Journal of Engineering Research and Applied Science
Available at www.journaleras.com
Volume 2(2) December 2013, pp 167-183
ISSN 2147-3471 © 2013

Bioenergy potential, utilization and policies in Turkey

A. Bahadır [1], S. Keleş [1], K. Kaygusuz [1,a], M.F.urker[2], M.Yeğin[3]

[1] Karadeniz Technical University, Chemistry, Trabzon, Turkey.
[2] Karadeniz Technical University, Forest Engineering, Trabzon, Turkey.
[3] Kocaeli University, Electrical Engineering, Kocaeli, Turkey.

Accepted 10 July 2013

Abstract
Since the turn of this century, in the early 2000s, the issues of energy and climate change have been put at the top of political and economic agendas. There are many reasons such as increasing petrol prices, the problem of energy safety and of natural gas supply are under debate, the Kyoto Protocol came into force in 2005. Turkey is heavily dependent on imported energy resources that place a big burden on the economy. Air pollution is also becoming a great environmental concern in the country. In this regard, renewable energy resources appear to be one of the most efficient and effective solutions for clean and sustainable energy development in Turkey. Turkey's renewable sources are the second largest source for energy production after coal. About two-thirds of the renewable energy produced is obtained from forest biomass and other bioenergy sources, which is used to meet a variety of energy needs, including generating electricity, heating homes, fueling vehicles and providing process heat for industrial facilities. The yearly amount of usable biomass potential of Turkey is between 15-18 Mtoe. Since biomass energy will be used more and more in the future, its current potential, usage, and assessment in Turkey is the focus of the present study. The paper not only presents a discussion of the potential and utilization of the biomass energy in Turkey but also provides some guidelines for policy makers.

Keywords: Climate change; energy issues; bioenergy; renewable energy; sustainability

1. Introduction

The Republic of Turkey, located in Southeastern Europe and Southwestern Asia (that portion of Turkey west of the Bosporus is geographically part of Europe), has an area of about 780,580 km^2 and a population of over 70 million [1]. With its young population, growing energy demand per person, fast growing urbanization and economic development; Turkey has been one of the fast growing power markets of the world for the last two decades. Turkey is an energy-importing country; more than half of the energy requirement has been supplied by imports.

The energy sources can be split into three categories: fossil fuels, renewable sources and nuclear sources. In this paper, the focus will be on renewable sources, specifically bioenergy, in Turkey. However, before getting into details of bioenergy use in Turkey, let me concentrate on the definition of ‘‘renewable source’’. In this paper, an energy source is regarded as renewable if it has the following two distinctive qualifications:

- carbon neutral and
- derived from those natural, mechanical, thermal and growth processes that repeat themselves within our lifetime.

Based on this definition, examples of renewable energy sources include bioenergy, hydro, solar, wind and geothermal sources.

Biomass combustion is carbon or carbon dioxide neutral compared with fossil fuel combustion because the biomass combustion is simply releasing the carbon or carbon dioxide that was sequestered by growing the biomass in the beginning is certainly true. It may be argued that such thinking completely ignores the fact that fossil fuel combustion is also carbon or carbon dioxide neutral for exactly the same reason; however, it should be noted that the obvious difference lies in the elapsed time between the sequestration from the atmosphere and the return of the carbon or carbon dioxide to the atmosphere [2-7]. Biomass is the term used for all organic material

[a] Corresponding author;
Phone: +90-462-377-2591, Email : kamilk@ktu.edu.tr

originating from plants, trees and crops and is essentially the collection and storage of the sun's energy through photosynthesis. Biomass can be either obtained directly from plants or indirectly from industrial, domestic, agricultural and animal wastes. The examples of biomass energy sources include wood and wood wastes, agricultural crops and their waste byproducts, municipal solid waste, animal wastes, waste from food processing, and aquatic plants, algae, energy crops such as trees and sugarcane that can be grown specifically for conversion to energy [3]. Biomass energy, or bioenergy, is the conversion of biomass into useful forms of energy such as heat, electricity and liquid fuels. Figure 1 shows the bioenergy conversion possibilities.

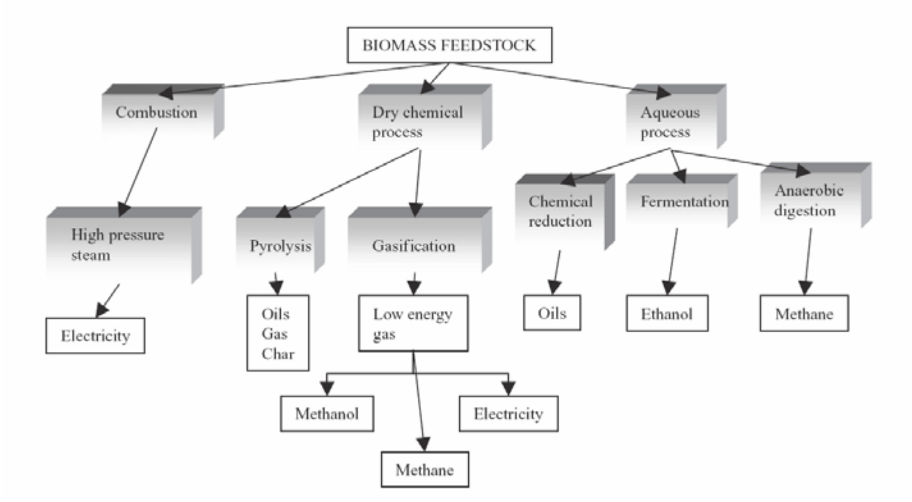

Figure 1. Bioenergy conversion possibilities (Mtoe: million tons of oil equivalent).

Table 1. Renewable energy added and existing capacities, 2009 (Mtoe)

	Added During 2009	Existing at End of 2009
Power generation (GW)		
Wind power	38	159
Small hydropower <10 MW	2-4	60
Biomass power	2-4	54
Solar PV, grid-connected	7	21
Geothermal power	0.4	11
Concentrating solar power (CSP)	0.2	0.6
Ocean power	0	0.3
Hydropower (all size)	31	980
Hot water/heating (GWth)		
Biomass heating	n/a	270
Solar hot water/space heating	35	180
Geothermal heating	n/a	60
Transport fuels (billion liters/year)		
Ethanol production	9	76
Biodiesel production	5	17

Bioenergy, the energy from biomass, has been used for thousands of years, ever since people started burning wood to cook food or to keep warm. Biomass is used to meet a variety of energy needs, including generating electricity, heating homes, fueling vehicles and providing process heat for industrial facilities. Today, worldwide, biomass is in the fourth place as an energy source and provides about 14% of the world’s energy needs [6-9]; it also accounts for about 38% of the primary energy consumption in developing countries and it often makes up more than 90% of the total rural energy supplies in those countries. The average majority of biomass energy is produced from wood and wood wastes (64%), followed by municipal solid waste (24%), agricultural waste (5%) and landfill gases (5%) [4-7]. Table 1 presents renewable energy indicators in the world [10].

The rest of the study is organized as follows. Section 2 introduces the key indicators of Turkish economy and her energy sector. Section 3 describes the current status of bioenergy in Turkey, while Section 4 deals with evaluation of bioenergy use in general. Then, some guidelines for policy makers are provided based on the findings of the study. Finally, Section 6 gathers the main conclusions derived from the paper.

2. Key indicators of Turkish economy and energy sector

The Republic of Turkey, located in Southeastern Europe and Southwestern Asia, has an area of about 780,580 km^2 and a population of over 72 million [1]. With its young population, growing energy demand per person, fast growing urbanization and economic development; Turkey has been one of the fast growing power markets of the world for the last two decades. Turkey is an energy importing country; more than two thirds of the energy requirement has been supplied by imports [10-13]. Turkey's dynamic economy is a complex mix of modern industry and commerce along with a traditional agriculture sector that still accounts for more than 35% of employment. It has a strong and rapidly growing private sector, yet the state still plays a major role in basic industry, banking, transport, and communication. Real GNP growth has exceeded 6% in many years, but this strong expansion has been interrupted by sharp declines in output in 2001. The economy is turning around with the implementation of economic reforms, and 2006 GDP growth reached 10%, followed by roughly 5% annual growth from 2005-08. Inflation fell to 7.7% in 2005 but climbed back to 8.5% in 2007. Despite the strong economic gains from 2002-08, which were largely due to renewed investor interest in emerging markets, IMF backing, and tighter fiscal policy, the economy is still burdened by a high current account deficit and high external debt. In short, the economic fundamentals of Turkey are sound, marked by strong economic growth and foreign direct investment [1]. Turkey's population of more than 72 million is growing at an annual rate of 1.01% and expected to grow to 85 million in 2030. In response to the growth rates of population and consumption, Turkey's total final energy consumption (TFC) grew at an average annual rate of 9.6% over the last three decades. This average annual growth rate of TFC is projected to decrease to 6.4% between 2010 and 2020 and 8% between 2020 and 2030. Table 2 presents some important selected Indicators for Turkey [1, 8].

Table2. Some important indicators for Turkey in 2008

Indicator	Value
Population (millions)	72
Population growth rate	1.01%
GDP (purchasing power parity, billion 2000 USD)	376
GDP (official exchange rate, billion USD)	664
GDP real growth rate	4.1%
GDP per capita (purchasing power parity, USD)	12,000
GDP per capita (official exchange rate, USD)	9,000
Electricity production (GWh)	200
Electricity consumption/population (kWh/capita)	2,650
Energy-related CO_2 emissions (Mt CO_2)	263.4

Turkey's primary energy sources include hydropower, geothermal, lignite, hard coal, oil, natural gas, wood, animal and plant wastes, solar and wind energy [11]. In 2008, primary energy production and consumption has reached 29 and 98.55 Mtoe, respectively as shown in Table 3.

Table 3. Energy production and consumption in Turkey

Energy source	1990	2000	2005	2008
Coal	12.37	12.49	10.81	16.68
Oil	3.61	2.73	2.23	2.13
Gas	0.17	0.53	0.74	0.84
Wood & Waste	7.21	6.51	5.36	4.88
Hydropower	1.99	2.66	3.40	2.86
Wind	-	0.0	0.01	0.07
Geothermal	0.43	0.68	1.01	1.15
Solar	0.03	0.26	0.39	0.42
Total production	25.82	25.86	23.93	29.03
Coal	16.91	22.91	22.79	29.46
Oil	23.40	30.40	28.75	29.55
Gas	2.86	12.63	22.79	30.18
Wood & Waste	7.21	6.51	5.36	4.88
Hydropower	1.99	2.66	3.40	2.86
Wind	-	0.0	0.01	0.07
Geothermal	0.43	0.68	1.01	1.15
Solar	0.03	0.26	0.39	0.42
Total consumption	52.76	76.35	84.38	98.55

Fossil fuels provided about 90.5% of the total energy consumption of the year 2008, with natural gas (30.62%) in first place, followed by oil (25.98%) and coal (29.89%). Turkey has not utilized nuclear energy yet [8, 9].

The Turkish coal sector, which includes hard coal as well as lignite, accounts for nearly one half of the country's total primary energy production (57.5%). The renewables collectively provided 9.5% of the primary energy consumption, mostly in the form of combustible renewables and wastes (4.95%), hydropower (about 3%) and other renewable energy resources (1.3%) [11-13]. As can be seen in Table 3, the general equilibrium of energy use and supply indicators shows that Turkey is dependent on imported resources very heavily. In 2008, 70.5% of the total energy supply was met by imports [9]. Turkey's total electricity production and installed capacity were 191.6 GWh and 41.7 GW, respectively, in 2007.

The distribution of the produced electricity energy according to primary energy sources was as follows: natural gas 49.6%, coal 27.9%, hydropower 18.7%, oil 3.4%, geothermal 0.08% and wind 0.2%.

Table 4 reflects the increasing reliance on natural gas in the power sector. The share of natural gas power plants in installed capacity was about 31.6% in 2007 and natural gas had the largest share in gross electricity output in 2007 [8].

Table 4. Installed capacity and electricity generation in Turkey (2008)

Fuel type	Installed capacity (MW)	Share of total (%)	Electricity generation (GWh)	Share of Total (%)
Natural gas	12 007.7	28.68	98 685	49.72
Hydropower	13 828.7	33.03	33 270	16.76
Coal	10 190.9	24.34	57 716	29.08
Oil	1 998.6	4.77	7 519	3.78
Geothermal	30.00	0.07	162	0.08
Wind	847.0	2.02	847	0.42
Others	2961.3	7.07	250	0.13
Total	41 864.2	10.00	198 450	100.00

3. Current status of bioenergy in Turkey

3.1. Bioenergy potential in Turkey

Bioenergy is the term used for all organic material originating from plants, trees and crops and is essentially the collection and storage of the sun's energy through photosynthesis. Biomass energy, or bioenergy, is the conversion of biomass into useful forms of energy such as heat, electricity and liquid fuels [14-23]. Biomass for bioenergy comes either directly from the land, as dedicated energy crops, or from residues generated in the processing of crops for food or other products such as pulp and paper from the wood industry. Another important contribution is from post consumer residue streams such as construction and demolition wood, pallets used in transportation, and the clean fraction of municipal solid waste.

Table 5. Production of crop residues in Turkey

Crop	Residue	Theoretical Production (tons)	Actual Production (tons)	Available Residue (tons)	Heating Value (MJ/kg)	Total Heating Value (x10^5 GJ)
Wheat	Straw	29,170,755	23,429,907	3,514,486	17.9	629.2
Barley	Straw	9,992,948	8,963,012	1,344,452	17.5	235.3
Rye	Straw	405,188	358,040	53,706	17.5	9.4
Oats	Straw	419,678	321,236	48,185	17.4	8.4
Maize	Stalk	5,911,902	4,970,259	2,982,155	18.5	551.7
	Cob	596,592	1,907,307	1,144,384	18.4	210.6
Rice	Straw	582,555	209,532	125,719	16.7	21.0
	Husk	88,527	77,742	62,198	12.9	8.1
Tobacco	Stalk	362,763	410,778	246,467	16.1	39.7
Cotton	Stalk	6,317,181	2,520,281	1,512,169	18.2	275,2
	Ginning	481,527	732,220	585,776	15.7	91.7
Sunflower	Stalk	2,341,554	2,259,121	1,355,472	14.2	192.5
Groundnut	Shell	27,621	28,638	22,910	20.8	4.8
Soybean	Straw	60,468	21,872	13,123	19.4	2.5

Biomass is the oldest form of renewable energy exploited by mankind, mainly in the form of wood burnt to provide heat and light for domestic and productive activities [21]. The main biomass resources are agricultural residues and wastes, organic fractions of municipal solid waste and refuse, sewage sludge, industrial residues, short-rotation forests, herbaceous lingo-cellulosic crops, sugar crops, starch crops, oil crops, wood wastes. In the long term, energy crops could be a very important biomass fuel source. At present, however, wastes are the major biomass sources [20-23].

Table 5 shows the production of crop residues in Turkey. As shown in Table 5, total heating value obtained from crop residues is about 2280.1x10^5 Gigajoul (GJ) and total available residue was about 12,950,232 tons in 2006. The production of fruit and fruit tree residues in Turkey is given in Table 6. As shown in Table 6, total heating value obtained from fruit residues is about 754x10^5 GJ and total available residue was about 3,250,212 tons in 2006. Table 7 also shows the total amount of animal wastes, available dry manure and biogas in Turkey. As shown in Table 7, available yearly amount of biogas is 2,650 billion m^3 and total heating value was 551.5x10^5 GJ in 2008. All these tables show that there is an important bioenergy potential for Turkey excluding fuelwood in 2008 [24-26].

Table 6. Production of fruit and fruit tree residues in Turkey

Crop	Residue	Theoretical Production (tons)	Actual Production (tons)	Available Residue (tons)	Heating Value (MJ/kg)	Total Heating Value (x10^5 GJ)
Apricots	Tree pruning	1,328,846	86,964	69,571	19.3	13.4
Olive	Cake	673,484	829,816	746,834	20.69	154.5
	Tree pruning	-	441,254	220,627	18.1	39.9
Pistachio	Shell	-	14,008	4,202	19.26	8.2
	Tree pruning	-	209,611	167,88	19.0	31.9
Walnut	Shell	173,546	75,792	60,633	20.18	12.2
	Tree pruning	-	50,480	25,240	19.0	4.8
Almond	Shell	44,366	25,784	23,205	19.38	4.6
	Tree pruning	13,076	28,500	22,800	18.4	4.2
Hazelnut	Shell	698,499	566,437	453,510	19.3	87.5
	Tree pruning	-	2,177,986	1,742,389	19.1	332.2
	Tree pruning	236,852	88,465	70,772	17.6	12.5
Orange	Tree pruning	3,424,439	237,686	190,148	17.6	33.5
Mandarin	Tree pruning	981,970	1,093,430	82,744	17.6	14.6

Table 7. Total amount of animal wastes, available dry manure and biogas in Turkey

Animal Waste	Waste quantity (tons/year)	Total dry manure (tons/year)	Available dry manure (tons/year)	Available Biogas (m^3/year)	Heating Value (MJ/kg)	Total heating value (x10^5 GJ)
Cow	27,654,932	16,211,033	10,535,172	2,107,434,345	22.7	478.4
Sheep	24,558,323	6,139,581	758,146	159,629,101	22.7	36.2
Poultry	7,731,694	1,932,924	1,913,594	382,718,866	22.7	36.9

Direct burning in Turkey for many years has used fuelwood, animal wastes, agricultural crop residues, and logging wastes [25-27].

These sources are often called non-commercial energy sources, but in Turkey, fuelwood is a tradable community since it is the primary fuel in rural and urban poor districts. Fuelwood is the fourth largest source of energy in Turkey. Wood is the major source of energy in rural Turkey (see Figs. 2-6). An average consumer in a year burns 0.80 m^3 fuelwood. The total forests potential of Turkey is around 930 million m^3 with an annual growth of about 26 million m^3.

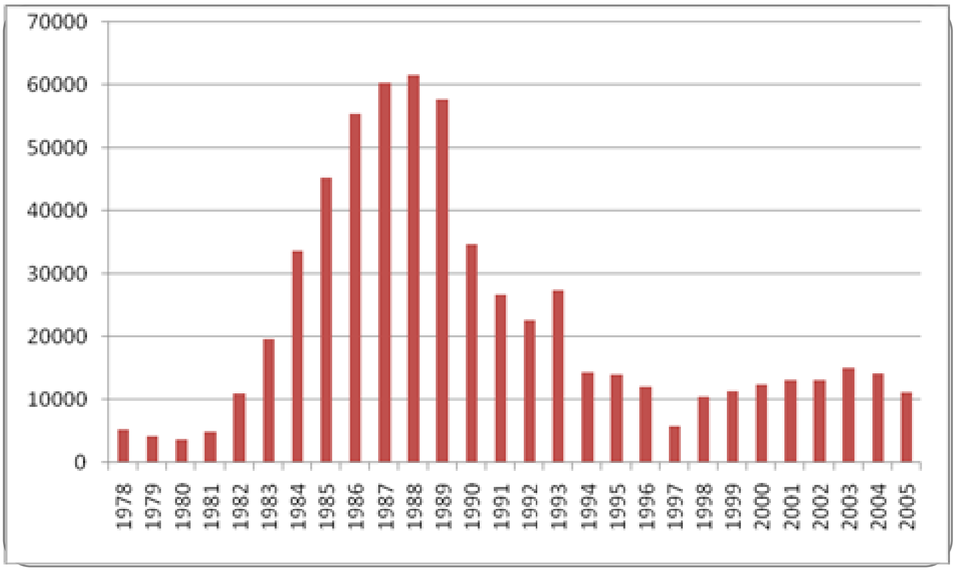

Figure 2. Energy forests area in Turkey (hectares).

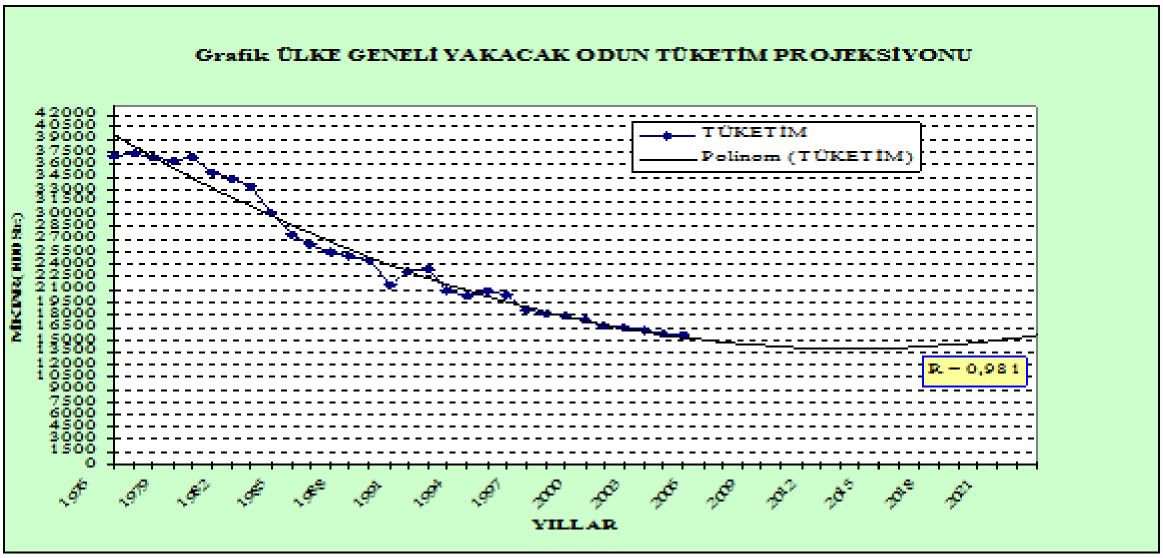

Figure 3. The projection of fuelwood consumption in Turkey.

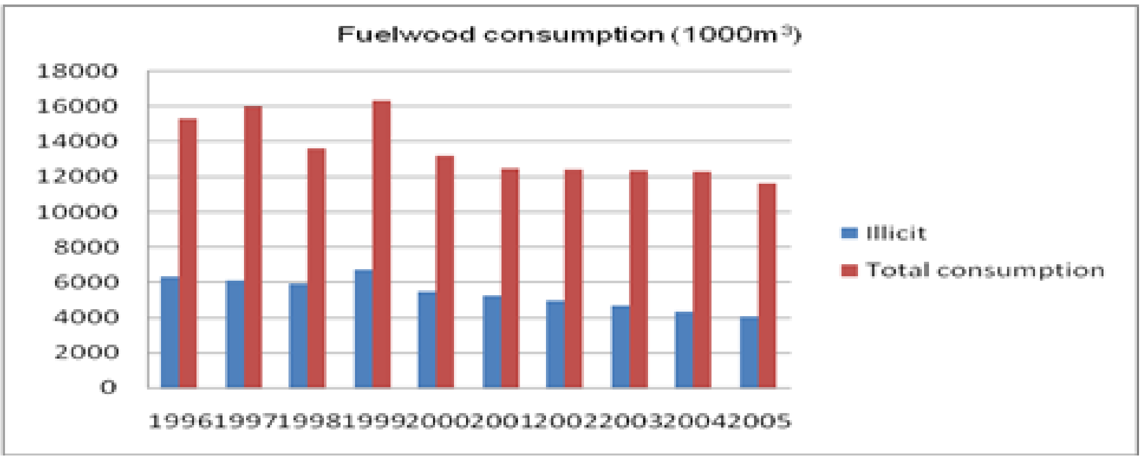

Figure 4. Fuelwood consumption in Turkey.

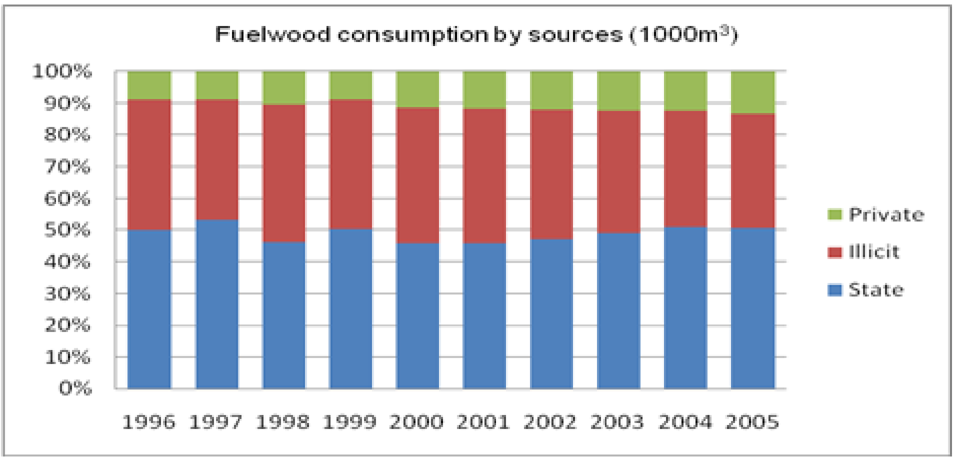

Figure 5. Fuelwood consumption by sources in Turkey.

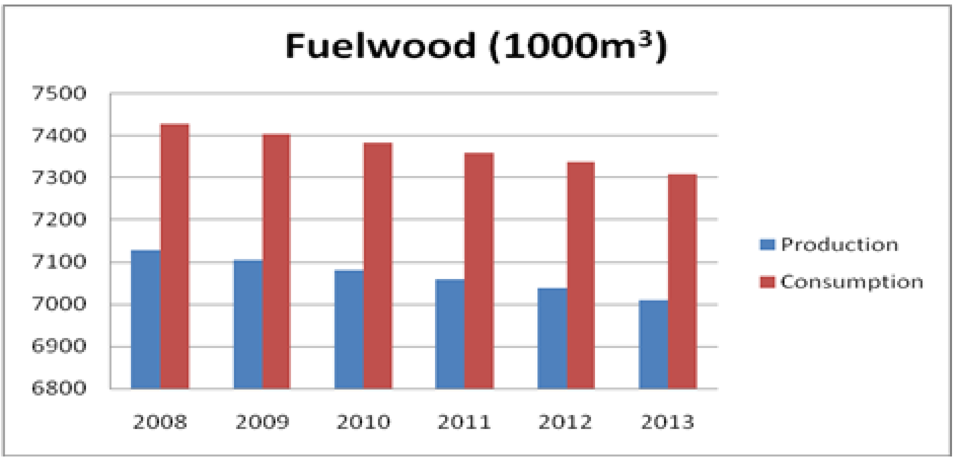

Figure 6. Production and consumption projections of the fuelwood in Turkey.

The total forest area in Turkey occupies 26% of the country's territory [1, 15]. Traditional fuels predominate in rural areas; almost all biomass energy is consumed in the household sector for heating, cleaning, and cooking needs of rural people. The lumber, pulp and paper industries burn their own wood wastes in large furnaces and boilers to supply 60% of the energy needed to run factories. In their homes, Turkish people burn wood in stoves and fireplaces to cook meals and warm their residences. Wood is the primary heating fuel in 6.0 million homes in Turkey [8, 11, 12].

Biogas energy is also derived from biomass, which is combusted as a gas comprising primarily methane [12]. Biogas is commonly generated from biomass waste products at sewage treatment plants, solid waste landfills, through forest sector activities, and agricultural operations [13]. The composition of Turkish municipal solid wastes (see Figure 7) shows that there is important potential for biogas production.

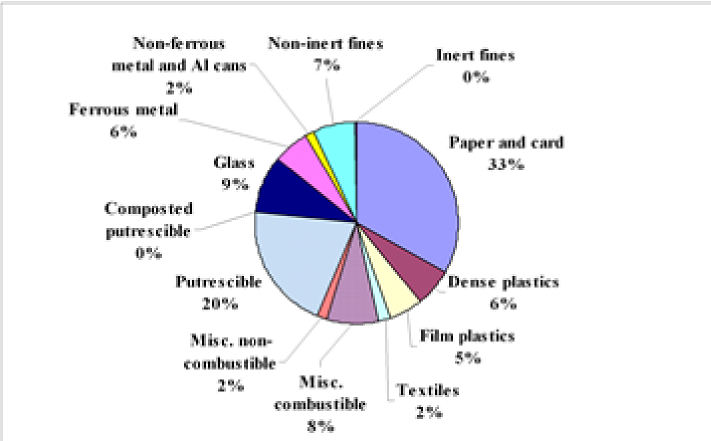

Figure 7. Fractional composition of Turkish municipal solid wastes.

The biomass products are converted to a gaseous fuel. Biogas is then combusted in a boiler to produce steam for power generation through a steam turbine or through a combustion turbine directly. In both instances, under cogeneration applications, the residual heat is used as energy for other applications [11, 12]. In the coming years, these energy sources will play an increasingly significant role for producing green power [8]. Biogas production potential in Turkey has been estimated at 1.0–1.5 million tons of oil equivalent (Mtoe) but only three small units are in operation and one new facility (1.5 MW) has been licensed [11]. Around 85% of the total biogas potential is from dung gas, while the remainder comes from landfill gas. The use of animal wastes as biofuel is limited because they are mostly used in agriculture as fertilizers [8, 9, 26]. Table 9 shows Turkey's biogas plant inventory.

3.2. Current Turkish legislation on bioenergy

Existing Turkish law and regulation with relevance to the use of renewable energy sources is limited to two pieces of legislation. One piece of legislation is the Electricity Market Licensing Regulation, and the second is the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy (Law no. 5346). As indicated by the titles, this legislation has been developed for the electricity sector. In both regulations, biomass is included in the definition of renewable energy resource. There is no legislation currently existing for biomass alone [8, 9, 11, 12].

In Turkey, market-based policies for renewables started in 1984 with third-party financing, excise and sales tax exemptions. The Turkish government's approach to the deployment of renewables reveals its priorities to develop indigenous and renewable resources in conjunction with the expansion of privately owned and operated power generation from renewable sources. The build-own-transfer (BOT) and the build-own-operate (BOO) schemes were put in place in 1984 and financed major power projects with the main objective of attracting private investors. BOT projects were granted a treasury guarantee. Although BOT and BOO approaches attracted significant investment, they also created large public obligations with the government covering the market risk through take-or-pay contracts. The BOT and BOO financing schemes ended in 2000 and were replaced in 2001 by financial incentives within the framework of the Electricity Market Law [2, 11, 12].

Table 9. Turkey's biogas plant inventory

Name of the company/place	Type of plant	Annual gas Production (million m^3)
Ekolojik Energy Company	Landfill gas	2.2
Gaziantep M. Waste Treatment Plant	Landfill gas	3.0
Adana M. Waste Treatment Plant	Landfill gas	1.9
Kemerburgaz Landfill Area-Odayeri	Landfill gas	51.6
Kemerburgaz Landfill Area-Komurcuoda	Landfill gas	35
Cadırtepe Landfill	Landfill gas	14
Mamak Landfill	Municipal waste & landfill gas	55
Eregli Sugar Plant	Waste Water Treatment	1.0
Yozgat and Afyon Sugar Plant	Waste Water Treatment	1.4
Kırşehir Sugar Plant	Waste Water Treatment	1.4
Eskişehir Sugar Plant	Waste Water Treatment	1.3
Burdur Sugar Plant	Waste Water Treatment	1.3
Bolpat Potato Production	Waste Water Treatment	1.2
Efes Beer Production	Waste Water Treatment	0.8
TekSut Milk Production	Waste Water Treatment	0.2
Mauri Yeast Production	Waste Water Treatment	2.6
Pakmaya Yeast Production	Waste Water Treatment	1.4
Total Production		178.15

According to the Electricity Market Licensing Regulation, promotion of renewable energy sources in the electricity market has been assigned to the Energy Market Regulatory Authority (EMRA). With regard to the environmental effects of the electricity generation operations, to take necessary measures for encouraging the utilization of renewable and domestic energy resources and to initiate actions with relevant agencies for provision and implementation of incentives in this field. In this context, there are some incentives and regulations related to renewable energy sources. The incentives brought into existence based on the Electricity Market Licensing Regulation are given below [8, 11]:

- Entities applying for licenses for construction of facilities based on domestic natural resources and renewable energy resources shall pay only 1% of the total licensing fee.
- The generation facilities based on renewable energy resources shall not pay annual license fees for the first ten years following the facility completion date indicated on their respective licenses.
- Turkish Electricity Transmission Company (TEIAS) and/or distribution companies shall assign priority for system connection of generation facilities based on domestic natural resources and renewable resources.

The aim of the Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy is to increase the use of renewable energy sources for generating electrical energy, as well as to diversify energy resources, reduce greenhouse gas emissions, assess waste products, protect the environment and develop the necessary manufacturing sector for realizing these objectives. In this law, the biomass definition given as: the fuels in solid, liquid or gaseous phase obtained from organic wastes and from the agricultural and forestry products including the waste products of agricultural harvesting and oil extraction from plants as well as from the byproducts formed after their processing. Specific incentives introduced in the law that are applicable to the use of biomass include [11]:

- Obligation to purchase electricity from renewable energy sources: Each legal entity possessing a retail sale license shall be required to purchase renewable energy source-certified (REScertified) electricity in an amount declared by EMRA.
- Purchasing of electricity from renewable energy sources with a higher price: Until the end of 2013, the applicable price for the electricity to be purchased in pursuance with the law within each calendar year shall be the Turkish average wholesale electricity price in the previous year determined by EMRA. The Council of Ministers is entitled to raise this price up to 20% at the beginning of each year.
- In the case of utilization of property is under the possession of forestry or under the sovereignty of the State for the purpose of generating electricity from the renewable energy resources included in the law, these territories are permitted on the basis of its sale price, rented, given right of access, or usage permission by the Ministry of Environment and Forestry. A 50% deduction shall be implemented for permission, rent, right of access and usage permission in the investment period.

3.3. International aspect

Rising concern for global environmental degradation have led to wide acceptance of sustainable development concept. Following its initial popularization, the concept of the sustainability has appeared in a wide range of forms in recent literature. Although different authors have given it a variety of meanings, sustainable development is best defined as meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. In this context, sustainability is used to characterize the desired balance between economic growth and environmental preservation [8, 11]. The Kyoto Protocol to the United Nations Framework Convention on Climate Change, agreed to in December 1997, marks an important turning point in efforts to promote the use of renewable energy worldwide [28]. Since the original Framework Convention was signed at the Earth Summit in Rio de Janeiro in 1992, evidences of climate change have spurred many countries to increase their support of renewable energy. Even more ambitious efforts to promote renewables can be expected as a result of the Kyoto pact, which includes legally binding missions limits for industrial countries, and for the first time, specially identifies promotion of renewable energy as a key-strategy for reducing greenhouse gas emissions. On the other hand, European Union opened accession negotiations with Turkey and there are many policies, directives, standards and norms in the EU designed to stimulate and support the biofuels industry. The Renewable Fuels Directive defines targets for 6% of petrol and diesel for transport by the end of 2010 and 10% by the end of 2010 [8]. To support the biofuels industry, the Energy Taxation Directive allows exemptions or reductions from energy taxation for biofuels [2, 8, 11]. The recently released Biomass Action Plan (BAP) outlines more than 20 actions to stimulate the development and diffusion of bioenergy in Europe. Many of the actions in the BAP are focused on meeting the targets in the Renewable Fuels Directive. Finally, there are a range of fuel standards and emission norms in the EU for petrol, diesel, bioethanol and biodiesel. Currently, Turkey is not required to comply with the EU norms but in the near future she will be obliged to do so in the course of accession negotiation.

3.4. Barriers to bioenergy exploitation in Turkey

The barriers holding back biomass exploitation in Turkey can be divided into two main groups: (1) barriers in the institutional, legal and administrative framework and (2) real and perceived risks and other inherent difficulties associated with promoting biomass energy. The most important barriers in the institutional, legal and administrative framework for the exploitation of biomass in Turkey are summarized below [2]:

- establishment of a responsibilities structure and organization at the institutional level, which requires a higher level of coordination and cooperation within and between institutions, agencies, institutes and other stakeholders,

- insufficient available information about existing and possible future costs of biomass utilization,
- insufficient detailed biomass energy resource assessments and data banks pertaining to Turkey,
- insufficient credit facilities, particularly for small-scale projects,
- administrative and time-consuming obstacles for foreign investors,
- need for support for infrastructure and management know-how at a local level,
- insufficient participation by the private sector,
- need for staff with sufficient technical information,
- difficulties possibly encountered in planning, project feasibility and project control activities,
- insufficient policy and market instruments in the environmental, agricultural and energy sectors, and
- need for public acceptance and willingness.

In contrast to fossil fuels, biomass fuels are characterized by their low density, and sources of biomass are small, dispersed, disparate and seasonal. Biomass fuels may be collected from, for example, individual farms covering a wide geographic area. Sources are very small in comparison to fossil fuel extraction industries, with the possible exception of the largest pulp and paper or wood processing units. These issues all contribute to potentially raised fuel costs-via logistics, contracting, transport, fuel preparation, and storage. On the other hand, a unique aspect of many agricultural waste materials is theirseasonality. The seasonality of agriculture is seen to be a key risk, for both establishing viable fuel supply businesses and for maintaining year-round fuel supplies for potential energy plants [4].

The high capital cost of agricultural waste or biomass power plants is a major disincentive to investors. Further, the upper size limit of biomass plants is lower than fossil fuel-fired plants, because long-distance transport of low-density biomass fuels is generally not considered feasible due to financial reasons. There are limited opportunities to achieve economies of scale with bioenergy. Thus, to achieve favorable power and heat generation costs, technology with high fuel conversion efficiency is selected. While improved technology may be able to battle some of the elevated investment costs of bioenergy, technology risks remain. Some relevant technology is proven, however, a lot of technology remains in research, development and demonstration phases. This technology risk is considered unacceptable to most investors.

4. Evaluation of bioenergy use

4.1. Benefits of bioenergy use

Bioenergy appears to have formidably positive environmental properties, resulting in no net releases of carbon dioxide and verylow sulfur content. The most important gain of bioenergy utilization is the environmental benefit of displacing fossil fuel usage and a reduction in any adverse environmental impacts that are caused by fossil fuel consumption. Bioenergy can contribute to the generation of new jobs especially in rural and farming communities, which in turn may result in an improvement of income distribution. Bioenergy has the potential to provide millions of households with incomes, livelihood activities and employment. A number of studies have now concluded that the development of bioenergy systems is a generator of jobs. Table 10 shows global production of bioenergy [15].

Table 10. Global production of bioenergy (Mtoe)

	1970	1990	2005	2020	2030
Africa	87	131	177	219	240
Asia and the Pacific	259	279	278	302	300
Europe	60	70	89	272	291
Latin America & the Caribbean	70	88	105	123	133
North America	45	64	65	86	101
Western and Central Asia	11	7	6	8	10
World	532	638	719	1010	1075

In Turkey, there are also substantial areas of abandoned agricultural land that are not managed and are becoming overgrown. Creating demand for biomass fuel would help to bring these areas back into economic exploitation. Furthermore, development of new dedicated energy crops and/or an energy market for residues from existing crops would help farm income and reduce the rate of land abandonment [3, 9]. Furthermore, provided that fossil fuel prices increase in the future, bioenergy appears to have significant economic potential.

Sustainable energy can be developed by laying more emphasis on domestic resources in the energy mix. In recent years, Turkey has begun to ignore the importance of energy usage based mainly on domestic sources. Today, about 78% of the Turkey's energy consumption is met by imports. The reliance on import resources to such an extent threatens the essentials of the sustainable development model seriously. On the other hand, not only bioenergy contributes to Turkey's energy diversification strategy but also substitution of current energy imports, mainly gasoline and diesel, with bioenergy is important for economic and national security reasons.
The abundant fossil fuels, such as coal, are often damaging to the environment throughout the fuel cycle, from mining to processing to consumption. Fossil fuels also carry the threat of global climate modification through increased discharge of carbon dioxide, particulates and other materials. Nuclear energy, while imposing no threat of climate modification, is associated with serious problems, such as waste disposal, accidents and weapons proliferation. We must also recognize that all fossil fuels and nuclear energy from fission are ultimately exhaustible. The substitution of fossil fuels and their derivatives by biomass and biofuels helps to conserve depletable fossil fuels. Bioenergy may replace petroleum fuels. Biofuels (mainly bioethanol, hydrogen and biodiesel) are obtained from biomass and can be used as a substitute for transportation fuels and to generate heat, power and/or chemicals. Because biomass can be converted directly into a liquid fuel, it could someday supply much of our transportation fuel needs for cars, trucks, buses, airplanes and trains. In addition, the use of a fossil fuel and biomass together in certain applications, such as electric power generation with coal and wood, can result in reduction of undesirable emissions.

4.2. Drawbacks of bioenergy use

Generally speaking, biofuel production cost is currently higher than that of the classic fuels; sometimes the critical factor is the raw material cost. Collecting, transporting and storing biomass is expensive. There are also significant costs of marketing, distribution and service. At the moment, biofuels are about 2.3 times more expensive than fossil fuels. For bioethanol, this figure ranges between 2.6 and 2.8 as compared with petrol. However, cost comparisons are highly dependent on the fluctuations in the international market for crude oil and refined products and in biofuel feedstock. On the other hand, the continuous efforts for the increase in the raw material yields as well as the advances in production technologies may make this cost relationship more favorable for biofuels [8, 20, 22].

The large volumes of water required to produce biomass constitute another point to consider. Also, water and soil nutrients are finite and may easily be degraded. Besides, the abundant use of fertilizers and manure for bioenergy production may result in considerable environmental problems in various regions: nitrification of groundwater, saturation of soils with phosphate and so on. In sum, there are numerous considerations that hint at the unsustainable nature of bioenergy. In case of an increase in bioenergy utilization, the demand for agricultural land could increase; growing amounts of virgin rainforest could be cleared for farmland and greater soil degradation ensues. Furthermore, deforestation, especially of high conservation value (HCV) forests, could lead to a considerable loss of biodiversity and the extinction of an incalculable number of species, some as yet undiscovered. On a global scale, deforestation has generally been assumed to be a key factor in altered weather patterns, soil degradation and erosion [21].

The most significant concern about bioenergy relates to inefficiency in its production process. For instance, bioenergy production, in the case of corn and wheat, rely on starch from the kernels of the plant or, in the case of sugar cane and sugar beet, on the sucrose produced [4, 21]. The remainder, at least for the purpose of fuel production, goes to waste. The same holds true for the seeds used to extract vegetable oil for biodiesel production. Thus, a large amount of energy is expended on cultivating, harvesting and processing the biomass, even though only a relatively small proportion is used to derive energy. The result is an arguably high level of inefficiency and a poor allocation of energy resources throughout. It is important to understand that biofuels have a limited application. From a business perspective, current technology militates against these fuels. Biomass fuels cannot replace conventional fuels on a one-for-one basis in unmodified vehicles. This means that the demand for hydrocarbon-based fuels is unlikely to tail off to any significant degree in the immediate future.

5. Guidelines for policy makers

Global energy consumption will continue to grow. Despite concerns about climate change and energy security, fossil fuels will continue to be the main source of energy. At the same time, high fossil fuel prices will encourage countries to become more energy efficient. The gradual conversion from fossil fuels to alternative fuels for the generation of power and for transport is already under way. Investments in bioenergy research and development are increasing. Technologies may soon be available to convert cellulose to liquid biofuels on a large-scale at economically attractive prices. This could have considerable impact on the future management of forests [2, 9, 15, 29].

In most countries, policies and programs to promote bioenergy development are still in their early stages. Most programs focus on liquid fuels, especially for the transport sector. These policies and programs tend to be limited in terms of scope, with more attention on regulatory measures than on investments in areas such as research and development, market liberalization, information and training. To date there has been relatively little transfer of technology or information about bioenergy from developed to developing countries [14-18].

Several developing countries have enormous potential to produce energy from forests and trees outside forests with relatively low investment and risk, but this potential is not properly reflected in national energy development strategies. Poor forest management and lack of proper data collection frequently prevents assessment of the full economic and social potential of forestry and of wood energy production. Putting forestry on a sustainable and transparent footing will provide multiple benefits including improved energy production [20].

Large bioenergy projects require extensive land area and can affect food security, social structures, biodiversity, the wood processing industry and the availability of wood products. To mitigate these impacts, land-use planning, consideration of policies in other sectors and effective governance are necessary. The involvement of all stakeholders when developing bioenergy strategies is also of great importance in balancing trade-offs between economic, social and environmental impacts and benefits [16-20].

In a national strategy, it is important to consider potential carbon and energy efficiencies of forest- and agriculture-based energy as well as cost-effectiveness and environmental performance. Planting trees can help mitigate climate change, combat erosion and restore ecosystems especially in degraded areas; but large-scale monoculture plantations can have negative impacts on soil and water resources [26].

All countries would benefit from better information about wood energy feedstocks, including biomass recovered from forest operations and trade of forest biomass. Resources are needed to assess bioenergy and wood energy development potential, in particular [14, 17]:

- quantifying the potential of forest biomass for the generation of different energy outputs (e.g. heat, power, cellulosic liquid biofuel);
- evaluating the potential contributions of natural forests, woody biomass outside forests, energy plantations, residues and post-consumer material to wood energy production;

Traditional analysis of wood supply and demand, centered on wood removals from forests and wood input to industries is no longer fully adequate. Therefore, in more advanced countries an updated approach based on wood resource balances, is likely to be beneficial. All countries need to develop clear national-level policy goals for forests and energy that reflect the principles of sustainable development and sustainable forest management. Goals should account for national and international impacts as well as impacts between economic sectors. Consideration should also be give to trade-offs between wood energy, agro-fuels and other energy sources and land-use options. The following points should be considered when developing wood energy policy at the national level [2, 4, 5, 14, 17].

- Policy processes should address bioenergy as a cross-sectoral issue and integrate energy into forest, agriculture and other land-use policies.

- Policy processes should involve adequate consultation and analysis of environmental, economic and social impacts in the context of specific regional, national and local conditions.
- Information flow to forest owners, tenure holders, the general public and consumers should be improved to support informed decisions about management of forest resources.
- Policy processes should consider rural employment, environment protection, land-use management, the forest products sector and other relevant areas to tap possible synergies and avoid negative impacts.
- Policy should provide broad support for facilitating bioenergy development including education and training, research and development and through transport and infrastructure measures, and not only incentives to producers, distributors and consumers.
- Policy processes should strive to create an appropriate balance between agriculture and forestry, as well as between imported and domestic biomass sources. Contingencies should also be taken to avoid competition with food production.
- The impacts of bioenergy policy on other economic sectors should be considered to avoid creating market distortions.
- Governments should verify that strategies and legislation outside the forestry sector do not have a negative effect on wood mobilization for bioenergy.
- Policies should be monitored regularly and systematically to avoid negative impacts on the environment and rural communities.
- Steps should be taken to avoid the destruction of valuable natural resources and biodiversity.

In relation to wood supply and wood industry the following issues should be addressed:

- sustainable mobilization of wood resources in relation to legal and institutional constraints (e.g. forest ownership structures), access to data, forest infrastructure, and adequate prices for wood;
- supportive laws, regulations and policies, as well as information and motivation of forest owners, entrepreneurs and other actors;
- efficiency gains through more intensive use of existing forest resources, including wood assortments and forest-based and industry residues not currently used, woody biomass from outside the forest; post-consumer recovered wood products;
- long-term expansion of the forest area and enhancements in the productivity of forest resources, such as silvicultural and genetic innovations.

6. Conclusions

International forest policies are suggesting the wise use of wood for energy purposes. These policies closely related to the greenhouse gases reduction policies. Wood is regarded as a renewable energy source if wood is coming from sound and sustainable sources. This is an important issue for Turkey as well, when we consider the share of the energy sector in the greenhouse production. Turkey, being an energy importer and having a growing economy, need to increase production and efficiency of renewable energy. On the other hand, renewable energy sources appear to be one of the most efficient ways to sustainable energy development in Turkey, since the biggest greenhouse burden is coming from energy sector and the emissions from the energy sector is the largest portion with 77.3%, the emissions from the waste disposal is the second largest one with a value of 9.6%, and the emissions from manufacturing industries with an 8.0% shares the third place in Turkey.

Though Turkey has great opportunities for using bioenergy, biomass energy has been traditionally used for heating and cooking in the country. Today there is a need to reconsider the status of bioenergy usage and to examine the ways forward to modern biomass energy production. Thus, firstly the government should analyze the capacity and potential on bioenergy. This analysis should conclude with the long term and short term strategies on bioenergy and then political and financial frameworks should be created. Forest villagers, living in terribly hard economic conditions, should also be considered in those analyses. Because they have some legal rights on forests that could be used for bioenergy production, they might feel reluctant to conducting of these operations. Employment creation possibilities for forest villagers may provide an important base for awareness raising activities in those villages. Total welfare effect of the energy plants needs to be determined regarding the social costs and alternative costs of potential lands.

References

[1] TUIK, Turkish Statistical Institute Turkey's statistical yearbook 2009, Prime Ministry of Turkey, Ankara, Turkey, 2009.

[2] Erdogdu, E. An expose of bioenergy and its potential and utilization in Turkey. Energy Policy 2008; 36: 2182-2190.

[3] Kaygusuz, K. Bioenergy as a clean and sustainable fuel. Energy Sources 2009, Part A; 31: 1069-1080.

[4] Rosillo-Calle, F., de Groot, P., Henstock, SL., Woods, J. The biomass assessment handbook: bioenergy for a sustainable environment. London, UK: Earthscan; 2007.

[5] Kaygusuz, K., Keleş, S. Sustainable bioenergy policies in Turkey. J. of Engineering Research and Applied Science 2012; 1(1): 34-43.

[6] A review of the current state of bioenergy development ın G8 +5 countries, FAO/GBEP 2007, available from www.globalbioenergy.org/ (accessed 10.04.2008).

[7] IEA, International Energy Agency. Bioenergy – a sustainable and reliable energy source a review of status and prospects, IEA BIOENERGY: ExCo: 2009: 06.

[8] IEA, International Energy Agency. Energy policies of IEA countries: Turkey 2009 review, OECD/IEA, Paris, 2010.

[9] Bilgen, S., Keleş, S., Kaygusuz, A., Sarı, A., Kaygusuz, K. Global warming and Renewable energy sources for sustainable development: a case study in Turkey. Renewable and Sustainable Energy Reviews 2008; 12: 372-396.

[10] REN21. Renewables 2009 Global Status Report, www.ren21net/ (date 10.11.2009).

[11] MENR, Ministry of Energy and Natural Resources. Energy statistics of Turkey in 2008, available from www.enerji.gov.tr, verified 10 august 2010

[12] MEF, Ministry of Environment and Forestry. First national communication of Turkey on Climate Change, this report edited by Apak, G and Ubay, B, MEF, 2007.

[13] Kaygusuz, K., Toklu, E. Energy issues and sustainable development in Turkey. Journal of Engineering Research and Applied Science 2012; 1(1): 1-25.

[14] Bioenergy Project Development & Biomass Supply, International Energy Agency, Good Practice Guidelines, OECD/IEA, Paris, France, 2007.

[15] FAO, Food and Agriculture Organization of the United Nations. State of the World's Forests 2009, FAO Rome 2009.

[16] Wright, L. Worldwide commercial development of bioenergy with a focus on energy crop-based projects. Biomass & Bioenergy 2006; 30: 706-714.

[17] Sims, REH (Ed.). Bioenergy options for a cleaner environment. London, UK: Elsevier; 2003.

[18] WEC, World Energy Council. Survey of Energy Resources 2007: Bioenergy, WEC, 2007; available from www.worldenergy.org/publications, verified January 20, 2009.

[19] Hoogwijk, M., Faaij, A., Vries, B., Turkenburg, W. Potential of biomass energy out to 2100 for four IPCC SRES land-use scenarious. Biomass & Bioenergy 2005; 29: 225-57.

[20] IEA, International Energy Agency. Renewables for heating and cooling, OECD/IEA, Paris, 2007, available from www.iea.org, verified 10 April 2009.

[21] FAO, Food and Agriculture Organization of the United Nations. The state of food and agriculture, Biofuels: prospects, risks, and opportunities, FAO, Rome, 2008.

[22] IEA, International Energy Agency. World Energy Outlook 2009, OECD/IEA, Paris,2009

[23] Demirbas, A. Biofuels sources, biofuel policy, biofuel economy and global biofuel projections. Energy Conversion and Management 49: 2106–2116, 2008.

[24] Exploration of agricultural residues in Turkey, http://www.agrowaste-tr.org

[25] Öztürk, HH., Bascetincelik, A. Energy exploration of agricultural biomass potential in Turkey. Energy Exploration & Exploitation 2006; 24: 313-330.

[26] Report of the Forestry Special Expertise Commission, Ninth Development Plan (2007-2013), State Planning Organization, Ankara, Turkey, 2006.

[27] Kara B, Emir Z, Kaygusuz, K. Thermal processing technologies for biomass conversion to energy. Journal of Engineering Research and Applied Science 2012; 1(1): 55-62.
[28] The Plan of Implementation of Johannesburg Summit on Sustainable Development, United Nations, New York, USA, 2002.
[29] Kaygusuz, K. Sustainable energy, environmental and agricultural policies in Turkey.Energy Convers Manage 2010; 51: 1075-1084.