Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Ambiental

Tesis

Energy Reuse of Cattle Manure from Anaerobic Digestion in the Town of El Mantaro

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Para optar el Título Profesional de
Ingeniero Ambiental

Huancayo, 2024

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Energy reuse of cattle manure from anaerobic digestion in the town of El Mantaro

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Abstract. This work will analyze the possible amount of energy produced from the biogas obtained by anaerobic digestion in the district of El Mantaro, in order to promote the use of biodigesters in this area and its surroundings, using a geopressing software such as ARCGIS to be able to properly locate the study area and the respective stables, In addition to the use of various mathematical formulas to obtain the amount of biogas and energy, our results gave us a total production of electrical energy of 2.4245 Kw.h that although it is true is something minimal, but serves as a starting point to promote the use of this renewable energy in areas surrounding it. It is suggested that the research be applied in the various livestock areas of the province of Jauja in order to provide an energy management plan of this type and contribute to adaptation to climate change.

Key words: electric energy, biogas, biodigester, renewable energies, anaerobic digestion.

1. Introduction

Currently a great advance is being generated regarding the design and development of alternative energies, this has become one of the priorities for those countries that are in the process of development, because it provides a better use of natural resources, in this way a decrease in costs is generated with respect to the handling of fuels that are derived from petroleum(1).

In recent years it has been noticed that the renewable energy sector has been increasing in Peru, which will clearly allow our country to be better prepared in the future for natural events such as climate change. One of the renewable energy generating sources is biomass, an energy that has many benefits.
Agricultural and animal waste could play an essential role in energy supply in the future, mainly through thermochemical, physicochemical, biochemical transformations and conventional combustion. In this sense, biogas, biodiesel and bioethanol are some of the

candidate alternative fuels from biochemical transformations that receive great attention due to their inherent potential.(2).
In this context, anaerobic digestion systems would be seen as one of the main systems for obtaining biogas and energy. These are based on biological metallogenesis, which consists of the natural degradation carried out by microorganisms in various environments such as the intestines of animals. and landfills.
These systems are applied to biowaste streams, including animal manure, municipal solid waste, grease sludge, spoiled animal feed, and other organic by-products, to generate biogas and other products such as compost and animal bedding.(3).
Biogas is considered a fuel, with a density of 1,133 kg/m3 and medium energy content (~22MJ/m3 of biogas). This implies an approximate performance of 6.35 kWh of electrical current per cubic meter. This gas is composed of approximately 40-70% methane (CH_4) and 30-60% carbon dioxide, as well as other trace pollutants as shown in (table 1). It is generated from biodegradation reactions of organic matter naturally (in swamps, ruminant stomachs, among others.) or artificially in systems called biodigesters CH_4(4). Biodigesters are systems that were designed to optimize biogas production based on agricultural waste, manure, industrial effluents, among others.(5).

Table 1: chemical composition of biogas.

Component	Formula	Percentage
Methane	CH_4	40-70%
Carbon dioxide	CO_2	30-60%
Hydrogen	H_2	0,1
Nitrogen	N_2	0,5
Carbon monoxide	CO	0,1
Oxygen	O_2	0,1
Hydrogen sulfide	H_2S	0,1

To obtain the biogas, an anaerobic digestion will be carried out, which consists of the biological degradation or oxidation of the organic material, in which specific microorganisms come to intervene due to the absence of air. Throughout this process, the material degrades and is transformed into two usable products, biol and biogas. After the process, both products have energetic qualities.(6).
The main objective of the research is to determine the amount of electrical energy that could be produced from the implementation of biodigesters in the El Mantaro area using programs such as ARCGIS software and the Senamhi website, in addition to requiring the respective mathematical calculations.

2. Methods and Materials

2.1 Description of the study area

For the selection of the study área, the evaluation of the various districts of the province of Jauja, since this has a large percentage of livestock activity, one of the districts that stands out in this area is El Mantaro, which corresponds to the province of Jauja and department of Junín, which is located at an estimated altitude of 3320 meters above sea level.
In the first place, the location of this was carried out with the help of the ARCGIS geoprocessing system in order to know the types of areas that it has to later carry out

field visits and take the UTM coordinates of the stables with which it is located. account this district, see (Figure 1 and 2).

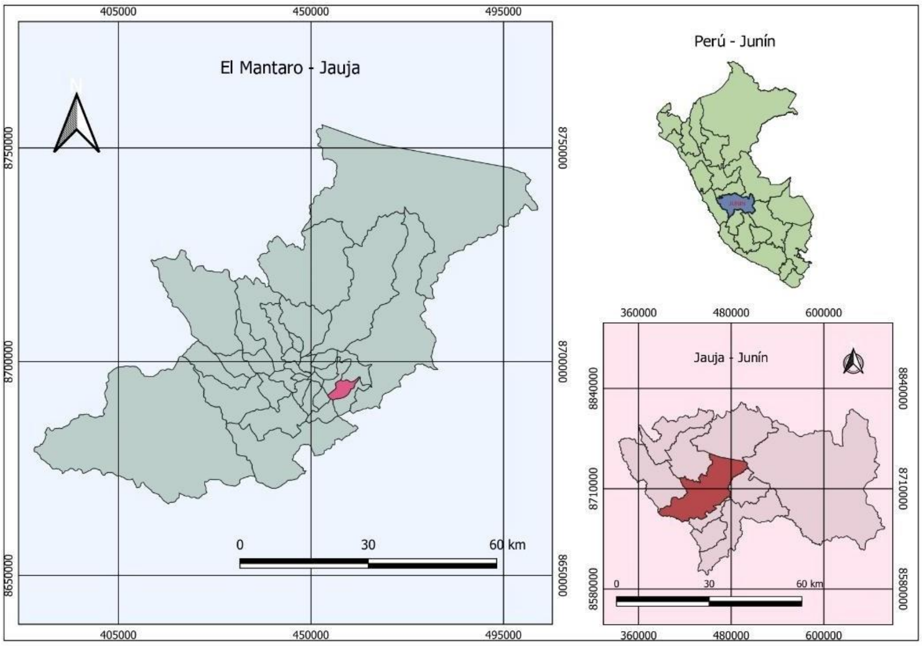

Figure 1. Location map of the areas of the district El Mantaro

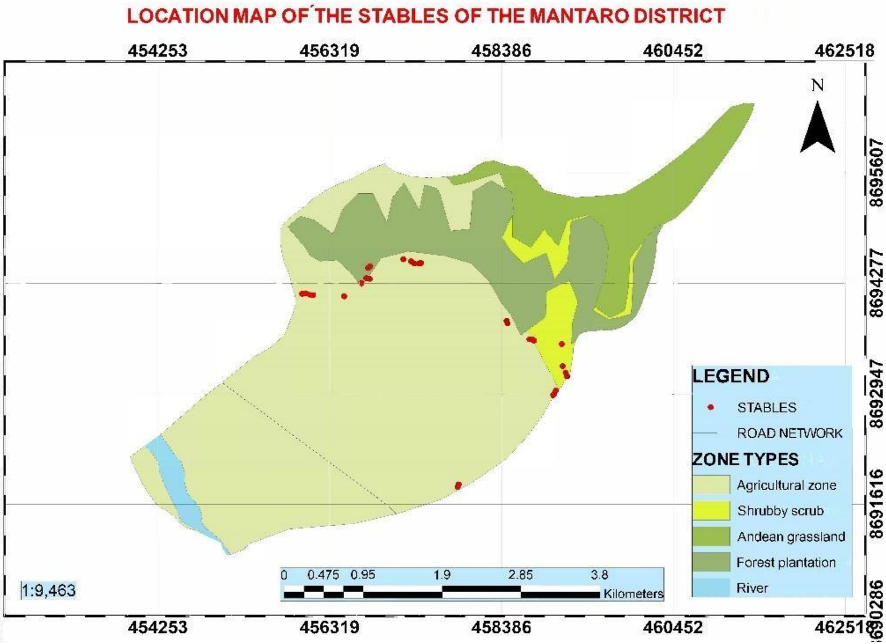

Figure 2. Map of Location of stables of the district El Mantaro

After processing the data in the ARCGIS system, 30 points were obtained, which correspond to the number of stables/ranches that exist in El Mantaro.

2.2 Weather conditions

According to the Senamhi(National Service of Meteorology and Hydrology of Peru),it could be noted that the town of El Mantarodoes not have a weather station that provides us with data corresponding to the minimum and maximum temperature of said locality, however, the data corresponding to a conventional station named INGENIO, which is closer to our study area, was used.

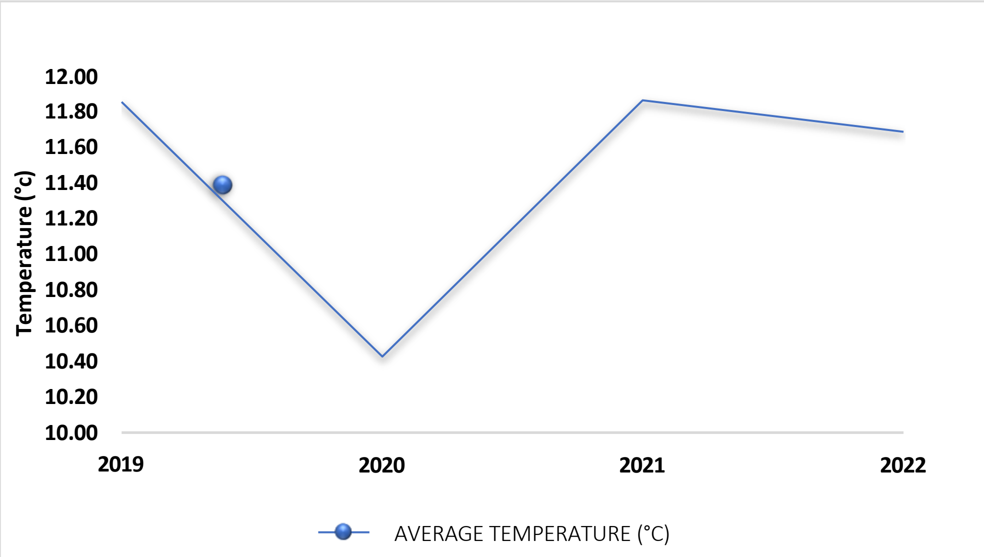

Figure 3. Average temperature per year

Once the data was obtained, the average of the maximum and minimum temperature corresponding to 4 years from 2019 to 2022 was verified as shown in (figure 3), resulting in the total average of these years is 11.46 °C.

2.3 Mathematical calculations

Subsequently, the following formulas were taken into account for mathematical calculations in order to obtain the volume of biogas and the amount of energy obtained from it.

$$ET = EpV \times Vr \ (6)$$

Where:

ET= Total amount of manure generated in one day
EpV= Average amount of manure generated per day.
Vr= Number of cattle available.

$$Vef = {}^{Et}/_{D} \ (6)$$

Where:

Vef= Available volume of fresh manure
Et= Total amount of manure generated in a day.
D= Manure density.

$Vs = Vef + agua$ (6)

Where:
Vs= Substrate volume.
Vef = available volume of fresh manure.
$Vc = Vs \times \#dia$ (6)

Where:

Vc= Cargo volume every 10 days.
#dia= Numbers of days to load the substrate

3. Results

To obtain the corresponding calculations, the field work was carried out, in which the average number of bovine animals that exist was obtained. It should be taken into account that information was only collected from 20 ranches/stables, see (Table 2).

Table 2. Average number of cattle per ranch/barn

RANCH	# CATTLES	AVERAGE
1	19	
2	15	
3	10	
4	19	
5	11	
6	17	
7	18	
8	16	
9	15	
10	12	15
11	15	
12	21	
13	15	
14	14	
15	14	
16	12	
17	18	
18	15	
19	20	
20	14	

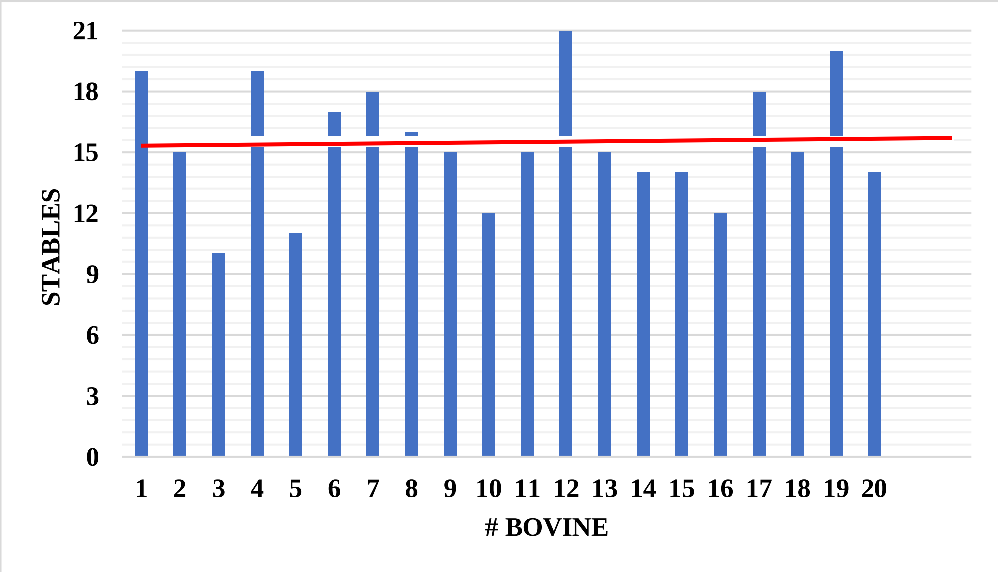

Fig 4. Average cattle per ranch/barn

After the count, it can be determined that the average is 15 cattle per ranch/barn. Subsequently, the calculation of the daily average of manure for 10 days was made, see (Table 3).

Table 3. Average manure per day

DAY	DAILY WEIGHT (Kg)	DAILY WEIGHT (lb)	DAILY AVERAGE (Kg)	DAILY AVERAGE (Lb)
1	19	40.5081		
2	20	41.9083		
3	17.5	38.4215		
4	19.5	39.7851		
5	17	37.8054	18.35	38.64812
6	15.5	30.1989		
7	17.5	38.4837		
8	22	42.1599		
9	18	39.8832		
10	17.5	36.8671		

3.1 Calculation of daily manure generation.

ET =	x	Kg/day
EpV=	18,65	kg/cow/day
#Vr =	15	Cows

$$ET = EpV \times Vr$$

$$ET = 18.35 \frac{\frac{\text{kg}}{\text{v}}}{\text{día}} \times 15 \text{ v}$$

$$ET = 279.75\ Kg/dia$$

3.2 Calculation of the available volume of manure

FEV =	x	L/day
ET =	279.75	Kg/day
D =	1000	Kg/m3

$$VEF = {}^{Et}/_{D}$$

$$VEF = \frac{279.75\ \frac{Kg}{dia}}{1000\ \frac{Kg}{m3}}$$

$$VEF = 0.27975\ m3/dia$$

$$VEF = 279.75\ L/dia$$

3.3 Calculation of the volume of biogas

The data of the amount of total solids produced by 1Kg of fresh manure, the average temperature of the 4 years, the available volume of manure generated in one day VEF and the data corresponding to (table 4) will be taken.

Table 4. Manure biogas ratios

N°	WEIGHT	DESCRIPTION	RELATION	DESCRIPTION
1	1	Fresh Manure (EF)	0.20 kg	Total Solids (ST) (x)
2	1	Total Solids (ST)	0.8 kg	Volatile Solids (SV)
3	1	Total Solids (ST)	0.3 m^3	Biogas @ (35C° and Pr. Atm.)
4	1	Total Solids (ST)	0.25 m^3	Biogas @ (30C° and Pr. Atm.)
5	1	Total Solids (ST)	0.2 m^3	Biogas @ (25C° and Pr. Atm.)
6	1	Total Solids (ST)	0.16 m^3	Biogas @ (22C° and Pr. Atm.)
7	1	Total Solids (ST)	0.10 m^3	Biogas @ (18C° and Pr. Atm.) (x)

Source: Eyner Toala.

$$279.75\frac{Kg}{dia}\times\frac{0.2\ Kg\ S}{1Kg\ ef}\times\frac{0.1\ m^3 Biogas}{1kg\ St} = 25.085\ \frac{m^3 Biogas}{dia}\ x\ 1000\frac{L}{m^3}$$

$$= 5595\frac{L\ biogas}{dia}$$

3.4 Calculation of substrate volume

For the development of the substrate volume, the manure-water ratio was used, which is observed in (Table 5).

Table 5. Manure-water ratio**.**

N°	ORIGIN	RELATION
1	Fresh cattle	1:1 (x)
2	Dried cattle	1:2
3	Porcine	1:2
4	Poultry	1:1
5	Equine	1:2
6	Human waste	1:1
7	Vegetable waste	1:0.5-2

Source: Eyner Toala.

Fresh cattle ratio 1:1

$$Vs = Vef + agua$$
$$Vs = 279.75\frac{L}{dia} + 279.75\frac{L}{dia}$$
$$Vs = 559.5\ L/dia$$

3.5 Calculation of cargo volume

A feeding time of 10 days was considered.

Table 6. Cargo volume calculation.

VC10days = Cargo volume after 10 days	x	Litres
#días= numbers of days to load the substrate	10	days
Fs= Safety factor	5	%
Ft= Total factor	100	%
Vg= Volume of the gaseous part	25	%
Vtd= Total digester volume	and	m3

$$Vc10\ dias = 559.5\frac{L}{dia} \times \#dia$$
$$Vc10\ dias = 559.5\frac{L}{dia} \times \#\ dia$$
$$Vc10\ dias = 559.5\frac{L}{dia} \times 10\ dias$$
$$Vc10\ dias = 5595\ L$$

Digester total volume formula.

$$Vtd = Vc10dias \times (Fs + Vg + Ft)$$
$$Vtd = 5595L \times (5\% + 25\% + 100\%)$$
$$Vtd = 7273.5\ L = 7.2735\ m^3$$

3.6 Calculation of total energy.

18.65 Kg of fresh manure was used, this amount corresponds to the usable manure for the sizing of the biodigester. The data corresponding to (table 4) will also be used and the factor to be used for the conversion is 1m3 of biogas → 6.5 Kw.h energy.

$$18.35kg\ EF\ \times \frac{0.2Kg\ ST}{1Kg\ EF} \times \frac{0.1m^3biogas}{1\ Kg\ st} \times \frac{6.5\ Kw.h}{1\ m^3biogas} = 2{,}4245Kw.h$$

From the calculations made, it was obteined 2,4245 Kw. Hof energy.

4. Discussion and Conclusion

This investigation is of the utmost importance for the various areas that make up the department of Junín and its respective districts, since it is shown that the use of cattle excreta plays an important role in the production of biogas and with it the generation of electrical energy. For this, various calculations were made, the study area was the district of El Mantaro.

For the field phase, we worked with 20 cattle stables and at home one of them an average of 15 cattle per stable in an average time of 10 days. From this it was obtained that an amount of 279.75 kg/day of manure is generated, which generated an available volume of 279.75 L/day, thanks to these data it was possible to proceed to the following calculations, which were the volume of biogas, where A total of 5595 liters of biogas/day was obtained and with this the energy calculation was made, which was 2.4245 Kw.h, thereby demonstrating that the incorporation of biodigesters in this area is feasible. investigations such asCastillo Yoisdiel in the year 2021 show that the construction of biodigesters is of the utmost importance.

For this investigation, it was obtained that from 2 341.44 Nm3/d a total energy of 4 320 KWh/day can be generated with the help of a motor generator, which is a very representative amount that demonstrates its profitability and also a key point for the promotion of the use of this renewable energy(7), this research helps to refute our results since it demonstrates the profitability of the construction of biodigesters.For Jeong, Jin Su and Ramírez, Álvaro in 2017, the use of GIS is of the utmost importance to optimize the location of a biomass facility and the livestock sector to obtain renewable energy, since this allows respect for the environment, Based on this analysis carried out in Spain, they demonstrated the sensitivity that exists in various areas for energy planning decision-making.(8)With this investigation, the importance of the use of GIS for territorial planning and environmental protection is demonstrated, in the same way, in this investigation, work was done with ARCGIS in order to be able to make a good location of the study areas and to know the respective characteristics of the place of study. study.With this we can appreciate the important role that energy production plays through this component and rescue the use of this renewable energy to be able to boost and promote at the level of the entire province of Jauja and in the future of the entire department of Junín since it is one of the departments that practice livestock farming in a large percentage.

5. References

1. **Mago, María G, José L. Sosa, Blanca Flores, Blanca Flores.** Proposal for the *design of a biogas plant for the generation of electrical power in livestock areas of Venezuela through the biodigester program*. 21(2), (2014).

2. **López-dávila, Edelbis, Hernández, Janet Jiménez, Luis, Ernesto, et al**. *Biochemical potential of methane from agricultural waste as an alternative renewable source for the production of electricity in Cuba.* 23(1), (1989).

3. **Bin, Qing, Li, Minhao.** *Anaerobic digestion systems (ADS) for multiple dairy farms: a GIS analysis for optimal site selection.* 61, (2013).
4. **León Torres, Carlos Alberto, Nomberto Rodríguez, Carlos, et al.** *Design and implementation of a pilot plant for the production of Biogas, Biol and Biosol.* 26(3), (2016).
5. **Savran, Valentina, Piñón, M R Díaz, Palacios, J Suárez A.** *Production of biogas and biofertilizers from effluents.25(2), (2012).*
6. **Toala, Edwin.** *Design of a polyethylene biodigester to obtain biogas from cattle manure at the Veronica ranch.* Riobamba : s.n., 2013.
7. **Castillo Yoisdel, Monteagudo José, Borges Reinier and Patiño Carlos.** *Design proposal for an industrial cachaça biodigester for the generation of electricity.* University and Society Journal *13, (2021).*
8. **Jeong, Jin Su and Ramirez, Alvaro.** A *multicriteria GIS-based assessment to optimize biomass facility sites with parallel environment - A case study in Spain.* Energies 10(12), (2017).

Acknowledgments
In these lines we would like to express our gratitude to the people who have given us their support to complete our thesis work.
To God for giving us the strength to complete the research successfully and not to give up at any time.
To my parents for their support, especially to my father for his trust and for accompanying me throughout the process of my academic training.
To my professors, people with wisdom who have tried to help me reach the point where I am now.

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