The Analysis of Renewable Energy Researches in Turkey

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Abstract. The rapid consumption of limited conventional energy resources mobilizes many countries in the world against global energy crisis. As well as the energy crisis, the environmental pollution caused by existing energy sources also encourages the researchers to study in new energy technologies and also renewable energy resources. From this point of view, it is important for each country to identify its wind, solar, geothermal, biomass, hydro and other renewable energy potentials. Considering this urgent energy requirement, the researches and especially the academic studies have been increased on renewable energy resources to meet the energy demand by means of indigenous resources in each country. Consequently, the main purpose of this study is to analyze the academic studies in Turkey to find out the increment rate of researches, their publication years and the more focusing branch on renewable energy by illustrating the statistical distribution of these data. Automated Data Retrieval Methods have been employed to achieve data from Web of Science database and statistical analyses have been made by SQL server management studio program. The academic studies in all variety of renewable energy areas have a tendency to increase which indicates the importance ratio of renewable energy in Turkey.

1. Introduction
The energy requirement in the world is increasing day by day with the rapid consumption of limited conventional energy resources [1]. Since the reserves of gas, oil and coal are seepulfucked deep in the sea or ground, it is difficult, expensive and also dangerous to identify and unearth these reserves [2,3]. Furthermore, frequentative crises in energy and also global warming influence the quality of life adversely and this situation promotes the researchers to find out new energy sources or benefit from renewable energy resources [4]. People have been used renewable energy resources for different purposes from past to present. For instance, while the energy of wind and water were used simply for mechanical drive many centuries ago, they are still being used with high power turbines today [5]. Although technological developments are necessary to produce energy to compensate the energy requirements, both technological developments and energy requirements have been increased in the world for years. This situation is also valid for Turkey and the production of energy increases with the consumption of energy as can be seen from Table 1. Turkey is highly dependent on imported energy resources which influence its economy unfavorably. In other aspects, air pollution also constitutes an environmental concern in Turkey. Considering these disadvantages, renewable energy resources seems
to be the most productive and efficient for clean sustainable energy development. Turkey has quite convenient geographical location for using distinct kinds of renewable energy sources. The major resources are hydropower, biomass, biofuels, wind power, solar energy, and geothermal energy which will have provided most of Turkey’s renewable energy as for many of the world countries in the future [6,7].

Table 1. Actual and target values of energy production and consumption of Turkey in ktoe units.

| Energy sources      | Energy production and consumption (in parenthesis) of Turkey by years |
|---------------------|---------------------------------------------------------------------|
|                     | 2000       | 2005       | 2010       | 2015       | 2020       | 2025       |
| Hard coal and lignite| 17 202 (20 256) | 21 259 (30 474) | 28 522 (50 311) | 31 820 (83 258) | 39 385 (129 106) | 45 944 (296 997) |
| Oil and natural gas | 3408 (59 250) | 2127 (73 256) | 1735 (92 637) | 1516 (112 993) | 1604 (136 365) | 1455 (179 765) |
| Central heating     | 253 (253) | 495 (495) | 884 (884) | 1336 (1336) | 2018 (2018) | 2748 (2748) |
| Hydropower          | 3763 (3763) | 5845 (5845) | 7520 (7520) | 8873 (8873) | 9454 (9454) | 10 445 (10 445) |
| Wood and waste      | 6963 (6963) | 6760 (6760) | 6446 (6446) | 6029 (6029) | 5681 (5681) | 5393 (5393) |
| Geothermal          | 432 (432) | 1380 (1380) | 3760 (3760) | 4860 (4860) | 4860 (4860) | 5400 (5400) |
| Nuclear             | 0.0 (0.0) | 0.0 (0.0) | 3657 (3657) | 9143 (9143) | 18 286 (18 286) | 29 200 (29 200) |
| Solar               | 204 (204) | 459 (459) | 907 (907) | 1508 (1508) | 2294 (2294) | 3248 (3248) |
| Wind                | 55 (55) | 250 (250) | 620 (620) | 980 (980) | 1440 (1440) | 2134 (2134) |

Hydropower is the major energy supply for many of the countries as it provides one-fifth of the world’s power generation. Although it has a crucial role in electricity generation, the remaining potential in Turkey is almost vast at present [8]. Taking advantage of direct combustion process, biomass production, especially as wild plant growth, is quite common in many of the world countries [9]. Biomass energy is also one of the major resources in Turkey for about 52% of Turkey’s domestic energy consumption [10]. Biomass is a promising energy type for Turkey with its great potential providing from rural energy services. Several academic studies have been presented on biomass energy resources and its potentials in Turkey [11-13].

Although there are many challenges when environmental factors are taken into consideration in the site selection of the wind turbines, wind energy production has a significant place among other energy resources [14]. Among European countries, the highest share in wind energy potential belongs to Turkey but this share is relatively low when compared with the average wind energy potential of world [15]. Turkey has also a high potential in solar-energy when considering the yearly average solar-radiation and total yearly radiation period with the values of 3.6 kWh/m² day and ~2610 h respectively [5]. The prediction of solar-radiation in different cities of Turkey has been presented by many academic studies [16-19]. Finally, geothermal energy which contained as heat in the Earth’s interior, [20] is a widely used renewable energy source with a projected life of 30–50 years. [21]. It has a considerable potential in Turkey and is used generally in electricity generation which will be estimated as the most important field for using geothermal energy in the future [22].
Eventually, with the worry of finding alternative energy sources, the academic studies converge to renewable energy which has a vital importance to solve the energy crisis and environmental pollution in the world. [23]. The goal of this study is to analyze the academic researches to find out the increment rate of researches, their publication years and the more focusing branch on renewable energy by illustrating the statistical distribution of these data.

2. Methodology
A data retrieval method was used to provide automatic retrieval of information based on data placed into Web of Science database. This data retriever program reads the clipboard periodically to see whether new data has been placed therein. The program detects whether the data satisfies a predetermined criterion during new data search in the clipboard. The data retriever program also starts a data-retrieval operation as a web-based search based on data if the criterion is satisfied. But if it is not satisfied, the program does not perform any data-retrieval action [24]. This operating logic of Automated Data Retrieval Method provides us to achieve data from Web of Science database and statistical analysis has been made by utilizing SQL server management studio. Analysis values were transferred to Excel Power Pivot to extract the statistical distributions of the increment rate of the researches, their publication years and the more focusing branch on renewable energy.

3. Results and Discussion
The statistical distribution of the increment rate of academic researches on renewable energy, their publication years and the more focusing branch of the renewable energy in Turkey has been analyzed. The distribution of the total number of researches versus research years is shown in Figure 1.

![Figure 1](image)

**Figure 1.** The distribution of the academic researches versus years on renewable energy is presented in a. The same data is presented cumulatively in b.

As seen from Figure 1, the academic studies in all types of renewable energy areas increase with the passing years. The increment rate of the academic researches by years can be attributed to the energy requirement increase in Turkey. Identifying the most focusing type of renewable energy among the total number of academic researches is also important when the increment of the academic researches over the years is considered. Figure 2 represents the total number of academic researches on different types of renewable energy in Turkey. The most studying research area up to now is bioenergy as seen from Table 2, but it must be noted that bioenergy also includes the energy types such as biofuel, biomass, biogas and etc. For this reason, the number of academic studies on wind energy and hydropower appear to be remarkable, and even impressive.
Figure 2. The total number of academic researches on different types of renewable energy in Turkey.

The distribution academic studies over years on distinct types of renewable energy forms are given separately in the following figures given with Figure 3 label.
The number of academic researches on all types of renewable energy forms increases by years as presented in Figure 3. This situation mostly valid for especially solar energy, wind energy and also hydropower and this can be interpreted as the energy requirement in Turkey emerges to these areas in recent years.

The environmental pollution caused by existing energy sources is also critical issue which should be handled in academic manner. The studies on environmental pollution were also statistically analyzed and the distribution of these studies by years is given in Figure 4. The distribution in Figure 4 can be defined as the sensitivity to environmental pollution increases in direct proportion to the interest in renewable energy sources by years.

**Conclusion**

The analysis of renewable energy resources in Turkey is strategically important when considering its variety of utilizable energy sources. The sustainable economic development and also the standard of living quality are directly related with energy resources. Turkey has not efficiently evaluated many of its renewable energy sources for some reasons such as technical, economic and also lack of researches. The increment of energy requirement with each passing day in the world and also in Turkey will also require an increase in researches on renewable energy resources. From this point of view, the academic studies on the subject of renewable energy in Turkey have gained a great importance to meet and support this energy requirement. This study concluded the statistical data analyses of the researches and academic studies in Turkey which were extracted from Web of Science database to reveal the importance academically given to the renewable energy resources. The academic studies in all types of
renewable energy areas have a tendency to increase which indicates the importance ratio of renewable energy in Turkey. The scientific correlation of the data uncovered the importance order of these areas by analyzing the statistical distribution of data. Consequently, the academic studies in Turkey on renewable energy forms and also environmental pollution caused by existing energy sources, increase with the increment of energy requirement in recent years.

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