Renewable and Sustainable Energy Reviews 29 (2014) 336–344

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Global estimates of energy consumption and greenhouse gas emissions

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ARTICLE INFO

Article history:
Received 11 June 2013
Received in revised form
13 August 2013
Accepted 24 August 2013

Keywords:
Energy consumption
Economic growth
Greenhouse gases
Cointegration
Global regions

ABSTRACT

The present study examines the long-run relationship between energy consumption and greenhouse gas emission for different groups of countries comprising lower middle income, upper middle income, and heavily indebted countries, East Asia and Pacific, East Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, South Asia, Sub-Saharan Africa and for aggregate data of the world. The data has been analyzed by using various econometric techniques, specifically the Johnson cointegration, modified version of Granger causality and variance decomposition analysis from the period of 1975 to 2011. The results confirm that there is a long-run relationship between greenhouse gas emissions (i.e. agricultural methane emission, agricultural nitrous oxide emission and carbon dioxide emission) and energy consumption. The results of Granger causality indicate that energy consumption Granger causes greenhouse gas emission but not vice versa. The important finding is that energy consumption Granger causes GDP per unit energy use, which confirms the energy led growth hypothesis in the world. However, the vice versa relationship does not hold. The results imply that a policy to cut energy consumption tends to diminish greenhouse gas emission though affecting GDP of countries negatively.

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1. Introduction

Efficient consumption of energy is widely viewed as a rather inexpensive way to cut total energy consumption and thus greenhouse gas emissions. Many agencies at national and international levels recommend energy efficiency measures. These measures in fact act as a way to reduce significant amounts of greenhouse gas emissions without incurring real cost and promise potential net benefits ([25]). The continued growth of global emissions and their possible adverse effects on global warming have shifted focus to relative contribution in total emissions and size of relative efforts undertaken by countries to mitigate these emissions [37].

Most of the greenhouse gas emissions that emanate from the residential and the commercial sectors are a direct result of energy use inbuildings. GHG emissions take place through direct emissions from the on-site combustion of fuels for heating and cooking, and emissions from the use of electricity for heating, cooling and providing power to

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http://dx.doi.org/10.1016/j.rser.2013.08.091

Table 1
Average electricity generation (terawatt-hours).

Terawatt-hours	1970s	1980s	1990s	2000s	2010	2011	Change 2011 over 2010 (%)	2011 share of total (%)
North America	2414.6	3018.3	3912.6	5012.3	5183.7	5204.5	0.4	23.6
South and Central America	6242.6	7017.3	8912.0	1023.9	1102.5	1145.6	3.9	5.2
Europe and Eurasia	3012.5	3721.9	4432.0	5171.9	5323.2	5278.6	−0.8	24.0
Middle East	6684.8	7342.9	8124.9	8848.0	871.4	912.1	4.7	4.1
Africa	464	512.3	588.3	639.8	659.3	657.1	−0.3	3.0
Asia Pacific	5124.3	6916.3	7825.3	8412.3	8225.7	8820.1	7.2	40.1
Total world	23942.8	28529.0	33795.1	29108.2	21365.8	22018.1	3.1	100.0

Source: Ref. [4].

Table 2
Regional energy use (kWh/capita).

kWh/capita	1970s	1980s	1990s	2000s
USA	91214	90124	89021	87265
EU-27	37214	39912	40240	40825
Middle East	812	11214	19422	34784
China	1216	4412	8839	18618
Latin America	7234	9121	11281	14428
Africa	5412	6124	7094	7792
India	1723	2568	4419	6280
Others	28652	26124	25217	24814

Source: Ref. [23].

buildings. Emission reductions from buildings can be achieved by controlling emissions from the energy supply or by decreasing energy consumption through improved building design, increased energy efficiency and conservation, and using other mechanisms which reduce energy demand in buildings [5].

The International Energy Agency [21] and the Intergovernmental Panel on Climate Change [24] have calculated that use of energy efficiency measures drives out the greatest portion of emission reductions and stabilizes the global climate. The renewed interest in the use of energy efficiency measures or mitigation assessment of greenhouse gases may also be attributed to the relationship between environmental pollutants, energy consumption and economic growth ([19] p. 358).

Table 1 shows the global trends of average electricity generation over the last four decades. The production of energy has resulted in global warming and poses a serious threat to the environment. To resolve the potential danger to climate by emissions from energy production, the Kyoto Protocol of the United Nations has been signed by a number of nations. This agreement aims at reducing harmful impacts of energy emissions on the climate. However, the dangerous concentration of energy production is playing havoc with the environment and hence has raised concerns. A global temperature rise of 2 °C is considered quite a high risk. Nevertheless, limiting this global temperature rise to 2 °C demands a 75% decline in carbon emissions in industrial countries by 2050. If the population reaches 10 billion in 2050, across 40 years, this averages to a 2% decrease every year. In 2011, the warming emissions of energy production continued rising regardless of the consensus on the basic problem. Table 2 shows the global estimates of energy consumption over the last four decades.

According to the Worldwatch institute [39] report carbon dioxide (77%), nitrous oxide (8%), and methane (14%) are the three main greenhouse gases that trap infrared radiation and contribute mainly to climate change. In order to prevent collapse, human civilization must stop increasing emissions within a decade regardless of the economy or population. Table 3 shows the global estimates of carbon dioxide emissions in different regions of the world.

In literature, there is sufficient evidence that increasing concentrations of atmospheric greenhouse gases from energy-related activities are responsible for changing the planet's climate. Other than the principal anthropogenic greenhouse gas, which is carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are also energy related greenhouse gases. An energy source's impact on the climate can be expressed in terms of its greenhouse gas emissions factor, which is, in this case, the volume of greenhouse gases emitted per unit of energy consumed [20].

There are a number of environmental problems that we face today. These problems range from continuously growing variety of pollutants and hazards, to ecosystem degradation over wider areas. In addition to this, acid precipitation, stratospheric ozone depletion, and global climate change are also noticeable. Of all potential climate threats, the most important environmental problem relates to the result of energy utilization which is the greenhouse effect. Unprecedented increase in atmospheric concentrations of greenhouse gases is expected to trap heat radiated from the Earth's surface, resulting in the rise of the surface temperature of the Earth and consequently rising sea levels [13].

The broad objective of this study is to empirically investigate the impact of energy consumption on greenhouse gas emissions in different regions of the world. The more specific objectives are

(i) To estimate whether there is a long-run relationship among greenhouse gas emissions, GDP per unit use of energy and energy consumption.
(ii) To explore the influencing directions between greenhouse gas emissions and energy consumption.
(iii) To compare the influencing magnitude of greenhouse gases on energy consumption in different group of countries.

The framework of the study is organized in the following manner. An introduction has been discussed in Section 1. Section 2 presents literature review. Data source and methodology are discussed in Section 3. Results are shown in Section 4. The final section concludes the study.

2. Literature review

The debate on climate change has brought focus to the problem of greenhouse gases emissions into the atmosphere. One of the most important issues in the policy debate is the role to be played by developing countries for reducing GHG emissions, and particularly CO_2 emissions side by side with developed countries. This debate demands reviewing the relationship among energy