Sustainable Biodigesters design for Low-income Communities

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June 2022

Abstract: Economical, simple, and integrated technologies such as biodigesters are a great tool for developing countries that have yet to provide basic services such as gas, and electricity to all population. In the following thesis, a proposal for a *family size, single-stage, wet, co-digestive, semi-continuous, high-rate,* digestion system capable to supply gas basic needs for a family of four people is developed.

This dissertation explores and presents the basic principles and updated technologies involved in the biogas generation process that could be applied and implemented in areas of informal housing.

Specifically focusing on the north Argentinian region, where basic resources are scarce but organic waste abounds, the target user group is defined by a family of four members, the estimated gas basic daily consumption is considered as 600L per group and the annual temperature of the region is within the mesophilic range.

The mathematical model shows that under normal working conditions and feedstock availabilities, the maximum amount of gas that can be obtained per day for a fixed 400L volume digester is equal to 583L, just by using pig manure and fry fat/oil. Digester performance could be improved by adding a manual mixer by a 7,56%, thus, producing a daily amount of gas equivalent to 627L.

Families could save over 4% of their monthly income by having a biodigester, and the Argentinian government could save over U$S132 million a month in the long term. Unit cost is estimated at U$S460 without considering installation.

Keywords: Social impact, biodigesters, developing countries, informal housing, biogas, family size.

1. Introduction

Why the implementation and development of new technologies such as biodigesters are necessary? In most developing countries, cooking and heating in homes is a dirty and time-consuming job that involves burning solid fuels to produce fire. It is estimated that around the world, 3 billion people are burning solid fuels, including biomass, agricultural residues, and charcoal, for their daily cooking and heating needs [1]. Worldwide, solid wood fuels used for cooking and heating, represent around 55% of global wood harvest and 9% of primary energy sources. However, about 50% of the wood fuel harvest is unsustainable [2]. The effects of utilizing solid fuels on a regular basis may have major consequences for its users. i.e. cooking in a home over a three-stone fire is comparable to smoking 400 cigarettes in an hour, releasing hazardous smoke and pollutants that mostly damage women and children [3].

The overdependence on solid fuels as the primary source of cooking fuel has led to global climate change, and environmental pollution, thus leading to human health problems [4]. The continued use of solid fuels cause long-term health concerns, particularly among the household's women and children. In addition to major contributions to climate change, environmental pollution, and health, the global depletion of solid fuels has led to the search for alternative sources of energy. Improvement of renewable and sustainable energy sources is the best strategy to meet developing countries energy demands.

According to studies, biogas has surpassed coal as the world's fourth-largest source of energy [5] and has been used to address a variety of current social and environmental issues, including food security, waste management, water protection, soil health restoration, improved air quality, and health, sanitation, and education. As the world's population grows, the health of billions of people depends on properly managing trash in cities and urban regions, particularly food waste and sewage.

Biogas generation, in technical terms, is a natural process that occurs spontaneously in an anaerobic (i.e., oxygen-free) environment. Microorganisms create and trigger this process as part of the organic matter biological cycle, which involves the fermentation or digestion of organic matter to produce various gases and microbial-rich liquid fertilizers.

Bioenergy power generation may originate from a number of feedstocks and employ a variety of thermochemical methods. These range from well-established commercial types with a long track record and a diverse selection of vendors to a less well-established and novel technology. The latter includes methods like atmospheric biomass gasification and pyrolysis, which are still in the early stages of research but are already being tested on a commercial scale. Direct combustion in stoker boilers; low-percentage co-firing; anaerobic digestion; municipal solid waste incineration; landfill gas; and combined heat and power are examples of mature technology.

Composting and digesting are two common ways of processing biodegradable materials, such as organic wastes. Many people believe these are two separate procedures, however, they are both degradation processes carried out by living organisms that change the materials through chemical reactions. There are inputs, outputs, and by-products in every process. The materials being treated (feedstocks) are the inputs, which include sludges, manures, food scraps, and so on. The outputs are those products with real or potential revenue value (compost, energy captured from composting piles or derived from biogas, and some digests). The by-products are process outputs with real or perceived negative value (gases/odours, leachate, and some digests).

Biodigesters are systems that maximize the generation of biogas from agricultural wastes, manure, or industrial effluents, resulting in clean, low-cost energy from a sustainable source. The use of this technology is not new, but over the last few years, it has gained interest due to the current energy crisis resulting from the exhaustion of fossil fuels. In addition, the use of biogas helps reduce emissions of greenhouse gases such as methane (CH_4), whose potential for global warming is 23 times higher than carbon dioxide (CO_2) [6].

Biogas is utilized as a car fuel in nations such as Germany and France. However, in countries like Costa Rica, Argentina, and other developing countries, the use of biogas has been limited to those locations where it is produced, where it may be used directly for combustion for cooking or lighting, or indirectly, to drive internal combustion engines that generate engine or electrical power [7,8].

2. Family size biodigester

To measure a biodigester gas production oriented towards waste treatment, it is necessary to know the characteristics of the waste, mainly its physical composition (moisture, consistency, hardness), chemical composition (nutrients, organic matter, undesirable compounds for the bio digestion process, etc.) and the amount generated, preferably per day.

As mentioned in previous sections, the biodigester volume and operational volume can be sized through the hydraulic retention time HRT (average time interval over which the substrate is kept inside the digester) or through the loading rate. i.e., for the “Pampeana” region, located in middle Argentina, the ideal residence time is 40/35 days (minimum 30). The HRT is determined by the average working temperature in the region, the highest the temperatures, the highest the efficiency in organic decomposition, and the lowest the needed HRT.

Another option for sizing a biodigester is according to the amount of biofertilizer that a family farmer may need, although this one is the least required for small-scale digesters, instead of being an objective is a consequence for small biodigesters.

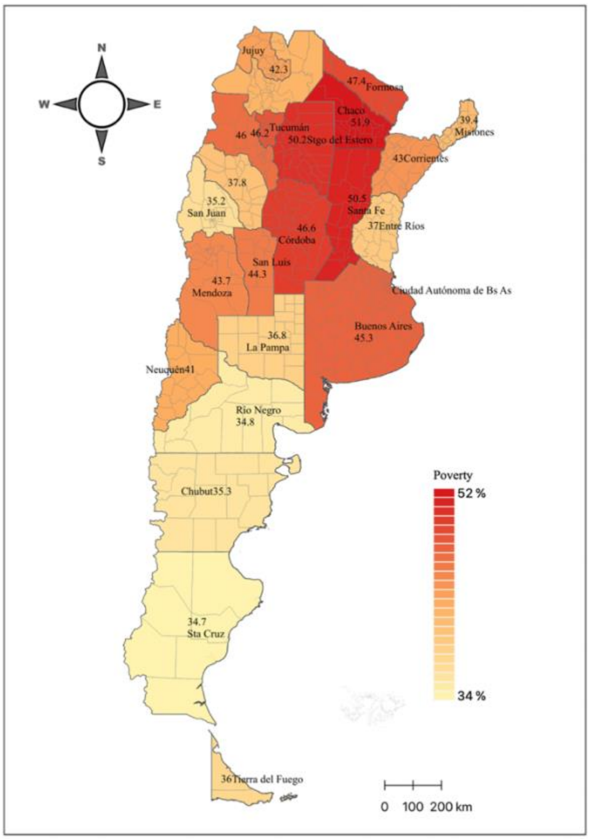

Figure 1.1. Argentine poverty index by province in QGIS.

In this specific case, different assumptions will be made in order to simplify the calculations and finally obtain the estimated daily gas production.

On the first hand, the feedstock available is characterized considering its chemical composition as the percentage of carbohydrates, lipids, and proteins per one kilo of matter, then the %TS and %VS are obtained through a simple calculation that will not be covered in this thesis.

3. Methodology

To correctly study and illustrate why this work is based on the northern Argentinian region, more specifically in northeast Santiago del Estero province and the northwest part of Chaco province, it is essential to combine quantitative and qualitative data as it improves the validity and reliability of the results.

The methodology is developed first through the spatial analysis, where a macro analysis is done, with the objective of making the first filter and focusing on a more specific region, and then moving to a microanalysis and characterizing in more detail the area of interest that could also be the starting point to implement the biodigester proposal presented in this work in regions with similar characteristics and thus ensure similar results.

Throughout the macroanalysis section, indicators such as the poverty index, urban density distribution, and the existence of basic public services of interest to the work (i.e., the scope of the national natural gas network) will be addressed.

On the other hand, in the microanalysis, more specific aspects of the target region will be addressed, such as the climatic specifications that will allow for determining the average working temperature of the digesters, the size of the families that will be the target public, and the identification of the main activities that are developed in order to determine the available feedstock per agglomerate.

3.1. Spatial analysis

An explanation and illustration of why this work is based on the northern Argentinian region, more specifically in northeast Santiago del Estero province and the northwest part of Chaco province is carried on through the implementation of a macro analysis with the objective of making the first filter and focus on a more specific region, and then move to a microanalysis and characterize in more detail the area of interest that could also be the starting point to implement the biodigester proposal presented in this work in regions with similar characteristics and thus ensure similar results.

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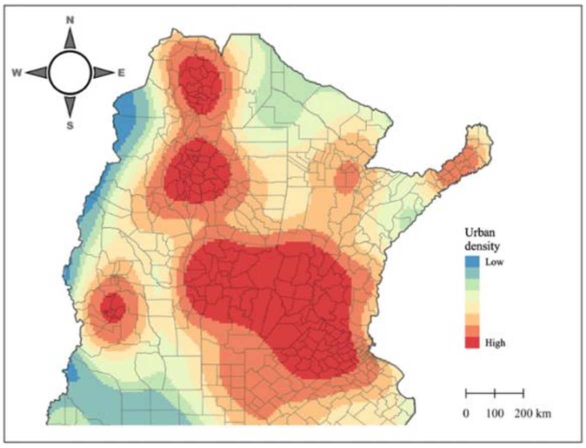

Figure 1.2. Urban density distribution in QGIS.

After introducing the selected region, an investigation of the organic matter produced by people in the already mentioned areas will be done in order to identify the main inputs available for the biodigester, such as the characterization of waste and the amount produced.

3.1.1. Macro-level analysis

Using a free and open-source geographic information system QGIS 3.22 [9] a visualization of all the information that is presented in table format in a resumed and presented in an easier way for analyzing the current situation of the country.

Findings on the situation of the country through the analysis of data synthesized in QGIS and visualized in the form of geographic layers, allowed to obtain a clear estimate of the distribution of poverty (Figure 1.1.), population density (Figure 1.2.), and the lack of existence of basic resources (gas network), obtaining as a result that the most affected region, or less attended with respect to these issues, is located in the north-central part of the country, more precisely in the provinces of Santiago del Estero and Chaco.

3.1.2. Micro-level analysis

Following the information obtained previously, further investigation of the identified region is done, with the objective of obtaining the necessary data that is used in later sections to predict the maximum gas production that is possible to obtain in that region.

For this purpose, a climate-temperature analysis carried out to predict the average maximum and minimum temperatures, corresponding to the winter (Figure 1.3.) and summer (Figure 1.4.) seasons, using the QGIS program and illustrating the information obtained from state entities that date from daily historical records of temperature for 32 measurement points of the national meteorological service (SME) [10], which are spatially distributed throughout the Argentinian territory and date from information corresponding to the last twenty years finally obtaining average temperature maps for both stations that allow to assume with greater accuracy than the working temperature range will be within mesophilic conditions. Also, a target size definition and the daily family gas cooking gas consumption is introduced according to the INDEC (national institute of statistics and census) [11] and stablished as a four members family and a daily total need of 0,6-1,2 $\frac{m^3 gas}{day}$.

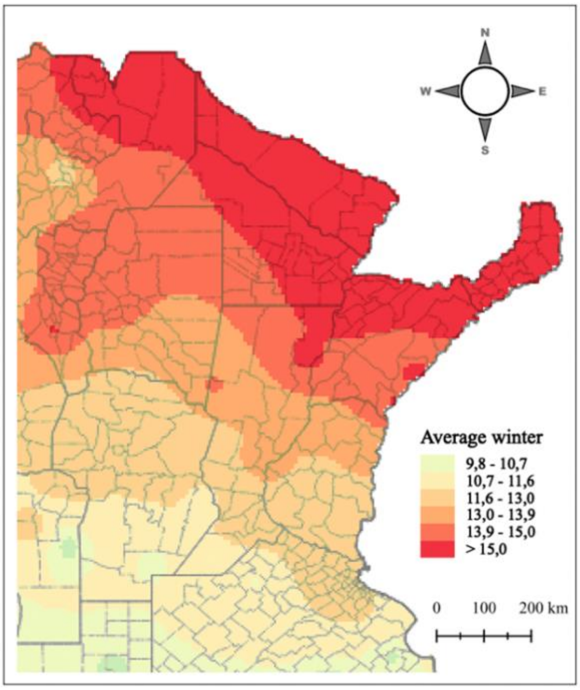

Figure 1.3. Winter average temperature in QGIS.

Specifications and feedstock availability study are carried out by identifying the main activities in the already mentioned areas, based on information regarding the main productive activities in each region, obtained from the Ministry of Economy of the Argentine nation [12] obtaining that most of the activities in both provinces are the same, therefore, the feedstock availability identified is assumed as the same, both in terms of kind and quantity as can be seen in Table 1.1.

3.1.3. Biomass characterization

Following the previous analysis regarding the main activities and the existing feedstock and considering that the amount of material (feedstock) that can be digested will depend mainly on two variables: the total solid content and the volatile solid content of the material added to the digester, the %TS and %VS for each existing feedstock is investigated and shown in Table 1.1.

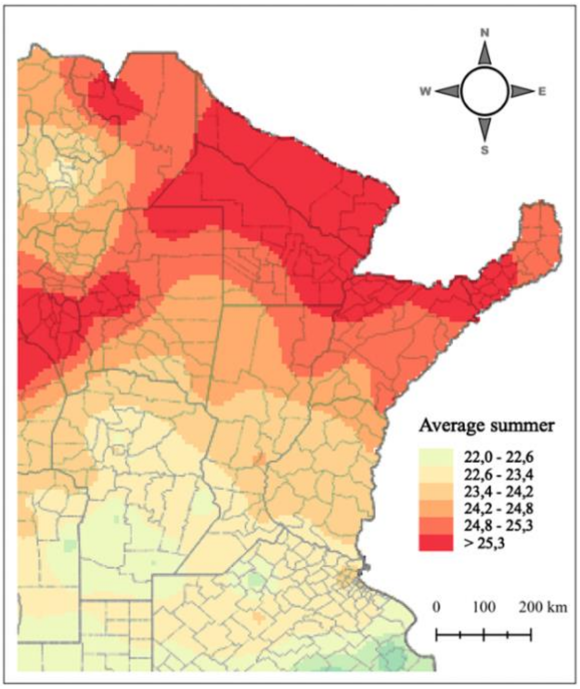

Figure 1.4. Summer average temperature in QGIS.

Table 1.1. Santiago del Estero and Chaco main substrates characteristics [13–17].

Substrate	% TS	% VS	Biogas yield m^3CH_4/Kg VS
Cattle manure	40%	32%	0,42
Caprine manure	80%	64%	0,37
Soy	85%	77%	0,3
Corn	30%	27%	0,35
Sorghum	80%	72%	0,35-0,4
Dog manure	80%	36%	0,15
Food waste households	25%	23%	0,32
Pig manure	35%	30%	0,50
Fry fat/oil	90%	88%	0,70
Horse manure	30%	24%	0,17

3.2. Design considerations

The biodigester volume and operational volume can be sized through the hydraulic retention time HRT (average time interval over which the substrate is kept inside the digester) or through the loading rate. The HRT is determined by the average working temperature in the region, the highest the temperatures, the highest the efficiency in organic decomposition, and the lowest the needed HRT.

In this specific case, different assumptions are done in order to simplify the calculations and finally obtain the estimated daily gas production, such as:

- Digester volume will be stablished as 400L and useful volume (95%) – 380L since gas will be stored in an external storage.
- Max %TS equals to 15% in digestion is known and constant.

- Daily charging volume is known and estimated as Volume/HRT.

- Daily availability for each feedstock from each region is known and constant along the year.

- Max amount of VS [KgVS/m3digester] depending on digester efficiency is known and constant.

- HRT (hydraulic retention time) is known and constant.

- Water density is assumed as 1:1, C/N ratio will not be considered into the equations and PH range is assumed in between 6,5 and 8.

- Working temperature is known and in the mesophilic range.

3.2.1. Sizing and calculation using linear programming.

The solution was approached by settling as the main objective of the model the maximization of the gas produced per day. The objective function objective is to maximize the daily gas production and is defined as the sum and product of the optimal amount of feedstock to be selected ($\boldsymbol{F_i}$), the %VS for each of these feedstocks, and their respective gas yield (ε_i), as can be seen in (eq.1)

$$Max \sum_{i=1}^{n} F_i \cdot \%VS_i \cdot \varepsilon_i \quad (eq.1)$$

Restrictions and conditions are established for calculating the optimal performance of the digester, such as not exceeding the maximum allowable OLR (organic loading rate) and that M3 (input mixture, feedstock plus water) does not necessarily need to be equal to IDCV (Ideal daily charging volume), meaning that it might be possible that the total amount of content in the digester could be lower than the RDV (real digester volume).

More restrictive equations were considered according to technical and theoretical limitations presented in the model. Limitations like the maximum theoretical amount of VS (eq. 2) and TS (eq. 3) that can be introduced in a digester in order to maintain a good microbial activity were considered in the model, together with limitations over the selected feedstock that cannot exceed the available feedstock in each region (eq. 4) and the restriction or condition over the real daily charging volume (M3) that cannot exceed the ideal charging volume (eq. 5).

$$\frac{\sum_{i=1}^{n} F_i \cdot \%VS_i}{RDV\ m^3} \leq 2{,}5\ \frac{KgVS}{m^3} \quad (eq.2)$$

$$\sum_{i=1}^{n} F_i \cdot \%TS_i \ \leq \ M3 \cdot 15\% \quad (eq.3)$$

$$F_i \ \leq \ A_i \quad (eq.4)$$

$$M3 \leq IDCV = \frac{RDV}{HRT} \quad (eq.5)$$

Balance and continuity equations are also considered for masses balance M1 (daily total summary of F_i), M2 (daily amount of water), and M3 as can be seen in Figure 1.5.

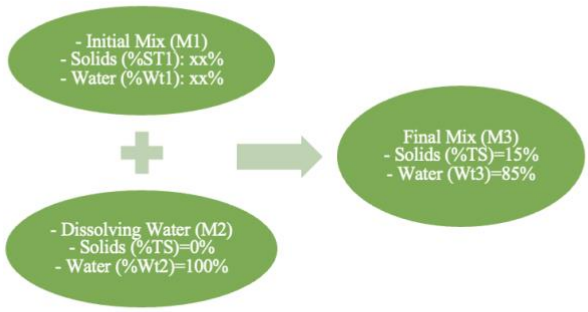

Figure 1.5. Mixture composition diagram.

4. Results

A first approach shows that the daily maximum amount of gas that can be obtained under these conditions is equal to $0{,}58 \frac{m^3}{day}$ and the optimal combination of feedstock between the available listed amounts are pig manure 1,38Kg and fry fat/oil 0,6Kg as can be seen in Figure 1.6. From here, can be noted that the results do not satisfy the basic daily gas demand of a typical family of four people, which was previously estimated at 0,6-1,2 $\frac{m^3}{day}$.

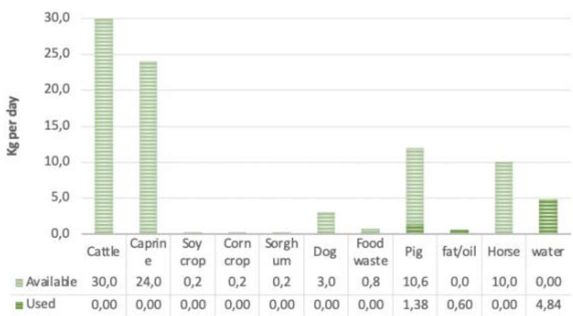

Figure 1.6. Feedstock optimal combination for a 400L digester.

With the purpose of detecting which were the parameters within the model that made it not possible to achieve the minimum daily gas objective for cooking a sensitivity analysis is done, finding that the main parameters affecting the model are the admitted OLR, that is directly dependent of the digester volume (eq.2), and the available amount of fry fat/oil available per family group. From the analysis, can be deduced that since the temperature and the allowed %TS in M3 are fixed parameters the only two ways of obtaining different results is by either increasing the digester volume or increasing the efficiency of the digester in order to increase the OLR and admit more feedstock per daily charge. Therefore, the solution is executed for different OLR rates maintaining the digester volume constant and equal to 400lt, and thus be able to evaluate the possible impact of implementing improvements in the digester design to increase the efficiency and consequently, the amount of volatile matter that can be digested per day, obtaining that the needed OLR for achieving the goal of $0,6\frac{m^3}{day}$ is around 2,6-$2,7\frac{KgVS}{m^3 digester}$.

It has been demonstrated in different experimental works that the simple fact of adding a mixer that allows mixing the contents inside the digester chamber, at least, before and after the daily charge, could have a significant effect on the effectiveness of the microbial activity in charge of digesting the VS content in the mixture [18].

It is not possible to calculate precisely the impact that would have on the implementation of a mixer over this specific and theoretical case, but approximations on the production level of the model can be established after considering different experimental results. Gas production efficiency assessments over digesters are usually done for both identical systems under identical working conditions, therefore, the same digester volume, the same amount of feedstock, the same amount of VS in digestion, etc. Under those working conditions it was proved that digester efficiency could improve by a 7,56%, meaning that if the originally OLR of 2,5 $\frac{KgVS}{m^3 digester}$ is maintained, the daily gas production could raise from 583 $\frac{Lt}{day}$ to 627 $\frac{Lt}{day}$ [19].

4.1. Model design

Since the current work is focused on the feasibility analysis and implementation of small-scale digesters in regions that meet the conditions listed in previous sections, there will not be an extensive detail on the design of the digester together with all its parts, but instead, a preliminary design is made. The design showed in Figure 1.7. intends to be a low-cost and easy-to-use model, that could be located inside homes and function as a modular kitchen. Such a design can be easily covered by a low-cost structure made of phenolic material leaving openings for the entry and exit of material into the system.

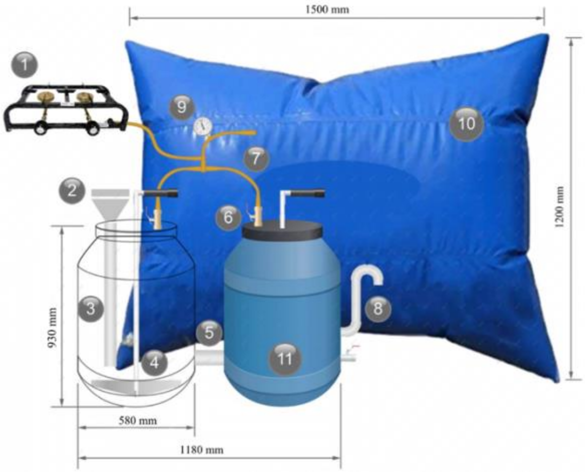

Figure 1.7. Model design scheme.

The list shown in Table 1.2. was made with regional and/or existing materials in Argentina in order to obtain an approximate cost of the materials required to assemble the equipment without considering installation costs.

Table 1.2. List of materials for model design implementation

Item	U$S Cost	
Removable inlet funnel	USD	-
PVC 90 degrees elbow	USD	8,67
Barrel 200lt	USD	250,00
PVC tubing	USD	9,17
PVC liquid valve	USD	15,83
Metal gas valve	USD	11,67
Manguera para gas	USD	1,86
Manguera para gas	USD	2,54
Balloon gas colecter	USD	50,00
Manometer	USD	8,33
PVC adhesive welding	USD	3,33
Stove	USD	66,67
Sealing silicone	USD	10,67
PVC tube cap	USD	2,50
SubTotal #1	USD	441,23
Manual mixer system:		
Polypropylene outer tube	USD	5,00
Roller thrust bearing	USD	2,50
Epoxy 90 degrees elbow	USD	3,50
Galvanized inner pipe	USD	6,50
Epoxy "T" union	USD	2,08
SubToal#2	USD	19,58
Total	USD	460,82

5. Discussion

5.1. Development considerations

Since the estimated minimum cost of implementing a digester system, such as the one proposed in the current work, is far beyond the purchasing power of low-income families in northern Argentina, it is necessary to count on the assistance and support of governmental agencies or non-profit organizations that could develop and accompany a progressive and comprehensive process of both capital and educational investment in these regions.

This work was made, from the beginning, with the main purpose of solving problems and basic needs of low-income communities in rural areas and in developing countries, where basic recourses like gas/energy are not provided by the government. Therefore, this work does not seek to monetize or generate profit from gas production using biodigesters, on the contrary, it seeks to provide a basic service to people in need and to solve health and environmental issues.

However, the Argentinian government is currently subsidizing gas bottles throughout the whole country area, under the "Hogares" program in a percentage corresponding to 80%, therefore, the implementation of biodigesters could not only help the family economy avoid the dependence on having to buy three bottles per month but also, in the long term, would benefit the Argentine state [20].

5.2. Energetic and economic analysis

Considering that a regular family of four people is demanding between 600-1200L of gas per day, for the current economic analysis, the lower end of the demand range is considered, since the purpose of this work is to provide basic cooking gas daily needs.

Different sources show that currently, four people families in northern Argentina are currently regularly consuming one liquified petroleum gas bottle (LNG) every 10 days, that means, a total of three bottles per month [21].

In terms of the cost of bottled gas in the regions covered by this study, it is subsidized by the state, as it was mentioned before, by an 80% under the "Hogares" program, and the cost for the people of the area is much lower than the regular cost of a home in any other place. It is estimated that the cost of a subsidized cylinder of gas in the region covered by the project is approximately AR$496 (U$S4,13) per cylinder of 10Kg or 13L.

Taking 600L/day as a reference value for biogas production, considering the ideal operation of the digester equipment, it is possible to cover in a the minimum daily gas demand which is equivalent to 150 L/day per person.

Note that the value used to estimate the daily demand was the minimum within the daily range of consumption that goes from 150L/day to 300L/day per person. If both ranges are considered, the daily demand coverage range is between 100% and 50% for each household.

These values support the importance of deepening efforts in the use of easy-to-implement alternative energies such as small-scale anaerobic digesters, in the energy efficiency of this equipment, and in discussing what plan should be carried out to cover this existing problem in low-income communities of northern Argentina.

The cost of materials for the construction of the biodigester, excluding labor, was estimated using regional products, giving a total of AR$54998 (U$S469). Estimating the durability of the biodigester of 10 years, its annual amortization could be calculated considering as a reference the equivalent cost of LNG currently consumed by the families, giving a total of 5499AR$/year (U$S46,9), equivalent to 458AR$/month (U$S3,9) and 15AR$/day (U$S0,13). The 600L/day, of biogas produced is equivalent to a cost in the cylinder of 49AR$/day (U$S0,42), considering that a regular family of four people in northern Argentina is using three LNG bottles per month and each of them cost AR$496 (U$S4,23).

Considering that the average monthly household income for low-income families is AR$37.830 (U$S322) [11], the current analysis indicates that the implementation of a project that allows the development of technology as simple as a biodigester could have an impact of 4% on the monthly economy of the families, without mentioning that in most cases it is necessary for people, in order to get one bottle, to get up early, make long trips and stand in long lines outside the gas distributors.

From the government point of view, considering that actually is subsiding the real LNG bottle price of AR$2480 by an 80%, therefore, paying a total of AR$1948 for each bottle for a total of 2,84 million homes [20] that are using on average three gas bottles per month, the impact would be direct in its energy matrix expenses, saving a monthly total equivalent to AR$16903,68 millions (U$S132,17 millions) if ideally all families that are actually using LNG bottles could be provided with biodigester equipment.

Hypothetically speaking, and considering the digester regional materials cost, the amount of houses under the poverty level and the monthly amount of money that the government is currently spending on gas bottles subsidizing, the government "payback" or "stop loss" period after investing the necessary amount of money to provide each of these families with a digestive equipment, would be no more than ten months as can be seen in Table 1.3.

When talking about cost, the digester system is a very strong and recommended alternative to the actual situation in the area. The main reason why this technology has not been developed in the area are the initial investment required to purchase the equipment, the logistics, the assembly, the instruction and training of the users, and the set-up of the equipment.

Table 1.3 Government initial investment and monthly savings.

Month	Investment	Savings	Difference
0	$ 1.308.728.800	$ -	$ (1.308.728.800)
1		$ 132.838.350	$ (1.175.890.450)
2		$ 132.838.350	$ (1.043.052.101)
3		$ 132.838.350	$ (910.213.751)
4		$ 132.838.350	$ (777.375.401)
5		$ 132.838.350	$ (644.537.051)
6		$ 132.838.350	$ (511.698.702)
7		$ 132.838.350	$ (378.860.352)
8		$ 132.838.350	$ (246.022.002)
9		$ 132.838.350	$ (113.183.653)
10		$ 132.838.350	$ 19.654.697
11		$ 132.838.350	$ 152.493.047
12		$ 132.838.350	$ 285.331.396
13		$ 132.838.350	$ 418.169.746
14		$ 132.838.350	$ 551.008.096
15		$ 132.838.350	$ 683.846.446

5.3. Social and environmental analysis

From the environmental point of view, i.e. the circular economy that is achieved from waste recovery to fertilizer production, it is convenient to implement an anaerobic digestion system, since the process has as its main objective the production of biogas (which will be transformed into caloric energy) and its by-product, secondary objective, can be used as fertilizer, thinking of the biodigester as an integrated technology in a system that is diversified in its production.

Particularly in the region studied in the present work, kitchen, vegetable garden, and farm wastes do not present a relevant problem, due to their low volume and distribution in the space they have. However, the existence of technologies that allow obtaining a valuable resource from something that is to give proper disposal to them, in order to avoid certain negative impacts that can cause bad management. In this case, the biodigester is a treatment alternative.

Socially, one of the main advantages of implementing new technologies in regions where there is great need is the education that can be provided to the people and the possibility of being self-sufficient and producing a valuable resource from waste that used to be discarded.

6. Conclusion

This thesis presents an effective implementation model of family-size small biogas digesters in low-income rural areas in northern Argentina.

Although in general, for regions such as the specified in the current work, technologies like the floating-drum, fixed-dome and inflatable-balloon, are developed, in this work, a different design suitable for a is proposed

Overall, the results of the several stages in this work resulted in a general portrayal of the biodigester potential to produce the minimal basic cooking needs for families in northern Argentina by using daily disposal from their activities, domestic animals, crops, and to generate, at the same time, some environmental, energetic and economic impact over the different actors involved.

The digestive system proposed for families living in low-income rural areas is simple and substantially for domestic uses and can even be installed inside homes. The maximum amount of biogas that can be daily obtained by following all instructions provided in the current work, satisfies the minimum cooking gas needs of one family.

The social, energetic and economic analysis shows that the impact of developing a sustainable project that would allow families to migrate from the subsidized liquified natural gas is positive and worthwhile in every mentioned aspect.

6.1. Future work

For future work, it would be interesting to develop real trials of the proposed model, following the instructions provided in the current work, to obtain real information and evaluate the possibility to design a more complex, more efficient, and easy to use the equipment by, for example, adding solar heating and a pH regulator, that would allow obtaining greater amounts of gas per day by lowering the HRT and increasing the daily load amount and therefore, the OLR. In terms of humanitarian matters, the development of an elaborated, extensive and exhaustive project, that would help people in need to be auto sufficient in energy matters, and a support program to accompany and train people in the use of this type of energy and the potential that it has could be explored. Finally, based on the positive impact that developing a solution like this may have not only on the user's life and economy but also on the government's economy, a deeper financial and economic study based on a long-term investment would be interesting to perform to know how much money could be saved over a ten-year period if an idea such as the one proposed here were implemented.

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