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Use of renewable energy resources in agriculture the case of Turkey

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The rapid growth in the world economy has led to significant increases in energy demand. However, due to the limited formation of fossil fuel reserves such as petroleum, coal and natural gas, and the damage they cause to the environment,it has brought the trend towards renewable energy sources.The main renewable energy sources that can be effectively utilized in agriculture sector are; solar, biomass, geothermal and wind energies.The type of energy that can be used in agricultural production depends on the design of the renewable energy source and the agricultural structure and processes. The main energy consuming processes during production are irrigation, drying of products, heating and cooling of greenhouse gases and animal shelters. Fossil fuels are used during these operations. New technological applications in agriculture, further increases energy consumption. However, due to the increase in the cost of fossil fuels and environmental pollution; the use of renewable energy resources, which have a great potential in the agriculture sector, can be eliminated from this problem. This study examines examples of renewable energy sources that can be effectively utilized in the agricultural sector, Turkey. Proposals have been made for energy efficiency through the use of renewable energy source technologies that can be utilized in energy agriculture and agricultural production operations.

Key words: Renewable energy sources, fossil fuels, agriculture, environmental impact.

INTRODUCTION

Energy as a sign of economic and social development is an indispensable requirement of mankind. Sustainability of energy resources has been one of the most important issues and problems in the world. Energy is also important for technological production and development as well as for increasing quality of life. In recent years; energy use, greenhouse gas emissions, and their potential impacts on global climate change are among the most debated topics. One of the most effective ways to reduce energy use in industry, transport, commerce, housing and agriculture is to increase energy efficiency. In today's industrial world, the use of energy resources has reached a significant level. Therefore, the origin of natural resources has begun to decrease and the damage given to the natural environment has continued to increase. In this direction, the diversity of domestic renewable energy sources has also been increasing. The term of renewable energy is used for energy resources such as water, sun, wind, geothermal and biofuels that are present in nature and sustain in their existence. Also,

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It should be noted that fossil fuels will be consumed (Kadıoğlu and Tellioğlu, 1996). When fossil fuels are burned, carbon dioxide, sulfur dioxide, nitrogen oxides, dust and other emissions spread to the atmosphere and pollute the environment with leading to deaths. Besides, carbon dioxide and similar greenhouse gases lead to global climate change and threaten life in all the countries of the world (Uyar, 2001). Unless measures are taken to protect the environment and human health from the use of fossil fuels, it will be inevitable that the future cost of living will reach a very large size (MNE, 2012). The energy requirement in the world has been increasing by about 4-5% each year. However, the search for renewable energy sources has accelerated because of the limited worldwide fossil fuel reserves and the fact that they will be consumed in the near future (Bayram, 2001). In addition, the use of fossil fuels has increased the world average temperature and has resulted in a noticeable increase in natural disasters such as floods and storms, which cause intense air pollution as well as billions of dollars in damages. Therefore, mankind must turn to renewable energy sources without waiting for fossil fuel reserves to be exhausted (Görez and Alken, 2005).

The importance of strategies, plans and policies for the adequate utilization of renewable energy sources are significantly increasing (Öztürel et al., 2001). Biomass and biofuels have an important potential in renewable energy sources. These are composed of oil seeds, carbohydrates, fiber plants, and all kinds of materials of animal origin. The energy generated from these sources is defined as biomass or biofuel energy. The use of animal and vegetable food wastes as clean energy is important for the prevention of environmental pollution and the development of energy resources. This energy is produced by converting organic wastes into methane gas in an oxygen-free environment, while the remaining part is used as an enriched fertilizer source. Increasing energy efficiency is important for assessing the environmental impact of energy resources. System efficiency needs to be increased to use less energy and to minimize damage to the environment.

Energy consumption requires careful planning of energy consumption against side effects that result from the scarcity of energy resources and careless use (Öztürk, 2004a). Like other sectors, energy dependency is increasing in the agricultural sector. This increase is increasing all over the world due to the use of technology (Gowdy et al., 1987). In addition, energy input is an important factor in the agricultural production function (Pachauri, 1998). Some studies have shown that the energy factor in agricultural productivity and efficiency are dominant (Felloni et al. 1999). Energy has also an important role in social and economic development. However, the policies developed for energy use in rural areas are insufficient. This may be due to the low pre-fertilization of agriculture due to the industrialization of emerging countries, and the low level of education and organizational skills in rural areas (Karkaciğer and Göktolga, 2004). The detailed studies have been carried out in regional and national production systems and product-based, and total energy use of Turkey agricultural sector (Barut and Öztürk, 2004). Agricultural production has played an important role in the level of welfare achieved by developed country economies. When the economic development process is examined, it is seen that the income obtained from agriculture first goes to the industrial sector after the commercial and this capital provides resources for industrialization. Turkey in terms of its geographical structure, ecological conditions, product variety and quantity has a great potential in agricultural production. With this rational, effective and planned use of this potential, it will grow in line with the discourses of sustainable development that are frequently discussed in the international public.

In today's industrial world, the use of energy and other resources has reached a significant level. For this reason, the damages of natural resources such as environmental pollution are increasingly increasing on one side as the natural resources of the other side are decreasing. However, energy conversion can not be achieved efficiently. There are many factors such as population growth, economic productivity, consumer habits and technological developments that need to be considered in order to determine future energy production and consumption levels in developed and developing countries. Effective management of the energy sector will play an important role in future energy production and consumption levels and distribution. Thus, efficient design methods will be developed by reducing inefficiencies in existing energy systems. One of the most fundamental elements of the economic and social development of countries is energy (Pamir, 2003). The demand for energy will continue to increase in the future. In 2030, energy consumption is foreseen to increase by 60% in the world and higher than 100% in Turkey (Satman, 2007). It is known that fossil fuels will meet the needs of today's energy needs in the coming years (Kumbur et al., 2005).

Renewable energy sources, on the other hand, are inexhaustible and they do not pose a significant threat to the environment and human health, unlike fossil fuels. Globally, the contribution of these energy sources is still low, but it has risen by 10-30% in recent years (Martinot et al., 2002). Direct energy is used during the mechanization of agricultural production. However, sufficient use of renewable energy resources is required in the agricultural sector for the effective prevention of environmental problems caused by the use of fossil fuels (Öztürk, 2010). Thus sustainable development will be achieved by using energy resources in a sustainable way. Nowadays, it is understood that the theme of sustainable development is understood and increased in the efforts towards energy efficiency. Therefore, the development of energy efficiency, the prevention of

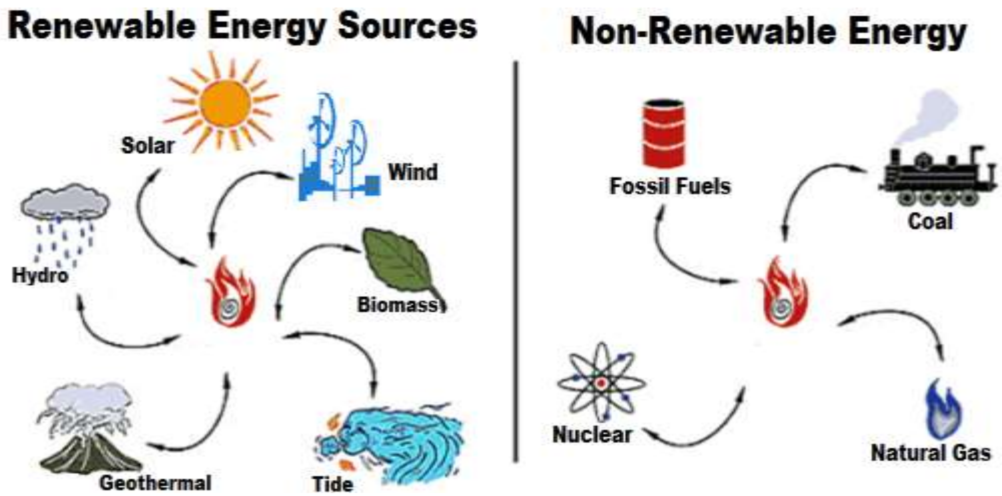

Figure 1. Renewable and non-renewable energy sources.

unconscious use and waste, and the reduction of energy intensity both at sectoral and macro level are priority and important components of national energy policies (Direk, 2017). While fossil fuels are energy resources that are burned and renewed, natural resources such as hydro (water), sun, wind, biomass and geothermal are not only renewable but also as a clean energy source. As of 2006, about 18% of the world's energy consumption is provided by renewable energy sources (Gönüllü, 2009). Renewable energy sources need to be utilized to effectively prevent environmental problems arising from the direct or indirect use of fossil fuels. However, the economic feasibility and implementation method of renewable energy sources in the agricultural sector varies depending on regional conditions. The main renewable energy sources that can be effectively utilized in agriculture sector are; solar, wind, geothermal and biomass energiesy. Renewable and non-renewable energy sources are given in Figure 1 (Anonymous, 2018).

In this study, the role of agriculture in renewable energy is examined and it is also aimed at establishing a relationship between agriculture and renewable energy sources and the current situation of environmentally sensitive renewable energy production, whether or not agriculture has an impact on renewable energy sources, and how effective agricultural products or other wastes are produced.

ENERGY USE IN AGRICULTURE

In the agricultural sector, vegetable and animal production processes require the use of specific amounts of energy. The use of energy in agriculture includes the energy used in irrigation-pump operations, the heat control processes in the greenhouse, the farms and vegetable productions, the transport of agricultural products, the agricultural machinery and tools used in the processing and evaluation of agricultural products, and the production, packaging and transport of chemical fertilizers and agricultural chemicals (Özkan et al., 2003; Hatırlı, et al., 2004). In overall energy consumption in Turkey, the change in the amount of energy consumed in agriculture between 1990 and 2011 is given in Table 1 (TurkStat, 2011). While the amount of energy consumed in agriculture sector was 1956 Thousand TOEs in 1990, it increased to 2556 Thousand TOEs in 1995, 3073 Thousand TOEs in 2000, 3340 Thousand TOEs in 2005, and 5755 Thousand TOEs in 2011, respectively. While the amount of energy consumed in agriculture sector increases regularly, the share of agriculture sector in total energy consumption does not change regularly. The share of agriculture in total energy consumption was 3.69% in 1990, 4.01% in 1995, 3.82% in 2000 and 3.65% in 2005 and 6.62% in 2011, respectively. The share of agriculture in total energy consumption was 4.66% on average basis between 1990 and 2011. While the share of agriculture in total energy consumption declined in 2002-2005, it started to increase after 2005.

In the agricultural sector, the changes in energy consumption per agricultural area in years between 1990 and 2011 are given in Table 2 (TurkStat, 2011). The amount of energy used per hectare in the agricultural sector was 0.78 TOE in 1990, 0.104 TOE in 1995, 0.128 TOE in 2000, 0.140 TOE in 2005, and 0.280 TOE in 2011, respectively. As a result of mechanization and advanced technology applications in the agriculture sector, energy use is seen to increase gradually. Therefore, the use of renewable energy sources in the agriculture sector and the increase in energy use efficiency are necessary.

USE OF RENEWABLE ENERGY RESOURCES IN AGRICULTURE

Turkey's energy production and targets based on

Table 1. Turkey energy consumption in the agricultural sector.

Years	Energy consumption (Thousand TOE*)		Share of agriculture in total energy consumption (%)
	Agriculture	Total consumption	
1990	1956	52.987	3,69
1995	2556	63.679	4,01
2000	3073	80.500	3,82
2001	2964	75.402	3,93
2002	3030	78.331	3,87
2003	3086	83.826	3,68
2004	3314	87.818	3,77
2005	3340	91.576	3,65
2006	3608	77.441	4,66
2007	3944	82.747	4,77
2008	5174	79.559	6,5
2009	5073	80.574	6,3
2010	5089	83.372	6,1
2011	5755	86.952	6,62
Average	**3712**	**78.912**	**4,66**

*TOE : Tons of oil equivalent .

Table 2. Energy consumption in the agricultural sector and per cultivated area in Turkey.

Years	Total energy consumption in agriculture (Thousand TOE)	Processed agriculture area (Thousand ha)	Planted field of agriculture (Thousand ha)	Total energy consumed in agriculture / working field (TOE/ha)	Total energy consumed in agriculture / fields farmed (TOE/ha)
1990	1.956	24.827	18.868	0.078	0.103
1995	2.556	24.373	18.464	0.104	0.138
2000	3.073	23.826	18.207	0.128	0.168
2001	2.964	23.800	18.087	0.124	0.163
2002	3.030	23.994	18.123	0.126	0.167
2003	3.086	23.372	17.563	0.132	0.175
2004	3.314	23.871	18.110	0.138	0.182
2005	3.340	23.830	18.148	0.140	0.184
2006	3.608	22.981	17.440	0.156	0.206
2007	3.944	21.979	16.945	0.179	0.232
2008	5.174	21.555	16.460	0.240	0.314
2009	5.073	21.351	16.217	0.237	0.312
2010	5.089	21.384	16.333	0.237	0.311
2011	5.755	20.539	15.712	0.280	0.366
Average	**3.711,6**	**22.977,3**	**17.476,9**	**0,164**	**0,216**

renewable energy sources are shown in Table 3 (Yılmaz, 2017). As of 2015, hydro-power and wind energy are the most used from renewable energy sources. Utilization of geothermal energy is in third place and its use is still limited. While the use of solar energy is at a low level, the use of wind energy and solar energy is steadily increasing in 2017. At the target of 2023, it is planned to increase the wind energy to 20000 MW and the solar energy to 5000 MW.

In case of using renewable energy resources in agriculture; operating costs, the need for imported fossil energies, the excessive demand for electrical power and

Table 3. Turkey's energy production and targets based on renewable energy sources.

Years	Hydropower energy MW	Wind energy MW	Solar energy MW	Geothermal energy MW	Biomass energy MW
2015	25.526	5.660	300	412	377
2017	28.763	9.549	1.800	559	530
2019	32.000	13.308	3.000	706	683
2023	34.000	20.000	5.000	1.000	1.000

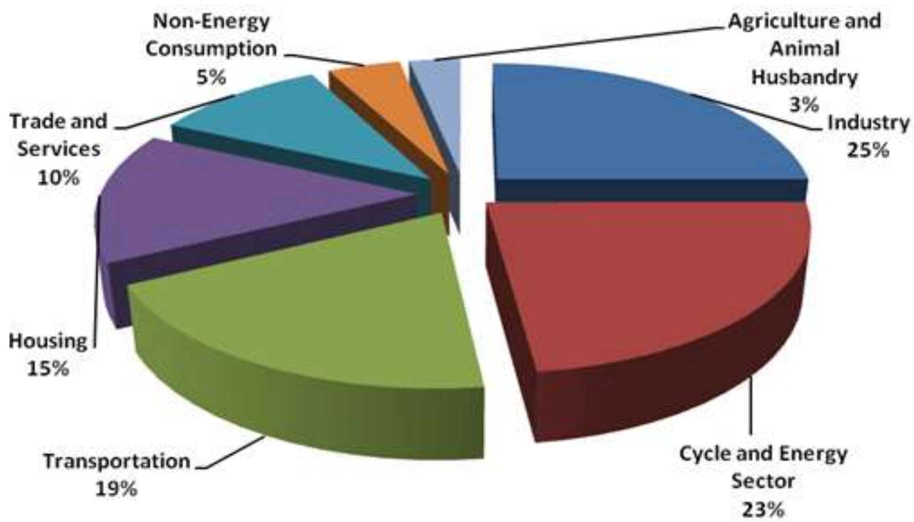

Figure 2. The distribution of primary energy consumption by sectors in Turkey.

environmental pollution are reduced. Economic development is achieved at this point. The choice of renewable energy technology that can be utilized in agricultural production operations and the type of energy required depends on the design of the renewable energy source and agricultural structures and processes. The main energy consuming processes among agricultural production processes are irrigation, crop drying, heating and cooling of greenhouses and animal shelters. During these operations, fuels such as diesel oil, natural gas, electricity, liquefied petroleum gas or propane are used. The distribution of primary energy consumption by sectors in Turkey is given in Figure 2 (MENR, 2018). As can be seen, the share of the agriculture and livestock sector in general energy consumption by 2015 is given as 3%. The distribution of installed power by sources in Turkey is given in Figure 3 (TEİAŞ, 2017). As can be seen, the total installed power by 2017 is given as 80.343,3 MW.

Renewable energy sources need to be utilized to effectively prevent environmental problems arising from the direct or indirect use of fossil fuels. The main renewable energy sources that can be effectively utilized in agriculture sector are solar, wind, geothermal, and biomass energies. 55 countries in the world began to focus on renewable energy sources in 2005, whilw more than 100 countries have set targets for renewable energy and developed some policies since 2010 (REN21, 2010). Ten countries, including the US, Japan, Scotland and Denmark, target 100% of renewable energy in some sectors (REN21, 2011). Support for renewable energy by governments around the world reached $41 billion in 2007, $44 billion in 2008, and $57 billion in 2009 (Deloitte, 2011). At the end of 2010, the Asian Development Bank provided $21 million to the Bhutanese region in South Asia to achieve electricity and promote clean energy use for their rural population under the Rural Renewable Energy Development project (Öztürk, 2011). Under the scope of rural development, Ministry of Agriculture, TUBITAK, and State Planning Organization in Turkey and the European Union institutions devotes significant resources to support the agricultural sector in recent years.

Use of solar energy in agriculture

Solar energy systems can be investigated under two

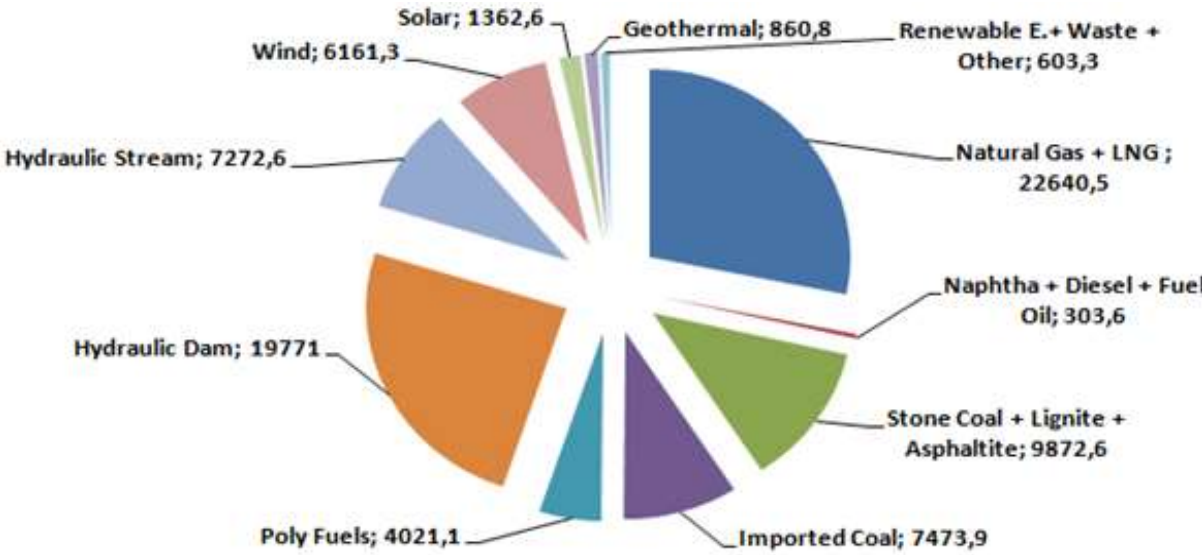

Figure 3. The distribution of ınstalled power by sources in Turkey (MW).

Table 4. The distribution of Turkey's solar energy potential by months.

Months	Monthly total solar energy (kWh/m^2-month)	Hours of Sunshine (hour/month)
January	51,75	103
February	63,27	115
March	96,65	165
April	122,23	197
May	153,86	273
June	168,75	325
July	175,38	365
August	158,4	343
September	123,28	280
October	89,9	214
November	60,82	157
December	46,87	103
Total	**1.311**	**2.640**
Average	**3.6 kWh/m^2-day**	**7.2 h/day**

groups as heat systems and electrical systems (Ultanır, 1998a), although they are very diverse in terms of method, material and technological level. It can be said that Turkey, with a nominal position, is in good condition in terms of solar energy potential. According to data provided by the General Directorate of Electrical Power Resources Survey and Development Administration, the distribution of Turkey's solar energy potential by months is given in Table 4 (Taşkın and Korucu, 2014).

Turkey's annual total sunshine hours of 2.640 h (average daily sunbath time is 7.2 h) and the total radiation intensity of 1.311 kWh/m^2-year (average daily radiation intensity is 3,6 kWh/m^2) have been identified. Turkey has a high solar energy potential, such as 110 days and the country can produce a total of 1.311 kWh of solar energy per square meter per year in case of necessary investments. Turkey's total annual solar energy potential by regions is given in Table 5 (Taşkın and Korucu, 2014). Looking at the region of the solar energy potential in Turkey, the most sunshine hours with 2.993 h/year is the Southeastern Anatolia region. Looking at the breakdown by region of the solar energy potential in Turkey, the most sunshine hours with 2.993 h/year is the Southeastern Anatolia region. On the other hand, the

Table 5. Turkey's total annual solar energy potential by region.

Regions	Total solar energy (kWh/m^2-year)	Hours of sunshine (hours/year)
Southeastern Anatolia	1.460	2.993
Mediterranean	1.390	2.956
Eastern Anatolia	1.365	2.664
Central Anatolia	1.314	2.628
Aegean	1.304	2.738
Marmara	1.168	2.409
Black Sea	1.120	1.971
Average	**1.303**	**2.623**

Figure 4. Turkey's solar energy potential.

least sunshine hours is the Black Sea region with 1.971 h/year. As can be seen from the table, it is determined that the solar energy potential can produce an average of 1.303 kWh of energy per unit per year while the annual average sunshine duration is 2.623 h (Figure 4) ((REGD, 2017a).

Drying agricultural products with solar energy

Most of the agricultural products, which are not consumed within a short period of time after they are produced, deteriorate and lose their nutritional value. Therefore, agricultural products need to be dried to extend their usable life. Drying is the process of evaporation of excess water in the agricultural products (Yağcıoğlu, 1996). After natural drying, the most economical method of drying is the process using solar energy (Kısakürek, 1980). Solar-powered dryers can be used to dry a lot of food because their operating costs are very low and they are hygienic (Ünalan, 2006). In combined type dryers, air is first heated in solar collectors, then dryer cabinet is dried under the sun (Dalgıç, 2006). There are various renewable energy sources in the literature such as solar powered and electric dryer system (Boughali et al., 2009), the desiccant system that generates heat and electricity from solar energy (Aktaş et al., 2013), photovoltaic-thermal (PV/T) greenhouse type dryer system (Barnwal and Tiwari, 2008), geothermal energy dryer design for drying granular products in geothermal field in Kamojang (Indonesia) (Sumotarto, 2007), the cabin type biomass energetic dryer system (Mukaminega, 2008), and hot water and solar collector dryer system (Amer et al., 2010).

Greenhouse heating with solar energy

In recent years, many researches have been conducted to reduce energy consumption in undergrowth cultivation. In these studies, new and renewable natural energy sources with the aim of developing low cost and efficient heating systems have been used as an alternative to heating systems consuming fossil fuels. In Table 6 (Kendirli and Çakmak, 2010a), the distribution of the

Table 6. The distribution of the greenhouse areas by regions (ha).

Region	Glass material greenhouse	Plastic material greenhouse	High tunnel	Low tunnel	Total	%
Mediterranean	7.525,4	17.355,2	5.115,9	17.131,3	47.127,8	86,9
Aegean	691,4	2.695,5	602,9	484,3	4.474,1	8,2
Black Sea	1.7	659,7	430	465,5	1.556,9	2,9
Marmara	2.3	359,7	481,3	10,4	853,7	1,6
Central Anatolia	0.3	58.4	45.7	-	104.4	0.2
Eastern Anatolia	-	13.7	14.7	6.9	35.3	0.1
Southeastern Anatolia	4.2	25.8	5.5	28.1	63.6	0.1
Total	8.225,3	21.168,0	6.696,0	18.126,5	54.215,8	100.0

undergrowth (greenhouse) areas by regions (ha) is given. As can be seen in Table 6, 86.9% of the total uncovered areas of the greenhouses are located in the Mediterranean Region. At the end of the 1980s, greenhouse activities started in other areas and show an increasing tendency today (Kendirli and Çakmak, 2010a; Tüzel, et al., 2010). The share of heating in production expenditures has increased by up to 60% in controlled greenhouses. Reducing this share will increase the profitability of the greenhouse sector, which constitutes a significant potential in agriculture, and will contribute greatly to the economy of the country. The methods used to heat the greenhouses with solar energy can be examined in two groups as active and passive (Öztürk, 2008a). Passive systems used to heat the greenhouses are the most important ones to work in natural ways. There is no need for any mechanism and energy to operate the passive system, which is easy and cheap. The most significant drawback to active systems is the fact that there is virtually no controlled operating opportunities (Yağcıoğlu, 2005). In the case of solar active heating systems, heat collection and storage units designed separately from the greenhouses are used. The overcapacity of the heat collection units in these systems and the high initial investment and operating costs significantly limit the economic feasibility of these systems.

Greenhouse ventilation with solar energy

There is always a need for clean air in agricultural applications that must be done in closed areas. Ventilation is carried out by replacing the air in the greenhouse with outside air to control high temperatures during summer and to protect the relative humidity and carbon dioxide concentration during winter months at an acceptable level. The movement of air also helps to develop plant respiration (Boyacı et al., 2017). In literature, a fan operating with 3 direct currents was installed in a greenhouse in Thailand. Low-voltage fans can be used effectively with a solar panel with 50 W installed power (Janjai et al., 2009).

Irrigation with solar energy

Solar water pumping systems are becoming increasingly common in irrigation systems for agriculture. Since solar panels transform the sunlight directly into direct current (DC), the efficiency and cost of the system decrease in case of direct current (DC) load of the receivers fed by solar energy. Therefore, in recent years, PV systems have been given considerable importance to electricity generation and significant progress has been made in this regard as a result of intensive research (Dursun and Saygun, 2005). Solar cell (PV) systems are designed specifically for water supply and agricultural irrigation where electricity can not be delivered. One of the applications of PV systems is to use them as a power source for the pumping of the water required to water a particular crop. Water pumping applications are the main application area of independent PV systems. In water pumping applications, water is pumped for the duration of sunlight or stored for later use. Power can be stored in the battery for use during periods when there is no sunlight. Electronic control units are required to control the system if a battery charging system is used. In the design of PV systems, the climate of the region, the characteristics of the water consumption of the plant, the characteristics of the irrigation system and the characteristics of water resources should be considered. The electric motor to be used in the PV system should be selected depending on the power requirement and current type (Öztürk, 2009). There is a filter on the connection pipes between the pump and the irrigation system to separate foreign substances such as fertilizer and drug additive as well as fertilizer tank and sand gravel likely to mix with water (Atay et al., 2009).

Pest control with solar energy

Pest control can be achieved throughout the year without damaging the environment with the solar energy harmful killer. Pesticide-free solar-powered pest killers are suitable for use on farms, fruit gardens and vineyards. Only harmful insects, whivh are active at night, are killed without affecting useful insects. With this method, night light traps were operated using power stored in the battery throughout the day, and killing of non-target insects could be prevented (Tianhua et al., 2014).

Drilling machine with solar energy

Agricultural warfare and herbal products are protected in economic measures from the effects of diseases, pests and weeds. In this regard, product losses are minimized and quality is increased. Along with the application of chemical-fighting drugs (herbicides, fungicides and insecticides), the selection and use of appropriate tools and equipment has greatly contributed to the reduction of product losses (Demir, 2005). With solar-powered back pumps, liquid formulations could be made and conversion to a free energy system instead of a fuel-based system could be achieved (Joshua et al., 2010).

Soil disinfection with solar energy (solarization)

Soil disinfection is the process of destroying pathogens so that plant species can develop before the planting and sowing of the root system from the risk of infection. Soil heating is used to control soil-borne pests in plant breeding in the greenhouses (Öztürk, 2008b). Steam disinfection and biofumigation applications and the use of high toxicity bases in soil fumigation cause not only the destruction of soil-borne pests but also the death of saprophytic bacteria and beneficial microflora (Gamliel et al., 2000). Soil solarization is a method of hydrothermal disinfection that can create physical, chemical, biological and thermal changes through mulching at a time appropriate to the soil that has been sufficiently humidified (Sesveren, 2007). In other words, soil solarization is the process of covering the soil with plastic for hot and warm days of the year for one or two months in order to heat and pasteurize the soil through solar energy. Solarization is an ideal method for soil disinfection in greenhouse production environments.

Fence system with solar energy

Solar-powered fence systems are emerging as one of the best ways to prevent the introduction of fertile agricultural land as well as especially wild and predatory animals into the meadows, beaks and beehives. With this method, animals can be kept together in large quantities, and predatory animals can be prevented which can damage production. Particularly with the use of bees, possible wildlife damages that may occur in hives are removed. These systems are operated with a 3 milliampere current which is not harmful to wild animals and human health (Ambarlı, 2014).

Use of wind energy in agriculture

Wind energy is a clean, abundant and renewable energy source as well as an opportunity to exploit many areas where agricultural activities are. Wind turbines are a more economical source of energy due to the fact that operating costs other than labor are zero compared to fossil fuel power plants (Turan, 2006). Today, wind turbines in high wind fields are able to generate electricity for several cents per kilowatt-hour and compete with unit production costs of fossil-fueled power plants (Fischer et al., 2006). In agricultural areas, energy production costs are reduced considerably through wind roses to be installed in each farm or settlement, and such systems to be installed in remote areas to transmission lines are economically in every way (NREL, 2004). By evaluating the wind potential in rural areas in Turkey, it is seen that wind farms can be built in these regions with a capacity of 50 MW in 371 different rural areas with high wind power. The number of workers to be employed in these plants has shown that 40439 persons will be employed during the installation and 6307 persons will be employed annually in the process of operation, thus contributing to rural employment. The wind is the movement of the air whose mass is certain. The kinetic energy of a mass in motion is proportional to mass. Wind energy can be converted to mechanical energy. From this point of view, it is possible that the drum or propeller, which can rotate about one mile, with winds backwards. Today, the wind has been converted to mechanical energy by braking with a rotary turbine. This technology is called as wind turbine technology (Yerebakan, 2001). According to a report from the European Wind Energy Association, the price of wind turbines has shown three-fold reduction. The investment costs of wind turbines of $ 1000/kW in 1997 decreased to $ 600/kW in 2006 (Öztürk, 2008c). The power of grid-independent wind electrical systems varies from a few kW to 100 kW, but often does not exceed 30 kW. Such wind turbines consist of the following units: a three-blade impeller, transmission system, guiding tail and braking system. The turbine is placed on a mast type pylon. DC electricity from wind energy can be stored with the battery. Grid-free large powerful (10-100 kW) systems are run in parallel with diesel generators as a backup power source. In wind-diesel systems, the consumer is supplied with AC by using DC/AC inverter. Agricultural application areas of wind energy are as follows (Vardar, 2009): Electrical applications, greenhouse climate, irrigation-drainage applications, heat pump applications, cooling applications and wind mill installations (Vardar, 2009). Because the wind energy is an intermittent source, it is used together with the storage systems in order to meet the water need continuously. Practically, the

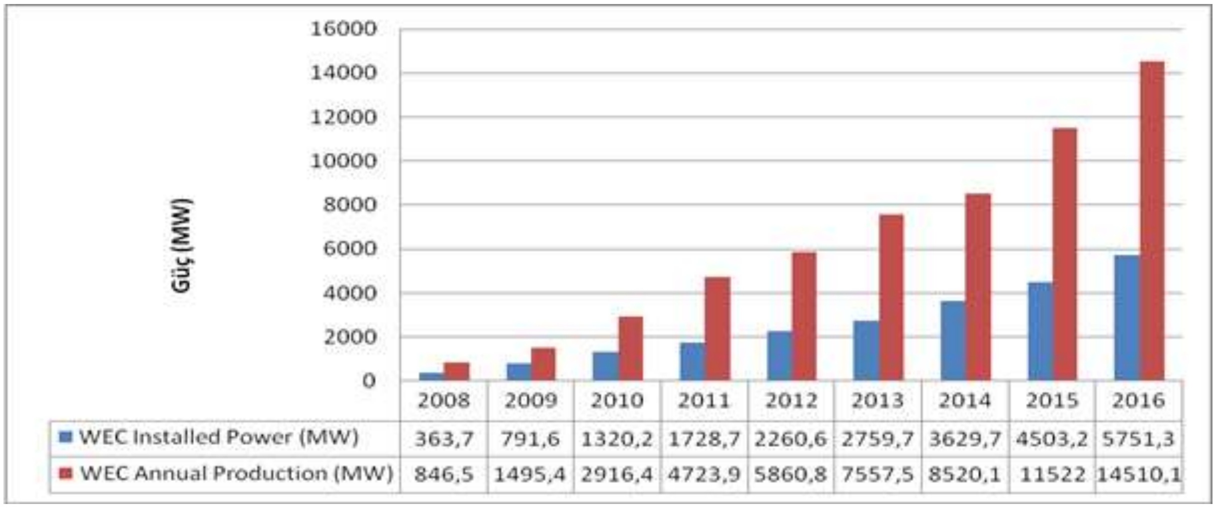

Figure 5. The development of wind energy in Turkey (installed power-production).

The Use of Geothermal Fields in Turkey	2002	2013	2017
Electricity Gen.	15 MEe	292 Mwe	858 Mwe
Residential Heat.	30000 KE 275 MWt	89000 KE 813 MWt	115000 KE 1033 MWt
Greenhouse Heat.	500000 m2 (100 MWt)	2985000 m2 (600 MWt)	3830000 (760 MWt)
Thermal Use	175 piece (300 MWt)	350 piece (600 MWT)	400 piece (1050 MWT)

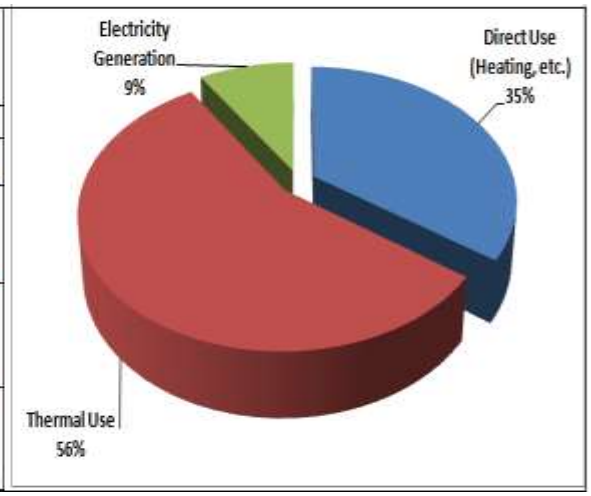

Figure 6. The use of geothermal fields in Turkey.

average water pumping time is estimated to be 6-8 hours at wind speeds of 4 to 7 m/s (Ultanır, 1998b). The development of wind energy in Turkey (installed power-production) is shown in Figure 5 (TWEA, 2017).

Use of geothermal energy in agriculture

Among the agricultural practices in the world, geothermal energy is used for heating the greenhouse at the highest rate of 14%. The rate of utilization of geothermal energy in fisheries and other livestock enterprises is 12%. Geothermal energy is also used in industrial farming areas such as reducing food water volume (dehydration), grain drying and fungal culture. Geothermal heat pump systems are used in agricultural areas in many parts of Europe and Australia, and the number of systems heated in the USA by in-ground grid system is estimated to be between 600.000 and 800.000 (Öztürk et al., 2010; Lund, 2005). According to data provided by the General Directorate of Electrical Power Resources Survey and Development Administration, a plurality of existing geothermal potential in Turkey is seen to be advantageous to heat the agricultural field. For example, by heating geothermal resources and 500,000 rural areas, it would mean saving an average of $1 billion m^3 natural gas imports a year and saving $400 million in foreign exchange savings (Alptekin, 2014). It is the energy source that is available geothermal resources in place and limited the transport over long distances (to be up to about 100 km) (Özyurt, and Dönmez, 2005), which limits the field of energy use for these resources in Turkey. Figure 6 (Kaya, 2017) illustrates the use of geothermal fields in Turkey, while geothermal wells

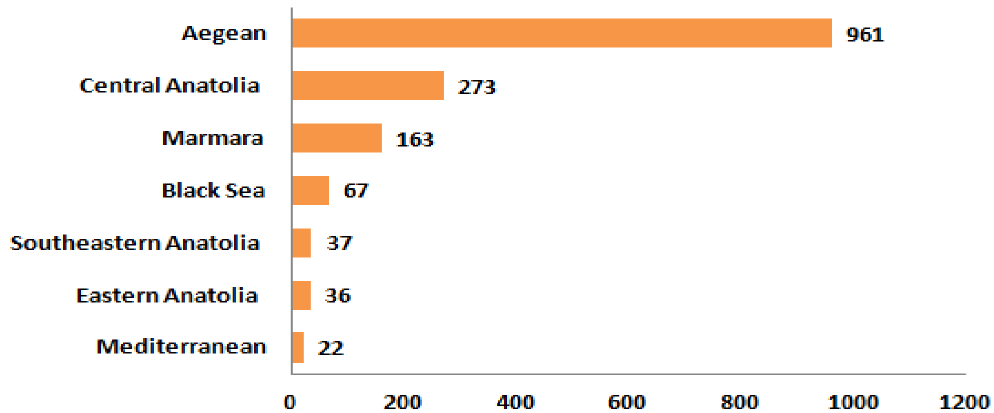

Figure 7. Geothermal well distribution by regions.

Table 7. Direct use of geothermal energy .

Chemical production	Heating applications	Industrial applications	Agricultural practices
Chemical production	Residential heating	Food drying	Greenhouse heating
Dry ice production	Soil heating	Sterilization	Animal shelters
	Street heating	Canning	Fish farms
	Fields heating	Logging	Soil heating
	Swimming pools	Wood coating industry	Product drying
	Thermal treatment centers	Paper industry	Mushroom production
	Touristic facilities	Weaving industry	Soil rehabilitation
		Paint industry	Irrigation
		Leather drying and processing	
		Brewing and distillation	
		Cooling plants	
		Concrete block drying	
		Drinking water	
		Laundries	

distribution by each region are shown in Figure 7 (Çerçioğlu and Şahin, 2016).

Direct use of geothermal energy

Heat exchanger systems can be in different designs depending on the field characteristics such as well heads and heat exchangers in the well. The efficiency of heating systems depends on their use in accordance with their continuity or success technology. Geothermal resources at low and medium temperatures can be used in many different areas. Direct use areas of geothermal energy can be summarized as in Table 7 (Özturk, 2006). Direct use of geothermal energy can be examined under three main groups, residential and business, industrial applications and agriculture. A common aspect of all these applications is the fluid distribution system. Depending on the flow of the fluid, the distribution system consisting of pipelines of different diameters and pump, valve, regulator and measurement-control device is insulated to reduce heat losses.

In geothermal applications, heat recovery from medium-temperature fluids with a temperature of 40-70°C can be achieved primarily with heat exchangers (Öztürk, 2008c). Geothermal energy is used as the greenhouse heating purpose at the highest rate of 12% among the agricultural applications in the world. The rate of utilization of geothermal energy in fisheries and other livestock enterprises is 10%. In agricultural applications, geothermal energy is used for drying products as low as 1%.

Use of geothermal energy for soil heating in open fields

Applications of geothermal energy and outdoor heating in open areas can be economical, especially for early spring and late autumn production. As in the case of greenhouse heating, it is necessary to take into account factors such as the most suitable soil conditions in the open-area soil heating applications, the optimum depth and range of the heating pipes, pipe material, soil temperature and effect of soil temperature on plants to be grown.

Use of geothermal energy in animal shelters

Geothermal energy can be utilized in cattle and small animal shelters in the presence of suitable environmental conditions. The fresh air entering the system is heated and delivered from the distribution ducts to the blowing holes, and the returning water is collected in a reservoir (Tüzel et al., 1994a). Therefore, the use of renewable energy resources in the greenhouse has reduced costs and increased product quality, while eliminating the environmental costs of using fossil fuels.

Greenhouse heating with geothermal energy

Research shows that fossil-based heating covers 60-70% of total greenhouse waste (Toros and Başçetinçelik, 1990; Şahin and Taşlıgil, 2012). The inability to regularly heat due to high cost brings problems such as low yield, limitation of production type and necessity of using hormone (Kendirli and Çakmak, 2009b). 95% of geothermal resources in Turkey is at a temperature suitable for heating. There are 172 geothermal areas with a temperature above 30°C. Geothermal energy and greenhouse heating systems are considered as a collection of elements used to transport the geothermal fluid to areas where consumers are located. Geothermal energy heating systems can be examined depending on the heat transfer, the materials used and the location of the heat exchangers. In regions with potential geothermal energy, this source has been shown to be useful for greenhouse heating due to the fact that the heat loss in some places is very high especially at night and because fossil-fuel heating systems increase operating costs (Çanakçı and Acarer, 2009). There are different application examples in greenhouse heating systems. However, the selection of the system to be selected in the greenhouse as well as the economics of the system to be selected is of great importance (Chiasson, 2005). In some applications, heat exchangers are used to provide heat transfer to the normal flow (water) circulation in the greenhouse due to the chemical components that are present in the geothermal fluid and cause corrosion (Yıldız, 2010).

Use of geothermal energy in fish farming

In fish breeding, the application temperature may vary depending on the species of fish, but may be utilized in fishing establishments from low temperature geothermal sources such as 21-27°C. However, fish species such as trout and salmon can be grown at low temperatures, not higher than 15°C (Öztürk, 2004b). When the water temperature falls below the desired values, the body metabolisms of the fish are negatively affected and the fish lose their nutritional ability. Providing a constant temperature value with geothermal water instead of only the sun that has the desired characteristics can be removed (Günerhan, 2010; Erden, 2005).

Use of geothermal energy in mushroom production

Since the increase in yield in fungal production depends on the environmental conditions, especially temperature, humidity, and ventilation, geothermal energy can be utilized in the production rooms and in pasteurization rooms. In the production of beech fungus which grows differently from culture cork, wheat stalks are taken to pasteurization after wheat stalks are wetted and rinsed with geothermal water at the stage of compost preparation (Tüzel et al., 1994b).

Geothermal energy use in soil remediation

Soil rehabilitation is a precautionary action that removes the limiting factors that prevent or restrict the cultivation of cultivated plants in the soil. The treatment of sodium soils is carried out only through chemical remediation. Additives such as soluble calcium salts, which reduce the proportion of the bound sodium, are given to replace the sodium that is attached to the soil (Kara and Çiftçi, 1994).

Use of geothermal fluid in ırrigation

Geothermal fluid is different from surface water in terms of its chemical properties. The amount of dissolved cations and anions is more than that. Beside the boron element, the cations important for irrigation are sodium, calcium and magnesium and the anions are chloride, sulphate, bicarbonate, carbonate. In order to use the geothermal fluid in the irrigation system, it is necessary to compare the chemical properties with the criteria of irrigation water. Although the boron boundaries of waters to be used for irrigation vary according to the plant species, it is suggested that water containing more than 1 ppm of boron should not be used in water (Kara and Çiftçi, 1994).

Use of geothermal energy in the drying of agricultural products

One of the technologies with the highest energy consumption in agriculture is the drying of cereals, vegetables, fruits and other products. The drying system

Table 8. Energy value by turkey biomass energy potential atlas.

Variable	TOE/year
Animal wastes	1.323.714,67
Vegetable wastes	15.941.321,26
Municipal organic wastes	2.186.228,09
Forest wastes	855.805
Total	20.307.069,02
	94.000 GWh/yıl
Elektricity generation assumed	
Annual production capacity	35.000 GWh/yıl
Power plant installed	12.000 MW

Table 9. Cycle techniques using biomass sources and fuels and application areas obtained using these techniques.

Biomass	Cycle method	Fuels	Application areas
Agricultural wastes	Pyrolysis	Ethanol	Heating, transport vehicles
Animal wastes	Fermentation, anaerobic digestion	Methane	Transport vehicles, heating
Vegetable and Animal oils	Esterification reaction	Diesel	Transportation vehicles, heating, greenhouse
Energy plants	Direct combustion	Hydrogen	Heating
Energy forests	Biophotolysis	Diesel	Product drying
Forest residues	Anaerobic digestion	Biogas	Electricity generation, heating
Algae	Hydrolysis	Synthetic oil	Rockets
Organic litters and wastes	Gasification	Methanol	Aircrafts

can be arranged together with the heating systems of other agricultural structures such as greenhouse to increase the utilization of geothermal resources.

Use of biomass energy in agriculture

Biomass refers to raw materials and waste that are agricultural, forestry and vegetable products and that are produced energy as whole or part. Today, biomass energy can be divided into two classes as classical and modern. While simple burning of wood and animal wastes is defined as classical biomass energy, various fuels such as biodiesel, ethanol and biogas derived from energy plants, energy forests, and refuse are regarded as modern biomass energy sources or biofuels (Karaca et al., 2004; ETO, 2009). The smell of animal fertilizers used in biogas production is lost during the process, and many elements that threaten human health are emerging (Kumba et al., 2005). The two main biofuels used today are bioethanol and biodiesel. Opinions that oil is not a sustainable resource, political instability, supply risk in large oil producing regions, and carbon emission results of fossil fuels have increased incentives for governments to use biofuels (Runge and Senauer, 2007; Hazell and Pachauri, 2006). Energy value by Turkey biomass energy potential atlas is shown in Table 8 (REGD, 2017b).

The conversion techniques using biomass sources and the fuels and application areas obtained using these techniques are given in Table 9 (Anonymous 2011). With the rapid advancement of technology and the increasing mechanization of agricultural production activities in Turkey, the use of diesel has increased in production stages such as tillage, fertilization, spraying, harvesting, agricultural product transport (Dellal et al., 2007). Despite its contribution to the environment and the country's economy, the biofuels sector has had negative impacts on the food industry, causing serious contraction in food supply, causing increases in agricultural product prices, threatening food safety with regard to access to food and affordability of food (Taşkaya, 2011). According to 2008 data, the size of available unused agricultural land in Turkey was determined to be about 146 million hectares. With an effective legal base and coordination, it is assumed that our country will be able to generate significant income from the biofuels sector by activating these idle resources (TEAM, 2009). In In the 2012 Global Renewable Energy Status Report, biomass, biofuels and biogas energy are employed around 2,480,000 people all over the world and this employment is a great opportunity for rural areas.

Biogas production

Anaerobic fermentation is used to obtain gaseous fuel from biomass sources. Anaerobic fermentation is the conversion of biomass into other products and by-products in an environment free of oxygen and microorganisms. Biogas consists mainly of methane (CH_4) and carbon dioxide (CO_2) gases, which are released as a result of biological degradation of organic substances under anaerobic conditions (anaerobic fermentation). Anaerobic fermentation is the process of converting biomass into other products and by-products in an environment free of oxygen and microorganisms. With a colorless, odorless, light, bright blue flame; biogas is the result of decomposition of organic waste/residues in an oxygen-free environment. Biogas consists of a gas mixture containing 60-70% methane, 30-40% carbon dioxide, 0-3% hydrogen sulfide and very little nitrogen and hydrogen, depending on the content of organic matter (Öztürk et al., 2009). Cultivating agricultural products for energy production is partly a new approach. Methane yield is the highest value in maize varieties ranging from 7.500-10.200 m^3/ha. The methane production of cereals ranges from 3.200 to 4.500 m^3/ha. The yield of methane production from wheat is 143-343 m^3/ton (Murphy and Power, 2008). Biogas is a high energy energy carrier. The energy value of biogas varies depending on the methane content. The energy value of 1 m^3 biogas with methane content of 55 and 95% is 21 MJ and 35,9 MJ, respectively (Murphy et al. 2004). As a result of the anaerobic fermentation process, the produced gas has very similar properties to the natural gas. The main product that has been uncovered as a result of this process is methane. Methane is a fuel with superior properties for many uses. In practice, it can be used in many applications where natural gas is used. One of the most commonly used fields of natural gas for power generation is internal combustion engines. The electrical conversion efficiency can be up to 25% in small-scale (<200 kW) installations. This activity is 30-35% in large installations (Öztürk, 2008c). Biogas is a versatile energy source that can be used for direct heating and lighting purposes as well as by converting electricity and mechanical energy. In addition, by-products resulting from biogas production can be used for a variety of purposes. Biogas is mainly used in electricity generation, heating, cooling and drying applications.

Biofuel production in Turkey

Biofuels in parallel with global developments in Turkey have come to the agenda again at the beginning of the 2000s and studies in universities has increased rapidly. In this direction, "Biodiesel Working Group" was established in the Ministry of Industry and Commerce in 2001. Legal arrangements have been made regarding the production and use of biofuels. Total fuel consumption in Turkey is 22 million tons and diesel and fuel-oil consumption is 16 million tons. In addition, 1.5 million tons of biodiesel and 160 thousand tons of bioethanol are available as installed capacity. Turkey is the second country in the world (after Germany) in terms of installed biodiesel capacity. Soybean, sunflower, date, cotton, canola and safflower are used for biodiesel production. However, canola and safflower are preferred due to higher quality in Turkey. The more preferred of these products in Turkey is the fact that they are not used as a food source. Another reason is that the effects of biodiesel can be observed in agriculture. The highest increase in Turkish agriculture production in the last three years is the result of the multiplier effect of biodiesel on oil seeds. Approximately 1.2 and 1.8 tonnes of bagasse are produced from 3 tons of canola used in the production of biodiesel. This process results in the addition of 1.2 kg of biodiesel and 120 kg of glycerin (soap base) with the addition of 120 kg of methanol. Albiyobir is established in order to monitor developments in the world in biodiesel alternative energy, to participate in activities in Turkey, to encourage the consumption and production of biodiesel and to promote alternative energy, to improve the country's agricultural potential of alternative products, and to assess the environmental problem of waste in Turkey. For the import of raw materials and oilseeds used in the production of biodiesel, \$985 million in 2004, \$1.1 billion in 2005 and \$1.4 billion in 2006 were spent (Akınerdem, 2007). With the use of domestic raw material, carbon dioxide will be absorbed in plant growth and internal migration will be prevented by creating employment opportunities in agriculture, industry and transportation sectors (Ar, 2007). The production of bioethanol from sugar molasses in Turkey is mainly supplied from the factory. As agreed in the TSE standards, 225.000 cubic meters of bioethanol per year is required when calculated on the basis of 5% mix. 2.5 kg of wheat is required for one liter of bioethanol with the current bioethanol production technology. The most suitable agricultural product for the production of bioethanol are corn and wheat and Turkey has the potential to increase these products. It is possible to increase corn production to 8 million tons and wheat production to 23 million tons in five years.

CONCLUSION AND RECOMMENDATIONS

One of the indispensable elements of human life is energy. A large part of the world's electricity needs are still provided by fossil fuels. This rate is up to about 86% In Turkey. These sources pose a great danger to human health and the environment. Hence, energy production based on fossil fuels is not a sustainable production. In response to this situation, renewable energy production is becoming increasingly important. Studies show that there is a direct relationship between total energy production and renewable energy production. This relationship has led people to renewable energy when natural resources are inadequate for human needs and unconscious use. Considering the problems that can be associated with energy nowadays and the expectations for the future, the prospect of renewable energy sources is accepted by most of the social sectors. The economic viability and method of implementation of renewable energy sources in the agricultural sector varies depending on regional conditions. An effective mechanization plan to be made at the enterprise scale should provide a suitable mechanization infrastructure for the enterprise. Progress in renewable energy technologies should be followed worldwide, and work across the country should be encouraged and supported. As in Europe, an attractive market for investors should be established for the widespread use of renewable energy. Investors and even users should be encouraged by the state (tax deduction, credit, etc.). A system should be established in which sustainable energies are rewarded for their social and environmental benefits, and added to the prices of the social costs of polluting energies. Moreover, in investment decisions, priority should be given to the projects with the lowest social cost in the long run. Priority national targets and implementation plans, supports and investments should be identified in the agriculture sector, which will increase the share of renewable energy. Importance of energy use should also be emphasized in agricultural production processes. Technologies that have high energy efficiency should be utilized for the mechanization infrastructure of the enterprises. Agricultural support policies should be provided to reduce fossil-based energy consumption and use of renewable energy in the agricultural sector. In addition, precautions should be taken such as the use of inputs and production optimization and the support of technology transfer in agriculture.

Renewable energy sources need to be utilized to effectively prevent environmental problems arising from the direct or indirect use of fossil fuels. Therefore, the introduction of incentives in the form of planned use of green energy is a top priority in order to protect today's energy presence in agriculture sector and to prevent negative effects on environment. The widespread use of renewable energy resources in the agricultural sector will benefit both socio-economic development and sustainable agriculture. For effective use of renewable energy resources, the application of photovoltaic-irrigation systems and modern irrigation techniques (drip and sprinkler irrigation) combined with photovoltaic-pump applications in agricultural areas by evaluating the feasibility of solar heating and greenhouse heating systems in terms of region contributes to energy saving as well as to solve important problems such as water waste, salivation and salting. With the electric energy obtained from the photovoltaic panels in summer, the energy needs such as lighting, ventilation and irrigation of the greenhouse can be met. Thus, regional development will be achieved with high added value products. Geothermal energy is one of the natural energy sources that can be utilized for the climate conditioning of agricultural structures in terms of technology level and economic feasibility. Development goals, rising levels of prosperity and increasing population bring energy demand growth. These factors increase the agricultural production and energy production is done from the energy plants. Bio-resources should be strengthened and brought to bioenergy production, which is the energy of the future in terms of environmental economy. Some of the energy should be supplied by making more production than the plants of agricultural origin. With an important and great potential, biofuels from renewable energy sources in order to ensure sustainable energy in Turkey meet a large part of the demand for energy imports.

Therefore, biofuels and the agricultural energy field that constitutes the basic raw materials should be considered as strategic areas and the national targets and programs should be determined in this respect. A "Biofuels Board" consisting of relevant ministries, official and scientific organizations and sector representatives should be established to coordinate the work in this area. The new premium system, which will be applied to the oil seeds used in biofuel production, has to be created in a way that will protect the producer and increase production. Selection and design of biomass power plants requires different optimization studies on the available amount of biomass in the area at a certain distance from the basin. The number of combined heat-power installations required depends on the presence of biomass in the region and the technical, economic and operational characteristics of the investment to be made. As a result, alternative energy resources (solar energy, geothermal energy, biomass energy and wind energy) will be used in agriculture to increase the level of income in the rural area. In this way, great contributions will be gained in the integration of agricultural production and agricultural industry and in the creation of alternative income sources in the rural area. A basic energy policy should be to present the energy to the consumers in sufficient, quality, sustained, low cost and sustainable. Domestic, new and renewable energy sources should be given importance in energy production. Energy planning should aim to protect national and public interests and increase social benefits, and enable citizens to access cheap, sustainable and reliable energy sources easily. Incentives for renewable energy production should be increased and production areas should be expanded. Fossil fuels, which are considered to be unsustainable in the world, are also restricted in the agricultural sector.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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