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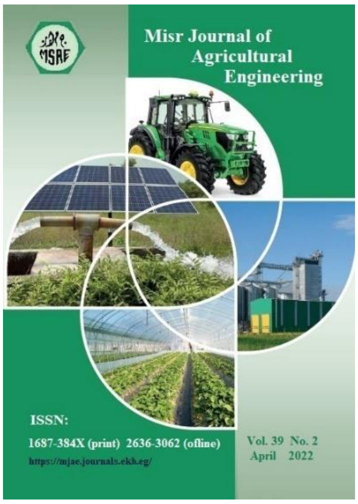
BIOGAS UTILIZATION SYSTEM FOR WARMING POULTRY HOUSES

M. E. Ebrahem [1&*]; M. M. Moustafa[2] and M. F. Abdel-Salam[3]

[1] MSc. Stud., Ag. Eng. Dept., Fac. of Ag., Ain-Shams U., Egypt.
[2&3] Prof., Ag. Eng. Dept., Fac. of Ag., Ain-Shams U., Egypt.
*E-mail: ENG.MDAHP@gmail.com



Keywords:
Warming; Poultry houses; Biogas; Organic west; Renewable energy.

ABSTRACT

*This study was carried out to evaluate three different resources of energy; liquefied petroleum gas (LPG), biogas and electricity (lighting) used to warm poultry houses. Experiments were carried out during winter 2019. The experimented poultry house has dimensions 1.6*0.8*0.8 m for each treatment. Each treatment included 11 chicks. The brooding cycle was 39 days. by adjusting the fuel consumption automatically, the chicks were brooding at a temperature of 32 °C in the first week, in the second week temperature is set at 29 °C, in the third week a temperature set at 26 °C and in the fourth week a temperature set at 23 °C. Temperature and humidity were recorded automatically every 1 minute, also energy consumption and broiler weight were measured for each treatment. Experiments showed the warming by lighting was recorded internal humidity lower than the warming by biogas and LPG, while the LPG treatment was recorded the largest value of humidity. The total cost of warming was 100, 120 and 168 LE/cycle with LPG, biogas and lighting, at respectively; The cost of heating per hen 9.1 LE for LPG unit, 10.91 LE for biogas unit and 15.27 LE for lighting unit. The Experiments showed biogas may be a feasible nontraditional resource for warming of poultry houses especially if the organic wastes were available free at the same farm.*

1. INTRODUCTION

Biogas can play a major role in the developing market as a function of renewable energy, it is estimated that biogas usage in the world will be doubled in the coming years ranging from 14.5 gigawatts (GW) in 2012 to 29.5 GW in 2022 **Kárászová *et al.*, (2015)**, **Maroneze MM. *et al.*, (2014).** Biogas is produced by anaerobic degradation of organic wastes and could be the substitute for natural gas and fossil fuels. It contains mostly three components, which are carbon dioxide (CO2), methane (CH4) and nitrogen (N2). However, other trace species exist as well, which are hydrogen (H2), hydrogen sulphide (H2S), ammonia (NH3), nitrogen (N2), oxygen (O2) and carbon monoxide (CO). The use of biogas heat for animal brooding can supply heat worth $20 000-$40000 a year in fuel cost for brooding uses for 50000 hen houses. **Zhenghou *et al.*, (1987)** poultry industry is one of the energy intensive industries that consuming a large quantity of fuel, thermoneutral zone for hens is somewhere between 20 and 35°C **Esmay (1978)** depending on the birds' age. at each stage of the birds' development there is optimum temperature in which the birds make the best performance **Kampen (1984)**

(1984) found that maximum feed efficiency is about 27°C. If the birds are kept at a temperature lower than the optimum, the bird increase feed intake and use it to keep their body warm, which increases the cost and decreases the meat yield. While, if they were kept at temperature is higher than the optimum, they reduce feed intake to limit heat production, which also results in lower meat yield **Donald (2009)**. Therefore, an efficient heating system is necessary for any broiler house to maintain the required temperatures all around the year. most heating systems use electricity, diesel fuel, gas, kerosene or other non-renewable sources. The amount of fuel used for warming poultry house depend on many factors. One of the main factor is the climatic conditions **Atilgan and Akyuz (2007)**. The main factor affecting the amount of fuel used is the amount of heat produced by the bird within the space to be heated. the yearly average heating consumption of diesel fuel in a commercial well insulated broiler house in Egypt is 0.44 liters/bird. However, broilers poultry sector in Egypt consumes about 350,000 tons of fuel per year for warming purposes **Heidi El Zanaty (2015)**. The research targets to utilize the biogas as a renewable energy source to warms the broiler houses. negative effect of high stocking densities on final body mass of broiler chickens Results of numerous researches indicated that **Škrbić et al., (2007)**

The objectives of this research are:
- Design and construction of warming system for the poultry houses.
- Evaluation of performance of the warming system.
- Determination of cost of the warming system.

2. MATERIALS AND METHODS

The experiment conducted from 24 march to 1 may (2019) at Training center for recycle agriculture remnants TCRAR belong to Agriculture Research Center; Moshtahar, Tukh ,El Qulibia governorate. Egypt.

Three prototypes of poultry houses were used to compare three types of energy sources used in warming; electricity and LPG (Liquefied Petroleum Gas) with the third prototype biogas as shown in figure (1).

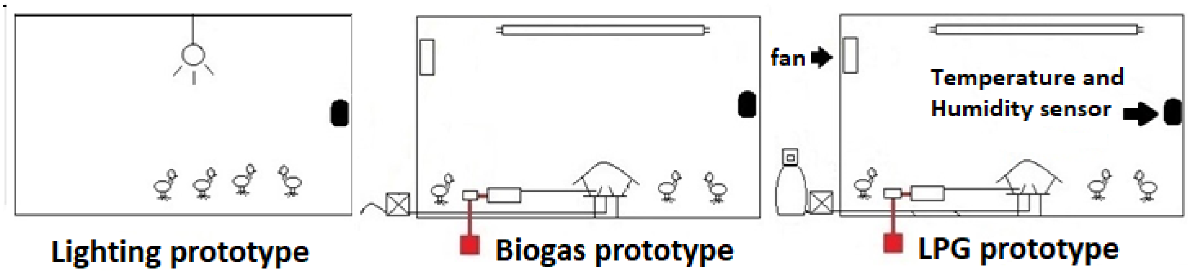


Fig. (1): Three prototypes

Dimensions was 1.6m length 0.8m width 0.8m high for each prototype as shown in figure (2)

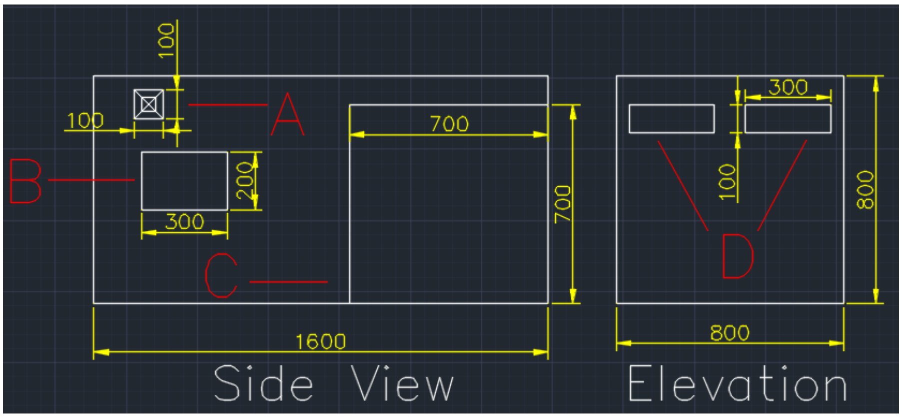


Fig. (2): poultry house Prototype dimensions

Table (1): poultry house Prototype components and dimensions

Code	Identification	Dimensions
A	Fan (veneration sys.)	100*100 mm
B	Observation window	300*200 mm
C	Door	700*700 mm
D	Vent hole	300*100 mm

The poultry houses were made of natural white ash wood **Alchalabi (2013)** (mosky wood) wood cutting edge dimensions 6*3 cm and the sides were coated with polypropylene paper have 1.2 mm thickness as a wall.

Inside prototype there are Observation window and Vent hole

Every single prototype has 11 chicks 1-day age **Arbor Acres (Aviagen)**

Electric prototype: has two bulbs were turned on each one 200-watt to reach the brooding temperature. the bulbs were reduced to one bulb 100-watt**.**

LPG prototype: has use a cylinder gas commercial size 25 kg gas and spark ignition was adding in unit.

Biogas prototype: has used biogas from 3 digesters and consumed about 30 cubic meters of biogas at the price of 120 LE (the price of organic waste) divide into two charges.

Temperature& humidity: was measuring automatically by data logger (electronic circuit based on Arduino board) as shown in figure (3)

Arduino: also used to control in open and close gas valve and spark ignition circuit.

Ventilation System: there is exhaust fan to exchange air inside Prototype with make negative pressure, the fan dimensions: 10cm Dim. &12 V DC,0.25A and air inlet Semi-closed in beginning of the cycle and totally open in ended of the cycle. Arduino is programing to control in the fan working time. The working time is allowed disposal a higher level of relative humidity and harmful gases (CO_2, CO, H_2S and NH_3). And not allowed to lose heat inside Prototype.

Broilers feeding & weight: 33 chickens divide into 3 prototypes ate 100 kg broiler feed and weight was measured every 2 days.

Lighting: in experiment I used fluorescent white lamp in Biogas and PLG Prototype and tungsten light lamp in electricity Prototype

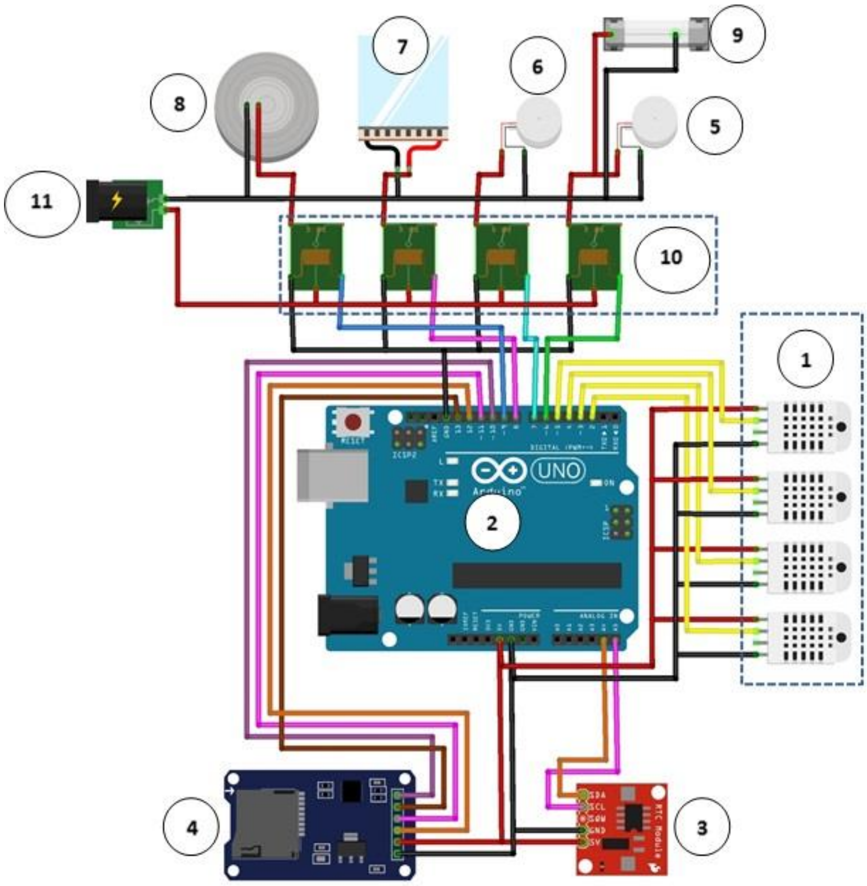


Fig. (3): data logger (electronic circuit based on Arduino board)

1	**DHT22 - temperature & humidity sensors**
2	**Arduino Uno board – microprocessor and microcontroller**
3	**DS1307 – real time clock module (RTC)**
4	**SD card module**
5	**Solenoid valve for biogas**
6	**Solenoid valve for LPG**
7	**Lamp**
8	**Fan**
9	**Spark ignition**
10	**Relays**
11	**AC power plug**

Poultry Bedding: During the experiment was used wood shaving 5 cm thickness(depth)
Heating system: in 40 cm above the bedding, we put DHT22. It is sensing and recording temperature and humidity and connected with Arduino. Arduino is programing to open solenoid of gas and spark module when temperature is under 33 °c in first week, 29 °c in second week, 26°c in third week and 24°c in forth week.

Temperature and humidity were recording in 4 positions:

1- Biogas poultry hose Prototype. 2- PLG poultry house Prototype.
3- Electric poultry house Prototype. 4- Ambient air.

3. RESULTS AND DISCUSSION

The experiment was measuring (temperature, humidity, fuel consumption and broiler weight) for every prototype during the experiment, Biogas prototype depend on biogas source coming from digester to warm poultry house prototype electricity prototype depend on tungsten lamp to warm poultry house prototype, Liquefied Petroleum Gas (LPG) prototype depend on LPG cylinder to warm poultry house prototype

Experiment measurements:

Temperature

The first curve is a comparison between the temperature inside the biogas prototype and the ambient air temperature. shows the temperature from the first day until the 9th day in a semi-linear relationship, because Temperature readings were taken every minute. from the morning of the 10th day until the end of the period readings began to fluctuate up and down Because Temperature readings were taken every 8 seconds.

In the curve appears obviously distinction between the ambient temperature and biogas prototype temperature is start bigger; because a low ambient temperature and a high brooding temperature needed; then the distinction begins shrinking because a high ambient temperature and a low brooding temperature needed. to illustrate on the first day of the cycle, the difference between ambient temperature and the poultry house prototype was 11 ° C, then decreased in 18th day from 1 to 4 ° C depending on the measurement period during the day and then on the 24th day the difference arrives from 0 to 4 ° C depending on the measurement period during the day. on the 16th day the temperature was reduced from 29 to 26 because it is the optimum temperature for that age and the temperature was not reduced in the first 15 days and due to the great fluctuation in daily temperatures outside the poultry house as shown in fig. (4)

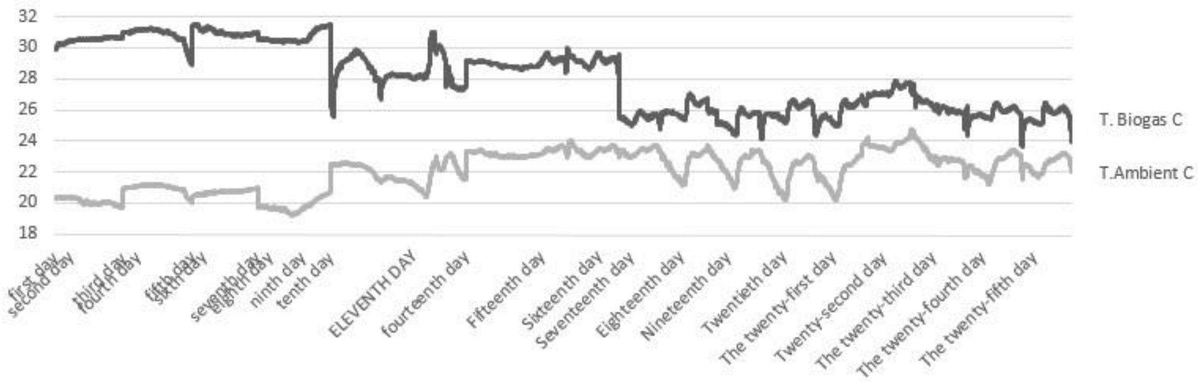


Fig. (4) comparison between the temperature inside the biogas prototype and the ambient air temperature

In the curve comparison between the temperature of the biogas prototype, LPG prototype and the ambient air temperature. we find that the fluctuation in the temperature of the LPG prototype is high of the biogas prototype, because the calorific value of the LPG is much higher than the biogas - (The specific calorific value of LPG is around 46 MJ/kg or 12.78 kWh/kg depending on the composition of LPG) (accepted mean calorific value of biogas 25 MJ/m$^{3)}$- so the optimum temperature is reached quickly and then soon to go down again as shown in fig. (5)

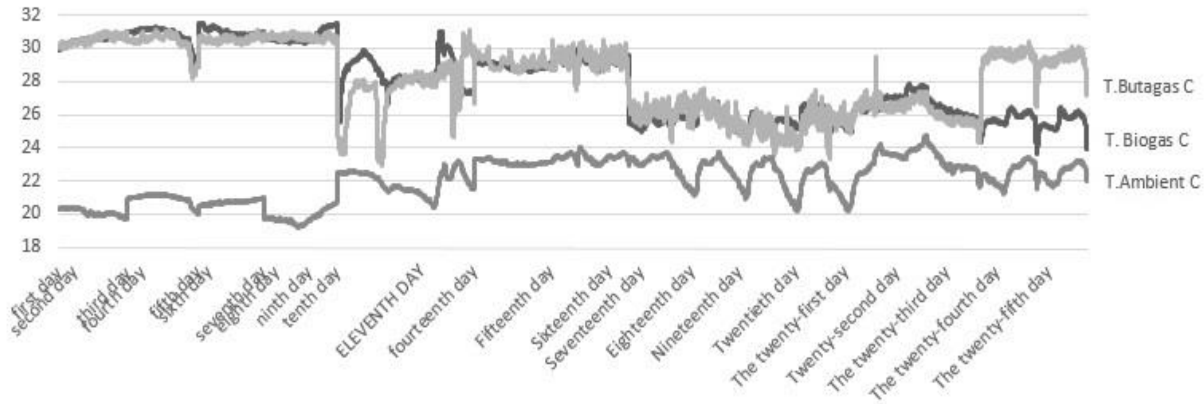


Fig. (5) comparison between the temperature of the biogas prototype, LPG prototype and the ambient air temperature.

In the curve comparison between the temperature of the biogas prototype, the electric prototype and the ambient air temperature. we find that the temperature fluctuation of the electric prototype is low relative to the biogas prototype because of the relative stability of the heat generated by the tungsten light lamp and also because the ventilation in the electric prototype is natural and the heat curve inside the electric prototype is semi-similar to the heat curve of the ambient air temperature with a semi-constant difference between them. inside the electric prototype, two bulbs were turned on each one 200 watts to reach the brooding temperature until the 11th day. As the ambient air temperatures rise and emersion the symptoms of heat stress on the birds, the bulbs were reduced to one bulb until the 17th day temperature rise the optimum degree it switches to 100-watt bulb is also evident on the curve as shown in fig. (6)

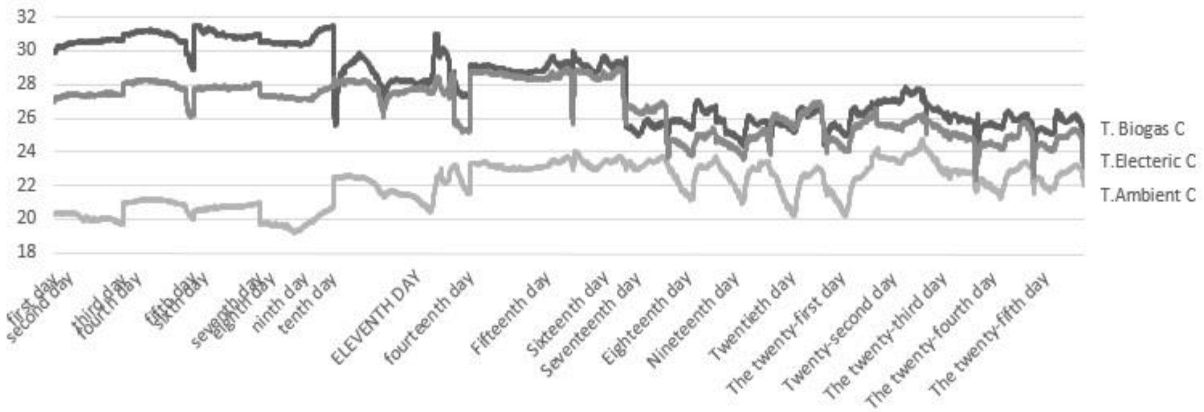


Fig. (6) comparison between the temperature of the biogas prototype, the electric prototype and the ambient air temperature.

Relative humidity

The first curve is a comparison between the relative humidity inside the biogas prototype and the ambient air relative humidity. shows the relative humidity from the first day until the 9th day in a semi-linear relationship, because relative humidity readings were taken every minute. from the morning of the 10th day until the end of the period readings began to fluctuate up and down Because relative humidity readings were taken every 8 seconds.

Relative humidity is closely related to heat and inversely to the rate of ventilation. relative humidity outside the poultry house has a direct relationship with the relative humidity inside the poultry house and with the ventilation (natural or mechanical) we seek to reach the optimum relative humidity. relative humidity inside the poultry house rises from outside to many reasons: evaporate drinking water, the phenomenon of bird panting and manure of birds (organic residues). It is also evident from the curve when the age of birds increases; relative humidity inside the poultry house will increasing as a reason of the rate of panting and increasing in consumption of water, which increases the moisture content of manure as well as increased quantities. As shown in fig. (7)

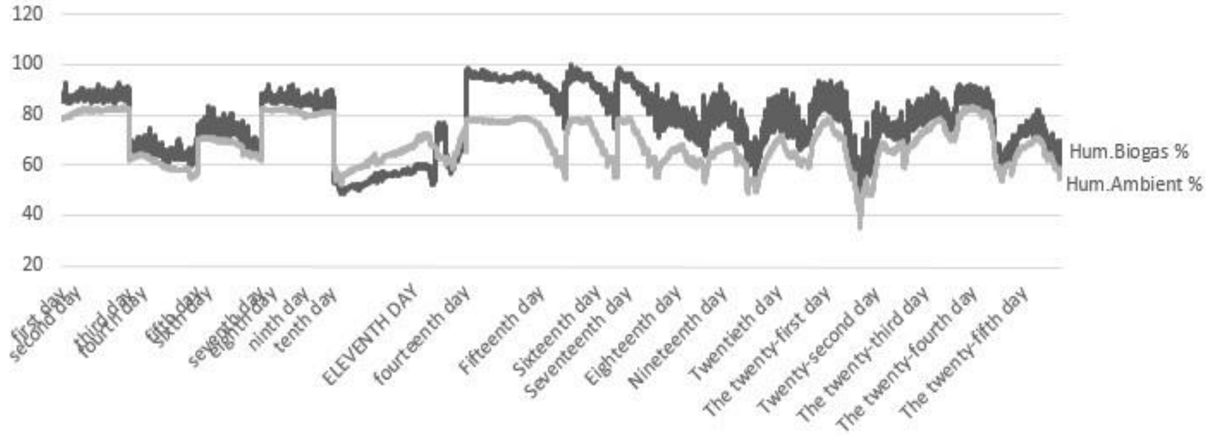


Fig. (7) comparison of the relative humidity within the biogas prototype and the ambient air relative humidity.

Comparison between the relative humidity of the biogas prototype, LPG prototype and the relative humidity of the ambient air. relative humidity inside LPG prototype is very high and reaches a great extent to saturation, especially in the big age of poultry due to the high rate of panting and increase the consumption of water, which increases the amount of manure as well as the moisture content of manure. burning LPG increases the relative humidity, especially when incomplete burning and occurs when the oxygen in the poultry house is low.as shown in fig. (8)

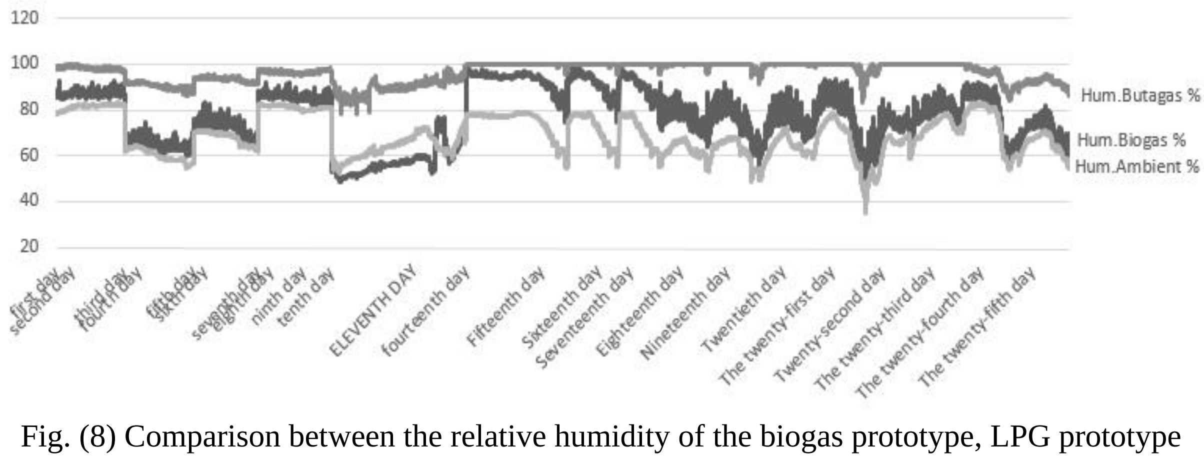


Fig. (8) Comparison between the relative humidity of the biogas prototype, LPG prototype and the relative humidity of the ambient air.

Comparison between the relative humidity of the biogas prototype, the electric prototype and the relative humidity of the ambient air. The relative humidity in the electric prototype rise is very small compared to the relative humidity of the ambient air, inverse that of the biogas prototype, because the heat-producing source in the electric prototype is not producing of water vapor. contrariwise, it is a source that reduces the relative humidity and helps in drying. inverse that sentiment the burning of biogas or butane increases the relative humidity. then on the 10th day, the change occurs in the relative humidity inside the electric prototype relative to the relative humidity of the ambient air to increase the ventilation holes (natural). The reason is the ambient temperature increases from 19 to 23 ° C. on the 11th day, the number of bulbs was reduced from 2 bulbs to 1 bulb 200 watts, which narrowed the difference between the relative humidity inside the electric prototype and the relative humidity of the ambient air. on the 17th day, the 200-watt lamp was disconnected and a 100-watt bulb was turned on, which led to a slight increase in the difference between the relative humidity inside the electric prototype and the relative humidity of the ambient air. due to the aforementioned reasons for relative humidity, as it is difficult to control inverse heat, the relative humidity inside. as shown in fig. (9)

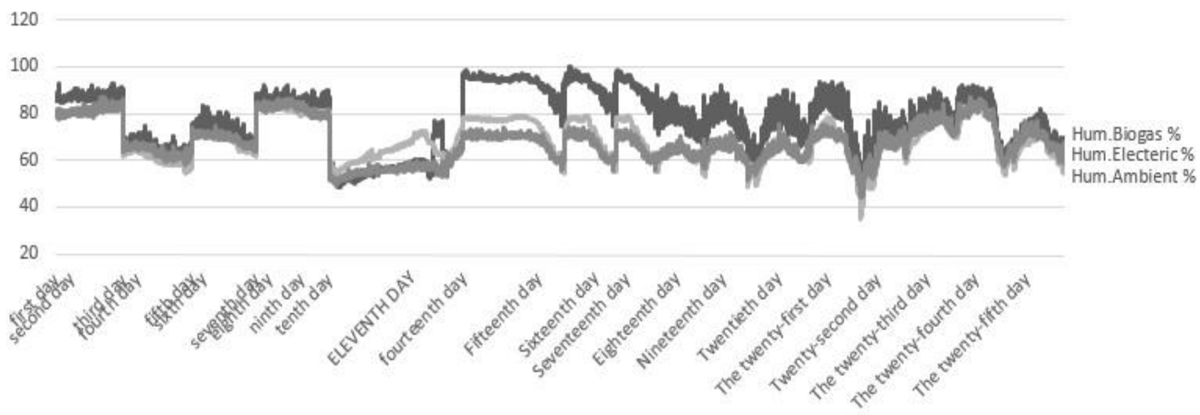


Fig. (9) Comparison between the relative humidity of the biogas prototype and electric prototype and the relative humidity of the ambient air.

Broiler weight

Differences in the weight of poultry are very small, but weights in the electric prototype are preferable, perhaps because it does not contain burning exhausts, including carbon monoxide, which is a growth inhibitor. As shown in fig. (10).

Prices of energy consumed:

consumed 146.7 kilowatt hours of electricity as a commercial segment at 168.75 LE in the winter of 2019 and was consumed a large LPG cylinder containing 25 kg mixture of propane and butane at 100 LE in the same period and was consumed about 30 cubic meters of biogas At the price of 120 LE (the price of cow dung), and is therefore preferable to LPG, but in the short term, but in the long run, renewable energy has the advantage for two reasons because it is renewable and continuous, and it is cheaper in price if a special fermenter is built in place of poultry house and also organic waste is not purchased from the outside, but from the same farm and thus can benefit from the poultry bed or chicken manure at the end of each cycle. because it can be derived from agricultural roughages, this is evident in the fig. (11)

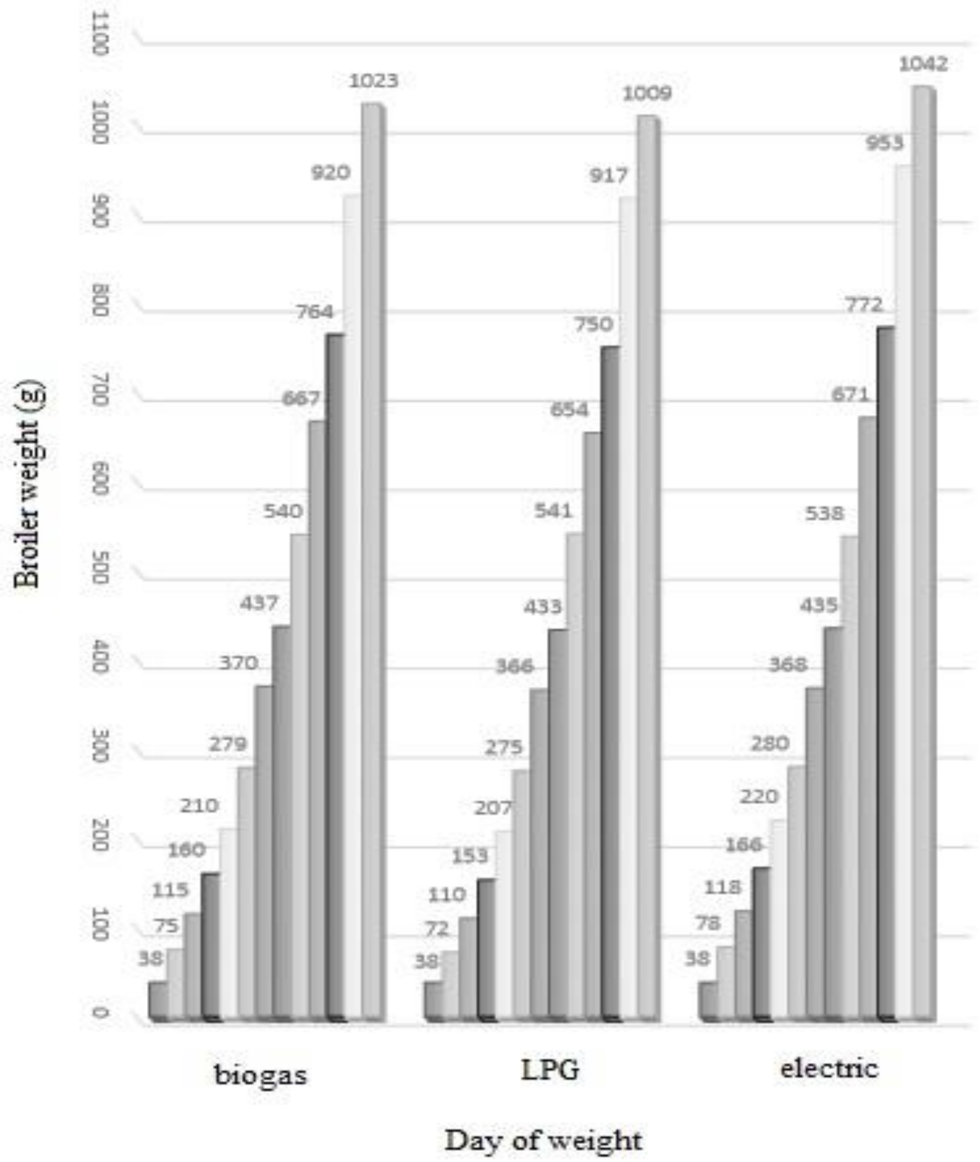


Fig. (10) Comparison between Broilers weight for three poultry house prototypes in warming days from 1st to 25th

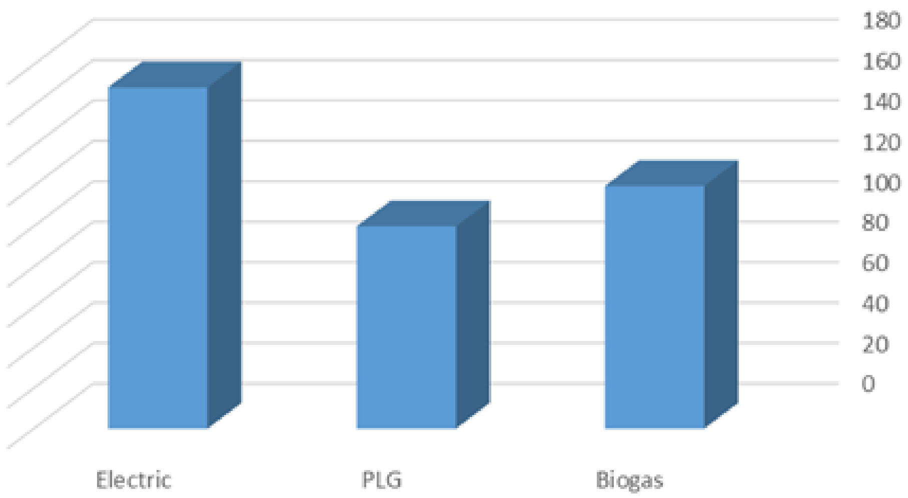


Fig. (11) Prices of power consumed in warming three poultry house model.

4. CONCLUSION:

the electric prototype is the best for poultry welfare but more money as cost needed and the relative humidity of LPG prototype is worse for poultry welfare.

1. In order for the production of biogas for warming to be economically feasible, it is preferable to provide the organic waste used in the production of biogas from the same farm and not be purchased.
2. Biogas cannot be relied upon in the process of warming completely in the case of small quantities of organic waste, which is less than 6 m3 of biogas gas per day for an area of 75 m 2
3. must always develop warming method do not increase the relative humidity of the poultry houses and must be warming method do not increase the toxic gases inside the poultry houses so as not to increase the ventilation rate, which leads to rapid loss of heat.

5. REFERENCE

A. Atilgan and A. Akyuz (2007). "The Investigation of Heating and Cooling Days with the Method of Degree-day in Broiler Poultry Housing," Asian J. Anim. Vet. Adv., vol. 2, pp. 140–145.

Alchalabi D.A (2013). Poultry Housing Design · DOI: 10.13140/2.1.2729.7280 University of Baghdad.

Andriani D, Wresta A. (2014) A review on optimization production and upgrading biogas through CO2 removal using various techniques. Appl Biochem Biotechnol;172(4):1909–28.

Donald J. O. (2009) "Environmental Management in the Broiler House." Aviagen.

Esmay, M.L. (1978) Principles of Animal Environment. AVI, Westport, Connecticut.

Heidi El Zanaty (2015) A Techno-Economic Study for Heating Poultry Houses Using Renewable Energy

Kampen, M.V. (1984) Physiological responses of poultry to ambient temperature.*Archiv fur Experimented Veterinar Medizin* 38, 384–391.

Kárászová M, Sedláková Z, Izák P. (2015) Gas permeation processes in biogas upgrading: a short review. Chem Pap 69(10):1277–83

Maroneze MM, Zepka LQ, Vieira JG, Queiroz MI, Jacob-Lopes E. (2014) Production and use of biogas in Europe: a survey of current status and perspectives. Rev Ambient E 9(3):445–58. http://dx.doi.org/10.4136/1980-993X.

Rasi S, Veijanen A, Rintala J. (2006) Trace compounds of biogas from different biogas

production plants. Energy 2007;32(8):1375–80. http://dx.doi.org/10.1016/j. energy.

ŠKRBIĆ Z., PAVLOVSKI Z., LUKIĆ M. (2007): Body mass and dynamics of growth of broiler chiickens of different genotype in improved rearing conditions. 2nd

International Congress on Animal Husbandry “New Perspectives and Challenges of Sustainable Livestock Farming”, Belgrade, October 3-5. Biotechnology in Animal Husbandry, 23, 5-6, Book 2, 347-357.

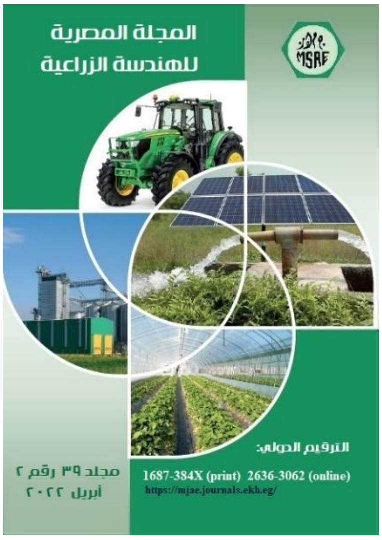
Zhenghou Jiang, S. C. Steinsbergerand Jason C. H. Shih. (1987). In situ Utilization of Biogas on a Poultry Farm: Heating, Drying and Animal Brooding. Paper No. 9554 of the Journal Series of the North Carolina Agricultural Research Service, Raleigh, North Carolina._Biotechnology Laboratory, Department of Poultry Science, North Carolina State University, Raleigh, North Carolina 27695-7608, USA

نظام استخدام البيوجاز لتدفئة عنابر الدواجن

محمد إمام إبراهيم[١]، مبارك محمد مصطفى[٢] و مصطفى فهيم محمد عبدالسلام[٣]

[١] طالب ماجستير - قسم الهندسة الزراعية - كلية الزراعة - جامعة عين شمس - مصر.

[٢و٣] استاذ - قسم الهندسة الزراعية - كلية الزراعة - جامعة عين شمس - مصر.



الملخص العربي

أجريت الدراسة بمشتهر بالقليوبية بمركز تدريب البيوجاز.

هدف البحث: البيوجاز بديل طبيعي يقلل من انبعاثات ثاني أكسيد الكربون ويوفر على الدولة ويساهم بخفض العبء الناتج من المخلفات العضوية

المشكلة المعالجة: ارتفاع أسعار البترول، تراكم المخلفات العضوية والوقود الأحفوري الملوث للبيئة.

ولتحقيق الاهداف تم الاتي:

اولا : انشاء ثلاثة نماذج لبيوت الدواجن مستخدم بها ثلاثة أنواع مصادر للطاقة (الكهرباء - غاز البوتاجاز مع غاز البيوجاز).

ثانيا: تحضين الكتاكيت على ٣٢ مئوي وتخفض ٣ درجات أسبوعيا حتى ٢٣ مئوي وتم تسجيل درجات الحرارة والرطوبة النسبية وتسجيل الأوزان كل يومين وحساب كمية الوقود.

أهم النتائج:

- ارتفاع الرطوبة النسبية بالتدفئة بغاز البوتاجاز عن البيوجاز ثم الكهرباء على الترتيب
- ارتفاع تكاليف التشغيل التدفئة بغاز البيوجاز نظرا لارتفاع أسعار خامات بناء المخمر. وعلى المدى الطويل تعتبر الطاقة المتجددة هي الأفضل والأقل سعرا.
- تم استهلاك ١٤٦,٧ كيلو وات ساعة من الكهرباء بسعر ١٦٨,٧٥ جنيه مصري (ج.م) بشتاء ٢٠١٩. تم استهلاك انبوبة غاز بها ٢٥ كجم بسعر ١٠٠ ج.م في نفس الفترة وتم استهلاك ٣٠ م٣ تقريبا من البيوجاز بسعر ١٢٠ ج.م.
- عملية الحرق ترفع الغازات السامة لذا يجب زيادة التهوية عند التدفئة بحرق الوقود.

التوصيات:

- توفير المخلفات المستخدمة بإنتاج البيوجاز من ذات المزرعة ولا يتم شرائها.
- لا يعتمد على البيوجاز بعملية التدفئة بشكل كلي في الكميات الصغيرة والتي تقل عن ٦ م٣ من غاز البيوجاز يوميا لمساحة ٧٥ م٢ .
- يجب استحداث وسائل تدفئة لا ترفع من الرطوبة النسبية كما يجب ان تكون وسائل التدفئة لا تزيد من الغازات السامة داخل حتى لا تزيد التهوية مما يؤدي الى فقد الحرارة سريعا.

الكلمات المفتاحية:

التدفئة؛ عنابر الدواجن؛ البيوجاز؛ المخلفات العضوية؛ الطاقة المتجددة.