



# The effect of renewable energy consumption on economic growth: Evidence from top 38 countries



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## HIGHLIGHTS

- Deployment of renewables is essential for sustainable development.
- Top 38 countries are selected using the Renewable Energy Country Attractiveness Index.
- Long-run output elasticities estimated for each country.
- Analysis for both panel and individual countries.
- The message varies for future renewable deployment into the growth process.

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## ABSTRACT

This research aims to investigate the effects of renewable energy consumption on the economic growth of major renewable energy consuming countries in the world. Using the Renewable Energy Country Attractiveness Index developed by the Ernst & Young Global Limited, we choose 38 top renewable energy consuming countries to explain the growth process between 1991 and 2012. With panel estimation techniques, our findings establish cross-sectional dependence and heterogeneity across the countries. We confirm the evidence of long-run dynamics between economic growth, and traditional and energy-related inputs. Findings from long-run output elasticities indicate that renewable energy consumption has a significant positive impact on the economic output for 57% of our selected countries. For robustness, we also carried out time-series analyses of long-run output elasticities. Our findings suggest that governments, energy planners, international cooperation agencies and associated bodies must act together in increasing renewable energy investment for low carbon growth in most of these economies.

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## 1. Introduction

The United Nations designated the decade 2014–2024 as the Decade of Sustainable Energy for All (SE4All, [1]). Attaining sustainability in energy use is likely to create a cleaner environment, wider access to electricity, improved energy efficiency with low-carbon renewables, and result in greater investment in cleaner technology. In the global context, there is an increasing deployment of renewable energy that helps in addressing climate change

and in creating wider energy access to the billions of people who are still in the poverty trap.

An estimated 19.1% of global final energy consumption was sourced from renewables in 2013.<sup>1</sup> The recent growth in the electricity sector is led by wind, solar PV, and hydropower. The growth in heating capacity is at a steady pace, and the production of biofuels for transport has recently climbed following a slump in 2011–2012. Following the most optimistic scenario developed by the International Energy Agency (IEA), the renewable share of electricity generation will increase to 39% by 2050 from 18.3% in 2002. In reducing the global CO<sub>2</sub> reduction by 50% by 2050, renewables will have a

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<sup>1</sup> [http://www.ren21.net/wp-content/uploads/2015/06/GSR2015\\_KeyFindings\\_Low-res.pdf](http://www.ren21.net/wp-content/uploads/2015/06/GSR2015_KeyFindings_Low-res.pdf) [2].

key role in limiting the long-term mean global temperature rise within the limit, between 2.0 and 2.4 °C [3].

Renewables growth in recent years has been driven by government-supported programs through subsidies, tax credits, and other incentives. This has increased the cost-competitiveness of renewable energy sources. In many countries, renewables are broadly competitive with conventional energy sources. Along with Europe and the United States, recent renewable energy initiatives have originated in countries in Asia, Africa, and Latin America. This has created emerging manufacturers and installers of renewable energy technologies outside Europe and the United States.

The literature on the energy consumption–economic growth nexus has been widely researched (e.g., [4–6]), however the renewable energy-based studies are still scarce.<sup>2</sup> The growing significance of renewables as a source of energy has created wide interest from both academics and energy policy analysts. Our contribution towards the literature is as follows.

The research makes several important contributions towards the renewable energy–growth nexus literature in Energy Economics. Almost all studies in the literature have considered panels of countries in explaining the dynamic relationship between renewable energy consumption and economic growth. A major criticism related to these studies, we notice, is the selection of panels. Countries within the considered panel have a greater degree of heterogeneity, and also could be cross-sectionally dependent across the panel. To overcome this problem, in this paper we employ recent heterogeneous panel estimation techniques with cross-sectional dependence. This is important, as energy policies set at the international level can also affect individual countries simultaneously, in addition to other exogenous shocks. This is the first piece of research dealing with renewable energy and growth using heterogeneous panel techniques for 38 top renewable energy consuming countries.

Second, unlike other studies, in our study country selection for our panel is not random. For this purpose we utilise the Renewable Energy Country Attractiveness Index (RECAI) developed by Ernst & Young Global Limited. The RECAI ranking is based on macroeconomic, technology, and energy-specific factors for each market.<sup>3</sup> We selected 38 out of 40 top countries following this RECAI index for our panel. It is the first time this index has been used in the literature for selecting a panel of countries.

Third, along with traditional inputs, we selected both renewable and non-renewable energy consumption so that we can identify the relative effect of each of these in the economic growth process.

Fourth, with long-run dynamics, we estimate the long-run output elasticities with respect to each type of energy for the panel and individual countries. These elasticities reflect both the time dimensions and the cross-sectional nature of the panel and provide significant power compared to the studies based on only time series techniques. These estimates are useful for policy purposes, as they reflect the long-run demand for renewable and non-renewable energy sources in the growth process for these countries.

The rest of the paper is organized as follows. Section 2 provides an overview of the energy consumption–growth hypotheses with a focus on the empirical literature on the studies explaining the dynamics of renewable energy consumption and economic growth. A brief update of renewable energy resources in different countries is presented in Section 3. Section 4 discusses the model, data and descriptive statistics of variables. In Section 5, we describe econometric methodology and empirical findings. Section 6 presents conclusions and provides policy suggestions.

## 2. An overview of literature

The energy consumption–economic growth nexus can be analysed under four hypotheses. The *growth hypothesis* assumes energy as a major source of input into the growth process, and uni-directional causality exists from energy consumption to economic growth. In this scenario, energy conservation policies will have a negative impact on economic growth. The *conservation hypothesis* implies that economic growth causes consumption of energy. Under this situation, conservation policy will not affect economic growth. The *feedback hypothesis* implies a bi-directional relationship between energy consumption and economic growth. This hypothesis suggests any change in energy consumption will affect economic growth with a reverse effect. The *neutrality hypothesis* indicates that energy consumption and economic growth are independent and do not affect each other. Most of the literature examines the relationship between electricity consumption and income, or the nexus of energy–income–emissions. The literature over the past decades has produced varied findings across countries under each of these hypotheses. No consensus has emerged from these studies. We refrain from the voluminous literature here.<sup>4</sup>

Our objective here is to review the scant literature on the role of renewable energy in explaining sustainable economic growth. A bi-directional causation was established between renewable energy consumption and economic growth by [10] for 18 emerging economies. Sadorsky reports that in the long run, a 1% increase in real income per capita increased the consumption of renewable energy per capita by approximately 3.5% for these economies. Bowden and Pyne [11] analysed the sectoral causal relationship between renewable and non-renewable energy consumption and economic growth in the US. Their findings established no causality between renewable energy consumption and real GDP in the commercial and industrial sectors, while positive uni-directional causality exists from residential renewable energy consumption to real GDP. On renewables, there are only a few studies examining the effects of biomass biofuels on the environment with varying results. Ozturk and Bilgili [12] reviewed this literature and investigated 51 African countries. They found that a 1% increase in biomass will increase GDP by 0.82% in these countries.

A summary of literature is presented in Table 1 to conserve space. It is noticeable that the findings from the literature are mixed even for the studies where energy-mix is disaggregated. Given that there is currently a worldwide effort to increase the share of renewable sources, we consider a panel study instead of a case study on a single country. The selection of countries following the RECAI index and heterogeneous panel estimation techniques provide new findings in the literature.

## 3. Renewable energy resources – overview of current status in sampled countries

Renewable energy is sourced from natural processes (e.g. sunlight and wind) and is either inexhaustible or can be replenished. Major types of renewable energy are solar, wind, geothermal, hydropower, bio-energy, and ocean power. The share of renewables has increased significantly in the electricity, heating and cooling, and transport sectors. Following the report from the Renewable Energy Policy Network for the 21st Century (REN21), China led in global investment in renewable power and fuels, followed by United States, Japan, United Kingdom and Germany. China was in the forefront in hydropower, solar PV, wind, and solar water heating. In terms of renewable power capacity per capita, the five top countries are Denmark, Germany, Sweden, Spain and

<sup>2</sup> For detailed reviews, see [7,8].

<sup>3</sup> [http://www.ey.com/Publication/vwLUAssets/RECAI\\_44/\\$FILE/RECAI%2044\\_June%202015.pdf](http://www.ey.com/Publication/vwLUAssets/RECAI_44/$FILE/RECAI%2044_June%202015.pdf) [9].

<sup>4</sup> Ref. [11] and follow references.

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