BIOGAS INCENTIVE IN IRAN

Akbar Shabani Kia, Giti Taleghani, Ali Nazari

Center for Renewable Energy Research and Application
Atomic Energy Organization of Iran
P. O. Box 14155-1339, Tehran – I.R. Iran
Tel. (0098-21) 8003315, Fax. (0098-21) 8003793
Email: gtaleghani@aeoi.org.ir

ABSTRACT

The ever increasing growth in the consumption of energy in the world, and the limitation of fossil fuels resources on one side and the destructive effects of consuming these energies or the environment on the other side, has increased the interest all over the world to use renewable energy resources, including biogas. In the biogas process from anaerobic digestion of organic waste material by different micro-organism, organic macro - molecules, are converted in to simpler molecules and the final result is a combust-table gas which is called biogas. This gas contains about 60% to 70%, methane and 30% to 40% carbon dioxide.

The increasing amount of production waste material in both urban and rural communities and also the production of thousands of tons of sludge, and sewage resulting from refineries, and different agricultural and food industries would be followed up by severe economic and environmental difficulties. There are different processes for getting rid of organic waste material. But in our country, in most cities, the first, and sometimes the only alternative for getting rid of waste material is either to burn or bury it in the ground. In such a process, not only the chemical pollutant would not be destroyed, but in the meantime, these pollutants and other microscopic ones would enter into the underground layers, and water, soil, plants and air cycles and thus pollute the who eco-system.

The existence of 15 million tons of municipal solid waste and production of $4.6*10^9$ cubic meters of urban and industrial sewage (with a collecting and burying cost of 225 million dollars) in this country would more than ever point to the necessity of developing the biogas technology. The development of biogas technology would provide not only part of the society's energy need but it will have a positive effect on environment, including protection of forests and pastures, prevent the pollution of underground water, reduces greenhouse effect, produces organic fertilizer and water for agriculture and green areas.

In this article, the different processes for getting rid of waste material, and also the potential for producing biogas in Iran, the status of biogas energy in term of providing part of the society energy requirements and its environmental effect and finally the technical analysis and performance of the 2000 cubic meter Saveh biogas Power Plant are analyzed.

Keywords: Biogas, Biogas Power Plant, Anaerobic Digestion, Municipal Solid Waste(MSW), Slaughter House Waste Water, Sludge of Leaching Pit.

Introduction

The ever increasing growth in the consumption of energy in the world, and the limitation of fossil fuels resources on one side and the destructive effects of consuming these energies on

the environment on the other side, has increased the interest all over the world to use renewable energy resources, including Bio-gas.

The increasing amount of production waste material in both urban and rural communities and also the production of thousands of tons of sludge, and sewage resulting from refineries, and different agricultural and food industries would be followed up by severe economic and environmental difficulties[1]. There are different processes for getting rid of organic waste material. But organic waste material in our country in most cities, the first, and sometimes the only alternative for getting rid of waste material is either to burn or bury it in the ground. In such a process, not only the chemical pollutant would not be destroyed, but in the meantime, these pollutants and other microscopic ones would enter into the underground layers and water, soil, plants and air cycles and thus pollute the eco-system.

On the other hand, if the buried waste materials are digested in MSW land fill by anaerobic micro organism a large volume of methane and carbon dioxide gases would enter into atmosphere and they would have a destructive effect on Ozone layers and increase the earth temperature.

.

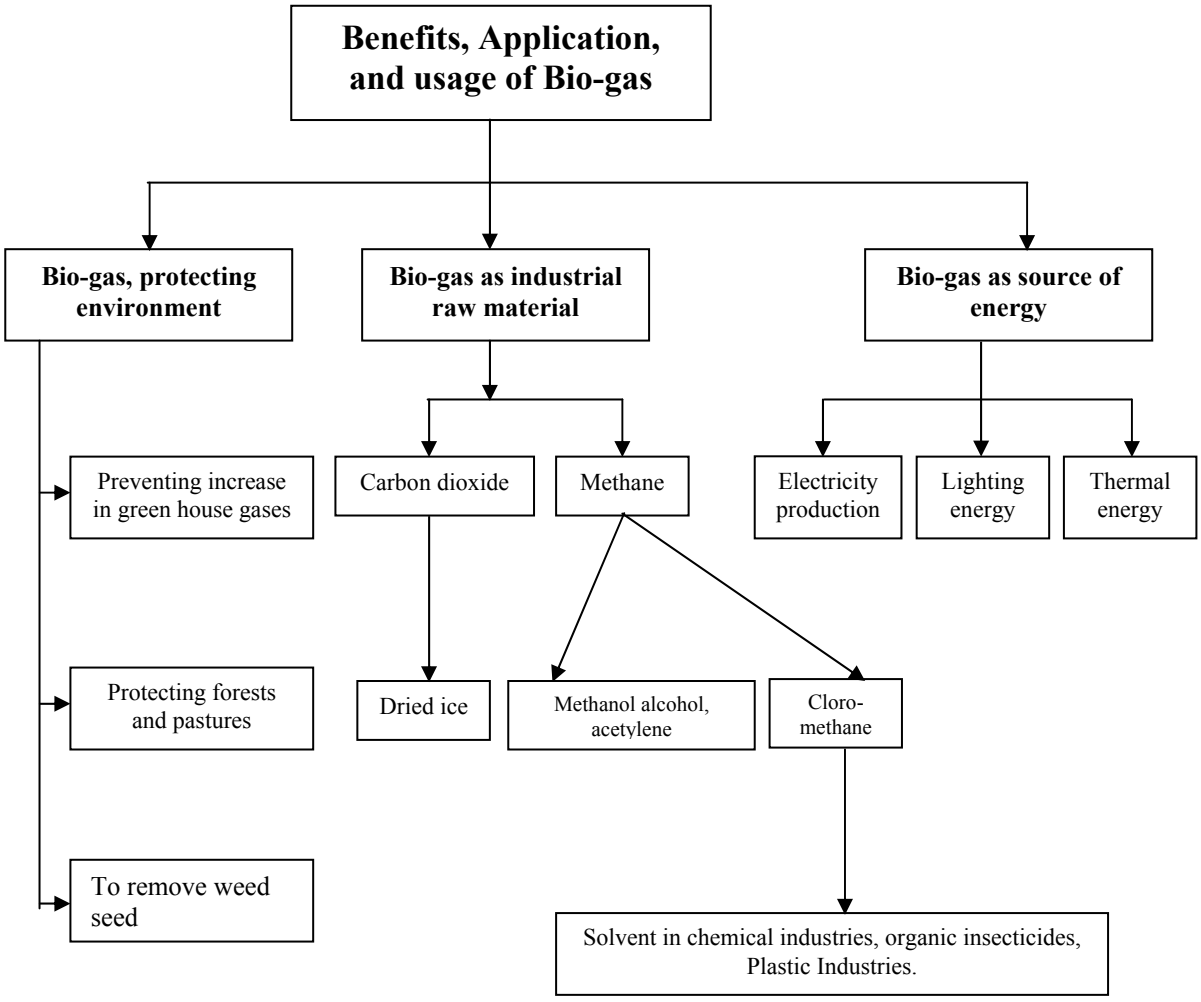

Fig. 1. Benefits, application, and usage of bio-gas [4]

One of the most effective process for getting rid of organic waste material and at the same time provide the needed energy, is to use Bio-gas technology. The existence of 15 million tons of municipal solid waste [2] and production of 4.6×10^9 cubic meters of urban and

industrial sewage (with a collecting and burying cost of 225 million dollars) [3] in this country would more than ever point to the necessity of developing the Bio-gas technology.

In the Bio-gas process from anaerobic digestion of organic waste material by different micro-organism, organic macro - molecules, are converted into simpler molecules and the final result is a combustible gas which is called Bio-gas. This gas contains about 60% to 70%, methane and 30% to 40% carbon dioxide.The development of Bio-gas technology would provide not only part of the society's energy need, but it will have a variety of other applications, too, (Fig. 1).

A study of Bio-gas development process in Iran

The recognition and application of bio-gas in Iran goes back to a few hundred years ago. Some researchers believe that Sheikh Bahaei's both house in Isfahan was heated by bio-gas. In away, aflame of bio-gas from adjacent sewage was used to heat up the water.

Even with such a background the development process of bio-gas in Iran in the lost 30 years has had a better rate of growth tan before. Thus in 1975 in the village of Neyaz Abad in Lorestan (western Iran) the first producing methane from animal dung was designed.
This apparatus has 5 cubic meter capacity and uses cow dung to heat up the bath house(1)
In 1980 two little experimental units were built in Boalisina university in Hamadon which were fed from slaughted house dungs.
In 1981, Sharif Scientific university built a 3 cubic mete experimental bio-gas unit using cow dungs and from then on center for the cerera in Atomic Energy Organization, and the ministry of power started research activities in this field. After establishing 10 bio-gas units by ministry of power in Sistan, Ilam and Kordestant. Bio-gas programs in central Jihad Sazendegi (Constructiveness Crusade) were followed and resulted in establishing 40 units in different villages of nine provinces.
It should be mentioned that beside these three units, the Center for rural Studies in Karaj under ministry of Agriculture, and Educational center of martyr Abbas Poor in Tehran has had some activities in the field of bio-gas- During 1983-85 Jihad Daneshgahi (university crusade) of Karaj Agricultural Faculty which built a 3 cub. meter bio-gas apparatus.
In recent years the bio-gas department of the center cerera of Atomic Energy Organization of Iran has done a tremendous job concerning Bio-gas development, among there building a bio-gas unit in Kish Island in 1998 in cooperation with Kish Service Company with 13.2 cub. meter volume and another unit with 68 cub. meter volume in Mahdasht Karaj Agricultural school affiliated to the ministry of agriculture.
The unit is used for research- application, and educational purposes.
At present saveh bio-gas section affiliated to the center for cerera by having suitable research reactors, equipped laboratory and Bio-gas analyser is the first comprehensive research, educational, and application center in the Field of anaerobic digestion and energy production from organic was the material in Iran.

The Study of Bio-Gas Production In Iran

The foundation of any work concerning the study of potentiality of a resources is the accessibility to reliable information and statistics. The existence of such documented data concerning the quality and quantity of environmental pollutants can be effective in a precise estimation of Bio-gas potential. Organic waste material with Bio-gas production capability can be divided into four groups: municipal solid waste, industrial waste water, agricultural waste, and animal dungs. Taking the quality and quantity of each organic waste material into

consideration, the potential of Bio-gas production in Iran can be estimated at 1008.49 billion cubic meters.

Table 1: The amount of Bio-gas Production from organic material in Iran

Organic material	Amount pear year	The volume of expected Bio-gas production (millions m^3)
Municipal solid waste	15.6 millions tons	429975
Waste Water	4600 millions m^3	563500
Animal dungs for 120 millions heads (Ave weight 150 kg)	328.5 millions tons	10676.25
Agricultural Waste	82.67 millions tons	4340

Different sections of an industrial Bio-gas power plant

The volume of a digester system in an industrial Bio-gas power plant is more than one hundred cubic meters. These plants are mostly used for anaerobic digestion of organic material in MSW and also sewage of refineries of large cities, ranches, and industrial plants. The largest usage of Bio-gas in these plants are for electricity generation, although the Bio-gas produced in these units can directly be used like any other fuel gas.

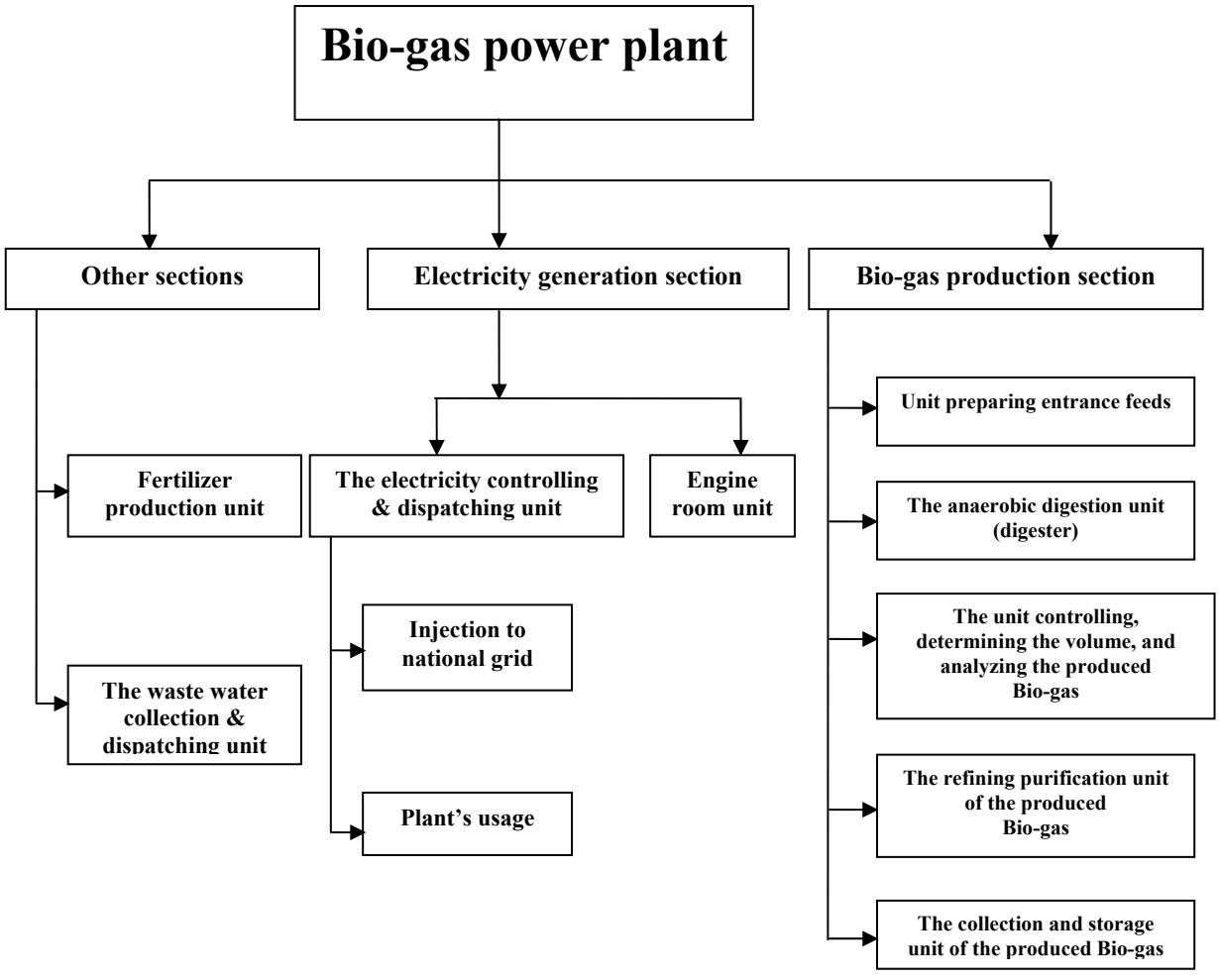

Fig. 2. Different sections of a Bio-gas Power Plant

The electricity produced in these units are more than their internal needs and the surplus can be transferred to the national grid. Execution of these plans requires varieties of skills and specialties. An industrial Bio-gas power plants designed to produce electricity has several important sections (Fig. 2), as explained below.

Bio-gas production section

The objective in this section is to produce desired Bio-gas with high quality and it is composed of several other sections:

Unit for preparation of entrance feeds.

The function of this unit is to prepare and lead the organic material that its quality and quantity has already been controlled, into the digester. This unit by combining different feeds, prepares the suitable condition in terms of the content and C/N ratio for producing the maximum amount of Bio-gas.

In order to prepare feed of the same size, this unit needs a suitable grinder for grinding the solid waste material completely and that it will have a suitable size that can be used in the digester. On the other hand, suitable pools must be built for the incoming sewage for to concentrate it. In addition to these concentration pools, mixing pools and suitable canals for directing the feed into the digester are also needed. However, it should be mentioned that all above-mentioned sections can be manufactured domestically.

The anaerobic digestion unit

This section has a series of anaerobic digesters that have completely been isolated in order to control the heat in a specific area and it is also equipped with a suitable coil to heat the content. Suitable pumps and equipments have also been installed in this digester for mixing and the consistency of the contents.

These digesters are equipped with heat alarm system and have special places for taking samples of the contents inside. The design and manufacturing capability for digesters with low volume, already exists in the country, but for digesters with large volumes there still exists the need for consultation and using the experience of foreign experts who have had working experience in this field.

Unit for refining and purifying produced Bio-gas

As it is known, Bio-gas is a mixture of Methane, Carbon dioxide, together with a little amount of steam water (H_2O), Hydrogen Sulfide (H_2S), and some little amounts of other gases.

The existence of some impurities together with methane in the Bio-gas not only reduces heating value but also causes corrosion of power plant's parts. For this reason designing and manufacturing of suitable filters for the separation of H_2O, CO_2, and also usage of equipments and processes to eliminate steam in the refining unit becomes of utmost importance. The manufacturing capability for such filters exists in Iran and at the same time using the experience of those countries that have been working in this field, would further improve the process.

In order to control the amount of impurities in the Bio-gas, it becomes necessary to install suitable sensors in the gas production and transfer lines, so as to record and report the amount

of impurities all the time, of these, the special sensors for H_2S , and also the sensor for CO2 can be pointed out.

The produced Bio-gas analyzing, volume determing, and controlling unit

In order to record the exact volume of the Bio-gas produced, it becomes necessary to use a suitable counter. The flow- meters are resistant to corrosion, since regular gas counters because of their contact with Bio-gas in time, lose their sensitivity caused by corrosion.

Knowing the percentage of methane and the amount of other gases produced with methane are very important in this process. In order to determine the percentage of methane, carbon dioxide ,and other impurities produced together with them, it becomes necessary to use gas chromatograph(GC) equipment, equipped by special columns and detectors.

The produced Bio-gas storage and collection unit

In some small units, the dome-shaped space above the digester is used for the collection and storage of the Bio-gas. However, in larger industrial units the Bio-gas produced from existing digesters in the power plant are directed into large floating storage tanks which have been installed in the unit through pipes. The advantage in using floating storage tanks is that pressure does not fall while they are in use. These tanks are made of metal and their lower parts are protected by a layer of concrete and to prevent corrosion, the metal part can be covered with a layer of paint or other suitable things. The technical capability of manufacturing floating storage tanks with small volumes exists in the country, but for designing and manufacturing large floating storage tanks for large industrial power plants consultation with experts and companies having experience in the field would be of much value.

Electricity production Section

Engine room unit

The objective in this unit is to use Bio-gas in different internal combustion engines to produce electricity. There are varieties of engines using Bio-gas and they can be used for producing electricity by either using pure Bio-gas, or a mixture of Bio-gas with other oil derivative fuels.

Electricity control unit

An electricity control unit is needed in a Bio-gas power plant in order to control and direct the electricity for consumption in the power plant itself and also for transferring it to the national grid.

Other units

Beside the above-mentioned units, a Bio-gas power plant includes other sections such as condensation, drying, and packing of organic fertilizers produced from digestion. The out coming water from the collecting pool and condensation of digested sludge can be used in watering green areas such as gardens, etc.

Technical Analysis of Saveh Power Plant

The city of Saveh is in the central province, 150 km from Tehran with a population of 120,000. It has a Semi-arid climate and the temperature during different seasons of the year fluctuates within the range of –10°C to 40°C. In order to establish the Bio-gas power plant in this city, the usable pollutants in Saveh were studied and they were divided into four groups: Household garbage, sludge of sewage treatment, slaughter house waste water and sludge of leaching pit [3]. Through statistical studies, separation operation, sampling and executing physical, and chemical tests, quantity and quality specifications of each of the four types of pollutants were determined. The results are shown in the following tables:

Table 2: MSW Specification

Parameters	Quantifies
Average garbage / day	78.3 tons
Household garbage/ day	58.7 tons
Organic material of garbage /day	38.2 tons
Total solids (15%)/ day	5.73 tons

Table 3: Specification of sewage treatment sludge

Parameters	Quantifies
Annual average of sludge	10000 tons
Daily average of sludge	27.4 tons/day
Total solids (1.002%)/ day	274.54 kg/day
Volatile solids/ day	5.73 tons

Table 4: Specifications of the Slaughterhouse sludge

Parameters	Quantifies
Annual average of slaughterhouse waste water	4380 m^3
Daily average of slaughterhouse waste water	12 m^3
Total solids (0.508%)/day	60.96 kg
Volatile solids/day	51.39 kg

Table 5: Specification of leaching pit sludge

Parameters	Quantifies
Annual average of discharged sludge from household wells	5000 tons
Daily average of discharged sludge of household wells	13.7 tons
Total solids (1%)/ day	137 kg
Volatile solids/day	83.57 kg

After determining the quantity and quality of each pollutant separately, anaerobic digestion situation, and the production of Bio-gas from combination feed including above mentioned pollutants, considering the existing real relations in the city in anaerobic reactor at 35 degree centigrade was investigated in a semi-industrial anaerobic reactor.

This reactor is metallic and has a volume equal to 10 cubic meter. In order to control the heat, it is completely isolated and in order to heat up the contents and create suitable heating conditions, the reactor is equipped with an internal coil and a sludge evacuation pump is also installed to mix the content. The reactor has been designed in a way that is the capable of operating both continually and dis- continually(batch).(Fig. 3) In order to study the anaerobic

digestion of these feeds on a contineuos basis, determining the stoppage time of the material in reactor becomes necessary. Thus, at first, the situation for producing gas in the related reactor on dis- continuous basis was studied. By investigating the volume of daily gas production and the speed of production during the dis-contineuos period and the related curve, the stoppage time was determined to be 20 days and for contineous studies the 20 days stoppage was also agreed.

Fig. 3. Anaerobic metallic digestion reactor with 10m^3 volume

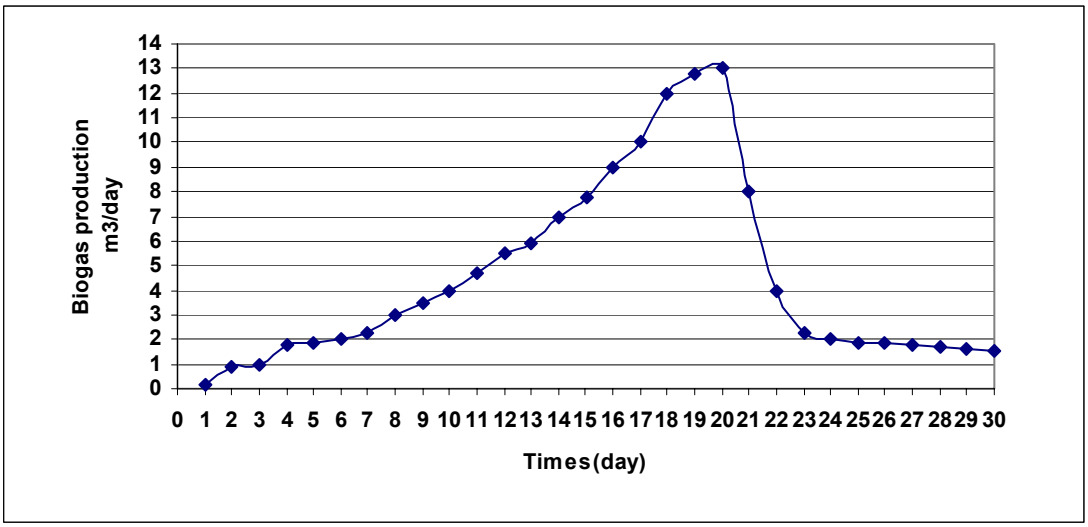

Fig. 4. Bio-gas production curve in dis-continuous loading at 35°C.

Studies during the contineous loading of combination feed including the four groups of urban pollutants with actual existing recording in the city of Saveh shows that for each kilogram of total solid as input, 500 liters of Bio-gas is produced in anaerobic digestion process. Thus on the basis of scientific studies carried out in Saveh Bio-gas power plant, the operation can be summarized as follows:

Table 6: Summary of operation and technical specifications of Saveh power plant

1	Amount of bio-gas produced for every kilogram of dried input/ day	500 liter/kg of total Solid
2	Percentage of T.S in combination feed entering reactor, including four types of pollutants	6.794%
3	Amount of daily input to the power plant	91.3 ton/day
4	Amount of Total Solids as input/day	6202.5 kg/day
5	The most suitable stoppage time in 35°C	20 Days
6	Total volume of Bio-gas produced/day	3101 m^3/day
7	Amount of Fertilizer produced / day	2500 kg/day
8	Extracted water suitable for agricultural irrigation	31025 m^3/year

Economic, Social, and health effects of Saveh Bio-gas power plant

Since most of the economy of Saveh depends on the export of agricultural products Such as pomegranate, grapes, cantaloupe, thus the establishment of the Saveh bio-gas power plant provides not only part of the needed fertiliser needs for agriculture, but also the necessary water for irrigation of the agricultural products, which altogether will have a positive effect on the economy.

On the other hand, anaerobic digesters of this plant eliminates most of the sickness elements during the digestion process and helps in Controlling bad smells, and flies, thereby providing undeniable health, and social effects that some of which are being summarized as follows:

Economic Effects

- Treatment of solid waste without long-term follow-up costs usually due to soil and water pollution.
- Reduction of foreign exchange needs
    - Through production of compost to reduce fertiliser, chemical herbicides and pesticides demand
    - Through direct utilisation of energy produced (biogas/ electricity/ heat) in the treatment process to reduce fossil energy demand
- Generation of income through compost and energy sales (biogas/ electricity/ heat) to the public/ public grid.
- Improved soil/ agricultural productivity through long-term effects on soil structure and fertility through compost utilisation.

- Recovery of material to be recycled or sold to the recycling industry, improving its economic prospects.
- Reduction of landfill space and consequently land costs.
- Application and test of the most modern treatment scheme for further duplication in Iran.

Social and Health Effects

- Creation of employment in the recycling sector.
- Improvement of health and hygienic situation, particularly
    - for women due to their role in private households
    - for people employed or active in the waste sector, both within and outside of the Biocomp
- Improved appearance of the streets and city of Save.
- Improvement of the general situation of farmers due to the local availability of soil improving fertilizer (transport distances, work load, budget).
- Mesophilic treatment of the waste at 35^0 C/ intensive composting improves the hygiene of the waste and makes the application of the final products (fertilizer) possible without health risks.

Conclusion

There are a variety of ways to get rid of garbage, but considering the low cost of anaerobic system in comparison with other processes and the simplicity of technology, climatic conditions, and the type of the components of the garbage in Iran, it seams that if priority is given to the utilization of anaerobic systems, then the establishment of bio-gas power plants would provide not only part of the required energy of the society, enriched fertilizer, and irrigation water, but it can also reduce the microbica, and chemical pollutants loads and further reduce green house gases. Elimination of stinking smells, and harmful insects from the edge of the city are among the some of the mentionable capabilities of utilizing anaerobic digesters in controlling garbage.

Thus taking the desirable economic, social, and health effects of Saveh bio-gas power plant into consideration, would create the necessary incentives that the establishment of larger bio-gas power plants around larger industrial cities should seriously be also considered.

References

[1] World Energy Council (WEC), internet search 2003.
[2] M. Sharifi Systani and et. al, waste water treatment in Iran, Iranian journal of water and climate, No.38, 2000.
[3] Statistical report on Manicipal waste of Saveh. department of executive services Saveh municipality 2001-2002.
[4] A. Shabani. Kia , G. Taleghani, benefit and application of Biogas. Center for Renewable Energy Research and Application, report, No. 58, 2002