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# The environmental sustainability of biogas production with small sized plant

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**Abstract**

In the century of the continuous evolution towards new technologies the renewable energy sector play a fundamental role in this direction. Use of these technologies in the small sized farm could help not only the production process but also the economic income of the farm. This paper underlines the availability of three different technologies adaptable to biogas plants for small sized farm. In this study three different technologies have been analyzed in order to present the environmental and economic benefits of these. Based on the use of a bagtank as digester (BT technology), the first technologies is compared with the use of a concrete structure with a storage balloon cover (BC technology), and with the use of a concrete structure as a concrete cover slab (CS technology). Through a streamlined comparative life cycle assessment, the characteristics of the three technologies as far as their environmental performance are analyzed, in order identify the most suitable for small sized biogas plants.


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*Keywords:* life cycle assessment (LCA); anaerobic digestion; small sized plant; future biofuel industry

## 1. Introduction

These days, renewable energy is showing a great potential to satisfy in a sustainable way energy demand, in particular for countries and regions with a low availability of fossil fuels and nuclear sites. In this way, growing interest

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in bioenergy is clearly present in recent EU policies, and highlighted in the Directive 2009/28/EC on the promotion with incentives of the production from renewable energy [1]. Among renewable energy sources, biomass plays an important role. There are several processes that transform solid and liquid biomass in secondary energy sources, such as biogas, landfill gas and pyrolysis gas [2]. In 2014, the whole Italian energy demand reached about 1,915,153 GWh, of which about 6.4 % us net through the exploitation of biomass, then also through biogas [3]. In fact, biogas energy comes from biomass, which is the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as biodegradable fraction of industrial and municipal waste. In the last two decades, a lot of interest has been posed to the development of technologies capable to optimize the entire Biogas energy process [4–6] and its applications go from sustainable farming and livestock breeding to district heating [7].

In a Biogas plant, the critical element is the "digester", in which the biodegradable fraction of biomass is fermented through anaerobic digestion and produces biogas that primarily consists of methane ($CH_4$) and carbon dioxide ($CO_2$). The percentage of methane depends on the type of organic substances that constitute the biomass, on the technology and on the size of the plant, and generally moves from 50 % up to 80 % [8]. To improve the biogas energy diffusion and to exploit its potential, one of the necessary conditions is the availability of sustainable technologies for biogas plants, particularly from the environmental and economic point of view [9–11].

In the following paragraphs, three different technologies applicable to small-scale biogas plants are described and their environmental performance are analysed using the life cycle assessment (LCA) methodology. An analysis of the economic sustainability of the same technologies can be found in literature [12, 13].

## 2. Anaerobic Digestion technologies for the production of biogas

As regards the Italian situation, Table 1 shows the number of biogas plants installed from 2011 to 2015 [14–18]. Most of them are in the northern regions. Table 2 shows the classification by size classes of installed power referred to 2011 (more recent data are not available).

Table 1. Italian biogas plants.

| Year | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|
| Number of plants | 521 | 1264 | 1391 | 1491 | 1555 |

Table 2. Italian biogas plants by size classes of installed power (2011).

| Class of installed power, kW | Number | Percentage |
|---|---|---|
| <100 | 54 | 10.4 % |
| 101–500 | 105 | 20.2 % |
| 501–1,000 | 289 | 55.5 % |
| > 1,000 | 24 | 4.6 % |
| Biogas in the boiler | 11 | 2.1 % |
| Data not available | 38 | 7.3 % |
| TOTAL | 521 | 100.0 % |

In a biogas plant, the natural process of fermentation and decomposition produces biogas which is subsequently used to obtain electricity and heat. After a phase of upgrading, it can also be used as biomethane. One of the most critical elements for the efficiency of the process in this sense is the "digester", in which the fermentation phase happens and the biodegradable fraction of biomass is fermented through anaerobic digestion [11, 19, 20].

An optimum control of the degradation process in a biogas plant requires a detailed knowledge of the main chemical and physical parameters [8]:

- Temperature, which plays a crucial role. Biogas plants are generally mesophilic or thermophilic. In the first case, the functionality is more efficient at a temperature between 35 °C and 41 °C, while in the second case at a temperature of about 55 °C;