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Evaluation of Renewable Energy Sources and Sustainable Development Planning of Turkey

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Abstract: The aim of this study is to analyse the possibility of using of the renewable energy sources and to find out the using for solving environmental problems in Turkey. Because at present, the preference of energy systems should be made according environmental conditions for sustainable development. The renewable energy resources, with having an important share in the sustainable development of Turkey constitute this studies' material. In this study also, the native and foreign literatures, related to use of non-renewable sources and landscape planning studies, were used as a materials. The study was carried out in some stages by collecting and analyzing data. Natural and cultural properties were also determined by surveys and data obtaining and on-site observation and measurement. The importance of the primary energy production and consumption of Turkey were emphasised. Throughout the paper several issues relating to renewable energy, environment and sustainable development are examined from both current and future perspectives in Turkey.

Key words: Sustainable development, renewable energy, landscape planning, Turkey

INTRODUCTION

Environmental problems have raised since 1930's of Industrial Revolution, its intensity has been increasing. Excessive use of non-renewable sources depending on increasing needs of energy day by day causes significant environmental pollution and extinction of the sources. This excessive use of the sources threatens the future of earth. For this reason, at the Stockholm Conference organized first time in 1972, then on the report called 'Our Common Future' which was prepared by the World Environment and Development Commission, the term of 'Sustainable Development' was regarded as a precaution against the world's anxiety to the future.

Sustainable development has the meaning of programming the development and the life of present and the future, in the art of supplying the needs of the future generation without exploiting the natural resources and also through setting up the balance between mankind and nature. Sustainable development is a term that includes social, ecological, economical, spatial and cultural aspects (Yildirim and Tas, 2000). Rapid growth mentality that causes excessive exploitation in the ecological balance has recently brought the "sustainable development" into the agenda. Briefly, the basis of sustainable development is using the natural resources minimally. It is stated that the energy need of our world inhabited by over 6 billion people, is increasing every year approximately 4-5%; whereas, the non-renewable energy used to meet the needs is rapidly decreasing. It has been realised that especially in the second half of the 20th century, the use

of non-renewable energy has affected the environment negatively. The production, consumption and waste of the energy cause a risk to the natural resources. This risk causes basic natural resources such as air, water and soil to be polluted (Dincer, 2000; Rabago *et al.*, 2001; Thomas *et al.*, 2002).

Problems with energy supply and use are related to global warming, air pollution, acid precipitation, ozone depletion, forest destruction, and emission of radioactive substances. The increase in greenhouse gases in the atmosphere and the associated potential global warming and climate change represent one of the greatest environmental dangers of our time. The anthropogenic reasons of this impending climate change can, for the greater part, be attributed to the use and combustion of fossil primary energy sources and the CO₂ emissions associated with this (Dincer, 2000; Barrow, 1991).

The unplanned urbanization and industrialization which started in 1950s and accelerated in 1980s, the rapid rise of population that developed parallel to them, caused increasing demand of energy. In the developing countries, energy consumption has risen rapidly in accordance with increase in economical growth in the last decades. This trend is expected to be gone one in the near future. Increasing demand has resulted in increase in supply and due to the non efficient use could cause serious economical, environmental and social problems. Also it has been measured that the rapid development has resulted in deterioration of the environment such as deforestation in ecology and health risk due to air pollution (Dincer, 2000).

This study has been presented to focus the renewable energy resources of Turkey and to discuss the sustainable developments and environmental problems.

MATERIALS AND METHODS

The renewable energy resources, with having an important share in the sustainable development of Turkey constitute this studies' material. In this study also, the native and foreign literatures, related to use of non-renewable sources and landscape planning studies, were used as a materials. Natural and cultural properties were also determined by surveys and data obtaining (maps, photographs, plans, documents, internet and interviewing authorities) and on-site observation and measurement.

The target of the research was to come with the renewable energy potential of Turkey. The research was conducted between 2003 and 2004 in Turkey. The method of this study constitutes from the different steps. In the first phase, the renewable energy potential of Turkey were analyzed with searching of the native and foreign literatures. In the second phase, the importance of the primary energy production and consumption of Turkey were emphasised. In the last phase, some suggestions were also given for the future renewable energy projects and sustainable development in Turkey.

RESULTS

Important renewable energy resources present In Turkey

Hydraulic energy: Hydraulic energy is a kind of energy that is obtained through the transformation of potential energy into kinetic energy. It is the most important resource energy because of its meeting the 10% need of the energy demand of the world.

Turkey has a total hydropower potential of 433 GW that is equal to 1.2% of the total hydropower potential of the world and to 14% of European hydropower potential. Only 125 GW of the total hydroelectric potential of Turkey can be economically used. By the commissioning of new hydropower plants, which are under construction, 34% of the economically usable potential of the country would be tapped. At the present, hydropower energy is an important energy source for Turkey due to its useful characteristics such as being renewable, clean, and having less impact on the environment, and being a cheap and domestic energy source (Kaygusuz, 1999).

Solar energy: Solar energy is in fact a inexhaustible natural resource. Turkey, located in 36° and 42°N latitudes, is in the solar zone (Fig. 1). Average annual temperature

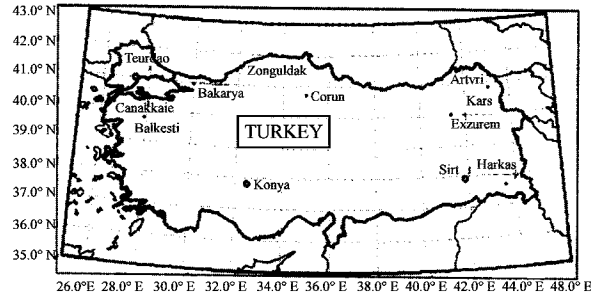


Fig. 1: Solar-radiation stations in the Turkey (Sozen and Arcaklioglu, 2005)

is 18 to 20°C on the south coast, falls to 14-16°C on the west coast and fluctuates between 4 and 18°C in the central parts. The yearly average solar-radiation is 3.6 kW h m⁻² day, the total yearly radiation period of Turkey is ~2610 h. Annual solar energy that exposes the land in Turkey is approximately 977×10¹² kW h. In case necessary investment is done, Turkey can produce nearly 1500 kW h annually from the unit meter square of its land. It has been calculated that Turkey receives sunlight equivalent to roughly 11 thousand times the amount of electricity generated in Turkey in 1996 (Sozen and Arcaklioglu, 2005; Sozen *et al.*, 2004).

Wind energy: Wind is defined as the air mass changes due to the differences of temperature and pressure in the atmosphere. Wind energy has been produced through wind turbines, wind farms and wind machines and it has been seen that it can be used effectively. Wind energy potential of the world is 4×10¹⁵ kcal, but only the 5 % of it, is useful. The cost of wind energy is 4.3-6.6 cent/kW h. This makes it the cheapest energy resource among other types (Sen, 2000).

It has been determined that in Turkey, the annual wind speed is 2.54 m sec. and density of wind power is 24 W m⁻². When taken into consideration that wind speed has to be higher than 3 m⁻¹ sec. in order to use wind energy for basic purposes, it can be said that in the 20% area of Turkey it is possible to make use of wind energy. The wind energy in Turkey is theoretically over 200 billion kW h. (Onat *et al.*, 2000).

There are a number of cities in Turkey with relatively high wind speeds. These have been classified into six wind regions, with a low of about 3.5 m s⁻¹ and a high of 5 m s⁻¹ at 10 m altitude, corresponding to a theoretical power production between 1000 and 3000 kW h/(m² y). The most attractive sites are the Marmara Sea region, Mediterranean Coast, Aegean Sea Coast and the Anatolia inland (Sen and Sahin, 1997; Borhan, 1998; Oztopal *et al.*, 2000).

Table 1: Primary energy production of Turkey TEP (Thousand tons of oil equivalent) (Anonymous, 1996, 2000, 2003; TEAS, 2000)

	1993	1994	1995	1996	1997	1998	1999	2000
Coal	1.722	1.636	1.319	1.382	1.341	1.143	1.030	1.159
Lignite	9.790	10.471	10.735	10.876	11.598	12.792	12.242	12.171
Asphalite	37.000	0.000	29.000	15.000	13.000	10.000	12.000	9.000
Natural gas	182.000	182.000	166.000	187.000	228.000	514.000	665.000	581.000
Petroleum	4.087	3.871	3.692	3.675	3.630	3.385	3.087	2.886
Other	67.000	92.000	116.000	154.000	207.000	253.000	176.000	1.192

Table 2: Primary renewable energy production of Turkey TEP (Thousand tons of oil equivalent) (Anonymous, 1996, 2000, 2003; TEAS, 2000)

	1993	1994	1995	1996	1997	1998	1999	2000
Hydraulic	2.921	2.630	3.057	3.477	3.424	3.632	2.982	2.657
Wood	5.451	5.482	5.512	5.512	5.512	5.512	5.293	5.081
Animal and plant waste	1.697	1.627	1.556	1.533	1.512	1.471	1.502	1.376
Geothermal	67.000	68.000	74.000	72.000	71.000	73.000	70.000	65.000

Table 3: Primary non-renewable energy consumption of Turkey TEP (Thousand tons of oil equivalent) (Anonymous, 1996, 2000, 2003; TEAS, 2000)

	1993	1994	1995	1996	1997	1998	1999	2000
Coal	5.834	5.512	5.905	5.357	7.388	8.921	7.634	10.450
Lignite	9.918	10.330	10.570	12.150	12.280	12.630	12.310	13.260
Asphalite	37.000	0.000	29.000	15.000	13.000	10.000	12.000	9.000
Natural gas	4.630	4.921	6.313	7.186	9.165	9.419	11.740	13.320
Petroleum	28.410	27.140	29.320	30.930	30.630	30.580	33.230	32.590
Other	67.000	92.000	116.000	154.000	207.000	250.000	174.000	1.992

Table 4: Primary renewable energy consumption of Turkey TEP (Thousand tons of oil equivalent) (Anonymous, 1996, 2000, 2003; TEAS, 2000)

	1993	1994	1995	1996	1997	1998	1999	2000
Hydraulic	2.921	2.630	3.057	3.477	3.424	3.632	2.982	2.656
Wood	5.451	5.482	5.512	5.512	5.512	5.512	5.293	5.081
Animal and plant waste	1.697	1.627	1.556	1.533	1.512	1.471	1.602	1.376
Geothermal	67.000	68.000	74.000	72.000	71.000	73.000	70.000	65.000
Other	67.000	92.000	116.000	154.000	207.000	250.000	174.000	1.992

Table 5: Energy production, consumption, imports and exports of Turkey (Anonymous, 1996, 2000, 2003; TEAS, 2000)

	1993	1994	1995	1996	1997	1998	1999	2000
Production	26.020	26.050	26.250	26.920	27.530	28.780	27.050	27.97
Consumption	59.840	58.670	63.210	66.880	71.490	74.110	76.690	82.27
Imports	36.180	35.340	39.770	41.820	45.620	48.320	52.500	5587.00
Exports	2.254	2.280	1.947	1.883	1.630	2.398	2.791	1.584

Geothermal energy: Turkey has one eighth of the world's geothermal potential and is ranked 7th in the world. Turkey, located in an intersecting position between the continents Euro-Asia and Africa, is among the lucky countries from the aspect of geothermal existence. Geothermal energy is an energy resource that can be used in its place and its transfer to far distances is limited (about 100 km max.). The geothermal energy potential of Turkey is estimated as 5000 MW electricity and 30,000MW heat usage. There are 26 geothermal district heating systems existing now in Turkey. Main city geothermal district heating systems are in Gonen, Simav and Kırsehir cities (Sahin *et al.*, 2000; Anonymous, 1996; Hutterer, 2001).

Energy production and consumption of Turkey: Especially after the 1950s in Turkey, energy consumption which increased parallel to industrialization, urbanization and rapid population increase, the dimension of energy consumption has reached a higher level than local resource production.

The major non-renewable energy production of Turkey according to years are shown in Table 1 (Anonymous, 1996, 2000, 2003; TEAS, 2000).

The major renewable energy production of Turkey according to years are shown in Table 2 (Anonymous, 1996, 2000, 2003; TEAS, 2000).

The major non-renewable energy consumption of Turkey according to years are shown in Table 3 (Anonymous, 1996, 2000, 2003; TEAS, 2000).

The major renewable energy total consumption of Turkey according to years are shown in Table 4 (Anonymous, 1996, 2000, 2003; TEAS, 2000).

Sustainable development: The nature and structure of the global energy industry is likely to change significantly in the 21st century. This is driven by a number of factors, including activities related to sustainable development (Rabago *et al.*, 2001). Energy is considered a prime agent in the generation of wealth and also a significant factor in economic development. The importance of energy in economic development has been recognized almost

universally. The historical data attest to a strong relationship between the availability of energy and economic activity. During the past two decades, the risk and reality of environmental degradation have become more apparent. Growing evidence of environmental problems is due to a combination of several factors, since the environmental impact of human activities has grown dramatically because of the sheer increase of world population, consumption, industrial activity etc. Achieving solutions to the environmental problems we face today requires long term potential actions for sustainable development. In this regard, renewable energy resources appear to be one of the most efficient and effective solutions. That is why there is an intimate connection between renewable energy and sustainable development (Dincer, 2000; Kaygusuz and Sarı, 2003).

Although the concept of sustainable development has had a considerable impact worldwide, as well as in Turkey, it is also true, on the other hand, that, it has not yet been able to realize the desired change and transformations in practical life. A secure supply of energy is resources is generally agreed to be a necessary but not sufficient requirement for development within a society. Furthermore, sustainable development demands a sustainable supply of energy resources are readily.

Energy saving which can be defined as minimizing the consumption of energy amount through energy productivity increase, prevention of present energy losses and profitable use of energy waste without hindering the economical development and the social welfare, will greatly contribute the energy needs to be met in Turkey. The needs of human communities and their economic causes an impact that is continuously increasing which resulted in abuse of resources. However, the increase in resource damage and the irreversible losses needs to be taken precautions at various levels.

The total energy production, consumption, imports and exports of Turkey according to years are shown in Table 5 (Anonymous, 1996, 2000, 2003; TEAS, 2000).

DISCUSSION

Urbanization and industrialization in Turkey has been very rapid during the last three decades and due to high rate population increase and industrial growth extensive pressure has been put on natural resources. Consequently, problems related to environmental pollution have been of public concern in recent years. Turkey is faced with increasing problems of environmental pollution.

There are a number of environmental problems that world face today. These problems span a continuously growing range of pollutants, hazards and ecosystem degradation over wider areas. Renewable energy

resources and their utilization are intimately related to sustainable development.

For Turkey, it is necessary to meet energy requirements with national resources as much as possible and to use new technologies which eliminate the adverse effects of energy production on the environment. Current international developments in the fields of technology transfer research development programs; education; financing and co-ordination have been followed and adopted to the country's conditions.

Whereas the major energy demand in Turkey being met with the local production has been estimated as 46% in 1995; it is calculated that this proportion will drop to 38% in 2010. Therefore; Turkey has to start using its renewable energy resources immediately. Turkey is a rich country from the aspect of renewable energy, but can still not make use of this advantage. The usage of wind, solar and geothermal energy resources will help the prevention of environmental pollution, but appropriate energy resources should be chosen for each region and studies on the infrastructure should be carried on. For instance, whereas wind energy will be suitable for the coastal area of Marmara Region, it would be more appropriate to use geothermal and solar energy for some parts of the Aegean Region.

Thus, long-lasting strategies should be formed. If we list the long-lasting strategies, these would be as stated below;

- Renewable energy should be introduced, and its use should be highlighted for the prevention of the extinction and exploitation of the natural resources in a short period.
- Inventory of renewable energy resources should be formed in order to provide the sustainability, development and protection of the natural resources.
- It should be aimed to raise the welfare of a nation through the prevention of environmental pollution.

Constructing the required substructures and legal arrangements, the participation of private and foreign investments in the electrical energy sector should be encouraged (Salvarlı, 1998).

Legislation applications have been improved. The difficulties in implementation of regulations have been reviewed by providing the necessary co-ordination with the relevant authorities (Tutunlu *et al.*, 2000).

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