REVIEW THE CASE STUDY OF BIOGAS FEED INTO THE NATURAL GAS GRID IN IRAN

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ABSTRACT

More than 30 million tonnes per year agricultural wastes are major part of sources which can produce 20 billion cubic meter biogas (almost 10 billion cubic meters per year methane) in Iran. Assuming 36 Mj per cubic meter heat value for methane, we can gain a huge energy for cars or industries very simply. It is why this research carried out and leads us to a feasibility study. Currently most of the global energy companies already have renewables in their program.

According to the companies information the majority of them are planning to increase the share of renewables in the future. The companies have learned how to gain profitability from these new energy sources that stimulates their commercial use and development. One of the most promising types of the renewable energy sources is biogas (generally) or bio methane – gas produced from organic waste.

This study is an evaluation of technical and economical potential for biogas production in Iran, focuses on the potential of upgrading produced biogas to biomethane (a renewable natural gas) and its subsequent sale in existing gas markets. During this study, technologies and existing biogas upgrading projects are reviewed to derive an average cost for production of biomethane from organic waste. Environmental impacts are assessed in light of different biomethane utilizations in Iran.

In a brief summary, although development of biogas production and feed into natural gas grid is an opportunity for Iran, but some following challenges are in front of this policy:

- Energy is cheap and there are not good drivers for development of renewable gases. Subsidies are the next important issue from economical point of view.
- Capital cost of biogas production plants in Iran is not comparable with other energies.
- Specified organization (SUNA) are defined and authorized in development of renewable gases but there is not a master plan and roadmap for development.
- New technology of biogas plants should be transferred and considered.
- Environmental impact assessment should be done for every new project.

Keywords: Biogas, Biomethane, Renewable gas, Sustainability, production, utilization

1. INTRODUCTION:

Renewable gases or gases from biological origin include methane- or hydrogen-based gases that can be produced by using different biomass fractions as raw materials and different technologies for fuel conversion. There are two main conversion technologies to produce methane-based gases: anaerobic digestion and gasification. Fig.1 shows renewable gas value chain and step by step production of by products.

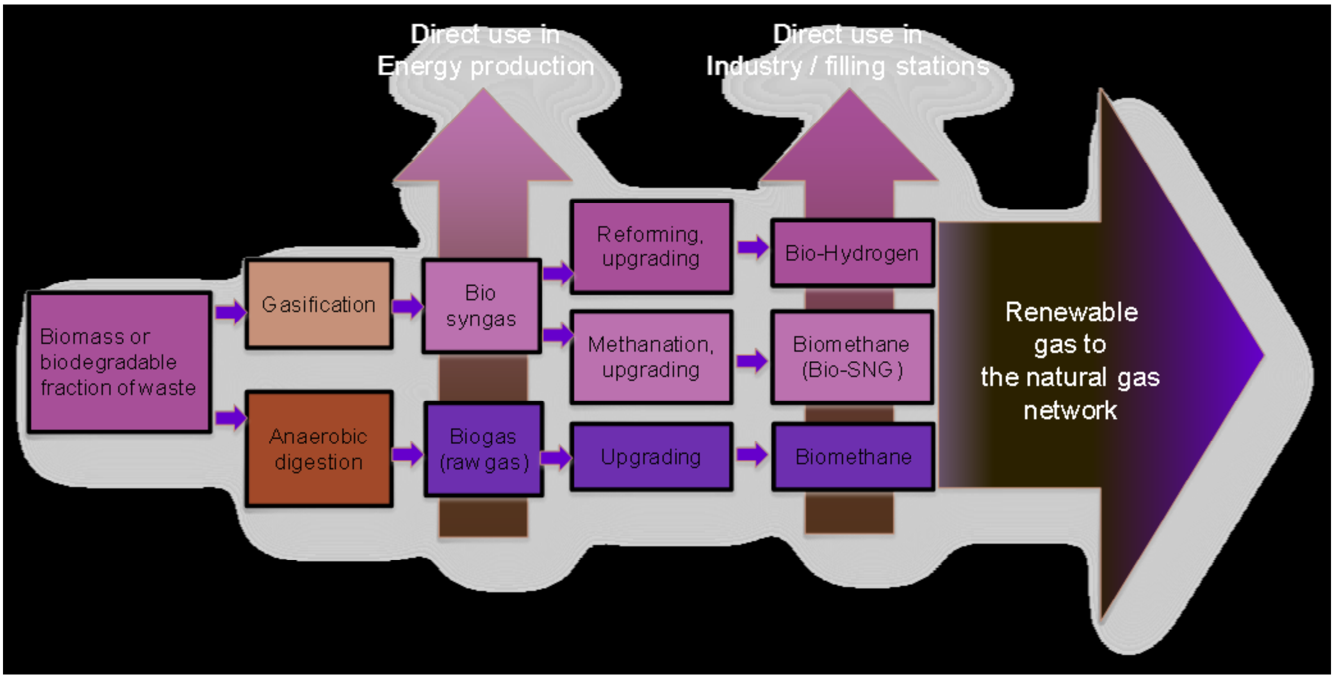


Fig.1: Biomass to renewable gas chain and applications

Anaerobic digestion is a bacterial process that is carried out in the absence of oxygen. The process can either be thermophilic digestion in which sludge is fermented in tanks at a temperature of 55°C or mesophilic, at a temperature of 30 to 40 °C. Thermophilic digestion is more expensive in terms of energy consumption for heating the sludge. Anaerobic digestion generates biogas with a high proportion of methane. The methane generation is a key advantage of the anaerobic process. Its key disadvantage is the long time required for the process (up to 30 days) and the high capital cost.

Aerobic digestion is a bacterial process occurring in the presence of oxygen. Under aerobic conditions, bacteria rapidly consume organic matter and convert it into carbon dioxide. Because the aerobic digestion occurs much faster than anaerobic digestion, the capital costs of aerobic digestion are lower. However, the operating costs are typically much higher for aerobic digestion because of energy costs for aeration needed to add oxygen to the process. For gas production aerobic digestion is not used.

The following sources are most common for the production of biogas.

- Sewage treatment plants: Sewage treatment plants produce methane rich gases.
- Landfills: All landfills produce methane rich gases. Collection and utilisation of the gases is quite well possible. Improved collection, processing and utilisation of landfill gases will be an important tool to increase the importance of landfill gas.
- Cleaning of organic industrial waste streams: Anaerobic digestion processes are often successfully applied to clean the waste streams of agricultural processing and food industries. The methane rich gases are mainly utilised to produce electricity.
- Grass and energy crops
- Algae
- Municipal organic waste: Compact installations convert municipal organic waste to methane rich gases at higher temperatures.

Studies by EPA Services demonstrate the CO2 savings associated with biomethane injection compared to other uses for biomethane. The table 1 shows that 100 M_3/hr of biomethane used on site to make electricity will save around 750 tonnes of CO2 compared to using fuel of average grid mix but this will rise to 1,723 tonnes of CO2 where the heat is utilised. Hence, where there is no local heat load, it is highly beneficial to create an option to utilise the biomethane where both heat and electricity can be fully used.

Table 1: EPA study on CO2 saving with biomethane injection

Options for use of 100 M_3/hr of biogas production	Co2 saving (Tonnes per year)
AD + on site elec (assuming no use for waste heat)	**754**
AD + on site electricity and heat	**1,723**
Biogas Injection - Transport end use	**1,305**
Biogas Injection - Heating end use	**1,026**
Biogas Injection - Electricity end use	**1,567**
Biogas Injection - average	**1,299**
Biogas Injection - average saving over onsite electricity generation	**545**
Biogas Injection = % increase CO2 saving compared to onsite electricity Generation	**72%**

The major technologies or methods for biogas production are categorized as below generally:

- Centralised biogas plants
- Farm biogas plants
- Sewage plants
- Landfill
- Macro and microalgae to biogas plants
- Dry biomass plants

Table 2 shows typical compositions of product gas for different processes. The production rate of biogas can be increased by additives or boosters. The optimum conditions are often defined by the CNPS-ratio which for methanogene organisms is given as 600:15:5:3 (C = Carbon, N = Nitrogen, P = Phosphor, S = Sulphur).

Table 2: Typical raw (untreated) biogas compositions at the different plants

Component	Digestion plant	Sewage plant	Landfill
Methane [%]	60 – 70	55 - 65	35 - 55
Carbon dioxide [%]	30 – 40	balance	30 - 40
Nitrogen [%]	< 1	< 1	5 - 15
Hydrogen sulphide [ppm]	10 – 2000	10 - 40	50 - 300

These boosters may promote the degradation and subsequent fermentation of substances such as grass or fibres. Excessive use of boosters may lead to acidification of the digestate and to a varying gas composition.When considering transport and distribution of biogas there are three basic options:

- Upgrade the biogas to biomethane and feed it into the natural gas grid. Upgrading biogas to biomethane and feeding it into the existing natural gas grid is a logical option. Logical, because by choosing this option, the consumers will observe no changes at all, since by definition the biomethane should have the same properties as the natural gas it is replacing. Full benefit is made of the existing grid and existing demand.
- Feed the biogas into the natural gas grid. Although upgrading biogas to biomethane before feeding it into the natural gas grid is a logical option, one might also consider to transport and distribute biogas through the natural gas grid without or with only partially upgrading it to natural gas quality first. This is only possible without further consequences when the flow of biogas is very small compared to the flow of natural gas. In practice, this means feeding in into high pressure transportation pipelines.
- Use a dedicated grid for the biogas. When using a dedicated gas grid for the biogas, there is no interference with existing natural gas grids. The advantage is that within such a biogas grid, all rules and contracts can be tailor-made to the producers and consumers on that grid. If a consumer, or group of consumers, is satisfied with the specific properties of the biogas of the producer(s), they can use it as their standard and adjust their appliances to these specific properties. The grid operator can take these properties into account and all work instructions or financial agreements can be right on. There is no need for expensive upgrading to biomethane.

There are many operational examples of biogas injection around Europe with Germany, Sweden and Switzerland operating biogas upgrade and injection plant for the last 15 years .Commercial activity is now particularly high in Germany where the biogas industry is the fastest growing renewable attracting over 1 billion Euros of investment per annum. In Germany, currently 55 plants with an injection rate of 40,000 m^3/h are operating and the number of injection plants will increase strongly in next years to 100 plants up to 2020 to substitutes about 10 billion m^3/year natural gas by biogas.

2. BIOGAS POTENTIALS IN IRAN

Based on previous studies (Adl and et al 2009) the summary of biogas potential evaluation in Iran is shown in Table. 3. In shows that the average annual biogas production potential in Iran is almost 20000 million cubic meter per year (it is equal 10000 million cubic meter of methane or 3.367 * 10^{17} J energy).

Table 3: Biomass and Biogas potential in Iran

	Animal manure	Agri. Biomass	Anaerobic wastes	Industrial waste treat.	Landfill
Estimated Tones /Year	75000	24000	6000	10000	14000
Biogas Potential million m^3	8700	5500	200	280	1600

The share of biomass in each states (Fig. 2) shows that majority of biogas potential is located in north of Iran where has more demands for energy. The vast population and major industries and agriculture activities are in the north and vice versa energy suppliers (major natural gas plants) are in the south and east where are far from them.

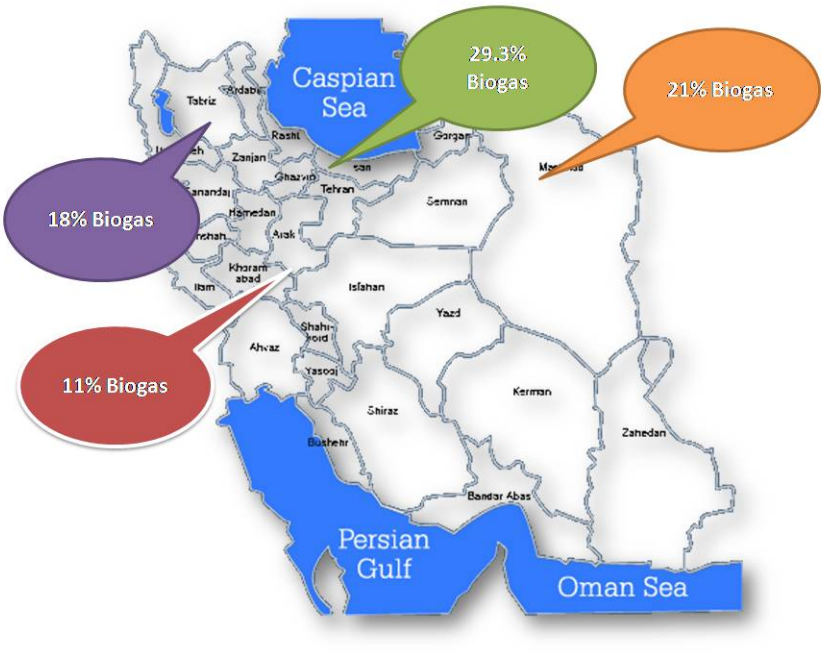


Fig. 2 : Biogas potential share of regions in Iran

3. TECHNOLOGY SURVEY

In general category in country side of Iran, the old designs of biogas plants currently used by people are: fixed gas tank and floatation gas tank plants. The fixed gas tank type which called “Chinese biogas” in Iran, has fixed tank and the produced gas accumulates in top of digester. When gas is producing, fermented sludge replace to external tank. More gas production leads to increase pressure in tank and therefore the tank volume should not exceed 20 m^3. (fig.3)

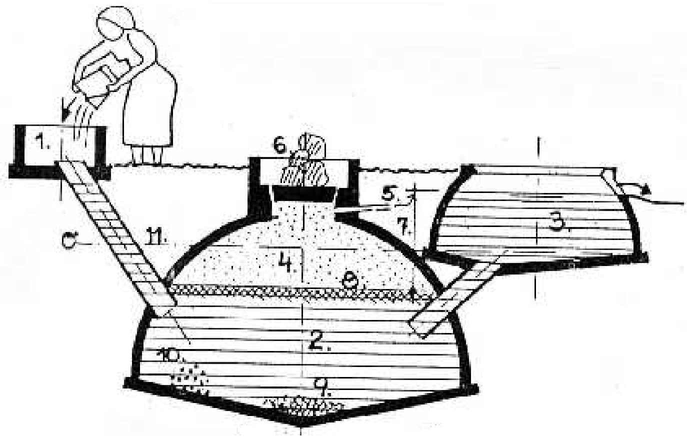


Fig 3. Fixed biogas tank plant (Chinese type)

The floatation gas tank system which is called “Indian biogas” in Iran, includes tank and digester. The gas storage tank is float on fermented sludge and produced gas collects in floatation tank. In this type the floatation cap cause fix pressure in plant and the control of produced gas is easy. (Fig. 4)

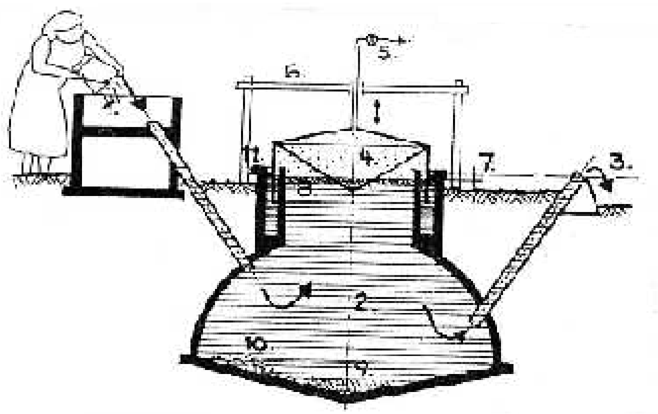


Fig 4. Floatation biogas tank plant (Indian type)

More than 100 floatation gas tank plant are constructed by some organizations in Iran. It is popular in country side now and it preferred for land and weather condition of Iran. The research on efficiency and optimized operation of these plants are ongoing now. Anaerobic reactors are another technology for biogas production in wastewater treatment plants which can produce considerable energy for use. In Iran, just a few plants, produce bio gas and consume it as required energy.

4. NATURAL GAS GRID IN IRAN

According to *Oil & Gas Journal*, as of January 2011, Iran's estimated proven natural gas reserves stood at 1,046 trillion cubic feet (Tcf), second only to Russia. Major natural gas fields include: South and North Pars, Kish, and Kangan-Nar. In 2010, Iran produced an estimated 5.2 Tcf of dry natural gas and consumed an estimated 5.1 Tcf. Natural gas consumption is expected to grow around 7 percent annually for the next decade.

Iran has an extensive natural gas pipeline system, which includes trunklines, import/export pipelines, and gathering and distribution lines. The backbone of the domestic pipeline system is the Iranian Gas Trunkline (IGAT) pipeline series, which transport natural gas from processing plants to end-use consumers.

Iran's natural gas production has increased by over 550 percent over the past two decades, and the consumption has kept pace. As demand growth rates persist, the potential for shortfalls in natural gas supply grows. Iran's natural gas exports likely will be limited due to rising domestic demand and it can be an opportunity for biogas production and utilization in local places.

The following range of natural gas pressure in Iranian gas grid shows that biogas feed in is feasible:

High pressure gird: 70-90 barg

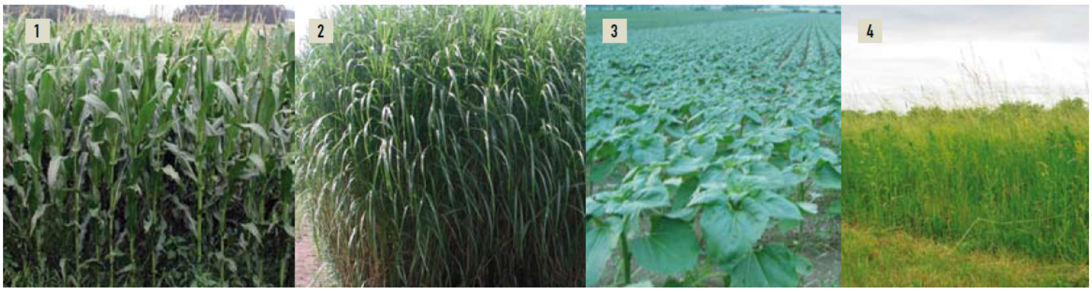
Low pressure grid: 25-40 barg

Lower pressure grid:0.25 barg

5. BIOGAS FEED TO NATURAL GAS GRID: CHALLENGES

5.1 Biogas Quality Issues

Although upgrading biogas to biomethane before feeding it into the natural gas grid is a logical option, one might also consider to transport and distribute biogas through the natural gas grid without or with only partially upgrading it to natural gas quality first. This is only possible without further consequences when the flow of biogas is very small compared to the flow of natural gas. In practice, this means feeding in into high pressure transportation pipelines. In each natural gas grid there are strictly defined natural gas specifications, describing minimum and maximum quantities of components and overall characteristics such as density and Wobbe index. If even after adding biogas to the flow of natural gas, these specifications are still met, then feed-in of the biogas is possible. This always needs close cooperation with the gas transporting company responsible for the gas quality in that pipe, for they know the margins between the actual natural gas composition and the extremes in the specification. The largest two advantages of this option are that there is always sufficient demand, meaning that the biogas producer has a very stable turnover, and that there is always back-up if the biogas producer fails to produce.



Financially it has the advantage that there is no need for upgrading, however, since this is an option which is typical for high pressure transportation pipelines, compressing the biogas to pressures like e.g. 40 bar, will be necessary. Also there is a strong limitation in the possible locations because connection to a high pressure pipeline is necessary.

The second option for feeding in biogas into the natural gas grid, is accepting that the flow of biogas is relatively high compared to the flow of natural gas. In this case, the gas composition will vary in time because of variation in production and consumption rates. This is only possible if the appliances are capable of handling these varying compositions. Financially, this is the optimal solution for society. There is no need for upgrading to biomethane, there is no need for compression to high pressures and there is always back-up by natural gas. Appliances that can handle varying gas compositions could be available for minimal additional costs. The complexity is the compatibility of the distributed gas, a question which is comparable to the question for a dedicated biogas grid with more than one producer.

5.2 Eco and Environ. Issues

Up to now, biogas does not sell on its own without any incentive. To touch the issue of biogas production and injection purely from an economical view would turn the entire issue down. Its production is so far always more expensive than producing natural gas and transporting it to the producer. For example in Germany, whilst natural gas is available at a cost of 5 – 6 Euro-Ct/kwh, the same amount of energy based on biomethane will not be available for less than 9 Ct. Most incentives come from the governments who foster biogas, but also other renewables for different political reasons, most of them being ecological, but also items such as the nationalisation of the energy supply.

For every product it is important to minimize the negative environmental and social impact. Renewable gases are no exception. Aspects that should be addressed are among others: land usage, water usage, fertilizer usage, energy usage, carbon footprint and employability. In the process of renewable gas production, each step should be considered and optimized to reduce the negative environmental and social impact. LCA projects are effective in this way.

6. BIOGAS REGULATORY and OUTLOOKS IN IRAN

In Iran, further to policies made by the Ministry of Energy's Deputy Directorate for Energy, Iran Renewable Energy Organization (SUNA) has been attending to this matter since 1995 in order to achieve updated information and technology in connection with utilization of renewable energy resources, measurement of potentials and execution of various projects (solar, wind and geothermal, hydrogen and biomass). Due to the volume and diversity of operations, at the end of the year 1378 [early 2000] the Ministry of Energy submitted it's proposal as to change the nature of SUNA to that of a governmental institution to the cabinet to fill the vacancy of a governmental organization responsible for renewable energy development. This was done pursuant to Articles 1 and 2 of the Establishment Act of the Ministry of Energy approved on February 17,1975 as wall as Note 2 of single Act of the 1999 General Budget Law. On February 27, 2000, in order for development of renewable energy as a crucial international/regional matter, the Cabinet approved (approval No H21343T/65004) the Ministry of Energy's proposal as to the establishment of SUNA Government Company who would be responsible for management of relevant projects. This was in congruity with government policies on energy, made by the state Expediency Council on January 13, 1999 and approved by the leader on January 22, 2001 (notified under No 76330/1) where two out of eleven articles related to the subject of renewable energy.

Accordingly, by virtue of the Cabinet's approval No H2528288T/2732 dated may 23, 2003 (concerning the approval of SUNA's Articles of Association), Iran Renewable Energy Organization [SUNA]- registered under No 161299 on April 18,2000- was changed into an absolutely government company aimed at developing the application of energies resulting from renewable resources, and assumed responsibility, as manager of Energy Deputy Directorate's projects, for carrying out R&D activities, rendering design and consultation services, manufacturing and operating renewable energy systems until the end of the year 1381 [mid March 2003] after which, it started executing relevant projects directly.

Although development of biogas production and feed into natural gas grid is an opportunity for Iran, but some following challenges are in front of this policy:

- Energy is cheap and there are not good drivers for development of renewable gases. Subsidies are the next important issue.
- Capital cost of biogas production plants in Iran is not comparable with other energies.
- Specified organization are defined and authorized in development of renewable gases but there is not a master plan and roadmap for development. Renewable energy organization(SUNA) has some activity but it should be developed.
- New technology of biogas plants should be transferred and considered.

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