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Drivers of Renewable Energy Adoption in the Built Environment: A Case of South Africa

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Abstract-

The built environment is regarded as the biggest consumer of energy globally due to its energy-intensive characteristics. Despite the over-reliance of both developed and developing nations on fossil fuels, there is a growing demand for energy as the population increases thereby exerting significant pressure on the energy production, generation, transmission and distribution infrastructure. To proffer a lasting solution to the energy challenges, countries are now advancing their quest for alternative energy sources. Hence, the growing clamour and global attention on renewable energy which is also identified as a clean and sustainable solution compared to the traditional fossil fuel-based energy source. This paper is aimed at identifying the drivers of adopting renewable energy in South Africa. Data was gathered through a well-structured questionnaire distributed to relevant construction professionals. A quantitative approach to data analysis was employed using percentages, standard deviation and mean item score. From the analyzed data, the results revealed that training and education of professionals, efficient energy sector reforms, awareness creation, government support, and increased supply of renewable energy technologies are the top five drivers of renewable energy adoption. It is therefore important for the government and relevant stakeholders to encourage and support the integration and adoption of renewable energy owing to its potential in significantly reducing the negative environmental footprint of the built environment.

Keywords: Clean energy, climate change, construction industry, energy efficiency, sustainability

1. Introduction

Energy is identified as vital to improving the productivity and quality of human life which in turn helps in the growth of the economy. Majority of the infrastructural amenities that support human life and economic development depend on energy to function optimally and efficiently. In the developing countries of Africa, Small, Medium and Micro Enterprises (SMMEs) which are regarded as the major drivers of job creation, innovation and economic growth solely rely on energy to thrive. However, fossil fuels (gas, oil and coal) remain the dominant energy sources for power generation and transportation sectors [1]. In South Africa, the primary



source of energy is coal, making it a resource-intensive means of energy supply. Despite the reliance on fossil fuel-based power generation, the incessant breakdown of energy infrastructure (generation, transmission and distribution) in South Africa resulting in load-shedding and total blackout in every part of the country has resulted in the economic downturn and growing concerns among the residents. Another evidence is the fact that 1.4 billion people around the world still lack access to electricity with 85% of this population living in rural areas [2], thereby necessitating the need for reliable energy sources other than fossil fuel-based sources.

As a major source of energy in most parts of the world, fossil fuels contribute significantly to the concentration of carbon dioxide emissions in the atmosphere resulting in the accelerated increase in global warming [3]. In developing countries, the rate of emission is perceived to be high due to the accelerated rate of infrastructure and economic development. For instance, a report has shown that Ghana contributes about 76.7% of greenhouse gas emissions in a bid to increase income levels and accelerate economic growth [4]. A study on the determinants of emissions in 20 economies from 1982 to 2013 revealed that energy consumption per capita, urbanization, real foreign direct investment (FDI) per capita, and real gross domestic product (GDP) per capita are the main contributors [5]. Also, recent studies have shown that from 2010 to 2040, annual carbon dioxide emissions will increase from 31.2 to 45.5 billion metric tons [6] as a result of the energy-intensive nature of the built environment which produces buildings and other infrastructures. Therefore, there is a need for rapid structural change in the energy sector to ensure a significant reduction in emission rate is achieved [7]. Hence, the need to embrace renewable energy sources (RESs) as a sustainable and reliable option to fossil fuels. This paper is therefore aimed at assessing the drivers of adopting renewable energy in the built environment of South Africa.

This paper is part of a recently completed research that evaluates the adoption and integration of renewable energy in South Africa. It presents the results of the questionnaire survey of the construction professional's view on the ways of promoting the adoption and integration of renewable energy. By identifying the drivers, the research study aims to create awareness on the need to replace the conventional fossil fuel-based energy sources with renewable energy solutions known to be eco-friendly and abundant. While the data for the study is derived from all the provinces that constitute the Republic of South Africa, the findings have the potential to be applied in other developing countries.

2. Overview of Renewable Energy

Renewable energy is described as the energy that is naturally generated from sources such as wind, sun, tides, hydro, geothermal and waves [8]. Owing to its abundance and eco-friendliness, the adoption and utilization of renewable energy is on the increase globally [9]. The adoption of RESs is due to its capacity to reduce the reliance on non-renewable sources of energy and to address the issues of global warming [10]. By replacing the use of fossil fuels with RESs, the consensus to drastically reduce the rate of emissions as documented in the COP21 agreement is set on the path of been achieved [11]. Renewable energy has the potential to reduce greenhouse gas emissions by a factor of 7 [12]. Renewable energy technologies such as wind power and solar photovoltaics are cogent determinants for decarbonizing the energy sector and the built environment [13]. In mitigating the current issue of climate change and global warming facing the world, renewable energy is essential in all economies as it generates energy with little or no harmful impact to the human and natural

environment [14]. To cater for the growing present and future energy demands, it is imperative to expand the distributed generation (DG) system which utilizes renewable energy sources (RESs) to generate electricity [15].

Population increase and the resultant movement of people into the urban areas in South Africa has given rise to a massive increase in carbon emission [16]. As a country that is reliant on coal, the increasing demand for energy makes it difficult to mitigate the environmental issues facing the nation, hence the need to adopt renewable energy. Another factor identified as hindering the country's transition to sustainable energy solutions is the weak synergy between energy and environmental law of South Africa as the energy sector still rely on fossil fuels which contributes heavily to greenhouse emissions [17]. The high cost of running a fossil fuel-based energy source, food insecurity, need to overcome global warming, and the adverse impact of the carbon-intensive sector on human health and ecosystem makes it imperative to embrace policies and technologies that supports eco-friendly energy generation [18, 19]. Also, Eskom which is the main energy provider in South Africa is facing numerous crises in recent times as it solely relies on coal. 30% of Eskom's energy supply is from burning coal while 94% of electricity supply is generated from coal-fired power stations [20]. However, the incessant blackouts, load-shedding and power cuts experienced all over the country due to increasing energy demand and infrastructure deterioration of Eskom's services attest to the fact that the system is highly unsustainable and no longer effective. Hence, the need for the country's national transmission system to adopt renewable energy as it is a cost-effective, abundant, environmentally advantageous and efficient source of energy [7, 21, 22].

3. Renewable Energy Sources

Technical and socio-economic benefits of RESs such as solar, geothermal, hydrothermal, wind and biomass make it a key contributor to the future global energy mix in developing countries [23]. The increased negative impacts of fossil fuels which have forced most countries to start exploring the use of renewable energy technologies will help in lowering carbon dioxide emissions, lessen the dependence on current energy sources (fossil fuel), and counter the threat to societal and environmental health [24, 25, 26]. Also, RESs will ensure rural communities have access to energy, create employment opportunities and guarantee energy security [27]. By implementing hydropower, solar, wind, biomass and geothermal technologies also regarded as "soft energies", the goal of achieving green growth will be realized thereby minimizing the reliance on conventional energies such as coal, gas and oil [28]. The next section presents a description of the hydropower, solar, wind, biomass and geothermal sources of renewable energy.

In basic terms, solar energy is generated from sunlight [29]. Solar energy is classified into two; photovoltaic technologies which transform the energy from the sun for power generation and solar thermal technologies which directly utilize sun energy for drying, cooking and heating [30]. Photovoltaic cells convert solar radiation straight to electricity with the aid of free-standing arrays of photovoltaic systems while thermal electric technology generates solar power using lenses or mirrors to concentrate a huge amount of sunlight onto a small area [31]. Solar installations are known to have a projected capacity of around 12MW [32]. To mitigate the problem of energy generation facing the country and the huge amount of electricity consumed for water heating, South Africa has embraced the use of the solar system [33]. More than 350, 000 solar water geysers have been installed to cater for water heating in homes [29].

Wind energy is used to pump water and power windmills while its large turbine design is used for power generation without polluting the atmosphere [22]. Due to its reliance on wind, wind energy is best effective in areas with high wind pressure. As it requires ample area of land, the deployment of this technology is therefore hindered due to fixed supply of land and its usage for nature conservation and agricultural purposes thereby limiting its use [34]. Also, wind energy is intermittent or uncertain because the wind does not always blow all the time [35]. However, wind energy still has the potential to complement efforts towards addressing energy demands in developing countries. For instance, wind energy installed capacity in South Africa is 0.05% which is generated from Eskom's Klipheuwel demonstration plant and Darling wind farm [36].

Biomass energy is recognized to be sustainable and affordable [37]. It entails the combustion of wood, wood waste, wood by-products, municipal solid waste and agricultural waste for heat and electricity generation [31]. Paper packaging and sugar mills combustion in South Africa (KwaZulu Natal and waterways of Mpumalanga provinces) using biomass produces electricity of around 210 GWh yearly [36]. The adoption of biomass energy is therefore important considering its potential in clean energy generation.

Hydropower uses the energy of flowing water without diminishing it to generate electricity, efficiently supporting intermittent wind and solar energy through its flexibility and storage capacity, limits vulnerability to floods and drought and prevent aquifers depletion [23]. The adoption of hydropower energy is maximized in countries such as USA, China, Brazil and Canada with an installed capacity of 50% [2]. This is because hydropower energy is cheap, eco-friendly, generated on demand, possess low fire risks, available in standard sizes, short delivery time, easy installation and readily available maintenance parts [22, 38, 39]. Small hydropower stations of 10MW power generation capacity have the potential to provide energy to remote areas in standalone mini or national grids [40]. Due to the numerous benefits, South Africa has invested heavily in hydropower energy infrastructures such as the two 1332 and 1000 megawatts Drakensberg stations and the 360 megawatts Gariep Dam [41]. However, lack of policy support, sustainable financial commitment and business models are identified factors hindering the full adoption of hydropower energy, especially the off-grid models [40].

Geothermal energy is acquired from natural geysers and hot water sources used for electricity generation or by using the deep dry hot rock as heat extinguisher by pumping water through natural rock openings to generate steams for energy generation [29]. Geothermal power plant installations generate little or no emissions and require little space for its development [30]. It is identified as a cheap, reliable and eco-friendly means of generating electricity, heating and cooling [42]. To reduce electricity bills, prevent future high energy costs and minimize reliance on oil, Jordan is planning to adopt the use of geothermal energy [43]. Geothermal energy is adopted in Turkey for greenhouse heating, space heating, heat pumps and industrial usage [42]. In Africa, potential geothermal energy generation is 9000MW with 57MW of that potential tapped in Kenya and less than 2MW in Ethiopia [30].

The transition to the sustainable energy mix will not only mean the provision of clean, safe, abundant and easily accessible energy but will also result in job creation and positive impacts on the economy [44]. The adoption of RESs will, therefore, create new business opportunities, lessen dependence on coal, gas and oil and simultaneously reduces the emission of greenhouse gases [45]. It is based on the afore-mentioned benefits accrued to renewable energy that this paper assesses the drivers of adopting renewable energy in the built environment of South Africa.

4. Research Methodology

This paper combines secondary data (literature review) and primary data (questionnaire survey) to present the benefits and drivers of renewable energy adoption in South Africa. A structured questionnaire survey was developed containing closed-ended questions which were divided into two sections. Section A of the questionnaire addresses the demographic information of the respondents. Section B of the questionnaire sought the respondent's evaluation of the drivers of renewable energy adoption in South Africa. The respondents used for the research study were construction professionals such as architects, quantity surveyors, civil engineers, industrial engineers, electrical engineers, mechanical engineers, project managers, construction managers, construction project managers, town planners and contract managers who are involved in renewable energy projects. Using a five-point Likert scale (strongly disagree-1, disagree-2, neutral-3, agree-4, strongly agree-5), the respondents were asked to indicate their level of agreement on the variables identified. From the distributed 150 questionnaires, a total of 103 was duly completed and returned representing a 68.67% response rate. Statistical Package for Social Sciences (SPSS) Version 16 software was used to analyze the data obtained. Descriptive statistics was employed using percentages, standard deviation and mean item scores.

5. Presentation of Result and Discussion of Findings

The presentation of the result and discussion of findings is presented in this section based on the two sections of the administered questionnaire survey.

5.1 Respondent's Demographics

The findings from the respondent's professional qualification revealed that 25.2% were quantity surveyors, 14.6% were civil engineers and industrial engineers respectively, 12.6% were town planners, 8.7% were mechanical engineers, 5.8% were construction managers and construction project managers respectively, 3.9% were architects and contract managers respectively, 2.9% were project managers while electrical engineers represent 1.9%. for the respondent's years of experience, 61.2% had experience ranging between 1-5 years, 20.4% had experience ranging from 6-10 years, 12.6% had experience ranging from 11-15 years, 3.9% had experience ranging from 16-20 years while 1.9% had an experience that is more than 20 years. survey.

5.2 Ways of Promoting the Adoption of Renewable Energy

Table 1 presents the agreement level of respondents on the ways of promoting the adoption of renewable energy in the built environment. From the table, it can be deduced that all the 25 variables are highly significant factors that promote the adoption of renewable energy. This is because all the variables assessed have mean values that are above 2.5, with the least recording a high value of 3.62 [46]. The respondents considered 'training and education of professionals', 'efficient energy sector reforms', 'awareness creation', 'government support', and 'increased supply of renewable energy technologies' as the five most important ways of promoting the adoption of renewable energy. Conformity with international standards, preservation of aquifers, and increased call for climate change mitigation are considered the least three drivers of renewable energy adoption. The results agree with the studies of

Mathews [8] which indicates that government support in form of policy formulation and implementation, reforms in the energy sector, financial commitment and strong political will accelerate the adoption and integration of renewable energy. Also, the result aligns with the study of Pegels [7] where the proliferation and supply of renewable energy technologies are identified as a major driver. The successful and accelerated roll-out of renewable energy is dependent on the number of personnel with the requisite knowledge and technical prowess in the installation, operation and maintenance of renewable energy technologies. Hence, the need for continuous education and training of professionals who will aid the deployment of these eco-friendly technologies.

Table 1: Ways of promoting the adoption of renewable energy.

Drivers	Mean	Standard Deviation	Rank
Training and education of professionals	4.30	1.008	1
Efficient energy sector reforms	4.22	0.839	2
Awareness creation	4.17	0.944	3
Government support	4.16	1.046	4
Increased supply of renewable technologies	4.14	0.886	5
Creation of renewable energy technology market	4.13	0.904	6
Promotion of clean energy	4.12	1.032	7
Increased funding for research and development	4.07	1.031	8
Increased level of awareness	4.06	1.046	9
Reduced reliance on fossil fuels	4.05	1.023	10
Improvement in the education sector	4.04	1.093	11
Direct market support for renewable energy	4.03	1.033	12
Improved structure of energy market	4.02	1.038	13
Preservation of local environment and wildlife	4.02	1.010	13
Formulation and implementation of policies and regulations	4.02	1.010	13
Increased sensitization on environmental impacts	4.00	1.066	16
Increased sustainability of energy grid	4.00	0.970	16
Security of energy features and infrastructure	3.99	0.955	18
Increased client demand	3.96	0.885	19
Increased funding of the energy sector	3.91	1.197	20
Provision of incentives	3.88	1.140	21
Increased support for Small, Medium and Micro Enterprises	3.86	1.048	22
Conformity with international standards	3.84	1.100	23
Preservation of aquifers	3.75	0.967	24
Increased call for climate change mitigation	3.62	1.130	25

6. Conclusion and Recommendation

This paper is aimed at identifying the ways of promoting the adoption of renewable energy in the built environment using South Africa as a case study. Based on the findings revealed from the data gathered from the respondents, the major drivers of renewable energy adoption were identified. From the study, it is established that renewable energy reduces pollution and atmospheric carbon footprint, minimizes environmental degradation and reduce resource

consumption. As a reliable, free, naturally abundant, and environmental-friendly source of energy, renewable energy has the potential to enhance the living standard of the people and improve the health and wellbeing of the human and natural environment. By massively investing in renewable energy technologies coupled with research and development, the ills and the negative impact of the conventional mode of power generation will be mitigated and substituted with a more sustainable energy mix.

The continuous challenges facing the energy sector in South Africa is an opportunity for stakeholders to fully explore the opportunities and potentials within RESs to meet the energy demands of the growing population. RESs also provide an avenue for the government to ameliorate the living standards and economy of the vulnerable households who lacks access to electricity. Other groups of people who find it extremely difficult to afford the use of electricity can also be provided with cheaper and cleaner energy alternatives which the government can subsidize. With a well-coordinated country-wide awareness program on the benefits accrued to the use of renewable energy solutions, it is believed the attainment of the sustainability agenda of the country will be fast-tracked and achieved within a short period. SMMEs known to be the main driver of economic growth and poverty alleviation mechanism in South Africa requires affordable and reliable energy such as the one offered by RESs. Furthermore, the adoption of renewable energy solutions will minimize the pressure on natural resources and the environment which is attributed to the conventional coal or fossil fuel-generated energy.

While this study identifies the ways of promoting the adoption of renewable energy in South Africa, it is suggested that generalizing the results in other countries should be done cautiously bearing in mind that the study is limited by the geographical location and the number of respondents used. It is therefore recommended that further study is done with a greater number of respondents encompassing all stakeholders in the energy sector to achieve a more robust result. Robust collaboration between all stakeholders in the energy industry is recommended to explore best practices and frameworks with the potential to maximize the benefits of adopting and integrating renewable energy.

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