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Economic Analysis of Insulation of a Broiler Breeding Hall

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Abstract: One of the methods to optimize energy consumption in the broiler industry is to insulate the roof and walls of the poultry hall. Economic analysis of this optimization method guarantees its applicability. Accordingly in this study considers heat loss by considering a sample broiler breeding hall. The roof and its walls are calculated in insulated and uninsulated. Due to heat loss the amount of fuel needed for it, is obtained. The results of this study show that the insulation of this chicken hall in Iran due to the cheapest price of natural gas in the world is not completely economical. In the Iranian broiler industry, about sixty percent of the total annual consumption of natural gas (eight hundred and forty million cubic meters) is related to the heat loss of poultry walls by insulating the roof and walls of poultry halls. This amount of fuel is reduced to two hundred and ten million cubic meters per year. The price of fuel saved due to poultry farming insulation in the whole country, based on the global rate, is equal to two hundred and sixty-five million U.S dollars. If the government pays this amount in the form of grants to subsidize poultry farmers, the industry will not have to burn the same amount annually.

Keywords: Energy Optimization, Broiler, Insulation, Economic Analysis

1. Introduction

High fuel consumption in the poultry industry has led to energy efficiency optimization methods be considered. On average in Iran, 1.2 liters of fossil fuel is consumed each chicken production which is not economical caused by the high cost of energy carriers. Studies on energy efficiency in the broiler industry show that the main reasons energy losses in this industry are low efficiency of heating equipment used, inadequate ventilation system of the halls Poultry farming and non-insulation of chicken buildings [1, 2].

Research on heating equipment use in this industry shows that the adjustment some variables such as preheating temperature and adjustment the air being ventilated based on daily and seasonal temperature changes in the air, causes a reduction in energy consumption [3]. The treatment of hot and polluted air leaving the poultry house and returning it to the hall has also been considered by researchers [4]. The use of solar energy shows that reduces in fuel consumption in meat chickens where in cold regions about 25 percent and in temperate regions about 30 percent, reported [5]. The use of radiant heating systems in broiler farms can reduce lead energy consumption. Intelligent control of heating systems used in the broiler industry can also be optimized build energy consumption. The required standards for insulation of various buildings are available, but there is cheap fuel in Iran and binding laws in this field have not caused the broiler industry to pay attention to the insulation of breeding halls. Accordingly, in this research, energy consumption optimization, based on thermal insulation of the walls of a chicken breeding hall and its economic aspects are analyzed. Heat loss from the ceiling and walls of this model's breeding room, it is calculated and the amount of fuel consumption is compared in cases before and after insulation. Economic reason of this method of optimizing energy consumption is done by comparing the cost of insulation with the reduction in fuel costs.

2. Material and Method

The surface area or wall area of a broiler breeding hall will be the total length of the exterior walls multiplied by the height of those walls, minus the square footage of the doors and windows in that wall. Heat loss for the doors and windows should be figured separately. The air infiltration heat loss is uncontrolled heat loss by ventilation. This figure is affected by air pressure differentials between the outside

and interior of the hall which causes air to move inside the hall, thereby producing heat loss as that air escapes the broiler breeding hall. Heat transfer is equal to [6]:

$$H = \frac{A(T_A - T_B)}{R} \quad (1)$$

Where H is the amount of heat transferred, either lost or gained, through the material separating both sides (W), A is the surface area of the material separating the two areas that are at different temperatures, it's the material that the heat is being transferred through (m^2), T_A is the larger of the two temperatures on both sides of the separator (K), T_B is the smaller of the two temperatures on both sides of the separator (K) and R is the R-value of the separating material (m^2K/W). The R-value is the resistance to the movement of heat through the separating material. The total heat loss of a building consists of several modes, heat loss due to transmission through walls, windows, doors, floors and more, heat loss caused by ventilation and heat loss caused by infiltration.

2.1. Specifications of Sample Broiler Breeding Hall

The basic information needed to estimate the heat loss of a broiler house is:

The average outdoor temperature outside the poultry house in winter is -5°C and the average indoor air temperature is 18°C. Dimensions of a standard poultry house, for breeding 10000 broilers is 10 m wide, 100 m long and 3 m high.

The poultry building has a wall with a thickness of 35 cm made of brick and cement, which has a coefficient of thermal conductivity 1.035 W/m K [7].

The roof of the poultry hall is made of pressed brick with a thickness of 12 cm with a layer of plaster 1cm below it and a layer 2 cm of cement and a layer of moisture insulation are formed on it. The coefficient of thermal conductivity of the whole roof is equal to 2.8391 W/m K [8].

2.2. Assumptions Made in Calculate Heat Loss

1. The walls of the poultry house are connected to the open air on all sides.
2. Heat losses are calculated only for ceilings and walls, for a period of two months (or a period of broiler breeding).
3. Insulations used for this poultry hall are polystyrene type, with a thickness of 5 cm and a thermal conductivity 0.2622 W/m K [9].

3. Result

Heat loss of walls and ceiling of sample broiler breeding hall, in uninsulated and insulated state is presented in Table 1.

Table 1. *Heat loss of walls and ceiling during a two-month breeding.*

	Heat loss, GJ		Deference, %
	uninsulated	insulated	
Roof	490.104	112.724	76.9
Walls	194.038	64.679	66.7
Total	684.142	177.403	74

In Figure 1, heat losses of this poultry house are compared in insulated and uninsulated cases.

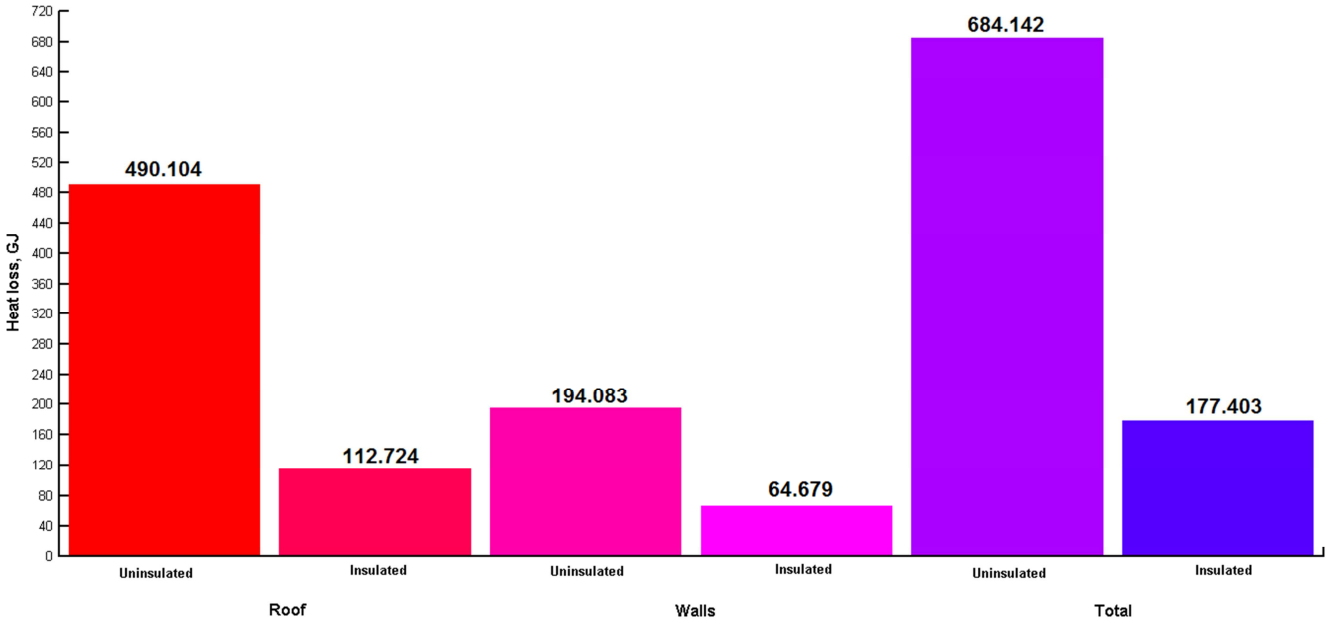

Figure 1. *Thermal losses of roof and walls in insulated and uninsulated condition during a two-month breeding.*

Considering that the calorific value of natural gas depends on the city and the pipelines, so the value can differ from 34 to 52 MJ/m^3 in Iran and its specific volume is equal to 1110 to 1430 liter/kg [10]. So, the fuel required to reward for heat loss of the ceiling and walls, in insulated and uninsulated during a two-month breeding period are shown in Table 2 and Figure 2.

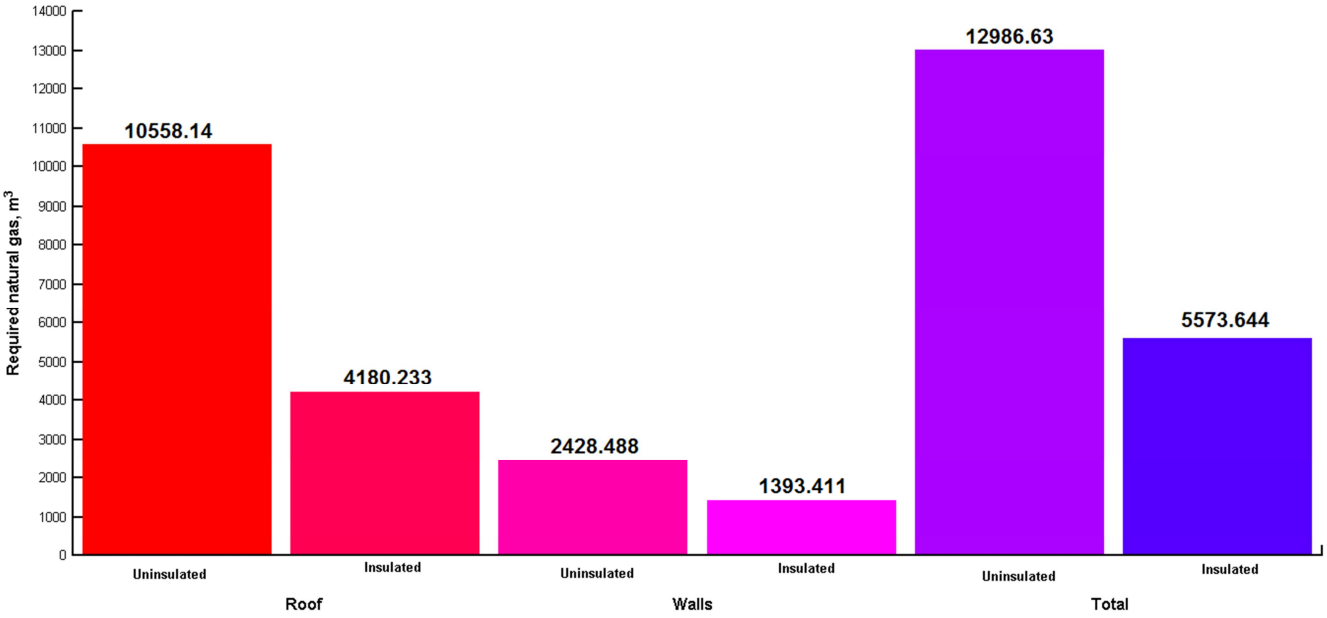

Figure 2. *Natural gas required for heat loss of roof and walls of poultry, in insulated and uninsulated, within two months.*

Table 2. *Natural gas required for heat loss of roof and walls of poultry, in insulated and uninsulated, within two months.*

	Roof, m^3	Walls, m^3	Total, m^3
uninsulated	10558.14	2428.488	12986.63
insulated	4180.233	1393.411	5573.644
deference	6377.907	1035.077	7412.984

4. Results

(1) According to Table 1, the heat loss of a poultry roof is more than twice the heat loss of its walls, while the area poultry hall ceiling (1000 m^2) is about one and a half times the wall area (2×330 m^2). The reason for this is the thickness; it has less poultry roof than its walls.

(2) According to the figure 1, the heat loss of the insulated roof and poultry walls is about 25 percent of the amount in state without insulation.

(3) Table 2 show that the insulation of the broiler room sample breeding hall reduces the required natural gas from 12986.63 to 5573.644 cubic meters for two months.

(4) Economic Comparison.

Considering that about sixty percent of the total heat loss of the sample poultry house is related to the walls and ceiling of the hall, Therefore, the insulation of this hall is a priority and its economic analysis is a comparison of the cost of insulation of walls and ceilings with the cost of saving on fuel consumption.

The area of the walls and ceiling of a standard hall for raising 10000 chickens is equal to 1660 square meters, which includes 1000 square meters of roof and 660 square meters of walls. Insulation cost related to these walls using the best type of polystyrene insulation with a thickness of 5 centimeters with 1150000 Rials (about 4.5 US dollar) per square meter [11] is about 2000 million Rials. The amount of natural gas saved by this insulation, according to Table 2 is 7412.984 cubic meters in two months, which is based on 690 Rials per cubic meters in cold seasons for agricultural consumers [12], its value is equal to 5114959 Rials (about 20 US dollar). Comparing these two numbers, due to the cheapest natural gas prices in Iran compared to the rest of the world it can be seen that the total costs of insulation of a 10000 poultry farm cannot be recouped during broiler breeding periods. Normally, each broiler farm has four two-month periods of activity in one year and between each period of activity is also one month there is time to clean up and start reactivating. Therefore, the cost of insulation of a sample poultry house, based on price each cubic meter of natural gas costs 690 Rials (0.003 U.S. Dollar) for a minimum of 15 years can be recouped. The world average price of natural gas is 0.42 U.S. Dollar per cubic metersin 2021 for business users [13]. This means that with the global average price of natural gas, the return on insulation costs will be reduced to six month.

5. Conclusion

Payback period related to poultry hall insulation with 690 Rials natural gas is much time (years) so that this low natural gas price, is not economical. Comparison of the price of natural gas in Iran with its global average price shows that the real price of natural gas is more than 140 times. Therefore, the actual cost of fuel related to the heat loss of the walls of a poultry house is much higher than what is even due to the Iran price of natural gas and this makes insulation economically necessary. In the Iranian broiler industry, about sixty percent of the total annual consumption of natural gas (eight hundred and forty million cubic meters) is related to the heat loss of poultry walls by insulating the roof and walls

of poultry halls. This amount of fuel is reduced to two hundred and ten million cubic meters per year. The price of fuel saved due to poultry farming insulation in the whole country, based on the global rate, is equal to two hundred and sixty-five million U.S dollars. If the government pays this amount in the form of grants to subsidize poultry farmers, the industry will not have to burn the same amount annually.

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