Determination of Electrical Specification of a Biogas System on A Poultry at Minalin, Pampanga

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Abstract- One of the effective approaches to address the issue of sustainability is to produce electricity using renewable energy. It is established that electrical loads on a poultry farm run 24 hours a day, and an alternate source of energy, such as a biogas system, can help keep the other electrical demands running, add in the fact that poultry farming is a rising industry. This study aims to determine the electrical specification of a biogas system on a poultry farm at Minalin, Pampanga, the equivalent electrical output from the biogas, and to see what if the biogas can power the electrical equipment on the farm.

To determine all the needed specifications and achieve the objectives, the researchers conducted an interview on the farm with one of the managing heads. The responses were analysed together with other references. Using the computations presented on this research the researchers concluded that the needed electrical specifications for the generators, wires, and panel board are two 24 kVA dual fuel generators, for panel board 1, 2-14sq.mm THW+ 1-8.0sq.mm THW(G) for panel board 2, 2-14sq.mm THW+ 1-8.0sq.mm THW(G), 70 AT, 100 AF, 2P, Single Phase. The researchers have also concluded the size of the digester/ gas holder which has a radius of approximately 3.5 meters and a height of 6 meters. Finally, the biogas system's production of 15.25 kWh demonstrates that all of the poultry's electrical equipment, which is listed in the load schedule and totals around 14.5 kWh, can be powered by the biogas system.

I. INTRODUCTION

Electrical energy is produced by the movement of electric charges called electrons (SolarSchool, 2020). It can be converted into a variety of forms, including mechanical, sound, light, and heat. It is one of the most commonly used energy in human life. Electricity on the other hand, is a form of energy generated through electrical energy. The need for electrical energy or electricity will rise in lockstep with the rapid growth of the world's population. The population of the Earth is currently increasing by 60,000 every eight hours, which equates to two children being born globally every second. According to experts, if it keeps expanding at this rate, it will take 50% more energy to support humanity in 2050 (Fisher, 2020). While it is critical that resources offer sufficient energy, it is equally critical to discover alternatives and renewable resources that are sustainable and can be renewed over time. The global energy crisis will deteriorate if it is not handled immediately. One of the most effective approaches to address this issue is to produce electricity using renewable energy and to minimise the use of non-renewable resources in generating electricity.

The fact that non-renewable energy has negative implications on our planet is becoming a significant issue. Non-renewable resources, mostly fossil fuels, are the world's principal source of electricity generation. It is used to power vehicles, factories, commercial buildings, and private residences. The process of burning oil and coal can have negative environmental consequences and be a major contributor to global warming, which contributes to climate change. Figure 1 shows the sources of Greenhouse emission and Generation of electricity takes the largest amount with 25 percent (Foley, 2020).

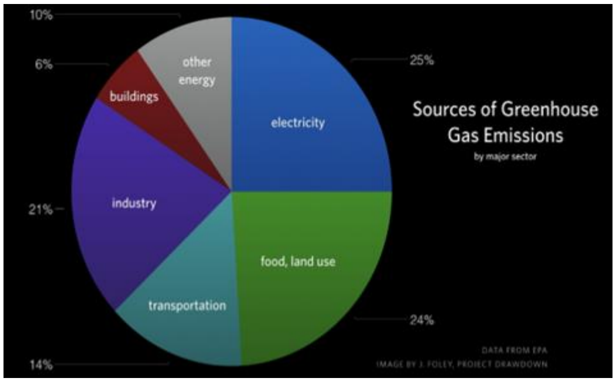

Figure 1: Sources of Greenhouse Emissions (Foley,2020).

The world's energy consumption by source as of 2020 shown in figure 1, shows that oil, coal, and gas are the ones that contribute the most in supplying the inflating power demand due to their reliability and affordability since they are way cheaper than the other energy sources and because of this reason, up to this time, the world is still reliant to these sources of energy regardless of their environmental issues.

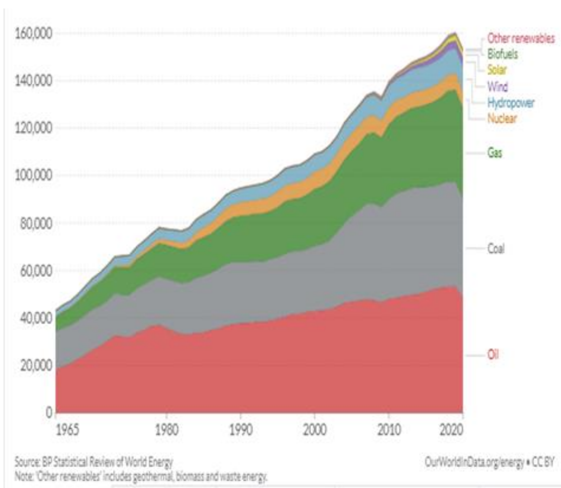

Figure 2: The world's energy consumption by source as of 2020 (Ritchie, Roser and Rosado, 2020).

On the contrary, Non-renewable energy is from resources that are not easily produced and it takes time to be replenished. It will run out due to constant use and dependency, and future generations will suffer as a result of not being able to use it.

The scarcity of non-renewable energy resources will have an impact on its value, making it more expensive and insufficient to meet demand. Philippine's reliance on non-renewable sources of energy such as coal, natural gas and crude oil that are being imported from foreign countries at fluctuating prices has also caused the Philippine electricity rate to fluctuate and relatively one the highest in Asia. Therefore, it is critical to consider the engagement of the world to renewable energy and to explore alternative solutions (World Wide Fund [WWF], 2017).

Renewable energy on the other hand is energy harnessed from natural sources like solar, wind, hydro, geothermal and biogas. It is a clean alternative way of supplying electricity with less environmental impact. Therefore, it is necessary to prioritise and to be acknowledged. Philippine Electricity Market Corporation (PEMC) report stated that Renewable Energy (RE) investments have already saved the Philippines PHP4.04 billion. Philippine Development Plan for 2017 until 2022 includes the goal to increase the share of RE to the national energy mix from 30% up to 50% by 30 while the National Renewable Energy Plan (NREP), which is also led by the government, intends to raise RE sharing 15,304 MW to the national energy mix, tripling its capacity by 2030. But the World-Wide Fund for Nature (WWF-Philippines) expressed that if the government will promote more energy-generating technologies while speeding up the implementation of RE mechanisms, the country can further develop 1200 MW of geothermal, 2308 MW of sustainable hydro, 235 MW of biomass and 7404 MW of wind generation capacity even before 2030. Relying more on RE can cause great impact that will benefit the country such as achieving the 100% electrification of the country by distributing energy systems like micro-grids since the Philippines is archipelagic in nature. Furthermore, it can also result in lower electricity rates while giving support in the world's fight against climate change (WWF, 2017).

Another issue is the exploration of resources that will be used to create enough electricity to meet people's demands or to power various systems in our houses. People's everyday lives rely on electricity, and the resources must be renewed on a regular basis. These resources are actually available and ready to be discovered if the researchers just focus on learning their potential. Human or animal waste is an example of resources with never-ending production. If a specific procedure occurs that utilises the use of these resources, it will benefit both ends; waste disposal and energy production.

Moving forward on the Poultries at Minalin Pampanga, the average chickens a medium sized poultry is at 5000, and multiplying the 1,250 pesos for electricity for a 500-chick farm to ten will give us the electricity monthly expenses for a 5000-chick farm. A total of 12,500 pesos will be needed in providing the electricity on the farm Poultry Manual (2019). Additionally, to maintain animal wellbeing and agricultural performance, a ventilation system is an important consideration in poultry farm facilities. In order to develop the metabolic processes intended by the environment and their organism, such as growth, posture, weight, and gain, the chicken must ingest a large amount of high-quality feed when operating a poultry farm. Ventilation helps reduce heat and humidity from the sheds where the birds are housed, generating comfort and welfare. Chickens do not sweat, excess heat is reduced by breathing, vigorous flapping and panting (Sáenz, 2020). The estimation mentioned does not include other electricity expenses on warehouses, sorting facilities, and offices. This consumption of electricity equates to the farm's expenses. This outlay when combined overtime is a huge amount that should not be ignored.

Introducing the use of biogas, it is a renewable energy that is generated through waste and other organic materials that are decaying. Biogas systems rely on the natural interaction between microorganisms and organic wastes – such as manure, sewage, agricultural by-products, and discarded food – to produce a clean and energy-efficient burnable gas. The gas is distributed through a network of pipes and is used for cooking, heating and generating electricity. Out of all the renewable energy resources that are available, one of the reasons why the researchers chose to focus on biogas is because compared to other renewables, utilisation of biogas does not threaten the safety of wildlife but in order to produce electricity out of biogas, a considerable amount of organic matter like animal manure that will be fed to the reservoir is needed.

In addition to helping poultry with other issues including foul odor and waste management, biogas systems will supply enough energy to use the electricity that is currently used by the animals. If there is a power outage, it might provide the poultry with electricity.

On the other hand, poultries are places that produce a great amount of chicken manure that are not actually being used to their full potential. These chicken manures can be utilised and serve as a feedstock in a biogas system to provide some electricity. It can be converted into biogas that will fuel the Biogas system.

This gives the researchers the reason to come up with the idea of using the chicken manure produced from poultry at Minalin, Pampanga, because it has different violations from illegal dumping of waste and they needed electricity to operate a lot of warehouses for eggs and chickens. It is essential for them to have a biogas system for them to mitigate the harmful effects of it on the environment. This will benefit them and will help them to lessen the odour and electricity bill and to provide another source of income because of the usage of fertiliser. The biogas system is a great solution to produce alternative energy while it gives a lot of benefits.

II. REVIEW OF RELATED LITERATURE

Why do major poultry sectors are getting to engage more in a biogas plant? Another renewable energy that stands out the most is biogas. Biogas recovery is proven and tested and is highly profitable for the poultry sector, widely used in industries like agriculture and wastewater treatment. In agriculture, biogas plant systems are used at hundreds of farms, cattle, hog, and poultry farms. Biogas is generated when microorganisms degrade organic material under anaerobic conditions. It is created when waste or manure decomposes. A biogas plant is a decentralised energy system that can lead to self-sufficiency in heat and power needs, and mitigates environmental pollution. Poultry manure has traditionally been disposed of by spreading it on the land as fertiliser or by sending it to landfill. The creation of biogas from chicken manure can lead to climate change mitigation, economic benefits, and landfill diversion opportunities (REURASIA 2020). As the world's population expands, so do our world's problems, one of which is the lack of electricity. It is not concealed that many countries throughout the world lack energy, and in certain cases, there are even locations where grids do not reach. Figure 2 shows the national electrification of the Philippines in which about 96.8% of the country has access to electricity and that leaves 3.2% of the Philippines population still living in the darkness. REURASIA has introduced a biogas energy solution that will aid in addressing the issue of electricity scarcity. Biogas is a dependable renewable energy source that is used in many parts of the world to produce power and to minimise the amount of electricity used in a certain area. It is also environmentally good because it aids in the reduction of pollutants caused by the poultries.

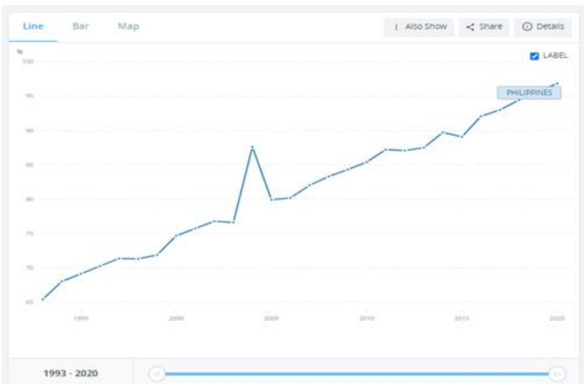

Figure 3: National electrification of the Philippines (The World Bank Group, 2022).

In biogas production, a digester is needed, which is an airtight container where the feedstocks are fermented and where the anaerobic digestion takes place. When it comes to biogas plant construction, it is extremely important to choose the right biogas digester. There are various types of biogas systems with different applications and their scale ranges from small, medium, and large. The main purpose of producing biogas is to produce a renewable energy carrier that can replace fossil fuels. If biogas production is utilised properly, it can significantly contribute to the national energy balance just like in some other countries like China and india. (IRENA, 2016) intended to provide a guide to help countries collect and report their biogas data in an internationally comparable format which includes two ways of calculations for the capacity of a biogas plant which are (1) rated daily gas production and (2) total plant volume with regards to the standard plant types and dimensions. The type and design of the digester to be used depends on the type of feedstock to be digested inside the tank. A study carried out by (M.Samer 2012) showed the different types and designs of anaerobic digesters and also how they are constructed for both commercial and household use. There have been two developed simple designs of biogas anaerobic digester that are widely popular among asian countries, they are (1) Indian-type digester also known as floating drum plant (2) Chinese-type digester also known as fixed dome digester. Both of these digesters have the same digestion process and are intended for use with dung or animal waste. The difference between the two is their method of collecting gas.

In terms of computing the system's capacity, some parameters are needed, such as, the digester's volume (maximum amount of feedstock that can be held inside the digester) and gas storage volume (the amount of gas the system can hold when the digester is maximised with slurry). The amount of material added to the biogas plant serves as its feedstock, thus includes the amount of waste and water which is usually mixed with waste for optimal biogas production. It is important to determine the capacity of the biogas system in order to determine how much biogas the system can yield. In addition, this will also help in determining how much energy can be converted into electricity with the use of a biogas system.

The system has many benefits. Biogas production can contribute to a sustainable development said by the Renewable Energy Directive (the RES Directive) (European Parliament, 2018b). The RES Directive promotes biogas as an option in the transport sector to reduce greenhouse gas emissions in the European Union (European Parliament, 2018b). Anaerobic digestion of organic waste can reduce greenhouse gas emissions as well as water, soil and air pollution, compared to landfilling (European Parliament, 2018a). Furthermore, it was said by the RES Directive that biogas can also contribute towards innovations, jobs and economic growth, as well as reducing reliance on energy imports (European Parliament, 2018b).

Systems analyses of biogas production systems have been performed previously. For instance, According to Börjesson and Mattiasson (2008), biogas has the potential to become one of the most sustainable vehicle fuels after they studied the resource efficiency of biogas as a vehicle fuel, with a focus on energy. Next, Tufvesson et al. (2013) performed a life cycle assessment (LCA) of biogas production from industrial waste for vehicle fuel. It showed reduced GHG emissions from the biogas system compared to fossil fuels. However, the study did not include an economic evaluation. The European Union has launched targets for 2030 of reducing GHG emissions by 40%, relative to 1990 levels, and achieving a proportion of at least 27% renewables in the energy system (European Commission, 2014).

Wu et al. (2016) executed a systems analysis of three different utilisation options for biogas: combined heat and power (CHP), biomethane and fuel cell. Energy, environment, and economy are the three different perspectives used. The results showed that the most preferable option for biogas utilisation depended on the perspective. The environmental perspective included nine different impact categories; however, the results were transformed to a "green degree" and thus, no results were shown for the individual impact categories. Moreover, utilisation of digestate was not included in this study.

Uusitalo et al. (2013) also compared three different utilisation options: raw gas to CHP, biomethane to CHP and biomethane as a vehicle fuel. The electricity produced at the CHP plant was assumed to be used for electric cars. The options with biomethane as a vehicle fuel resulted in the highest amount of output and were the most profitable from an energy perspective. Moreover, the biomethane for vehicle fuel option resulted, together with the biomethane to CHP option, in the largest decrease in GHG emissions.

The most common heat engines used for biogas energy conversion are gas turbines and combustion engines. Combustion engines are popular as they are more efficient and less expensive than small gas turbines. Cogeneration or Combined Heat and Power (CHP) describes the simultaneous generation of both electricity and useful heat (Joshi et al., 2017). The combustion engine is one of the most commonly employed for energy conversion because it can produce heat to produce energy. In a biogas system, combustion is needed to produce mechanical energy that can be converted into electricity and hence biogas is one of the most reliable renewable energies that can be used.

The conversion of biogas to electric power by a generator set is much more practical. In contrast to natural gas, biogas is characterised by a high knock resistance and hence can be used in combustion motors with high compression rates (Joshi et al., 2017). The study on the conversion of biogas into electrical energy is necessary as it will help in preventing the occurrence of an electricity crisis. Although the biogas can be used as a water heating, space room heating, serves as cooking gas in rural areas etc. the main purpose of this study is to generate renewable energy by introducing the utilisation of the biogas system.

An article titled "Biogas Technology: Fuelling the Future of Agricultural Development", written by Queenie P. Peneyra (2018), discusses the development of the biogas system in the Philippines, it was stated that it is not very new to the eyes of some Filipinos. Due to the amount of awareness of the properties being polluted by animal manures and other concerns for the environment the introduction of a biogas system is slowly being accepted, especially in places like livestock producing areas, with both the support from the local government unit and the people.

As reported by DA Communications Group (2018) Poultry production contributes 13% of agriculture's gross value added (GVA), and dressed chicken output in the Philippines increased by 40% from a million metric tons to 1.4 million between 2009 and 2018. Additionally, the poultry industry grew at a 2.5 percent annual pace in the second quarter of 2021. This proves how the poultry industry is growing and shall be considered to be further innovated and optimised.

Dr. Felix D. Maramba, an agricultural engineer at the time honoured by the Araneta University Foundation is a pioneer of biogas technology in the Philippines. In 1965 he established the technology in the country. He is the founder of the Maya Farm Biogas Model, which was first implemented at Maya Farms, a commercial piggery farm 40 kilometres east of Manila, in the early 1970s.

In the early stages because firewood was plentiful, the main interest in biogas was in its ability to minimise pollutants and contribute favourably to public health, rather than in its fuel energy generating potential. Now, biogas is regarded as the most practical renewable energy alternative for rural areas. Biogas can be produced from domestic urban wastes, agricultural and animal wastes, as well as food processing, distillery, and industrial wastes.

The spread of biogas technology and its development in the country is rising but it cannot be denied that it is still lacking especially in areas where the technology is not readily available and where people are not well oriented on its benefits. However, the introduction of this system to the poultry farmers of Minalin Pampanga will be easy because the acceptance of such a system to the Philippines is good and it helps in their disposal of waste (Penayra, 2018).

Poultry farming has been a highly specialised business in the country since 1973. The construction and expansion of chicken breeding farms gave the industry a new dimension. The Philippines' poultry sector has grown rapidly, but issues such as ineffective management and the development of numerous harmful poultry illnesses and parasites must be addressed. This includes poultry raising technologies and management know-how that we believe current and future poultry producers will find valuable in properly managing their poultry farms and in helping them make considerable financial returns from their business during this period of high production costs (Cavite et al., 2014).

To forge ahead, poultry farming in the Philippines remains a relatively safe investment option for many Filipinos and foreigners alike, despite several hurdles. In the Philippines, you can grow poultry using a variety of profitable techniques, ranging from contract poultry farming to independent poultry farming.

A cost estimation of a 500 chick operation poultry farm is at 112,547.5 pesos. The breakdown of this cost estimation includes a monthly operating expense where 5,000 pesos is allotted to labour, electricity, water, rent. Dividing the monthly expense to four will give 1,250 pesos for electricity (Poultry Manual, 2018).

Biogas production systems are more than just a waste management system or the production of a renewable energy carrier. Systems analyses need to be carried out from different perspectives to grasp more of the advantages of biogas production systems. Roadmap said, to a Resource Efficient Europe, “Resource efficiency implies that greater value can be delivered with less input, that resources can be used in a more sustainable way and that the impact on the environment can be minimised, as well as minimising waste.” (European Commission, 2011). According to Ersson (2014) relates the concept of resource efficiency to energy, environmental and economic perspectives.

III. STATEMENT OF THE PROBLEM

Electrical loads within a poultry farm are continuously operating every day, and an alternative source of energy like a biogas system can give support in sustaining the other electrical loads. This study will answer the following questions:

1. How much electrical energy can a biogas system produce using chicken manure as an input?
2. What are the needed electrical specifications of the components in the biogas system?
3. Will the biogas system be able to cover the electricity demand of the poultry?

Any system is composed of different elements where they all work synchronously to perform a specific task. Determining the specifications of the components needed on a biogas system is an integral part of the process in developing and implementing it in a specific area. The electrical equipment needed will be recognized in this study as it progresses. In the agricultural sector, one of its fastest growing segments is poultry. An average person consumes 279 eggs per year (Petreicik, C.2019). In order to meet this demand, poultry farms operate non-stop. One of the focal points of this study as well is reducing the electricity bill of a poultry farm in Minalin, Pampanga with the use of the said system.

IV. OBJECTIVES OF THE STUDY

This study aims to determine all the electrical specifications on the components of a biogas system on a poultry farm at Minalin, Pampanga. The specific objectives of this study are:

1. To identify the equivalent output electrical energy when the chicken manure produced by the poultry is used as a feedstock in a biogas system.
2. To specify type and size of the electrical equipment needed in the process of converting the produced biogas into electricity.
3. To determine the capability of the biogas system to power up and sustain the electrical loads at the poultry farm.

V. SCOPE AND LIMITATION

This study pivots around the equivalent waste material needed for the production of biogas which then is converted as Electrical output for the poultries at Minalin. Details from the poultry will provide researchers the data needed in identifying the determination of electrical specification of a biogas system. This system then is expected to lessen the monthly bill of electricity from the poultry farms at Minalin, Pampanga. A comparison of their current electrical bill to the expected produced electricity from the biogas system will be done in concluding whether the system is helpful or not. Furthermore, the utilisation of a biogas system on a rising industry, like poultry farming will create awareness on other industries.

Due to the time this research was held, the researchers experienced some shortcoming in doing the study itself. The pandemic raises a few limitations on the study. The researchers were not allowed to meet in person and were forced to work remotely. Unavailability of resources, especially books and articles found in a library is not allowed due to the threat from the virus, thus the researchers had to look for materials related to the study on the web, and other existing researchers from their peers. The gathering of data with the use of an interview method has to be done following certain protocols due to the pandemic. In the time of this research being conducted, a bird flu outbreak occurred thus, resulting in a strict health protocol in the gathering stage of the research. The research only explored the determination of electrical specification of a biogas system on a poultry farm at Minalin, Pampanga, and did not investigate other aspects of the implementation of the project.

VI. SIGNIFICANCE OF THE STUDY

Understanding the utilisation of biogas system as an alternative renewable source of energy may lead to following results:

- Increase public understanding of the importance of renewable source of energy
- Appreciation of biowastes
- Encourage the public to move towards sustainable economic development
- More people will invest and utilise renewable source of energy such as biogas

This study is significant to the following:
The community. Biowastes especially when it comes to manures, proper handling and management of these wastes are crucial. Because if not properly handled, it may cause and spread various illnesses and diseases to its surrounding community. This research will give them an idea on how the manures can be useful when utilised while having a safe and secure way of managing these wastes.

The future researchers. This study can also give them a background overview of computations regarding the electrical specification of a biogas system.

The poultry owners. Running a poultry farm is not easy and beside that is a large amount of electricity bills waiting to be paid. This study will help the poultry owners an idea on how they can utilise the chicken manures as an alternative source of energy to power.

VII. CONCEPTUAL FRAMEWORK

The biomass used to produce biogas can be food waste, agricultural products, agro-industrial by-products, animal manure, or wastewater biosolids. Organic waste such as chicken manure can be manoeuvred to produce energy.

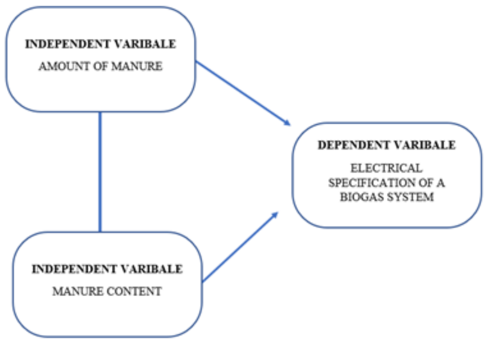

Figure 4: conceptual framework block diagram

As shown in Figure 2, the researchers are considering two independent variables in determining the electrical specification that will be used on the applied biogas system. In order to obtain the researchers' desired output, the gathered data will be used and serve as the given parameters that should be considered in computations of the anaerobic digester capacity and the yield biogas equal amount when converted into electricity. Moreover, in determining the electrical output of the biogas system based on the manure's content and amount, the researchers can simultaneously identify the electrical specification that will be used.

VIII. METHODS

Figure 3 (research design) shows the successive steps in determining the electrical specification of a biogas system on a poultry farm at Minalin, Pampanga. This includes data gathering, establishment of base case analysis, determining the electrical specification which involves all the necessary computations, and lastly the system evaluation.

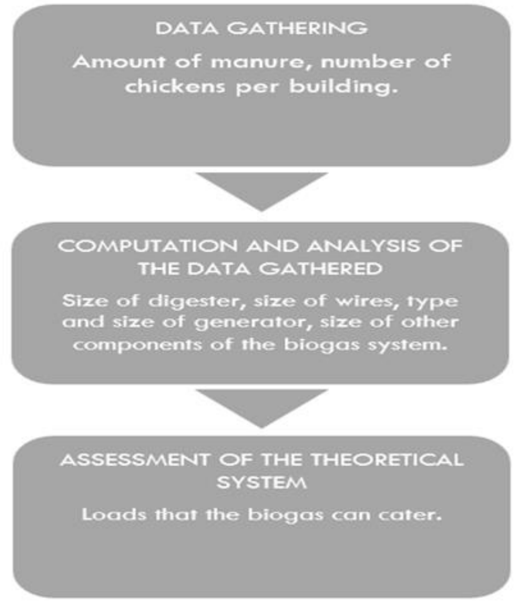

Figure 5: Block diagram of Methods

Figure 3 shows the first step in determining the electrical specification of a biogas in a poultry is through data gathering. One representative from the researchers is tasked to visit the site and conduct an interview where information is collected. The included information is; the type of hens that comprises the farm and the feeds that they consume for the analysis of manure content, the number of egg laying hens for the estimation of chicken wastes a poultry building can produce and on top of that, the ventilation on each building–their type and how they function. Furthermore, the researchers also need the data concerning the poultry's backup power supply when an unwanted power interruption occurs and in addition, the electrical loads in each building is also necessary in completing the evaluation of the poultry.

Next step is the part where the electrical specifications of the biogas system will be determined. This process contains the computation for the amount of biogas that can be converted into electricity when the poultry farm's chicken wastes are utilised. The first computation involves the size or capacity of the anaerobic digester which will hold the slurry and the produced biogas. The slurry contains the combination of chicken waste and water with a ratio of 1:1. There are steps in obtaining the electrical equivalent output of biogas, first is determining the number of chickens per building multiplying the amount of manure produced per day. Since it is a 1:1 ratio, adding water to the manure is only equivalent to how much manure is extracted. Total biogas per day is needed to calculate the equivalent output, in order to get the total biogas per day, multiplying the total chicken manure per day to the equivalent value of every 100 kg of chicken manure is equal to 20 cubic meters of biogas. Lastly, to get the electricity per day, for every 1 cubic meter of biogas there is 2kWh of electricity multiplied by the total biogas obtained per day and to get the electricity per hour, for every 1 day there is 24 hours multiplied by the total electricity per day (BIOGAS WORLD, 2022).

After the anaerobic digestion takes place, the produced biogas which will be contained by the gas holder integrated with the digester. The volume of the gas holder …

Therefore, the capacity of the digester should be 10 to 20 percent greater than the summation of volume of the slurry and the gas holder, putting safety factors into consideration.

The final step involves the assessment of the theoretical system. This step includes the identification of the loads that the biogas system can accommodate, parallel to the loads that the poultry uses on an everyday basis.

- Data gathered

This section of the paper is where all the data that the researchers have gathered from their data gathering procedure, using an interview method, is presented.

- Brief history of R.L Navarro poultry farm

R.L. Navarro Poultry Farm, is founded by Mr. Ronald Navarro. He also founded a fish farm under the same name. They started in May 2018, and ever since then they have been operating for four years, up until now. The farm is located at Minalin, Pampanga specifically at a barangay called San Pedro, along with other poultry farmers and fish farmers in the area. Most farmers on the site were faced with violations due to the improper waste disposal of chicken manure to the water bodies around them. The governor of Pampanga had already ordered an instant compliance by the poultry farms regarding the waste disposal problem they faced, and the complaints about the foul smell from the farms (Flora, 2021).

- Interview proper

The researchers conducted an interview with one of the managing heads of R.L. Navarro Poultry Farm at Minalin, Pampanga. In this interview they collected information that may be relevant and useful with the determination of electrical specifications of a biogas system on their poultry. The data that was given were data that are necessary for the computation of gas yield from the biogas system in relevance with the amount of manure produced by the chickens on the farm. In this presentation of data, two factors were considered; the average amount of manure produced, and the manure properties. These two variables are vital in determining the gas yield. After the researchers have identified the gas yield from the manure, they can proceed into the specification of the size of the digester that will be used, and the right specification of the generator. The equivalent electricity produced from the gas yield, will help the researchers in a thorough determination of the other components of the biogas system. The figure below shows the breakdown of the process of determination of electrical specification.

The whole poultry farm's area is 20, 000 square meter. R.L. Navarro Farm is catering ten buildings that are all filled with chicken. And each of the buildings is composed of 5000-7200 hens. With the information given, the researcher can reduce the amount of manure collected every week. A weekly collection of the manure is done by the farm to lessen the waste on the poultry.

The type of chickens that are present on the farm are laying hens. The procedure of growing laying hens differs from the process of raising meat birds. Most laying chickens live for five to seven years, laying practically every day for around three of them. You'll have to decide if you want to feed chickens that aren't laying as well as they used to or whether you're in the egg-selling business and can't afford to have "grain burners" living in your coop (Arcurie, 2021). The electricity bill that each building consumes ranges from 7,000 to 8,000 pesos, this does not count the warehouse and the office where they used different types of loads, these are but not limited to the egg sorting machine, lights, fans, and air conditioning unit.

IX. DISCUSSION

- Design

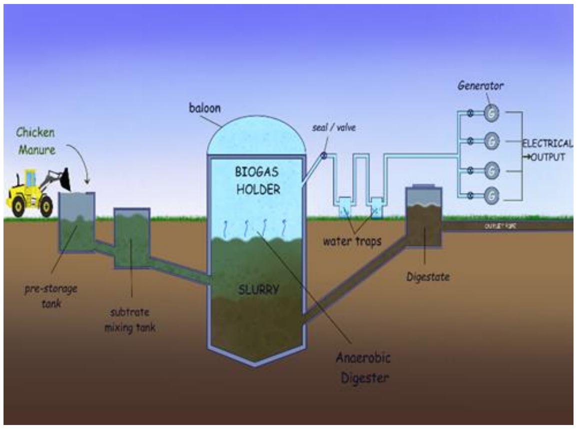

Figure 6: Block diagram of the Biogas system design

The Figure 4 above shows the design that is supposedly to be applied to the poultry farm. It starts with the collection of the manure, water will be then added on the substrate mixing tank of manure, and waste will travel through the canals that will then deliver it to the digester directly. The digester includes a substrate inflow to prevent it from filling up and a high-density polyethylene (balloon) that holds the gas upwards and serves as an indication if there is gas on the digester. Gas will then be produced by the anaerobic process that will occur inside the digester. The digester doubles as a gas holder, and the said gas will travel to the installed water traps that eliminates water vapour. This installation of water traps will deliver the purified gas to the dual fuel combustion engine, and the generator will be used to produce electricity. The said electricity will be used by the loads of the farm. This design is based on multiple references that were considered from different farms that utilise the biogas technology. The detailed calculations for the various parameters needed to satisfy the objectives of this study can be seen on (appendix D).

- Equivalent slurry to gas production

In order to acquire the equivalent slurry to gas production the following parameters shall be determined; total chicken manure produced per day, substrate input per day, digester volume, and gas yield. The first step is to determine the Tolat chicken manure per day (CM/day) which can be computed by the formula:

$$\left(\frac{\text{CM}}{\text{day}}\right) = (\text{No. of Bldgs}) \times (\text{no. of Chickens per bldg.}) \times (\text{Ave. manure per day of 100 chickens})$$

Considering 2 buildings will be used to power the biogas, and each building contains an average of 6,100 chickens, multiplying these numbers to the average manure per day of 100 chickens will give us a result of 915 kg per day. This data will then be used for the calculation of Substrate Input per day.

Putting into consideration that the ratio of chicken manure to water is 1:1, Substrate Input per day can be calculated by multiplying 915 kg CM/day by 2 which will result in a 1,830 kg of substrate input per day.

$$\text{Substrate Input per day} = \text{CM}\ \frac{\text{kg}}{\text{day}} \times 2$$

Next is the computation of gas yield which is one of the parameters needed to calculate the total volume of the anaerobic reactor. Taking into account that for every 100 kg of chicken manure is equal to 20 cubic meter of biogas, Gas yield can now be equated to:

$$\text{Gas yield} = \frac{\text{CM}}{\text{day}} \times \frac{20\ \text{m}^3}{100\ \text{kg}}$$

by substituting the value 915 kg of CM/day will result in 183 cubic meter of gas yield per day.

Aside from gas yield, another important parameter to be considered for the computation of the total volume of anaerobic reactor is the Digester Volume (Vd) which can be calculated by using the formula:

$$V_d = \text{HRT} \times \frac{\text{Substrate Input}}{\text{day}} \times \frac{1\ \text{m}^3}{1{,}000\ \text{kg}}$$

(Energypedia, n.d.) states that a 15-day hydraulic retention time as the average time interval over which the substrate is kept inside the digester. This resulted in a 27.45 cubic meter of the volume of the digester.

- Determination of size of digester and gas holder

Figure 5 shows the radius and height of the digester/ gas holder which is 3.4 meters and 6 meters, respectively. These values were concluded by the researchers by combining the volume of the digester and the gas yield, and assuming a value for the radius.

The 11 ft radius was derived from an available area in the farm which has the exact parameter that could fit a 22 ft diameter cylinder.

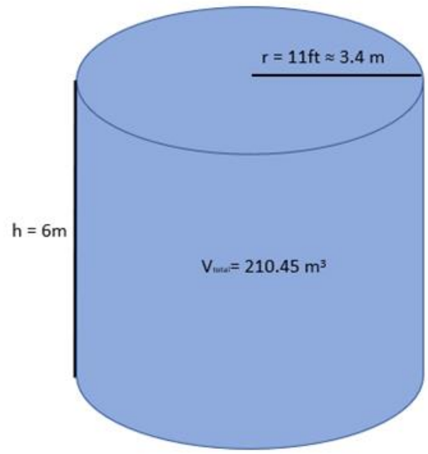

Figure 7: Parameters of the Anaerobic digester

$$V_T = V_d(\text{Volume of Digester}) + V_g(\text{Gas Yield}) = \pi r^2 h$$

- Equivalent gas to electricity

Moving forward to the electrical side, (*Biogas FAQ*, n.d.) declares that biogas contains the equivalent of 6 kWh of calorific energy per cubic meter (m^3). However, in a biogas-powered electric generator, it can only get about 2 kWh of usable electricity, with the rest being converted to heat. Considering all these parameters, the equivalent electrical output will be 15.25 kWh using the equation:

$$\text{Equivalent Electrical Output} = \text{Gas yield} \times \frac{2\ \text{kWh}}{1\text{m}^3}$$

- Identification of specification of generator

Based on the equivalent electrical output of the biogas, the researchers figured out the size of the generator with all the conditions and formula based on (Power Electrics, 2020) presented below. To ensure that the generator will run safely even if the gas yield is used to its maximum potential, the researchers considered the full load to be 15.25 kW. The result indicates that a 24 kVA generator must be used. Two of these generators will power the farm, alternating them in between 12 hours, to prevent a high temperature on the generators. The system that will be used to alternate the two generators between 12 hours will be a double throw circuit breaker.

Specifications of Generator

For 100% power,

$$\text{Generator size} = \text{Full load, kW} + \text{Reserve Capacity}$$

Where:

$$\text{Reserve Capacity} = \text{Full Load kW} \times 0.25$$

Taking into account that generators are usually rated in kVA, to get the equivalent kVA rating of the generator, the generator rating in kW just need to divide it by its power factor.

kW to kVA

$$\text{kW} \div \text{power factor (p.f)} = \text{kVA}$$

Note: Generator has 0.8 pf (International Standards)

If G – set is used as main power supply, leave 20-30% safety margin

Generator

- Electrical specification of wire and panel board

The researchers came up with the specification of the wires and panel board to be used considering the variety of electrical loads in the poultry. In order to find the appropriate ampacity for the wires and the ampere trip for the circuit breaker, the researchers referred to the standards that are set in PEC 2017 (see appendix F.)

Load Schedule and Computation

PB-1

						Circuit Breaker				
ckt.#	Qty.	load description	VA	V	A	AT	AF	P	Size of Wire	Size of Conduit
1	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
2	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
3	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
4	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
5	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
6	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
7	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
8	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
9	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
10	27	Lighting Outlet (50 watts max)	1350	230	5.86957	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
		TOTAL	13500		58.6957					

IF= (58.6957 x 100% demand factor) + (0 x 0.25)
= 58.6957

I MCB= (58.6957 x 100% demand factor) + (0 x 1.5)
= 58.6957

USE:
2-14sq.mm THW+ 1-8.0sq.mm THW(G)
60 AT, 100 AF, 2P, Single Phase

Figure 8: Load Schedule for the Panel board 1

PB-2

						Circuit Breaker				
ckt.#	Qty.	load description	VA	V	A	AT	AF	P	Size of Wire	Size of Conduit
1	17	Lighting Outlet (50 watts max)	850	230	3.69565	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
2	1	INDUSTRIAL FAN 1 HP	1840	230	8	30	50	2	2-5.5sq.mm.THW+1-3.5sq.mm.TW(G)	20mm.dia PVC
3	1	INDUSTRIAL FAN 1 HP	1840	230	8	30	50	2	2-5.5sq.mm.THW+1-3.5sq.mm.TW(G)	20mm.dia PVC
4	1	INDUSTRIAL FAN 1 HP	1840	230	8	30	50	2	2-5.5sq.mm.THW+1-3.5sq.mm.TW(G)	20mm.dia PVC
5	1	EGG SORTING MACHINE 1/2 HP	1127	230	4.9	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
6	1	EGG SORTING MACHINE 1/2 HP	1127	230	4.9	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
7	1	EGG SORTING MACHINE 1/2 HP	1127	230	4.9	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
8	1	EGG SORTING MACHINE 1/2 HP	1127	230	4.9	15	50	2	2-3.5sq.mm.THW+1-2.0sq.mm.TW(G)	20mm.dia PVC
9	1	ACU 1 HP	1840	230	8	30	50	2	2-5.5sq.mm.THW+1-3.5sq.mm.TW(G)	20mm.dia PVC
10	10	CONVINIENCE OUTLET	1800	230	7.82609	30	50	2	2-5.5sq.mm.THW+1-3.5sq.mm.TW(G)	20mm.dia PVC
		TOTAL	14518		63.1217					

IF= (63.1217 x 85% demand factor) + (8 x 0.25)
= 55.6535

I MCB= (63.1217 x 85% demand factor) + (8 x 1.25)
= 63.6535

USE:
2-14sq.mm THW+ 1-8.0sq.mm THW(G)
70 AT, 100 AF, 2P, Single Phase

Figure 9: Load Schedule for the Panel board 2

CONCLUSION

This research's goal is to determine the electrical specification of a biogas system on a poultry farm at Minalin, Pampanga. After some calculations, the researchers were able to identify the equivalent electrical output from the biogas, which is 15.25kWh. In addition, the researchers were also able to impart the type and size of electrical equipment needed in the process of converting the produced biogas into electricity; these are; generator, wire, and panel board to be used. Two 24 kVA dual fuel generators, for panel board 1, 2-14sq.mm THW+ 1-8.0sq.mm THW(G) for panel board 2, 2-14sq.mm THW+ 1-8.0sq.mm THW(G), 70 AT, 100 AF, 2P, Single Phase. The researchers have also concluded the size of the digester/ gas holder which has a radius of approximately 3.5 meters and a height of 6 meters. Lastly, with the biogas having an output of 15.25kWh, it proves that the biogas system can cover the electricity demand of the poultry and all the electrical equipment used within the poultry which are specified within the load schedule having a total of approximately 14.5 kW, can all be powered by the biogas system while only utilising ⅕ of the chicken manure produced by the poultry

RECOMMENDATIONS

The researchers recommend to include the Return of Investment (ROI) and the economic aspects that will utilise the electricity consumption of the poultry farm. The gathered data can also be established as a guide on determining the ROI and other aspects. For the data gathering, it is also essential to execute the plan on site visit. It is also advisable to give advance notice before visiting the site and to be aware of the situation on poultry farms, which may prohibit access due to the spread of harmful diseases among the chickens. For the future researcher, this research can be used as reference on considering other poultry farms on utilisation and discovering the potential of the chicken manure as an alternative source of energy.

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