



Biomass energy potential and utilization in Turkey



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ABSTRACT

Biomass is the most widely used renewable energy source in the world today. It is used mostly in solid form and, to a lesser extent, in the form of liquid fuels and gas. The utilization of biomass for energy production has increased at only a modest rate in modern times. Biomass is the major source of energy in rural Turkey. Biomass is used to meet a variety of energy needs, including generating electricity, heating homes, fueling vehicles and providing process heat for industrial facilities. Biomass potential includes wood, animal and plant wastes. Among the biomass energy sources, fuel wood seems to be the most interesting because its share of the total energy production of Turkey is high at 14%. The total biomass energy potential of Turkey is about 33 million tons of oil equivalents (Mtoe). The amount of usable biomass potential of Turkey is approximately 17 Mtoe. The electrical production potential from usable bioenergy sources are 73 MW in 2010 and corporate income and represent more than 280,000 jobs. This study shows that there is important biomass energy potential for climate change mitigation and energy sustainability in Turkey.

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1. Introduction

The 2014 edition of the World Energy Outlook (WEO) assesses two indicators of energy poverty at the household level: the lack of access to electricity and the reliance on the traditional use of biomass for cooking. In Sub-Saharan Africa the electrification rate are 31% and the number of people relying on the traditional use of biomass 80%: this is where the greatest challenge lies [1].

Today, there are 1.4 billion people around the world that lack access to electricity, some 85% of them in rural areas. Without additional dedicated policies, by 2030 the number of people drops, but only to 1.2 billion. Some 15% of the world's population still lack access, the majority of them living in Sub-Saharan Africa. The number of people relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 (Tables 1 and 2) [2]. It is estimated that household air pollution from the use of biomass in inefficient stoves would lead to over 1.5 million premature deaths per year, over 4000 per day, in 2030, greater than estimates for premature deaths from malaria and tuberculosis [1–3].

Demand for energy and associated services, to meet social and economic development and improve human welfare and health, is increasing. All societies require energy services to meet basic

human needs and to serve productive processes. Since approximately 1850, global use of fossil fuels (coal, oil and gas) has increased to dominate energy supply, leading to a rapid growth in carbon dioxide (CO₂) emissions. The Greenhouse Gas (GHG) emissions resulting from the provision of energy services have contributed significantly to the historic increase in atmospheric GHG concentrations. The IPCC Fourth Assessment Report [4] concluded that “Most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in GHG concentrations [4].

Bioenergy can be produced from a variety of biomass feed stocks, including forest, agricultural and livestock residues; short-rotation forest plantations; energy crops; the organic component of municipal solid waste; and other organic waste streams (see Table 3) [1–5]. Through a variety of processes, these feed stocks can be directly used to produce electricity or heat, or can be used to create gaseous, liquid, or solid fuels [6–8]. The range of bioenergy technologies is broad and the technical maturity varies substantially. Some commercially available technologies include small- and large-scale boilers, domestic pellet-based heating systems, and ethanol production from sugar and starch [9–11]. Advanced biomass integrated gasification combined-cycle power plants and lignocellulose-based fuels are examples of technologies are at a pre-commercial stage [12–16]. Bioenergy technologies have applications in centralized and decentralized settings, with the traditional use of biomass in developing countries being the most

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Table 1

Number of people relying on the traditional biomass use as their primary cooking fuel in 2009 (million people) [1].

	Rural	Urban	Total
Africa	481	176	657
Sub-Saharan Africa	477	176	653
Developing Asia	1694	243	1937
China	377	47	423
India	765	90	855
Other Asia	553	106	659
Latin America	60	24	85
Developing countries ^a	2235	444	2679
World ^b	2235	444	2679

^a Includes Middle east countries.

^b Includes OECD and transition economies.

widespread current application. Bioenergy typically offers constant or controllable output. Fig. 1 shows the share of bioenergy in the world energy mix [3].

2. Bioenergy for sustainable energy development

Biomass energy is one of humanity's earliest sources of energy. Biomass is used to meet a variety of energy needs, including generating electricity, heating homes, fueling vehicles and providing process heat for industrial facilities. Biomass potential includes wood and animal and plant wastes. Biomass is only an organic petroleum substitute which is renewable. The term "biomass" refers to forestry, purposely grown agricultural crops, trees and plants and organic, agricultural agro-industrial and domestic wastes (municipal and solid waste). Biomass is the name given to the plant matter which is created by photosynthesis in which the sun's energy converts water and CO₂ into organic matter. Thus, biomass materials are directly or indirectly a result of plant growth. Biomass energy is derived from plant and animal material, such as wood from natural forests, waste from agricultural and forestry processes and industrial, human or animal wastes [5,21–23]. The release of energy from the combustion of biomass imitates natural processes. Therefore, the energy obtained from biomass is a form of renewable energy and, in principle, utilizing this energy does not add carbon dioxide to the environment, in contrast to fossil fuels. Of all renewable sources of energy, biomass is unique in that it is effectively stored solar energy. Furthermore, it is the only renewable source of carbon and is able to be converted solid, liquid and gaseous fuels [7–10].

Biomass differs from other alternative energy sources in that the resource is varied, and it can be converted to energy through many conversion processes. Biomass resources that can be used for

Table 2

Number of people no access to electricity and relying on the traditional use of biomass, 2009 (million people) [1].

	Number of people lacking Access to electricity	Number of people relying on the traditional use of biomass for cooking
Africa	587	657
Sub-Saharan Africa	585	653
Developing Asia	799	1937
China	8	423
India	404	855
Other Asia	387	659
Latin America	31	85
Developing countries ^a	1438	2679
World ^b	1441	2679

^a Includes Middle east countries.

^b Includes OECD and transition economies.

Table 3

Overview of the global potential of bioenergy supply [1–3].

Biomass category	Technical potential in 2050 (EJ/yr)
Energy crop production on surplus agricultural land	0–700
Energy crop production on marginal land	<60–110
Agricultural residues	15–70
Forest residues	30–150
Dung	5–55
Organic wastes	5–50
Total	<60–>1100

energy production cover a wide range of materials. Biomass energy can be separated into two categories, namely modern biomass and traditional biomass. Modern biomass usually involves large scale uses and aims to substitute for conventional energy sources. It includes wood and agricultural residues, urban wastes and biofuels, such as biogas and energy crops. Traditional biomass is generally confined to developing countries and small scale uses. It includes fuel wood and charcoal for domestic use, rice husks and other plant residues and animal wastes [8–14].

Biomass is the term used to describe all biologically produced matter. World production of biomass is estimated at 146 billion metric tons a year, mostly wild plant growth [3]. The renewable energy sources are solar, wind, hydroelectric, biomass and geothermal power. The nuclear powered sources are fission and fusion [4].

Woody biomass is the accumulated mass, above and below ground, of the wood, bark, and leaves of living and dead woody shrubs and trees. Woody biomass is primarily comprised of carbohydrates and lignin produced through the photosynthetic process [6–10]. Woody biomass can be used for generating electricity, producing biofuels, and making biochemical such as adhesives, solvents, plastics, inks, and lubricants. Rising fuel costs, uncertainty about energy supplies, dependence on foreign energy sources and concern about global climate change and air quality make renewable natural energy alternatives such as that produced from woody biomass more attractive. In fact, Turkey can reduce its dependence on nonrenewable energy feed stocks, reduce wildfire risk, offset greenhouse gas emissions, mitigate declining pulpwood markets, enhance rural economies and improve forest health and sustainability by simply increasing the utilization of woody biomass [17–20].

Biomass can be used directly (e.g. burning wood for heating and cooking) or indirectly by converting it into a liquid or gaseous fuel (e.g. alcohol from sugar crops or biogas from animal waste) using converting technologies [56]. The net energy available from biomass when it is combusted ranges from about 8 MJ/kg for green wood, to 20 MJ/kg for dry plant matter, to 55 MJ/kg for methane, as compared with about 27 MJ/kg for coal. Many biomass fired electricity generators use wood and waste materials of forestry and agricultural processes [6].

Biomass, mainly, now represents only 5% of primary energy consumption in industrialized countries [5]. However, much of the rural population in developing countries, which represents about 50% of the world's population, is reliant on biomass, mainly in the form of wood, for fuel [3]. Biomass accounts for 35% of primary energy consumption in developing countries, raising the world total to 14% of primary energy consumption [3–5].

Bioenergy is a domestic, renewable CO₂-neutral energy source which is readily available and therefore an increase in its use is forecasted in the future. Many countries around the world have been developing new crops since the mid-1970s in order to increase the biomass resource base for production of bioenergy. The

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