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Introduction

Electricity generation and supply in developing countries across the world has been a big challenge to their sustainable development. Studies have shown that Quality electricity supply has been an integral part of economic, social and environmental development of industrialized nations. Due to high population growth and growing increase in appetite for modern gadgets coming out of industrialization, the demand for electricity is increasing at a very high rate for both domestic and industrial use. Unfortunately, most developing countries are saddled with energy crises due to their dependence on non-renewable energy sources (which are pollution agent) that have limited generating capacities coupled with poor distribution channels (United Nations, 2010). Therefore there is the need for developing countries as a whole to confront this challenge by providing reliable, affordable, clean and secured electricity supply in remote, rural, semi urban and cities in order to keep in touch with the rest of the world. Solar electricity (from photovoltaic) is clearly one of the most promising prospects to these problems since it is non-pollutant, abundantly, freely and locally available in all developing countries.

1. Impact of ICTs

For the purpose of our study, we will keep to United Nations definition of Information, Communication Technologies (ICTs) as encompassing telecommunications equipment (cellular systems) and services, electronic networks (computer

hardware and software) information technology equipment and servers, internet service provision, network-based information services, media and broadcasting, libraries and documentation centres and other related information and communication activities (Saccaggi, 2011).

For the past two decades, the role of ICTs in economic growth, social change and transformation in various developmental sectors have received considerable attention. ICT through data communication and telecom networks have transformed society drastically and have opened opportunities to reduce the production of goods in a short amount of time with the assistance of computerized systems. ICT have been driving innovations, efficiency of organizations, and has introduced great competitions which have led to improved productivity. It has been argued that extensive applications of ICTs improve organization or managerial performance which contributes to increasing the overall efficiency of all sectors of production, thus increasing the total factor of productivity (TFP) (Ngoma, 2010). It is also fueling electronic businesses and creating jobs (McCauley 2004) and providing people new opportunities for employment, education and training, governance etc. Investment in ICTs is a capital input which contributes to overall strengthening of other sectors, thus helping to increase labour productivity. (Avgerous, 2003). The use of ICT has also resulted in increasing efficiency that provides access to new markets or services, create new opportunities for income generation, improve information and knowledge management within firms and reduces transaction costs and increase the speed and reliability of transactions for both business to business and business to consumer transactions which consequently lower cost of manufacturing, lower prices and cause increase in demand (Berkhowt, Muskens and Velthuijsen 2000) (Heiskenen and Jalas 2003). Therefore, ICT has become a general purpose technology (GPT) that has changed how economic activities are organized. It is regarded as a reliable innovation for changing and modernizing educational systems, a platform for expressing ideas and communication, a means for improvement in health sector and a powerful tool for economic growth. The use of email, e-commerce and online banking have significantly cut down on the physical transportation involved in sending mail, banking and buying goods, which results in saving money and time.

Many Developed countries in Europe, United States of America and other countries invested enough in IT systems and over the time, it has paid off well. Few examples of ICT benefits are the rapid growth in employment and its contribution towards growth in United States of America (Dale 2001) and the European Union (European Commission 2006), general GDP growth and the related employment in all economic sectors within European Union (Forneld, Delaunay and Elixmann 2008). ICT has also been responsible for the economic boom of many developing countries such as Taiwan, Singapore and South Korea (Dale 2001). Globally, the ICT sector contributed 5 percent of GDP growth between 2003 and 2008 and the sector itself saw an upwards improvement across the world' GDP of 5.4 percent. It

was predicted that ICT sector' share of the economies will leap to 8.7 percent of GDP worldwide by 2020 (Beardsley, et al. 2010). McKinsey estimate that "bringing mobile broadband levels in emerging markets up to those of more matured market could add between USD$300 to USD$420 billion to the world' GDP and 10 to 14 million direct and indirect jobs" (Beardsley, et al. 2010). The Information Technology Innovation Fund (ITIF) also estimated investment of extra USD$30 billion in America's IT industry in 2009, will create approximately 949000 jobs within United Stated (Atkinson, Castro and Ezell 2009). Furthermore, ICT sector has the potential of leading substantial ecological benefits through more efficient production processes, dematerialization and much more sustainable human behavior (The Boston Consulting Group 2008) (Roeth and Wokeck 2011).

2. Indirect Impact of ICT on Economy

The indirect economic impact of ICT could be interpreted as socio-economic development thus, a way of empowering individual citizen and businesses through changes in social interactions and education by creating an improved living standards and better paying jobs and as well as increase in economic activities. The positive impact of ICT will therefore bring about: Changing the Way we do Business, Nurturing Human Capital through Education and Lifelong Learning, Better Healthcare for Citizens, A Government that now delivers, and Early Warning & Better Preparedness to Support Rural Livelihoods. The theoretical model of socio-economic development of Madon (2000) attempts to show that economic productivity, health, education, poverty alleviation, empowerment, democracy and sustainable development constitute the elements of socio-economic development. The concept of social and economic development has been used in different perspectives to describe enhancement of quality of life from individual to societal and from organization to international levels depending on many considerations (Baqir 2009). The World Bank explains socio-economic development to mean the qualitative changes and restructuring in a country's economy in connection with technological and social progress. The World Bank used Gross Nation Product (GNP) per capita (GDP per capita) as its main indicator of economic development, which reflect an increase in the economic productivity and average material wellbeing of a country's population (World Bank 2010) (World Bank, 2008). According to a report published by the Climate Group and the Global e-Sustainability Initiative, ICTs could help reduce global carbon emissions by 7.8 GtCO2e by 2020, an amount that is five times larger than its own carbon footprint. (GESI, 2008) (Connected Urban Development 2013).

3. ICT in Developing Countries

To achieve a sustainable economic development, a country requires a well-developed infrastructure and a substantial number of high value added industries which developing countries lack. Developing countries have been saddled with constraints such the digital divide due to imbalance of diffusion of ICTs infrastructure between urban and rural areas (poor basic infrastructure), lack of affordable and sustainable electrical energy (Walsham, 2010), high cost of the technology such as high cost of bandwidth and high cost of ICT devices, lack of human resource capacity which limits the ICT implementation, lack of awareness about the benefits of ICTs, Local content and language barrier, environmental degradation (Leblois, 2004), lack of availability and investment in technology in meeting the ongoing costs of maintaining equipment, staff training, connectivity and content materials acquisition, high rate of unemployment, high population growth (Damasen, 2010), lack of transport and communications (particularly in remotes areas), insufficient food supplies in remote areas, lack of educational infrastructures, poverty and climate change, illiteracy, etc., that hinders development in general and ICT in particular. Electricity availability and reliability is the major pre-condition to ICT development and implantations because all ICT devices use and need regular supply of electricity. Electricity is the engine for development, access and implementation of ICTs. It is impossible to operate any form of ICT in the cities, urban areas or remote locations without electricity or urban areas without adequate and reliable grid electricity. It would be difficult for ICT to make a significant impact if the computers cannot be used in the cities and urban areas due to unreliable electricity supply or because of lack of grid electricity the website in the rural areas cannot be accessed.

However, the advent of mobile telephony is altering many activities especially in Sub-Saharan Africa. Thus developing countries regard ICTs as an enabler and catalyst for successfully shifting away from economic dependency on low value added industry sectors, such as agriculture and raw materials extraction. Many African countries are using the innovation to meet their own domestic demand perhaps because, people who never had access to fixed line telephone in the past now could communicate with the world. ICT growth has ballooned from 1 percent to 65 percent within the past ten years (Kroes, Neelis, 2011). Since ICT have become an all-purpose technology, that can make impact on all developmental activities, it is anticipated that as soon as ICT become accessible to most people in the public and private sectors (both in urban and rural areas), it will stimulate economic development through the creation of new employment. ICTs also play a social role, in providing medical consultations via mobile to those otherwise out of reach, to supporting educational projects, giving farmers access to the data they need to respond to market demands, access to best practices to improve productivity (economic growth), free flow of government information (transparent governance), natural

disaster warning and mitigation, life-long learning, good price for food products, forecast and prediction, access to finance information (credit and payment), tourist information and entertainment information (TV show, sports, movies, music, newspapers and books) emerge. These will result in sustainable development in developing countries.

All in all, ICTs play a significant role in the delivery of the millennium development goals (Kroes, Neelis, 2011). It has been argued that the contribution of ICTs to economic growth and sustainable development in developing countries depends on the way new information technologies are used by organizations and individuals. Kuppusamy (2009) stressed that the greater use of ICTs in the production process may, help raise the overall efficiency by reducing inventories and transaction costs (Kuppusamy, Raman, & Lee, 2009). For instance, the use of internet by many people connected, the greater the potential of benefits. Therefore, some of these large scale challenges that confront developing countries can be addressed if education is promoted with access to and use of ICT made possible for the people in the public and private sectors. Also, ICT sector has the potential of playing a meaningful role in confronting climate change in developing countries by improving the efficiency in the transportation, construction and power industries. (Ospina & Heeks, 2010). According to a report published by the Climate Group and the Global e-Sustainability Initiative, ICTs could help reduce global carbon emissions by 7.8 GtCO2e by 2020, an amount that is five times larger than its own carbon footprint. (GESI, 2008) (Connected Urban Development 2013).

4. Electricity scenarios in developing countries

Many developing countries (Africa) are richly endowed with natural, non-renewable energy resources such as petroleum, natural gas, coal and uranium and renewable energy resources such as solar energy, wind, geothermal and hydropower. However, the general status of electricity in both urban and rural areas in these countries does not reflect the enormous resources they have. Due to variation in economic muscles, technology, and the type of energy sources, the energy sources used for electricity also differ from one country to another. For example Access to electricity in Ghana is 47.3 percent serving the entire population mainly in the urban area (15 -17% of the rural areas inclusive) as compared to an average of 17.9 percent for West Africa. Therefore the greater majority are without access to electricity. (Institute of Statistical, Social and Economic Research, University of Ghana, 2005), (Tsivor, 2011). The existing generating plants owned by the government of Ghana has an effective capacity of 970MW from hydropower plant and three small thermal plants (crude oil fired) also having effective capacity of 555MW and a 100MW private thermal power plant. In the remote isolated villages, electricity is

supplied through decentralized small diesel plants. However, the cost of electricity generated from diesel power plants in rural areas is high due to high costs of fuel and transportation. The situation in Ghana depicts the energy crises in most parts of Africa. The sources of power generations are usually small capacity thermal plant, hydropower or diesel engine generators entire networks. (John, ICT and the Environment in Developing Countries, 2010). (Goldemberg, Rovere, & Coelho, 2004). Access to electricity in rural areas has widened strongly throughout the past years. It has thus become evident that each country is facing challenges in providing universal access to clean and affordable electricity which requires more effort and strategies.

5. Solar Electricity for ICTs and Sustainable Development

From our earlier discussions, electrical generation in developing countries have been from non-renewable energy sources (mainly thermal and gas) which are environmental polluting agent. Worse of all, the generating capacity is limited and the power is not uniformly distributed. Therefore there is a regular routine power interruption, random power outages to all customers including the telecom and all ICT providers. By the nature of scattered settlements in developing countries, extending grid electricity to many rural villages would not be economically viable in the near future and in some villages not practically possible due to low load densities, low capacity utilization rates, high electricity line losses and requirement for accompanying infrastructure development such as roads. However, due to increasing appetite for modern goods and services as well as increase in population and industrial expansion, the demand for electricity is likely to go very high.

This suggests that many rural communities in developing countries will continue to live without ICTs for several decades; a situation that is a recipe for retardation of economic growth and also threatens the process of climate change mitigation. To address these challenges, an alternating sources of electricity generation such as solar must be embraced and given the necessary attention by opinion leaders, policy makers etc., in developing countries. Solar electricity is clearly one of the most promising solutions to the energy crises since it is renewable and available to all developing countries.

Electricity generated from solar energy could come as a simple system of photovoltaic module that can be used to power basic services such as lighting, radio, television, computer, internet devices and operation of small appliances. Another system could comprise of the photovoltaic module which converts the solar radiation into electricity; rechargeable battery which stores the generated energy for use in the night and during cloudy days; charge controller which controls the charging of the battery; an alternative current (AC) inverter to convert direct current (DC)

to AC current, switches, interconnecting wires and (PV) mounting rack (Robert, 1991).

Some developing countries are fully aware of the relevance of modern forms of energy supply for their rural areas through the renewable energy source like solar electricity and they are making the effort to harness the technology. Few examples are Morocco, Kenya, and South Africa. There is evidence that access to electricity services in rural areas in the developing world has significant impact on the standard of living of rural communities. Figure 1 below shows few of the benefits of renewable energy. Solar electricity for charging mobile phones improves access to communication, social and economic activities of the rural folks.

In spite of the great positive impacts enumerated which will make a good case for ICTs and sustainable development, the utilization of solar electricity in rural areas of developing countries have been extremely poor due to the following reasons:

- lack of education on renewable energy at various levels,
- lack of qualified solar technicians which result into system failures leading to high cost for users, disappointment with the solar electricity and a strong negative perception about the technology (Chaurey & Kandpal, 2009),
- high initial cost of the Technology,
- lack of a tailored markets and entrepreneurial arrangement,
- fear of Uncertainty about the development and sustainability of the technology,
- challenge of import duty tax, tariff and subsidies,
- lack of definite plans of grid extension.

Conclusions

ICTs are growing rapidly in developing countries, but its benefits on general development have been heavily concentrated amongst the few urban dwellers because majority does not have access to ICT backbone networks. However, the provision of clean, reliable and available electricity through the use of solar photovoltaic electricity will make ICT available, accessible and affordable especially to the rural majority of the population. The expansion of ICT facilities has the potential of enhancing small scale businesses, healthcare delivery and improvement in education.

Electricity generation from the direct sun shine promises to minimize the challenges of energy crises in developing countries as well as accelerating sustainable development and reducing the effect of climate change. The approach to minimize the energy crises in developing countries is as modeled in figure 1. Sustainable Energy Application for Development (SEAD) model in figure 1 shows a direct linkage of solar photovoltaic electricity production to economic development result-

ing in extra income for small and medium scale enterprises (SMEs), creating employment and saving on use of kerosene fuel. The social developmental gains are access to information via radio and TV sets, telephone and internet, improvement in healthcare delivery through storage of vaccines, extended period of night health services. Other benefits are access to educational media, extended hours of studies, etc. With regards to the environment; solar PV will reduce the indoor smoke from oil-base equipment and reduce the per capita carbon dioxide (CO_2) emission.

Efforts must be made to establish good photovoltaic markets and tailored business model, appropriate training for the installation and maintenance technicians, appreciation of solar electricity as one of the major energy component, lowering initial cost of the PV technology, providing subsidies, import tax exemption and finally considering electricity as one of the basic necessities of live.

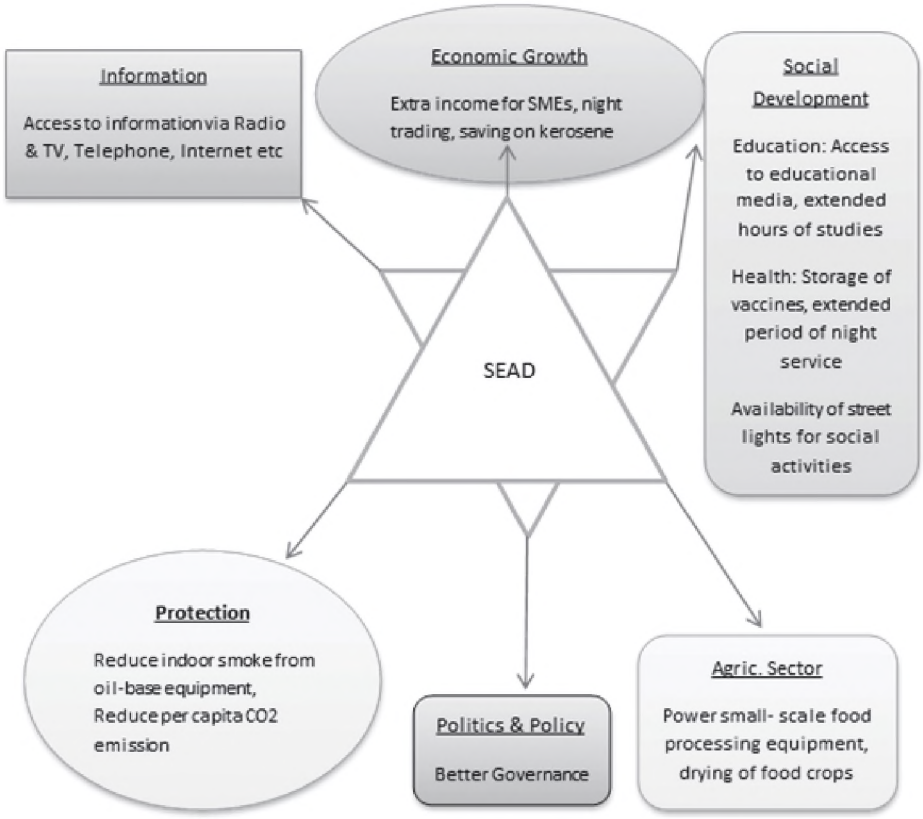

Figure 1: *Schematic Representation of SEAD*

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Summary

Poor basic infrastructure and reliable electricity supply play a significant role in development of Information, Communication Technologies (ICT) industry and could eventually lead to attaining sustainable development, particularly in emerging economies. From research studies, quality electricity supply has been an integral part of economic, social and environmental development of society. The demand for electricity in both residential and industrial sectors of developing countries is most likely to increase

as a result of growing increase in appetite for modern gadgets coming out of industrialization and increase in population and urbanization. Unfortunately, electricity delivery in the third countries is so much appalling due to limited electricity generating capacity, poor distribution networks, etc. which is hindering effective development including the ICT industry in these countries. To address some of these challenges locally without recourse to importation of fossil fuel energy resources that will compromise sustainable development goals, it is important that locally, abundantly and freely available energy source such as solar electricity are given priority by policy makers, researcher and industries in third world countries. Solar electricity should be of interest to the energy sector in third world economies because it offers the possibility of generating renewable electricity using sunlight, a resource that is widely and freely available in most third world countries, if not all the. The aim of this paper is to examine and draw attention to the potential benefits of solar electricity generation for access to and use of ICT by showing the major contribution of solar electricity in various sectors such as economic, social and environmental benefits in developing countries. We conclude with discussion on the solar electricity generation in third world countries and their strategies for promoting solar power generation for increased access to ICT by people and sustainable development of society.