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ADVANCED EDUCATION AND TRAINING PROGRAMS TO SUPPORT RENEWABLE ENERGY INVESTMENT IN AFRICA

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ABSTRACT

African countries have initiated programs to generate electricity from renewable sources such as; wind, solar, biomass and hydropower. These initiatives are intended to reduce the carbon footprint of these countries in the wake of heavy dependency on fossil fuels and also provide cheap and accessible electricity to rural areas. These renewable energy programs are expected to deliver regional development and economic empowerment. However, the lack of trained manpower for repair and maintenance of renewable energy technologies devices is likely to result in failure of these technologies, cause losses in revenue and reduction in consumer faith in renewable energy technologies. African universities must be at the core of solving these challenges by training specialized professionals in renewable energy at graduate level and through short courses to meet the increasing demands for qualified human resource to support the sector. Thus to establish the "readiness" of Universities in Africa to offer advanced education and training in renewable energy, a review of all Masters Courses, Ph.D. programs and short courses was carried out. The results identified 21 English-language Masters courses, 3 providers of Ph.D. studies and 9 short courses in or with significant renewable energy content. Generally, there is inadequate advanced training in renewable energy especially at Ph.D. level in Africa thus the need to attract more African Universities to offer such programs at both masters and Ph.D. levels.

Keywords: African countries, Higher education, Masters and PhD training, Universities.

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Contribution/ Originality

This paper contributes to efforts geared towards underscoring the need for capacity building in renewable energy in Africa. Energy-poverty remains a key issue in Africa with a critical need for capacity building particularly at higher degree level.

1. INTRODUCTION

The world and particularly Africa has vast renewable and non-renewable energy resources that are untapped. These energy resources in African countries include; biogas, wind, biomass, solar, geothermal heat, and wood (Bugaje, 2006). As stated by Huang and Wu (2007) renewable energy is a sustainable and clean source of energy got from nature while non-renewable energy is not sustainable. According to Bugaje (2006) energy is a catalyst for economic growth of a country thus African countries need to utilize their abundant renewable and non-renewable energy resources in such way to achieve sustainable development. However, Africa's main source of energy based on the three distinct regions is oil and gas for North African, coal for South African and biomass for Sub-Saharan countries (Karekezi, 2002).

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Africa has about 96600GWh, 1,750 TWh of, 470 PWh, 660 PWh, and 460 PWh for geothermal potential, hydropower potential, solar concentrated power (SCP), photovoltaic, and wind on yearly basis respectively (United Nations Industrial Development Organization (UNIDO), 2009; Viebahn *et al.*, 2011; Hermann *et al.*, 2014). Furthermore, the solar power production potential in most locations in Africa ranges from about 300 to 600 Wh per day, except in winter season in the extreme North and South of the continent (Huld *et al.*, 2005). Specifically, there is a 155MW Nzema project in Ghana, Morocco has just also commissioned a huge solar system and a 280 MW Olkaria geothermal power plant in Kenya. Eastern Africa has the highest potential for CSP and PV (175 PWh and 220 PWh, respectively), followed by Southern Africa (150 PWh and 160 PWh respectively) (Hermann *et al.*, 2014).

However, only 5% of Africa's hydropower potential has been exploited (UNIDO, 2009). However, United Nations Economic Commission for Africa (UNECA) (2014) study shows that about 1.3 billion people in the world lack access to electricity and 2.7 billion lack clean cooking facilities, Africa and Asia constituting 95%. Furthermore, the International Energy Agency states that with the increasing population growth rates particularly in Africa even with an investment of 14 USD billion per year between 2010 and 2030, billions of people will still live without access to clean energy and cooking facilities by 2030 (UNECA, 2014).

African countries' main source of electricity is hydropower. There is however massive load-shedding in many African countries and this could probably be because of recurrence of drought that has reduced water inflows in rivers. According to Isingoma (2007) the impact of climate change on hydropower generation include: lower levels of water in catchment areas, reduced capacity of hydropower generation, inability to meet growing demand for power and increased electricity costs in many African countries. Hence renewable energy options such as geothermal, small hydro, biomass cogeneration and wind energy are viable options to complement large-scale hydro-power generation in African countries (Mas'ud *et al.*, 2015; Wesseh and Lin, 2016). These renewable energy options are all environmentally friendly, sustainable and more suitable adaptation responses to the adverse impacts of climate change-related drought on the power sector (Mohammed *et al.*, 2013; Nakumuryango and Inglesi-Lotz, 2016).

Access to energy is a bottleneck to socioeconomic development in many developing countries, African countries inclusive and thus is now part of global priority agenda (Bugaje, 2006). In many parts of the world particularly in Africa, forests are being cut down in order to satisfy the energy needs (Blair, 2011). According to Blair (2011) deforestation contributes a fifth of the increasing carbon dioxide emissions in the world. Further still, deforestation is not a sustainable means of meeting Africa's energy demands and it is a threat to food security. Furthermore, poor utilization and poor regulation of water resources with the view of meeting Africa's energy demands have caused significant changes in the flow regimes of rivers and deterioration in water quality. According to Pietersen *et al.* (2009) large dams threaten fresh water resources by fragmenting and transforming aquatic systems. Further still, such regions are marked by recurrence of climatic extremes in the form of flooding and drought that further result into soil erosion, change in land use, and climate change (Pietersen *et al.*, 2009). In addition, most African countries use fossil fuels to meet their energy demands releasing a lot of greenhouse gases that results into global warming hence climate change.

2. REVIEW OF ADVANCED EDUCATION AND TRAINING IN RENEWABLE ENERGY IN AFRICA

The availability of qualified and resourceful human capital is paramount to the capacity building process in the renewable energy sector (Aïssa *et al.*, 2014; Eder *et al.*, 2015). African countries are far lacking in this area. They are confronted with challenges in developing scientific education and technologies in renewable energy tailored to local conditions due to the lack in equipment and laboratory materials (Colenbrander *et al.*, 2015). African universities seek to solve the energy problem by training professionals to help stimulate indispensable creative capabilities and

open mindedness through research and development as a key success factor for the sector (Lewis and Wiser, 2007). The training in the scientific field is important at three levels including: the staff and researchers, technicians and qualified workers. In recent years in some African countries, significant strides have been made in this regard. Some African universities have engaged in advanced education and training in renewable energy and incorporated a diversified training program in form of masters and doctoral degrees to meet increasing demands for qualified human resource in judgment and decision making (Colenbrander *et al.*, 2015). Both of the above qualities are necessary for renewable energy related project planning and management and to ensure appropriate application and utilization of renewable energy technologies for local conditions. In the light of the above, the establishment of renewable energy programs such as South Africa's Renewable Energy Independent Power Producers Procurement Programme designed to reduce South Africa's carbon emissions depends on the availability of qualified human resource (Msimanga and Sebitosi, 2014; Baker, 2015; Walwyn and Brent, 2015). Jain *et al.* (2002) reported that the government of Botswana through the ministry of minerals, energy and water affairs commissioned studies to assess the training in renewable energy in technical schools of Botswana to make recommendations toward the desired training programs and create facilities to meet the training needs. The Cameroonian government also initiated vision 2035 with significant investments in renewable energy to foster rural electrification (Wirba *et al.*, 2015).

The need for advanced training and education in renewable energy technologies is important due to the sustainability of the technologies. In the wake of energy costs and the role played in the economy, recent growth in energy consumption has influenced some countries to develop and execute various strategies including: improvement in the efficiency of energy use, increase in energy conservation and development of new renewable sources of energy (Sebitosi and Pillay, 2008). Furthermore, the increasing awareness of the role that renewable energy can play in the world energy systems, especially for the supply of energy in rural areas, has increased the interest of most countries in creating appropriate training programs such as short courses related to these energy sources (Kruckenberg, 2015). It is evident that all projects relying on renewable energy and equipment rely on the availability of specialists of various levels, who are able to use and maintain the installed equipment. Thus, the need for the training of specialized personnel is crucial and several African universities have already confirmed their interest in training staff and specialists who will be able to rationally utilize renewable energy resources. However, the long term government commitment through public funding to supporting the sector is important for the success of renewable energy technologies (Walwyn and Brent, 2015).

Renewable energy provides a significant employment potential (Sawin, 2006). Ban-Weiss *et al.* (2004) indicates that about 30 PV-related jobs per peak MW installed capacity are created on average. With these jobs categorized as operations (1%), manufacturing (14%), module assembly (36%) and installation (49%) (Ban-Weiss *et al.*, 2004). More than 54% of the manufacturing jobs are module assembly and this accounts for 6% of the overall labor costs in the value chain, implying that the renewable energy sector has a high ratio of employment creation to cost (Kirkegaard *et al.*, 2010; Mulcahy, 2012). A comprehensive review of all Masters Courses, Ph.D. programs and short courses in renewable energy has been carried out. The results are summarized in Table 1 for English language Masters Courses on renewable energy engineering, Table 2 for PhD providers in the same area and Table 3 for short courses in renewable energy. This review identified 20 English-language Masters courses in or with significant renewable energy content, 2 providers of PhD studies and 9 short courses.

2.1. Masters Programs

Twenty one English-language taught Masters Courses were identified in African universities that include at least some renewable energy content and a full listing can be found in Table 1. The spatial distribution of the Masters courses providers with respect to the regions include: 42.9% for southeastern Africa, 14.3% for southern Africa, 19% for western Africa, 9.5% for the horn of Africa and 14.3% for northern Africa. It is important to note that there are additional Masters Courses offered in other languages of African countries, but these were not

included since they could not be accessed. The results show that few universities in Africa are currently able to home grow researchers necessary to foster technical innovations in renewable energy.

2.2. Doctoral (Ph.D.) Programs

Ph.D. programs in renewable energy in Africa are still meager and only 3 providers of Ph.D studies in renewable energy have been identified in African universities. PhD providers include South Africa and Tanzania and can be found in Table 2. These results suggest that there is inadequate doctoral research in renewable energy in Africa.

Table-1. Masters Providers in renewable energy by country in 2016

Institution	Course	Website
Uganda		
Makerere university	M.Sc. in Renewable Energy	http://cedat.mak.ac.ug/
South Africa		
Stellenbosch university	M. in Renewable and Sustainable Energy	http://www.crses.sun.ac.za/
University of Cape Town	M.Sc. in Sustainable Energy Engineering	http://www.mecheng.uct.ac.za/mec/postgrad
Rwanda		
University of Rwanda	M.Sc. In Renewable energy	http://www.ur.ac.rw/
Tanzania		
University of Dar-es-Salaam	M.Sc. in Renewable Energy Engineering	http://postgraduate.udsm.ac.tz/
The Nelson Mandela African Institution of Science and Technology	M. of Sustainable Energy Sciences and Engineering	http://nm-aist.ac.tz/degree.html
Zimbabwe		
University of Zimbabwe	M.Sc. in Renewable Energy	http://www.uz.ac.zw/
Zambia		
The University of Zambia	M. of Engineering in Renewable energy	http://www.unza.zm/
Sierra Leone		
Njala university	M.Sc. in Renewable Energy and the Environment	http://njala.edu.sl/
Mauritius		
University of Mauritius	M.Sc. in Sustainable Energy Engineering with Environmental Management	http://www.uom.ac.mu
Kenya		
Moi University	M.Sc. in Energy studies	https://www.mu.ac.ke
Kenyatta University	M.Sc. in Sustainable Energy	www.ku.ac.ke
Jomo Kenyatta University of Agriculture and Technology	M.Sc. in Renewable Energy	www.ku.ac.ke
Benin		
University of Abomey-Calavi	M.Sc. in Renewable Energies and Energetic studies	www.uac.bj
Ghana		
University of Energy and natural resources	M.Sc. in Sustainable Energy Management	www.uener.edu.gh
Kwame Nkrumah University of Science and Technology	M.Sc. Renewable energy Technologies	www.knust.edu.gh
Ethiopia		
Addis Ababa University	M.Sc. in Hydropower Engineering	www.aait.edu.et
Jimma university	M.Sc. in Sustainable Energy Engineering	www.ju.edu.et

Institution	Course	Website
Egypt		
British University in Egypt	M.Sc. in Renewable Energy Engineering	www.bue.edu.eg
	M. Eng. in Renewable Energy Engineering	
Cairo University	M.Sc. Renewable Energy and Energy Efficiencies for the Middle East	cu.edu.eg

Source: Compiled by authors

The inadequacy of doctoral programs presents limitations to train future educators that can effectively communicate this knowledge to undergraduate and postgraduate researchers. Therefore, Africa has to rely on universities outside Africa to bridge this gap.

Table-2. PhD programs Providers in renewable energy by country in 2016

Institution	Course	Website
South Africa		
Stellenbosch university	Ph.D. in Renewable Energy	http://www.sun.ac.za/
University of Cape Town	Ph.D. in Sustainable Energy Engineering	http://www.mecheng.uct.ac.za/mec/postgrad
Tanzania		
The Nelson Mandela African Institution of Science and Technology	Ph.D in Sustainable Energy Sciences and Engineering	http://nm-aist.ac.tz/degree.html

Source: Compiled by authors

2.3. Short Courses

Short Courses are often used to introduce renewable energy processes and technologies to potential stakeholders, acquire specialist expertise in specific areas and update professionals on the latest technological developments. Short Courses in renewable energy can include professional development courses for renewable energy professionals such as managers, researchers, designers, planners, engineers, installers and policy makers to acquire expertise in specific areas and training courses to provide renewable energy stakeholders such as farmers with more knowledge of renewable resources production and energy technology. These courses provide the necessary knowledge required to become involved in renewable energy production. Short courses offered by some African countries by 2016 are presented in Table 3 with the southern Africa region accounting for 66.7% and western, central and southeastern regions each accounting for 11.1%.

Table-3. Short courses Providers in renewable energy by country in 2016

Institution	Course	Website
South Africa		
Stellenbosch university	Postgraduate Diploma in Engineering (Mechanical Engineering) in Renewable and Sustainable Energy Studies	http://www.crses.sun.ac.za/
Stellenbosch University: Centre For Renewable And Sustainable Energy Studies	Renewable Energy Systems, Renewable Energy policy, Introduction to Solar Energy, Thermal energy systems, Advanced PV Systems, Renewable energy finance, Hydro & Ocean Energy, Bioenergy, Wind energy	http://www.crses.sun.ac.za/
Nelson Mandela Metropolitan University: Advanced Mechatronic Technology Centre	Renewable Energy Finance and Policy, Renewable Energy Technology, Wind Energy, Photovoltaic Systems	http://amtc.nmmu.ac.za/

Institution	Course	Website
Cape Peninsula university of technology: South African renewable energy technology center	Short course in Solar PV	http://www.saretec.co.za/
Energy training foundation	Certified renewable energy professional course	http://www.energytrainingfoundation.co.za/
Central University of Technology	Higher Certificate in Renewable Energy Technologies	http://www.cut.ac.za/
Cameroon		
Higher Institute of Technology of Central Africa	Higher certificate in Renewable Energy Technologies	Wiki.listed.tech.com/wiki/Higher Institute of Technology/ of Central Africa
Uganda		
Center for research in energy and energy conservation	Solar PV and Biomass services	http://www.creec.or.ug
Senegal		
Wecass Technology	Solar Energy Techniques, Wind Energy Techniques, Solar and Wind Energy Project Management	http://wecass-senegal.com/

Source: Compiled by authors

3. CONCLUSIONS AND RECOMMENDATIONS

Renewable energy has played a role in providing access to low carbon clean energy in urban centres and cheap energy to rural areas. This has helped some African countries to reduce on carbon emissions by cutting down on the use of fossil fuels and deforestation. These achievements obtained by using renewable energy can best be enhanced through knowledge development with respect to advance training in renewable energy technologies. Currently there is inadequate advanced training in the central Africa region, the horn of Africa while southeastern and southern Africa regions are doing well as regards to advanced education and training in terms of Masters and short courses in renewable energy technologies. Most African countries are still lacking in PhD. training except for South Africa and Tanzania. This reveals a significant opportunity for African countries to put in place doctoral programs to redress the skills shortage in low carbon technologies despite limited infrastructure.

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