficulty arises in analytical solution due to non-homogeneous and anisotropic nature of ground. So it is important to optimize the available water resources to achieve maximum return.

#### Aim and objectives:

The main objective of the study is to explore the potential use of groundwater and surface water in the conjunctive use scenario and to attain an optimal cropping pattern for optimal use of water resources by maximizing the net benefits under various physical and economic constraints. The specific objective of this study is to formulate a model that allocates ground water and surface water to maximize net annual benefits and mitigate the fluctuation of water table problem in the command area of the proposed irrigation system. The proposed model will be applied for Kankai Irrigation System command area of eastern Nepal.

#### Short overview of methodology:

The conceptual framework of conjunctive use model consists of three sub models viz. Surface water model, ground water model and optimization model. The objective of surface water model is to find the net ground water recharge in the basin and this net recharge will be the input to the ground water model.

The quantity of recharge depends on geomorphology, soil and hydro-geological parameters. The process of flow of water through the porous media is conceptualized as ground water model. The objective of optimization model is to maximize the crop water productivity (net benefits) by sustainable use of surface water and ground water. The three sub models in the conceptual model leads to a decision support system (DSS) where a suitable decision will be taken considering optimal utilization of water resources.

#### **Results or findings:**

Data on existing cropping pattern of the study area has been collected. With the help of CROPWAT software reference evapotranspiration and required water depth for different crops are obtained. Net water requirement from ground water aquifer on monthly basis is obtained.

Now, the study will determine the optimal groundwater extraction for supplementing canal water to avoid shortage of irrigation water in the proposed irrigation command area.

Currently, ground water flow model, Visual MODFLOW Flex 5.1 has been used for simulation and optimization scenarios of conjunctive use of surface and ground water along-with current and proposed cropping pattern.

This will help the planner and policy makers in decision making for the optimum allocation plans of water resources within the different irrigation districts of the country.

# Challenges and how these have been adressed:

For the analysis, historical data of hydrometerology, hydrogeology, shallow tube well and deep tube well have been collected so far. The hystorical data obtained are neither consistent nor sufficient. The physics of groundwater flow and its interaction with surface water is a complex process due to the heterogeneity of the geo-hydrological formation, the complexity in the recharge and the boundary conditions of the aquifer system.

However various tools and methods will be used for calibration and validation of the model to obtain a satisfactory output.



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Education background

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M.Sc

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July, 2019

#### Supervisor(s)

Samuel Adaramola Joshua Ampofo & Akwasi Afrifa Acheampong

### Wind Resource Assessment in Ghana with Mesoscale and Microscale Models

Numerical Weather Prediction (NWP)

#### Background including justification or problem statement:

As part of efforts to diversify electricity sources in Ghana, a Renewable Energy (RE) Act was passed in 2010, to encourage development of Ghana's RE resources.

However, though Ghana has significant wind power potential, the country is still not generating power from wind. This is 2013. partly due to the limited wind resource assessments (WRA) that have been conducted in the country, owing to a lack of the data needed for such assessments.

models have proved to be a very useful tool in this regard, serving as alternative sources of data for WRA. In addition, they are also used in the development of wind atlas databases for further assessments. One such model (the Mesoscale Atmospheric Simulation System (MASS) model) was used in the production of the first wind map for Ghana in

A major challenge with the use of NWP models is how to configure them for optimal performance. This is further complicated by the fact that model configurations and performance tend to vary for different parts of the world.

Over the years, further assessment of potential sites, which were selected based on the 2013 wind map, has not always yielded the expected results. In addition, the MASS model is a propriety model, and this has partly hindered attempts to perform further assessments and researches in the country with the model.

However, the Weather Research and Forecasting Model (WRF) is an open source NWP model that has proven to be a popular research and operation model for wind resource assessments worldwide.

We aim to investigate alternative configurations, and assess the performance of WRF for wind simulations over parts of Ghana.

#### Aim and objectives:

Aim: Optimize and assess WRF for Wind Resource Assessment in selected parts of Ghana.

#### Objectives:

1) Determine optimum model configuration(s) for wind simulations with WRF over South-East Ghana.

2) Assess model performance in predicting wind speeds and energy estimates.

3) Assess effects of microscale coupling with WRF on predictions of wind speeds and energy estimates.

## Simulated and measured data, as well as their power estimates will be compared in this assessment.

WRF is coupled with WindSim to simulate data for a 12-month period. Model performance (with microscale coupling) will be assessed as before.

#### **Results or findings:**

1) The UW, YSU and MYNN3 Planetary Boundary Layer parameterization schemes produce the best simulations of wind speeds over South-East Ghana [Manuscript 1 - submitted to Re-

#### Short overview of methodology:

Candidate configurations were tested and evaluated with a Skill Score measure calculated from selected statistical metrics. Wind Power estimates from



simulated and measured data were also compared in these tests.

Long-term model performance will be assessed with a model run spanning 20 months, with the best configuration(s).

newable Energy (Journal); and Manuscript 3 - not vet submitted]

2) Shorter simulation run times produce better results, but require more computing power. Where computing power is lacking, error can be reduced by choosing an appropriate nudging technique for the simulations [Manuscript 2 - submitted to Helivon (Journal)]

#### Challenges and how these have been adressed:

1) Limited ground data:

Findings are being limited to Southern Ghana.

2) Limited computational

power:

A new testing approach was developed and used to reduce large numbers of candidate configurations to a few.



#### Name Doreen Jeremiah Mrimi

Expected completion date

December, 2019 Supervisor(s)

Pål Vedeld & Julius Nyahongo

### Impact of the Tazama Pipelines on Soils and Plants Health and Diversity: Mikumi National Park Tanzania

Education background

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#### Background including justification or problem statement:

Protected areas worldwide face degradation from both internal and external stressors. One of the major challenges is traversing transportation infrastructures.

Mikumi National Park is an important ecosystem since it is a home for vast species of flora and fauna and some being endemic. Despite it's importance, it has hosted the Tazama pipeline for more than 50 years.

The pipeline started operation in 1968,

by the year 1973 it had experienced more than 100 spills at different locations along its route (Tazama, 2016). Crude oil leakages lead to emission of heavy metals and total petroleum hydrocarbons (TPH).

This study aims to examine the effect of the Tazama pipeline on soil and plants health and diversity, as this previously has not been studied despite several leaks.

#### Aim and objectives:

The aim is to examine the effect of the Tazama crude oil pipeline on vegetation

and soil health and diversity along the Tazama pipeline in MINAPA.

Objectives:

1) Measure the actual total and bioavailable heavy metals concentration in soils across the segments of the Tazama pipeline.

2) To measure total petroleum hydrocarbons (TPH) in the soil around the pipeline.

3) Assess physicochemical characteristics of soil across the segment.

4.) To measure heavy metal accumulation in the segment. (Themeda triandra, Panicum maximum and Hype-

#### renia rufa)

5.) To examine vegetation biological diversity and abundance across the segment of the TAZAMA pipeline through the MINAPA

#### Short overview of methodology:

Soil samples were collected at a distance of 5, 20, 35, 50, 100 and 200 meters from the pipe to the North and South. Samples were excavated to a depth of 1.5m or a limiting layer. For, 0m, 50m, 100m and 200m away from the pipeline soil samples were taken by auger to 60cm down.

A total of 30 soil profiles were examined in all sites. Soil samples were taken from each designated horizon described using FAO guideline for soil profile description (FAO, 2006).

Plant samples were collected a distance of 0 m, 5 m, and 20 m 35 m, 100 m and 200 m away from the edge of the pipeline. Nested quadrats (Stohlgren, Falkner, & Schell, 1995) as modified by (Barnett & Stohlgren, 2003) were used. Geo-referenced rectangular plots measuring (30 x20) m were used for trees, subplots of (4 x2) m for shrubs and subplots of (2x 1) m for herbaceous species.

laboratory analysis for heavy metals accumulation.

#### **Results or findings:**

Six heavy metals were detected along the pipeline. In the order of abundance metals were Cu>Pb>Cr>As>Hg>Cd. In actual total concentration, all metals with the exception of Mercury were detected in both sites, but in their bioavailable forms they were only detected in segments of the pipeline with recorded incidences of oil spillage.

The concentration of heavy metals in both forms decreased with increased distance from the pipeline. There was no significant difference in concentration of the metals to the Northside and South side from independent samples.

The regression analysis also showed a negative relationship between soil depth and heavy metals. The concentration of heavy metals decreased with increased distance from the top soil profile.

Total Petroleum Hydrocarbons (TPHs) were only detected in habitats with a history of oil spillages, to a distance of

Representative samples were taken for 35 m away from the pipeline in both sides.

> Species richness, abundance and diversity was high in habitats, which never experienced oil spills compared to the ones with spills. Simpson and Shannon wiener diversity indices suggested higher species diversity in habitats with no spillage compared to ones with spills. Generalized linear mixed model suggests that diversity in vegetation between the two habitats is not statistically significant (p-value >0.05).

> Man-Whitney U test statistic suggests that species richness and abundance increased significantly with distance from the edge of the pipeline in both habitats to the north and south of segments of the pipeline p-value < 0.05.

> Therefore, Tazama pipeline leads to accumulation of heavy metals and TPHs, in soils which is further taken up to the rest of the ecosystem in MINAPA

#### Challenges and how these have been adressed:

All is well thus far.



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John B. Kirabira & Wilson B. Musinguzi

### Optimization of Energy Recovery from Organic Waste Streams for Productive Biogas Applications in Uganda

# Background including justification or problem statement:

Despite Uganda's low biogas technology adoption rate (about 5,800 biogas plant installations since technology inception in the 1950's), the same technology is being dis-adopted at a very high rate. A survey by Lwiza et al. (2017) revealed that 79% of households in Luwero district dis-adopted within 3.5 years, while in Mpigi district 29% of households dis-adopted the technology in the first 1.8 years after installation. Nabuuma & Okure (2006) reported that 48% of the plants in central Uganda were non-functional, of which 80% failed in less than 6

years after construction, yet the average life of a biogas plant is estimated at 25 vears (Nzila et al., 2012). Kariko-Buhwezi et al. (2011) also reported a 55 % failure of biogas plants in western Uganda in the first few years of installation. Reported causes of failure include among others: lack of alternative feedstock in times of scarcity of cow manure, inappropriate digester operation and maintenance practices, and unfavorable digester operating conditions. Most biogas digesters operate between 18°C to 25°C, which is far below optimum i.e. 30-40°C (Athanasoulia, Melidis, & Aivasidis, 2012; Mital, 1996; Kumar et al., 2013;

Melville et al., 2014; Walsh et al., 1998).

Productive biogas could go a long way in accelerating sustainable energy utilization given its ability to overcome the several bottlenecks that have not only limited uptake of domestic biogas but also threatened its complete dis-adoption. Unfortunately, this technology has not yet received deserved attention. According to Wehkamp (2013), Productive Biogas aims to provide waste management, nutrient recycling and renewable energy services supporting economic activities of entrepreneurs. Therefore, bottlenecks to adoption and system long-life performance such as high installation and operation costs (Mittal et al., 2018: MEMD, 2015: Kahubire et al., 2010), technical & socio-cultural impediments (Walekhwa et al., 2009), and lack of sustainable supply of digester feedstock (Lwiza et al., 2017), could be overcome by promoting productive biogas systems. This is so because the productive biogas plant owner expects a return on investment and so the high upfront cost of installation and operation may not be a rate limiting step to adoption. Socio-cultural issues have less to do with productive biogas since the gas generated is not used directly for cooking but rather for running an economic activity which generates income to the plant owner. The only challenge that may pose threat to the success of productive biogas is sustainable feedstock supply, and the factors that influence anaerobic digestion (AD) process, which when not identified and optimized could cause failure of biogas generation process.

This research therefore, purposes to develop feedstock substitutes for biogas generation, and investigate key biogas generation impeding factors such as quality of feedstock, bio-digester design and operation, in order to control the AD process with intent to optimize biogas yield. These factors present consequential impediments to sustainable utilization of Productive Biogas systems, and to anaerobic digestion (AD) process, and must terefore be optimized in order to drive system outputs to better economic gain

#### Aim and objectives:

The research aim is to develop an optimal integrated system for energy recovery from organic wastes with a bias to anaerobic digestion for productive applications.

The objectives are: 1)To determine the bio-chemical characteristics of selected organic waste samples and develop substrate mixing ratios for optimal biogas production

2) To develop the potential of the organic waste samples for biogas generation based on the derived characteristics

3) To develop and evaluate a biogas system configuration that regulates digester temperature for improved efficiency and determine its economic viability for productive applications

#### Short overview of methodology:

Evaluation of performance of installed productive biogas systems to gerate data for optimizing biogas production. Biomass characterization determine both the physical and bio-chemical properties of selected organic waste samples for biogas generation using standard methods. Bio-digestion experiments on lab-scale to develop the potential of the waste for optimal biogas generation. Bio-digester design and configuration for process optimization, including design and analysis of digester thermal insulation, design and configuration of reactors & stirring mechanism, construction and piloting of the plant on the differentiated organic waste streams in real working environment.

The organic waste streams under investigation include: Dairy barn dung (DBD), Dairy barn dung mixed with cow urine (DBD+%CU), Chicken droppings (CD), Dry chichen droppings (DCD), Free range herd dung (FRDH), and DCD mixed with Rice husks (RH), coffee husks (CH), wood shavings (WS), at different concentrations. RH, CH & WS are poultry bedding materials commonly used in chicken houses.

#### **Results or findings:**

Experimental results so far indicate that the characteristics of organic waste streams vary widely according to source and type, and therefore require different treatment both at bio-digester feed time and operation. All the samples investigated were found to be good candi-

dates for biogas production when mixed with water to scale down the concentration of solids to optimal limits of 90-94% moisture (Steffen, Szolar, & Braun, 1998). The derived substrate mixing ratios (gH2O/g) were found to vary significantly for most samples as can be seen in Fig.1 below.

The substrate mixing ratio of CD is way higher than that of FRHD and DBD.



When mixed with poultry bedding materials, the mixing ratios significantly increase from that of CD treated alone. This therefore suggests that different feedstock require different treatment methods at digester feed time for the success of any biogas installation. However, this has not been the case for Uganda since such data is unavailable. Again, the results suggest that co-digestion of DBD with urine improves digester C/N ratio which should translate into improved microbial activity hence more gas recovery and reduced hydraulic retention time according to Forster-Carneiro et al. (2012). The same applies to CD when mixed with poultry litter material although the C/N ratio remains below optimum.

# Challenges and how these have been adressed:

Late release of research funds. This challenge is yet to be addressed through alternative funding. Completion date is therefore hard to predict

Fig 1. Variation of substrate mixing ratio and other characteristic properties with type of organic waste for optimal biogas production



**Name** Emily Barnabas Kiswaka

Supervisor(s) Maarten Felix, Arve Næss & Olav Kvamme Leirfall

## The Norwegian Sea Area Permo-Triassic Organic-Carbon-Rich Deposits from Seismic

#### Abstract:

Seismic surveys of the Permo-Triassic successions in the Norwegian Sea area have been studied to predict their organic carbon content.

These sequences have long been thought to incorporate Ravnefjeld Formation equivalent deposits postulated to lie in the deeper parts of the Helgeland and Froan Basins.

The Ravnefjeld Formation is a late Permian organic-carbon-rich succession that has been extensively studied in the eastern Greenland. The available

seismic surveys indicate deep and possible Palaeozoic reflectors within these basins but the deeper parts are unclear due to limitations in the seismic data quality.

Here the amplitude versus offset (AVO) analysis technique is employed in combination with an assessment of strata-bound deformation structures to investigate the existence and distribution of possible Permo-Triassic organic carbon rich sediments.

Reflection from seismic surveys can display different AVO characteristics

depending on the variation of the associated petrophysical properties and thus different AVO classes can be defined. AVO class IV has a negative normal incident reflection coefficient that decreases with offset and it has been used to predict the tops of organic-carbon-rich reflectors in this work.

The intercept (I) and gradient (G) plots (IG-crossplots) together with the Near-Far offset amplitude comparison of the seismic surveys have been used to facilitate the AVO interpretation.

The IG cross-plotting was done by se-

lecting small windows (data probes) along the top reflector of the formations speculated to be organic-carborn-rich.

Any data probe which displayed AVO class IV elements on the IG crossplots and exhibited amplitude dimming with offset has been considered to indicate the top of an organic-carbon-rich section.

The results of this work have predicted the presence of both Late Permian and Mid Triassic organic carbon rich sediments in the deeper parts of sub-basins within the Froan and Helgeland Basins in the Norwegian Sea area.

The early Triassic sections did not show AVO characteristics indicative of organic-carbon-rich sediments on IG crossplots.



Name Emmanuel Yeboah Osei

Expected completion date

M.Sc in Mechanical Engineering

2020/2021

Supervisor(s) Albert K. Sunnu, Richard Opoku & Samuel M. Adaramola

## Optimization of Wind Turbine Blade Profile for Low Wind Speed Application

Education background

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#### Background including justification or problem statement:

Issues of climate change threaten global existence and wind energy can be a major solution to this problem. However, a significant proportion of global locations have low wind speeds which are not suitable for large wind turbines.

In this case, properly designed small wind turbines can be used. Since low wind speeds generally have low energy levels, the design of the blade/rotor configuration of a small wind turbine is critical in order to minimize losses and maximize energy capture.

The span-wise distributions of airfoil type, chord, and twist for the blades and the number of blades for the rotor must be optimized for higher aerodynamic efficiency.

In this regard, this research seeks to apply analytical tools to design, optimize, fabricate, and test a small wind turbine blade system for low wind speed application.

#### Aim and objectives:

The main aim of this research is to develop and optimize a small horizontal axis wind turbine rotor for low wind

speed application.

#### Short overview of methodology:

The research methodology to be applied is summarized as follows:

1) Selection of four low Revnolds number airfoils.

2) Application of Blade Element Momentum Theory to integrate airfoils and develop four rotor concepts.

3) Selection of best rotor concept based on power coefficient.

4) Optimization of best rotor concept for power coefficient and startup wind speed.

5) Test and empirical modeling of fabricated rotor concept.

#### **Results or findings:** The expected outcomes of the research

are summarized as follows:

1) An efficient blade/rotor configuration for low wind speed utility.

2) Theoretical and empirical modeling of rotor aerodynamic characteristics.

3) Power coefficient versus tipspeed-ratio.

4) Power coefficient versus wind speeds.

5) Start-up wind speed / mechanical power curve.

6) Rotor mechanical performance (torque, thrust, etc.)







**Name** Fabrice Abunde Neba

Expected completion date

December, 2019

Supervisor(s) Razak Seidu

### Model-Based Synthesis for Optimal Operation of Methane Bioreactors: Bioenergy Generation and Waste Management

Education background

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# Background including justification or problem statement:

In recent years, economic challenges in environmental management and organic waste sanitation has led to a change in waste management concepts from waste-to-discharge to waste-to-resource.

Anaerobic digestion (AD) as part of an on-site waste treatment method offers special advantages due to its ability to generate biogas and biodigestate, which are important alternatives to fossil fuels and chemical fertilizers respectively. Due to the highly complex nature of the AD process, careful design of methane bioreactors is central to optimal operation of anaerobic treatment process, as it is required to provide an appropriate environment for the complex interaction of anaerobic microorganisms to grow and produce biogas.

Studies have shown that when the reaction mechanism of a process is complex, the best performance is often achieved in a reactor network or reactor structure. However, current practice for design of anaerobic digesters is often simpler in nature, employing one or rarely two different digesters in the so-called "rational basis of design," i.e., determination of digester capacity based on volatile solids (VS) loading, temperature, extent of mixing, and so on. Thus, despite the potential of digester networks to improve process performance as opposed to single digesters, previous studies on the design and operation of anaerobic digesters have seldom dealt with the use of digesters networks.

This is because digester network synthesis includes a decision on how many digesters to consider, what digester types, where to include bypass and recycle streams, where to include parallel reactors, etc. This poses a challenge because there exist several different digesters each having different characteristics and nominating specific reactor structures in an exhaustive way is not feasible as different structures can always be devised, which may have better digestion performance.

In addressing this knowledge gap, the current study has introduced a new technique, which incorporates multi-criteria decision making tools and attainable region theory for the synthesis and optimization of anaerobic digesters considering renewable energy generation, waste sanitation & greenhouse gas mitigation.

The technique involves elements of process kinetics and model identification as well as geometric optimization to understand how systems can designed and be improved. The power of the Attainable Region targeting approach is that the answer to all possible optimization problems, even the ones not considered are first determine, and then we look for ways of achieving that answer. In digester operation, knowledge of all possible states for all possible digester configurations, even those that have not yet been devised, is obtained. Figure 1 presents a framework for the study.

#### Aim and objectives:

The aim of this study is to develop a set of model-inspired multi-criteria design tools for synthesis of methane bioreactors considering renewable energy generation, waste sanitation & greenhouse gas mitigation. In order to achieve this, we set the following objectives:

1) To develop a set of simplified kinetic models suited for design of anaerobic digesters and introduce the an optimization technique for reliable model identification

2) To Assess the reliability of the developed models for synthesis of methane bioreactors through a sensitivity-based identifiability uncertainty quantification

3) To introduce the concept of attainable regions for synthesis and optimization of anaerobic digesters 4) To Assess the effect of different organic substrates and substrates mixtures on the structure of the optimal anaerobic digester configuration

5) To incorporate the use of multi-criteria decision making tools into the attainable region synthesis process for optimal selection of anaerobic digesters for practical implementation

#### Short overview of methodology:

Starting from a digester network design problem, the methodical framework consists of seven main steps:

1) Define the design or optimization objective of the digester. This can be biogas generation, waste stabilization, process stability, greenhouse gas mitigation as well as economic objectives.

2) Substrate selection and anaerobic treatability studies to identify appropriate kinetic model and/or kinetic constants for the specified substrate.

3) Attainable region construction using the kinetic model and application to synthesize an optimal digester configuration based on any objective in (4) Selection of appropriate plug flow digester for incorporation into and field test of the optimal digester configuration.

(5) Establish a design specification and operation manual for the optimal digester configuration

#### **Results or findings:**

#### Main findings

The study has designed and standardized a 5 step process for synthesis of anaerobic digester networks considering bioenergy generation, greenhouse gas mitigation, process stabilization and economic objectives. The study presents the first of its kind using attainable regions for synthesis of anaerobic digester networks

#### Specific findings

The adjoint based optimization algorithm has been introduced as a reliable technique for estimation of kinetic models constants and Kernel density as well as Joint confidence contours are presented as new strategies for model discrimination. Using the simplified models, the study has introduced a strategy to easily determine the maximum number of reactor structures required to synthesize a digester network, which helps as a preliminary guide for designers of digester networks (papers 1 and 2).

A critical task in the development or use of kinetic models is the identification of unknown model parameters in order to completely define the system. Reliable

and accurate model parameters are extremely important for possible application of the model in the synthesis of digester networks. A practice to assess the reliability of simplified models before using them for digester synthesis has been introduced, and the study shows that different kinetic model structures gives different set of model parameters that needs to be identified.

Trying to overestimate the model will result in a model that accurately reproduces experimental data but is not reliable for use in digester network synthesis (paper 3)

The attainable region concept has been introduced in details for synthesis of anaerobic digester networks. The main findings of this section is that the optimal configuration of digester network changes with a change in the kinetic model structure, which in turn changes with the type of substrate used for anaerobic digestion. This implies the optimal configuration of the digester network is unique for a particular organic substrate to be digested but if two substrates show similar biodegradation kinetics, they may have similar configurations of the digester structure (Paper 4)

It is possible to use attainable regions to design anaerobic digester networks that answer specific design objectives and as the objectives change, the optimal digester structure also changes to better align the needs. Some of the objectives presented in the study include waste stabilization and volumetric gas productivity (paper 5). More interestingly, economic objectives such as Net Present Value. Internal Rate of Returns. Payback Period and Benefit Cost Ratio can directly be used to synthesize anaerobic digester networks using attainable regions. This is highly interesting for investors in the anaerobic digestion technology (Paper 6)

In cases where only biogas measurements are available, it is also possible to design anaerobic digester networks using attainable regions. Even for those who do not understand the AR concept, a simple decision support system has been developed for easy synthesis of digester networks for any organic substrate (Paper 7)

Attainable regions are a reliable strategy for synthesis of anaerobic digester networks. However a reliable and simple kinetic model is highly required for accurate use of the technique. The study has laid out a theoretical framework for the use of digester networks in the operation of anaerobic digestion process.

Since a model is only a representation of a process, could the technique be applied to anaerobic digestion without having a kinetic model?

This is what the next phase of the work will answer.



Figure 1



Name Frank Kwabena Afriyie Nyarko

Expected completion date

April 30th, 2019

#### Supervisor(s)

Gabriel Takyi, E. Amalu & S. M. Adaramola

### Modelling Interconnections in c-Si Solar Photovoltaic Modules for Improved Reliability in Sub-Saharan Africa

Education background

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#### Background:

The warranty period of solar photovoltaic (SPV) modules has increased rapidly and significantly in recent years. The industry aims to develop SPV system that can attain a thirty-year field service life by the year 2020. This effectively translates to module power degradation of between 0.5% and 1.0% per year (maximum). However, the current reported annual power degradation is between 0.5% and 10% [1, 2].

Several factors account for the degradation of installed SPV modules. Key amongst these factors is the exposure of

modules to a range of cyclic temperatures coupled with elevated temperature operations. The cyclic thermal loading induces thermo-mechanical damage in the solder joint in SPV module interconnects.

Operations under a range of currents and voltages play a significant role in accumulating power degradation in the SPV modules.

Field modules installed at a test site in a sub-Saharan Africa experience a reported average temperature swing of about 34.4 °C each day. The outdoor weather-

ing effects expose PV modules to direct sunlight in an alternating day/night cycles which exposes modules to thermal load due to the variation in the co-efficient of thermal expansion of constituent materials forming the individual cells in the module [3].

The daily temperature swings induce fatigue related failure mechanism occasioned by mismatch of the respective temperature co-efficient of thermal expansion of silicon, glass, copper and solder bonded together.

One effect of solder joint degradation

is the formation of micro-cracks across the entire joint area could result in an increase in electrical resistance across the solder joint. This phenomenon significantly affect (SPV) module output power.

#### Justification/Problem Statement:

The development of indoor tests that have the ability to predict real outdoor conditions accurately is quite challenging. A number of research findings suggest various methods which include expanding on the certification procedures outlined in IEC 61215 thermal cycling test (TC 200) by increasing the number of cycles, increasing the temperature range or ramp rates[4].

Other studies have also used field data for PV reliability prediction. For in- ca. stance, Cuddalorepatta et al [5] in their study of the durability of Pb-free solder between copper interconnect and silicon in PV cells used a field condition with a temperature range between 63°C and 17°C from a data provided from a sponsoring company.

Park et al [3] on the other hand used field data with a cycle time of 24 hours:

23-67°C: 390 minutes ramp up and 330 minutes ramp down; 2 hours dwell in high temperature and 10 hours in low temperature to estimate the degradation Sub-Saharan Africa Ambient. rate of multi-crystalline silicon. However, the authors did not demonstrate how they generated the temperature cycle parameters in their respective studies.

An improvement of the current IEC 61215 (TC 200) temperature profile that would lead to improvement in the prediction of module long-term outdoor reliability remains a research task.

#### Aim:

The aim of this research work is to Study the interconnections in photovoltaic modules for improved thermo-mechanical reliability in Sub-Saharan Afri-

#### **Objectives:**

1) To generate temperature cycle profile from in-situ climatic condition for accurate prediction of thermo-mechanical degradation of c-Si photovoltaic module in a Sub-Saharan Africa Ambient.

2) To evaluate the impact of en-

capsulant (EVA) constitutive behaviour on interconnect damage in C-Si Solar PV Modules installed at a Test site in

3) To evaluate the effect of IEC 61215 thermal cycle and operating module temperature cycle on creep damage and fatigue life of interconnection in photovoltaic modules.

4) To evaluate the effects of temperature ramp rates and dwell times on degradation of interconnections on SPV modules operating in sub-Saharan African region.

#### Short overview of methodology:

Data was obtained from a test site (The site location is on latitude 6° 40" N and longitude 1° 37" W, at an elevation of 250 m above sea level

The modules are unshaded and mounted on an inclined rooftop with a tilt angle of 5°, and oriented toward the equator (southwards)

Calibrated Platinum sensors (PT100) with measurement accuracy of  $\pm 0.5$  °C, resolution of 0.1°C and positioned at the center of each module (on the backside) measured the module temperatures.

A rainflow counting algorithm developed using a MATLAB program to determine the number of temperature cycles experienced by the modules each vear.

An algorithm was also developed in MATLAB to select the temperatures at the peaks.

3-dimensional representative geometric models of the H-patterned frontto-back interconnected c-Si solar cell assemblies were created by using a combination of Constructive Solid Geometry (CSG) and Boundary Representation (B-Rep) modelling technique.

To ensure that the simulation was optimized for accuracy and computational speed within the power of the computing resource, a quarter symmetry comprising of a cell-to-cell interconnect model was utilized in the Finite Element Analysis.

A bonded contact type formulation with default trim tolerance was used in modelling all the contacts created by the dif-

ferent materials in the cell assembly.

A direct solver was employed in the computation of the numerical solution to improve the accuracy of simulation **References**: results.

A high performance computing resource (HPC) at The Energy Center (TEC). KNUST was used for the study.

#### **Results or findings:**

SOE 1) Analysis of the data on temperature variation and thermally induced stresses demonstrates that the region has a profile with a ramp rate of 8.996 degrees celcius/hr, a hot dwell time of 228 minutes, cold dwell time of 369 minutes. Maximum and minimum module temperatures of 58.9 degrees celcius and 23.7 degrees celcius, respectively; and a cycle time of 86400 s.

SOE 2) Results from Finite Element Analysis show a lower equivalent von-Mises stresses, a lower strain energy density in solder, a lower stress-strain hysteresis and lower interconnect directional deformation when EVA encapsulant exhibited a linear viscoelastic behavior.

SOE 3 & 4) Results/findings (Discussion of findings ongoing)

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2) Sørensen, B. and G. Watt, Trends in Photovoltaic Applications, Survey report of selected IEA countries between 1992 and 2005. 2006.

3) Park, N., J. Jeong, and C. Han, Estimation of the degradation rate of multi-crystalline silicon photovoltaic module under thermal cycling stress. Microelectronics Reliability, 2014. 54(8): p. 1562-1566.

4) Owen-Bellini, M., et al. Environmental Stress Potentials of Different Climatic Regions. in Proc. 31st European PV Solar Energy Conference. 2015.

5) Cuddalorepatta, G., et al., Durability of Pb-free solder between copper interconnect and silicon in photovoltaic cells. Progress in Photovoltaics: Research and Applications, 2010. 18(3): p. 168-182.





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Expected completion date

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#### Supervisor(s)

O. J. Nydal, C. Z. M. Kimambo & J. H. Kihedu

## Investigation of Flow Transients in Gas Pipeline Networks

# Background including justification or problem statement:

Natural gas consumption increases worldwide, and pipelines appears the most convenient way of transporting gas to consumers. These pipeline networks encounter several challenges related to pressure variation, volumetric losses, pressure and energy losses. The consequences of these challenges include poor service delivery to customers, reduction of economic usable volume of natural gas, highigh operational cost, failure of pipeline facility such as valves and pipeline disruption or rupture (Herrán-González et al., 2009; Woldeyohannes and Majid, 2011). The failure of pipeline facility may have negative impact to the community such as occurrence of accident leading to environmental pollution, life and property losses.

The effects of pressure variation, volumetric loss, pressure and energy losses usually leads to flow transients in pipeline network. Comprehension of these flow transients during pipeline operations helps in mitigating operation inconveniences and pipeline or facility failure. Events like demand fluctuation, operations of valves, compressors and regulators needs to be carefully monitored to avoid causing extreme flow transients in the pipeline network and addition of new customers can lead to significant pressure drop in the networks if not well designed. Effect of line break or pipeline rupture leads to gas loses and may cause fire outbreak and severe damage of properties.

In order to maintain safe and efficient service delivery, transient flow behavior in pipeline network needs to be properly understood and evaluated. Ongoing efforts by researchers have led to development of numerical flow transient models covering single pipeline and pipeline networks. These models have different approach basis, assumptions and simplifications. Efficiency of these models in simulating flow transient's behavior in pipeline networks differs and most of them have only been validated numerically and in order to compare and qualify these models based on real flow transients in gas pipeline networks, experimental data is required.

Besides transients from demand fluctuation, flow transients resulted from facility operation, line break or pipeline rupture has not been widely considered in model development and their effects differs depending on the pipeline structure or network topology. Therefore, the aim of this research is to investigate flow transient in gas pipeline networks by covering transient effects from facility operation, pipe rupture as well as demand fluctuation by taking Tanzania natural gas distribution pipeline network as a case study.

Currently in Tanzania a total exposure of natural gas transmission and distribution network is approximately 6304 of which 1278 covers a medium and low-pressure distribution network with maximum pressure of 7 bar and a number of accidents has occurred in the distribution pipeline network which covers minor and major accidents from year 2014 to 2018.

Only physical and social economic losses are known from this accident and its essential to establish models to study the flow behaviors and provide best operation strategies of the pipeline network.

#### Main objectives:

The main objective of this research is to investigate flow transients in gas pipeline networks using the Tanzania pipeline network as a case study.

#### Specific objectives:

l) To analyze operational characteristics of gas pipeline networks.

2) To characterize flow transients in gas pipeline networks.

3) To develop strategies for mitigation of effects from flow transient events in gas pipeline network

#### Short overview of methodology:

The methodology will cover mapping of the pipeline and establishing experimental setup based on existing pipeline configurations. Conduct transient flow experiment by studying effects of facility operation such as valves, pipe rupture, demand fluctuation and obtain data that will be used for model development and model qualification. The developed network model will be adapted to study the natural gas distribution pipeline in Tanzania and establish strategies for mitigating effects of effects from transient flow events in natural gas pipeline As summarized in Figure 1.

#### **Results or findings:**

1) Pipe network configuration has been established as shown in Figure 2 and the network is shown in Figure 3.

2) Simplified lab scale pipe network designed as shown in Figure 4 and the proposed experimental setup shown on Figure 5

# Challenges and how these have been adressed:

1) Lack of well-established mapping data and pipeline distance data of Tanzania distribution network: these was addressed by abstaining coordinate data from pipeline network operators and establish the pipeline network as shown

2) Lack of readily available data of flow rate and pressure in different parts of the Tanzanian distribution network at time of event occurrence such as pipeline rupture, this will be addressed by conducting experiment on laboratory scale pipeline network.

3) Difficult in network scale down from actual pipeline to meet geometric, kinematic and dynamic parameters. The challenge was addressed by considering only geometric parameters of the network and the experiment will consider only behavior of flow parameters such as pressure and flow rate in the pipeline rather than scale correlation of these parameters to the actual pipeline network.



gas pipeline networks work flow

Figure 2: Location of natural gas pipeline incidents at Dar es Salaam city



Figure 5: Proposed pipeline network experimental configuration



Figure 4: Simplified gas pipeline network





#### Name Getachew Sime Feyissa

Expected completion date

December , 2019

#### Supervisor(s)

Jens B. Aune & Trine Hvoslef -Eide

### Technical, Economic and Socio-Cultural Constraints to the Domestication of Biogas Technology in Rural Ethiopia

Education background

PhD in Environment and

**Development Studies** 

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# **Background including justification or** es on soil fertility, rainfall pattern, and energy and food security. This was the

Natural gas consumption increases In Ethiopia, the energy demand has been increasing and is expected to extensively increase in the coming times. Biomass, including firewood, dung and crop residues account for a staggering majority of rural energy supply in Ethiopia while these traditional sources are rapidly depleting, further exacerbating the rural energy insecurity.

Deforestation for firewood and farmland continues to rise and drive land degradation, with severe consequenc-

energy and food security. This was the reason for the development of alternative renewable energy sources, where domestic biogas technology becomes an available option for the rural population.

In two phases (phase one (2008-2012) and phase two (2013-2017)), the Ethiopian government has implemented a National Biogas Program (NBPE) in four populous regional states. The NBPE focuses on three major areas – sanitation, energy, and organic fertilizer production

#### Aim and objectives:

The objective of this study is to provide an overview of technical, economic, socio-cultural barriers to the implementation of biogas technology in Ethiopia.

#### Short overview of methodology:

Data were collected from key-informant interview as well as desk study of legislation documents and strategy documents. Furthermore, observational assessments and triangulations were conducted by visiting households operating bio-digesters.

#### **Results or findings:**

The major barriers to the biogas technology domestication in Ethiopia are pertained to the adequacy of institutional follow up of installed bio-digesters; underestimation of bio-slurry: quality of design and materials for bio-digester construction; quality, availability and cost of maintenance service: price, availability and accessibility of appliances at local markets; availability of credit associations for bio-digester installation; adequacy of mason's skill of bio-digester installation; users' level of awareness of the technology; and socio-cultural acceptance to connecting toilets to bio-digesters.

Though few of these barriers were halted, most of them were found to influence the execution of the second phase to meet the planned goals of the NBPE. These technical, financial and socio-cultural limitations were found to emanate primarily from the weak organizational and institutional alignment among key stakeholders in the NBPE structure, which could have considerably contributed to meeting the targeted goals, thus, hindered the adoption rate.

Thus, for improved and sustainable use of the technology, the NBPE should emphasize on dissemination, monitoring and ownership strategies, on realizing institutional commitment to form a strong consortium among key stakeholders, and on improving the technical, financial and socio-cultural limitations.

#### Challenges and how these have been adressed:

The major challenges encountered were reluctance of key informants in providing information and remoteness and poor road infrastructure of visiting places.

Repeated conversation for building trusteeship with key informants and all partner organizations and personnel about the purpose of the research.



#### Name Gloria Boafo-Mensah

Expected completion date

August 25th. 2021

#### Supervisor(s)

Razak Seidu, Francis Kemausuor. Lawrence Darkwah & Mensah Darkwah

### Design and Construction of Efficient Biomass Cookstove for Clean Cooking

#### Background including justification or problem statement:

Biomass is a predominant feedstock for household cooking and heating in developing countries. Charcoal fired cookstoves can be considered an important intermediary for sustainable energy consumption as well as promoting healthy kitchen environments due to the significant reduction in the emission of indoor pollutants associated with smoke in wood fires.

- Current methods of cooking for over 3 billion of the world's population which includes open fires and leaky

stoves are inefficient and produce high levels of household air pollution.

Education background

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- Current stove designs in the Ghanaian market do not differ significantly from the traditional stoves in terms of global benchmark (thermal efficiency of 45% and a low power specific consumption of 0.017MJ/min/L)

- Fuelwood balance has gone below break-even point due to increased consumption leading to decreased forest cover.

- There is a problem with the

adaptation of new technologies due to variance in the new technological interventions with current practices and know how.

#### Aim and objectives:

1) To select appropriate metallic and ceramic materials by calculating their thermal properties (heat capacity, thermal expansion and thermal conductivity) in promoting heat retention.

2) To obtain design parameters for the construction of fuel efficient and low emissions cookstove.

3) To construct an improved fuel efficient cookstove using local refractory materials and metal components.

4) To test for efficiency and emission levels of the stove constructed.

Short overview of methodology:

- Use of differential scanning calorimetry method (ASTM E1269-11(2018) to determine the thermal properties (heat capacity, thermal expansion and thermal conductivity) of metallic materials for their heat retention capabilities.

- Use of x-ray diffraction (XRD) to determine the A-alumina contents of locally available clay and their application as refractory materials (ISO 19950:2015).

- Modelling aerodynamics of airflow (combustion chamber dimensions, air inlet dimensions and height between air inlet and outlet on airflow velocity, air fuel ratio, flue gas and heat flux retention) for the construction of fuel efficient and low emissions cook stove.

- Conceptual design development using Computer Aided Design (CAD) Software.

#### Expected results or findings:

stoves.

how.

- Improved cookstoves designs that meet global benchmarks

- Reduction in indoor air pollution (and its associated health effects) as a result of using efficient biomass cook-

- Adaptive technology taking None so far. into account current practices and know

- Significantly reducing deforestation due to low consumption of fuelwood and charcoal for cooking.

Challenges and how these have been adressed:





#### **Name** Joan Nakajigo

### Expected completion date

September 18th, 2020

#### Supervisor(s)

Tor Arne Johansen, John Mary Kiberu & Simon Echegu

### Quantitative Reservoir Characterization Using Seismic, Rock Physics and Geological Constraints Examples from Semliki Basin

# Background including justification or problem statement:

The petroleum potential of Uganda was discovered in the Albertine Graben located within the western arm of the East Africa rift valley.

Seismic reservoir characterization is important in hydrocarbon prospect evaluation both during exploration and production.

The fundamental challenge in the Semliki Basin, is lack of a clear understanding of the distribution of various reservoir properties such as porosity,

lithology and fluid saturation. Due to the above, this basin has not availed the government of Uganda with hydrocarbons accumulations in commercial quantities.

Education background

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M.Sc in Petroleum Geoscience

B.Sc in Geology

E-mail

It is on this foundation that, this research purposes to use various methods to quantify the prevailing uncertainties in this basin. Burial history combined with RPM, IRPM and quantification of uncertainties in relation to facies distribution using probability distribution function (pdf) will be done for the first time in this basin.

#### Aim and objectives:

1) To determine the effect of burial history on seismic properties or signatures.

2) To establish the statistical relationship between reservoir properties.

3) To examine uncertainties in different reservoir property distribution

#### Short overview of methodology:

Modelling of appropriate rock physics model using the local geology of the area. State the evolutionary scenarios of the area or basin and predict the seismic signatures. The procedure for IRPM will involve three steps namely; (1) seismic inversion; (2) forward rock physics modelling; and (3) inverse rock physics modelling.

#### **Results or findings:**

The evolutionary stages were identified with the help of geological knowledge of the area. Constant cement model was predicted for a certain depth of the area

and this was tested with other surrounding wells of the basin.

#### Challenges and how these have been adressed:

There is a challenge of lack of softwares and specialized personnel in rock physics at my university. However, this has been addressed by providing exchange programs between university of Bergen and Makerere university courtesy of EnPe project (Ju-MakBe).





#### Name Maame Tabuah Ankoh

Expected completion date

2022

#### Supervisor(s)

Dr Tamakloe & Muyiwa Adaramola

### Field Performance Evaluation of Solar Photovoltaic Module Under Various Installations and Ambient Conditions

Education background

M.Sc in Renewable Energy

B.Sc in Civil Engineering

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E-mail

#### Background including justification or problem statement:

The average cost of capital expenditure per MW for solar PV continue to reduce which steadily improves the competiveness of an already competitive technology. The industry is therefore likely to see significant growth in the near term, especially so for Ghana, with over 70MW of utility scale grid connected solar plants projected to come online by 2020.

This expanding industry requires the availability and access to reliable information which better characterise the

performance of these PV Systems. The performance of PV modules in particular under actual operational conditions plays a key role in determining the output and the reliability of the overall PV system.

Ghana's climate is predominantly tropical savannah (Aw) under the Köppen-Geiger classification with some parts in the western region falling into the tropical monsoon (Am). Interestingly, a few cities in the Greater Accra region such as the Accra, Tema and Kpone falls under the hot semi-arid climate (Ash). Unfortunately, there is very little information or inadequate data on the performance of PV modules in these climates, and the study seeks to contribute to filling gap. The study is looking to characterise the performance of py modules under the hot semi-arid and the tropical savannah climatic zones.

It is the hope that results will contribute to the greater body of knowledge to better inform researchers, manufacturers, solar developers and the likes to optimize the selection of locations, types and installation conditions of PV modules to enhance the reliability of energy generation from solar resource.

#### Aim and objectives:

The research seeks to better understand how installation conditions affect solar PV modules performance under two main climatic conditions. Questions to be answered are:

1) To what extent does the degradation rates and the Current-Voltage( I-V) characteristics of mono-Si and Poly-Si module change under the hot semi-arid climate and the tropical savannah sclimatic zones in Ghana?

2) What is the impact of soiling on mono-Si and Poly-Si module performance under the hot semi-arid climate and the tropical.

3) To what extent does the different installation conditions affect the local micro climate of the solar installation

#### Short overview of methodology:

The research work will be conducted in two distinct climate zone in Ghana- the hot semi-arid and the tropical savannah given the comparatively high solar resource availability and the already keen investor interest in areas falling under these climatic zones.

A test site will be set up in each of these two locations with the setup completely identical in order to better compare results from these two zones. Short to tion date May 2021. medium term performance test (2years modules installed at different installation conditions for each of the test sites. The expected energy will be predicted using a solar modelling tool in order to compare modelled yield results with measured outputs.

The solar monitoring station will continuously measure Current-Voltage (I-characteristic of all modules including ambient and module temperature, solar radiation, wind speed, soil moisture and humidity conditions under mounted modules and direction(frequency of about 15min). throughout the entire test period

Analyses of the I-V characteristics and all measured conditons will be done to identify factors impacting the PV performance in the two sites and the impacts on the microclimates.

#### **Results or findings:**

Data yet to be collected. Expected start date April/May 2019, Expected comple-

#### or more) will be performed on a set of **Challenges and how these have been** adressed:

Instrumentation and limited budget.



#### Name Mesele Hayelom Hailu

Education background

Expected completion date

December , 2019

#### Supervisor(s)

Ole Jørgen Neydal, Mulu Bayray Kahsay & Asfafaw Haileselassie Tesfay

### Development of Direct and Indirect Solar Thermal System for Small Scale Applications

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M.Sc in Sustainable Energy Technology

# Background including justification or problem statement:

The household sector in Ethiopia accounts for a lion share of the total energy consumption, with 96% of this energy contributed from biomass. Majority of this domestic energy requirement is for baking and cooking purposes, making the traditional staple food baking activity as the most energy-consuming process in every household in Ethiopia.

The conventional baking process mostly employs a traditional large size clay plate which has relatively low thermal property hence it requires higher amount of energy than typical for boiling. The conventional baking method uses either biomass in rural areas or Electricity in majority of urban areas. Biomass based baking process is inefficient, poses pollution hazard and it is becoming expensive due to limited biomass resource in the country while electricity access is very low as majority of Ethiopians live off grid.

Therefore, the development of alternative technology for baking application will have significant contribution in the energy consumption profile and socio-economic aspect of the country. From Ethiopian perspective, a solar energy-based technology is the most promising alternative to the existing energy resource for baking application as it can be converted into thermal energy as per the baking process energy consumption requirement more easily and in a sustainable way than other alternative energy sources.

#### Aim and objectives:

The intention of this study is to develop simple, robust and cost effective direct and indirect solar thermal system (Fig. 1) that meets the requirement of the baking application in Ethiopia.

#### Short overview of methodology:

The study will include solar thermal system design, optimization, development and performance evaluation, through:

- System Development

- Experimental Work

- Process Modelling and Simu-

#### **Results or findings:**

lation

Two prototype of the direct solar fryer model, with continuous heating and baking application vs alternating heating and baking application mode are developed. The direct solar fryer with continuous application mode will provide a baking power of 563W and a system thermal efficiency of 37%. The alternating mode direct solar fryer has slower

heat up period and thermal efficiency as compared to the continuous mode application. Due to the effective thermal property of the baking material, the continuous mode solar fryer provide equivalent application time i.e. heating time, baking time and thermal efficiency as compared to the conventional baking application, while enabling to harvest cost-free solar energy. A modelling and optimization of direct solar fryer system is performed. This optimization process is used to decide and select an appropriate solar collector, heat up time and the minimum solar irradiation required from a site for a given size of solar fryer (i.e. size of staple food). One prototype of an indirect solar fryer model that employ an edible oil as



heat transfer fluid between the collector/receiver to the application/fryer is developed. This indirect fryer offers the flexibility of using for indoor application as compared to the direct solar fryer system. In the indirect system, a solar collector with an average heating capacity of 2.3KW is used, providing a solar fryer with a baking power of 325W and thermal efficiency of 14.5%. The system is designed for indoor solar baking application without storage option.

#### Challenges and how these have been adressed:

Purchasing scientific equipment is impossible, but solved by conducting the purchase through NTNU and transporting it to Mekelle Ethiopia.





Name Michael John Education background

Expected completion date

November, 2019

Supervisor(s) O. J. Nydal, C. Z. M. Kimambo

& 1 H Kihedu

### Development of Solar Adsorption Refrigeration System for Off-Grid Application

M.Sc in Renewable Energy

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F-mail

#### Background including justification or problem statement:

Lack of cold-storage facilities for food products, vaccines, medicines and artificial insemination services is a serious problem in many developing countries.

FAO estimated that 32% of food produced in the world was wasted in the year 2009 while the IEA reported that more than 20% of the world's population lacked access to electricity in the year 2010.

Among them 57% lived in rural-areas in sub-Saharan Africa. Water-ammonia kerosene and gas-driven absorption systems have been used to store vaccines.

However, they do not meet the minimum standards established by WHO on Performance, Quality and Safety for the required +2 °C to +8 °C temperatures. PV powered cooling systems preserve vaccines more efficiently and in an environmental friendly manner.

However, batteries are needed. Batteries live shorter than refrigerators, implying extra costs.

Also, PV systems have low possibility of

being manufactured in most developing countries. Adsorption refrigeration systems have shown great potential to meet cooling needs in off-grid locations. They can utilize low temperature waste heat and renewable energy sources like solar thermal energy to providing cooling

#### Main objective:

Experimental investigation on the potential of application of solar adsorption refrigeration system in off-grid locations.

#### Specific objectives:

1) To select adsorption pair that

is most suitable for use in solar refrig-Tanzania. eration.

2) To develop a laboratory scale prototype of solar adsorption refrigeration system.

3) To evaluate the performance characteristics of the prototype.

4) To develop guidelines for up scaling the prototype to suite technical and social economic requirements of application.

#### Short overview of methodology:

The methodology includes desk study, design and manufacturing, laboratory experiments and computation **Results or findings:** 

1) Review of the adsorption

pairs and adsorption refrigeration systems presented at SWC 2017 / SHC 2017 / ISES Conference at Abu Dhabi, UAE and SPSN18-International Conference on Solar Power Systems, Windhoek, Namibia.

2) A single bed water cooled condenser adsorption refrigerator prototype, which utilises CaCl2-ammonia pair has been developed and tested in the laboratory (Fig. 1). Results presented on international conferences. WREC 2018, London, UK and MIE 2018, Arusha

3) New adsorption system utilizing pair of Activated Carbon- Ammonia have been developed, laboratory experiment expected January 2019.

#### Challenges and how these have been adressed:

Main challenge is lack of technical people in this area to help in laboratory experiment preparations and manufacturing of the prototype. This lead slow progress on my research activities since I must do everything by myself.



Fig 1: Adsorption refrigeration test rig: utilizing CACI2- ammonia pair



#### Name Ombeni John Mdee

Education background

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Expected completion date

May, 2019

#### Supervisor(s)

T.K. Nielsen, C. 7, M. Kimambo & J. H. Kihedu

### Improvement of Performance Prediction Methods for Selecting Pump as Turbine in Micro Hydropower Systems

best efficiency point. The same pumps

#### Background including justification or problem statement:

The centrifugal pumps have more advantages of being available with spare parts in the markets of developing countries compared with turbines. But, these pumps are mostly manufactured in Europe and North America continents. China and India.

The pumps have the wide-ranging of capacity and head that used in water pumping for domestic and industrial use, irrigation, livestock, and sewage systems. Although, each pump has been characterized by specific speed with the head and flow rate measured at the given

work in reverse mode of operation as turbines for mechanical rotational energy generation. But, it runs with a different head and flow rate given from the pump manufacturers (Barbarelli et al, 2016; Tan and Engeda, 2016; Nautiyal et al. 2011: Derakhshan and Nourbakhsh. 2008). Also, the conversion methods predict the different head and flow rate for pump running as turbine (Tan and Engeda, 2016; Williams, 1994).

#### Aim and objectives:

The aim and objectives of this research were to improve the performance prediction methods for selecting the centrifugal pumps to be used as turbines for stand-alone micro hydropower plants.

#### Short overview of methodology:

The research methodology grouped into three case studies.

Case study one consists of reviewing the performance characteristics of the pump application as turbine.

Case study two consists of construction of laboratory test rig (Figure 1) to determine the performance characteristics of off-the-shelf pumps to run as turbine. The off-the-shelf pumps consist of the impeller with blades enclosed in the volute-casing and induction motor. Case study three consists of model formulation and development of conversion methods. Also, the study developed the prediction equation to test other prediction methods and define the threshold coefficients as the acceptable range.

#### **Results or findings:**

For case study one, from the literature indicated the pumps run in the reverse mode of operation with energy losses, flow swirl and separation higher than pump running in normal operation.

#### Equation 1:

Also, the modification of impeller diameter, blades angle, suction side and attached the fixed guide vanes to the volute-casing increased the efficiency by

h =



For case study two, the constructed test rig indicated the pumps operated with higher head and flow rate of ratios of 2.106 and 1.448. The efficiency is lower with the ratio of 0.9409.

Equation 2:

For case study three, two conversion methods were developed for head (Eq. 1) and flow rate (Eq. 2). The symbol h, q and "n" present the head ratio, flow rate ratio and pump efficiency.





$$q = \sqrt{\left|\frac{2h\eta_{p}^{0.5}}{1-2h\eta_{p}^{0.5}}\right|}$$

Equation 3: Prediction coefficient equation (C) to test the conversion method is presented in Eq. 3 and acceptable range from -4

to +4.

 $C = q^2 (h-4) + 4$ 

#### Challenges and how these were adressed:

Modification of induction motor to run as an induction generator. The induction motor consists of two parts including the rotor and stator. This challenge was addressed by introducing four pieces of square magnets at the centre of rotor, plugged at 900 and followed the magnetic field direction. Also, the stator was rewound with the same size of wire.

Transformation of the complex characteristic model developed into simple and user-friendly model equations. The model equations expected to solve the stated problem. The challenge was addressed by considering the mathematical knowledge related to differential calculus techniques.



Name Oras Joseph Mkinga

#### Education background

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August 31st, 2019 Supervisor(s)

Expected completion date

Jon Kleppe, Richard W. Rwechungura & Matheo L. Raphael

### Development of Methods for Reservoir Description and Modelling Under Production and Prediction of Future Performance

# Background including justification or problem statement:

Reservoir simulation is a standard method for achieving the prime objectives of reservoir engineers to estimate hydrocarbons in place, the recovery factor and the time scale for recovery. The quality and reliability of the reservoir simulation outputs are highly dependent on the quality of the input to the reservoir simulation. The inputs to the reservoir simulation are the geological model containing structural, stratigraphic, and facies details; petro-physical properties of porosity, permeability and fluid saturation; and the other fluid properties. Most geological models of subsurfacereservoirs are constructed using measurement of data from samples of few wells and seismic data.

These data face the significant challenge of capturing the heterogeneities of reservoirs because of the issue of under-sampling. Facies heterogeneities are not resolvable using current seismic methods and well data provides limited data on 3D geometries beyond the wellbore. This is the gap to the quality and reliability of the architecture of reservoir simulation models. The integration of outcrop analogue and wellbore data in reservoir description and modelling to capture heterogeneities of reservoirs can reduce the gap in the quality of the model. Examples of field cases whose models quality were improved using this approach are Heidrum and Smørbukk in Norway with Lajas outcrop in Argentina.

#### Aim and objectives:

To create a reservoir simulation model using outcrop and wellbore data:

l) Characterizing reservoir using data collected from outcrop analogue and wellbore. 2) Constructing a reservoir simulation model from so collected data.

3) Simulating production behaviour of the reservoir.

#### Short overview of methodology:

Field mapping and aerial digital Photogrammetry method using drone was used to collect outcrop data. Subsurface data from a field were integrated with outcrop data to build reservoir simulation model. Software used are Contex-Capture, Virtual Reality Geological Studio, Petrel, TechLog, PhazeComp, and Eclipse 100.

#### **Results or findings:**

Reservoir simulation model is constructed by integrating outcrop and wellbore data.

Contribution is provided in some stages of the workflow to improve reservoir characterization and model construction.

# Challenges and how these have been adressed:

It was difficult to access subsurface data of the field analogous to the outcrop data and obtaining permit to publish manuscripts. We had to write several reminders, having physical visit and disDevelopment strangy

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cussing with the company on handling confidentiality of agreement. We waited 6 months to obtain permission to access and use data, and 4 months to obtain permit to publish manuscripts.





**Name** Oscar Jose Nhabanga

Expected completion date

June 30th, 2019

Supervisor(s) Philip Ringrose

### Rock-Physics Models for Overburden Sequences in Contrasting Basin Settings in Offshore Rovuma Basin, Mozambique

Education background

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# Background including justification or problem statement:

Rovuma Basin is located in East Africa in the northern Mozambique. It covers both offshore and onshore sections and contains important petroleum resources (Davison & Steel, 2018). The basin is characterized as a passive basin margin, but with a complex tectonic history following the formation of the East Africa rift system in the early Triassic followed by episodes of rifting and inversion in the Late Jurassic to Cretaceous Periods (Macgregor, et al., 2018).

The thick post-rift sequences, dominat-

ed by the Rovuma Delta system, were deposited during the Upper Cretaceous and Tertiary periods, with continuing but reduced sedimentation in the Quaternary Period (Francis, et al., 2017; Davison & Steel, 2018).

This relatively under-explored basin presents new challenges for the interpretation of petrophysical data from exploration to wells' development. We evaluate the petrophysical characteristics of exploration wells from the offshore Rovuma basin in order to establish the effects of lithology and basin history on the rock properties. In many offshore basins around the world, pore pressure has been successfully predicted using various models based on the principles of mechanical and chemical compactions; however, it is unclear to what extent these models can be applied to this basin.

#### Aim and objectives:

Improved understanding of mechanical compaction in mudstone units in off-shore Rovuma basin.

To assess the applicability of Eaton's method, and to evaluate its implications for prediction of pore pressure.

#### Short overview of methodology:

The method suggested by Eaton's was used and it aimed at establishing a relationship between well log data, such as deep resistivity, acoustic and d-exponent data and the effective stress theory (Eaton, 1975). The procedure is to examine the relationship between vertical stress and vertical depth (TVD) and to make a ratio comparison between log data and normal data in the normal compaction trend (NCT).

Eaton's method has proven to be useful and robust for many exploration wells, and it relates changes in pore pressure to departure from normal log attributes, such as deep-resistivity and acoustic data. The underlying assumption of Eaton's method is that a ratio of deep resistivity (or P-wave velocity) may be obtained from regions of normal and abnormal pressure for the region of interest (Kumar, et al., 2006).

The predicted pore pressure from mudstone sections is then compared to well test pressure measurements in near mudstone sections.

#### **Results or findings:**

Mudstone sections in the Rovuma Basin in Paleogene and Cretaceous periods are slightly and highly overpressured. The Eaton's method shows its applicability at temperatures below the onset of chemical compaction. Due to high temperature (chemical compaction intervals), Pore pressure is underestimated in some regions. Fitting line to mechanically compacted mudstone is defined and contrasted

Fitting line to mechanically compacted mudstone is defined, and contrasted with published data from the North Sea (Sclater & Christie, 1980), and experimental data from Mondol, 2009.



# Challenges and how these have been adressed:

A major challenge for deep-water wells is related to overpressure, where drilling of high-pressure sediments may cause significant time delay in drilling, due to excessive pressure kicks, borehole instability, or stuck pipe incidents, and may even cause a complete loss of the well if not accurately predicted.



#### Name Patrick Byakagaba

#### Co-authors

Frank Mugagga & Dianah Nakayima The findings may not be conclusive, but show *prima facie* reasons to hold that there was distributive environmental injustice during oil and gas exploration in the two study sites. The insights acquired are important in designing frameworks that will ensure oil and gas sector improves local livelihoods and environmental quality.

### Oil and Gas Discovery: Exploring Perspectives of Local Communities in the Albertine Region of Uganda using an Environmental Justice Lens

The recent oil and gas exploration activities in Uganda has raised a debate on the plight of the local people. This is partly because increasingly extractives industries are enjoying policy and legal privileges at the expense of citizens. We explored local perspectives on the socio-economic and environmental impacts of oil and gas exploration activities viewed through an environmental justice lens.

Data were collected from Kyeihoro and Kaiso villages in western Uganda within the Albertine region where oil and gas exploration activities have been imple-

mented. Exploratory research design in which a total of 285 households randomly selected participated in a survey.

The most mentioned positive socio-economic impacts were not directly linked to oil and gas exploration and these included: construction of roads and increased business opportunities. The perspectives on the socio-economic impacts especially increase in income, increased cost of land, increased land conflicts, price inflation, and increased fear of displacement varied between men and women and income level suggesting that oil and gas exploration can have

asymmetric effects on men and women, poor and rich households respectively.

Spread of social ills such as prostitution, drug abuse, child abuse, petty crime was mentioned across all social categories. Noise pollution, soil erosion and wildlife disturbance were the most mentioned environmental impacts. There were relatively more respondents from Kaiso village who mentioned forest and rangeland loss, soil erosion and noise pollution than Kyeihoro, suggesting that they are majorly borne by communities in close proximity to exploration sites.



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December, 2019 Supervisor(s)

Expected completion date

Laxman Poudel & Shree Raj Shakya

### Sustainable Renewable Energy Business **Promotion in Nepal**

#### Background including justification or problem statement:

Energy is derived from the different fuel resources which are grouped into different categories based on the fuel characteristics, monetization, resources availability, dependency etc.

Every country has their own energy demand characteristics with populations. About 28 million Nepalese population total annual energy consumption in FY 2014/15 is 500 million Giga Joule (GJ); among which, fuel-wood is the largest energy resources and occupies about 70.47% of the total energy demand.

Other sources of bio-masses are agricultural residues and animal dung which contribute about 3.48% and 3.68%, respectively. Share of petroleum fuels in the total energy system is about 12.53 %.

Other sources of commercial energy are coal and electricity, which contribute about 3.97% and 3.39%, respectively in the total energy supply. In aggregate, the share of traditional fuel is 77.63%. Commercial (coal, petroleum and electricity) is 19.88 % and Renewable (Solar, Biogas, Micro hydro, Wind) is 2.59% only.

In addition per capita electricity con-

sumption of Nepal is about 140kWh(Key World Energy Stastics, IEA, 2016) which lies in TIER-2 of SDG7 goal.

In Nepal's context, renewable energy technologies are being promoted since 1997 formally after the establishment of Alternative Energy Promotion Center (AEPC) under ministry of Environment, Science & Technology. APEC is executing all the renewable energy technology promotion under public private partnership. There is arrangement of subsidy that covers around 40% to 75 % of the total installation cost for respective technologies.

#### But the share of renewable

energy in Nepal's energy mix increasing from 0.5% in 2004 to 2.6% in 2014(Economic survey 2014/15) which is not significant.

Moreover three families out of every ten families of rural areas of Nepal are forced to stav in darkness due to lack of electricity supply(economic survey 2017/18). The very difficult geographical terrain and acute poverty in the rural areas of Nepal, among all rural electrification barriers, financial barrier for initial investment is considered to be main challenges in increasing access to electricity in rural areas.

According to the Sustainable Development Goal-7, by 2030, investment must be focused to increase the share of renewable/alternative energy in order to double the improvement rate of global energy efficiency(economic survey2017/18). Many countries have made efforts to promote the development of renewable energy. Several subsidy policies, e.g. feed-in tariff, investment subsidy, grants, rebates and favorable tax rates, are designed to compensate for renewable energy investors. Similarly,

in Nepal different subsidy delivery policy and mechanism are formulated and design with in certain interval. Subsidy for Renewable Energy, 2000, Renewable (Rural) Energy Subsidy Delivery Mechanism, 2006, Pro-poor Smart Subsidv Mechanism, 2009, Subsidv Policy for Renewable Energy 2069, Renewable Energy Subsidy Delivery Mechanism. 2013 and Renewable Energy Subsidy Policy, 2073 which all have their own strength and limitations.

All these documents are based on District Human Development Index (HDI),-VDC Category ,Distance to median RET site from the nearest road head, Trail category (Difficult, Medium, Easy),RET rated capacity, average power to be generated per year ,HH wise energy demand and threshold volume of business/production in the case of traders/ manufacturers.

But during the project period there may - Secondary data: vary in material cost labor, carbon price, Energy supply and demand trend interest rate of Loan and other unknown Energy pricing, energy policy and subdynamic parameters. To deal with these sidv programs. dynamic variable optimal design of sub-Project status from site, subsidy amount sidy is required. Recommended busistochastic process to describe the CO2 ness promotion modality will fulfill the price, market price of electricity and

gap of private investment and minimized the risk in the investment. It will be comprehensive document for the renewable energy sector in case of Nepal.

#### Aim and objectives:

Optimal design of subsidy for the promotion of renewable energy technology in Nepal is the main aim of the thesis. Additionally scientific subsidy delivery modality with real option scenarios gives the alternatives.

#### Short overview of methodology:

- Litterature reviews:

Existing subsidy policies, delivery mechanics and business models.

- Identification of the issue: Research gap (optimal design of subsidy for business promotion)

- Field survey and data collection.

#### - Calculations:

and Micro-hydro) NPV and subsidy calculations with real option methods (sensitivity analysis)

- Data analysis: Project value and threshold value. Optimal level of subsidy.

- Results: Sustainable modalities. Carbon emission trading scheme is non-existent and existent. Real option method (make up the pure cost and opportunity cost).

#### **Results or findings:**

Most of the renewable energy technology projects are facing the financial sustainability in Nepal. This study demonstrated that real options method is very suited to evaluate the subsidy policies for renewable energy in Nepal.

In this thesis, we propose a real options model for estimating the optimal subsidy for renewable energy power genera-

tion project. First, the results illustrate the optimal subsidy level when carbon emission trading scheme is non-existent Subsidy calculations with BAU for the and existent. Carbon emission trading various technologies(biogas, wind-solar scheme, which may bring extra benefit to renewable energy investors, helps reduce the subsidy.

> option method is higher than the one calculated with NPV method because it can make up the pure cost and opportunity cost simultaneously. Thus the subsidy calculated by real options method is more useful.

#### Challenges and how these have been adressed:

Most of the projects are not consider as carbon emission trading scheme and dynamic variables. Moreover assumption of the grid emission factor on Nepal for CDM project is not specified vet.

Second, the subsidy calculated with real For example Indian grid have emission 0.8 and other country have their own. The bundling of the projects may the opportunity for the CDM projects. Similarly we may refer Indian grid emission factor because we have grid connection with India for the power transmission.

	TIERO	TIER 1	TIER 2	TIER 3	TI
Annual consumption levels, in kilowatt-hours (kWh)	<4.5	24.5	≥73	≥365	≥1,25
Daily consumption levels, in watt-hours (Wh)	<12	>12	≥200	≥1,000	>3,42



### Name

Saeed Abdul-Ganiyu

Expected completion date

2020

#### Supervisor(s)

Muviwa S Adaramola, Seidu Razak & Emmanuel W Ramde

## Performance Analysis and Enhancement of Hybrid Photovoltaic/Thermal (PV/T) Solar Systems

#### Background including justification or problem statement:

Access to energy is germane for a country's socio-economic development and transformation.

Most sub-Saharan African countries'. like Ghana, annual electricity consumption per capita since 2010 has been averagely below 400 kWh compared to the global minimum average of 500 kWh for lower middle-income developing countries [Ghana Energy commission, 2016]. This combined with the rising fossil fuel prices and frequent grid power challenges favor decentralized power generation among domestic consumers

and small industries on the continent using its vast solar potential.

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However, conventional flat plate solar photovoltaics have a major shortfall with a typical efficiency range of 5-20%. A major part of the incident solar energy rejected as heat. For each degree rise in temperature above 25°C, the panel output decays by about 0.25% for amorphous cells and about 0.4-0.5% for crystalline cells [Michael et al., 2015]. The temperature of a standard PV module may attain 110 °C during peak sunshine, resulting in a 43% electrical efficiency loss [Salif et al., 2016]. A solar Photovol-

taic/thermal (PV/T) technology recovers part of the generated heat and uses it for practical applications. The simultaneous cooling of the PV module maintains electrical efficiency at satisfactory level. Thus, the PV/T collector offers better way of utilizing solar energy with higher overall efficiency [Tyagia et al., 2012]. Nonetheless, there is little evidence in open literature about studies carried out in sub-Saharan Africa on PV/Ts.

#### Aim and objectives:

The research aims at providing scientific evidence on the performance of PV/T system in Ghana and hence, provide useful performance information to potential users. The specific objectives are:

1) To assess the performance of various configuration of flat plate water PVT in an uncontrolled environment.

#### **Results or findings:**

2) To assess the efficiency of the optimal configuration of flat plate water PVT units against stand-alone conventional system.

3) To assess the cost effectiveness of flat plate water PVT units in relation to existing energy tariffs in Ghana

4) To assess the market potential for PV/T systems in Ghana

#### Short overview of methodology:

Field-based experiment was set up in an uncontrolled Ghanaian environment to investigate research objectives using monocrystalline based PVT and PV.

Primary data, mainly quantitative, is to be collected for a minimum of six months from experiments and any other available relevant sources.

This will form the bases for a perfor-

urations, including cost-benefit analysis and economic savings. Life cycle, social and environmental impacts will be evaluated

Data collection is at the preliminary stages. Nonetheless, findings so far confirm high temperature of modules as shown in Fig 1 below. Also, uneven orientation of PVT module results in uneven water flow through it leading to poor surface temperature distribution. Water flow rate through PVT affects its performance.

#### Challenges and how these have been adressed:

1) Erratic power fluctuation: A stand-alone experimental setup independent of grid power.

2) Water shortages: A closed loop water circulation with heat exchangers (air and water cooled) for the cooling of PV/T.

Components availability: Most of the components used in setup are not on the Ghanaian market result-

mance analysis of various PVT config- ing in unnecessary delays in times of components failure. Innovative alternatives used in most cases.



Fig 1: Field setup overview



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# Stochastic Facies Modeling Applied to a Geologic 3D-Grid

#### Background including justification or problem statement:

Represent physical properties (facies, porosity, permeability, etc.) within a reservoir model should be taken into account its distribution in an adequate way; this requires the application of a series of criteria and techniques that help to get an understandable and trustful model based on geological concepts.

Sedimentary facies are directly related to porosity and permeability, and to understand its distribution has huge impact in reserves estimation, and future investments for oil companies.

#### Aim and objectives:

Get the best possible facies distribution and apply all required steps to accomplish a successful facies modeling, this task include: work on data analysis. identify suitable sedimentary features optimum for modeling (facies representativeness), get the best possible stochastic modeling parameters and analyze results.

#### Short overview of methodology:

Methodology for this work took into account the following steps:

- Identify sedimentary features with the use of seismic attributes (Coherence, Root Mean Square).

- Analyze well log data (gamma ray, sonic, density, neutron, spontaneous potential, resistivity, etc.) to identify optimal vertical resolution, and understand rock properties near wellbore.

Completion date

Supervisor(s)

November 14th, 2018

Marco Antonio Montesinos

- Do well top correlation to understand formation continuity.

- Define algorithm parameters and apply stochastic modeling technique, well known as Sequential Indicator Simulation (SIS), this allows to calculate spatial facies probability constrained to distance.

#### **Results or findings:**

Sedimentary bodies were found with seismic attributes usage.

Optimum vertical layer distribution was quantified as result of well log data analysis.

Faults do not have negative impact on bodies visualization, most of the time



Fig 1: (Catuneanu, 2006)

effect was minimum.

adressed:

nized

faults generate noise and this case this

#### Challenges and how these have been

difficult due to they were subtle and near the edge of seismic resolution to overcome this problem, advanced color templates were used, in this way sediment deposition tendency was recog-

Well data available was huge and hard to handle at first. There were many repeated and spliced well logs it would have been a very time consuming task to incorporate all from the beginning. That Sedimentary bodies visualization was is why each well was trated for a filtering data procedure. The result is that only important well logs were imported and these well reports summarized to the thesis scope.



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### Identification of Efficient Technology for Sustainable Production of Biodiesel from Different Bio-Energy Sources

# Background including justification or problem statement:

Biodiesel is one of the alternatives to substitute conventional diesel fuel due to its environmental and fuel benefits. However, its full-fledged substitution to conventional diesel is hindered mainly due to its high cost of production. More than 85% of the production cost is attributed to the cost of the feedstock, and this drives to look for alternative raw materials at a lower cost, which usually have high amount of impurities, such as high free fatty acid content.

A number of investigations have been done to evaluate the technical and eco-

nomic efficiency of biodiesel production from such acidic oil. Among the alternative catalyst technologies, sulfuric acid and calcium oxide are effective to produce biodiesel from low cost feedstock.

Accordingly, in this study, three alternative production processes were designed using these two catalysts separately and in combination to study their techno-economic performances.

#### Aim and objectives:

To assess and compare techno-economic performances of biodiesel production from acidic oil using three process alternatives; H2SO4 catalyzed transesterification, CaO catalyzed transesterification, and CaO catalyzed transesterification with H2SO4 catalyzed pre-esterification.

#### Short overview of methodology:

Three biodiesel production process models based on catalyst options were investigated.

Model I: Homogeneous sulfuric acid catalysis;

Model II: Heterogeneous calcium oxide catalysis; and

Model III: Heterogeneous calcium oxide

catalysis with sulfuric acid pre-esterification.

The optimum reaction conditions, for all of the process models in this study, were considered from existing literatures.

A conceptual simulation of the processes was designed using Super Pro and Aspen Plus software. Using the process flow sheets, a material balance for total capacity of 41 thousand tons feedstock per year was done.

Accordingly, the technical performances were evaluated in terms of the quantity and quality of biodiesel and glycerol produced, and the amount of biodiesel produced per oil feedstock consumed.

The economic competitiveness of the three different scenarios were compared based on the economic parameters such as Total Investment Cost, Capital Investment Cost, Operating Cost, Unit Production Cost, Net Present Value, Return over Investment, and Gross Margin.

The economic effects of change of oil cost and biodiesel selling price were also

analyzed using Net Present Value as the main economic indicator.

Results or findings:

Model III provided higher biodiesel amount, whereas Model II produced the least. At optimum production conditions, biodiesel yield variation between these two models could get up to 176 kg/ hr.

Model III showed maximum performance by producing 1.03 metric ton of biodiesel for each metric ton of oil feedstock used.

The purity of biodiesel from all process models was in line with the quality requirements of American Society of Testing and Materials in terms of percentage of total glycerol.

Model II provided high quality glycerol, as it used heterogeneous catalyst. Whereas, in Models I and III, glycerol quality was less due to presence of CaSO4 as a product of catalyst neutralization reactions in the two Models.

Economically, Model II was a superior alternative by scoring better in all of the

parameters. It showed lower unit production cost, shorter payback time, and larger amount of Net Present Value at 7% interest rate, among others.

Model II was more tolerant concerning fluctuation of market values of inputs and outputs.

# Challenges and how these have been adressed:

While redesigning the process flows using Super pro, the pure component properties of each chemical involved in the processes had to be similar for both software, to get similar results.

The problem was that Aspen calculates the missing data based on drawn molecular structures; where as in Super pro the user has to put each manually. And it was difficult to find some of them from literature. Thus the solution was calculating/estimating the values of the pure component properties using the NIST Thermos Data Engine in Aspen and putting the resulting figures manually in Super pro.

Evaluation criteria	Results from the different models			Comment		
	Model I	Model II	Model III			
Technical performances				Model III provided higher		
Biodiesel produced (kg/h)	5107	5132	5308	Model II produced the leas At optimum productio conditions, biodlesel yiel		
Biodiesel quality (%)	99.9	99.9	99.8	two models could get up 176 kg/hr.		
Glycerol quality (%)	76	99	76	Model II provided his quality glycerol, as it us heterogeneous cataly Whereas, in Models I and		
Glycerol Quantity (kg/h)	500	505	501	due to presence of CaSC as a product of catalys neutralization reactions i the two Models.		
Quantity of biodiesel produced per oil feedstock consumed	1.00	0.99	103	Model III showed maximu performance by produci 103 metric ton of biocle for each metric ton of feedbtock used.		
Economic performances	Economically, Model II w					
Total Investment Cost (MUSS)	7.7	48	70	scoring better in all of th parameters. It showe		
Annual Operating Cost (MUS\$)	36	72	36	shorter payback time, an larger amount of Ne		
Unit Production Cost (US\$)	0.89	0.78	0.86	Present Value at 7% interes rate, among others.		
Net Present Value (MUS\$)	-19	7	-30	Model II was more toleran concerning fluctuation of market values of inputs an		
Return over Investment (%)	15.6	75.1	28.4	outputs.		
Gioss Margin (%)	38	16.2	81	1		
Payback time (years)	6.40	1.33	3.53	1		

**Conclusion:** CaO Catalyzed transesterification is better choice for feasible production of fuel quality biodiesel and high quality glycerol from cheap oil feedstock.



Name Shitaye D Gebrewold

Supervisor(s) Meseret T. Terfa, Amsalu G. Roro & Trine Hvoslef-Eide

### Physiological Responses of Jatropha Accessions to Climate Under Controlled Environment: Photoperiod and Temperature

#### Abstract:

Jatropha curcas L, is a non-edible flowering plant native to Mexico and Central America which is explored as a plant with multitude of benefits. To mention some: the tree has long economic life span of 30-50 years still giving feasible yield (Banapurmath et al., 2008), the seed part has higher oil content (40-60%) compared to other plants (Achten et al., 2008), with rapid growth habit and easy propagation and drought tolerance and better adaptation (Edrisi et al., 2015). Despite all these benefits, there is a discrepancy between the envisioned potential of Jatropha and its performance under field conditions (Wendimu, 2016 and Edrisi et al., 2015). As pointed by some recent publications, the sustainability of Jatropha-based biofuel program is put under question mark.

Because of the fact that Jatropha is overemphasized as a "miracle plant" that can grow even in "marginal lands" without any problem, less attention was given to its specific environmental requirements like temperature and day length. Therefore, the objective of this study was to investigate the effects of day length and temperature for several ecotypes (accessions) on their growth and physiology.

The 9 different Jatropha accessions which were collected from varies regions of Ethiopia were grown under different growth rooms at the Norwegian University of Life Sciences (NMBU) which mimic the actual field conditions for Jatropha growing areas in Ethiopia.

The climate of the rooms were set as: short day (10 hours x 24 degrees Celsius, 11 hrs x 24 degrees Celsius) and (10 hours x 30 degrees Celsius, 11 hours x 30 degrees Celsius) long day (12 hours x 24 degrees Celsius, 13 hours x 24 degrees Celsius), and (12 hours x 30 degrees Celsius, 18 hours x 30 degrees Celsius).

The results obtained from physiological and growth data revealed that there is a variation in response to different day lengths, temperatures and interaction between these two factors.

The linear regression analysis for the plant height data shown that the accessions were responded differently to different day length and temperature levels. In addition, day length x temperature interaction also effected plant height.

The tallest plants; 55.17cm and 54.33cm were recorded in 10 hours x 24 degrees Celsius and 12 hours x 24 degrees Celsius rooms respectively from accession #6.

The other higher height record was 54.67cm in room with 11 hours X 30 degrees celsius from accession #7. Plants grown in 10 hours X 24 degrees celcius, 11 hours X 24 degrees celsius and 13 hours x 30 degrees celsius rooms were found to be shortest; 46.3-49.1cm only.

The tallest accession, with relatively highest height under most conditions, was accession #6 followed by accession #8 and accession #7. Similarly, the difference in collar diameter (stem thickness) also showed variation across the growth conditions.

The accessions grown under 10 hours x 24 derees celsius and 11 hours x 24 degrees celsius were 36.31mm and 35.68mm thick in collar diameter record, respectively.

The lowest stem thickness was 21.75mm in room with 11 hours x 30 degrees Celsius. In addition, the stage of the meristem under microscope examination showed different developmental stages across the growth room conditions, indicating a physiological response, perhaps towards flowering.

Meristems from 12 hrs and 13 hrs has a meristem stage that is closer to transition for flower formation. These results revealed that photoperiod and tempera-

ture might have significant impact on growth and flowering of Jatropha accessions.

We have planted the Jatropha accessions in different locations in Ethiopia with respect to day length and temperature, so verify these findings under field conditions. The growth room experiments will then serve as explanations of the field results.

Moreover, the findings need to be confirmed with some molecular work like flowering gene expressions that is a part of this research work is going on to back up the results obtained so far.



Name Suraj Lamichhane

Expected completion date

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Supervisor(s) Narendra Man Shakya

### Land Use Land Cover (LULC) and Climate Change (CC) Impact in River Basin Hydrology

Education background

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#### Background including justification or problem statement:

Water management is very critical for the growth and development of any economy, more so in developing countries like Nepal. Surface water is completely renewable, usually within days or weeks, while groundwater is not completely renewable, since it may take decades, centuries, or even longer time to recharge.

Under present climatic variability, most of the developing countries are already experiencing water stress due to changes in water quantity and quality both in

time and space (IPCC, 2014). Kathmandu valley is the most densely and haphazardly populated city in Nepal.

Due to the rapid construction of physical infrastructure, the land is made impervious and reduce the groundwater recharge. Encroachment of natural groundwater recharge area resulting decline the groundwater table. Similarly, in the river basin increase the peak runoff during the rainy season and decrease the water flow during the lean period.

Such unbalancing runoff in the river system creates a problem in water resources management. However, the resource is now under stress, because of land use land cover (LULC) change, climate change (CC) and excessive groundwater abstraction in the course of socioeconomic development and meeting increasing needs of growing population.

This research aims to address these knowledge gaps considering both available surface and groundwater resources, their status, artificial recharge location and their response, and how those spatial distributions of water availability will affect with change context.

#### Aim and objectives:

The broader objective of the research is to evaluate the integrated effect of Land use Land cover and climate change impact in river basin hydrology and recommend wavs forward.

These results will contribute to evaluating the impact of land use land cover and climate change, assess the dynamics of surface runoff, lateral flow, groundwater flow and artificial recharge of groundwater.

- To evaluate the impact of land use/cover (LULC) change on the spatial-temporal distribution of water resources available in Bagamati basin, Kathmandu Valley (KV).

- To assess the impact of LULC and climate change (CC) on Surface runoff of Bagamati River Basin

- To assess the impact of GW recharge in the shallow aquifer for water resources management

- To evaluate the integrated LULC and CC impact on surface and subsurface runoff of Bagamati river basin

Short overview of methodology:

Initially, land use and a land cover map was produced from the Landsat image in the different time period. From the secondary sources of input data (Population, Geology, Road network, River network, DEM etc.), CLUE-S (The Conversion of Land Use and its Effects) model is used for the generation of future land use change.

The recharge area within the basin was theoretically identified using Multi-Criteria Decision Making (MCDM) techniques by Analytical Hierarchy Process (AHP). Similarly, the infiltration field test is carried out for the verification of the recharge area map and prepare present and future recharge area map within the basin.

This result contributed to evaluating the impact of land use land cover and climate change, assess the dynamics of surface runoff, lateral flow, groundwater flow and artificial recharge of groundwater.

With the application of the computer programs SWAT and MoDFLOW, a developed conceptual surface and

groundwater model of the shallow aquifer are used. It is meant to simulate the change in the surface runoff, lateral flow, groundwater storage, groundwater flow, the profile of shallow aquifer with artificial recharge with recharging areas and wells.

#### Challenges and how these have been adressed:

Due to the repaid urbanization of the Bagamati river basin, there has been serious encroachment of recharge area and agriculture land. These changes will create the imbalance in the river basin system as well as groundwater storage. Planned urbanization and prevention of high recharge area (open area, natural ponds, well, recharge canal (Raikulo) etc) will be done for the reducing such problem.

#### **Results or findinas:**

The generated land use land cover map shows the land use change within the river basin. From these change context and model application, groundwater recharge area and LULC change map was produced with the different scenario.

From the Normal Land Use Growth Scenario, agriculture land is changed by 48.87% to 19.53% and built up area is increased by 16.96% to 44.78% from 2010 to 2050.

Initially, from the use of LULC and climate change scenario, the mean daily discharge, minimum discharge, maximum discharge of the Bagamati river at Khokana station (550.5) is increased by 5.54 %, decreased by 28.01 % and increased by11.16 % respectively within the 40 (2010 to 2050) years.

Similarly, mean monthly discharge, minimum discharge, maximum discharge of the river is increased by 5.47 %, decreased by 10.31 % and increased by 15.26 % respectively. from those land use agricultural land having high recharge tendency and low runoff capacity to compare the built-up area.





im_Swat_ 050LULC	Monthly (2001 - 2014)							
	Observed	Sim_Swat _2010LULC	Sim_Swat_ 2020LULC	Sim_Swat_ 2030LULC	Sim_Swat_ 2040LULC	Sim_Swat		
15.24	14.46	14.37	14.48	14.69	14.92	15.1		
5.54%		0.00%	0.79%	2.27%	3.85%	5.47		
0.54	1.07	1.04	0.99	1.00	0.99	0.5		
-28.01%		0.00%	-4.43%	-3.90%	-4.65%	-10.31		
699.00	107.76	68.23	70.10	72.75	75.51	78.6		
11.16%		0.00%	2.75%	6.63%	10.68%	15.26		
25.85	17.37	14.72	15.29	16.09	16.88	17.8		
0.72		0.84	0.83	0.83	0.83	8.0		
0.71		0.82	0.83	0.83	0.83	0.8		
-0.05		0.01	0.00	-0.02	-0.03	-0.0		



Name Surya Gyawali

Expected completion date

May, 2019

Supervisor(s) Narendra Man Shakya

### Energy Integrated Settlement Planning: The case of Post-Earthquake Sustainable Rural Reconstruction

Education background

M.Sc in Urban Planning

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#### Background including justification or problem statement:

Today's energy system is unsustainable because of equity issues as well as environmental, economic, and geopolitical concerns that have implications far into the future (UNFE 1992). The availability of electricity and clean fuels, however, is highly unequal, resulting in dependency upon unsustainable natural resources that limits social capabilities, resilience and sustainability for more than 2 billion people in developing countries and less developed countries. Accordingly, access to modern energy services is a foundation for sustainable development

and has recently become a foremost international and national priority (Lewis 2017). Developing countries have to address the increasing energy demands of growing economies, as well as address poverty issues often highlighted by extreme disparities (ICLEI,2009). It is needed to deal with the real and potential impacts of climate change. In ad-

dition to these challenges, is the global imperative to reduce carbon emissions in order to prevent climate change.

The concept of sustainable development is slowly starting to be deployed to the various sectors of economy. One is energy, which plays a key role in the

modern development.

Bioenergy as a renewable energy resource offers many advantages: It can be converted into various forms of secondary and final energy. Biomass, the primary energy source, can be transformed into solid, liquid and gaseous energy carriers. The combustion of these energy carriers can produce heat, cold, electricity, mechanical power or a combination of these. Even better than this, bioenergy is storable, so it can be converted right at the time when energy is needed to balance the differences between energy supply and demand. Nepal relies heavily on traditional energy resources, since more than 70 percent of the rural population rely on biomass for fulfilling their household energy demand. Nepal is in the process of post disaster reconstruction. The lesson learned from this study are highly relevant for preparing an approach to energy integrated sustainable rural settlement planning for Nepal.

#### Aim and objectives:

This research aims to recommend an approach to energy integrated sustainable rural settlement planning for Nepal

This research focuses to address the broad question: how can energy be integrated into settlement planning for sustainable development of post-earthguake rural reconstruction? The specific research questions of the research are:

1) How to integrate energy into planning?

2) How to create sustainability (Environment)?

3) How to promote sustainable livelihoods?

#### Iterature Study: translate land nergy integration and ost-disaster construction





#### Short overview of methodology:



# Challenges and how these have been adressed:

Major challenges to integrate energy into rural communities include increasing energy demand by redesigning settlement, enhancing sustainable energy future, guarantying for energy and resource production within environmental capacity limits, coordinating energy and resource planning, promoting sustainable livelihoods and environmental sustainability into spatial planning. These challenges have been addressed

through: Energy resource efficiency, increasing the use of mini grid and stand

alone, encouraging the use of modern biomass which has low or no carbon, promotion of bioenergy and links to food security, ensuring the access to energy from basic energy needs to productive use, linking all the activities of relief, recovery and reconstruction should links to livelihoods etc.

# Research framework



#### **Results or findings:**

Initial findings of the research reveals that:

- National grid as well as minigrid have been the means of lighting sources.

- Firewood is used traditionally for cooking, space heating, preparing food for cattle and wine making

- Access of energy is limited to household level and not available for productive use in community level.

- Energy resources (Forest) have been well conserved.

- Traditional buildings have been replaced by modern buildings, hence use of LPG has also been increased.

- Traditional farming/ livestock/tourism are the main sources of livelihoods.

- All three case study areas have tried to implement innovative cooking stoves and producing modern bioenergy but have not succeeded due to climatic condition.

- The process of reconstruction is very slow and is concentrated only on technically safer buildings but other issues like energy, livelihood, and sustainability have been neglected.



#### Name Tomas Nhabetse

IOIIIds Mildo

Expected completion date

2019/2020

#### Supervisor(s)

Ole Jørgen Nydal & Boaventura Chongo Cuamba

### Experimental Investigation of An Oil Based Solar Thermal System for Cooking

Education background

M.Sc in Renewable Energy

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B.Sc in Physics

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Aim:

# Background including justification or problem statement:

Biomass represents the major source of energy in Sub-Saharan Africa. Fumes and soot are released when biomass is burnt causing many respiratory diseases. So this region is challenged in delivering safe, modern and clean cooking technologies for its communities. Direct solar cooking has been unsuccessfully introduced in some countries because it exposes the cooker to direct sunlight and it can only be done in some specific hours of the day. Indirect solar cooking represents one of the solutions for this problem.

Design, construct and evaluate experimentally the performance of an oil based solar thermal system for cooking purposes

#### **Objectives:**

l) Analyze the performance of an oil based solar thermal collectors;

2) Analyze the performance of an integrated oil based solar thermal system;

3) Analyze the contribution of a PV panel for topping up heat in a thermal solar collector.

#### Short overview of methodology:

Flat plate solar thermal collector, storage tank with a heat exchanger and auxiliary equipment are being installed at Eduardo Mondlane University, Maputo.

So far, water has been used as energy carrier and in few days Heat Transfer Fluid (HTF (), which is a B22 oil is going to replace water. Currently, passive circulation is being tested. A self circulation pump and controllers are going to be integrated later.

Another task is to replace the flat plate collector by an evacuated tube collector

and perform tests using oil as HTF. And finally, a PV panel connected to dump load charge controller and a DC heating element is going to top up the heating.

# Challenges and how these have been adressed:

The big challenge has been the purchase of HTF (oil) and evacuated tube collectors because the Mozambican market does not have this type of equipment. To overcome this challenge we have to travel to South Africa to buy the equipment. Another challenge we are predicting is the assembling of the heating module which comprises the heating element, the controller –the thermostat valve or the floater valve. For this last challenge we think that collaboration between the partner universities is an important key to overcome it.

#### **Results or findings:**

The output temperature from the solar thermal flat plate collector while using water as energy carrier is around 90 oC. The mass flow rate at outlet is in order of 0.1 l/min for an average global solar radiation of 700 W/m2.





## Name

Wilson Mbile Tumushabe

### Expected completion date

December, 2019

#### Supervisor(s)

Betty Nagudi, Simon Echegu, Kevin Aanyu & William Helland-Hansen

### Impact of Depositional Architecture on Reservoir Quality on South Lake Albert Basin, Albertine Rift, Western Uganda

Education background

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Aim:

#### Background including justification or problem statement:

Depositional architecture impacts the reservoir quality of any given area. Different depositional environments are also affected differently by the depositional processes (Martinius et al., 2014). "This study therefore is aimed at understanding how depositional processes influence the depositional architecture and thereafter establish how depositional architecture affects the reservoir quality of the study area (South Lake Albert basin)"

To establish the impact of depositional architecture on reservoir quality in South Lake Albert basin (SLAB).

#### **Objectives:**

1) To determine the tectono-stratigraphic architecture of reservoir rock units in the study area

2) To quantify Porosity, Permeability and Vshale in the reservoir rock units.

3) To develop a reservoir quality predictive model for the study area

### Short overview of methodology:

- Faults were interpreted on the 3D seismic volume.

- The horizon and faults interpretations were used as input in generating structural maps

- A velocity model was created using structural maps (surfaces) as inputs and this velocity model was used for depth conversion.

- Horizon and fault interpretations were depth converted using the velocity model, and then used in structural modeling.

- Continuous properties such as effective porosity, total porosity, permeability and Vshale were upscaled in order to obtain discrete values for each property along the well.

- For effective porosity, total porosity and Vshale, an average method was used to run the upscaling for Mputa 1, 2, 3, 4, 5, Nzizi-1, 2, 3, Waraga 1, 2, 3 and Ngassa-2 wells.

- However, for permeability, both average and harmonic methods were used to run the upscaling to obtain horizontal and vertical permeability respectively.

- Property models for effective porosity, total porosity, permeability, Vshale and facies were generated from their respective upscaled logs.

- Continuous properties (effective porosity, total porosity, permeability, Vshale) and discrete properties were generated through petrophysical and facies modeling processes in petrel 2016.3 and finally property maps were created through an average method run based on a particular formation top (s) i.e., Base Nyaweiga, Base Mputa, Base Nkondo.

#### **Results or findings:**

From the studies made, Kaiso Tonya basin gets deeper northwards.

- The structural maps for Base Nyaweiga, Base Mputa and Base Nkondo formation tops get deep towards the lake, with a very distinct fault close to the lake, and minor faults within the basin.

is the deepest and Base Nyaweiga is the shallowest from the model. Hence the basin gets deeper towards the Lake Albert

- Kaiso Tonva Basin has dif-- Distinctive channel (fluvi-

ferent compartments separated by different normal fault sets and wells were drilled in different compartments thus the basin is heavily compartmentalized. al deposits) was identified around the Mputa-Nzizi fields, alluvial deposits were identified around the Waraga field and deltaic deposits were identified around the Ngassa area and the section under the lake.

In conclusion, the depositional architecture of Kaiso Tonya basin, the basin has ity. a basin bounding fault and a major fault that makes a terrace towards the Ngassa field/section of the lake that were identified to influence the deposition in the

area, and minor faults with in the basin with generally fluvial, alluvial and deltaic types of reservoir units.

The depositional architecture of Kaiso Tonya basin: The basin has a bounding fault and a major fault that makes a - Base Nkondo formation top terrace towards the Ngassa field/section of the lake with a channel at Mputa and Nzizi fields, alluvial deposits around Waraga field and deltaic deposits around Ngassa and section under the lake. Ngassa field and section under the lake majorly have deltaic reservoirs, Mputa and Nzizi fields majorly have fluvial reservoirs (pre-dominantly channel deposits) and Waraga field has alluvial deposits.

> - From the interpreted reservoir rock properties i.e. porosity (total and effective), permeability (horizontal and vertical) and Vshale values, it has been deduced that:

> - Base Mputa and Base Nyaweiga are good potential reservoir units however Base Warwire is also a possibil-

> - Around Ngassa, Waraga and Mputa fields generally have good reservoir rock properties, and section under the lake also present good reservoirs for

#### future drilling.

- Thus, drilling the section under the lake present a good option for future exploration drilling in the study area.

#### Challenges:

1) 3D seismic data from Kingfisher Basin had failed, now loaded and under interpretation.

2) Time constraints on my side.

3) Delays in installing petrel

software

4) Delays to provide funds for research (not able to conduct field work in time).

#### Way forward:

l) Working very hard to have results and start write up!







Name Yadessa Gonfa Keneni

### Expected completion date

December 31st, 2019

#### Supervisor(s)

Jorge M. Marchetti, Trine Hvoslef-Eide & Legesse A. Bahiru

#### Drying Jatropha Curcas L. Seeds from Ethiopia and Mathematical Modelling of the Drying Kinetics

#### Background including justification or problem statement:

Jatropha (J. curcas L) seeds contain non-edible oil and has been considered as a promising biodiesel feedstock. Drying oilseeds to reduce their moisture content is crucial in order to preserve the seeds and their contents.

However, due to the nature of conventional storage facilities, it is ideal to dry seeds just before using them for oil extraction and/or in situ biodiesel production as the seeds dried in advance might recover the equilibrium moisture content due to the humidity from the air.

### Aim and objectives:

Education background

PGD in Educational Supervision

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The objectives of the present study was to investigate the impact of five different drying air temperatures (313, 323, 333, 343, and 353 K) on the moisture removal from Jatropha seeds at storage and adjust the drying kinetics to selected drving mathematical models.

#### Short overview of methodology:

Drying experiments: Non-pretreated seeds (whole seeds) and pretreated seeds (crushed seeds) at storage (with moisture content of 6.81%) were dried at five different air temperatures (313, 323, 333, 343 and 353 K) in a standard heating furnace. The moisture loss from the seed samples was systematically recorded, changed to moisture loss percentage to compare the rate of moisture evaporation from the crushed and whole seeds.

The moisture loss from the seeds was also converted to unit less moisture ratio and adjusted to four frequently used semi-theoretical mathematical models: Lewis model. Henderson and Pabis model, Page model and Avhad and Marchetti model.

The fitness of the models to the experimental data was compared using the coefficient of determination. chi-square test, root mean square error, mean bias error and mean absolute error.

#### Challenges and how these have been adressed:

1) According to the plan, Jatropha seeds should be collected from the eastern, western, southern and northern part of Ethiopia. However, it became difficult to get the seeds as planned as fruiting of Jatropha plant depends on the presence of rainfall rather than fruiting in a particular season. Thirteen different collections of Jatropha seeds were collected from the most Jatropha growing areas in Ethiopia, particularly from the North Central and Southern part of Ethiopia for the experiments.

2) The other challenge was that extraction of Jatropha oil from the seeds (for biodiesel production) took longer time than planned.

#### **Results or findings:**

It was found that increasing in the drying temperature promoted the rate of moisture loss, and the evaporation of moisture from the crushed seeds was faster than that of the whole seeds.

However, the largest moisture loss vide dried seeds with suitable moismoisture content (0.34%) were obtained

The findings of the present experi- found to be the most suitable to repments suggested that drying the whole resent the drying kinetics of Jatropha seeds of Jatropha at 353K could pro-seeds at the storage moisture content.





(6.47%) and the smallest seed residual ture content for oil extraction and/ or in situ biodiesel production. when the whole seeds dried at 353K. From the four mathematical models. Avhad and Marchetti model was

Graphical Abstract

The EnPe programme is sponsored by



# THE OBJECTIVES OF THE ENPE PROGRAMME

// To support the development of master's programmes and research in low and middle income countries (LMIC) within the fields of renewable and non-renewable energies.

To strengthen the institutional capacity of higher education institutions in the LMICs to deliver quality education and research.

// To stimulate South-South-North cooperation through supporting the development of regional Master programmes and research.

// To enhance gender equality in all programme activities.