Future Energy Systems and Sustainable Emission Control: Africa in Perspective.

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Abstract

The authors of this paper propose strategies and discuss innovations, beyond regulatory policies that will drive future energy systems for Africa, as a way of mitigating climate change and improving energy conservation. The shared effort towards the reduction of Greenhouse Gasses (GHG) during manufacturing and other industrial service operations while trying to meet the global carbon-footprint must conform to specific standards and initiatives, and will also require the optimum use of renewable resources, energy efficient practices, systems, and materials. The global agenda for a sustainable green future from the African perspective is developed annually at the African Carbon Forum (ACF). This exploratory study focuses on the issues raised at the ACF, and the contentions used to draw inferences about the most strategic approach to tackle anthropogenic effects, and temperature rise above 2˚C. Intergovernmental policies on energy management and collaborations on sustainable technologies are critical for achieving the green future. The authors, however, argue that fossil fuel will continue to play an integral part to meet commercial energy demands, at the same time, leveraging on renewables and energy efficiency optimization would facilitate a robust, cost-effective transformation that will bring about a secure and sustainable power sector in a decarbonized ecosystem -Africa.

Keywords

Energy Efficiency, Green Future, Innovation, Sustainable

1. Introduction

The incessant burning of fossil fuels have led to a dramatic rise in carbon dioxide emissions, increasing the earth's surface temperature, and leading to drastic change, and discomfort in the ecosystem, with probable detrimental consequences for the earth's habitat (Hurink et al., 2016). As Africa continues to compete with the technological paradigm shift to meet sustainable energy needs, moving from coal, natural gas, and oil sources. There is a generalized concept on cost with regards to the processes to overcome the barriers that will lead the transition of the industrial sector to low carbon solutions, premised on economic impact and benefits accruing from access to power (electricity), operational migration, and availability of technical skill set. Conversely, to what level does a Government hold as challenging the effect of climate change after recently discovering oil, especially for developing states. The policies and actions to control carbon emission become a potential threat to their capacity to generate wealth. Intergovernmental collaboration within African member country and critical stakeholders is facilitated through IRENA (IRENA, 2015) to implement and check sustainable energy practice. The expectation is that member states make significant efforts to provide a futuristic amount of fossil deposits to be efficiently used while the search for sustainable clean energy technology continues, to checkmate carbon dioxide emissions.

Many countries have commenced full-scale implementation of green growth strategies inspired by the advent of the worldwide "Global Green New Deal" (Guo et al., 2018). With countries like South Africa, Egypt, Morocco, Ethiopia, and Kenya investing heavily in renewable energy technologies and exploiting energy development strategies which are sustainable to foster prosperity over long-term (IRENA, 2015). The drive is towards achieving the Africa 2030 commitment on energy transition; a combination of latest renewable sources and techniques that will meet up to 22% of energy demand for Africa is targeted by 2030 (Aliyu et al., 2018). In this paper, we contest the propensity and potential of Africa to reach this new socio-economic target without ensuring necessary measures as a whole and discuss tactics that will bolster the realization of GHG emission reduction, practicable by their capacity. The future energy expectation is a rebirth for African thinking to revamp operational strategies and a reconsideration of her energy options. As the world prepares to embrace the industry 4.0 era of internet communication revolutions, is Africa positioned to transform at the pace set by its international counterparts, with regards to the emerging revolutionary green future? Can renewable energy systems and other conservative energy-efficient technologies applied for generating power, cooling, and heating for both industrial and domestic exertions, transport, lighting, or with the utilization of machine-driven mechanism of minimal losses to achieve the de-carbonization society envisaged? Hence, this research article contributes to the knowledge-base, on strategies and policies in existence within Africa, and towards the achievement of the decarbonized future. The paper is summarized as follows: the first part presents activities in the framework of the Technology Executive Committee (TEC) mechanism for climate mitigation through energy efficiency in industries. The second part to achieve the de-carbonization society envisaged? while the concluding part of the article reiterates Africans energy potentials and a strategic pathway to compete in the future.

2. Near- Zero Energy Systems for the Future

2.1 Renewable Energy Systems and Industrial innovation

The need for an industrial emissive carbon-free society based on selected technologies is a concept which is briefly referenced in this text. The fast-growing forms of renewable energy; hydro, biomass, solar, geothermal, wind, and hydel power, accounts only for less than 20% of the global energy supply (IEA, 2017a) and 'other,' 0.3% make up energy supply from sources like fuel cells as shown in figure 1. According to Ref. (Adefarati and Bansal, 2017), the World Energy Council (WEC) recent investigation showed power output from renewable energy sources is currently at 23.7% and projected to increase up to 34% in 2030. In Africa, large hydro and biomass technology are rapidly growing because of their current popularity in the energy market and have led to a competitive market and falling cost. An easy target for the Government to focus their interest for investment and inline with economic diversity. Today, more than two million jobs worldwide are as a result of interventions in renewable energy manufacturing, operations, and maintenance (Flavin et al., 2006; Johansson, 2013). Sensitization and training workshops backed by research and development programs have come a long way to introduce homeowners and business operators to find means of becoming independent, more energy efficient and reduce their carbon footprint. Currently, countries, private and public stakeholders' are massively increasing their renewable energy-based option to reposition their energy scenario and balance energy consumption. These go to reflect their determination to raise the energy target from renewables; new technological breakthroughs now makes it possible to design and create structures which can generate energy from renewable energy sources, and are locally sourced. Hence, innovations in future buildings and transports are re-conceptualized to become self-sufficient in energy. These structures will utilize different renewable energy sources to provide sufficient supply to meet its power demand as well as the excess energy to be used for other purposes.

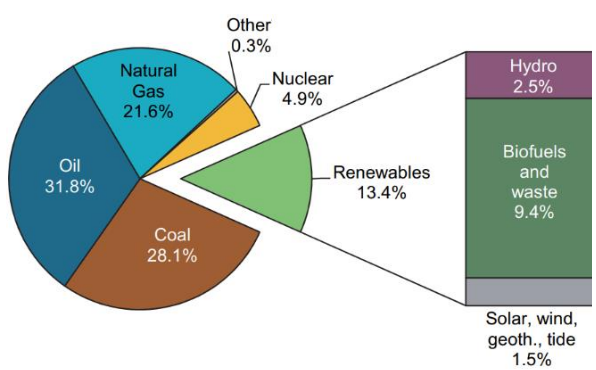

Figure 1. 2015 Fuel World Total Primary Energy Supply (IEA, 2017a)

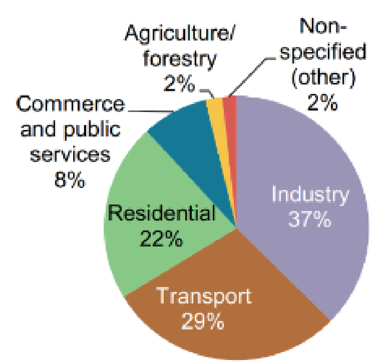

Figure 2. 2015 Total Final Consumption by sector (IEA, 2017b)

Better can mean a lot of different things, and the measure of success can take different forms, as well as technologies. Sustainable development agitation will dominate the future, and 'small' and 'large' industries will strive through innovation to operate sustainably. Liu et al., (2016) termed sustainability to be the most effective component besides the complexity of Renewable Energy Systems (RES) integration, to drive corporate strategies on environmental pollution reduction, and promotion of climate mitigation (Liu et al., 2016). No doubt, future innovations are towards optimal exploitation of renewable resources. These sources are abundant and do not face the risk of long-term non-availability as is the case with conventional fossil resources (International Energy Agency, 2014), which in reality are less concentrated in a single geographical location. More so, renewable energy sources suffer challenges of dependence, especially competition for scarce land (Johansson, 2013). Research and development in biomass technology currently look beyond power and heat generation (Cheng et al., 2016), as industrial processes now find productive use of biomass for GHG emission reduction through a replacement process of biomass used in place of coke in the sintering of iron ore as a sustainable mechanism. Other new concepts in biogas production are experimented by Grosser and Neczaj (2016) on fast decomposable organic waste with sewage sludge for stability and enhanced performance in anaerobic digestion, thus yielding remarkable results and the process recommended for futuristic exploitation (Grosser and Neczaj, 2016).

2.2 Energy Efficiency and Materials

Energy efficient practices in some areas may be achieved through the replacement of high power demand systems with the less energy consuming ones operating at optimal performance, or through conscious efforts to manage power consumption. Hence, preserves resources and reduces pollution. It is essential to distinguish the inefficient energy component and offer solutions, to improve system efficiency and throughput especially in the energy-intensive industrial sectors (Aliyu et al., 2018). According to (Olanrewaju and Mbohwa, 2018), the raw chemical materials and chemical products industry, nonmetal mineral products and smelting industry, and the pressing of ferrous metals are the three prime industries which contributed up to 59.31% of CO_2. Hence, it is essential to facilitate the development of energy policies which will address low-carbon emission propagation and GHG emission management in both the industry and from residential homes. Hence, promoting energy efficiency and optimizing energy systems will incline climate migration and achieve the green future. Global energy consumption will rise invariably as the population growth rate increases. Also, with the industry sector alone consuming more than one-third of the global total energy value as seen in figure 2, it becomes imperative to design and improve material efficiency and energy consumption respectively. The industrial energy efficiency, defined as; per GDP use of energy improved in the previous year, is different underdeveloped and developing countries (Henzler et al., 2017). Nevertheless, a lot more improvement needs to be done to reach the 2°C target. Already Professional bodies like TEC and others coopt from the Conference of Party (COP) are undertaking works aimed at identifying technologies and promoting policy options for climate change mitigation through energy efficiency strategies that are actionable in the short term in industries. Nonetheless, sectors like transport, constructions and consumer product are also noticing the spring-up rapid in energy efficient innovations.

Further, on the amelioration of GHG emission effects which finds prominence from the African view, and based on her green potentials, frames the suggestion of the pathway towards the diversification of choices which becomes a choice in itself. Thus, a case of encouraging bioenergy production to reduced dependency on conventional fuels (Amigun et al., 2011). More so, from observation will lead to the reduction of the share of CO_2 emission as per the 29% proportion from the transport sector (Figure 2). Another pathway is through a rethink for better designs, processes, and operations and maintenance of industrial equipment to conserve energy or energy generation through waste heat conversion. Lastly but not the least, 'materials' substitution to increase performance and maximize energy savings is also a viable pathway towards energy conservation. Innovations in materials that can improve furnace efficiency (Peter et al., 2017) and save power consumption thereby increasing productivity and avoid emission is needed for future industrial exploitation. Whereas the authors affirm the possibility of gradual actualization of the aforementioned sustainable emission control strategies, more answers are required to wage the balance with regards to the continents preparedness. Thus, a new energy paradigm of reducing fossil fuels energy utilization hits Africa; and most countries in their development stages. How fast will the certainties impact on the individual nations economic model and previous strategies is one question which beacons, another is, and that which is rarely asked; the problem of world population growth, estimated to nine (9) billion (Bradbrook, 2011) by 2050? To what extent will the robustness and investment in this energy initiative translate on the anticipated population demand for energy in the future.

2.3 Microgrids and Energy Storage Technologies

Rapid industrialization, population size and drive to support the industry 4.0 era will lead to increased energy consumption and result in the installation of renewable energy and storage systems. Because of the variation in wind direction, speed, solar irradiation and temperature, wind and solar power always change, and it becomes more challenging on a large scale. However, a smart energy management system which can meet short-term energy supply at optimal, but with the low costs of the technology been used, considering microturbines and hydrogen fuel cell are instrumental for the green future. Power storage technologies are currently on the increase to meet energy demand in different industries, thereby making way for utilization of energy storage technologies as a potentially viable solution for microgrid flexibility problem, (Adefarati and Bansal, 2017; Dawoud et al., 2018). Investigations are ongoing towards the development, and the use of advanced and efficient materials to improve thermal energy technology; holds great potential in future solar power projects (Zhang et al., 2014). The Republic of South Africa under a Research, Development, and Innovation (RDI) programme is currently leading in the area of hydrogen technology research for transport and electricity generation in Africa. A comprehensive work is carried out on storable energy and innovations in energy storage techniques that capture the interest of saving and distributed power solution for sustainable climate mitigation (Olabi, 2017). Strategizing for future energy will, therefore, sort between the cost of the technology and storage option with regards to localized supply, to obtain an adequate report on domestic energy demand and supply balance. In subsequent sections, we explore the next steps for Africa towards a post-carbon society and review how the benefits identified should guide/encourage the re-evaluation of previous policies, ensuring sustainable processes and a carbon-free society.

3. Renaissance Africa of the 21st Century

The realization that fossil fuels consumption for energy generation will not be sustainable for long-term utilization, and the effects also, not beneficial to our ecosystem is a detrimental issue to Africa and the world in general. Thus, requires the Governments, public and private stakeholders to act vehemently on the solutions. Africa is enormously empowered through her resources and workforce and needs to deploy modern alternative energy-option to maximize its potentials and eliminate power shortages, stimulate developmental opportunities for rural and urban dweller, promote industrial growth, and entrepreneurial breakthroughs across the continent. Besides initial financing of energy efficiency initiatives or processes, exchange of the machines serves to allay a significant drawback to energy efficient practice in industries. Uncertainty in the technical and economic viability of industrial facilities presents the risk of a technology skepticism situation that discourages SMEs and hinders energy efficiency rollout. For Africa to survive this new trend, and join the match into a sustainable green future; energy price subsidy, financial support mechanism (incentives), and training programs must be part of the overall process of reducing dependence on imported energy. Primarily through the design and implementation of favorable policies. The authors (Feng et al., 2015; Olanrewaju and Mbohwa, 2018) enumerate four vital policies toward lowering a countries GHG: energy saving and improvement policy, energy optimization and low-carbon technology policy, updates of manufacturing structure policy and domestic GHG emission management policy. These policies are sufficient to propel the energy efficiency campaign, driven by innovations through reliable, cheap, fast and environmentally friendly energy option. The authors identify that systemic regulatory policies which will encourage low-interest rates over the long-term payments period are a strategic step toward supporting SMEs. Also, the collective governmental effort on energy efficiency training will promote confidence among public and private businesses to invest in energy-efficient technologies.

3.1 On Technology

Technical innovation and environmental regulations possess significant challenges in determining the factors that will facilitate the green future envisaged. The question beams again, on how to successfully execute specific energy strategies based on demography, landscape, and availability of the lands, or favorable climatic elements, etc., to meet the suitability requirement of any particular country, district or provinces developmental scope, premise the robustness of the policy targets. Implementing advance technological and efficient ways to meet energy demand (Re-design), reduce emission level of existing plants, or new coal-fired industrial systems in iron production or electricity generation (considering cogeneration and carbon capture and storage) is a sustainable option towards long-term energy security solution. These choices should benchmark, but not be limited to the processes as compared to selected

European, Asian, and American countries strategy and based on cost efficiency, society, environment, and type of technology. Centralized energy sharing on transportation and heating, in the case of a small community, will offer a more viable option toward a sustainable future and decarbonized economy. Country leaders must sort means to discourage private commuting and promote train transport of commodities and passengers, support Sustainable building designs that are self-sufficient and generates energy from different renewable sources (Distributed generation) as well as the remittances of excess power for sales. Also, in other cases, there will be the need for agreeing parties to utilize an optimal technique to meet the hot and cold demand for a selected settlement from a single source to increase energy efficiency and reduce emission.

Technological innovations have always provided a more clean and efficient option, from a wide variety of sources, and led to a significant breakthrough upon its' affordability and abundance. The intermittent tendencies of renewable energy sources like solar, wind and tidal, etcetera require efficiency improvement and robust storage designs, which has prompted innovations in pumped and hydrogen storage systems. However, more is yet to be accomplished. Fission technology as an alternative clean energy source offers a sustainable solution for climate change mitigation with high potential to meet the world's electricity demand. Still, fears with regards to the uncertainties in operating nuclear power plant are imminent; the International Atomic Energy Agency (IAEA) are consistently formulating standards and safety frameworks for efficient operation of nuclear reactors around the world. As such, it is arguable that the gain far outweighs the loss and there is no better time to explore its future potential than now. African countries with nuclear potential especially thorium minerals can now improve their energy infrastructure as a long-term energy strategy for climate mitigation and be prepared to share the excesses with neighboring countries

3.2 On Emission

The green future will, by all means, strive in the face of interdependencies. However, this is possible through a cogent bilateral institutional framework built on the mutual disposition to support one's breakthrough and to compensate for the shortcoming of the other. The global effort talked about will perhaps become futile when some Government invests hugely on carbon emissions curtailment, while counterpart countries do nothing. More negotiations are expected among Governments to understand and design appropriate long term and short term power strategies together, to support the reduction of GHG emission. Information sharing, enlightenment campaigns and the resolves on energy policies must reach the grassroots community. The use of fossil fuel poses significant advantages which surpass the challenge of reducing oil price inconsistency and fear of depletion as the basis for judgment to be replaced by renewables. Although fossil fuel power generation will continue to decline, it is critical in the short term to have it in the energy mix. Hence, increasing operational efficiency and optimal reduction of transmission losses is strategic to cause a decline in carbon emission significantly, and possible through formative legislation and Government supports to encourage domestic consumers to use power efficiently. Furthermore, ensuring the transition to distributed power generation will unleash unprecedented opportunities to cause transformation in societies and nations and lead to a post-carbon, a sustainable, wealthy, and the more equitable federation that envisions the green future as paramount.

Current EU milestone is targeted toward improving energy efficiency by 20% in 2020, 30% in 2030 and a further reduction of their chief energy consumption by 27% in 2030 (Henzler et al., 2017). The question goes to say, 'What is best for Africa.' The production share on a global scale of energy contribution by Africa measured up to 8.1% in 2015 comprising of oil (36%), and traditional biomass (34%), followed by natural gas (15%) and coal (14%) (IEA, 2017b). The results indicate significant release of CO_2 to the atmosphere. In developed countries, each nations emission count is based on the different combination of energy sources (Bradbrook, 2011). The Republic of South Africa (RSA) has a conceptual energy target of coal (48%); atomic (13.4%); gas turbine (11%); hydro(6.5%), and other renewables (14.5%) by 2030 (Pollet et al., 2015). Reducing energy generated from fossil and drastically increasing alternative clean sources of energy so far. Other African countries (Nigeria, Egypt, Algeria, Kenya, Ethiopia, and Gabon) are enjoyed to mirror the RSA approach and come up with energy target. As such, the gathering of African leaders on cogent agreement to benchmark international standards with regards applicability and achievability within the continent, and meet energy target while tackling GHG emission is pertinent. Innovations that will birth economic model which originates from public policy debate to understand the continent's welfare system will result in a formidable process where market initiatives and social interests receive commensurable attention. The initiation of such concepts will create a new area for thoughts that can foster a free energy market and promote economic growth, prosperity, and sustainable development among member states continentally.

3.3 On Socio-economic Benefits

Needless to mention that the African energy security drive, will require wholesome innovative ideas to dominate. African nations must aspire to grow and prosper together through innovation and share in energy concerns through joint research and development, and usher a modern renascence conscious of carbon reduction and energy efficiency. Information sharing, awareness creation, and innovative thinking forms that means, through which future enriching opportunities will be met, and leading the pathway for a revolutionized advancement of the labor market in the continent. The breakthrough in energy technology, sustainable and efficient practices will form the bedrock of economic opportunity and energy security in Africa and for the continent. A decarbonized society holds excellent potential for the renascent Africa, where power itself, will be efficiently distributed, and the socio-economic benefits impacting beyond cost savings and climate protection. The continent can thereby increase their energy security with a reduction in risks related to volatile fuel (Fossil) prices, reduce emission and promote a sustainable economy. Also, increase industrial productivity through reduced material losses and higher product quality. Besides the expected huge contribution, purposefully to improve working conditions, direct job creation from manufacturing, installation, maintenance and repair services, energy audit and certification jobs associated with the new renewable energy industry will position Africa for a holistic transformation to succeed and contribute to reducing the global carbon footprint in the long run.

4. Conclusions

The per capita energy and electricity consumption of Africa is by far lesser than that of the European Union, measuring up to 35 and 100 times respectively, below their averages (Belward et al., 2011) which translates to relatively higher GHG emission from their quarters. Notwithstanding, Much pressure is on Africa to quickly join the decarburization process, while they are still in the infant stages of contributing to the damage of the current climatic conditions witnessed. Also noticeable, that one-time mechanisms to check poor climate activities (Kyoto protocol –carbon trading) which holds somewhat benefits for African nations became ineffective due to the withdrawal of crucial international players or unclear contractual technicalities between interested parties to enter into the carbon business (Newell et al., 2013). Regardless, the actualization of energy trading is gradually coming to fruition in Africa. The chances are that: energy systems innovation and sustainable development efforts will become stagnant. However, when the right statutory policies are strategically implemented, will lead to technological competitiveness (Johnstone et al., 2010) considered both on the regional and country basis. Most 'successful' countries already have set targets and adequately designed policies. However, the option for Africa is to embrace the paradigm remotely and cautiously, and join the transition to the fourth industrial revolution with frameworks which encompasses sustainable financing of emerging technologies, international collaboration, formative regulatory tool/approach, innovation driven by Research Development, Demonstration and Deployment (RDDD), joint education, knowledge sharing, information dissemination and strict monitoring. Such combined effort will multiply Africa's bid to diversify energy demand, meet energy efficiency, and thus contribute to the global reduction of harmful gases, a primordial towards achieving the post-carbon society.

Based on the contentions shared at the AFC in the last three years (AFC, 2018) on carbon emission reduction which were analyzed using combined qualitative techniques (document reviews and critical content analysis), the authors briefly recommend four strategic stages geared towards emission control: (1) Critical re-evaluation and proper understanding of the continent's energy demand/utilization/requirement. (2) Introduce incentives which award credits on energy conservation achievements, by targeting energy-intensive industries, then follow-suit to residential homes. (3) Promote diversification and innovative thinking through research, training, and international collaborations on carbon issues. (4) Construct inter-nations policies which will require industries: to mandatorily save needed percentage of subsequently utilized energy, optimize/replace less energy efficient systems and factory processes, and permit sustainable development and energy conservation to become a compulsory study for mid-level students, and embedded in the school's curriculum. Also, promulgate ways which will encourage career interest in energy sustainability and carbon emission reduction (monitoring, auditing, managing, etc.). Finally, the article covers ideas shared among academics and experts, interacted with at the different AFC – meetings, with conscientious agreement on the topic, that carbon emission reduction is mainly possible upon global agreement and collaborations; sharing of ideas and resources, but more importantly, by first starting the initiative from Africa, and as a continental agenda.

Thus, inspire future research on the possibility of inter-nations policies on energy management in Africa and the nitty gritty of the process for successful implementation.

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