Sustainable Developments and Energy Strategies in Turkey

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Abstract: Fossil fuels have been used as energy source which is used in a variety of fields such as running factories, transportation, electricity generation and also homes and buildings, since the Industrial Revolution. As the energy consumption is strongly related with the living standards and development of the countries, new energy sources should be created. This is also necessary because of the causing global warming, climate change, melting of ice caps, and increase in sea levels, ozone layer depletion, acid rains, and pollution of fossils. Country such as Turkey is developing and thus energy consumption getting larger, needs to develop new strategies for energy in order to compensate this energy need. For the purpose of this study, Turkey is considered as representative of the various spectra of development in the continent and a review is presented on the energy policy of Turkey and how far these policies are meeting up to the challenges of sustainable developments.

Keywords: Energy policy, sustainable development, Turkey.

Introduction

Sustainable development has been at the center of recent policies and development plans of Turkey. This is a pattern of development that delivers basic environmental, social and economic services without threatening the viability of natural, built and social systems upon which these services depend. In terms of development indices, energy consumption is a recognized indicator. With its geographical position, Turkey connects Europe to Asia. It has a surface area of 783 562.38 m^2. The current population of the country is over 70 million and the annual population growth rate is about 1.73%, which is 5 times higher than that of the European Union (EU) average. Moreover, the country has a young population with an average age of 26. The country has a very dynamic economy. As a net effect of these factors, Turkey's energy demand is growing rapidly and is expected to continue grow in near future. Turkey has made strong efforts to integrate to the EU and compete more effectively in world politics both socially and economically. Up to now, Turkey has taken steps towards sustainable economic and social development and towards closer relations with the EU. But these aims cannot be achieved without a stable basis, which before all else requires the development of the infrastructure, one of the most significant input of which is the energy sector. Although Turkey has a wide range of energy resources, these resources are limited. Since, Turkey is an energy importing country, more than about 60% of energy consumption in the country is met by imports and the share of imports continues to grow each year. Therefore, it is critical to supply its energy demand by using domestic nonrenewable resources (such as lignite, hard coal, oil and natural gas) and renewable resources (Kaygusuz & Turker, 2002). The aim of this paper is to describe the various energy policies adopted in Turkey to ensure long-term reliability and security of energy supply. The roles of both, non-renewable and renewable sources of energy are discussed. Apart from that, this paper is described the various alternative energies and the implementation of energy efficiency program in Turkey.

Sustainable Development and Energy System

Energy constitutes one of the main inputs for sustainable economic and social development. Energy consumption is increasing simultaneously with increasing industrialization, population, urbanization, and technological improvement. In order to achieve a sustainable development, which supports economic and social development, energy supply and demand at minimum amount and cost with the minimum destructive effect on the environment should be set as the main objective. The sustainability of the mainstream development model of industrialization requires a transition to a sustainable energy system in which the production and use of energy at least compatible with long-term human well-being and environmental limits (Spalding et al., 2005). A sustainable energy system comprises two core components. The first is increased efficiency in the production, distribution and end-use of energy. The second is the introduction of energy conversion technologies that reduce or eliminate environmentally impacts (Dincer & Mark, 1999).

In an effort to adapt the principles of sustainable development to the energy system, many questions are arising. Mostly, the concern is what the best policy should be, in order to take into account the present needs but also satisfy our sense of commitment to future generations. A global and local long term vision is crucial. Today, the maturity of the technology seems to provide improved energy efficiency and to take advantage of the renewable energy sources. By changing the structure of the current energy production system, a first step towards sustainability is made, keeping in mind of course that it is not only the production that should be changed but also the current patterns of energy consumption.

The major components of a successful strategy for sustainable development include changing present energy production and consumption patterns, diversifying energy sources and the structure of power production and establishing an energy structure that is less or not at all harmful to the environment. Furthermore, the energy industry is fundamental to the national and global economy and is of critical importance to socioeconomic development and the improvement of human living standards (Afgan et al., 1998). The sustainability concept should, therefore, reflect not only concern about the shortage of natural resources and environmental protection but also should be closely correlated to the society needs and economical development.

The successive petroleum crises and the need for protection of natural resources and protection of the environment as the vital habitat of man impose systematic promotion of large scale plants for the exploitation and operation of renewable energy sources (Maria & Tsoutsos, 2004). At the same time, other precautionary measures, such as energy saving or informing and awareness of the consumer, were promoted. Much of today's energy activities are unsustainable because they fail in terms of equity as well as environmental, economic, and geopolitical realities. This reality seems to be more critical in developing countries as Turkey.

The continuously increasing energy demand is directly connected not only to the population increase and to the configuration of new conditions on a social level and economical status but also to the improvement of living standards. Continuously increasing energy needs in Turkey are completely covered by and will continue to be covered in the short term, to a large extent, by petroleum with the self evident consequence of an increase in CO_2 emissions and sea pollution near the power station.

Sustainable development demands a sustainable supply of energy resources. Supplies of energy resources such as fossil fuels (coal, oil, natural gas) and nuclear fuels (uranium and thorium) are generally acknowledged to be finite; other energy sources such as solar, hydropower, biomass and wind are generally considered renewable and therefore sustainable over the relatively long term (Dincer & Rosen, 1998). Sustainable Energy Development Strategies typically involve three major technological changes: energy savings on the demand side (Blok, 2005), efficiency improvements in the energy production (Lior, 2002), and replacement of fossil fuels by various sources of renewable energy (Afgan & Carvalho, 2004). Consequently, large-scale renewable energy implementation plans must include strategies for integrating renewable sources in coherent energy systems influenced by energy savings and efficiency measures (Hvelplund, 2006).

The Role of Energy in the Sustainable Developments in Turkey

Energy constitutes one of the main inputs for economic and social development. Its consumption increases parallel to increase in population, urbanization, industrialization, spreading of technology, and living standards. A secure supply of energy 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. The implications of these statements are numerous, and depend on how sustainable is defined. One important implication of these statements is that sustainable development within a society requires a supply of energy resources that, in the long term, is readily and sustainable available at reasonable cost and can be utilized for all required tasks without causing negative societal impacts. Supplies of such energy resources as fossil fuels and nuclear fuels are generally acknowledged to be finite; other energy sources such as solar, hydropower, biomass and wind are generally considered renewable and therefore sustainable over the relatively long term (Dincer & Rosen, 1998). A second implication of the initial statements in this section is that sustainable development requires that energy resources be used as efficiently as possible. In this way, society maximizes the benefits it derives from utilizing its energy resources, while minimizing the negative impacts (such as environmental damage) associated with their use. This implication acknowledges that all energy resources are to some degree finite, so that greater efficiency in utilization allows such resources to contribute to development over a longer period of time, i.e., to make development more sustainable (Ozturk, 2008).

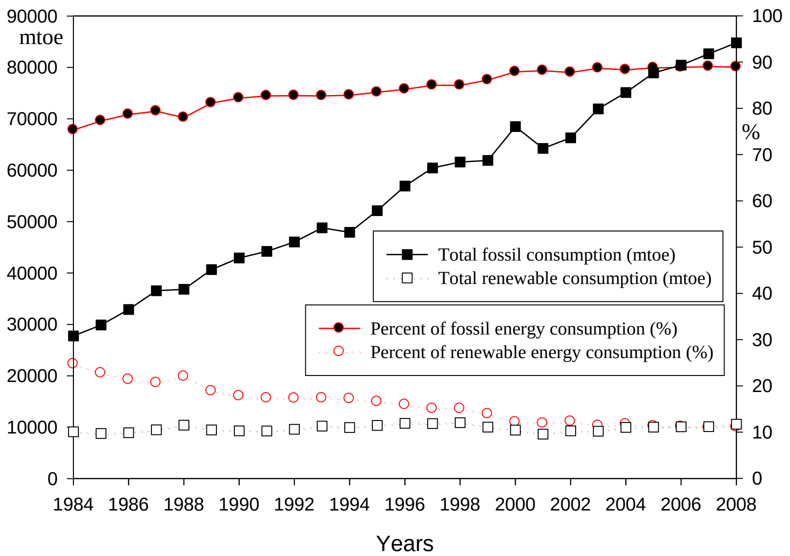

Figure 1: Total fossil and renewable energy consumption and percent of total energy consumption in Turkey, adapted from (WEC, 2008)

Even for energy sources that may eventually become inexpensive and widely avail-able, increases in energy efficiency will remain sought after to reduce the resource requirements (energy, material, etc.) to create and maintain systems and devices to harvest the energy, and to reduce the associated environmental impacts. Although renewable energy consumptions in Turkey is nearly stationary from 1984 to 2004 as seen in Figure 1, percent of renewable energy consumption in total energy consumption is increased from nearly 26 to 16, respectively in indicated years. Turkey has annual growth potential above 7% and a fast growing energy demand due to the rapid increase in population and development in industry. With Total Primary Energy Supply (TPES) growth rates of 4% to over 5% per annum and Total Final Consumption (TFC) growth of around 4% over the last three decades, Turkey is among the fastest growing energy markets in the world (IEA, 2001).

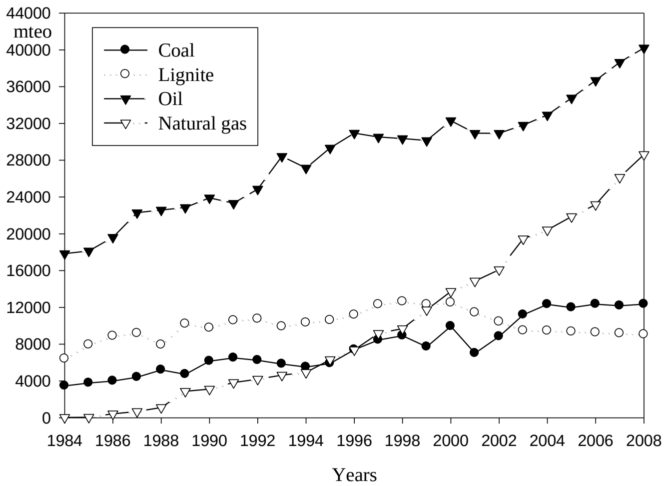

Figure 2: Fossil energy consumption in Turkey (mtoe), adapted from (WEC, 2008)

The energy demand of Turkey will be doubled between the years 2000–2010 and will be fivefold between 2000 and 2025. This rapid increase in demand is due to the high economic development rate of Turkey. The estimated amount of investments for the production facilities by the year 2010 is around 45 billion dollars. Transmission and distribution facilities will require an additional 10 billion dollar investment in the same period. The government has undertaken measures to attract local and foreign private sector for new investments, and also to transfer operational rights of existing units to the private sector for their renewal and efficient operation (WECTNC, 1999). The major part of the energy demand has been met through oil and natural gas imports, as seen see in Figure 2, although the country has considerable potential of renewable energy sources. For example, in 2008, nearly 70% of the energy sources were imported and only about 30% of the primary energy demand was met by Turkey's own energy resources, see Figure 2 and 3. Major domestic energy resource in Turkey is coal, while natural gas and petroleum are considerably limited. Thus, Turkey has to import petroleum and natural gas, and its dependence on foreign resources is constantly increasing.

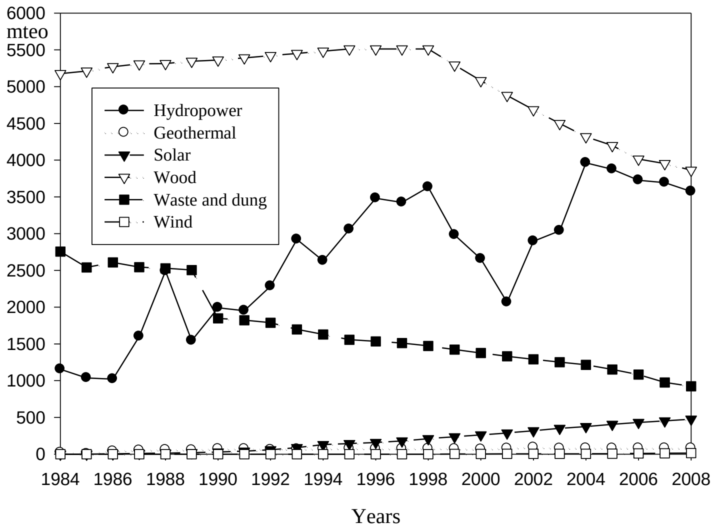

Figure 3: Renewable energy consumption in Turkey (mtoe), adapted from (WEC, 2008)

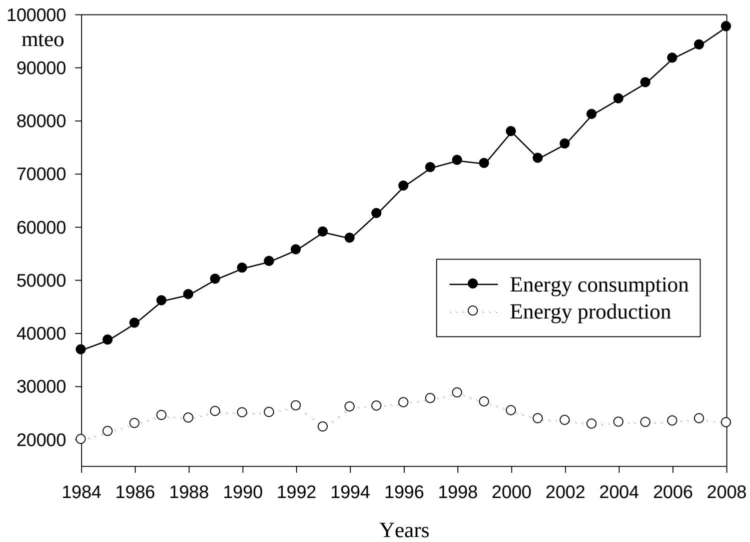

Figure 4: Energy consumption and production in Turkey, adapted from (WEC, 2008)

Wide gap between energy consumption and production is observed for Turkey (see Figure 4). In 2008 primary energy production and consumption has reached 23,210 and 98,079 million tons of oil equivalents (mtoe), respectively. The main reason for this deficit is attributed to high increase in population and economic growth, despite limitations in the domestic energy resources of Turkey. The most significant developments in production are observed in hydropower, geothermal, solar energy and coal production. Turkey's use of hydropower, geothermal and solar thermal energy has increased since 1990.

Sustainable Energy Sources and Policy in Turkey

Throughout the years, Turkey has formulated numerous energy-related policies in order to ensure the long-term reliability and security of energy supply for sustainable social-economic development in the country. Turkey's energy policy is based on the following items:
√ Meeting long term demand using 2P and F (public, private, and foreign) capital
√ Privatization activities, especially accelerating privatization activities, in the energy sector
√ Taking into consideration supply costs of energy imports, especially oil and natural gas
√ Ensuring optimum development of all the indigenous energy sources
√ Ensuring sustainable operation of the energy utilizations
√ Ensuring rational use of total energy sources
√ Ensuring environmentally sound sustainable energy development programs causing minimum damage to the environment
√ Meeting demand as much as possible through domestic resources
√ Diversifying energy supplies and avoiding dependence on a single source or a country
√ Adding renewable sources (geothermal heat, solar, wind, etc.) as soon as possible to the energy supply system
√ Ensuring sufficient, reliable and economic energy supplies on time
√ Ensuring energy security of supply
√ Implementing measures for energy efficiency
√ Planning energy research and development activities to meet requirements for increasing energy demands
√ Minimizing losses in energy production, transmission, distribution and consumption in the country
√ Protecting the environment and public health in the production of energy

Coal and Lignite

Being the cheapest and most abundantly available fossil fuel, coal will always have a role in the energy mix of a particular country. The increasing energy import of Turkey is a sign of country's not being able to meet the demand through national energy resources. Taking into account the low quality and the negative impact on the environmental pollution, utilization of lignite as the most abundant primary natural resource is not the solution of a sustainable energy policy. Additionally, the total lignite reserves of Turkey are 8075 mtoe (WECTNC, 2003). 25.5% of these reserves are estimated to be consumed by the end of year 2010. Taking into account that about 63% of the reserves have very low calorific values, it is possible that they are completely depleted by year 2060. Due to the abundance and stable price of coal, it has been and will continue to be an essential component of long- term sustainable development, not only in Turkey but also the world. Turkey has both hard coal and lignite reserves. Turkey's total fossil fuel reserves are 2454 mtoe and 48% of this amount belongs to lignite, 15% is Elbistan lignite and 28% is hard coal, as shown in Figure 5.

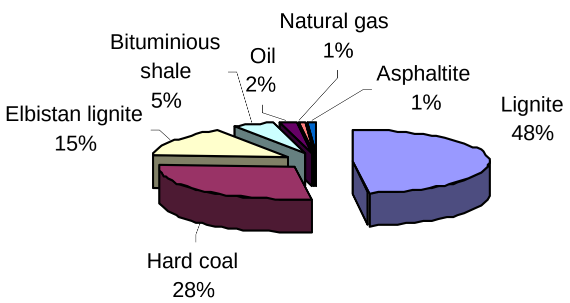

Figure 5: The share of hard coal and lignite among Turkey's fossil fuel reserves

Although coal is projected to play a far more important role in the energy mix, nevertheless, its utilization faces several major challenges. Among some of them are the emissions of green house gasses and air pollutants such as sulfur dioxide (SO_2) and oxides of nitrogen (NO_X). The major part of Turkish lignite reserves has low calorific value and contains high amount of ash. 85% of the reserves have more than 20% ash value. 68% percent of Turkish lignite has low calorific value, which is under 2000 kcal/kg, and only 3.4% (264 mt) has a calorific value greater than 4,000 kcal/kg. Additionally, more than half of the reserves have 2- 3% sulphide content. An important part of Turkish lignite reserves are not at the standards of industrial usage. Thus, the environmental problems associated with coal must be closely studied to find new ways to overcome these problems. Fortunately, technological advances achieved in the recent years have made coal a much cleaner fuel today. In particular, significant increases in thermal efficiency and reductions in sulfur and nitrogen oxides and particulate emissions have been achieved. With the right technology, the process of coal extraction, movement and more efficient combustion system will help to reduce the environmental concerns associated with the use of coal for producing electricity. In this context, Turkey will remain committed to the goals of sustainable development and thus measures will be continuously improved to ensure that the production and utilization of coal will meet environmental standards. Clean-coal technology, which includes electrostatic precipitators and flue gas desulphurization technology for air pollutants emission control, will be utilized in the new coal-fired power plants to ensure that environmental standards are met. However, the installments of gas cleaning technology will increase the capital costs of the power plant. For instance, the installation of a wet-type flue gas desulphurization that has an efficiency of removing more than 90% of the SO_2 produced will add an additional US$ 80–150/kW to the capital cost (Kataoka, 1992).

Natural Gas

Turkey's natural gas reserves are similarly limited. They were estimated to be 20.3 billion m^3 (Bcm), the 10.2 Bcm of which is available recently. The reserves are situated in the Thrace region, around Bayramsah, Danismen, Osmancik, Sogucak, Hayrabolu, Hamitabat, Karacaoglan, Kandamis, Karacali, Kumrular, Umurca, Silivri fields and in the Southeastern Anatolia around Camurlu, Katin, Derin Barbes, G. Dincer, and G. Hazro fields. The highest amount of natural gas suppliy is provided form the Hamitabat region, with 83% share. Natural gas imports increased parallel to increasing demands. In 2002, the domestic production could only supply the 2.3% of the overall demand that had reached 17.2 Bcm. In 1985, Turkey signed its first natural gas purchase contract with Russia, after which the imports of gas increased drastically. To date natural gas consumption has 11% share among other utilized energy resources.

Oil

One major non-renewable primary energy source, which is mainly imported by Turkey, is petroleum. Petroleum reserves of Turkey, which are mainly located in Hakkari Basin, are estimated to be 954 mt and 156 mt of the reserve is available for production. According to estimations, Turkey will consume the remaining 39 mt of the reserve completely by 2020; the 117 mt has already been consumed. The 90% of the country's demands are met through imports mainly from Saudi Arabia, Iran, Iraq, Syria, Libya, Egypt, Algeria, and Russia. The energy fulfilled by oil, constitutes about 40% of Turkey total energy demand. This number has been decreasing since utilization of natural gas started to accelerate.

Renewable Policy and Energy Resources in Turkey

Renewable energy sources are replenished naturally and their use has minimal environmental impacts. Renewable energy sources include wind power, solar energy (thermal and photovoltaic), hydropower, biomass and geothermal. Because of their nature, renewable energies are considered to be sustainable development technologies (Hart, 1997). The use of renewable energy technologies can lead, as stated before, to the birth and development of sustainable developments. Although the use of renewable energy resources has a lot of benefits, it faces numerous challenges. Firstly, the development of technology to convert the renewable energy resources into usable forms is still not that established. Although it was reported by several research and studies that there is a technical feasibility in the generation of energy from renewable resources, but the commercialization of research findings has not been fully undertaken on a large scale. Secondly, the high cost of renewable energy generation faces stiff competition from cheaper alternative energy such as from fossil fuels. For instance, the electricity costs from biomass, geothermal and solar sources are within the range of US$ 7–25 cents/ kWh, compared to the conventional (coal, natural gas, etc.) electricity costs of US$ 4–6 cents/kWh (Hitam, 1999).

The development of renewable energy technology is now widely seen as important if the world is to move towards a sustainable approach to energy generation. However, there are a range of obstacles facing the rapid development of these technologies: they are trying to establish themselves in an outdated institutional, market and industrial context. The development of renewable energy in Turkey is still in the early stage. Turkey's geographic location has several advantages for extensive use of most of the renewable energy sources. It is on the humid and warm climatic belt, which includes most of Europe, the near east and western Asia. A typical Mediterranean climate is predominant at most of its coastal areas, whereas the climate at the interior part between the mountains that are a part of the Alpine–Himalayan mountain belt is dry with typical steppe vegetation. This is mainly because Turkey is surrounded by seas on three sides: the Black sea to the north, the Marmara sea and Aegean sea to the west and the Mediterranean sea to the south (Kaygusuz, 2002). The average rainfall nationwide is about 650 mm, but this average masks large variations, from about 250 mm in the central and southeastern plateaus to as high as 2500 mm in the northeastern coastal plains and mountains. In the western and southern coastal zones, a subtropical Mediterranean climate predominates, with short, mild and wet winters and long, hot, and dry summers. Arid and semi-arid continental climates prevail in central regions where winter conditions are often extremely harsh, with frequent and heavy snowfall in the higher parts of the Anatolian Plain. On the Black Sea coast, winters are very wet and summers mild and humid. The average annual temperature varies between 18 to 20°C on the south coast, drops to 14 to 16°C on the west coast, and in central parts fluctuates between 4 to 18^{o}C. Local micro-climates can vary widely from the regional averages because of the highly variable terrain and exposure to hot and cold winds. Hydroelectric generation, biomass combustion, solar energy for agricultural grain drying and hot water heating, and geothermal energy have been in use in the country for many years.

Solar Energy

In Turkey, the climatic conditions are favorable for the development of solar energy due to the abundant sunshine throughout the year. The preliminary studies made by EIE, based on the data measured by the State Meteorological Services indicate that, the country has an average sunshine duration of 2640 hy^{-1}. Southeastern Anatolia has the longest sunshine duration of 2993 hy^{-1} while the Black Sea Region receives the least sunshine with 1970 hy^{-1}. The solar energy potential of Turkey in different geographical regions is given in Table 1.

Region	**Total Solar Radiation (kWh/m^2-year)**	**Annual Total Sunny Hours (hours/year)**	**Region**	**Total Solar Radiation (kWh/m^2-year)**	**Annual Total Sunny Hours (hours/year)**
South Eastern Anatolia	1,460	2,993	Eastern Anatolia	1,365	2,664
Mediterranean	1,390	2,956	Marmara	1,168	2,409
Aegean	1,304	2,738	Black Sea	1,120	1,971
Central Anatolia	1,314	2,628	Average	1,311	2,640

Table 1: Regional Distribution of Solar Energy Potential of Turkey (EIE, 2009)

The yearly average of solar radiation intensity is 3.6 kWh/m^{2}day on horizontal plane with higher peaks at some locations and varies between 1.75 kWh/m^{2}day and 5.9 kWh/m^{2}day on monthly basis. In Turkey solar energy has a technical potential of 8.8 mtoe electricity generation and heating capacity of 26.4 mtoe [36]. Main solar energy utilization is the flat plate collectors in the domestic hot water systems which are mostly used in Aegean and Mediterranean Regions. Turkey has a total installed capacity of 13.86 million m² collector area with a total energy production of 580 ktoe, as of 2008. At the moment, the utilization of solar power or PV system in Turkey is only limited to solar water heating systems in hotels, small greenhouse and beverage industries and urban homes. According to Ministry of Energy and Natural Resources (MENR) projections, solar energy usage for heating systems will be 745 ktoe in 2020 and 932 ktoe in 2025. It is possible to increase the energy production from solar collectors to 1.4 mtoe in 2010 and 5.5 mtoe in 2025. Utilization of photovoltaic systems is solely limited with some state organizations which use PV in order to meet remote electricity demand. Main application areas include the telecom stations, fire observation towers, lighthouses and highway emergency systems. Total installed peak power is estimated as 300 kWp [35]. Turkey, currently, does not have an organized photovoltaic (PV) program. Global energy strategies and policies are laid down in periodic five years development plans. On the other hand, it is encouraged to invest in the energy sector through some financial incentives. Plans for industrial-scale production of PV modules are concentrated in thin-film areas rather than crystalline materials. PV cells are produced in various research establishments in order to study the feasibility of local manufacturing. So far, none of these studies yielded a sufficiently positive result to justify a large production facility in Turkey. The potential of Turkey as a PV market is very large, since the country is very suitable in terms of insulation and large areas of available land for solar farms. There are more than 30000 small residential areas where solar powered electricity would currently likely be more economical than grid supply. Solar energy technologies development and use is very important and useful for the developing countries like Turkey provided that the factors of long-term sustainability and economic feasibility are not completed.

Hydropower

Hydropower dams can and have made important and significant contribution to human development. Firstly, hydropower dams can generate electricity and are clean and renewable. In the longer term, electricity from hydropower is relatively cheaper as compared to other sources (oil and natural gas) and the cost will not be affected by the changing fuel prices, which is currently determined by international market. Apart from that, many hydropower projects had also brought socio-economic development such as flood control, irrigation, tourism, local employment and skills development, rural electrification and the expansion of physical and social infrastructure such as roads and schools or rather as a whole, the opening up of interior areas of the country to other economics (Mohamed & Lee, 2006). Table 2 shows technical and production potential of some countries. According to that the rate of utilized HEP to technical HEP is only 20.4 % in Turkey, whereas this ratio is 98.8% in Sweden. Turkey is the richest country after Norway in Europe for its economic hydroelectric potential which is 130 TWh/year. On the other hand, Turkey's technically useable potential is 216 TWh/year (see Table 2) and it is higher than Norway. But the hydroelectric power production is quite behind than Norway and even from Italy which has an economic potential less than half of Turkey. This is basically due to the high capital investment required to develop the hydropower and often involve socio-economic issues. The development of a hydropower dam is overwhelmingly complex because the issues are not confined to the design, construction and operation of dams themselves but embrace the issues of social, environmental and political issues (Ozturk, 2009).

Country	**Technical Potential (TWh/y)**	**Percent of Europe Total (%)**	**Economic Potential (TWh/y)**	**Percent of Europe Total (%)**	**Production (TWh/y)**	**Percent of Europe Total (%)**	**P/T (%)**
Turkey	216	17.14	130	14.29	35	6.08	16.2
Norway	200	15.87	187	20.55	136.4	23.70	68.2
Italy	105	8.33	65	7.14	36	6.26	34.3
Sweden	100	7.94	85	9.34	72.1	12.53	72.1
France	100	7.94	70	7.70	56.2	9.77	56.2
Austria	75	5.95	56	6.16	39	6.78	52
Spain	66	5.24	32	3.51	23.2	4.03	35.2
Iceland	64	5.08	40	4.40	7	1.22	10.9
Switzerland	43	3.41	41	4.50	30.1	5.23	70
Romania	35	2.78	25	2.75	20.1	3.49	57.4
Germany	32	2.54	20	2.19	27.7	4.81	86.6
Portugal	25	1.99	20	2.19	5.1	0.89	20.4
Rest of Europe	199	15.79	139	15.28	87.5	15.21	42.3
Total Europe	1,260	100	910	100	575.4	100	25.3

Table 2: Hydroelectric potential in Europe and actual production, adapted from (WEC, 2008)

Wind Power

As it provides a clean and renewable form of electricity, wind energy is one of the most widely used alternative sources of energy today. According to the figures released by Global Wind Energy Council (GWEC) in year 2005, the total installed capacity of wind energy worldwide reached 59,335 MW_e by increasing 25% compared to year 2004. Approximately, 11,769 MW of new wind energy generating capacity were installed in year 2005 representing a 43.4% increase in annual additions to the global market up from 8,207 MW in the previous year. In Europe, as much as 25% of its current electricity demand could be met from wind energy sources (Boyle, 1998). Europe is still leading the market with over 40,500 MW of installed capacity at the end of 2005, representing 69% of the global total. In 2005, the European wind capacity grew by 18%, providing nearly 3% of the EU's electricity consumption in an average wind year. Technical wind potential of Turkey is given as 83,000 MW_e and the economic potential is estimated as 10,000 MW_e.

Regions	Annual average wind density (Wm^{-2})	Annual average wind speed (ms^{-1})	Regions	Annual average wind density (Wm^{-2})	Annual average wind speed (ms^{-1})
Marmara	51.9	3.3	Black Sea	21.3	2.4
Southeastern Anatolia	29.3	2.7	Central Anatolia	20.1	2.5
Aegean	23.5	2.7	East Anatolia	13.2	2.1
Mediterranean	21.4	2.4	Turkey average	25.8	2.6

Table 3: Wind Energy Potential of Turkey

Turkey has the highest share in technical wind energy potential in Europe. However, Turkey had only a share of 0.04% in Europe's installed capacity. Although the installed capacity of Turkey's wind energy has increased from 9 MW_e in 1998 to26 MW_e in 2005 it is still very small compared to its potential. Annual average wind speed and annual average wind energy potential of various regions of Turkey are shown in Table 3. The annual average wind speeds range from a low of 2.1 ms^{-1} in the East Anatolia region to a high of 3.3 ms^{-1} in the Marmara region. The most attractive regions for wind energy applications are the Marmara, the southeastern Anatolian and the Aegean regions. These regions are highly suitable for wind power generation, since the wind speed exceeds 3 ms^{-1} in most of these areas (Ediger & Kentel, 1999). These have been classified into six wind regions, with a low of about 3.5 ms^{-1} and a high of 5 ms^{-1} at 10 m altitude. These correspond to a potential power production of between 1,000 and 3,000 $kWhm^{-2}yr^{-1}$).

Biomass

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high. Since 1984, the contribution of the biomass resources in the total energy consumption of Turkey dropped from 21.53 to 5.51 % in 2008. Biomass in the forms of fuel-wood and animal wastes is the main fuel for heating and cooking in many urban areas [48,49]. The total recoverable bioenergy potential is estimated to be about 16.92 mtpe. The estimate is based on the recoverable energy potential from the main agricultural residues, livestock farming wastes, forestry and wood processing residues, and municipal wastes that are given in the literature (Kaygusuz, 1997). Biomass can be classified as classic and modern biomass according to the method used for biomass utilization for energy production. The former is the recently most commonly utilized one and consists of burning biomass such as wood, plant residues and animal dung directly. Modern biomass technologies are relatively new technologies, most of which are still on the developmental stages. These include conversion of biomass to solid, liquid and gas fuels by much complex biochemical and thermochemical processes. Projections of planned biomass production, classic and modern in Turkey are given in Table 4. It is estimated that Turkey has a theoretical gross biomass potential of 135-150 $mtoeyr^{-1}$, and a theoretical net potential of 90 $mtoeyr^{-1}$. But the economical potential is given as 25 $mtoeyr^{-1}$.

Year	Classic biomass	Modern biomass	Total
2010	5.754	1.660	7.414
2015	4.790	2.530	7.320
2020	4.000	3.520	7.520
2025	3.345	4.465	7.810
2030	3.310	4.895	8.205

Table 4: Classic and modern biomass energy production projections for Turkey (mtoe)

Geothermal

Major part of Turkey is situated on the Alpine-Himalayan orogenic belt, a characteristic that gives the country a high geothermal potential. Turkey is the seventh highest geothermal potential in the world and this resource can be utilized both for electricity production and as direct heating use. Since 1960s, the General Directorate of Mineral Research and Exploration (MTA) has determined as many as 170 geothermal fields and over 1,000 hot and mineral water resources (spring discharge and reservoir), the temperatures of which ranged from 20 to 242ºC. Turkey's geothermal fields are more available to direct-use applications, since 95% of geothermal fields are low-medium enthalpy resources. Gross geothermal potential of Turkey is given as 31,500 MWt, corresponding to 5 million residence heating whereas the economic potential for heating purposes is estimated to be 2843 MW. 31 500 MWt equals to, 140 thousands m^2 greenhouse heating, 9,3 billion $/year Fuel-Oil equivalent (30 $mtoneyr^{-1}$) or 30 $Bcmyr^{-1}$ natural gas equivalent. This capacity equals to decreasing the CO_2 emission of 30 million motor-vehicles as well. Turkey's gross geothermal electrical potential is estimated as 2,000 MW_e and seven geothermal fields are identified to be appropriate both technically and economically for electricity generation. Some of the geothermal fields of Turkey are given in Table 5.

Geothermal Field	Temperature (ºC)	Geothermal Field	Temperature (ºC)
Denizli-Kizildere	242	Aydin-Salavatli	162
Aydın-Germencik	232	İzmir-Seferihisar	153
Canakkale-Tuzla	174	İzmir-Balcova	126
Kutahya-Simav	171	Ankara-Kizilcahamam	106

Table 5: Some of Turkey's high enthalpy geothermal fields

Conclusions

Since energy is required for industrialization, energy development is a basic component to ensure economic and social development. There is a need to find alternatives to the import of electricity and increase the domestic production of electricity in Turkey. Renewable energies are just starting to play a significant role in Turkey's energy matrix while the oil sector is still expected to be the biggest player during the next few decades. In order not to become more dependent on other countries, it is essential that Turkey utilizes its own renewable energy resource. This is an opportunity not to be missed for Turkey to achieve an economic, sustainable energy-supply. This is done by using domestic renewable energy resources and using the knowledge that already exists in the country about producing energy technology and to co-operate with foreign companies and institutions to develop technologies adapted to the local conditions in Turkey. Apart from promoting the use of renewable energy and alternative energy to ensure the sustainability of energy supply and consequently of the country's sustainable economic development, the government of Malaysia has also been implementing the energy efficiency program. Energy efficiency covers the efficiency of power generation, transmission and distribution of electricity and various end-uses of energy. The Turkey energy sector is still heavily dependent on non-renewable fuel such as fossil fuels and natural gas as a source of energy. These non-renewable fuels are finite and gradually depleting and also contribute to the emission of greenhouse gas. While it is recognized that the world, including Turkey is not ready to displace non-renewable energy with renewable fuels, the implementation of various policies and programs by the government of Turkey has increased the awareness of the importance of the role of renewable energy in a sustainable energy system. Renewable energy resources and their utilization in Turkey are intimately related to sustainable development. For the governments or societies to attain sustainable development, much effort has to be devoted to utilizing sustainable energy resources in terms of renewables.

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