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A perspective for potential and technology of bioenergy in Turkey: Present case and future view

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ABSTRACT

Biomass easily can replace fossil fuels in the use of modern biomass energy due to the environmental benefits and the renewable. Biomass energy in Turkey is one of the most important renewable energy sources in terms of energy potential. Traditional biomass (wood and dung) in Turkey has a significant energy production rate. This ratio has been decreased with the decline of forests and the reduction seen in animal husbandry, recently. Traditional biomass is usually used in the form of non-commercial fuel and meets a quarter of the domestic energy production. Traditional biomass energy production has been planned 7530 Btep in 2020. In Turkey, the use of modern biomass energy is important in terms of the country's economy, and the environment pollution. Turkey has the potential to provide an alternative source of energy from the most appropriate and most cost-effective agricultural products according to its ecological conditions. Modern biomass started with 17 Btep in 2000. However, there has not been the foresight to future production. Whereas traditional biomass energy production should increasingly be reduced and modern biomass energy production should be increased. This situation will offer new investment fields to investors. This study shows that biomass energy continues to be the main source of energy for climate change mitigation and energy sustainability in Turkey, particularly in its traditional forms.

Contents

1. Introduction

Global use of fossil fuels has increased since 1850 for dominate energy supply. In this case, increases in carbon dioxide emissions have been inevitable. The provision of energy services have increased in atmospheric GHG concentrations. Biomass is gaining importance as a potential source of renewable energy due to need of sustainable energy and reduction in greenhouse gases [1]. Today the main source of energy production is fossil fuels, but biomass has an opportunity to substitute the usage of fossil fuels to certain extent [2].

Reduction of carbon emissions [3], increase of energy security [4] and minimize of dependence on finite fossil fuel reserves are the basic goals in usage of renewable energy [5]. Renewable energy sources such as forest biomass have been the focus of attention to reduce greenhouse gas emissions. Bioenergy contribute towards renewable energy. Therefore it is a useful component for many government and industry strategies [6,7]. Biomass gives a lower emission of SO_2, NO_x and soot compared to conventional fossil fuels because it has a negligible content of sulfur, nitrogen and ash. If CO_2

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released from biomass is incorporated into the plants by photosynthesis quantitatively, zero emission of CO_2 can be achieved [8].

Fossil fuels will continue to play an important role in energy generation. However, renewable energy sources will increase in importance in the energy market. Bioenergy has all of the properties required to meet the challenges associated with increased fossil fuel use. It can provide a viable and reliable source of fuel [9]. Bioenergy can be produced from a variety of biomass feedstock [10,11]. Bioenergy typically offers constant or controllable output. About 13–15% of the global energy demand is provided from biomass [12–14]. More than half of the world's population relies on biomass as main source of energy [12,13]. This rate is over 90% in some countries [15]. However, developing countries consume about 75% of biomass for energy [12]. In developed countries, bioenergy is generally used in form of electricity or liquid energy [16]. In contrast, domestic woody biomass is largely used inefficiently for cooking and heating [13]. Goals in development of biomass energy are different for developed and developing countries. Developed countries use bioenergy to displace fossil fuels whereas developing countries use it serves basic livelihood purposes [17].

Woody biomass can be used for generation of heat, electricity, and biofuels. The price of woody biomass energy has not been competitive with traditional fossil fuels. Therefore, the technology for converting woody biomass into energy has been established for decades. However, current projections of future energy use and renewable energy and climate change legislation under consideration suggest increased use of both forest and agriculture biomass energy in the coming decades [18].

Biomass technologies are complex. Parameters such as technological robustness, economic vitality, environmentally harmless, and social admissibility should be taken into account in the selection of technologies. Technological advances increase efficiency of energy and produce to environmentally beneficial options in the development of bioenergy.

Turkey is a country that imports the most part of its energy need, so the foreign dependency on energy is steadily increasing. Although the fossil energy sources provide the significant portion of energy need in this country, national oil and natural gas reserves are incapable of meeting the need. On the other hand, a great deal of coal reserves in Turkey is comprised of lignite which has low calorific value and high mineral matter. On the other hand, Turkey has a big potential of biomass energy resources. Although Turkey has a great biomass energy potential, most of the waste biomass species could not be evaluated properly for the energetic purpose [19].

As Table 1 shows, the direct cost of electricity production is more expensive when it is produced through biomass than that of fossil fuels. However, since Turkey is an agriculture and stockbreeding country, in the long term it has a good potential to replace crude oil and natural gas with biomass for electricity production. It is worth noting that the 2011 cost of Turkey's imported energy was over US$54 billion. This figure means that close to 40% of Turkey's annual exports are utilized to fund energy imports. This will mean that future policies will trend towards the development of generation technologies using indigenous energy resources which can achieve the aims of supply security and sustainability [20].

2. Bioenergy as clean, sustainable and renewable energy source

Renewable energies can direct people toward energy sustainability and security of supply [21]. The most important renewable energy sources are solar, wind, bioenergy, geothermal, and hydropower and they contribute to reducing greenhouse gas emissions [22]. Renewable energy in energy policies related to the research, development, and demonstration has been a phenomenon of growing importance [23]. The development of new energy sources other than petroleum-based energy sources in modern society is

Table 1
Leveled cost of electricity (LCOE) from different energy sources.

			EC (2008)	EPRI (2008)	House of the Lords (2008)	MIT (2009)	Min. ($/kWh)	Max. ($/kWh)
Nuclear	Overnight cost	$/kW	2.552–4.378	3.980	3.000	4.000		
	Capacity factor		85%	90%	77%	85%		
	LCOE	$/MWh	65–110	73	90	84	0.06	0.11
Coal	Overnight cost	$/kW	1.295–1865	2.45	2.14	2300		
	Capacity factor		85%	80%	81%	85%		
	LCOE	$/MWh	52–65	64	82	62	0.05	0.08
Gas	Overnight cost	$/kW	622–946	800	1.046	850		
	Capacity factor		85%	80%	81%	85%		
	LCOE	$/MWh	65–78	73–87	78	65	0.06	0.08
Biomass	Overnight cost	$/kW	2.617–6.580	3.235	3.674			
	Capacity factor		85%	80%	80%			
	LCOE	$/MWh	104–253	73–86	180		0.07	0.25
Onshore wind	Overnight cost	$/kW	1.295–1.775	1.995	2.222			
	Capacity factor		23%	33%	27%			
	LCOE	$/MWh	97–142	91	146		0.09	0.14
Offshore wind	Overnight cost	$/kW	2.267–3.562	1.995	3.148			
	Capacity factor		39%	33%	37%			
	LCOE	$/MWh	110–181	91	162		0.09	0.18
Hydro	Overnight cost	$/kW	1.116–8.549					
	Capacity factor		50–57%					
	LCOE	$/MWh	45–240				0.04	0.24
Solar PV	Overnight cost	$/kW	5.311–9.938					
	Capacity factor		11%					
	LCOE	$/MWh	674–1.140				0.67	1.14
Solar thermal	Overnight cost	$/kW	5.181–7.772	4.6				
	Capacity factor		41%	34%				
	LCOE	$/MWh	220–324	175			0.22	32.4