



Electricity consumption and human development level: A comparative analysis based on panel data for 50 countries [☆]



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ABSTRACT

As a representative of modern energy, the level of electricity consumption can be regarded as an appraisal criterion of a country's development level. This study analyses the causality between electricity consumption and human development and assesses the changing trend of electricity consumption. The models in this study are established using panel data from 1990–2009 for 50 countries divided into four groups according to income. For human development indicators, per-capita GDP, consumption expenditure, urbanisation rate, life expectancy at birth and the adult literacy rate were selected. The results show that long-run bidirectional causality exists between electricity consumption and five indicators. Additionally, the higher the income of a country, the greater is its electricity consumption and the higher is its level of human development. Further, the variables of four income-groupings vary considerably. Specifically, as income increases, the contribution of electricity consumption to GDP and consumption expenditure increases, but the urbanisation rate, life expectancy at birth and adult literacy rate present a weakening trend. This mainly because that the latter indicators in high-income countries are increasing to converge. To improve human development, electricity should be incorporated into the basic public services construction to enhance the availability of electricity for low-income residents.

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1. Introduction

As a manmade source of energy [1], electricity can be generated from primary energy [2] and/or convertible into an ultimate form of energy with the help of various technologies [1]. Beyond its availability and flexibility, electricity has other advantages. For example, it can be supplied continuously and transmitted over long distances by power lines or grids. In addition, it is clean (the utilisation process does not emit greenhouse gases), convenient, renewable and efficient. Therefore, electricity is thought to be the energy that has the widest application and plays an important role in the economic and social development of all countries [3,4]. Lenin famously asserted in 1920 that communism was the result of Soviet regime and the national electrification [5]. Furthermore, a large number of studies have indicated strong causality between electricity consumption and economic growth [4,6–8].

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An electric power service has been the basic requirement for improving living standards and supporting social development for five main reasons. First, when obtaining electricity, food, vaccines and drugs can be stored in a refrigerator for a longer time, thereby improving people's health conditions [9–11]. Second, lighting makes people study longer with the result that the adult literacy rate increases. In addition, the application of computers, televisions and the Internet improves people's ability to obtain information and knowledge [12]. It can be said that modern society is highly reliant on network information and communication technologies [6].

Third, the available electricity makes widespread use of various household appliances. It is more convenient for people in heating, cooling, sanitation, entertainment and so on, which greatly improves quality of life [13,14]. Fourth, electricity can take the place of traditional biomass energy and coal, which is able to reduce indoor pollution and improve the quality of the environment. Meanwhile, it can be produced without carbon emissions. When renewable energy (e.g. wind, solar, nuclear and hydro energy) or fossil fuels that can capture and store carbon are used to generate electricity, it can efficiently reduce carbon emissions and mitigate climate change [15].

Finally, the utilisation of electricity not only releases people from hard work, but also saves much time for people. In particular,

for rural women it provides opportunities for self-employment and potential development [10,11]. Therefore, electricity consumption is regarded as the reference of well-being [16] and a key measurable index of life quality [2]. Statistics by the International Energy Agency (IEA) [17] showed that 1.4 billion people around the world have no access to electricity and that 2.7 billion people still lived by traditional fuel. The common shortage of electricity supply has become an obstacle to social development. For instance, in Africa and South Asia there is no available electricity for most rural residents [18].

Electricity consumption is an indicator that reflects the level of social development in a country. In the process of modernisation, it is necessary to produce adequate amounts of electric energy to advance sustainable development. As is well known, as a kind of secondary energy, electric energy is transformed from primary energy such as hydro energy, nuclear energy and coal [2]. The process of generating electricity, from resources development to end use, needs a series of links, such as production and transmission. In addition, supporting engineering facilities and a service system are required to guarantee electricity supplied sustainably and safely, especially to construct a perfect grid system [1]. In turn, this requires corresponding economic strength and techniques for support. Therefore, an increase in electricity consumption cannot be achieved overnight.

Electricity is clean in terms of consumption, but generates some environmental problems in terms of production [19]. In particular, when coal is used to generate electricity, it emits large quantities of greenhouse gases. To promote socioeconomic development, it is necessary to increase electricity consumption. However, an increase in electricity consumption would have an adverse impact on the environment. Faced with this dilemma, we need to quicken the development and utilisation of a clean energy source, such as hydroelectric, nuclear, wind, solar and biomass power [20]. However, developing new energy leads to an increase in technology costs, rising electricity prices and higher consumer spending [21]. In particular, it places a larger financial burden on medium- and low-income earners.

This paper studies 50 of the main countries around the world, which are divided into four groups (low-income countries, lower-middle income countries, upper-middle income countries and high-income countries) according to the latest income-grouping standards of the World Bank (2010). In 2009, the total population of the study region was 5.478 billion, the GDP was 32.983199 trillion dollars, the area of land was 89.0008 million square kilometres and electricity consumption was 16.058834 trillion kilowatt-hours, accounting for 81.00%, 83.13%, 68.61% and 86.91% of the world's totals, respectively. In this study, we analyse the inherent relation between electricity consumption and human development indexes (HDIs) using the methods of the panel Granger causality test to the parameter estimation of panel models. The results not only show that electricity consumption is a big promotion to economic and social development but also show the changing features and regularity of electricity consumption on the time series and different individual sections. Finally, this paper provides suggestions on improving public service and promoting electrification for undeveloped countries and areas.

For China, electrification reached upper-middle income levels in 2010. Nevertheless, regional development is unbalanced and the income gap between urban and rural residents continues to expand. Specifically, the Beijing-Tianjin region, Yangtze River Delta and Pearl River Delta have already achieved a high-income level, while other large cities and eastern rural areas belong to the upper-middle income level. The income levels of small- and medium-sized cities and villages in central China is medium or comparatively low, whereas the agricultural and pastoral areas in the western region are still at a low-income level. Using the above

research method of different countries to study the correlation between electricity consumption and human development in different areas of China can provide reference to launch aid projects and reduce the development gap between regions. Therefore, it has great significance in putting forward policy recommendations on how to improve electricity consumption in lower-middle income families based on the historical background of building a well-off society.

This paper is structured as follows: We review relevant literatures regarding electricity consumption and human development in Section 2. Section 3 describes the data source, research ideas and methods. Section 4 analyzes the results calculated by models. Section 5 gives the conclusions and policy proposals.

2. Literature review

Since the correlation between electricity consumption and human development is not as direct as close as that between electricity consumption and economic growth, the relevant research is rarer. Kanagawa and Nakata [22] found that electricity consumption has significant correlation with GDP as well as HDI for 120 countries, and the countries which mark high consumption level of per capita electricity, attain upper rank of both economic activities. Ghali and El-Sakka [23] also noted that per-capita energy and electricity consumption are highly correlated with economic development and other indicators of modern lifestyle, with the inference that the more energy that is consumed, especially in the form of electricity, the better life is. Mazur [3] demonstrated that electricity consumption was essential for people to improve their well-being in less-developed countries, especially in populous China and India. However, in industrialised nations, increasing electricity consumption has little relationship with improving life quality. Zahnd and Kimber [24] demonstrated that electrical energy can provide for appropriate and sustainable lighting, which brings potential health, education, social and economic benefits to the people who have previously lived in homes with excessive indoor air pollution. Wu et al. [25] evaluated the inequality of energy consumption using the Lorentz Curve, Gini Coefficient and Theil Index, which reflect differences in the economic development levels of countries that are categorised into high, middle and low groups. In Brazil, rural electrification has become an important factor to reduce energy poverty, although it is not the only one [18]. The case analysis of Assam state in India suggested that rural electrification helped promote social and economic development and achieve the goal of poverty relief [22]. Holtedahl and Joutz [26] gave two possible reasons why higher urbanization might lead to higher energy use. Firstly, urbanization implies greater access to electricity, since households can be more readily connected to the grid. Secondly, households who already had access to electricity in rural areas are likely to increase their consumption in urban areas because of increased use of existing appliances and purchase of new ones. Burney [27] found that higher growth in income accelerates increases in electricity consumption; Increase in electricity consumption is compounded by socioeconomic development, as reflected by increases in literacy, share of industry and urbanization (see Table 1).

3. Data and methods

3.1. Selection of research subjects

This paper studies 50 of the main countries in the world, including 15 developed and 35 developing countries. These are distributed across different continents (except Antarctica). The main economies are selected and 19 countries of the G20 are included

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