ORIGINAL ARTICLE

Feasibility of Introducing Solar Energy into a Poultry Production System

Factibilidad de la introducción de la energía solar en un sistema de producción avícola

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ABSTRACT: The present research was developed in the poultry production system of the "El Guayabal" University Farm; its objective was to determine the feasibility of the introduction of solar energy (photovoltaic and thermal) under the conditions of the aforementioned scenario. In the study, the theoretical-methodological foundations oriented towards the two renewable energy sources addressed in the research (solar photovoltaic and solar thermal) were considered. Among the main results obtained, it was evident that from the energy-productive diagnosis of the poultry production system under study, it was determined that the installation of a hybrid system composed of an isolated photovoltaic system made up of 160 photovoltaic panels and a solar heater, which could cover of the energy demand; in addition, it was determined that the installation of a solar dryer is not appropriate; because drying or dehydration of agricultural production is not required to feed established poultry species.

Keywords: solar energy, poultry production, environmental impact, renewable energy.

RESUMEN: La presente investigación se desarrolló en el sistema de producción avícola de la Granja Universitaria "El Guayabal", el objetivo de la misma consistió en determinar la factibilidad de la introducción de la energía solar (fotovoltaica y térmica) en las condiciones del escenario antes mencionado, en el estudio se consideraron los fundamentos teórico-metodológicos orientados en las dos fuentes renovables de energía abordadas en la investigación (solar fotovoltaica y solar térmica) entre los principales resultados obtenidos se evidenció que a partir del diagnóstico energético-productivo del sistema de producción avícola objeto de estudio, se determinó que la instalación de un sistema híbrido compuesto por un sistema fotovoltaico aislado conformado por 160 paneles fotovoltaicos y un calentador solar, con lo cual podría cubrirse la demanda energética de dicho escenario; además se determinó que la instalación de un secador solar no procede; debido a que no se requiere del secado o deshidratación de producciones agrícolas para la alimentación de las especies avícolas establecidas.

Palabras clave: factibilidad económico-energética, impacto ambiental, energías renovables.

INTRODUCTION

The poultry sector continues to grow and industrialize in many parts of the world due to the powerful drive of population growth, increasing purchasing power and urbanization processes. Advances in breeding methods have resulted in birds that serve specialized purposes and are increasingly more productive. This evolution has caused the poultry industry and the concentrated feed industry to rapidly increase in size, to concentrate around input sources or end markets and to become vertically integrated (FAO, 2022).

The United States of America is the world's largest producer of poultry meat (17%), followed by China and Brazil. In egg production, China ranks as the largest producer (38%), followed by the United States (7%) and India (7%). In 2020, poultry meat accounted for almost 40% of global meat production, while in the last three decades, global egg production has shown a 150% increase (FAO, 2022).

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For the development of poultry production in the current context, food represents the highest cost in poultry production and the availability of these at a low price and with high quality is essential for poultry production to remain competitive and increase to meet the demand for animal protein (FAO, 2013).

The Cuban government seeks to be self-sufficient in terms of the production of eggs and chicken meat, which, at present, it costs to import from abroad and does not meet the demand of the population. In Cuba, one thousand nine hundred million eggs are currently produced intensively, and two hundred million in an unconventional way, supported by the genetics developed in recent years, represented by the laying hen that is exploited industrially, and the semi-rustic and free-range chicken, used for alternative poultry farming, in turn reaching nine thousand five hundred tons of waste poultry meat.

In the specific case of the poultry system established at the “El Guayabal” University Farm, this production system is linked to the national electro-energy system, due to the impact of the same by the lack of fossil fuels, the implementation of solar energy (photovoltaic and thermal) is valued to generate heat, electric energy, so that this production system is sustainable, which is supported by the production of eggs from laying hens and free-range hens, as well as the fattening of turkeys (Cadena Avícola, 2023).

At the international level, one of the main renewable energies used in poultry farms is solar energy (Smyth, 2012; Talavera et al., 2012; Rodes, 2017). Solar panels can be installed on the roof of farm facilities or on nearby land, and can provide electricity to meet the needs of the farm, another option is the use of solar heating systems to maintain the appropriate temperature in the facilities and in the birds (Cadena Avícola, 2023).

Considering the aforementioned background, the objective of this research was oriented to determine the feasibility of introducing solar energy (photovoltaic and thermal) in the poultry system established at the “El Guayabal” University Farm.

MATERIALS AND METHODS

The "El Guayabal" University Farm, belonging to the Agrarian University of Havana (UNAH), is located at 23°00'12.5" North latitude, and 82°09'57.9" West longitude in the municipality of San José de Las Lajas, Mayabeque province, Cuba. The soil existing in it is classified as Typical Red Ferralitic Hernández et al. (2015) throughout its extension. It has a flat relief, height above sea level of 120 m and annual sunshine of 1825 kWh/m2. The meteorological variables recorded at the Tapaste Meteorological Station, San José de las Lajas, during the period January-September/2023, showed that the maximum temperatures reached in the region exceeded 32 ºC between the months of June to September and the coldest dropped on average to 21.1 ºC in January. Precipitation increased from June onwards, with the highest average values in May and August at 72 and 77 mm, respectively. Relative humidity varied between 47% (minimum in March) and 84% (maximum in September), while wind speed reached a maximum value of 3.6 km/h during the month of August. The behaviour of these climatic variables allows for the successful development of poultry production. The facilities include a poultry production system, which is made up of three production areas. One of these areas is used for egg production using White Leghorn laying hens. This area has a maximum capacity of 2,872 animals. Another is the area for turkey production, the capacity of which varies depending on the time of year: 1,500 animals (summer) and 3,000 animals (winter), and finally the area for free-range hens, also intended for egg production, with a capacity of 700 animals.

Table 1 shows the data obtained regarding the movement of animal mass in the poultry production system during the observation period.

In the system of production poultry study object, for their operability, they are used a group of energy payees, those that are related in the Table 2.

For the establishment of the specific methodologies for the sizing of the photovoltaic system and of the solar heater, they are considered the basics outlined for (Morejón *et al.*, 2022).

Methodology for the sizing and installation of photovoltaic panels

To determine the energy that should give the photovoltaic installation, they must consider you the losses that the batteries, the investor and the drivers involve.

To calculate the half daily (Emdn) consumption of the installation one will keep in mind the consumption half real critic of the load (Emd) and not the half consumption for constant loads neither the number of inventories.

TABLE 1. Movement of the poultry in the period of investigation in the Farm "Guayabal" system

Mov. of Flock	Initial Existence	Final Existence	Animals/day	Mass Average kg
Egg-laying hens Leghorn White	2872	2872	2872	1,40
White turkeys of wide chest	3000	1500	2250	6,50
Country hens	700	700	700	2.20

TABLE 2. Means energy consumers installed in the system of poultry production

Means energy consumers (Quantity)	Power, kW	Time of Operation , h	Consumed energy / day , kWh/day
System of production of hens White Leghorn			
Tubes LED 20W (10)	0.20	14	2.80
Tubes LED 40W (18)	0.72	14	10.08
System of production of turkeys of wide chest			
Tubes LED 20W (79)	1.58	14	22.12
Extractor I (1)	0.01	24	0.24
Extractor II (1)	0.02	24	0.48
Heater III (1)	0.01	24	0.24
Heater IV (1)	0.03	24	0.72
	0.06	24	1.44
	0.03	24	0.72
Heater V (1)	0.15	24	3.60
System of production of country hens			
Tubes LED 40W (10)	0.40	14	5.60

$$E_{mdn} = \frac{E_{md}}{\eta_{bat} \cdot \eta_{inv} \cdot \eta_{cond}}, \quad kWh \qquad (1)$$

where: E_{md}: Consumption half real critic of the load, kWh; η_{bat}: Efficiency of the batteries; η_{inv}: The investor's efficiency; η_{cond}: Efficiency of the drivers.

If it is not had meter-accountant in the investigation scenario, it is possible to determine the energy demand by means of the rising of the means and electric teams located in the area study object, being determined the power (N) of each one of them and the daily (To) time of operation, with these two parameters you can determine the energy consumed daily () in the installation, that which you can determine by means of the following expression:

$$E_{md} = N \cdot T_0, \quad kWh \qquad (2)$$

where:
N: Power of the teams and electric means, kW;
T_o: Daily time of operation, h.

Sizing of the photovoltaic generator

For the determination of the number of solar required panels, it is possible to use the approach based on the estimate of the consumption of Amperes-hour of the installation Hernández (2007), León *et al.* (2021), being the daily required half consumption of current:

$$Q_{Ah} = \frac{E_{mdn}}{V_{bat}}, \frac{Ah}{día} \qquad (3)$$

where: V_{bat}: Voltage of the batteries.

Likewise, according to Alonso (2011; 2017), the current that should generate a photovoltaic reception field in the most critical month in solar (IGFV) radiation is determined as:

$$I_{GFV} = \frac{Q_{Ah}}{TS_{crit}}, \text{A} \qquad (4)$$

where: TS_{crit}: Hours of sun pick of the most critical month, h.

Then, the (I_{GFV}) current generated by the photovoltaic (the total of solar installed badges) reception field, is divided among the unitary current of each photovoltaic (I_{MOD}) module, the total of necessary modules is obtained connected in parallel:

$$Np = \frac{I_{GFV}}{I_{MOD}} \qquad (5)$$

where: I_{MOD}: Unitary specific current of each photovoltaic module, A.

Sizing of the system of accumulation

As to Mascaros (2015), for the calculation of the number of batteries required for a photovoltaic installation, they must consider you:

- the time of autonomy wanted for the photovoltaic installation;
- the depth of discharge seasonal maxim of the batteries;
- the depth of discharge daily maxim of the batteries.

According to Alonso (2011), the nominal capacity of the battery in function of the maximum seasonal discharge is determined according to:

$$C_{ne} = \frac{E_{mdn} \cdot N_{DA}}{P_{Dmax,e} \cdot F_{ct}}, \quad kWh \qquad (6)$$

$$C_{neAh} = \frac{C_{ne}}{V_{bat}}, \quad Ah \qquad (7)$$

where: N_{DA}: Number of days of autonomy of the installation; $P_{Dmax,e}$: Depth of discharge seasonal maxim of the batteries; F_{ct}: Factor of total load of the batteries; C_{neAh}: Nominal capacity of the battery in function of the maximum seasonal discharge, Ah.

Likewise, the nominal capacity of the battery in function of the maximum daily discharge is determined according to:

$$C_{nd} = \frac{E_{mdn}}{P_{Dmax,d} \cdot F_{ct}}, \quad kWh \tag{8}$$

$$C_{ndAh} = \frac{C_{nd}}{V_{bat}}, \quad Ah \tag{9}$$

where: $P_{Dmax,d}$: Depth of discharge daily maxim of the batteries; C_{ndAh}: Nominal capacity of the battery in function of the maximum daily discharge, Ah.

After certain the nominal capacity of the batteries in function of the values of discharge stationary and daily maxim, takes that of more value and it is divided by the nominal capacity of current of one of the batteries, to obtain the number of these necessary one:

$$N_{bat} = \frac{C_{nAh}}{C_{nAh,bat}} \tag{10}$$

Sizing of the regulator and the investor

To determine the capacity of the regulator, they must determine you the current to their entrance and their exit. So:

$$I_{ent} = \left(1 + F_{seg}\right) \cdot N_r \cdot I_{mod,sc}, \quad A \tag{11}$$

where: F_{seg}: Factor of security to avoid occasional damages to the regulator; Nr: Number of branches in parallel; $I_{mod,sc}$:: Unitary current of the photovoltaic module under short circuit conditions A.

$$I_{sal} = \frac{\left(1 + F_{seg}\right) \cdot E_{md,max}}{\eta_{inv} \cdot T_{tpc} \cdot V_{bat}}, \quad A \tag{12}$$

where: $E_{md,max}$: Consumption maximum of the load; T_{tpc}: Time of maxim demands of the load, h.

Mascaros (2015), he/she refers that for the determination of the investor's power required for the installation you proceeds according to:

$$P_{inv} = \left(1 + F_{seg}\right) \cdot P_{AC}, W \tag{13}$$

where: $P_{AC} -$ Power of outburst, W

Alonso (2011) it outlines that many of the appliances and teams that have motors have current picks in the outburst. It supposes it that these devices, in the moment of the outburst, will have a demand of more power that the nominal one, in occasions of until 4 or 5 times more than the one foreseen. Hence, it is convenient to consider in the investor's sizing, the effect of the picks of the outburst of the motors whenever it is necessary to guarantee a satisfactory operation of the installation.

When a solar photovoltaic park is used he/she is taking advantage in an efficient way a clean, renewable and sure energy. Being contributed directly in the reduction of causing gases of effect hothouse of the climatic change, and he/she improves in a significant way the quality of the air, since it diminishes the use of fossil fuels significantly. Product to the ones exposed it becomes necessary to know how much it is stopped to consume in fossil (avoided monthly number of kWh of electricity and yearly) energy with the implementation of this solar photovoltaic park (Canvi Climatic, 2011).

Starting from the use of these solar photovoltaic parks certain quantity of electric power is saved reason why in one month:

$$Q_{CM} = E_{md} \cdot D_m, \quad kWh \tag{14}$$

where: : Days that he/she has one month.

Being the energy saved in one year:

$$Q_{CA} = 12 \cdot Q_{CM} D_m, \quad kWh \tag{15}$$

For the determination of the cost of the energy saved in one year, that settled down by Bolaños (2021), was considered, where the electric rates settle down in Cuban (peso) pesos for the collection of the electric service. In the specific case of the system of rates for high tension with continuous activity, specifically the one that responds to the energy consumed during the schedule of the day. Being the cost of the energy saved in one day:

$$C_{día} = (a \cdot K + b) \cdot Q_{cdía}, \quad peso/día \tag{16}$$

where:

a, b: Coefficients to apply according to the rate (1,5282 and 0,7273 respectively) type, peso/kWh;

K: Factor of adjustment of variation of the price of the fuel;

Q_{cdia}: Energy consumption in one day, kWh / day.

In a similar way, you can determine the cost of the energy saved in one year according to:

$$C_{año} = (a \cdot K + b) \cdot Q_{CA}, \quad peso/año \tag{17}$$

where: Q_{CA},: Energy consumption in one year, kWh/year

Methodology for the determination of solar heaters

To determine the quantity of solar heaters that you/they should settle, it becomes necessary to know the consumption of water that it demands the installation through the following expression:

$$C_{H_2O} = \frac{N_{C(H_2O)} \cdot C_{hd} \cdot W}{100}, \quad L \tag{18}$$

where: $N_{C(H_2O)}$: Norm of consumption of water, L / animal; C_{hd}: number of animals in the flock or people in the housing; W: percentage of occupation of the location,%.

In Cuba the solar half radiation per day, in the months of November to February, is 4200 kcal/m2; being this period of smaller heatstroke in the year. A heater of tubes to the hole of 200 L of capacity, it can give, I lower these conditions, around 300 daily L of hot water at 50ºC.

It is valid to point out that this technology can also favor to the family that resides in the cattle scenario, where in general, in the specific case of the Cuban families, these they have customs of carrying out alimentary several activities throughout the day, (considering breakfast, lunch and food) more the hot water to scrub the china, with a norm of 20 L for person with a temperature of 55ºC (Bérriz & Álvarez, 2014; Aguilera, 2021). The demand of hot water of a location you can determine according to:

$$C_{H_2Oc} = \frac{N_{C(H_2Oc)} \cdot C_{hd} \cdot W}{100}, \quad L \tag{19}$$

where:

$N_{C(H_2Oc)}$: Norm of consumption of hot water, L/ person or L/animal;

Knowing the quantity of water that it demands a location, you can calculate the quantity of necessary heaters to satisfy the necessities of the same one, according to the expression:

$$N_{cs} = \frac{C_{H_2Oc}}{C_{ae}} \tag{20}$$

where: N_{cs}: Quantity of water that he/she gives a heater with a certain heatstroke, L/day.

According to Canvi Climatic (2011), to determine the energy that demands to heat the water (QC) to use, it is needed to keep in mind the jump of temperature, of 15 ºC to 50 ºC, so:

$$Q_c = K_{CU} \cdot m \cdot C_e (T_f - T_i), kWh \tag{21}$$

where: K_{CU}: 3,6 × 106 J/kWh; *m:* mass of water, kg; C_e: specific heat of the water, 4187J/ºC×kg; C_e: initial temperature, ºC; T_f: final temperature, ºC.

With the use of these teams of heating of water certain quantity of electric power is saved reason why in one month (QCM):

$$Q_{CM} = Q_c \cdot D_m, \quad kWh \tag{22}$$

where: D_m: days that he/she has one month.

Being the energy saved (QCA) in one year:

$$Q_{CA} = 12 \cdot Q_{CM} \tag{23}$$

RESULTS AND DISCUSSION

Technician-economic valuation of the introduction of the solar photovoltaic energy under the conditions of the system of poultry production

For the realization of the proposal of a solar photovoltaic system in areas of the system of poultry production, they are considered the solar panels marketed by the Cuban company COPEXTEL. The technical corresponding data are shown in the Table 3.

Also, the batteries Trojan was selected whose technical data are shown in the Table 4

For this proposal one also kept in mind the investor that COPEXTEL markets, with a power 20 bigger% to the defendant for the team.

In this case it is not considered the employment of a regulator of pursuit of the maxim point it develops the photovoltaic systems that include it, since they constitute systems that improve the efficiency of the installation between 10 and 25%. The fundamental problem of these regulators resides in its high cost for facilities of small and medium behavior. In the case of the proposal, for the energy volume to generate would require a regulator of great capacity with capacity of pursuit of the maxim point it develops that would elevate the total cost of the installation at least in 30 and 40 more alone% for this concept.

As it is evidenced in the Table 6, for concept of reduction of the fossil fuel not required for the production of the electric power and the mass of CO_2 emitted to the medioambiente the economic and environmental feasibility of the introduction of the photovoltaic system it is demonstrated in the investigated system of poultry production.

Technician-economic valuation of the introduction of the solar thermal (heaters and solar dryers) energy under the conditions of the system of poultry production

For the determination of the technology of solar heaters under the conditions of the system of poultry production of the Farm "Guayabal", one kept in mind the quantity of heaters that you/they should be used for the correct sanitation of the workers.

Before proceeding to the mentioned determinations, one should know the quantity of hot necessary (norm of consumption of water) water for workers, data that are reflected in the Table 7.

TABLE 3. Technical data of the solar panels marketed by COPEXTEL

Parameter	Specification
Power pick of the module under standard conditions,	270
Maximum voltage of the module,	$55,10$
Current of short circuit of the module,	$5,30$
Current unitary maxim of the module,	$4,9$
The investor's yield	$0,9$
Yield of the drivers	1
Yield of the batteries	$0,95$

TABLE 4. Technical data of the batteries Trojan proposed monoblock

Parameter	Specification
Depth of Discharge Seasonal Maxim, %	70
Depth of Discharge Daily Maxim, %	15
Yield	$0,9 \quad - \quad 0,95$
Voltage,	12
Current capacity,	240

TABLE 5. Sizing of the photovoltaic total solar system and for the three species settled down in the poultry system and economic analysis of the proposals

Parameter	Symbol	Value
Half daily consumption in the whole installation	$L_{mdn}, \ kWh$	50,28
Daily half consumption of current in the whole installation	$Q_{Ah}, \ Ah/día$	52 92
Current that should generate the photovoltaic field in the critical month of solar radiation	$I_{gfv,mpp}, \ A$	10 584,4
Total of solar panels	Np	160
Total of photovoltaic modules	Nm	40
Required area	Ar, m^2	124,24
Energy to take place with the photovoltaic system	$Ep, \ kWh$	1 192,7
Investment Cost	$C_{inv}, \ peso$	487 026.21
For systems of hens Leghorn White		
Half daily consumption of the installation	$L_{mdn}, \ kWh$	15,06
Daily half consumption of current	$Q_{Ah}, \ Ah/día$	15 842
Current that should generate the photovoltaic field in the critical month of solar radiation	$I_{gfv,mpp}, \ A$	3 168,4
Total of solar panels	Np	44
Total of photovoltaic modules	Nm	11
Required area	Ar, m^2	33,31
Energy to take place with the photovoltaic system	$Ep, \ kWh$	319,77
Investment Cost	$C_{inv}, \ peso$	130 576.6
For systems of production country hens		
Half daily consumption of the installation	$L_{mdn}, \ kWh$	0,65
Daily half consumption of current	$Q_{Ah}, \ Ah/día$	688
Current that should generate the photovoltaic field in the critical month of solar radiation	$I_{gfv,mpp}, \ A$	137,6
Total of solar panels	Np	20
Total of photovoltaic modules	Nm	5
Required area	Ar, m^2	14,48
Energy to take place with the photovoltaic system	$Ep, \ kWh$	139,03
Investment Cost	$C_{inv}, \ peso$	56 772.41
For systems of production of turkeys		
Half daily consumption of the installation	$L_{mdn}, \ kWh$	34,57
Daily half consumption of current	$Q_{Ah}, \ Ah/día$	36 392
Current that should generate the photovoltaic field in the critical month of solar radiation	$I_{gfv,mpp}, \ A$	7 278,4
Total of solar panels	Np	96
Total of photovoltaic modules	Nm	24
Required area	Ar, m^2	76,45
Energy to take place with the photovoltaic system	$Ep, \ kWh$	733,90
Investment Cost	$C_{inv}, \ peso$	299 677.2

[*] peso: he/she refers to the national (MN) currency, it is considered the rate of change 25 MN = 1 USD

TABLE 6. Results of the half environmental impact as consequence of the proposed installation

Parameter	Dear value
Left electric power of consuming, kW/day.	42,44
Saved electric power, kWh/year.	99 046,18
Mass of left CO_2 of emitting to the atm, t//year	1 591,5
Mass of fossil fuel to produce electricity, t//year	79,2

TABLE 7. Quantity of hot necessary water in the productive scenario

Cant. of workers	It demands of water for the sanitation $N_c(H_2O)$, L	% of occupation in the location
5	20	100

As you he/she can observe in the Table 7 in the system poultry study object it is necessary a total of 20 liters of hot water for the correct sanitation of the workers, being considered that you/they are five workers in that area, that which makes a total of 100 L/day.

For the realization of the proposal of heaters, those were used from tubes to the hole, since they are those more marketed in the country and their conditions are suitable for the productive scenario as you can appreciate in the Table 8

Being already known the quantity of water defendant in the area (Table 7) and the supply of hot daily water of the heater (Table 8) he/she intends the introduction from a single heater of tubes to the hole which can satisfy the demand of hot necessary water in the scenario study object.

To have a dear of the cost of the constructive process and of installation of the solar heater of tubes to the hole (without considering the manpower), in the Table 10 are related the materials required for the installation of the technology.

In the case of the technician-economic valuation of the employment of solar dryers it is not considered necessary this technology under the conditions of the poultry system, belonging to the University Farm "Guayabal", since in this productive unit it is focused in the production of eggs or meat and any type of food animal is not processed in the one that the solar drying is required.

As you he/she can observe in the Table 5 and 10, if it is considered the investment required for both technologies, which ascends at 487 026.21 peso, being reached a total value of 496 676.21 peso and this is analyzed in function of the production average of eggs that ascends to 252 units/day and the price of the egg is equivalent to 2.20 peso/unit, then it is possible to collect 554.4 peso/day (16 632 peso/month), for what is possible to collect annually an I mount of 199 584 peso, this way it is demonstrated that the total investment is possible to recover it in a 2,5 year-old period.

TABLE 8. Technical data of the heater of tubes to the hole

Capacity of the heater, (L)	Give from hot daily water to 50^{o}C, (L/day).
200	100

TABLE 9. Contribute energy of the heater of tubes to the hole to obtain with the installation of the technology

Save Potential Energy	
Electric power , kWh/day	5,341
Electric power kWh/year	1 949,465
Mass of left CO_2 of emitting to the atm , t/year.	200,29
Mass of fossil fuel to produce electricity t/year.	0,97

TABLE 10. Lists of costs from the installation of solar heater of tubes to the hole

Materials	UM	Quantity	Price unitary, peso/u	Cost, peso
Module of solar heater	u	1	6 000	6 000
Tank of 55 gallons	u	1	2 500	2 500
Pipes for reception and conduction of the water	Accessories: Unions, elbows, cleaner and paste PVC, closing valves (the quantity varies in function of the distance)		550	550
Pipes for supply of water	Tubes of 13,75 mm (0,5”) (2): 5 m/cu		300	600
Total				**9 650**

* peso: he/she refers to the national (MN) currency, it is considered the rate of change 25 MN = 1 USD

CONCLUSIONS

- The proposed theoretical-methodological foundations made it possible to determine the feasibility of the introduction of solar energy (thermal and photovoltaic) in the conditions of the poultry production system of the "El Guayabal" University Farm.
- Starting from the energy-productive diagnosis of the system of production poultry study object, it was determined that with the installation of a hybrid system conformed by a photovoltaic isolated system and a solar heater, it could cover the energy demand of the scenario.
- It was determined that the installation of a solar dryer doesn't proceed; because it is not required of the drying or dehydration of agricultural productions for the feeding of the poultry species that you/they settle down in this scenario.
- The total (installation and assembly of a block of photovoltaic isolated panels and a solar heater) investment recovers in a 2,5 year-old period

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