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PRESENTING THE CONTRIVANCES IN ORDER TO USE BIOGAS ENERGY IN URBAN AND RURAL HOUSES

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ABSTRACT
By expanding the use of renewable energies as clean fuels with low prices, biogas is identified as one of the most appropriate, for providing energy. The aim in writing this article is having an architectural insight to biogas that is analyzed for the first time in the frame of a scientific paper. The methodology of the research is descriptive and it is done via document research tools. Extracting biogas for operation is from methane. The advantage of methane as compared to other fuels is that it does not produce the hazardous carbon monoxide during burning. Thus, it can be used as a safe and sound gas inside houses. Also, methane can be used effectively in electrical and heating projects. To construct a biogas unit in an urban or rural district and by foreseeing a place for collecting the waste, a concrete or brick fermentation tank could be made. Using biogas energy requires architectural contrivances, some of which are indicated in this paper. Due to paying attentions to renewable energies in recent years and their economic and environmental features, the use of biogas is under specific considerations. But, achieving appropriate aims for that without precise plans is not possible in architectural and urban projects.

KEYWORDS: Biogas, methane, renewable energy, rural residential houses, solid waste materials.

INTRODUCTION

By expanding the use of renewable energies in industry and urban life, the use of biogas energy has increased extensively. Regarding agriculture and breeding animals in extensive range in Iran and rural areas in particular, there is a required potential for using this type of energy that, due to lack of recognizing suitable strategies and approaches, is not used as it should. Moreover, the biological refining method is identified as the best alternative for refining low calorie organic materials from urban waste materials. Hence, the secondary criteria of that, including production of biomasses is quite effective for developing agriculture.

The history of using biogas in engineering techniques in Persian architecture goes back to Esfahan Sheikh Bahaei public bath. By designing a systematic method, Sheikh Bahaei extracted the generated biogas in a marsh under the bath to keep the bath furnace ignited and lit, sin order to have hot water inside the bath. According to many people, this action is still regarded as a scientific miracle, and of course, identifying and using biogas in the architectural structure of a public bath about 300 years ago by an Iranian architect is still considered as a scientific honor for the Iranian people. The certain thing in the Iranian Islamic civilized history is that many people have definitely had the knowledge of this valuable energy, but using that requires an architectural decisive action.

Alborz and Zagros mountain ranges have placed many parts of Iran to be in cold climate. Since energy generation is expensive in cold regions and the people in these regions are usually occupied in farming, despite being renewable and clean, biogas could be quite economical. Although biogas generation in winter is reduced to a great extent, especially in the cold regions and some of the produced gas is used for heating the unit, itself, but it is still economical. Thus, due to considerable attention in recent years, renewable energies are specifically considered in rural regions, because of their clear economic and environmental features.

In this article, we try to introduce biogas and its production ways and also provide architectural contrivances for its application. The importance of using biogas was considered in Aug. 1993, in a meeting held by the participation of energy groups and the president for I.R. Iran 2nd Developing Program.

TYPES OF COMMON GASES FOR GENERATING ENERGY BY FOCUSING ON BIOGAS

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There are various useful gases as fuel and for generating energy that three types of that are mostly used in the world. These three types are as follows:

1. Liquid gas (L.P.G): It is a mixture of crude oil refined substances such as propane, butane, propilene, and butilene. Since this gas is liquefied easily, it is used in fuel gas cylinders.

2. Natural gas: It is provided from the two main resources of independent gases and attendant gases (resulted from separating actions on crude oil).

3. Biogas: Biogas is referred to gases that are produced due to fermentation of organic materials by anaerobic bacteria. The produced gases are odorless, clean, combustible and lighter than air. Biogas is made from fermenting animal or plants organic materials (cellulose), in vacuum and by metallurgic bacteria. Biogas is as known by other names, too such as marsh gas. Chemically, the main part of biogas is methane. Biogas burns with blue flame and the temperature of 800°C. This gas is mixed with air with the ratio of 1:20 and has a high igniting speed, with the heating value of 5650Kcal/m3. The technology of producing this fuel consists of fermenting anaerobic organic materials fermentation, being done in 4 stages under the influence of 4 different groups of anaerobic bacteria:

(1) Resolving heavy molecules of raw materials (cellulose, protein, starch, fat) to smaller molecules (H2, CO2, fatty acids, amino-acids) by a group of bacteria called "hydrolytic" bacteria.

(2) Transforming the product of the 1st stage to acetate and hydrogen by acetate-making bacteria.

(3) Extensive transformation of H2, carbon and other obtained compounds from the 1st and 2nd stages to acetate, by a structure called "homoacetogen".

(4) Transforming acetate and some of other compounds like CO2 and H2 to methane by "methanologonic" bacteria. (Najafi, 75: 90)

Generally, production o, but all the stages could be expressed by a simple chart as in Fig. 1:

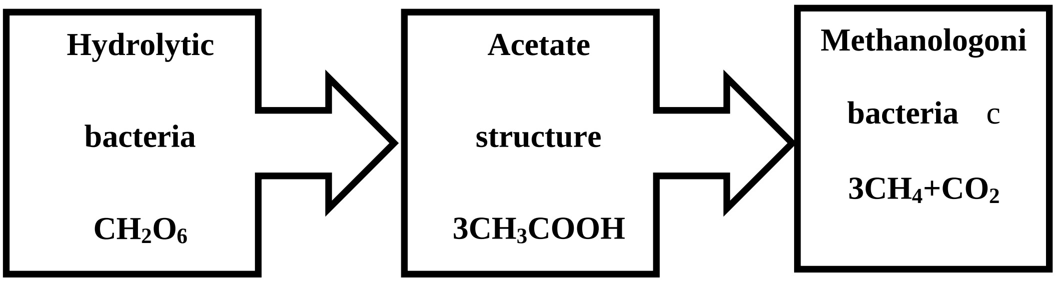

Fig. 1: Chemical process of producing biogas (Najafi, 75: 90)

Different parts of biogas are named in table (1) and the rates of each substance are indicated.

Table 1: The forming substances of biogas (Wikipedia)

Gas	Composition percentage	Formula
Methane	55-65	**CH4**
Carbon dioxide	35-40	**CO2**
Nitrogen	0-3	**N2**
Hydrogen	0-1	**H2**
Oxygen	0-1	**O2**
H2S	0-1	**H2S**

By dissolving humid animal and plants refuse in anaerobic digestion way by bacteria, biogas and biomass could be produced. Extensive usage could be taken from biogas, as a source of heating energy and biomass (the solid or liquid residues after digestion) could also be used as organic fertilizer and materials for fertilizing the land.

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Specific anaerobic bacteria transform the stagnated organic materials to organic acids (acid acetic), in the first stage of this biological reaction. Another group of bacteria dissolves the created organic acids in the second stage and thence, biogas with the main part of methane will be produced. The important point is that increasing organic acids especially acid acetic in low temperatures in the fermentation compartment causes rapid acidification (increasing PH) of the biological environment of the bacteria and "methanologonic" bacteria could no longer continue their vital metabolism. Thus, for the survival of "methanologonic" bacteria, the density of organic acids should be controlled.

The anaerobic digestion process includes the fermentation process that is done in large and warm compartments in 30-35°C or 55°C, during which 60% of the organic materials is transformed to natural gas (methane). Fermentation process micro-organisms like warm environment, to some extent and could be active at 24-38°C, though scientists have considered the temperature of 35°C as the best temperature for the growth of these bacteria, at which the bacteria have the highest rate of enzimatic activities for dissolving organic materials and production of biogas. These bacteria are categorized into the following three types:

1) Thermophilic micro-organisms: According to physiologic conditions, they need the temperature of above 45-70°C. Thermophilic micro-organisms may produce higher rate of gas, but they are not generally economic, since the required heat should be deducted from the resulted energy from the fermentation, especially in cold regions.

2) Mesophilic micro-organisms or the micro-organisms fond of moderate temperature survive at 20-45°C and produce biogas from their vital metabolism. Mesophilic fermentation process has a higher efficiency and is more economical.
3) Psychrophilic or cold-loving micro-organisms could grow in temperatures close to zero and have the enzymes with exclusive characteristics. Using these enzymes is considered economical in energy consumption for producing the biogas. There is a comparison in table (2) between the three types of micro-organisms. Table (3) compares the thermal values regarding the biogas and other fuels. Chart (1), is also dealing with comparison of biogas with other gases.

Table 2: Thermal limit in anaerobic fermentation in centigrade [Omrani, 1996]

Fermentation	Fermentation time	Max.	Average	Min.
Thermophilic	10-15 days	75-80	50-60	**25-45**
Mesophilic	30-60 day	35-45	28-33	**15-20**
Pschophilic	More than 100days	25-30	15-18	**4-10**

Chart 1: Comaring biogas with common combusting gases [Omrani, 1996]

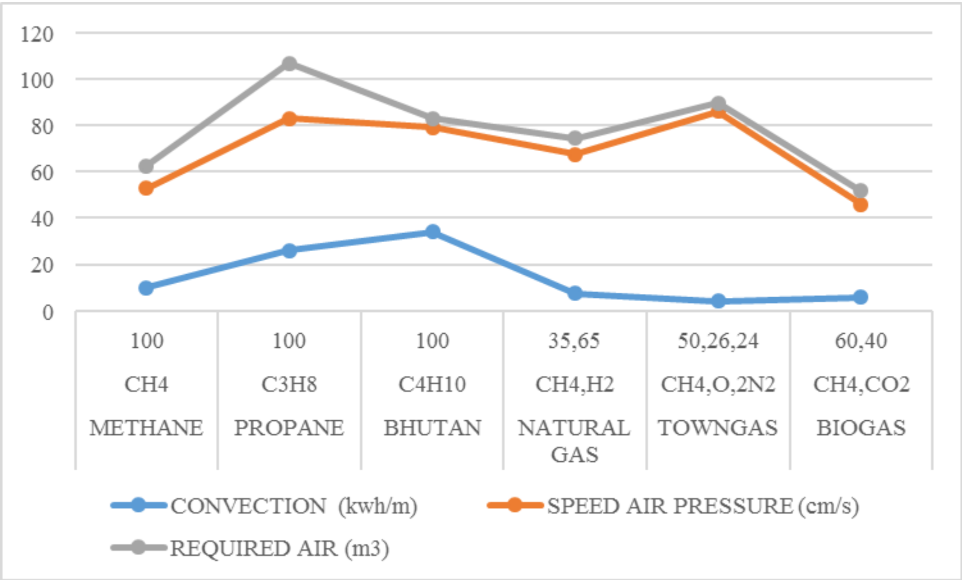

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Table 3: Comparison of biogas with other common fuels [Omrani, 1996]

Fuel	Unit	Thermal value	Application	1m^3 biogas	Biogas equivalent	Efficiency
Cow manure	Kg	2.5	kitchen	11.11	0.09	**12**
Wood	Kg	5	kitchen	5.56	-	**0.6**
Coal	Kg	8	kitchen	1.64	0.61	**25**
Coke	Kg	9	kitchen	1.45	0.69	**25**
Butane	Kg	13.6	kitchen	0.4	2.49	**60**
Propane	Kg	13.9	kitchen	0.39	2.54	**60**
Diesel fuel	L	12	Engine house-kitchen	0.36-0.55	1.83-2.8	**30-50**
Electricity	Kwh	1	Engine house-lighting	1.79-2	0.5-0.56	**9-80**
Biogas	M3	5.96	Kitchen	1	1	**55**

PROPERTIES OF METHANE AND USING THAT IN THE HOUSE

Methane is a colorless and odorless gas that is not soluble in water and it is more permeable anf lighter than air, with the melting point of -182°C and boiling point of 162°C. 252Kcal of thermal energy is generated by burning one cubic meter of it that is considerable as compared to other fuels. Methane is a saturated cross-linked hydrocarbon and of alkane group (fig. 2), with the general formula of CnH2n+2. The natural gas that is used in houses is a mixture of saturated cross-linked hydrocarbons with 95% of methane and produces CO2, water vapor and heat due to combining with oxygen.

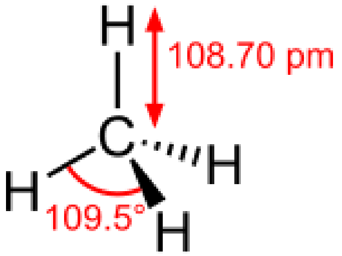

Fig. 2: Methane molecule structure

Methane is a greenhouse gas that due to capability in absorbing heat has more greenhouse effects than CO2. But, since its rate is less than CO2 in the atmosphere, carbon dioxide is considered as the main element having the greenhouse effect. An attempt in controlling the warming of earth is transforming methane obtained fro waste waters or marshes to carbon dioxide.

One of the important advantages of methane as compared to other fuels at burning is that it does not produce the hazardous and toxic gas of carbon monoxide. Hence, it can be used as safe fuel in houses. This causes changes in the heating structure of the houses using heaters, in cold regions, such that the pipes used as exhaust of CO and have no beauty are eliminated and heat loss will also be prevented.

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EXTRACTING METHOD OF BIOGAS IN RURAL AND URBAN AREAS

A village or an urban district could use biogas out of plant wastes, manures and sewege, to generate electricity and thermal energy, required for its houses. People could collect wastes and manure and store then in a tank. Some of the waste materials and manure are transformed into liquid and in a very short time, the liquid produces methane that could be kept in a tank with mobile lid and could be used in the houses for cooking, heaters and as fuel for a motor or an electric generator.

The direct way of extracting biogas is using a set of vertical wells that is connected to a blower to remove the gas.
The outgoing extracted materials and gas enter a motor that moves the generator. Burning is used in this motor to minimize the dispersion of nitrogen oxide and carbon monoxide.
The biogas technology is used in extensive lands such as Turkey and Denmark, for their electricity generation and heating purposes. Cooperative companies collect plants waste materials, livestock manures, industrial waste materials and the waste resulted from food and store then in warehouses in non-toxic ways and use them for electrical generation and for heating purposes.

Biogas equipment that is easy to be made, can be manufactured for producing biogas in rural areas and agricultural complexes and husbandries. This equipment is made with the following sections.

1- **Fermentation tank:** Fermentation tank is the main part of biogas equipment that is usually cylindrical and of brick or concrete. This reservoir can be constructed either totally or partially in the ground. Organic waste materials are kept in it for a month or two after being placed in it. During this time, the organic materials are dissolved in anaerobic conditions and due to the effects by the bacteria. The result of this dissolution is production of biogas and some biomass that could be continued all through the year by removing the biomass and adding new waste materials into the tank.

2- **Gas chamber:** This chamber is placed on top of the fermentation tank, either with mobile or fixed lid. The produced gases in the fermentation tank are collected in the lower part of the lid and could be transferred by pipe to the consuming device or area.

The important point about this chamber is that the extra gas pressure should be avoided in that and it can be done by installing a pressure gauge on the chamber.

3- **Inlet and outlet pipes:** The aim of inlet and outlet pipes in biogas equipment is entering raw materials and removing of biomass from the fermentation tank. The material of the pipes could be selected to be either PVC or concrete.

CONTRIVANCES FOR BIOGAS APPLICATIONS IN HOUSE ARCHITECTURE

Contrivance and preparations (1): Hydrogen sulfide (H2S) (fig. 3) is a colorless, toxic and flammable gas with the odor like rooton eggs. Hence, bacterial activities are made, producing acids with water drops inside the biogas that causes metals corrosion. Home appliances such as water heaters and refrigerators are exposed to corrosion.

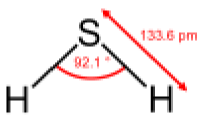

Fig. 3: Hydrogen sulfide structure

1: Combustion chambers and gas cookers should be made by resistant steel to corrosion, or should be somehow covered and manufactured against corrosion.

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2: Sulfur of biogas could be separated and released by the use of iron oxide filters:

$$FeO+H_2S \rightarrow FeS+H_2O \quad (1)$$
$$2FeS+O_2 \rightarrow 2FeO+2S \quad (2)$$

The filter should be continuously changed for high volumes and hence it requires plenty of tasks. In that case, filtration is omitted. However, despite high costs, home appliances should be manufactured with quality steel. The gas should not be filtered for the biogas consumption inside the engine motor.

Contrivance and preparations (2): Rubber hoses and PVC pipes face porosity due to the rations by the sun and gas may leak from the pores. Also, pressure loss may occur due to long pipes.

Contrivance and preparations (3): Gas pipe should have special outlet for removal of water drops. Biogas equipment includes home appliances used for normal services.

Contrivance and preparations (4): Floating tanks have the most rate of energy loss. Biogas units with the fixed gas chamber under the ground usually preserve heat at lower temperatures. Although fixed reservoirs with floating gas keeping tank are more expensive, but they could be the most appropriate solution for cold regions.

Contrivance and preparations (5): Fine results are obtained from the indoor units, since in case of freezing conditions in cold regions, constructing an indoor place is essential for the mixer and the tank to be fed.

Contrivance and preparations (6): Solar heating systems could be used for using hot water in order to prepare the required sludge. The obtained sludge from the diluted manure could be prepared and mixed in the inlet pond and keep during the day to be heated, to be used by the sunset for loading.

Contrivance and preparations (7): Adding organic materials with high rate of nitrogen, such as urine, excrement, etc. increases the gas production and the quality of the obtained fertilizer resulted from biogas. a sewerage pipe of a lavatory is entered into the digesting tank. Required predictions should be made for that case.

Contrivance and preparations (8): The gas chamber should be covered during the nights with plastic bags to prevent heat losses.

Contrivance and preparations (9): The canopies made of plastic sheets could prepare greenhouse effects in case they are completely sealed. This may even increase the gas production to 50-65%. The other method is to collect the waste materials beside the fermentation tank walls and be mixed. Mixing and airing the materials provide high rate of heat. Simultaneous with these operations, the gas tank is insulated during the night. It may produce an extra gas rate of 20-30%.

Contrivance and preparations (10): Using residual sludge from the equipment together with fresh sludge increases the bacterial population in the fermentation tank. Thus about 2 liters of residual sludge is added to 100 liters of fresh sludge. It certainly increases the speed of gas production process.

Contrivance and preparations (11): Insulation should be used for the walls of the fermentation tank in the regions that are freezing in winter, in order not to have thermal energy losses.

CONCLUSION

Governments and industrial authorities and owners are seeking energies nowadays that produce less pollution. It is why that the world has is looking for renewable energies. Using the potentials regarding wastes and sewege for energy can solve two main problems, simultaneously. Economically, by using cheap raw materials, the cost for producing biogas reduces about 40% in comparison with the cost of one cubic meter of consuming urban gas and the price for the unit of electricity could be reduced to an acceptable rate by this process, due to not needing the required expenses for destruction and burial of the garbage and also by receiving tax due to producing waste materials. On the other hand, biogas has many advantages for the environment since it causes the burning of methane due to destruction and rottening waste materials at the burial places of garbage. Nevertheless, the problem of greenhouse gases will be increased that by itself is quite an important matter.

Definitely, using biogas for providing the energy in residential places requires architectural and urban planning for the reqired contrivances to be onsidered for its appropriate structure. Not only the contivances for achieving the aims regarding renewable energies and buildings requiring no energy will be verified without consideration of the contrivances, but it also may provide problems in some cases. Hence, by complementary scientific knowledge about renewable energies and biogas in particular, it is necessary for the architects to apply them in architectural and urban planning. Thus, in case of preparing an architectural planning in accordance with renewable energies, it will make the

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clients to certainly use such energies. In national scales, this move guarantees the access towards clean and cheap fuels; the affair that could never be achieved without architectural and urbal attempts.

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