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Energy consumption and CO_2 emissions in Turkey: Empirical analysis and future projection based on an economic growth

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Abstract

In this study, Turkey's energy sector was overviewed during the period of 1970–2002. The total energy consumption (TEC) was modeled by using the economic growth (proxied by gross national product—GNP) and population increase, which are the two important factors to determine the energy consumption for developing countries. In addition, the relationship between the TEC and total CO_2 (TCO_2) emission was studied. For this purpose, regression analysis was performed and the strong relationship between TEC and TCO_2 ($R^2 = 0.998$) was modeled. Also, results showed that a regression model can be used to predict the TEC from the country population and the GNP with high confidence ($R^2 = 0.996$).

Using the models developed in the study, TEC as a function of the targeted economic growth (annual rate of GNP increase) published in the National Development Plan and TCO_2 based on the TEC were forecasted up to year 2015. Additionally, the TCO_2 was also calculated by the intergovernmental panel on climate change (IPCC) method and the results from the two methods were compared. It was seen that the values predicted by IPCC method were considerably higher.

Based on the findings of the study, some recommendations were presented to be considered for the future energy policies to conform to the Framework Convention on Climate Change signed by Turkey on 18 December 2003.
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Keywords: Turkey; Regression; CO_2

1. Introduction

Development plans, which are the guiding principles for private investments and the mandatory rules for state institutions, have been prepared every 5 years since 1963 in Turkey. After the beginning of the development plans, the political decisions regarding all sectors have been made according to these plans. Targeted economic growth based on the rate of the population increase is one of the bases for the constitution of the policies about the sectors in the development plans.

In the beginning, these plans were designed to encourage the short-term economic benefits disregarding the environmental problems in Turkey, like in many developing countries. Therefore, these plans have not included any information regarding the environmental problems that will be caused by the economic growth and the recommendations to reduce the impact of these problems.

Economic growth rate of all the sectors in Turkey has been raised by several factors, particularly the free market economics introduced in the 1980s. The growth of the sectors, especially in the industry, resulted in considerable increase in energy consumption. Since 1970, the energy consumption increased by 415% and reached 79 million ton of oil equivalent (mtoe) (Energy Statistics, 2003) while CO_2 emission increased by 410% and reached 200 million ton (SIS, 2003).

Large-scale energy production plants established to meet the demand resulted from the increased population and growing economy have negative domestic and cross-border effects on the ecological balance. The main source of the CO_2 emission due to the fuel consumption (FC) is the thermic power plants which uses fossil fuels in Turkey. The second important source is the industry. CO_2 emission

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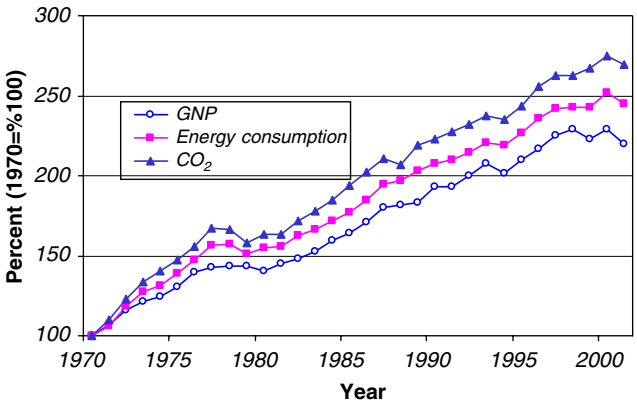

Fig. 1. Relationship between GNP, energy consumption, and CO_2 emission in Turkey.

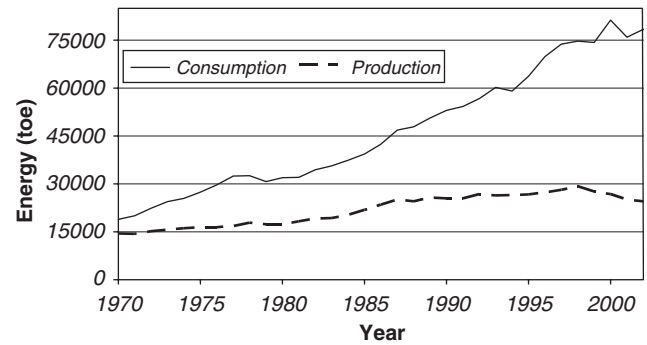

Fig. 2. Energy production and consumption in Turkey (Energy Statistics, 2003).

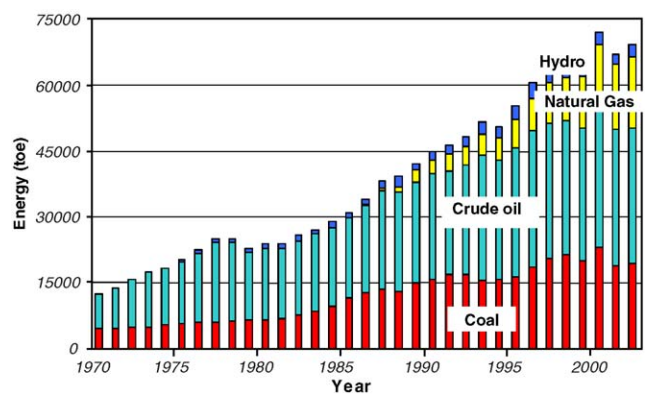

Fig. 3. Primary energy resources consumption of Turkey (Energy Statistics, 2003).

(38%) was due to the energy transformation (thermic plants) sector while the industry had a share of 28% in 2002 (SIS, 2003).

There are few studies that investigate the relationship between economic growth, energy consumption, and the environmental considerations around the world. Some of them investigated the relationship between energy demand, gross national product (GNP), the real energy prices, and the estimation of CO_2 emissions (Lester and Ninomiya, 2005), while some of them focused on the relationship between economic growth, energy consumption, and environmental considerations with recommendations for sustainable development (Zhidong, 2003).

As seen from literature, there is a strong relationship between GNP, energy use, and CO_2 emission in Turkey for years 1970–2003 (Fig. 1) (Energy Statistics, 2003; SIS, 2004; CBRT, 2004).

The objective of this study was to investigate and model the relationship between economic growth by means of GNP, energy consumption, and CO_2 emission and to present recommendations based on future estimates by considering the energy politics applied in last 30 years in Turkey. In addition, total energy consumption (TEC) and total CO_2 (TCO_2) emission models were developed to predict the energy consumption and CO_2 emission up to year 2015. The characteristics of the energy sector of Turkey, modeling techniques used in the study, and the results were given in following sections.

2. Energy sector in Turkey

A deficit between the production and the consumption of energy has always been reported in Turkey due to the population increase, economic growth, and the limited energy resources. Energy deficit is met by importing electricity and energy resources. The energy production and consumption in Turkey are depicted in Fig. 2.

Total energy production in this period increased by 70% and reached 24.7 mtoe while the consumption was 79 mtoe in 2003 with an increase rate of 415%. The share of the domestic energy production in TEC was 77% in 1970 and 31% in 2002. The increasing difference between the production and consumption means that the rate of energy import has been in an increasing trend (Energy Statistics, 2003).

The reason of the decrease in the production and the consumption of the energy could be attributed to the domestic economic recession. Regional and national economical problems can decrease the production in all sectors and this consequently results in a reduction in energy consumption. As seen in Fig. 1, decreases in energy consumption and CO_2 emission were observed when a decrease occurred in the GNP. For instance, in 1995, while the GNP decreased, energy consumption and CO_2 emission also declined (Fig. 1).

2.1. Energy resources

The energy sector is highly dependent on fossil resources in Turkey. The share of the fossil resources in TEC was 87.3% in 2002 (Energy Statistics, 2003). As depicted in Fig. 3, the main fossil resources are petroleum and coal. It is seen that natural gas use was markedly increased especially after year 1990.

The energy reserves of Turkey are summarized in Table 1. It can be seen that Turkey has a significant coal potential. This reserve is mostly used in thermic power

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