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Research Paper

Evaluation of The Best Location for a Biogas Plant Implementation

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ABSTRACT: *This paper presents an analysis of the best location for a biogas plant implementation. The evaluated region is located in the Agronomy District of Porto Alegre in Rio Grande do Sul. Three basic criteria were used: i) legislation; ii) soil quality, slope of the land, size of the area, access to transportation and alteration of local traffic, access to local, public infrastructure and use of the area; iii) noise, visual and olfactory pollution. The results indicate to a specific area of the location analyzed as most appropriate for the implementation of the biogas plant.*

Keywords: *Biogas, Biogas plants, Implementation criteria.*

I. INTRODUCTION

Biogas results from the decomposition of organic matter produced in nature. In the absence of treatment of the organic residues, an increase of greenhouse gas emission may occur in the future. Biogas is composed mostly of methane (CH_4) and carbon dioxide (CO_2). Methane has a potential greenhouse effect of 24 times the value of carbon dioxide [1].

Biogas system is the key to solve the problems like pollutions from swine manure, bad smell, wastewater and insects proliferation [2]. Biogas technology is considered as one of the important drivers to struggle challenges as access to energy resources, economic development and environmental pollution. As it solves waste management problems and simultaneously produces biogas and digestate as a by-product [2].

Many developing countries has a limited conventional energy supply and is therefore forced to look for alternative and renewable energy routes to foster its development programmes, especially in rural areas [4].

As a strategy for building a sustainable agriculture in rural areas, the development of biogas is an important means to convert agricultural wastes to clean and safe energy, thereby reducing the need for fossil fuel and alleviating environmental pollution [5].

Biogas plant implementation offer a benefit from by-product utilization in agro-industry, both of which are significant strategies to address energy shortage and global warming issues [6].

Direct benefits of biogas plants development for agriculture and rural areas consist not only in income source diversification and new jobs, but also in creation of a new market for local agriculture production, effective pro-environment by-products and leftovers from agriculture and agri-food production utilization [7].

Certain financial mechanisms have to be put into effect, such as increasing market price of electricity produced from biogas plants to give an incentive to biogas producers, as well as fundraising to support implementation of biogas plants, and offering both long-term [8].

Biogas production occurs in the anaerobic digestion (DA) of biomass. Biogas and fertilizer are obtained with the use of bioreactors loaded with organic substrate and with a biological process [9-10-11].

For the energetic conversion of the biogas, purification is necessary. Reducing the concentration of CO_2 and other gases leads to the production of biomethane. Biomethane has the characteristics of Natural Gas (NG) used commercially, reducing the equipment adaptations. Applications of NG occurs in internal combustion engines, turbines, furnaces and boilers.

First, the physical and climate characteristics were verified at the installation local. With visits to the local and maps of the area, the following items were investigated: transportation access, layout of the physical elements of the site, presence of the public infrastructure and the partitioning of the local in zones for analysis.

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The climate study was carried out in meteorological stations to obtain data of temperature variation and identification of climatic events characteristic of the region.

The analysis to define the best local to install a biogas plant must consider several determinants of its viability. An evaluation strategy can be divided into specific aspects of the study site, social and legislation [12].

The first item is about characteristics of the land and its cost, the infrastructure, the local available, the storage of substrate and products and the raw material available for the biogas plant.

The social aspects considered are the inhabitants and enterprises located near the plant. The acceptance of these communities and institutions must be verified. Negative impacts of pollution such as visual, noise, odor emissions and traffic change around the installation are considered. Legal aspects such as environmental regulation and civil implementation.

The three basic criteria found are interdependent. The set of them form specific constraints to facilitate the decision to choose the best place of installation. Figure 1 presents the Venn diagram with the relationship of the fundamental criteria.

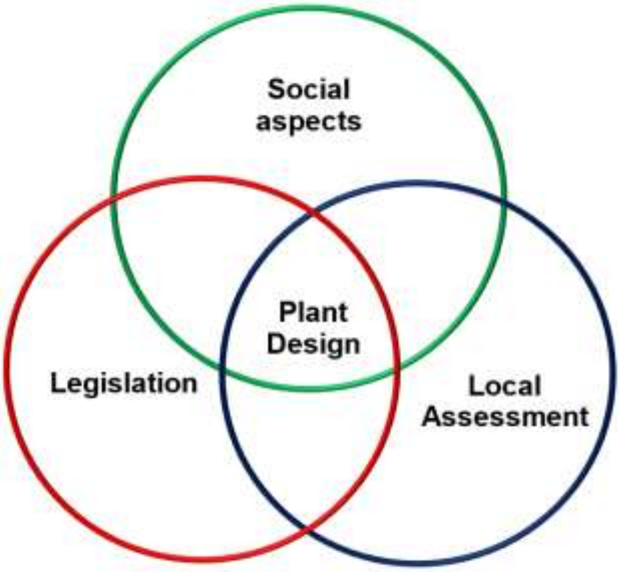

Figure 1. Criteria for choosing the best location for the installation of the biogas plant.
Source: Adapted from FISCHER et al., (2010) [12].

With the concepts presented, a decision support methodology can be adopted for the application of a biogas plant project.

1. Local assessment for the installation of the Biogas Plant

For the evaluation of the place of installation, local and social aspects were considered. The installation area was divided into different zones within an educational institution. The legislative aspect will not be restrictive between those zones available for the decision to choose the place of installation. For the other two aspects, criteria based on data and on local singularities were defined.

Specific local criteria: soil quality, slope, area size, access to transportation and local traffic change, access to local public infrastructure and use of the site.

Social criteria: noise, visual and olfactory pollution.

Based on these two aspects, the analysis of each of the available zones was applied through a scoring system for each criterion. Based on a technical visit at the installation site, the three zones were ranked by scoring 3 points for the first, 2 points for the second and 1 for the latter. After the analysis of each criterion, summed the points of all of them the one that obtains the highest score wins as the choice for zone of installation of the plant.

2. Biogas Plant Design

Follows the method used to design the biogas plant proposed [13].

Data survey: Characterization of the location to search for available substrate potential, location of installation and climate data, verification of space restrictions, operation and movement.

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II. CHARACTERIZATION OF THE INSTALLATION LOCAL

The installation place is located in the *Agronomia* neighborhood in the city of Porto Alegre. Figure 2 shows the limits of the municipality of Porto Alegre.

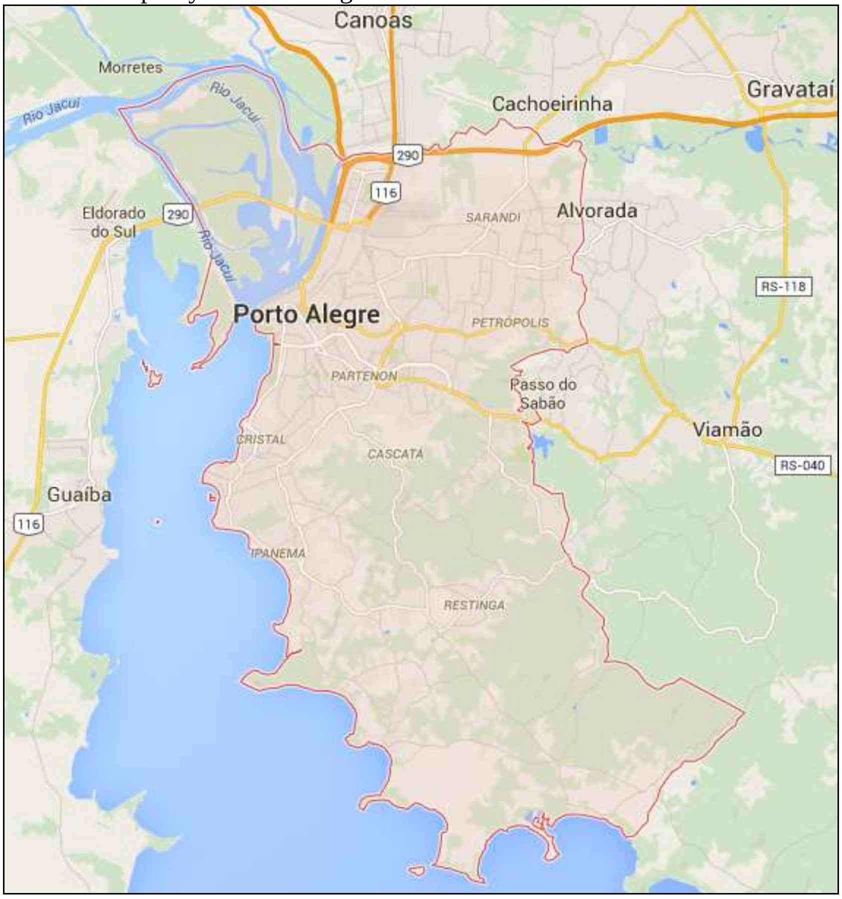

Figure 2. Limits of the municipality of Porto Alegre.
Source: Adapted from Google ([2015]a) [14].

Figure 3 shows the boundaries of the *Agronomia* neighborhood of the eastern zone of the city of Porto Alegre.

Figure 3. Limits of the neighborhood Agronomia.
Source: Adapted from Google ([2015]b) [15].

The local has three transport accesses, the main one for the RS-040 with limited width only for light vehicles. Accesses 2 and 3 are service entrances, with adequate dimensions, for the entry of heavier vehicles, indispensable for the implementation of the project. Access to entrance 2 is by João de Oliveira Remião Street and 3 by Tocantins Street. The total area have approximately 105 km². Consisting of 14 buildings, an on-line high-voltage transmission training area, another for distribution training, a soccer field and an extension of preservation area. Figure 3 indicates each element described above.

Figure 4. Identification of the elements of the implementation local of the biogas plant.
Source: Adapted from Google (2015) [14].

Three zones were available for analysis of the biogas plant installation. Figure 4 presents these areas. The aerial image is highlighted in red. Table 1 shows the elements shown in Figure 4.

Table 1. Legend of the Campus Elements Identification.

	Color	Element
-------------	Red	Possible installation zones
-------------	Blue	Campus access gates
-------------	Lilac	Training areas in transmission and distribution lines
-------------	Brown	Buildings
-------------	Green	Area of vegetation

Based on the defined indicators, the analysis of which zone will be chosen from the three selected as plant installation potentials is carried out. The study was done for each indicator presenting justifications based on the field visit to the site, in order to choose a winner for each topic of the specific local and social criteria. And finally, the one with the highest score wins as zone for plant installation.

Soil quality: in this indicator was carried out a qualitative analysis of the visualization on site visit. The soil characteristics are the same for the whole extension area being the soil of the red-yellow podzolic type. This soil is characterized by good drainage, with smooth relief, presence of deep water table and good soil support capacity, for these aspects it is considered suitable for engineering works and consequently urban occupation [16]. In the case, zone B has proximity to a lake, this can compromise the foundations of the plant. This was considered as a factor for site evaluation, but requires technical confirmation from a qualified professional to make the final decision. In addition, no distinction was found in this criterion for determining the best place, then zones A and C were scored with 3 points and B with 2 points.

Slope: Zone A has little need for intervention to correct this criterion, a slight slope is noted. Zone B, for example, shows that is quite irregular, with different dimensions, which requires work to correct the criterion. After this correction step the slope can be a positive differential, since it can be used to reduce the power required of the pumping systems. In zone C there is a level area, because it is a leisure area, a soccer field. It has improved features, but therefore it is an area of current use, which may be restrictive considering it as potential space for installation. Zone B was better because it is an extension that is not used and has the advantage of the possibility of the advantageous use of the inclination. The second best place is zone A, which

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has less need for intervention to carry out the project. There is no obvious advantage at location B. The worst place for this criterion is C.

Size of areas: Areas A, B and C have approximate areas of 0.78, 3.72 and 2.4 km² respectively. For this criterion was chosen to the largest area, due to the greater sizing of the plant and the layout of its elements, thus beating zone B followed by C and finally A.

Local transit and transit access: in this criterion, it considered only entries 2 and 3, which are service entrances that are distant from the areas with the highest traffic of vehicles on campus. A route has been chosen to minimize local traffic interference on campus. The zone A is immediately adjacent to the access 2 and has greater advantage than the others. Zone A would be the least influential in the internal dynamics of campus traffic. Zone C in the current scenario can cause disruption for users in building 15, or in the university rectory. B zone, however, needs to pass through the university's rectory if access 2 is used, which increases even more in relation to the previous scenario of location C, the interference in traffic. But it is possible to use input 3 for access, thereby considerably reducing vehicle flow disorders. On the basis of the justifications presented, the zones A, B and C, respectively, ranked 1, 2 and 3.

Access to infrastructure: from the public services considered, it was highlighted the connection of the electricity distribution network, water supply and sewage, that were found restrictive situations for the zones. There is no natural gas NG distribution network, and the road transport conditions around the campus are compatible with the size requirements of the vehicles to be used.

In zone A, by consulting the database of the Municipal Department of Water and Sewerage (Departamento Municipal de Água e Esgotos – DEMAE - 2013) [17], it was verified the presence of an underground sewage duct, which causes complications in installing the plant in this place.

In zone B is no presence of water and sewage networks, so this is not a restrictive factor. In relation to the connection with the electricity distribution network, this location is the closest to the point of Tocantins Street, which may be advantageous depending on the amount of generation of the plant. It is necessary a study of the influence of the electric network, and consequently implantation of electrical structure.

In Zone C there are no underground water and sewage pipelines. With regard to access to the grid, this point is further away, which demands an expansion of the internal electrical installation networks of the campus in relation to zone B.

According to the study, zone B was chosen, followed by C and finally zone A.

Land use: for the analysis of this criterion it is considered the use of zones by current or eventual activities, and the level of vegetation cover if there is not use.

In zone A, from a visual analysis it was verified a light vegetation cover, which reveals little use in the last years.

For zone B there is vegetation cover with large trees, this reveals that there is no use of this space. However, due to the ecological characteristic, it may be restrictive to consider intervention at this location for plant installation.

In zone C, as already raised in the slope criterion, it is an area of eventual use, a soccer field, so of the three spaces this is the most restricted by the analyzed criterion.

Therefore, place A was chosen as the first, followed by B and C.

Sound, visual and olfactory pollution: the influence of this criterion on campus is inevitable as a consequence of the plant installation. It has been tried to avoid the regions that cause inconvenience to the users of the unit.

Zone A is the furthest from the buildings, so it is preferable that it be chosen. Areas B and C are very close to the rectory building, which also houses the refectory, the latter being an odor sensitive area that the plant emits. For the differentiation of the last two zones, it selected the one that is farthest from the rectory, so zone B becomes secondary and C finally, because the elements of the plant can be installed more distantly.

Table 2 presents the analyzes in order to facilitate the verification of the final results and the scores for each zone.

Table 2. Results of the ranking of the zones for each criteria.

Criteria	Score		
	Zone A	Zone B	Zone C
Land Quality	3	2	3
Inclination	2	3	1
Size	1	3	2
Transport access and influence of local traffic	3	2	1
Access to public infrastructure	1	3	2
Land use	3	2	1
Pollution	3	2	1
Total	16	17	11

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With the application of the method to define the site choice, zone B was chosen for the installation of the biogas plant.

III. CONCLUSION

The choice of location was based on general concepts for the installation of a project. For this reason, some common indicators were not used, because these vary significantly only in relation to elevated distances and locations with different characteristics, which is not the analyzed case, defined as the choice of different internal zones at the installation site.

The criteria were based on infrastructural and social physical characteristics, with exceptions for the reason already discussed. The zones were ranked in order to assign scores to each one and then to select the winner, which was zone B by a slight difference with respect to zone A. The physical justifications used were mostly qualitative, due to the need to use techniques of Topographic measurements, which requires a qualified technician to perform the measurements, but it is important to establish a project in order to confirm or demystify possible misconceptions in the assertions made in this work.

The influences of social impact had as main argument the maximum reduction of the inconveniences, that can be caused to the users of the campus with the installation of biogas plant. Therefore, zone B is the one that corresponds with the most adequacy to the analyzed criteria. The most negative are the proximity to the lake to the north, but this requires a deeper technical inquiry from a qualified professional. The vegetation cover is important, since the intervention in it for the establishment of the biogas plant can be environmentally questionable. Zone A had as main restriction the passage of underground sewage ducts in the location, which even with high scores in other criteria may be a restrictive factor at all. Therefore, excluded as potential area for the use proposed by the work. On the other hand, zone C has as restrictive aspects the fact that it is a space of eventual use of sports leisure, and also because it is located in a point too internal of the campus, these two were the most determinants for the failure of zone C like local Installation.

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