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Decoupling energy development, economic growth and environmental sustainability in African states: the tradeoffs

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Abstract

The International Energy Agency has predicted that by 2030, 70% increase in energy demand will come from the developing countries and the rest 30% by the developed west would grow richer. This implies that a higher energy demand in Africa would make global energy market competitive and countries with inverse terms of trade in Africa would be disadvantaged. An examination of energy scenarios: demand and supply in most African States point to unsustainable consumption pattern and this has an inverse relationship with the economic growth in the continent. Thus, how energy sector is developed and consumed in most African States in relation to the level of economic growth and sustainability of the African environment becomes germane for Governments, policy makers and researchers to focus on in the 21 century. This is due to the challenge of achieving a higher access to sustainable energy services in Africa. Most African countries are blessed with abundant natural capitals like crude oil, bauxite, diamond, gold, natural gas and ore. Energy sources in some African States come from fossil fuel (coal, oil, natural gas) and solar energy and biomass /wood energy. Wind energy, tidal, and nuclear energy are yet to take off in most African states. This makes any transition to environmentally friendly energy sources a challenge and calls for a decoupling of energy sources from economic growth and sustainability. The authors argue that decoupling energy development, economic growth from environmental sustainability would help African states draw a line between energy sources and environmental sustainability. However, this might entail some tradeoffs between environmental benign energy sources and security of supply of energy, which would help to alleviate poverty and accelerate economic prosperity. This research aims to critically examine how this decoupling can work in order that African states might meet economic growth which does not undermine their ambient environment. Part A would focus on energy scenario in selected African States. Part B would evaluate the relationship between energy sources and economic growth in these States while Part C would attempt to draw a line in balancing energy sources, economic growth and environmental sustainability. Part D would make recommendation and conclude.

Keywords: Decoupling, African States, Environmental Sustainability, Economic growth and Tradeoffs

1. Introduction.

The International Renewable Energy Agency IRENA REPORT [1] on Africa's Renewable Future-the Path to Sustainable Development states that Africa has the potential and the ability to utilize its renewable resources to fuel majority of its future growth. The report, maintained that although, doing so would be economically competitive with other solutions, it would however unlock economies of scale, offer substantial benefits in terms of equitable development, local value creation, energy security, and environmental sustainability. Africa is a large and diverse continent. The ranking of

economic and energy sector development differs widely across its 54 countries. Energy resources, whether fossil or renewable, are not distributed evenly **[2]** Therefore, every country faces a different set of challenges of access to sustainable energy. This paper found that energy poverty, unsustainable energy pattern and ambition to fast track development to meet up with the developed western Countries, through a readily available and cheaper energy sources, pervades most of the African states surveyed in this research. The objective of this paper is to evaluate the current energy pattern and to promote a reawakening in the continent of its abundant sustainable energy potentials, coupled with the benefits of clean energy that would accelerate Africa's economic development without undermining its ambient ecosystems. This part examines the energy scenarios of Nigeria, South Africa, Kenyan, Algeria, and Cameron.

NIGERIA

Nigeria is the most populous African country with a population of well over 170 million people **[3].** Nigeria is blessed with abundant conventional energy sources like oil, gas coal and renewable energy sources like hydro, solar, wind biomass geothermal, energy. Nigeria possesses strong potentials for renewable energy, which form sadly a very ignoble part of its energy mix [4]. A study has shown that Nigeria has significant potential to produce bio fuels and even become a major world player in the bio fuel energy technologies [5]. Presently, natural gas accounts for 5% of the energy consumption, while traditional biomass and waste account for 83%, oil consumption is about 11%, hydropower is at 1%, while coal has declined drastically to an insignificant position [6]. There is also potential reserve of uranium for nuclear energy in the northern part of the country. Although, an average Nigeria is energy poor-cannot meet its daily need for energy uptake at affordable and sustainable way, the Country is energy resource rich and the sixth largest exporter of crude oil in the world [7]. Nigeria is also Africa's largest oil producer and in 2012, was the world's fourth largest exporter of liquid natural gas (LNG from associated petroleum gas [8]. However, harnessing its great energy potential has been hindered by a number of factors ranging from corruption, lack of consistent policy, political will and inadequate investment in the energy sector. Energy Sources like biomass (wood), oil and gas are indiscriminately consumed in Nigeria with no or little consideration for sustainability. Proper development of crude oil through indigenous technology has become an albatross due to political instability, lack of effective policy, regulatory instability and corruption in the oil sector. Consequently, energy supply in Nigeria is met largely by imports due to the constraints on public financing and mismanagement of investment. Furthermore, electrification rate is only about 54% of the entire country [9]. The consequence is that even with the abundance in crude oil reserve, petrol (AGO) kerosene (DPK) and diesel NPK are hardly available, accessible and affordable even in the midst of high level subsidy on their production [10].

SOUTH AFRICA

The Southern African SA region accounts for about 91 per cent of Africa's coal reserves [11]. SA depends heavily on imported crude oil, which is then refined locally [12]. While coal is the major energy supplier for the nation, accounting for its 75% energy supply, the country is very concerned about both the local and international environmental challenges of such heavy dependence on fossil fuel. SA has embarked on diversifying its energy supply base towards the development of its renewable energy technologies thereby reducing its reliance on the coal [13]. Energy sector in SA is faced with a number of challenges namely; its heavy dependence on coal, a fossil fuel which is unsustainable and energy consumption that outstrips supply [14]. A large proportion of SA population is energy poor and majorly depends on domestic burning of wood, coal and paraffin in order to meet their domestic demands [15].

ALGERIA

Algeria is a major oil and gas producers and one of the oldest Africa's oil producers with exports of oil and gas forming its main source of income. It is also the European Union's third largest gas supplier [16]. In 2011, the proven oil reserves in Algeria were 12,200 thousand million barrels.[1] The demands for energy in Algeria, like other African nations, currently surpass the supply due to an increase in population. It has been posited that domestic gas consumption will exceed exports by 2025 if other energy sources, such as solar or unconventional shale gas, and potentially offshore exploration and production fail to come online [17]. Apparently, Algeria has national plan to develop renewable energy technologies [18]. With 86 per cent of its area covered by the Sahara, solar energy is seen as one possible way to implement its target of supplying 40 per cent of domestic electricity consumption through renewable energy sources by 2030, according to the national plan drawn up by the Ministry of Energy and Mining. As with most African States, the development of renewable energy in Algeria centered on the problem of lack of technical and financial capacities and foreign investment inertia [19]. Other factors are the existence of institutional barriers, regulatory uncertainty and the price regulation of fossil fuels with its subsidy [20] .This is coupled with the lack of renewable energy incentives.

KENYA

Kenya's energy mix is predominantly defined by three energy sources: biomass, petroleum, and hydropower for electricity [21]. Traditional biomass use for 21% and 9% respectively. It is argued that oil and gas sectors are still in their infancy while exploration and exploitation are expected to emerge in the coming years. Fossil-fuel generation plants make up 33.5% of the total capacity while geothermal, wind and cogeneration make up the other portion of renewable in the mix. Power outages have been estimated to cost the Kenyan economy 7% in lost private sector sales revenue, 2% of total GDP and 1.5% of GDP growth [22] Kenya, like other African nations has the challenges of inadequate energy finance, infrastructure, technological deficit and the lack of adequate incentives for the development of renewable and conventional fossil fuel, which results to the lack of adequate and affordable energy for the growing Kenyan population.

CAMEROUN

Cameroon is a central African country which has been referred to as "Africa in miniature and diverse [23]. Cameroon has the highest population among the central African nations with coal, petroleum, hydropower, bio fuel and waste as her major sources of energy. These sources of energy have not been fully utilized. Oil accounts for 27.2% of primary energy consumption, natural gas (3.7%), hydro (5%) and biofuels with waste (64.10%) [24]. This Central Africa country is endowed with abundance of renewable energy (RE) sources,[i]but this energy also has not been fully utilized or harnessed due to policy shortfall and inadequate incentives. Among the rest energy sources, hydro power is the dominant electricity source with little attention paid to the other renewable` like solar, wind, geothermal [25]. Cameroon possesses the highest hydroelectric power stations [26] However, by 2015, Cameroon electricity generation capacity was at 817MW and its hydroelectricity contributed to 88% while the remaining is from thermal power generation. The demand for electricity in Cameroon surpasses the supply with only a negligible percentage of the population having access to the national grid.

2. The relationship between energy sources and economic growth in African states.

This part will examine the relationship between energy sources and economic growth in some of the African states. The authors argue that most of the African states surveyed do not rely on one energy source to meet their economic growth as there are several sources of energy technologies, explored and

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unexplored. However, the available energy sources do not transform into economic growth and development in real terms as most African citizens are still energy poor [27]. Energy is the golden thread that connects economic growth, increase social equity, and creates an environment that allows the world to thrive [28]. Similarly, energy is very vital to the attainment of Millennium Development Goals [29]. However, making energy available faces three" trilemma": delivering security of supply, ensuring sustainability of energy systems and providing access to affordable energy to all [29].There is always a need for tradeoffs among competing dilemmas and making a choice has never been easier in developing energy resource nations. The United Nations realizing the need to deliver energy sources in a sustainable way developed the Centre for Sustainable Energy for all in 2011 [30]. The aim was to make energy available in a manner that will reduce carbon emission, while stimulating economic growth through renewable energy technologies and the application of efficient energy system. However, the case of African continent is a challenge due to poverty, poor governance and inadequate infrastructure for renewable energy uptake and energy efficiency measures. .

Energy efficiency (EF) has been defined as a decline in energy intensity of total primary energy which is due to the application of efficiency methods and process in energy uptake [31]. In this paper, energy efficiency is defined as the energy services provided per unit of energy input. For example, the energy efficiency of an air conditioner is the amount of heat removed from air per kilowatt-hour (kWh) of electricity input .The authors argue that EF would enhance greater energy uptake while ensuring their sustainability. Energy efficiency EE practices have been found to address both demand -side and supply side impacts of energy supply and is more cost effective than the deployment of renewable energy technologies [32]. Therefore, it is also important that nations look beyond renewable energy to consider the deployment of energy efficiency practices. Further, the benefits of deploying energy efficient measures include enhanced energy security, reduced investment in energy infrastructure, lower fossil fuels dependency, increased competitiveness and improved consumer welfare. There is also improvement in the mitigation of green house gas and indoor air pollution [33].

3 Decoupling energy sources, environmental sustainability and economic development

A close examination of some of the energy scenarios would reveal that energy sources in Africa have not transformed into economic development in real term - affecting the lives of the African poor in a sustainable way. This is due to the limitation posed by some prevalent energy sources in Africa which do not have optimal relationship with economic growth. According to International Renewable Energy Agency Africa's economies are growing currently at an average rate of 4% per year and Six of the world's ten fastest growing economies over the past decade were in sub-Saharan Africa. If this growth is maintained, Africa's GDP should increase roughly three-fold by 2030 and seven-fold by 2050. However, sustaining such growth will only be possible if fuelled by a much larger and better performing energy sector. Africans currently consume only one quarter of the global average energy per capita, using a mix of hydropower, fossil fuels and traditional biomass – mostly in traditional uses**.** However, there are inherent challenges to meeting the continent's demands for sustainable energy future. This can be explained by examining major energy technologies that would facilitate access such as hydro, gas, coal and nuclear energy. Hydropower, which provides the single largest share of renewable electricity worldwide, is used increasingly to balance systems with high shares of variable renewable, sometimes with the aid of pumped storage [34, 35]. Although, .Hydro power (HP) is the most common renewable which produced 3,288 TWh equivalent to 16.3% of global electricity production, or 12.9% in OECD countries and 20.1% in non- OECD countries in 2008, it has not been fully optimized for economic development especially in Africa because of its technical

limitation as an energy source in some African States. For instance, the generation cost of HP plant is about USD 50 to 100 MWH and a typical plant could last between 50 to 100 years, thus cancelling out the cost [36]. However, Hydro power is also affected by both social acceptance problem and negative environmental impacts, with the likely emission of carbon and methane in fresh reservoirs. Nigeria, as a major player in African energy scenarios, is yet to optimize, its great hydro potentials for economic development due to the lack of infrastructure and intermittent water supply through rainfall [37]. Similarly, there are also serious limitations in the deployment of solar energy as a sustainable energy form for economic development globally and in Africa. Solar energy (SE) is energy from the sun and one of the largest energy sources of all the renewable energy sources. It can be available as solar thermal for electricity generation and solar photovoltaic through radiation usually mounted on roof tops [38]. Solar requires adequate investment and infrastructure development in the manufacturing and deployment of solar cells and this large scale investment and infrastructure are lacking in some African States. Bio energy (BE) is another source of renewable energy which is mainly from biomass wood, waste, animal dung and agricultural crops.[2] Biomass, when properly harnessed could produce bio fuels and bio- diesel and thus become the main source of cleaner fuels in some African countries. Further, Agriculture is the mainstay of the economies of most African states and Biomass is mainly derived its raw from agricultural products. As Biomass energy depends importantly on plants and agricultural crops, its deployment might affect food security and leads to deforestation. Besides, the burning of animal dung and wastes generate carbon monoxide and methane gas that not only affect human health but contributes to the formation of green house produced during the anaerobic digestion of biomass [39]. It is for this reason, that biomass continuing deployment is contested as a veritable source of energy [40]. Wind energy is a form of renewable energy from the natural wind. Wind energy has not fully penetrated globally and worse in developing countries as an important energy mix. The total theoretical potentials of wind energy in the whole Africa are estimated at around 470 Petawatt hours (PWh), 660 PWh, and 460 PWh for CS [41]. However, most wind turbines contribute to noise pollution and create visual negative impacts. They are likely to affect migratory birds and offshore wind farms affect fish and other marine lives which support human and natural systems [42]. Another source of energy in terms of sustainability- which is determined by the minimal or low presence of carbon emission is Nuclear energy [43]. Nuclear power is the largest source of low-carbon electricity in OECD countries, with an 18% overall share of electricity production in 2013. Globally, it is the second-largest of such source, with an 11% share [44]. The continuing deployment of nuclear energy in most western countries and OECD nations faces social acceptance, safety challenges and political issues due to occasional catastrophes [45]. For instance, the Furkinshima Daiichi incident contributes to the negative acceptance of nuclear as part of the continuing global energy mix [46]. In Africa, apart from South Africa, Nuclear energy is yet to be harnessed for sustainable economic development [47] due to lack of political will, investment in research and development, and funding which are presently lacking. Fossil fuels represent about 54% of total primary energy supply in Africa and, oil, coal and natural gas contributed respectively 22%, 16% and 12% of the continent's total primary energy supply in 2009. In 2010, about 80% of the continent's electricity was gene-rated from fossil fuels. Fossil fuels are major carriers of green house gasses such as carbon dioxide, methane and nitrous oxide. According to World Energy Outlook, demand for oil rises by 14 mb/d, to reach 104 mb/d in 2040, despite measures and policies aimed at promoting energy efficiency and fuel switching. Its production would exceed 6Million

barrel per day by 20202 [48]. However, crude oil investment is no longer attractive due to low price of crude oil in the global oil market and the continuing application of subsidy by some African hydrocarbon nations coupled with the influx of shale gas and shale oil in the traditional importing nations like USA. Besides, managing the past fortune of crude oil in some African States has turned the sector into a curse rather than a blessing [49]. Apart from the funding inertia, the internal conflict generated by oil in sub-Saharan African States, have all contributed to less economic development in Nigeria Angola, Congo, and Southern Sudan [50]. In Africa, energy subsidies benefit industrial user and richer households rather than the poor and this have inverse relationship with economic growth. For example, an estimated 44.2% of fossil fuel subsidies go to the richest 20%, while the poorest 20% benefit from only 7.8% of these subsidies [51]. In the case of Coal, it was considered the dirtiest and most unsustainable energy forms due the crude technologies employed in the industry. However, the contribution of coal to security of supply and economic development has not been overlooked in countries like China[52]. Coal was the "king" of fossil fuels, until the discovery of gas for steam engine -powered vehicles. All fossil fuels are finite and are precursors to climate change and other environmental risks [53]. To maintain both sustainable economy that is capable of providing essential goods and services in both developed and developing countries, coal energy must be delivered sustainably and efficiently [54].

6. Conclusions

The application of any energy source depends on the resource availability, potential for security of supply and environmental sustainability of energy type. The choice of any technology depends on the need of a country and global regulatory regimes- in the case of climate change deal or agreements to curb green house gas by all countries. Certainly, there must be winners, losers and tradeoffs. However, according to Taverne [55], to deliver fossil fuels in sustainable ways, would require such tradeoffs that include: curbing the consumption of fossil fuels through fiscal measures. In the case of renewable energy, there must be global intervention and greater commitment, with targets, together with the recognition of huge investment required to bring renewable to the market place. However the adoption of widespread energy efficiency and conservation measures would promote security of supply, environmental sustainability and economic growth in African states and this would require better governance, reduction in corruption and greater investment in the sustainable energy features.

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Commonwealth Energy and Sustainable Development Network (CESD-Net)

CESD-Net is a major global initiative in energy and sustainable development. The objective of network is to promote energy and sustainable development in commonwealth countries.
Focussing on Multidisciplinary Research, Promoting Future Low Carbon Innovations, Transferring Knowledge and Stimulating Networking among Stakeholders to Ensure the UK Achieves World Leading Status in Energy and Sustainable Development. https://www.weentech.co.uk/cesd-net/

The 1st International Conference on Energy, Environment and Economics (ICEEE 2016) was held at Heriot-Watt University, Edinburgh, EH14 4AS, UK, 16-18 August 2016. ICEEE2016 focused on energy, environment and economics of energy systems and their applications. More than fifty eight delegates from 31 countries with diverse expertise ranging from energy economics, solar thermal, water engineering, automotive, energy, economics and policy, sustainable development, bio fuels, Nano technologies, climate change, life cycle analysis etc. made conference true to its name and completely international. During conference total 51 oral presentations and six posters were shared between delegates. The presentations showed the depth and breadth of research across different research areas ranging from diverse background. ICEEE2016 aimed:

- To identify and share experiences, challenges and technical expertise on how to tackle growing energy use and greenhouse gas emissions and how to promote sustainability and economical, cost effective energy efficiency measures.

In total 11 technical sessions and two invited talks both from academia and industry provided insight into the recent development on the proposed theme of the conference. Preparation, organisation and delivery of the conference started from July 2015 and further co-ordinated by vibrant team of Conference Centre, Heriot Watt University. Conference organisers would like to acknowledge support from the sponsors particularly World Scientific Publication ltd and its team members for the delivery of the conference. Organisers are also thankful to all reviewers who contributed during peer review process and their contributions are well appreciated. At the end and during vote of thanks following awards have been announced and we would like to congratulate all well deserving delegates.

- Best Paper –Academia: Amela Ajanovic, EEG, TU Vienna, Austria
- Best Paper – Student : Christian Jenne,University of Duisburg-Essen, Germany
- Best Poster – Student: Yoann Guinard, University of New South Wales, Sydney, Australia
- Best Poster – Academia: E. Salleh, Universiti Kebangsaan Malaysia, Malaysia
- Active Participation Award - Yoann Guinard, University of New South Wales, Sydney, Australia

At the end we would like to extend our gratitude to all of you for your participation and hopefully welcome you again during ICEEE2017.

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