A Study on the Role of Biomass Power Plants in Electricity Generation from Municipal Solid Wastes of Isfahan City

M. Malekiha[1], H. Haji Ahmadi[2]

1- Department of Chemistry, University of Isfahan, Isfahan, Iran.

2-Department of Electrotechnic, Azad University of Najafabad, Isfahan, Iran.

Abstract

In the twenty-first century, energy producers must meet environmental targets, leading to shift away from fossil fuels towards renewable source of energy. As a result, biomass is becoming an increasingly attractive option to energy providers. Biomass is a clear, cost effective and simple method which is estimated to produce more than 50 percent of the world's energy in the next century. In this study, the role and feasibility of incineration power plants in producing energy, based on the municipal solid wastes in the city of Isfahan, as well as, the income to be earned through such power plants, have been investigated. Based on the investigations made, the applicable power for incineration power plants in cities of Isfahan is 11.45 MW, and the environmental income to be earned by the same, is 955,388,000 Rials.

Keyword: Biomass, Municipal solid wastes, Power plants, Environment, Isfahan.

[1] Master Degree of Analytical Chemistry, Isfahan University, Isfahan, Iran.

[2] Bachelor Degree of Electrotechnic, Azad University of Najafabad, Isfahan, Iran.

1) Introduction

Biomass resources are very abundant and great, all over the world. Energy utilization from biomass is an important way to national economic sustainable development on renewable energy, as well as reducing pollution to the environment. Wastes are considered as one of the biomass resources. Disposal of garbage and wastes has always been one of the social problems; and by the population rise, especially the urban population, the problem gets more serious. Perhaps, the oldest way to dispose of wastes, has been their burying under the ground, which may lead to contamination of water, soil and air, if improper ways are applied, as a result of which terrible consequences will arise.

According to the research made by N. Themelis et al. in the year 2003, it was found that by burying each ton of municipal wastes, 1/3 ton of green house gas pollutants, as carbon dioxide, are emitted. To this end, the European Union has decided to forbid or limit burying of wastes from the year 2010 onwards [1]. In the process of incineration, wastes burn in the adjacency of flames, producing energy, exhausted gases and ashes. Exhausted gases normally contain CO_2, H_2O, NO_X and SO_X. Ashes also contain metals, nonmetallic compounds, glass and incombustible materials which are recoverable.

Incineration of wastes has got certain advantages such as the following: decrease in volume and weight of wastes in a short time, decrease or exclude spaces required for burying of wastes, disposal of hazardous wastes and prevention of environmental pollution, lower consequences of burying hazardous wastes, recovery of energy as electric energy, recycling of ferrous and non ferrous metals, reduce rate of relevant costs, mitigation of greenhouse effect and destruction of harmful creatures' dwelling place [2].

2) Survey of incineration power plants and related technology

In the industries for regeneration of energy from waste materials, approximately 130 million tons of municipal wastes are burnt at 600 centers in 35 countries around the world. Total capacity of these plants goes up to 6757 MW [3]. Among them, Japan has got the highest rate, United States of America, the second and European countries come next [4]. These are mainly four kinds of biomass power generation technologies: Direct combustion, mixed burning, gasification and biogas power generation.

Biomass & power generation technology

Biomass is directly combusted in the boiler allocated to biomass, providing high pressure & high temperature vapor for steam turbine unit to generate directly. The key points of this technology are high efficiencies of boiler & steam turbine. Biomass mixed burning & power generation technology generation with mixed burning of biomass to coal power plants, which uses both and biomass as their fuel to generate electricity. There are two kinds of mixed burning modes: (1) Biomass is directly mixed with coal to burn in boiler of coal fired plant, (2) biomass is first gasified and then the gas is introduced into boiler to burn together with coal. In this method, efficiencies of boiler & steam turbine are also important.

Biomass gasification & power generation technology

Biomass is gasified in gasifier to produce combustion gas. After cleaning, the gas is burnt in internal combustion engine unit or small gas turbine units, to generate electricity key points of this technology include biomass pretreatment, high efficiency gasification technology & suitable internal combustion engine or gas turbine

Biogas power generation technology

Biogas obtained through an aerobic fermentation from organic liquid waste, is utilized as fuel gas for internal combustion engines, gas turbines or boiler generated electricity.

3) Incineration power plants

General

According to a report issued by EPA, 17% of municipal solid wastes, in America, have been burnt in incineration power plants to produce energy, 55% buried and 28% recovered to be used again[5]. Studies made by Themelis, show that capacity of the incineration power plants totally is over 40 million tons per year and their capacity of producing electricity and thermal energy, is 41 and 110 Million Giga Joules, respectively [6].

Material handling

The incoming waste materials, after being unpacked by means of mechanical equipment, are firstly placed on belt conveyors. Magnetic wastes are taken by electric magnet and aluminum wastes are taken manually by workers. Remaining materials are then transferred to the crushing unit where they get crushed and homogeneous. This provides for optimum use of thermal energy capacity of the waste materials.

Energy Production

Municipal wastes, due to their organic contents, have got calorific value, solid municipal wastes, before being processed, bear calorific value of 8000-13000 KJ/kg An incinerator, generally produces 450-600 KW electricity out of each ton wastes. Recovery output at incineration power plants varies between 20-30 percent. [7]

Air pollutants control

Incinerators are usually equipped with an emission purification system, designed in compliance with environmental rules and regulations and with regard to the incinerator's technology, as well as quality of incoming materials.

Handling of wastes and ashes

Burning of waste materials leaves ashes and sludge Magnetic materials are separated by electric magnets and the remaining mass can be packed and transferred for sanitary land filling.

According to the 2006 senses, population of Isfahan city was 1,602,110 [8]. All the wastes in the city of Isfahan are transferred to recycle plant. Physical analysis of wastes in this city, shows that nearly 62% of the same, are decomposable, 0.5% paper and cardboards,4.5% metals and magnetic,1.5% aluminum and around 12% remainders are wood , textile and other household wastes[8]. On the average 1200 tons of wastes are delivered to recycling plants.

4) Recycling Process

In a recycling plant, received wastes are transferred to the machine by a loader, where they are opened, and placed orderly on the conveyor belt. The conveyor belt is magnetized, thus metals which can be absorbed magnetically, are so separated. Then, wastes are transferred to another place so that their polymer compounds and aluminum contents can be separated. Then, wastes are transferred to another place so that their polymer and aluminum contents can be separated. Next, the materials are conveyed into crusher, where they are crushed into small pieces of 5 Cm and the remainder which cannot be recycled, are pressed, packed and transferred to Segzi area for sanitary land filling.

The small sized pieces of wastes(5 Cm in size), after 6 months of being aerobically decomposed are turned to organic fertilizer compost which are then crushed into smaller pieces of 1 Cm in size for agricultural purposes. In recycling process, the removed metals are sold to steel plants for further usage. The polymer materials, taken to another unit in recovery complex are turned to free plastic garbage bags which are given to houses in the city. Going through the recycling process reveals that waste pices, of 5cm in diameter and the dried compost pieces of the same size constitute a proper potential for incineration process, since they need less initial energy to activate burning.

5) Environmental resources

The products formed by decaying and fermentation of biomass resources are mainly methane and carbon dioxide gases. The produced carbon dioxide is returned to life cycle by plants. The resource of this gas is of a nature quite different from that of carbon dioxide obtained from combustion of fossil fuels, due to the fact that the gas produced by consumption of fossil resources, is an environmental pollutant which is added to the environment.

Methane produced from decomposition of organic resources and materials contained in biomass, has a potential 21 times as much carbon dioxide, therefore, the amount of energy produced by burning of biomass resources and the environmental & social costs, resulting from producing electricity by using this method, can be considered equal to the amount of environmental benefits achieved from setting up such utilities. According to the investigations made, the average external costs for producing carbon dioxide in a thermal power plant, being borne by the society, is equal to 11.92 Rials /Kw hr [9,10].

Therefore, due to constructing of such a power plant, the amount of energy and the value of social benefits gained from non-establishment of a thermal power plant using fossil fuel can be calculated as follows:

Randeman= 20%

$$P = \frac{1200\ ton\ waste}{day} \times \frac{79.5ton\ biomass}{100\ ton\ waste} \times \frac{0.06MW}{1ton\ biomass} \times \frac{20}{100} = 11.45Mw \quad (1)$$

$$\text{Energy produced per Year} = 7000hr \times 11.45 \frac{Mw}{hr} \times \frac{1000\ Kwe}{1Mwe} = 8.015 \times 10^{7}\ Mw \quad (2)$$

$$\text{Environmental Profit} = 8.015 \times 10^{7}\ KWe\ hr \times 11.92 \frac{Rials}{KWe\ hr} = 955,388,000Rials \quad (3)$$

6) Result & conclusion

Studies are necessary to be made in order to find local potentials for setting up power plants, which can certainly lead to elimination of some part of environmental problems and supply of electricity demand in our country. In the meantime, in Isfahan, with regard to the volume of wastes being produced, there is also a considerable potential for constructing 11.45 MW incineration power plant and the environmental income to be earned by this, is 955,388,000 Rials. In other cities of our country, according to the studies, especially in the northern cities where disposal problems exist, suitable potentials for constructing such power plants are also available which by making applicable studies, due measures are expected to be taken to utilize them effectively.

7) References:

[1] Nikolas, J. Themelis, An overview of the global waste to energy industry, 2003, Waste management world, www.jxj.com.

[۲] پژوهشگاه نیرو, گزارش بررسی انواع نیروگاه های زباله سوز,۱۳۸۰.

[3] Solid Waste Landfills in Middle and Lower Income Countries, A Technical Guide to Planning, Design and Operation, World Bank Technical Paper No.426, Pugh and Rushbook, 1999. Bioenergy in Europe , Kopetz, H., Bioenergy 2003, Proc. International Nordic Bioenergy Conference, Jyväskylä, Finland, 2.5 September 2003. pp. 21.24.

[4] European Commission. report on Energy and Climate-Global Challenges of the 21 st Century, Lubeck, October 9 , 2006. Werring, Principal advisor Directorate General Energy. Luc

[5]-Electericity from municipal solid waste,www.powersource.org.

[6] Nationwide Survey – Japan, 2003, Agency fornatural resources and Energy, Government ofJapan, official website http://www.enecho.meti.go.jp.

[7] The Validability of Advanced Thermal processes in UK, Fichtner Consulting GmbH, Estet, 2004

[۸] بررسی وضعیت بازیافت کاغذ ومقوا از زباله های شهر اصفهان وارزیابی جنبه های اقتصادی وزیست محیطی آن, آرش دالوند , مهدی فرزادکیا، حمیدرضا پورعلاقه بندان، مجید عرفان منش, دهمین همایش ملی بهداشت محیط, ۱۳۸۶.

[۹] جباریان امیری، بهمن .ابراهیم رئیسی، محمد .برآورد هزینه محیط زیستی و اجتماعی تولید برق در ۲۸ کشور، مجله محیط شناسی،شماره ۳۴.

[۱۰] امکان سنجی احداث نیروگاه زباله سوز در شهر تبریز, آرش حقپرست کاشانی بهروز بوغلان دشتی حمیدرضا لاری, بیست و چهارمین سمینار بین المللی برق.