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Investigation of Anaerobic Digestion Backed by Solar-Wind System for Clean Energies in Rural Areas

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Introduction

About 90% of the Tanzanian population is not connected to the national grid, and depends solely on firewood (for cooking) and kerosene (for lighting) (Felix and Gheewala, 2011), which are not environmentally clean. With the population annual growth rate of 2.7% (NBS, 2015) and some other hindrances, long term reliable supply and access to energy from the grid in the near future cannot be guaranteed in rural areas. Henceforth holistic strategic measures are needed to handle availability and accessibility to energy in Tanzania. Improving energy and soil nutrients accessibility in rural areas will essentially require strategies which will facilitate the utilisation of the locally available cheap and low value materials and resources, e.g. animal wastes (biomass), solar radiation and wind energy.

One of the strategies for supplying energy to communities is to invest on hybrid (to be more specific integrated) systems incorporating clean energy sources. Integrated system consisting of renewable energy resources is suitable for energy generation and a source of soil nutrients (nutrient cycling). It is suitable for rural areas where electricity from the grid and firewood for cooking is a challenge (Sahu et al., 2013; Felix et al., 2011; Mishra et al., 2014). The system being a source of soil nutrient may facilitate improvement of Food Value Chain (FVC) components, mainly being Natural Resources and Production; Processing and Consumption in rural areas especially in Tanzania. Therefore researching on this system is important.

There are some examples of integrated systems utilizing renewable energy sources. They include solar-wind, solar-biogas, wind-hydro, and solar-wind-diesel generator systems (Pradhan et al., 2013; Chowdhury et al., 2012; It is noted that anaerobic digestion (AD) technology may produce biogas for cooking and generating electricity as well as bio-slurry for soil nourishment(Silayo, 1992; Mrema et al., 2011). AD is among of clean energy technologies.

Limitation of the existing system utilizing AD in rural settings is the lack of efficient and effective digester temperature control mechanism. The digester temperature is a key parameter for survival of microbes generating biogas (Yadvika et al., 2004). Also another limitation is that the system has to be large enough, resulting in high investment cost, for offering energy for both lighting and cooking in the rural areas. The challenges and possibility of getting good source of soil nutrient from AD as highlighted above lead to this research on investigating the anaerobic digestion backed by solar-wind system for production of clean energies (biogas and renewable electricity) in rural areas, specifically in Chamwino district, Dodoma-Tanzania. The research approach will involve a feasibility of the cheap and low cost materials and resources. Data collection from literature on renewable resources for the task mentioned above at the research site has been done. Other tasks to be undertaken regarding research approach are optimising,

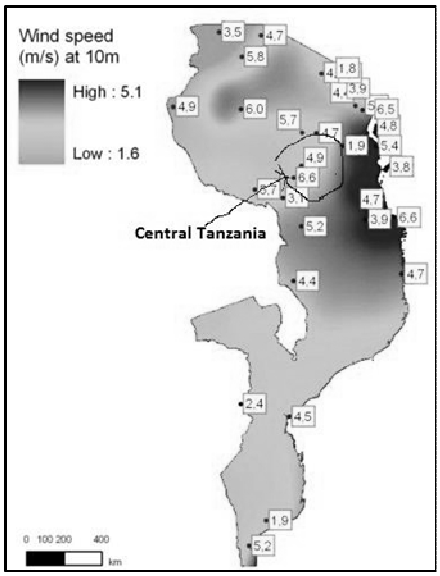
designing, and testing, modelling (Logan et al., 1994; Rea, 2014) and conduct techno-economic analysis of intended hybrid energy system. The research results i.e. model will be very useful in making pre-informed decisions by policy makers, biogas production investors, and other clean energy practitioners as well as agronomists for soil nutrient issues.

Material and Methods

The investigation of the anaerobic digestion backed by solar-wind system for production of clean energies (biogas and renewable electricity) in rural areas, specifically in Chamwino district, Dodoma-Tanzania is a researchable task. The approach to handle the task is involving: characterising the available renewable energy resources (biomass/cowdung, wind and solar) and rural households energy demand; designing the integrated solar-wind energy and anaerobic digestion system and characterising bioslurry nutrients; developing a model for predicting the performance of integrated solar-wind energy and anaerobic digestion system, and techno-economical appraising of integrated solar-wind energy and anaerobic digestion system.
Preliminary data on characterising the available renewable energy resources and rural households' energy demand were collected from literature (NBS, 2014) by extracting and analysing relevant data. They involve wind, solar radiation in a day (insolation) and percentage distribution of households by firewood for cooking in rural areas. The decreasing rate of firewood resources was derived from the percentage distribution of households by firewood for cooking. The other parts of the investigation of the anaerobic digestion backed by solar-wind system for production of clean energies have not yet done as the research is at early stage.

Results and Discussion

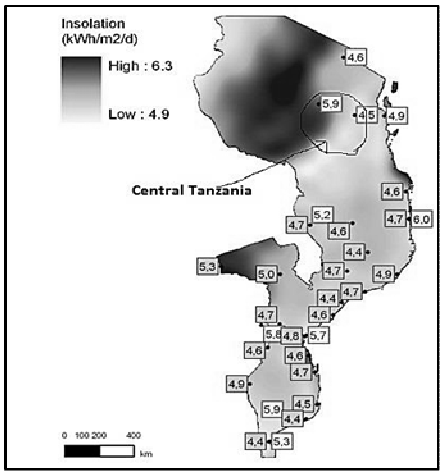
Preliminary data resulted from extracting and analysing process of information from literature is presented in the figures below. The data are referred to the rural area especially of central Tanzania where Chamwino district of Dodoma region is located. They involve wind, solar radiation in a day (insolation) and percentage distribution of households by firewood for cooking in rural area. An annual average wind speed is 6 m/s as depicted from the irregular circle indicated as Central Tanzania in Figure 1. The speed is appreciable for generating energy for useful domestic purpose in rural area.



(Source: Hammar, 2011)

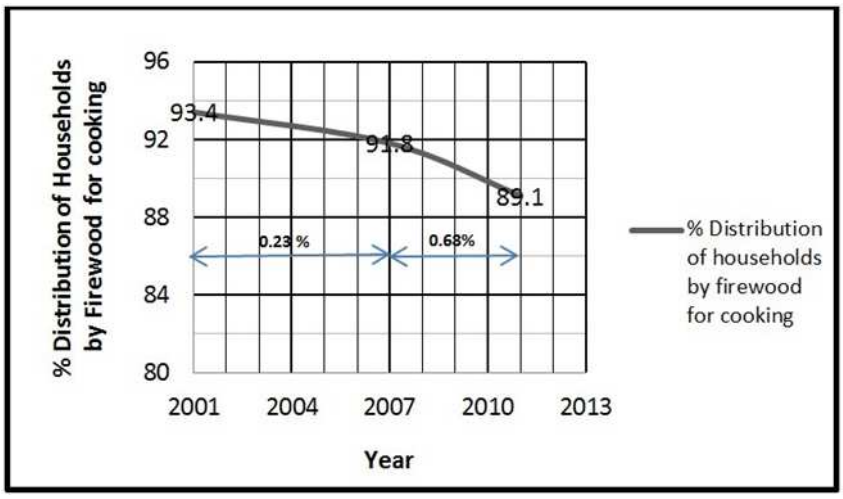
Figure 1: Annual averages of wind speed in Tanzania and Mozambique

Figure 2 present the results on annual average solar radiation in a day (insolation). For the location of interest, demarcated by irregular circle, the annual average insolation is 4.7 kWh/m^2/day. Also this level of insolation is enough for harnessing solar energy to serve rural energy demand. The decreasing rate of fuel wood (firewood) sources was estimated at 0.68% per year since 2007 to 2011 exceeding that of 0.23% per year from 2001 to 2007 as it has shown in Figure 3. The trend might be enhanced by expansion of agricultural land, increase of charcoal production which results in poor replenishment of biomass (trees) chief source of firewood for cooking purposes in rural areas.



(Source: Hammar, 2011)

Figure 2: Annual averages of insolation in Tanzania and Mozambique



(Extracted from NBS, 2014)

Figure 3: Percentage distribution of households by firewood for cooking in rural area, Tanzania Mainland

Conclusions and Outlook

As the wind and solar sources are available at appreciable levels as shown in the results section, then introducing the conversion systems to utilize the stated sources (renewable sources) in the rural area of interest(Chamwino district) may be logical. Through these systems we may obtain the intended heat and electrical energy for supporting of anaerobic digestion process and other domestic purposes. The anaerobic digestion process produces biogas which is a supplement to the cooking fuel as well as the bio-slurry which may be used as soil nourishment. The decrease of fuel wood/firewood sources for cooking in rural areas at stated decreasing rate is alarming. This

necessitates the formulation of strategies to that decrease which is tied to environmental degradation and diminishing useful cooking fuel (firewood) in the rural area.

The obtained preliminary results give the indication of the relevance to investigate the anaerobic digestion backed by solar-wind system for production of clean energies (biogas and renewable electricity) and bioslurry in rural areas, specifically in Chamwino district, Dodoma-Tanzania. Therefore detailed characterising of available renewable energy resources and rural households energy demand; designing and testing the integrated solar-wind energy and anaerobic digestion system as well as characterising the bioslurry nutrients; developing a model for predicting the performance of integrated solar-wind energy and anaerobic digestion system, and techno-economical appraising of integrated solar-wind energy and anaerobic digestion system will be undertaken.

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