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Energy efficiency evaluation of provinces in Turkey using data envelopment analysis

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Abstract

Renewable energy is an indispensable alternative energy source due to the environmental benefits and price advantages over conventional energy sources. From global to local level in the world, all policy makers and strategic authorities are aware of the superiorities of renewable energy. Hence, there are enormous studies, action/master plans and researches about significance of renewable energy have been conducted to meet growing energy demand with green energy sources in a long term. Renewable energy potential of Turkey provides an advantage due to the climatic conditions. In this study, a nonparametric method and powerful benchmarking tool, Data Envelopment Analysis (DEA) has been utilized in order to analyze the renewable energy efficiencies of the each provinces (81 cities) in Turkey. According to the obtained results, investment decisions should be applied particularly, in inefficient regions to provide overall technical efficiency for future.

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Keywords: Data envelopment analysis; Efficiency analysis; Renewable energy; Strategic investment

1. Introduction

Turkey is one of the fastest growing countries in terms of population, urbanization and industrialization level according to IEA (International Energy Agency). All these indicators which are important signs of the economic

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expansion of countries that leads to increasing energy demand. Under this viewpoint, Turkey has been forced to carry out energy actions and strategic plans to respond rapid energy demand with domestic sources in a long term. In global energy market, Turkey's strategic position and geographic location make it an important energy player. Dependence on foreign energy sources is a major challenge for governments to sustain energy security and uninterrupted energy flow with a low cost. The over-dependence on oil and gas causes long term economic problems because energy costs constitute the largest share of imports (70 %). For this reason, investments on renewable energy resources should be increased substantially for economic independence and sustainability of energy. The climatic conditions of Turkey provide several advantages to obtain energy production from renewable energy sources when compared with other countries. The Turkish government has increased the share of renewable sources 30 percent to meet increasing energy demand by 2023 according to energy strategies, plans and regulations. To achieve this, energy investments have been encouraged with incentives and feed-in tariffs. Energy efficiency investments have gained much significance from the world over the past decades. In the literature, Data envelopment analysis (DEA) is a commonly used benchmarking tool in order to measure productive efficiency of decision making units (DMU) to show their performances in many managerial problems.

Data envelopment analysis (DEA) is a nonparametric method which first introduced by Farrell (1957) then developed by Charnes, Cooper and Rhodes in 1978. DEA is an easy applicable method, since it does not require any assumptions of the related function and it can handle multiple input and output variables of various units. Due to the several advantages, it has an extensive application area to analyze efficiency level of the organizations (companies). In the literature, lots of studies related to DEA have been broadly applied in the energy sector in order to evaluate the efficiency analysis of renewable energy power generation companies, and efficiency analysis of alternative renewable energy source technologies. Barros (2008) analyzed the total productivity of the hydroelectric plants using DEA in order to rank the plants according to their performances. Jha and Shrestha (2006) measured the performance of hydropower plants during 2001-2004 using DEA in Nepal. They considered the installed capacity, total operations and maintenance expenditure and the number of employees as inputs and three outputs which are energy generated by the plant, winter peaking capacity, and summer peaking capacity. Chien and Hu (2007) utilized DEA to compare renewable energy technology at the country level. They analyzed 45 countries according to technical efficiency and they have obtained that OECD countries have higher share on renewable energy sources than non-OECD countries. San Cristobal (2011) used DEA in order to evaluate renewable energy technologies and they have taken as inputs investment ratio, implement period, and O & M costs and they have considered power, operating hours, useful life, and the tons of C_2O avoided, as outputs. Kim et al. (2015) evaluated the investment efficiency of renewable energy technologies in Korea with DEA tool and they concluded that wind power is the most efficient renewable energy for policy makers. Woo et al. (2015) used DEA to measure environmental efficiency of renewable energy with Malmquist index between 2004 and 2011 years. Menegaki (2013) has taken into consideration energy inefficiencies of European countries with DEA model conducting panel data set.

According to the literature surveys, there are a few studies about analyzing efficiency of Turkish energy sector by utilizing DEA. Bagdadioglu et al. (1996) investigated Turkish electricity distribution sector to analyze performances of the publicly operated organizations utilizing DEA tool. Another study of Bagdadioglu et al. (2007) which analyzed efficient level of the merger of the companies using DEA model for the period 1999–2003. Ertürk and Aşık (2011) has evaluated the natural gas distribution companies by using a non-parametric method, Data Envelopment Analysis (DEA). Sözen et al. (2012) used DEA for efficiency analyses of hydro-power plants by implementing two various models which consist of multiple inputs and outputs to assess their relative performances. According to analyses, Gökçekaya hydro-power plant has the highest performance in both models.

In the literature, the most widely used inputs are the number of employees, transformer capacity and network length (Azadeh, Ghaderi, Omrani, & Eivazy, 2009; Yadav, Padhy, & Gupta, 2010). The most commonly used outputs are units of energy delivered, number of customers and size of service area in all efficiency analysis studies concerning distribution companies (Lins, Sollero, Calôba, & da Silva, 2007; Pombo & Taborda, 2006). Different from other studies in the literature, we have considered the renewable energy potentials of the regions as input and the gross energy generation from renewable sources is taken as an output variable, except for other variables, which are network length (input), total installed power of renewable energy (input), transformer capacity(input), number of consumer (output), respectively. The main objective is to measure of renewable energy efficiency of the regions according to renewable energy potentials.