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**Review article**

## **Energy extension and energy literacy for sustainable energy development in rural Nigeria**

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### ABSTRACT

Energy is a very important part of any sustainable development strategy. Without modern energy services, the poor will go on being poor and the sick will continue to be sick. Access to clean, abundant, reliable domestic energy services is an enormous challenge facing Nigerian and Africa because energy is fundamental for socio-economic development and poverty reduction. Since majority (about 70%) of the Nigerian population live in rural areas, with agriculture as their major occupation, clean energy development and provisioning is important to meet their livelihood needs. Renewable energy technologies have been developed but most of these rural dwellers are ignorant of these technologies. This paper thus brings to the fore, the issue of energy extension and literacy. Energy extension is a necessary tool for education, development and adoption of renewable energy technologies in the rural areas. In developing energy technologies, extension by nature has an important role in promoting the adoption of new technologies and innovations with rural dwellers as the target group. The paper thus outlines the energy situation in the country, need for extension education in energy development and the veritable roles of extension in energy development, education and information provisioning.

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## **1. Introduction**

Rural energy is recognized as a vital element of rural socio-economic development, this is because of the demand for the services made possible through energy inputs, such as potable water pumping, extension of the day by lighting and cooking. As a general trend, an increasing energy demand-both in quantity and quality is highly correlated with socio-economic development. Sadly, the rural populations of most developing countries have been excluded from most of the benefits of economic development and the transition to better (quality) energy services (Van Campen et al., 2000).

Energy is essential in poverty reduction, providing major benefits in the areas of health, literacy and equity. In peoples' daily lives, energy provides essential services for cooking and heating, lighting, food production and storage, education and health services, industrial production, and transportation (Yianna and Grazia, 2006). In order to raise productivity and to improve the living standards of their populations, developing countries need sustainable energy development and access. Nigeria is one of the countries which are on transition /developing/ process, but still with great problem of energy supply, however it has huge amount of hydropower, wind, geothermal and solar potential (Awash, 2014). It is well known that the most rural parts of the country are highly dependent on fire wood for cooking purposes and these countries have addressed their energy needs by expanding the supply base with little attention to the efficiency and energy conversion. For this reason, the rural area is highly exposed to deforestation and for several eye and breathing related diseases. Wood fuel dependence was thought to contribute directly to deforestation and environmental degradation in rural areas of developing countries and reducing household demand was a logical solution. One response to reducing the pressure of the local community on their rural hinterlands could be switching from one fuel source to another, known as energy transition. Switching from fuel wood to other renewable energy, for instance, leads to reduce pressure on the forest resources and lower indoor air pollution (Awash, 2013).

Energy has a vital role to play in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. Security, climate change, and public health are closely interrelated with energy (Ramchandra and Boucar, 2011). Energy is an important factor in all the sectors of any country's economy. The standard of living of a given country can be directly related to the per capita energy consumption. The recent world's energy crisis is due to two reasons: the rapid population growth and the increase in the living standard of whole societies. The per capita energy consumption is a measure of the per capita income as well as a measure of the prosperity of a nation (Rai, 2004).

Energy supports the provision of basic needs such as cooked food, a comfortable living temperature, lighting, the use of appliances, piped water or sewerage, essential health care (refrigerated vaccines, emergency, and intensive care), educational aids, communication (radio, television, electronic mail, the World Wide Web), and transport. Energy also fuels productive activities including agriculture, commerce, manufacturing, industry, and mining. Conversely, a lack of access to energy contributes to poverty and deprivation and can contribute to the economic decline. Energy and poverty reduction are not only closely connected with each other, but also with the socioeconomic development, which involves productivity, income growth, education, and health (Nnaji, et al (2010).

The importance of energy in any economy cannot be over emphasized; sectors such as manufacturing, health, construction, entertainment, education and communications significantly need power for their activities. Energy extension is an essential for sustainable development; and any decision-making about energy use has complex linkages with policies affecting poverty, food security, health, population, gender disparities, environmental quality, investments, foreign exchange, trade and national security (Yianna and Grazia, 2006). Increased recognition of the contribution of energy extension makes to rural development, lower health costs (linked to air pollution), energy independence, and climate change mitigation is shifting renewable energy from the fringe to the mainstream of sustainable development.

So, the aim of the paper is to show how energy extension and literacy contributions to sustainable development and gender equality and how to solve rural and urban energy scarcity and health problems by improving on any energy development programme, new technology adoption and energy conversion technique to the farmers, pastoral and semi-pastoral societies. Such programme should engage communities in renewable energy training to build the capacity of local community, and preparing them to successfully assess the impacts of

renewable energy technologies (Eric Romich, Nancy Bowen-Ellzey, 2013). Because, energy security, economic growth and environment protection are the national energy policy of the country and the programme helps to ensure the policy and improve the living standard of community people by promoting the use of renewable energy technology for protecting the environment through energy extension.

## **2. Energy situation in Nigeria**

Nigeria is Africa's energy giant. It is the continent's most prolific oil-producing country, which, along with Libya, accounts for two-thirds of Africa's crude oil reserves. It ranks second to Algeria in natural gas (Sambo, 2008)). Most of Africa's bitumen and lignite reserves are found in Nigeria. In its mix of conventional energy reserves, Nigeria is simply unmatched by any other country on the African continent. It is not surprising therefore that energy export is the mainstay of the Nigerian economy. Also, primary energy resources dominate the nation's industrial raw material endowment.

Several energy resources are available in Nigeria in abundant proportions. The country possesses the world's sixth largest reserve of crude oil. Nigeria has an estimated oil reserve of 36.2 billion barrels. It is increasingly an important gas province with proven reserves of nearly 5,000 billion m<sup>3</sup>. The oil and gas reserves are mainly found and located along the Niger Delta, Gulf of Guinea, and Bight of Bonny. Most of the exploration activities are focused in deep and ultra-deep offshore areas with planned activities in the Chad basin, in the northeast. Coal and lignite reserves are estimated to be 2.7 billion tons, while tar sand reserves represent 31 billion barrels of oil equivalent. The identified hydroelectricity sites have an estimated capacity of about 14,250 MW. Nigeria has significant biomass resources to meet both traditional and modern energy uses, including electricity generation (Ighodaro, 2010). There has been a supply and demand gap as a result of the inadequate development and inefficient management of the energy sector. The supply of electricity, the country's most used energy resource, has been erratic (Okafor et al., 2010).

The situation in the rural areas of the country is that most end users depend on fuel wood. Fuel wood is used by over 70% of Nigerians living in the rural areas. Nigeria consumes over 50 million tonnes of fuel wood annually, a rate which exceeds the replenishment rate through various afforestation programs. Sourcing fuel wood for domestic and commercial uses is a major cause of desertification in the arid-zone states and erosion in the southern part of the country. The rate of deforestation is about 350,000 ha/year, which is equivalent to 3.6% of the present area of forests and woodlands, whereas reforestation is only at about 10% of the deforestation rate (ICDD, 2000).

The rural areas, which are generally inaccessible due to the absence of good road networks, have little access to conventional energy such as electricity and petroleum products. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices 150% in excess of their official pump prices. The daily needs of the rural populace for heat energy are therefore met almost entirely from fuel wood. The sale of fuel wood and charcoal is mostly uncontrolled in the unorganized private sector. The sale of kerosene, electricity and cooking gas is essentially influenced and controlled by the Federal Government or its agencies - the Nigerian National Petroleum Corporation (NNPC) in the case of kerosene and cooking gas, and the PHCN in the case of electricity. The policy of the Federal Government had been to subsidize the pricing of locally consumed petroleum products, including electricity. In a bid to make the petroleum downstream sector more efficient and in an attempt to stem petroleum product consumption as a policy focus, the government has reduced and removed subsidies on various energy resources in Nigeria. The various policy options have always engendered price increases of the products (Famuyide et al., 2011; Sambo, 2009).

## **3. The need for energy extension in Nigeria**

Renewable energy development in rural areas faces several challenges such as slow adoption; lack of research and development; lack of awareness, slow dissemination of information; inadequate policy, poor integration of renewable energy in development plans and inadequate commitment by government (Mfume and Boon, 2008). Sambo (2005) pointed out that one of the main barriers in adopting the renewable energy in Nigeria was lack of awareness of potential alternatives in energy resources. Although research and development activities are still being seriously undertaken in various aspects of renewable energy utilization, a number of the technologies have since been shown to be feasible and ready for adoption (Sambo, 2005).

In a study about localization of new energies concluded that informing rural population about benefits of new energies would accelerate the speed of adoption in rural areas of Iran. As is often the case with technological innovation, potentials and expectations can outpace reality (Gelb and Bonati, 1998). The adoption of any new technology and innovations has not been an easy task and it is usually not spontaneous, the technology has to be taught and learned to adopted to existing experience and integrated into production. As is often the case with technological innovation potential and expectations can outpace reality (Gelb and Bonati, 1998).

The issue is not only the access to technology, but also to provide training, tools and guidance to make rural population aware of what technology can do for them and what they can do with technology (Hosseini et al., 2009). Several parameters have been identified as influencing the adoption behavior of farmers and social scientists investigating farmers who adopt the biotechnology showing the demographic variables, technology characteristics, information source, knowledge, awareness, attitude and group influence affect adoption behavior (Oladele, 2005). A wide range of economic, social, physical and technical aspect of farming influences adoption of agricultural production technology. Wheeler (2005) citing Rogers and Pannell pointed the factors which influence the adoption of new innovations by farmers. She mentioned factors such as perception about risk and profitability; uncertainty and certainty about adoption; amount of required information and attitude about risk and uncertainty.

Again, energy consumption patterns in the world today shows that Nigeria and indeed African countries have the lowest rates of consumption. Nevertheless, Nigeria suffers from an inadequate supply of usable energy due to the rapidly increasing demand, which is typical of a developing economy. Paradoxically, the country is potentially endowed with sustainable energy resources. Nigeria is rich in conventional energy resources, which include oil, national gas, lignite, and coal. It is also well endowed with renewable energy sources such as wood, solar, hydropower, and wind (Okafor et al., 2010).

The patterns of energy usage in Nigeria's economy can be divided into industrial, transport, commercial, agricultural, and household sectors (ECN, 2003). The household sector accounts for the largest share of energy usage in the country - about 65%. This is largely due to the low level of development in all the other sectors. The major energy-consuming activities in Nigeria's households are cooking, lighting, and use of electrical appliances. Cooking accounts for a staggering 91% of household energy consumption, lighting uses up to 6%, and the remaining 3% can be attributed to the use of basic electrical appliances such as televisions and pressing irons (ECN, 2005).

The predominant energy resources for domestic and commercial uses in Nigeria are fuel wood, charcoal, kerosene, cooking gas and electricity (Famuyide et al., 2011). Other sources, though less common, are sawdust, agricultural crop residues of corn stalk, cassava sticks, and, in extreme cases, cow dung. In Nigeria, among the urban dwellers, kerosene and gas are the major cooking fuels. The majority of the people rely on kerosene stoves for domestic cooking, while only a few use gas and electric cookers (Abiodun, 2003).

The rural areas have little access to conventional energy such as electricity and petroleum products due to the absence of good road networks. Petroleum products such as kerosene and gasoline are purchased in the rural areas at prices very high in excess of their official pump prices. The rural population, whose needs are often basic, therefore depends to a large extent on fuel wood as a major traditional source of fuel. It has been estimated that about 86% of rural households in Nigeria depend on fuel wood as their source of energy (Williams, 1998). A fuel wood supply/demand imbalance in some parts of the country is now a real threat to the energy security of the rural communities.

Agricultural extension by its nature has an important role in promoting the adoption of new technologies and innovations. Extension organizations have a key role in brokering between providers of technologies and farmers. Agricultural extension and education has the highest economic impact and sustainability in agriculture by providing information to increase farmer's awareness, knowledge, adoption and productivity (Hosseini et al., 2010). The extension-teaching methods are the tools and techniques used to create situations in which communication can take place between the rural people and the extension workers. They are the methods of extending new knowledge and skills to the rural people by drawing their attention towards them, arousing their interest and helping them to have a successful experience of the new practice. The extension teaching methods can be classified based on their use: individual contacts, group contacts and mass contacts. Extension-teaching methods are also classified according to their forms, such as written, spoken and audio-visual.

#### **4. Energy extension and energy literacy for sustainable energy development in Nigeria**

Extension is no longer just about men from public sector agricultural agencies riding around on motorcycles talking to farmers. It is retooling to address all issues affecting rural and urban dwellers. Extension is therefore an amorphous umbrella term for all the different activities that provide the information and advisory services that are needed and demanded by farmers and other actors in agrifood systems and rural development. Extension includes technical knowledge and involves facilitation, brokering and coaching of different actors to improve market access, dealing with changing patterns of risk and protecting the environment. This takes place within complex systems involving old and new service providers and even information and communication technologies (phones and mobile phones, internet, radio and television).

Extension is defined here as systems that should facilitate the access of farmers, their organizations and other market actors to knowledge, information and technologies; facilitate their interaction with partners in research, education, agri-business, and other relevant institutions; and assist them to develop their own technical, organizational and management skills and practices. The role of extension has thus widened to include issues in rural areas that go beyond agriculture and may include services such as:

- (a) Dissemination of information about technologies, new research, markets, input and financial services, and climate and weather;
- (b) Training and advice for individual farmers, groups of farmers, farmer organizations, cooperatives and other agribusinesses along the market chain;
- (c) Testing and practical adaptation of new technologies and practices on-farm;
- (d) Development of informal and formal farmer organizations, and rural youth organizations, and helping them to articulate their demands;
- (e) Support to implementing government policies and programmes through information, awareness and advice on technological options;
- (f) Increasing awareness of new opportunities for certification of 'green,' fair trade and other production methods. Environmental services and other schemes related to carbon credits;

Energy extension (diffusing among the people of the Nigeria useful and practical information on subjects relating to agriculture, uses of solar energy with respect to agriculture, home economics, and rural energy, and to encourage the application of the same) is the catalyst without which other goals on issues such as health, education and gender equality cannot be achieved. Extension is defined as the delivery of information and technologies to farmers. Swanson et al. (1997) defined energy 'extension', as extending relevant energy information to people. The World Bank defines extension as the process of helping farmers to become aware of and adopt improved technology from any source to enhance their production efficiency, income and welfare. This leads to the technology transfer model of extension, seen by many as the main purpose of energy extension (Moris, 1991). Based on the idea, energy extension services enable farmers to take up innovations, improve efficiency, and protect the environment and to reduce the differential between potential and actual energy yields in rural areas by accelerating technology transfer (i.e., to reduce the technology gap) and helping rural people become better Energy managers (i.e., to reduce the management gap). It is an off-campus training program (or non-formal education) which improves the life of rural community. The content of the training related to energy saving, efficiency improvement, alternative energy production and conversion technology using different communication techniques and aids for more expansion throughout the country. Generally, Energy extension shows positive effects on knowledge, technology adoption, efficiency improvement and environmental protection of the rural household.

Energy literacy simply means understanding of the nature and role of energy in the universe and in our lives. Energy literacy is also the ability to apply this understanding to answer questions and solve problems. An energy-literate person: can trace energy flows and think in terms of energy systems; knows how much energy he or she uses, for what, and where the energy comes from; can assess the credibility of information about energy; can communicate about energy and energy use in meaningful ways; is able to make informed energy and energy use decisions based on an understanding of impacts and consequences; continues to learn about energy throughout his or her life. A better understanding of energy can: lead to more informed decisions; improve the security of a nation; promote economic development; lead to sustainable energy use; reduce environmental risks and negative impacts; help individuals and organizations save money.

Without a basic understanding of energy, energy sources, generation, use, and conservation strategies, individuals and communities cannot make informed decisions on topics ranging from smart energy use at home and consumer choices to national and international energy policy. Current national and global issues such as the

fossil fuel supply and climate change highlight the need for energy education. For Extension therefore, to play a meaningful role in energy education, Extension must embrace and react to the opportunities by providing research-based energy education to inform decisions and strengthen communities. Extension professionals share energy programs offered in their states and addressed topics such as energy conservation, energy efficiency, renewable energy technologies, bioenergy crop production. Extension is also well suited to help disseminate energy information through a Web-based interactive learning environment that connects resources from various institutes and universities across the country. As Extension professionals we strive to be world leaders in research-based educational programming and value our credibility with clientele. Extension has built a reputation as a reliable source of fact-based information to guide informed decisions rather than promoting a specific agenda. It is essential that Extension remain a trusted source of reliable information to promote informed decision-making.

Extension is in fact the most reliable trusted source for energy education. It is imperative that as Extension educators we engage our communities in dialogue on local energy challenges and goals. We must better understand how energy impacts our communities and the roles Extension can play in energy education. As educators we must embrace change, build on the foundation of existing energy programming, and expand our efforts in energy research, outreach, and education. In doing so, we can support our mission of strengthening lives and communities through research-based educational programming to address one of the most critical issues facing society in the future.

Extension could work to document existing efforts in research and technology development. An example might be developing case studies to highlight work in timber to biofuels efforts. In a time of information abundance, Extension must balance providing the most up-to-date information on research and discoveries with ensuring the information is well vetted and maintains the integrity and credibility of Extension. Extension can translate primary research data for other stakeholders and disseminate the findings. This role serves to reinforce the role of Extension system and leverages the localized nature of field faculty in Extension to make research real in communities.

Extension can help to encourage technology adoption at the farm-level through demonstrations and variety trials. Some examples of this type of work might include: Providing field days on biofuels crops/demonstration plots; Facilitating partnerships between researchers and end-users (tech transfer); Identify conversion partners: if we want to move faster, we have to collaborate with entities that also move fast. Extension can also play an important role in notifying users of technologies that are not viable. This can be done through research-based education and demonstration projects.

Extension can play a significant role in expanding society's energy literacy in agricultural sectors. Extension's roots in encouraging adoption of ideas and technology in agriculture can be leveraged to expand the knowledge of energy and adoption of best practices at the farm level. Extension should encourage collaborations of professionals within each state, across regions, and nationally. It is also important to encourage partnerships with other government agencies, NGOs, and other relevant entities

## **5. Participatory extension and needs assessment for sustainable energy**

The starting point in rural energy programmes should be to ask 'What do men and women need energy for? What are their different energy needs?', followed by looking at the overall context of community life, and addressing household needs as well as productive and entrepreneurial activities. Energy projects should be integrated in a holistic way with other improvements relating to health, education, agriculture and job creation. In reality, what people want is not energy per se but the services that it provides, such as heating, lighting, cooking, and storage of food, space conditioning and the provision of clean water and sanitation. Men and women also need energy for transportation, motive power for industry and agriculture, heat for material processing, for education, health, commerce, communication and other economic and social activities. The challenge is to "energise" rural economic and social development, and at the same time assure the sustainability of this process in environmental terms.

Energy planners must realize that not everything will be directly under their control, and that they need to understand the decision-making frameworks of other sectors and work closely with them (Wamukonya, 2002). This is an important message for the design and implementation of successful energy programmes and associated initiatives in the context of sustainable and equitable development. If appropriately designed to meet women's

practical, productive and strategic needs, energy initiatives can have positive effects on the general well-being and welfare of rural livelihoods and communities.

Although biomass fuels still represent the primary energy source for rural poor people, the adverse health and environmental impacts of burning these fuels can be reduced by improved stoves and new technologies that convert solid biomass into cleaner, more convenient energy forms, including gases, liquids and electricity. Besides bio-energy crops, agricultural wastes such as biogases from sugarcane processing, sawdust and off-cuts from the timber industry, fruit pits and pruning from orchards, coffee and rice husks and coconut shells can be used to produce considerable amounts of energy (Kammen, Bailis and Merzoga, 2002).

Energy initiatives should be part of a framework where technology and social programmes have the same objective: promoting people's welfare. Focusing on people, who must be empowered with know-how and access to resources, makes the issue of energy and development much more open to considering gender differences. The challenge is to develop sustainable multi-dimensional energy strategies that integrate gender variables, with women treated alongside men as strategic partners rather than passive beneficiaries. It is here that Energy Extension education comes to the forefront of advisory role.

Since the needs of different groups and communities vary widely, the expertise of local people represents an essential input for the success of any energy initiative. They can use their experience to contribute to finding appropriate solutions. A people-centred approach to energy planning should be based on an assessment of people's needs rather than a technology driven approach. Undertaking a needs assessment prior to considering project design will ensure that the approach is grounded in the specific reality of the people involved, not driven by pre-conceived intentions (Dutta, 2003). However, effective participation requires the involvement of all people, both men and women, in needs assessments for energy planning.

For the most part, women have had limited opportunities for participation in rural energy development. But they are the experts most familiar with the household fuel supply strategies, cooking needs and habits, appliances and utensils, and environmental conditions. They may have contributed to the design of their own stoves( if someone has asked them!), or become familiar with tree species and their different uses in order to manage their fuel supply, or made complex decisions about optimising time and costs in situations where fuel is scarce (WEC/FAO, 1999).

Again suitable arrangements are therefore needed to facilitate women's active involvement in energy sector planning. But participation in energy decision-making within households, communities, and different levels of government will require greater levels of social and political empowerment for women. Currently, when energy technologies must be purchased, men tend to play a central role in the decision-making because these are important financial decisions, even when they involve the kitchen, which is generally viewed as a women's domain.

Simple and effective technologies should be available to deliver clean and efficient energy to energy poor communities, both in remote rural settings and in towns and cities. Technology performance and costs improve with experience, and there is a pattern to such improvements common to many technologies. Access to modern energy equipment means the ability to satisfy basic energy needs through the use of reliable, efficient, affordable and environmentally friendly modern energy technologies. Available improved technologies can improve the efficiency of supplying and converting energy into useful forms and of developing multi domestic energy resources. And it can also moderate the environmental effects of energy production. A number of other innovative low-cost energy technologies suitable for the rural African poor have been developed and are beginning to demonstrate positive levels of success especially in the Northern part of Nigeria. Energy extension tries to explore energy transition and technology adoption as the possible means of reducing the pressure of urban and rural centers on the rural hinterlands.

Extension plays an important role in serving as a third party resource for research-based information. Based on existing energy policy influences, the integration and implementation of renewable energy technologies such as wind, concentrated solar, Photovoltaic solar, biomass, hydroelectric, geothermal, landfill gas, and tidal into rural Nigeria seems inevitable. Renewable energy development is ramping up in rural communities across the country, promising to play a role in meeting our future energy needs.. Extension can use its understanding of broad socioeconomic trends and its experience with other communities to help community decision makers ask the right questions (Weber, 1987).

## **6. Conclusion and recommendation**

Energy extension improves access to energy by most of the population, and also reduces emissions of local and global pollutants and may create a private local socioeconomic development opportunities. The study recommends that energy extension should be carried out to enhance energy management, performance improvement and also, environmental protection to ensure gender equality and sustainable development. Extension educators should engage communities in renewable energy education to build the capacity of local officials, preparing them to successfully assess the impacts of renewable energy projects. To effectively address this emerging need Extension must: Recognize energy and the environment as a critical issue; maintain credibility by developing programs that are non-biased and research-based; address social, economic, and environmental impacts; promote outreach and education to foster informed decision-making.

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