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Biogas potential for electric power generation in Pakistan: A survey

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ABSTRACT

From last decade, Pakistan is facing the severe problems of energy deficiency. Every year Pakistan's government is spending more than 14.5 billion US dollars to import crude oil in order to fulfill the energy gap. Energy demand is increasing rapidly but exploration and use of renewable energy is not meeting the needs of requirements. The unavailability of power in Pakistan lasts for 14–20 h per day. In this paper, the potential of biogas is reviewed to meet the energy requirement of Pakistan. One cubic meter of biogas can generate an electrical energy of 2.5 KWh. The annual growth rate of livestock sector is 4% in Pakistan and its dung can produce 35.625 million KWh of electric energy per day. We can overcome the energy crisis by efficiently using biogas as an alternative energy source. The installation cost of biogas plant is not only economical but also beneficial in reducing respiratory and eye infections. PCRET has installed 4109 biogas plants across the country which saves average of Rs. 37.925 million per month in terms of kerosene oil, wood, liquefied petroleum gas and bio fertilizer.

Contents

1. Introduction

Pakistan is facing a significant challenge in energy sector and demand is growing at a rate of 11–13% per year. The energy requirement of Pakistan was 57.9 million tons of oil equivalent

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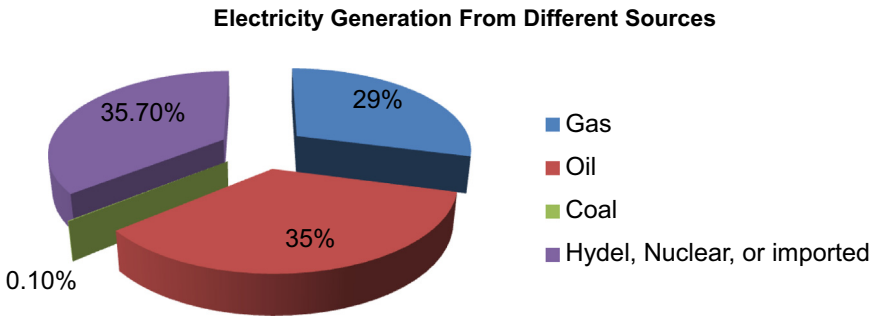

Fig. 1. Shares of conventional energy sources for electric power generation in Pakistan [2].

(TOEs) in 2006 and it is estimated to reach 179 million TOEs in 2020. In 2012, Pakistan electricity crisis short falls to 8500 MW during summer due to inductive loads and the entire country faces 14–20 h load shedding per day. This shortfall conversely affects the exports of Pakistan due to severe underproduction in industries as electricity generation of Pakistan shrunk to half during past recent years [1]. In order to fulfill the energy requirement, Pakistan imports crude oil of worth 1400 million US dollars that was just 530 million US dollar in 1996, which has negative impact in the economic growth. Pakistan spent approximately 20 percent of foreign exchange for the import of fossil fuels [2] and almost 14.5 billion US dollars for conventional energy resources that is 40 percent of total import of country [3]. Energy demand of Pakistan is expected to be three times more by 2050. However, the growth rate of energy production is far less than the demand [4,5]. Pakistan is currently dependent on only conventional energy resources to meet its energy demand as shown in Fig. 1. However, Pakistan is facing serious energy crisis from last decade. Therefore, to mitigate the energy crisis we have to explore alternative green energy resources along with conventional resources.

Due to natural endowment and location, Pakistan has potential for alternative renewable resources like solar, wind, geothermal and biogas. Mostly, solar and wind energy is used as alternative sources for production of electricity. However, these two sources are not enough to reduce the energy crisis of Pakistan. Therefore, too fulfill the country power needs, initiative is required for other energy sources i.e. biomass, biogas, geothermal, micro, hydro and biodiesel [6]. Shortfall of conventional energy resources is an indication to increase dependency on renewable resources to revive economic growth of Pakistan [3].

Pakistan is an agricultural country, which plays an important role in economic growth and contributes 22% to Gross Domestic Products (GDP) of Pakistan. It is further explained by economic survey of 2012–2013, Pakistan livestock department contributes 56% to agriculture which is 12% of the GDP. During 2012–2013, there are total of 72 million livestock animals that produce 1140 million tons of dung [3]. Currently all of this manure is stored in outdoor place for decomposition, which leads to diseases, unpleasant odors and air pollutions. According to Ref. [7], the chemical composition of the livestock waste is discussed and shows that the waste has gases like ammonia, hydrogen sulfide and some other dangerous gases which cause serious health problems. Ammonia also leads to the contamination of ground water. In the light of aforementioned problems, efficient utilization of the manure in the form of alternative renewable energy is required.

Biogas is a process in which livestock manure is converted to methane gas [8,9] via anaerobic digestion, that is odorless [10] and can be utilized as fertilizer [11]. So being a valuable fuel biogas can be utilized in variety of applications like domestic, industrial, heating, as a Compressed Natural Gas (CNG) (by scrubbing process) [12,13] and for electricity generation. One major advantage of biogas is its utilization as a substitute of coal in power generation, which helps in minimizing greenhouse gases, as coal is the primary cause of carbon dioxide emission [14].

Pakistan Council of Renewable Energy Technologies (PCRET), Pakistan Council for Appropriate Technologies (PCAT) and Pakistan Renewable Energy Society (PRES) works for the research and development of biogas in Pakistan. Currently 5357 biogas plants are installed in different areas of Pakistan. The estimated biogas potential is 12–16 million m^3/day [15]. These renewable energy resources not only help in mitigation of the energy crisis but also create new employment opportunities with positive impact on environment. Therefore, Pakistan should introduce renewable energy resources like biogas to fulfill its energy demand to a significant level. Pakistan is an agricultural country. Therefore, it is rich in biogas resources. Comparative analysis of biogas to overcome electrical energy problems is listed in Table. 1.

The main contributions of our survey are listed as:

- We present the biogas as an alternative energy source and its impact on Pakistan economy and health related issues. In the aforementioned feature of the biogas power generation will overcome the Pakistan energy crises.
- We discuss in detail the biogas production from different substrate and chemical decomposition.
- We elaborate schemes of enhancing bio gas production from the recently published literature in the field of the biogas production.
- We also survey the applications of biogas power generation in the prospects of Pakistan. Moreover, we quantitatively analyze the current and future prospects of biogas generation in Pakistan.
- The survey also presents economic and environmental impact of biogas plants. Moreover, different biogas plant models applied in Pakistan are also surveyed.

The remainder of the survey is organized as follows. In Section 2, the biogas production from various substrate and chemical decomposition is discussed. The different schemes of enhancing biogas production are presented in Section 3. In Section 4, biogas current and future generation prospects of Pakistan are analytical analyzed. Economic growth and environmental impact of biogas plants are reviewed in Section 5. In Section 6, different biogas plant models applied in Pakistan are presented. Section 7 concludes the survey with brief summary and proposal for future work.

2. Biogas generation

Biogas is the result of anaerobic bio-degradation process of organic materials. Livestock wastes, agriculture biomass residue,