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Quantitative appraisal of biomass resources and their energy potential in Egypt

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ABSTRACT

The utilization of biomass as a renewable source of energy is important from the energetic as well as the environmental viewpoint. It can reduce the rate of fossil fuel depletion caused by the rapid increase in energy consumption. This paper presents an estimation of the biomass and its potential energy in Egypt. Four main types of biomass energy sources are included: agricultural residues (dedicated bioenergy crop residues), municipal solid wastes, animal wastes, and sewage sludge. The potential biomass quantity and its theoretical energy content were computed according to statistical reports, literature reviews, and personal investigations. The results show that Egypt produces a considerable amount of biomass with a total theoretical energy content of 416.9×10^{15} J. The dry biomass produced from bioenergy crop residue sources has been estimated at about 12.33 million tons/year, of which 63.75% is produced from rice straw. This source represents the highest percentage (44.6%) of the total theoretical potential energy in Egypt, followed by municipal solid wastes, which could produce 41.7% from an annual amount of 34.6 million tons. Meanwhile, the rest of the total theoretical potential energy could be produced from animal and sewage wastes. The estimated biomass with its considerable potential energy content represents an important renewable energy source in Egypt.

Contents

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1. Introduction

Widespread and massive consumption of fossil fuels has led to rapid economic growth in advanced industrial societies but has also increased carbon dioxide in the atmosphere and consequently caused global warming and climate change. Renewable energy sources should replace fossil fuels fundamentally and structurally; they are receiving worldwide attention and will play an important role in meeting the future needs of the world [1,2]. Renewable energy sources are natural resources such as sunlight, wind, biomass, and geothermal heat, which are naturally replenished. Based on factors such as the availability and choice of technologies in Egypt, Khalil et al. [3] positioned wind energy and solar water heating as leading renewable energy technologies in power generation, followed by biomass technology.

Biomass represents an important source of energy which includes a large variety of different fuels with different chemical compositions and combustion characteristics. Its utilization as a source of energy is important from an energetic as well as an environmental viewpoint [4,5]. Unlike coal, CO_2 emissions from biomass are negated by the photosynthetic contribution during the growth cycle of biomass, resulting in a net zero impact on the environment [6,7]. Moreover, biomass reduces the rate of fossil fuel depletion and has the theoretical potential to supply 100% of the world's energy needs [2,8].

Due to the vital role played by the energy sector, energy demand is increasing in direct proportion to the increase in population and industrial development to satisfy technological needs and the development of lifestyles in Egypt. Primary energy demand has grown at an average annual rate of 4.64% during the last years [9]. Securing energy supply on a continuous basis is a vital element for sustained development plans, and Egypt, as a country of limited fossil fuel resources as well as growing demand for electrical energy, has given due consideration to the diversification of its energy portfolio by utilization of its renewable energy resources [10].

In Africa, about half of the energy used originates from biomass or agricultural residues [11]. A study by Smeets et al. [12] projected that Africa has the largest potential for bioenergy production by 2050 in the world: 317 exajoules (EJ) per year, which could constitute a quarter of the projected total world potential (1272 EJ per year). In this sense, during the last decade, Egypt has been one of the developing countries following successful programs for the development of renewable energy resources [13]. It produces millions of tons of biomass waste every year, which could contribute more than 151 PJ (petajoules) of primary energy [14], but nowadays these wastes are causing pollution and health problems [2]; in consequence, the incorporation of biomass with other renewable energy sources will increase the potential for solving energy and environmental problems.

However, there have been insufficient investigations regarding the production of biomass in Egypt and an analysis of existing and potential biomass sources will be required well before the start-up of large-scale production of bioenergy from this renewable fuel. As a consequence, a quantitative appraisal of biomass resources and their energy potential in Egypt represents the main objective of this study.

2. Energy situation in Egypt

2.1. Geography, climate, and energy balance in Egypt

Egypt forms the northeast corner of Africa and covers a total area of almost one million Km^2 (Fig. 1) [15]. It has hot and dry weather in summer and a warm winter with average rainfall of 50 mm/year. The inhabited part of Egypt is the 1000 km valley from Aswan to Alexandria, flanked by desert [16]. According to the Central Agency for Public Mobilization and Statistics (CAPMS) [17], Egypt has an estimated population of about 83 million in 2013.

The energy sector plays a major role in Egypt's economic development. The primary energy resources and production in Egypt are shown in Fig. 2. It is clear that crude oil is the most important, representing 53.11% of the total resources. Electricity from the High Dam in Aswan accounts for a share of about 5% and natural gas accounts for 41.89% of the total resources. On the other hand, primary production of coal accounts for only 1.6 PJ, and Egypt has to import coal. The sectoral energy consumption in Egypt is summarized in Fig. 3. The industrial sector accounts for about 46% of consumption, representing the highest value of energy consumption among the sectors [18].

Production of crude oil continues to decline despite new discoveries and improvements in oil recovery techniques at mature fields. Its production had fallen from 740 thousand barrels per day (bbl/day) in 2004 to 680 thousand bbl/day in 2009. On the

Fig. 1. Map of Egypt [15].

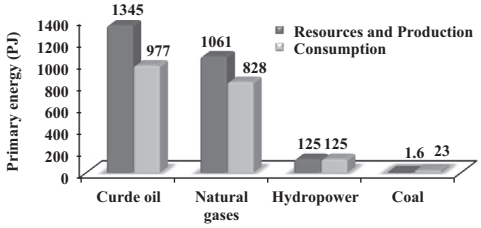

Fig. 2. Primary energy resources production and consumption in Egypt [18].