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Is renewable energy a model for powering Eastern African countries transition to industrialization and urbanization?

Presley K. Wesseh Jr., , , Boqiang Lin*

Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, School of Management, Xiamen University, Fujian, 361005, China

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ABSTRACT

This study profiles a conversation on the appropriateness of renewable energy as a model for powering development in East African countries. Estimated output elasticities of nonrenewable energy (0.29 – 0.48) are by far larger than those of renewable energy (−0.12 – 0.08); and as such, highlights the relative importance of the former. Also, the biased component of technical change shows higher technological progress for nonrenewable energy. Furthermore, substitution elasticities are positive (0.77 – 0.92); suggesting huge potential for a transition towards renewable energy. However, inherent limitations in renewables, documented in Wesseh and Lin **[52,53], undermine the usefulness of East African countries reliance on renewable energy.

1. Introduction

According to the United Nations geographic scheme, the Eastern African region constitutes 20 territories. As is the case for most Sub-Saharan African countries, this region suffers one of the most devastating electricity gaps in the world thus threatening the region's industrialization and urbanization. In line with achieving the United Nations Millennium Development Goal (MDG) which calls for providing energy access to all, ensuring supply security and mitigating greenhouse gas emissions, policies limiting the use of fossil fuels are gradually gaining grounds in most African countries. In fact it is popularly argued that, with their low capital and adaptive capacity, African countries and developing economies in general would be more vulnerable to extreme weather and that climate change would negatively impact their energy systems. For instance, unlike richer nations, it would be difficult for these countries to pay for air conditioning, import food from far away regions, and build out of the rage of rising waters.

To substantiate these claims, the African Development Bank (AfDB) has marked green growth as the top priority of its development strategy, i.e., between 2013 and 2020. Wind and solar which are among the fastest growing renewable energy technologies would be at the forefront of power generation. The point is climate change would still persist if African countries reduce emissions and other countries don't. Furthermore, this study argues that developing countries would be able to reduce the effects of climate change if accelerated wealth creation coming at the hands of increased investment and policy support for cheaper and more stable production recipe (like fossil energy) is allowed. Moreover, developing renewable energy would sound much reasonable if such opportunities are able to end the energy poverty stimulate economic growth and ensure environmental sustainability. In fact, it is now becoming a general consensus among policy makers that large-scale deployment of renewable energy technologies, due to recent technological advancement and cost reductions, provide a cost-effective recipe for sustainable growth in African countries.[1]Although more abundant solar and wind resources are located in the North and West and in the North and East respectively (Table 1), the present study further argues that reducing cost cannot increase the competitiveness of renewables, at least not anytime soon, since renewable technologies are still in their early stage of commercialization.

Therefore, relying on review work of [54] and [55], the objectives of the present study will be to: (i) develop reliable estimates of the economic impact of both renewable and nonrenewable energy, classical factors and technological progress for a group of East African countries using country-level panel data. (ii) Estimate the efficiency with which energy and other production inputs are used. (iii) Produce estimates of the substitution potential between renewable and non-renewable energy. (iv) Discuss the possibilities of deploying renewable energy technologies to alleviate energy poverty, ensure supply security and

* Corresponding author at: Collaborative Innovation Center for Energy Economics and Energy Policy, China Institute for Studies in Energy Policy, School of Management, Xiamen University, Fujian, 361005, China

E-mail addresses: masterpresley@yahoo.com (P.K. Wesseh), bqlin@xmu.edu.cn, bqlin2004@vip.sina.com (B. Lin).

[1] A more comprehensive discussion of these issues is left as valuable opportunity for future research and model improvement.

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Table 1
Renewable energy potential across Africa.
Source: AfDB (2012).

Region	Wind (TWh/yr)	Solar (TWh/yr)	Biomass (EJ/yr)	Geothermal (TWh/yr)	Hydro (TWh/yr)
East	2,000–3,000	30,000	20–74	1–16	578
Central	–	–	49–86	–	1,057
North	3,000–4,000	50,000–60,000	8–15	–	78
South	16	25,000–30,000	3–101	–	26
West	0–7	50,000	2–96	–	105

mitigate greenhouse gas emissions in the East African region. (v) Advance relevant policy implication for East Africa's industrial transition.

Indeed, the originality and scientific contribution of this study adds value to the literature. First, this study is the first of its kind approach to renewable energy – economic growth potential for the East African region. Second, substitution elasticities between renewable energy and non-renewable energy have never been estimated for East African countries before despite the significant implications these may have on the region's economic development [1,2]. Third, the applied methodology is novel in the energy consumption – economic growth literature; although the approach has been recently applied by very few studies[2] to estimate energy substitution effects. For we use the translog production model, which in applied production analysis, is considered to be the most flexible functional form. Finally, this study brings innovation into the literature not only in terms of the kind of data used but also the method of calculating the difference in technological progress to determine which energy type, weather renewable energy or nonrenewable energy, would be more significant for powering the region's transition to industrialization and urbanization.

The remainder of the paper proceeds as follows: Section 2 reviews the relevant literature for Africa. Section 3 presents the data and documents technical details of the applied methodology. Section 4 reports the estimated results. Section 5 discusses East Africa's clean development possibilities in the context of the empirical findings and Section 6 draws the conclusions advancing relevant policy suggestions.

2. Review of relevant studies for Africa

This section reports two strands of the empirical literature. First, a review of studies which examine the causal links between energy consumption and economic activities in African countries are presented. Next, studies that have attempted to investigate energy substitution effects in Africa are reviewed.

Different methods and proxy variables for energy consumption have been applied in the literature for African countries. It is not surprising that this literature also produces mixed results. A summary of these studies is reported in Table 2. For a comprehensive review of the energy consumption – economic growth nexus literature, interested readers are referred to [58] and [59].

There are a number of country-specific studies which provide support for the feedback hypothesis. In other words, these studies suggest bidirectional Granger causality between energy consumption and economic growth. The vast majority of these studies have employed cointegration and error correction techniques. These include: [3] on Nigeria and Tanzania; [4] on Malawi; [9] on South Africa; [15] on Burkina-Faso; [17] on Cote d′Ivoire; [20] on Liberia; [21] on Cameroon; [25] on Angola; [27] on Algeria and Egypt and [30] on Algeria.

In contrast, some studies on Africa have supported the growth hypothesis. This hypothesis asserts that energy consumption complements capital and labor as important factors in the production process. This means that energy is crucial for growth as the economy is energy dependent. As a result, energy conservation policies may have negative effects on real GDP. Studies in this category are: [10] on Tanzania; [11] on Nigeria; [12] on South Africa; [24] on Cameroon; [29] on South Africa and Kenya and [1] on South Africa.

On the conservation hypothesis, [56] examined the causal relationship between the logarithm of per capita energy consumption (LPCEC) and the logarithm of per capita GDP (LPCGDP) during the period 1965–2008 using the threshold cointegration and Granger causality tests. Results from the study indicated that the LPCEC and LPCGDP for Algeria are non-cointegrated and that there is a unidirectional causality running from LPCGDP to LPCEC, but not vice versa.

There also exist multi-country studies in which all four hypotheses including feedback hypothesis, growth hypothesis, conservation hypothesis and neutrality hypothesis are supported. These studies include: [5–8,13,14,16,18,19,22,23,26,28,31,32].

The next strand of literature we discuss is the one dealing with inter-fuel/inter-factor substitution possibilities in Africa. There are studies for European countries, Asian countries as well as North and South American countries. A comprehensive review of these studies is given in [38]. [33,34] also cite a number of studies. Surprisingly, very little research on energy and resource substitution possibilities have been conducted for Africa despite the general consensus that African countries need to reduce their consumption of environmentally harmful resources and switch towards cleaner fuels like renewable energy. Moreover, given AfDB ambitious targets for green growth, research along these lines is necessary to explore the possibilities of replacing fossil energy with cleaner energy.

To the authors' best knowledge; there are only three studies for Africa currently. [2] investigated the potential for inter-factor and inter-fuel substitution between capital, labor, petroleum and electricity in Liberia. The authors employed Ridge regression to estimate the translog production function and reached conclusions that all inputs considered are substitutes. Notwithstanding, the study pointed out that opportunities to substitute petroleum for electricity; or labor and capital for electricity are limited in practice because of Liberia's current low scale electricity generation. Following similar line of research, [57], employed Ridge regression to examined the possibilities of substituting between fuels and factors in Ghana. Similar to results obtained in [2], these authors found that all the input pairs are substitutes.

In a more recent study, [39] developed a translog production function for a group of 24 African countries. The authors applied random effects estimation to the model and found that African output is driven by a more intensive use of petroleum and electricity and to a lesser extent capital, labor and coal; relative to technological progress. The study also documented that petroleum, coal and electricity are substitutes. However, the authors pointed out that the extent to which substituting coal (or petroleum) for electricity will be successful in mitigating greenhouse gas emissions will largely depend on the extent to which these fuels are used in generating electricity.

A summary of these studies is presented in Table 3. As may be observed, the inherent shortcomings of the above two studies is that they focus exclusively on the substitution between fossil fuels and factors while neglecting the possibilities of substituting renewable energy for fossil fuels in Africa. The present study would therefore add value to the literature by attempting to fill this gap.

3. Data and methods

The applied dataset, model and methods of estimation form the domain of this section.

[2] To the best of the authors' knowledge, only five studies have applied the translog production model to the investigation of problems in the energy economics literature namely: [2,33–37]