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Thème

Study of a HVAC system for energy-efficient poultry houses in Arid Zone

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DEDICATION

The search locomotive passed many obstacles, but we tried to overcome them steadily, thank God and from Him.

To our fathers, brothers and friends, because they were the supporters to complete the research.

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We ask God Almighty to make this graduation a good beginning for us and to grant us halal provision and to guide us in our professional path.

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INTRODUCTION

General Introduction :

The globe has experienced an aggravation of global environmental concerns since the end of the twentieth century and the beginning of the twenty-first century, arguably the most notable of which is the phenomena of global warming and climate change. Many publications point to the significance of traditional energy sources (fossil fuels) in these alarming statistics, which anticipate the worst if no structural changes to the energy paradigm are made, particularly in developing nations [1].

Renewable energy sources including wind, solar, and hydrogen power are better for the future. Geothermal energy is a type of renewable energy that is taken from the earth and utilized for a variety of purposes including heating, cooling, bathing, and medicinal uses. It is also one of the few renewable energies capable of producing power continuously 24 hours a day, and under the correct conditions, it may be cost-competitive with coal or natural gas, allowing countries to lessen their reliance on fuel imports and boost their energy security. Deep geothermal resources are widespread around the globe, and they may be exploited repeatedly while remaining ecologically benign and efficient[1].

Renewable energy is derived from renewable resources that are renewed naturally on a human timeline. Sunlight, wind, rain, tides, waves, and geothermal heat are all examples. [1] In contrast to fossil fuels, which are depleted significantly faster than they are regenerated, renewable energy is rapidly renewed. Some renewable energy sources are not sustainable, despite the fact that the majority are. Some biomass sources, for example, are deemed unsustainable at current utilization rates. [2] [3]

Geothermal HVAC refers to geothermal heating, cooling and ventilation. Geothermal HVAC uses energy stored in the ground to heat and cool your home. That way, heating, ventilation and air conditioning benefit from the free and renewable geothermal energy[4].

Geothermal HVAC is part of the geothermal heating system along with:

- The ground source heatpump
- The underground heat exchanger (loop system)

In this research, we will address a study that enables us to exploit geothermal energy in creating a system that allows heating, ventilation, and air conditioning and the distribution of heat in an ideal and uniform manner inside poultry houses at lower costs and good returns[4].

The objective of our work is to Study of the heating, ventilation and air conditioning system produced or exploited from geothermal energy and the method of using this system in poultry houses located in arid areas In four main chapters :

- In the first chapter there will : Literature review on Broilers and its housing and information about the breeding regime and details about the operation techniques, what interventions are planned.
- The second chapter will : a detailed estimation for the Broiler needs in terms of temperature, ventilation, lighting according to its life daily and season to be done.
- The third chapter will :the construction characteristics (geometrical characteristics, size and position of openings, construction materials and insulation etc...)
- In the fourth and final chapter, I willthe installed equipment which consumes energy (the kind of the equipment, the power, the number of identical devices, the efficiency performance coefficients, the position where is sited inside the farm and finally the operational characteristics) and Thermal and air quality demands of poultry houses.

CHAPTER 01

Literature review on Broilers and its housing

I.1 Introduction :

According to the International Energy Agency (IES), fossil fuels produce 81 percent of the primary energy required worldwide. Despite the fact that fossil fuels are rapidly depleting, their consumption has increased dramatically as a result of technological advancements. This has resulted in severe environmental consequences such as acid rain and global warming. [4] Many developed and developing countries are taking steps to improve building energy efficiency through a variety of sustainable solutions; however, despite the promise of globally abundant renewable energy resources, the poultry industry continues to rely on fossil fuels to meet its heating and cooling needs [6].

In the livestock sector, classification and general guidelines suggest that an optimal moisture rate and litter are critical for health and welfare in chicken management. [5] Heat stress is one of the most major environmental stressors that chicken producers face, particularly during the summer. Heat stress can kill birds if their body temperature rises more than 4°C over their normal temperature of 41°C. [6] [7] This has a significant influence on broiler production, resulting in both energy and financial losses for the livestock business. Heat stress in chicken houses, for example, is projected to cost between $127.3 and $164.6 million per year in the United States, accounting for 7.0 to 7.5 percent of overall livestock sector losses [8] [9].

To ensure the wellbeing of hens, breeders should use the proper management plan. The thermo neutral zone at the ideal temperature for hens, as shown in Figure 1, varies with their age. [6] While there is law for European poultry producers on bird density stocking, this rule does not include the wellbeing of the hens in the building or other issues that might lead to inadequate poultry management. [8] In cold regions, the most typical ventilation systems feature merely a minimum ventilation level controlled by a timer system, with 0.5 m/s air velocity. [10] [11]

On the other hand, the field of poultry farming in Algeria and near El-Oued still suffers from some problems, especially in providing appropriate conditions such as heating, ventilation, air conditioning and lighting, where breeders still rely on traditional methods (fossil fuels and gas) to provide them.

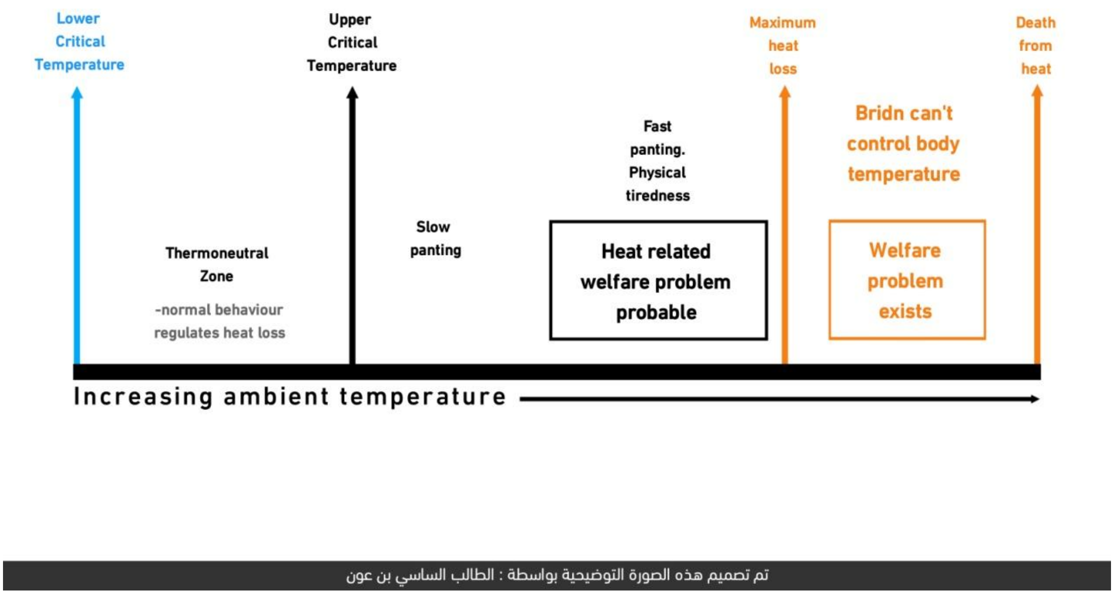


Figure I.1: Thermoneutral zone diagram [6].

I.2 poultry houses :

Poultry housing design is critical in determining the inside climatic conditions of the home for the birds' health, development, and productive performance. As a result, the planned poultry farm's chicken housing system is determined by the prevalent climatic conditions in the region where the farm is located. While the open poultry house system has been deemed a suitable form of housing in tropical nations due to its ease of building, ease of heat management, and low management costs, the controlled poultry house system is the most frequent in temperate locations. [12] [13] [14]

Figure I.2: poultry houses[12].

I.3 Poultry birds and their thermoregulatory mechanism :

Birds are flighty feathered oviparous animals with a high metabolic rate and a typical breathing rate of 40–50 breaths per minute [15]. Birds have an internal body temperature of 39 to 42.2 degrees Celsius on average [16] [17] [18]. In hot weather, poultry birds maintain thermo-neutrality by losing heat mostly by conduction, convection, radiation, and evaporative cooling [5] [19] [20].

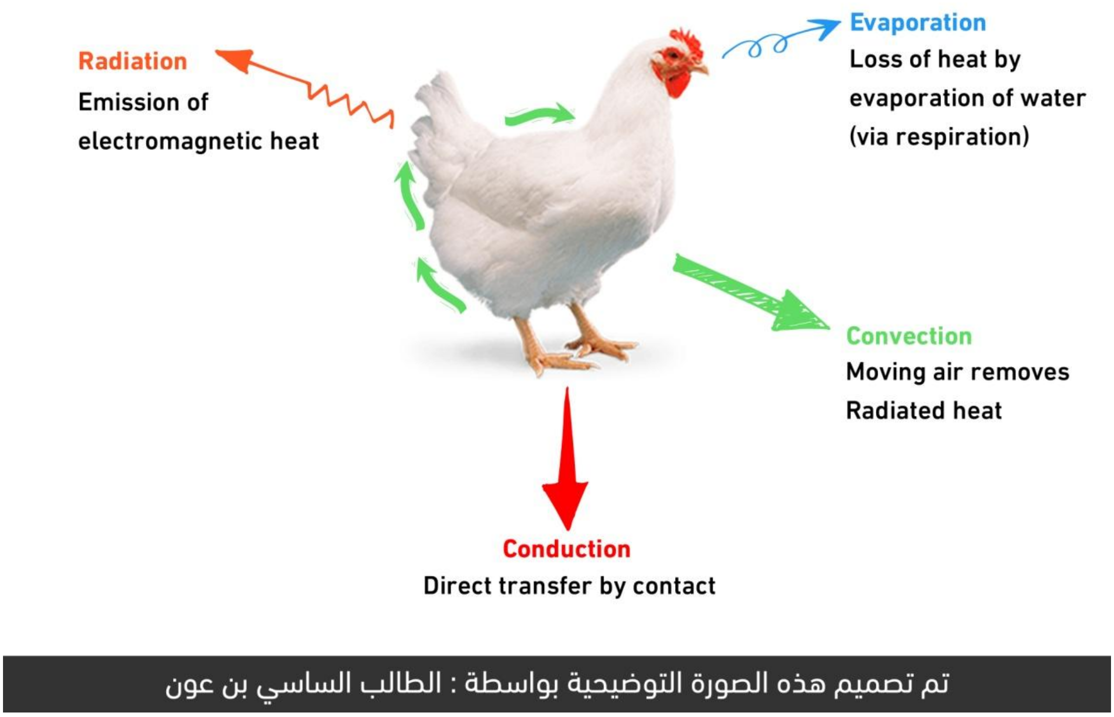


Figure I.3: Poultry thermoregulation mechanism.

Sensible heat loss via convection, radiation, and conduction works best when the ambient temperature is below or within the Thermoneutral zone of the bird. Within the thermoneutral zone, however, evaporative cooling contributes for around 60% of the heat released during body temperature regulation [5]. Heat loss through open surfaces such as wattles, shanks, and other featherless areas around the neck and wings is considered sensible [21]. This method of heat loss for body temperature regulation has no effect on the bird's behavior, feed intake, or metabolic [22]. The efficiency of sensible heat loss is determined by the temperature differential between the bird and its surroundings.

When the ambient temperature rises over 24°C, evaporative cooling (latent heat loss) becomes the primary route of heat dissipation in birds of all ages [21]. When the bird loses heat by evaporative cooling at temperatures above the thermoneutral zone, the energy necessary for growth and development must be redirected to panting. Panting, on the other hand, can cause dehydration and respiratory alkalosis due to insufficient water delivery and a reduction in blood pH due to excessive carbon dioxide ejection [21]. Evaporative cooling happens when water evaporates from the bird's respiratory system while panting. However, extreme humidity might make this difficult.This is a concern in high-humidity areas, where chicken producers use evaporative cooling as their major means of reducing air temperature throughout the summer [5].

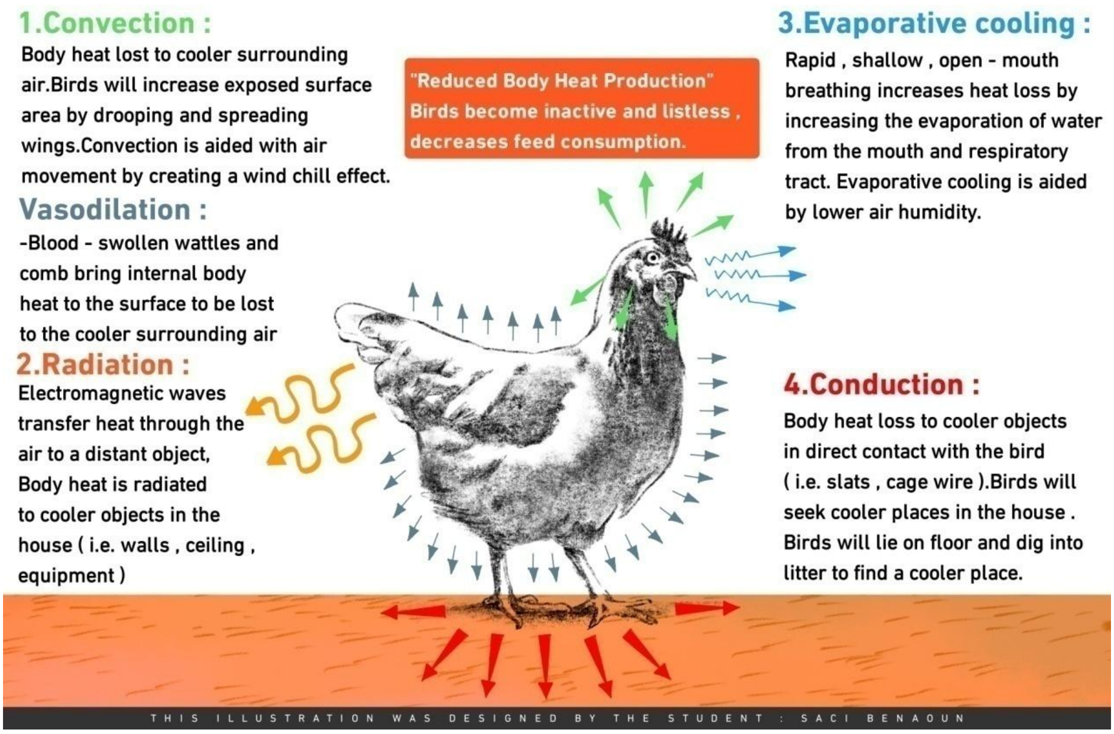


Figure I.4: thermoregulation.

Heat loss in birds owing to convection, evacuation of heat trapped within the chicken house, and decrease of the effect of high humidity on evaporative cooling are all improved by increasing the volume and velocity of air moving over birds [5]. Simmons et al. [23] did a research in which 3 week old male broilers were exposed to a cyclic temperature of 25–30–25°C in a controlled setting for 4 weeks at various wind speeds of still air (0.25 m/s), 2 m/s, and 3 m/s. The higher wind speed benefitted older birds in terms of growth and development.

Water is a valuable commodity in chicken production because of the minerals it contains and the influence it has on feed consumption [24]. Nipple drinkers have replaced the traditional open water system to give cleaner water, decrease water leakage, and labor for drinker cleaning. May et al. [25] found that chickens reared with a standard open water system ingested more water than those reared with a nipple drinking system in an experiment.However, when these drinkers were utilized to grow chicken in a controlled environment with air velocity of 0.25 and 2.1 m/s, birds on nipple drinkers gained more weight and had greater feed conversion than those on open water drinkers [26]. As a result, it's critical to supply and maintain adequate ventilation in the poultry house so that the birds may control their body temperature through sensible heat loss.

I.4 Heat stress in chicken :

Heat stress is a common concern in the poultry business, particularly in the meat and egg production. When the ambient temperature reaches or exceeds 26.7°C, chickens suffer from heat stress. Birds begin to pant at this temperature and above, which can be damaging to the bird's optimal development rate, hatching ability, egg size, egg shell quality, and egg output. When the humidity rises in a hot setting, the problem of heat stress might become much worse. Heat stress has been linked to decreased comfort, growth rate, feed conversion, and live weight gain in broilers [21].

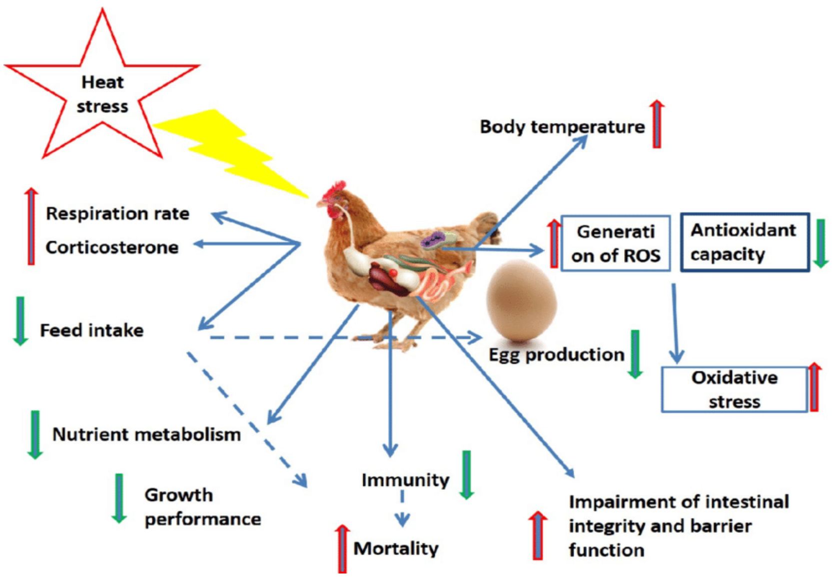


Figure I.5: Heat stress in chicken[21].

Acute heat stress refers to the quick exposure of birds to high temperatures for a short period of time, whereas chronic heat stress refers to prolonged exposure. Birds raised in open-sided huts, which are often utilized in the tropics, suffer from chronic stress. In broilers, laying hens, and breeders, it has been found to have a negative impact on growth and production efficiency, egg quality, meat quality, embryonic development, reproductive performance, immunity, and illness incidence [21, 27, 28, 29, 30, 31].

I.5 Effects of internal climate conditions on chicken :

It's critical to comprehend the impact of a poultry house's indoor climatic conditions on birds, how birds react to them, and how heat management for poultry production is affected. The data will help with architectural design requirements for an open-air poultry house that will decrease heat stress and assure optimal chicken production in dry areas. Temperature, relative humidity, air composition, speed, and lighting conditions are all important climatic aspects to consider.

I.5.1 Temperature :

The best temperature range for various classes and age groups of chicken to achieve optimum output is a hot topic of controversy. This might be due to other environmental parameters like humidity and wind speed, which impact temperature change and chicken response to past climate change. Chickens do well in a wide variety of temperatures, independent of their breed or age (broiler, pullet, or breeder). High temperature exposure, on the other hand, has been shown to reduce chicken production performance [17]. It might be exacerbated by higher relative humidity, which has a detrimental effect on evaporative cooling [32].

For day old chicks, Ketelaars [16] advised a temperature of 30–32°C at chicken height. As demonstrated in Table I.1, the temperature should be reduced by 3–4°C until the chicks are 4 weeks old. Growing broilers requires a temperature range of 18–22°C, according to Daghir [19]. Holik [15] observed in previous reviews that birds are most comfortable when the temperature is between 18 and 24 degrees Celsius. However, the best performance of chicken is determined by the market value of the product in proportion to the cost of feeding.

The table below represents (Table 1) the recommended temperature for poultry farming in the El-Oued area.

Table I.1 : Recommanded température Schedule.

Age of chicken (week)	Température range (°C)
1	30-32
2	30-26
3	26-23
4	23-20
25	20

Maintaining the ideal production temperature in the tropics is difficult, thus the poultry house designer must pay close attention to temperature variation.

I.5.2 Relative humidity :

Internal temperature exceeding 26.7°C mixed with high relative humidity significantly reduced feed efficiency, feathering, pigmentation, and weight increase in chickens, according to Oloyo [17]. Furthermore, independent of the change in relative humidity, the birds' performance was poor at an internal temperature range of 35–37.8°C. This suggests that increased humidity can help birds perform better at lower temperatures. Humidity, on the other hand, must be managed since it might offer home for microbes, putting the birds at risk of sickness [18, 33].

Temperature and relative humidity have a close connection. Internal relative humidity may be low or excessively low during the brooding period, particularly in the early weeks, due to the heat the chicken requires at that age or when the chicks are thirsty or born at a warmer temperature. The water vapor released by the evaporative cooling process of chickens to maintain their body temperature as they grow causes the internal relative humidity to rise quickly [16]. As a result, regardless of the bird class, the third week and beyond are key stages in chicken production.

According to Oloyo [17], laying birds require relative humidity levels of 60–80 percent during brooding and 50–70 percent following brooding for optimal success.

I.5.3Air composition :

The breakdown of bird feces creates noxious and polluting gases such as ammonia, carbon dioxide, methane, and hydrogen sulphide, among others. Because of their negative effects on the performance of birds, cages, human poultry homes, and the environment in general, these gases are of special concern [16, 18, 34, 35, 36, 37, 38]. As a result, for optimal chicken production, ammonia and carbon dioxide concentrations of 25 ppm and not more than 2500 ppm were suggested [18, 39]. Removal of fecal waste from the poultry house should be done often to limit the amount of gas emission for optimum bird health management [17].

Figure I.6: Air installation in poultry houses.

The air composition changes in an enclosed structure where poultry is confined if the air is not changed. Carbon dioxide, ammonia, and other hazardous gases will reach unacceptably high concentrations. Table I.2 shows the critical and ideal levels of certain gases identified by study. The ventilation system exchanges the air in the building, bringing in the oxygen required for survival and removing the toxic gases and smells produced by respiration and waste breakdown. The device also dilutes disease-causing germs in the air, keeping them at a safe level for the birds' health.

Table I.2 : Common gas levels in poultry houses.

Gaz	Symbol	Lethal	Désirable
Carbon Dioxide	CO_2	Above 30%	Below 1%
Methane	CH_4	Above 5%	Below 1%
Ammonia	NH_3	Above 500ppm	Below 40ppm
Hydrogen Sulfide	H_2S	Above 500ppm	Below 40ppm
Oxygen	O_2	Below 6%	Above 16%

To eliminate excess moisture from the home, ventilation must be employed. Proper ventilation lowers relative humidity, improves health, and avoids moisture condensation on walls and ceilings. Heat expands the volume of air, allowing it to contain more moisture. When the air temperature is increased by around 20°F, the moisture-holding capacity of air doubles.

I.5.4 Air velocity :

Variable air velocity within the chicken house can help reduce high interior temperatures to some extent. In addition, air velocity is significant in convectional cooling and air quality management [5, 18]. It is suggested that the ventilation capacity in hot climates be at least "5m3 per chicken each hour, with inlets averaging 1.5cm2 per m3 ventilation" [16]. According to Hulzebosch [18], if the temperature stays between 25 and 30°C, still air velocity (0.1–0.2 m/s) may be maintained. Under the same temperature conditions, Lacy and Czarick [40] found that broilers grew faster at 2 and 3 m/s air velocity, respectively.

The ages of chicken were considered within the temperature range of 25–30°C with varied air velocity in order to better understand the influence of air velocity on chicken. Increased air velocity of 2 and 3 m/s helped 6 week old broilers more than 4 week old broilers, according to the research. This might be due to the high warmth that younger birds demand during the brooding period.

I.5.5Lighting :

Early-life lighting has little or no influence on the hormone system in birds; it only enhances their activity, which includes feed intake, development, and physical and physiological activities [15, 41, 42]. Increases in illumination duration and intensity may result in fatigue, cannibalism, immunological reactions, limb deformities, and even mortality [41, 43, 44, 45, 46, 47].

The continuous illumination scheme of 16 hours light and 8 hours darkness is widely utilized and has been shown to improve overall chicken performance [15, 48, 49, 50]. However, intermittent illumination, which alternates short periods of light and shade, has been shown to improve chicken performance [16, 51, 52, 53, 54]. At the post-hatch period (1–7 days old), a continuous illumination program with a minimum light intensity of 20 lux is advised to help the chick adjust to their surroundings and improve eating [41]. As a result, the light intensity is decreased to 3–5 lux, and an intermittent lighting system is implemented for simple regulation of the birds' activity, resulting in improved performance and production [16, 41].

Figure I.7: poultry house lighting.

Compared to birds grown under red and orange light sources, birds reared under yellow, green, and blue light sources had better body weight [55, 56, 57]. In a review, Lewis and Morris [55] found that birds bred under blue light are more docile, but those reared under red light are more energetic and hostile. Furthermore, the red light was found to boost sexual activity in birds.

I.6 Poultry housing system :

It is impossible to overstate the significance of the fowl house system used in chicken production. It shields the hens from harsh ambient climatic conditions that might harm their performance and output. The overall heat created in a chicken house is the sum of heat produced by the birds, the surrounding environment, and fecal material biodegradation [58, 59, 60]. As a result, the sort of housing system to be employed in the poultry farm is a crucial determinant element in the management style to be applied. The naturally ventilated open housing system and the mechanically ventilated open housing system, both of which are employed in the tropical area, are examined.

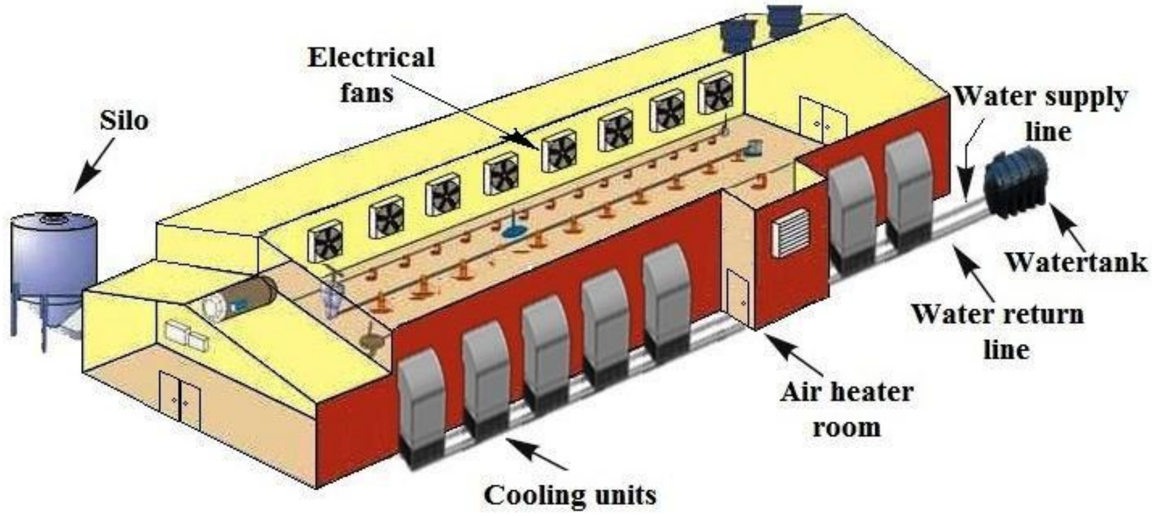


Figure I.8: An illustration of the broiler poultry house.

I.6.1 Naturally ventilated open housing system :

For its simplicity, economic consequences, and ease of regulation of heat generation within the building through natural ventilation, the open poultry housing system has been associated with the tropical area [5, 32, 61]. However, it is vulnerable to bug, rodent, avian, and other tiny predators, all of which can negatively impact chicken welfare, productivity, and performance. To combat this issue, dwarf sidewalls are elevated to the roof eaves and covered with corrugated wire mesh to keep predators at bay. In addition, a gutter filled with pesticides is installed around the home to prevent bug infestation. Design issues to consider while creating an open poultry house for maximum chicken performance and productivity are discussed below.

I.6.2 Building orientation :

The chicken house should be oriented east-west to decrease sidewall exposure to direct solar rays [5, 60]. Heat stress in birds can be accelerated when they are exposed to direct sun radiation, therefore this is critical. Although deep litter raising allows the birds to avoid direct sunlight, it may result in bird gathering or congestion in one section of the home. As a result, cooling becomes difficult, which can lead to stampedes and even death [5].

I.6.3 House width, length and height :

A chicken house's east-west orientation may diminish the benefits of prevailing east or west breezes. As a result, Daghir [5] proposed that the building's breadth not exceed 12 m to avoid this problem. Furthermore, the issue of an unequal air exchange rate and temperature within the building is resolved.

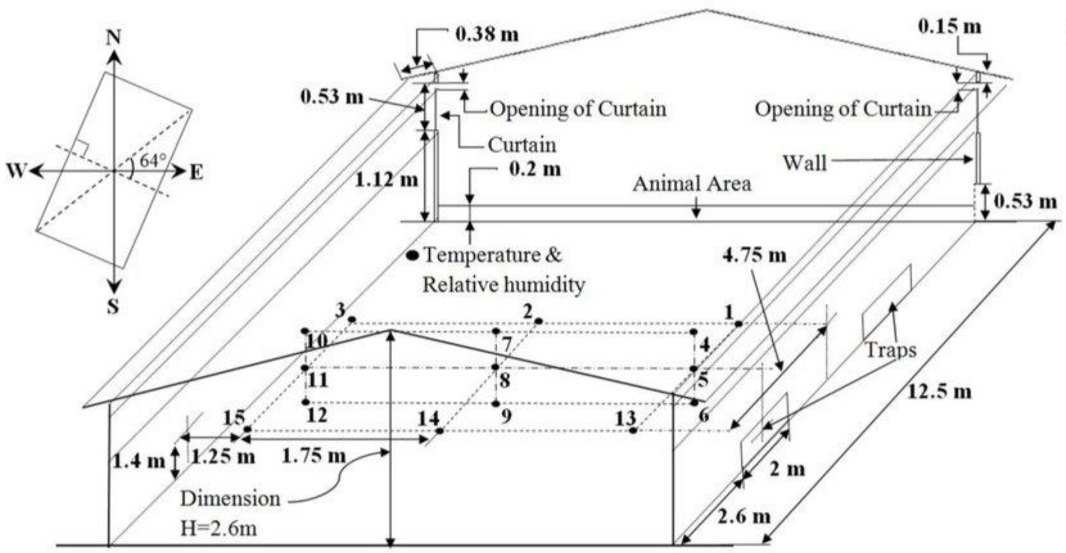


Figure I.9: Dimensions and location of the poultry house building[5].

Furthermore, the design must factor in the activities and services rendered by poultry farmers and professionals within the building. These activities may include transfer of chicken, feeding, de-pecking, waste management, vaccination, and so on. Therefore, longer pen house could be strenuous to maintain especially when the activities are carried out manually. Doors can be placed at interval of 15–30 m to make for easy circulation and service delivery [5]. Qureshi [32] recommended that for battery cages, it is rather advisable to factor in the number of tiers to be used. Two–tier cage system facilitates easy air exchange within the building whereas, three and four tier cage system can be problematic for air exchange. Therefore, it is recommend that rows of cages should not exceed three with center aisles not less than 1.2 m and a minimum height difference of 1 m from the ceiling.

I.6.4Roof slope:

A 45-degree roof slope was recommended because it reduces the roof's heat gain from direct solar radiation, increases the distance between the bird and the heat accumulated under the roof, allows for quick escape of the heat accumulated under the roof through the ridge opening, increases air space to improve air exchange rate, and provides open space above for equipment installation [5, 60, 62]. The slope of an insulated roof, on the other hand, is determined by the quality of the insulation.

I.6.5Roof overhang:

Roof overhang can be utilized to protect a building's sidewalls from both direct and indirect solar radiation. The length of the roof overhang, on the other hand, is determined by the height of the sidewalls [2]. Roof overhang shading, when appropriately placed at a roof slope of 45° [60], may minimize heat uptake by the sidewall by around 30%.

I.6.6Ridge opening:

Due to a difference in air density, hot air naturally rises over colder air. The installation of ridge openings in the chicken house can help with ventilation by creating a stack effect. To avoid insufficient ventilation and circulation, appropriate setback between buildings is essential [2, 61]. However, owing of the temperature consistency throughout the house, ridge opening has been shown to be inefficient in insulated chicken houses [63].

I.6.7 Sidewall openings:

A permeable membrane such as corrugated wire mesh and an adjustable curtain make up the sidewall, which is erected up to the roof eave. To protect the home from water seepage, direct and indirect sun radiation, pests, and predators, a minimum height of 0.4 m is recommended [2]. The corrugated wire mesh allows for easy ventilation both within and outside the structure, while the movable curtain controls the flow and air velocity. To help in the management of intermittent lighting schemes, the curtain might be translucent or of variable hues [5, 15, 63].

Figure I.10: Poultry sidewall inlets - wall vent poultry house ventilation.

I.6.8 Building obstruction:

To avoid insufficient air exchange rates in buildings, a proper distance between buildings is essential. Wind speed, wind direction, and topography are all important factors to consider when determining the best home spacing. However, the equation below [63] may be used to calculate the distance between buildings.

$$\boxed{D=0.4HL0.5} \quad \text{.....................................E1}$$

where **D** : housing spacing (ridge of the closest wall of the next house).

H :height of the adjacent building.

L : length of the adjacent building.

Vegetation should be kept as minimal as possible and at average height to reduce the nest of wild birds and invasion of rodents and other predators. Also, the branch of trees should be kept at eaves level to prevent obstruction of airflow across the house [2].

I.6.9 Roof, end-wall and sidewall insulation :

Farmers in the tropics have successfully built naturally ventilated chicken homes using locally sourced materials including thatched roofs and bamboo roofing [32]. Ceiling insulation in naturally ventilated poultry buildings should have a minimum R-value of 1.25 m2 C/W. For temperatures over 40°C, a minimum R-value of 2.25 m2 C/W is required [2]. A chicken house ceiling can be insulated in a variety of methods, including a drop ceiling, rigid board insulation, spray polyurethane insulation, and reflective insulation.

I.6.10 Cooling system :

Rooftop sprinklers have been shown to be effective in cooling the roof significantly [5, 60]. The material of choice in this situation, however, must be able to withstand constant water exposure [2]. The use of a fogging device can reduce evaporative cooling in birds during hot weather. It creates mist with high water pressure, which helps birds stay cool. However, the amount of humidity within the home must be controlled since excessive temperatures can be harmful to the health of birds [5, 60]. A circulation fan reduces heat stress by increasing air velocity, which promotes convection cooling. Circulation fans, in general, produce air velocity of at least 0.5 m/s and cover an area 15 times the horizontal diameter by five times the vertical diameter [5], Furthermore, it should be positioned 1–1.5 m above the floor and inclined downward at a 5o angle for optimal circulation fan use.

I.6.11 Vegetation :

Shade and convection cooling are used by shrubs and grasses to minimize reflected and direct sun radiation [60]. To keep predators and pests at bay, vegetation should be maintained clean and clipped [2].Tall trees planted along the sides can act as a canopy, shielding the sidewalls from direct or reflecting sun radiation during the hotter parts of the day.

I.7 Open housing system with mechanical ventilation :

The implementation of a mechanically ventilated housing system was prompted by the inability to provide acceptable interior environmental conditions necessary for maximum bird performance during harsh weather conditions. In addition, mechanical ventilation allows for more control over air exchange, wind velocity, and wind direction [2, 16]. Positive or negative pressure systems are used in mechanically ventilated systems. The most typical negative-pressure system in mechanical ventilated houses expels air out of the building via fans through an air inlet system, resulting in low pressure within the home, allowing fresh air to rush in via the same air inlet system [2].

Inlet or tunnel ventilation can be used to create negative-pressure systems. Inlet ventilation distributes exhaust fans and air inlets evenly throughout the home, whereas tunnel ventilation has exhaust fans on one end and inlet pipes on the other. This benefits tunnel ventilation by increasing air speed, which results in more positive air exchange [2].

I.7.1 Building a poultry houses :

Housing is very important factor for poultry farming and how to build a poultry house is a common question for the producers. Basically the poultry housing is the main process of keeping your birds healthy, fast growing and producing the maximum [5].

The home must be properly insulated and securely built for optimum ventilation management [2]. However, instead of a full wall, the sidewall can be outfitted with insulated moveable curtains for usage during the cooler months of the year or in the event of a power outage. It's worth noting that solid walls provide better insulation than moveable drapes.

The floor should be composed of concrete and should be rat-proof and damp-free. To avoid rat and snake problems, the house's floor should be extended 1.5 feet beyond the wall on both sides. In the case of deep-litter poultry homes, the door must be open to the outside. The door should be at least 6 x 2.5 feet in sizeThe picture below shows the geometric and structural shape of poultry houses (Figure I.10) [65].

Here is some basic information about building a good poultry housing system :

- The poultry house must have to be well ventilated.
- Ensure sufficient entrance of sunlight and fresh air inside the house.
- It will be better if the house become situated north to south faced.
- If you make several houses, then the proper distance of one house to another house is about 12 meter.
- Clean the house properly before keeping the birds inside the poultry house.
- Make a deep liter and keep it dry and clean always.
- Keep feed and feeding equipment in proper distance inside the poultry house according to the number and demand of poultry birds.
- It will be better if you can build the house in an open air place [65].

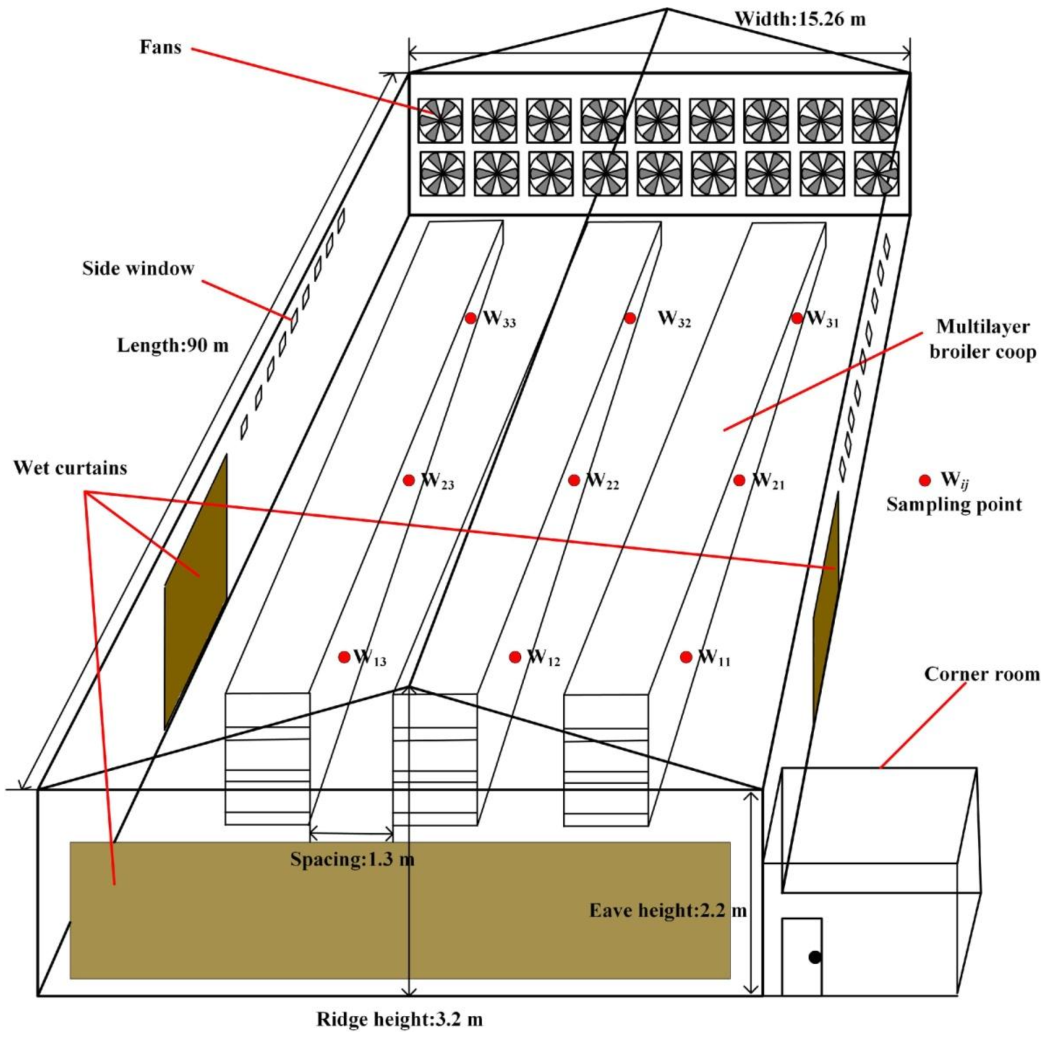


Figure I.11 : Building poultry houses[65].

I.7.2 Exchange of air :

The temperature of the inside air is raised by the high exterior temperature combined with the heat created by the activities within the chicken house. An efficient mechanical ventilation system must exchange air swiftly to keep the indoor air temperature within 2.8 degrees Celsius of the outside air temperature. The formula below may be used to determine the size of exhaust fan needed for proper ventilation [2].

$$\textbf{Building surface heat(watts)} = (A/R) \times (T_o - T_i) \quad \text{.......................E2}$$

where **A** : is the size of the building surface (m2)

R : is the wall material's insulation value (m2C/W).

Outside temperature (°C); Inside temperature (°C).

To is the warmest exterior temperature that is not included in the external environment. When calculating heat gain for a roof in a home with attic space, however, the To value for ceilings with insulation directly below the roof is considered to be 65°C [2]. In order to keep birds comfortable, Ti should be considered to be 27°C. The cumulative sum of the insulation value of the wall segment will be the value of R.

The total heat produced (sensible and latent) in commercial broiler is 7.9 W/kg while broiler, pullets and broiler breeders is 5.1 W/kg [2, 64]. The heat generated by birds is expressed below [2] :

$$\textbf{Bird heat}(W) = \textbf{sensible heat}(W/kg) \times \textbf{weight of the bird}(kg) \quad \text{..................E3}$$

50 percent of the total heat produced by birds is sensible heat.

$$\textbf{Total heat}(W) = \textbf{building surface heat}(W) + \textbf{bird heat}(W) \quad \text{..................E4}$$

However, the air movement capacity required to maintain a temperature difference of 2.8°C between intake and exhaust air is shown below.

$$\text{Air } \textbf{capacity}(m^3/h) = \textbf{total heat}(W) \times \textbf{3.4/2.8}^{\circ}C \quad \text{..................E5}$$

I.7.3 Air inlet system :

The withdrawal of air from the barn leads to the formation of negative air pressure inside the barn, which leads to the outward air rushing automatically through specific openings for this purpose into the barn, and the speed of the air rushing into the barn depends on the speed and quantity of air drawn out.

Negative-pressure air intake pipes are used to adjust the internal climatic condition by regulating the location, pace, and direction of fresh air entrance. The exhaust fan, on the other hand, controls how much air enters the home.

Figure I.11 depicts the most typical system graphically. The exhaust fan(s) in the poultry house create a slight negative pressure or vacuum, allowing air to enter the barn through the designed inlets.

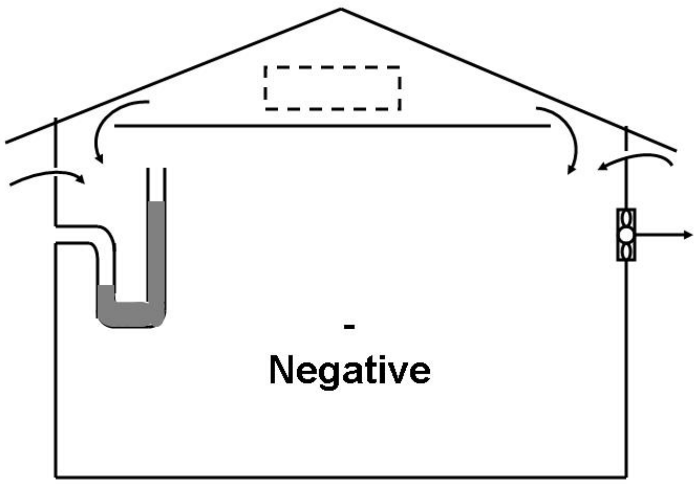


Figure I.12 : Negative-pressure air intake pipes[2].

I.7.3.1 Inlet speed :

Fresh air entrance speed is determined by the pressure differential between the inside and exterior environments [2]. The pressure, on the other hand, is determined by the quantity and size of air inlets. As a result of the ease with which differential pressure can be controlled, the airflow pattern within the building and the negative-pressure air entry pipes used to manage the interior climatic condition may be controlled.

I.7.3.2 Inlet area :

The exhaust fan must create a static pressure of around 12–25 Pa [2] for simple control and distribution of air throughout the chicken house.

I.7.3.3 Air inlet control :

Because the direction of air depends on external climatic conditions, age, and chicken class, the air intake design should be carefully placed. During the cooler months of the year, air inlets should be built to send air towards the ceiling, whereas during the hotter months of the year, air should be directed towards the floor [5].

Figure I.12 represents the control of the air inlet for poultry houses.

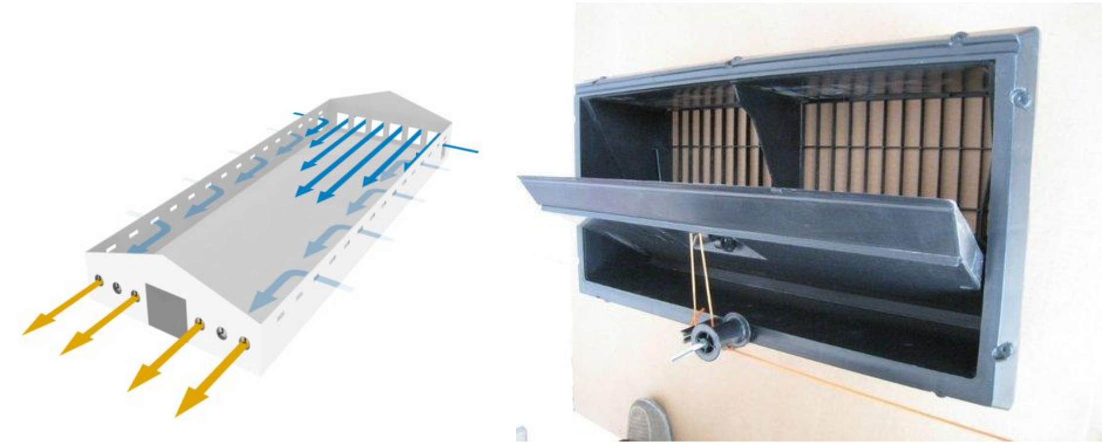


Figure I.13 : Air inlet control in poultry houses.

I.7.4 Types of inlet ventilation system :

I.7.4.1 Cross ventilation :

The exhaust fans are on one side of the poultry house, while the air input pipes are on the other. It's suitable for small poultry houses (less than 10 m) since it causes differences in environmental conditions in bigger homes [2].

I.7.4.2 Ventilation via the sidewall :

On both sides of the building walls, exhaust fans are installed beneath the air input pipes [2]. However, the distance between the exhaust fans and the air input pipes should be at least twice the diameter of the fan. The exhaust fans suck air through the floor, which is aimed towards the center. It's also appropriate for houses with a maximum width of 12 meters [2].

I.7.4.3 ventilation attic inlet :

The exhaust fans are on the lower sides, while the air inlets are in the ceiling. This type of ventilation necessitates adequate ceiling insulation and is best suited to hot climates. For laying hen raising, the ventilation approach is highly recommended [2].

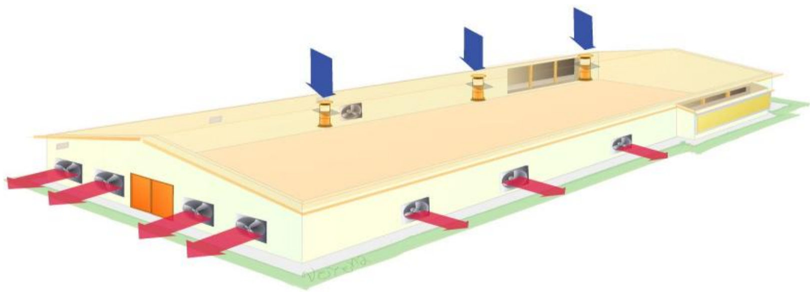


Figure I.14 : Overhead ventilation in poultry house.

I.7.5 Air movement inlet ventilated house :

Fresh air enters at a speed of 3.5–6 m/s through the air intake pipes, however this speed rapidly drops to around 1 m/s depending on the size and style of the home. As a result, circulation fans are utilized to increase air speed in order to ensure enough air flow in the building [2].

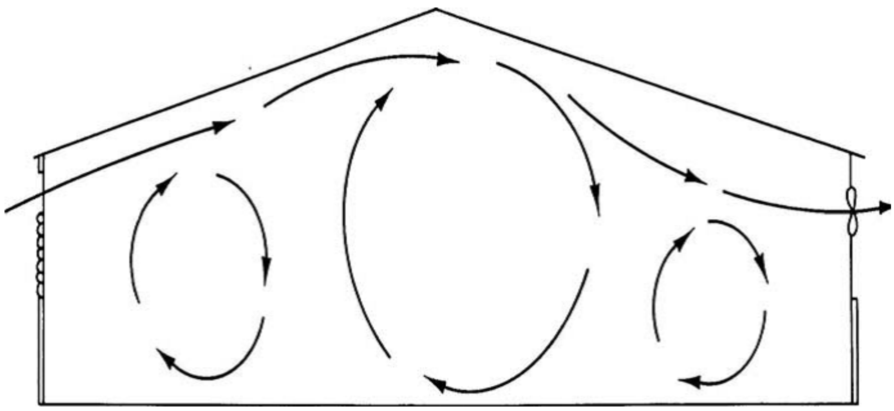


Figure I.15 : Air movement inside the poultry house.

I.7.6 Tunnel ventilation system :

The tunnel ventilation system is built to maintain the required air velocity and exchange rate. The needed air velocity, on the other hand, is determined by the type of bird in issue. The recommended air speed for growing various types of poultry birds is shown in Table 2 [2].

TableI.3 : Air velocity recommendations for tunnel-ventilated dwellings.

House type	Air speed (m/s)
Broilers	2.5–3
Pullets	1.75–2.25
Broiler breeders	2.25–3
Commercial layer	2.5–3

I.7.6.1 Tunnel fan capacity and air velocity :

The capacity of the tunnel fan is determined using the same procedure as the input ventilation system. Unlike the entrance ventilation system, which uses a circulating fan to maintain an acceptable air velocity, the needed average air velocity within the tunnel house is computed using the formula below [2].

Air **velocity=tunnel** fan **capacity/(cross−sectional area of the house)×3600**

where air velocity, m/s; tunnel fan capacity, m^3/h; cross section area, m^2.

However, it's worth noting that the house's cross sectional size has a negative impact on the air speed within. As a result, narrow and long houses with lower ceilings are recommended [2]. As a result, the following statement may be utilized to construct the required air velocity.

Tunnel fan **capacity=desired** air **velocity/(cross−sectional area of the house)×3600** E7

where desired air velocity, m/s; tunnel fan capacity, m^3/h; cross section area, m^2.

When space is limited, air deflectors with a large cross-sectional area can be fitted to lower the cross-sectional area within the chicken house. Air deflectors are drapes that reach 2.5–3 meters from the ceiling to the ground. Air deflectors have been shown to boost air velocity for a distance of 1.2 and 6–9 meters upwind and downwind, respectively. However, the air deflector must be placed at least 2.5 meters above the ground to avoid interrupting fan performance and air exchange rate by raising static pressure [2].

I.7.6.2 Air velocity distribution :

The air velocity in a tunnel house is usually believed to be consistent throughout. It varies somewhat, however, depending on the smoothness of the building surfaces, the presence of poultry machinery, and other air-deflecting impediments. The variation in air velocity between the center and sides of the house might range from 15% to 40% [5].

I.7.6.3 Bi-directional tunnel house :

To ensure the highest air speed in the tunnel house, it is recommended to position the fans on one end and the intake on the other end. However, if the poultry house is longer than 180 meters and the needed air velocity in one direction is greater than 3.5 meters per second, the bi-directional tunnel house system should be used. The fans are situated on the building's end walls, with the tunnel intake in the center. To maintain the same temperature differential between the intake and the fan, the air velocity in both directions is reduced to half of the needed velocity while maintaining the same air exchange rate [5].

I.7.6.4 Tunnel fan placement :

The fans can be put at the end-walls or on the sidewalls towards the end, and their performance is unaffected by their placement. However, when the width of the dwellings increases, a dead area can be detected when the fan is put on the sides.

I.7.6.5 Tunnel inlet opening :

In the absence of evaporative cooling pads, it is suggested that the intake area be at least 10% larger than the house's cross sectional area. Meanwhile, the intake size for tunnel houses with evaporative cooling pads is determined by the pad utilized. It is advised that the intake aperture on the sidewall be positioned as near to the end wall as feasible. If the house width exceeds 15 m, the inlet ports should be installed on the end-wall [2].

I.7.6.6 Cool weather inlet system for tunnel ventilated houses :

The usage of a tunnel ventilated system is advised in hot weather since cool weather reduces the air exchange rate. As a result, it was advised that the old intake system control at least 60% of the tunnel fan capacity before converting to tunnel ventilation for simple switching during cooler weathers [2].

I.7.7 Poultry exhaust fans :

I.7.7.1 Types of fans :

I.7.7.1.1 Exterior and interior shutter fans :

It is the most basic form of exhaust fan. When the fan is not in operation, the shutters are closed. The outside shutter, on the other hand, inhibits circulation since air spins off its blades when it comes into contact. The shutters on the intake side of an interior fan, on the other hand, are on the intake side of the fan, reducing airflow obstruction. It has larger shutters, allowing for increased air flow. When compared to an outside shutter fan, Daghir [2] claims that airflow is improved by 5–10%.

I.7.7.1.2 Discharge cone fans :

It improves fan performance by 5–10% by making the transition from drawing to fans easier [5].

I.7.7.1.3 Belt-drive fans :

A simple pulley mechanism drives the fan blades. To avoid belt slippage, it may be updated with an automated belt tensioner [5].

I.7.7.1.4 Direct-drive fans :

The blades of the fan are directly linked to the motor shaft, avoiding the need for a belt. In comparison to belt-driven fans, they are less energy efficient [2].

I.8 Conclusions :

Finally, a conclusion and a summary of the content of this chapter, which includes a review and study of the literature on broiler chickens and their homes, we conclude that Heat loss in birds by convection, radiation and conduction only when the ambient temperature is below or within the thermally equivalent region of birds. In the tropics, the design of open, ventilated dwellings was examined to improve the environment for optimal bird production. Heat loss in birds increases when air volume and velocity increase, according to studies. Also, architectural aspects such as building orientation, roof slope, roof overhang, landscaping, building height, building width, and building length should be considered. It should be mentioned that improved structures with natural ventilation are necessary for successful chicken production. Furthermore, incorporating cooling systems into naturally ventilated housing systems, such as a fogging system, a sprinkler system, and a circulating fan, has been demonstrated to improve overall bird performance.

Consequently, in cases where the environmental temperature is severely high and unbearable for birds the mechanical ventilated open housing system have been introduced. Despite the harsh weather conditions, the usage of tunnel and intake ventilation systems has been reported to sustain better bird production in this location. However, to design an effective, mechanically ventilated house due attention should be given when calculating the fan capacity of the house, heat generated by the birds, sizes of inlet, level of installation, positioning of inlet pipes and exhaust fan and finally the capacity of circulation fans required in inlet ventilated systems.

CHAPTER 02

Estimating the heating, ventilation, air conditioning, and lighting requirements of broiler chickens based on their daily activities, the season in which they will be raised, and the poultry house.

II.1 Introduction :

Poultry farming is an energy-intensive industry that uses a lot of energy to create an appropriate indoor environment for chicken health and meat and egg production. There are now several studies and practices involving the application of renewable and sustainable energy technology to chicken farming in order to save energy and reduce carbon dioxide emissions. As a result, it is worthwhile to review current developments and describe the major aspects in this sector. Photovoltaic (PV), solar collector, hybrid PV/Thermal, thermal energy storage, ground/water/air source heat pumps, lighting, and radiant heating are the primary technologies. In compared to typical poultry houses, these modern technologies have been proven to save up to 85 percent energy and have a payback time of 3–8 years.

In this chapter, we will give great importance and a comprehensive study of energy-saving **heating, ventilation and air conditioning systems in poultry farming** and estimating the requirements of broiler chickens from heating, ventilation, air conditioning and lighting based on their daily activities and the season of their breeding, as well as the use of such systems in poultry houses in **Algeria** in general and in **El-Oued** Province in particular.

II.2 Poultry production in Algeria :

The Algerian poultry industry produces annually on average 340,000 tons of white meat and more than 4.8 billion eggs. The industry consists of 20,000 farmers employing about 500,000 people. Most feed and other inputs are imported and correspond to 80% of 2,500,000 tons of feed (which is typically based on corn and soybean meal), three million breeder birds, veterinary products and equipment. The current structure of the Algerian poultry industry is derived from government development policies initiated in the 1980's. Currently the high dependence on external markets for feed materials remains the main limiting factor in the development of the Algerian poultry, especially for corn and soybean meal which represent over 75% of the content of poultry feed. Difficulties encountered by producers, particularly in terms of supply, increased expenses, disengagement of the State and problems in commercialization of their products, has caused many skilled farmers to leave the poultry industry, creating a net loss in experience within the sector. In addition, the industry is also going through a period of modernisation and adaptation of this sector to meet the new world standards, including imminent integration of Algeria to the World Trade Organization (WTO) and partnership with the European Union, which involves free movement of goods, resulting in more competition and requires more integration with different partners (professional organisations, inter-professional associations) and various state structures and competent authorities (industry, agriculture and trade) with the establishment of an institutional framework for the development, implementation and monitoring of development policies in the poultry meat and egg sector[66].

Furthermore, the abrupt appearance of bird flu (H5N1 virus) globally led to a net drop Poultry production in Algeria[67]. in poultry production resulting in a drop in poultry breeding and production, even though no cases of avian influenza have ever been detected in Algeria. Significant decreases in white meat production were observed; 15.5% less in 2005 compared to 2004 [68] (Figure II.1) although an abrupt increase (68%) was seen in 2006, causing outputs to reach 241,166 tons [68]. During the avian flu crisis, nearly 80% of the 20,000 producers ceased trading.

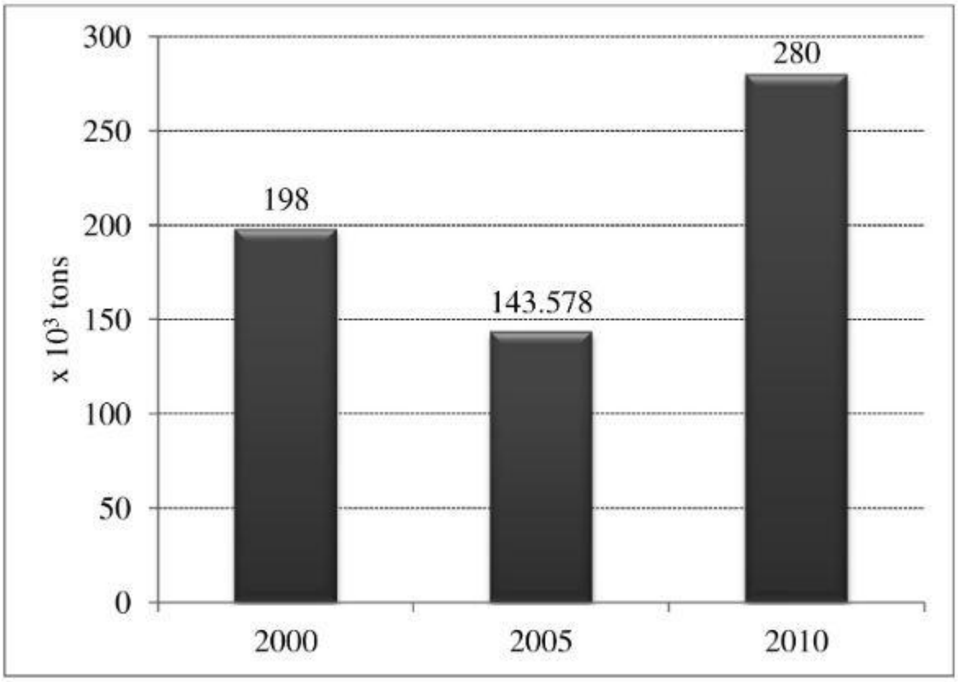


Figure II.1 : Evolution of white meat production in the last decade[69].

II.3 HVAC Techniques for Modern Livestock and Poultry Production Systems :

II.3.1 Definition of HVAC system for poultry :

First and foremost, HVAC stands for heating, ventilation, and air conditioning. This system provides heating and cooling to residential and commercial buildings As well as animal husbandry, including poultry houses. HVAC systems may be found in a variety of places, from single-family houses to submarines, and they provide environmental comfort. These systems, which are becoming increasingly common in new buildings, utilise fresh air from the outside to produce great interior air quality. The process of replenishing or exchanging air inside a room is represented by the V in HVAC, or ventilation. This improves interior air quality by removing moisture, smoke, smells, heat, dust, airborne bacteria, carbon dioxide, and other pollutants, as well as controlling temperature and replenishing oxygen.

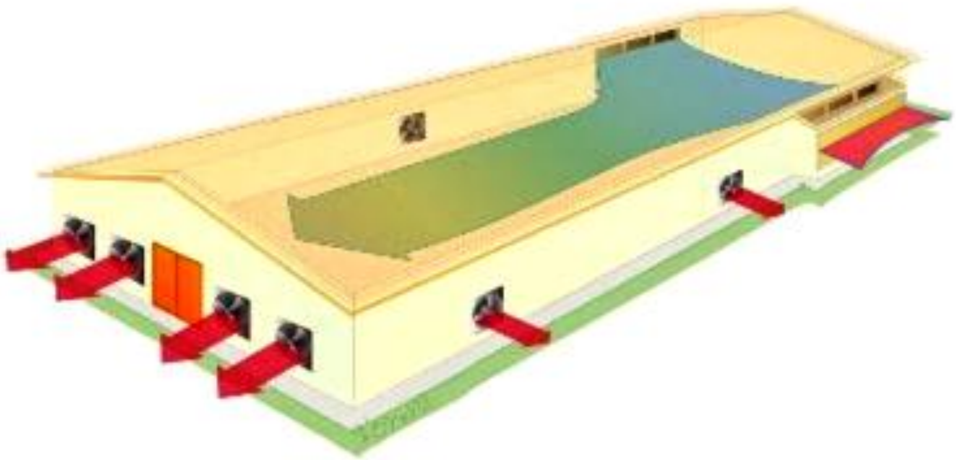


Figure II.2 : Air conditioning system in poultry houses.

II.3.2 HVAC system working principle :

The HVAC system stands for heating, ventilation, and air conditioning. A full HVAC system contains heating pumps and air conditioners to meet various temperature needs in the A specific area. The functioning concept of an HVAC system is depicted in order to explain the role and significance of this technology in today's Poultry farming.

Thermodynamics, fluid flow, and heat transfer are the three sub-principles that control an HVAC system. The HVAC system uses all three sub-principles at different stages of the overall process. Thermodynamics are used to keep the indoor air quality of a building in good condition. Fluid flow mechanics are used to maintain temperature stability by flowing refrigerant through the coils of the air conditioning system. The heat transfer part of the main principle, where the required heat supply to the air in the room is connected, is the third component of the principle.

When there is winter, air heating is required to maintain good conditions for broiler chickens. In the summer, cooling is required in countries such as Algeria, and exactly the **El-Oued** and the **south of Algeria** in general, because temperatures reach high levels.

The following image (Figure II.3) represents a simplified and schematic explanation of how the heating, ventilation and air conditioning system works.

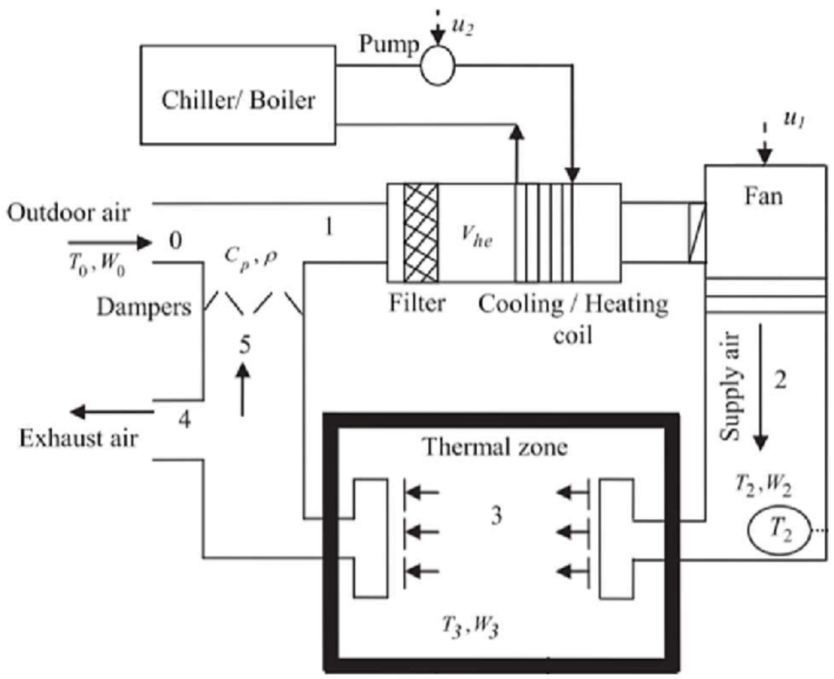


Figure II.3 : HVAC system Diagram.

II.3.3 Basic components of the HVAC system :

It consists of 14 components, which are as follows :

- HVAC water chiller and heaters

- Hot water generators or furnaces.
- Chilled water pumps.
- Electricity supply system.
- Cooling towers
- Piping for chilled water supply.
- Valves for chilled water and cooling.
- Air Handling Units (AHU) heating coils and cooling coils.
- Ducting for ventilation system supply duct and return ducts.
- Fan coils units (FCU) and thermostats
- HVAC diffusers and grills.
- HVAC controls installed at various locations
- HVAC controls for making HVAC control or BMS building management system.
- The assembling of the abo**ve** components forms an HVAC system [67].

II.3.4 Types of the HVAC systems :

There are four main common types of HVAC systems used in animal and poultry farming. This is the following:

II.3.4.1 Split HVAC system :

A split HVAC system is an assembly of five main components including an indoor unit, furnace, or an air handler, outdoor unit, air conditioner or heat pump, Thermostat programmer or non-programmer, Indoor air quality component, filtration system, and humidity control devices.

The compressor condenses the air and circulates the refrigerant via an exterior unit, which is how a split HVAC system works.

The outside unit subsequently converts the gas to liquid, which is then fed through the coils of the inside evaporator. The indoor unit's fan circulates the interior air as it passes through the evaporator's fins [66].

II.3.4.2 Hybrid HVAC system :

The hybrid HVAC system works similarly to a hybrid automobile, which uses both gasoline and battery power depending on the conditions. The control panel computing device in a hybrid HVAC system is the source of energy, which can be an electrically driven heat pump or a furnace that runs on natural gas, fuel oil, or propane.

A hybrid HVAC system allows you to select from a variety of heating choices while also conserving energy [66].

II.3.4.3 Duct free HVAC system :

A ductless or ductless HVAC system does not require ductwork to manage the temperature in a room. Wall-mounted systems that bring chilled air straight into the living area are common. With the use of sensors, it can also adjust the air quality in the room. This sort of air conditioning is typically seen in living rooms and homes. Such HVAC systems are not as successful in sectors where items are created. Such systems typically failed to maintain excellent indoor air quality (IAQ) in deep building rooms[66].

II.3.4.4 Packaged heating and air system :

HVAC systems that prepare perfect air outside of the room or home, generally on the roof, and then provide fresh, filtered cooled air through built ductwork throughout the house or office are known as packaged heating and air systems. These HVAC systems are employed when there is a lack of interior space and no room to put HVAC components within the regulated area [70].

II.3.5 Difference between AC and HVAC systems :

The conventional air conditioner is a device that regulates the room's temperature and recirculates the air without meeting any air quality criteria. It just regulates the temperature and humidity of the room in question [71].

A full solution for the temperature conditioning of an area or room, on the other hand, is an HVAC system. The temperature, relative humidity, indoor air quality, and cooling of the room's environment may all be controlled effectively [72].

The heating, ventilation and air conditioning (HVAC) system allows you to provide good air-conditioned conditions in poultry houses. In animal husbandry (broiler farming), HVAC system plays a vital role to produce high quality broiler chickens for long periods [73].

II.3.6 General poultry thermoregulatory systems:

Broilers have only a short lifespan. So the growing conditions must be perfect from the moment of hatching. This is especially true for small breeders. Keeping the air and ground temperatures in the home under complete control is essential during the incubation period.

On hatching day, the chicks appear to be anatomically complete. However, besides organ development, some physiological systems require maturation to support further growth and development. The three major systems that are not fully developed on hatching day are the digestive system, the immune system, and thermoregulation.

Chicks of the thermo neutral zone, which remain thermodynamic (variable body temperature) on hatching day, gradually change to homeostatic (constant body temperature). Before chicks are completely accustomed to their home temperature, they cannot control their own body temperature. They behave like cold-blooded animals by adjusting their body temperature to that of the environment. However, unlike cold-blooded animals, chicks have an optimal anal temperature.

For chicks, the ideal rectal temperature is between 40 and 40.6 °C. When rectal temperatures are in this range, the chick is in its heat-neutral zone. Through physical thermoregulation, chicks are able to maintain their body temperature at a constant level through physical thermoregulation without raising their metabolic rate. It is important to keep the chicks in their neutral thermal zone to ensure early development and growth. [68]

1.4 Basis of structural design for HLPP building system in Algeria:

The majority of HLPP buildings in Algeria are traditional poultry houses in arid regions, with a semicircular shape and front air conditioning and ventilation. It is 44 meters long and 11 meters wide and can accommodate 4,500 chickens. The house has six heaters, and the floor has a material that helps protect chickens from eating dust like sawdust. The pictures below show the house.

AB

CD

Figure II.4:represents pictures of the poultry house we studied.

A : Poultry house at the level of length

B :the front of the poultry house containing the air conditioning system

C : High level poultry house entrance

D : From inside the house, the flooring material (such as sawdust), where the house contains broiler chickens, cooling, heating and feeding devices

II.5 VENTILATION PRINCIPLES

II.5.1 Economic importance of ventilation :

The relevance of in-house environmental conditions has grown as the contemporary broiler chicken has evolved. Geneticists have increased the growth rate as well as the output of carcass components in response to market demands. The additional meat output in these broilers, which is mostly concentrated in the breast, makes them more susceptible to high temperatures, ammonia, and dust. As a result, much of the variation in broiler flock performance may be ascribed to how effectively the in-house environmental conditions, particularly temperature and air quality, are regulated.

Figure II.5: Ventilation in poultry houses**.**

The main objective of the broiler industry is the production of saleable chicken meat. To this end, it is important to maintain a healthy environment in the poultry house. Broiler health, live weight, feed conversion, carcass quality, and carcass yield will all suffer as a result of problems maintaining the proper environment in terms of temperature and air quality, all of which will negatively affect the grower's bottom line and could be the difference between a below average and a high performing flock. The majority of the development rate of modern broiler genetic lines is dictated by the broiler's willingness to feed. Broilers will not consume as much as they could or will not eat at all if the temperature is too high. Managing in-house conditions to maximize broiler genetic potential is essentially a consequence of improving the ventilation system.

II.5.2 Air quality :

Water vapor, nitrogen, oxygen, carbon dioxide, and traces of other gases make up air. Although water vapor makes up less than 1% of the total, it is a significant influence in defining the state of the air mixture. This is owing to the importance of water in the life cycle as well as its high energy content in vapor form. Water vapor has the most latent heat of any common liquid (the energy in the form of heat necessary to transform water from liquid to vapor). As a result, the modest amount of water vapor in an air mixture frequently comprises the majority of the combination's total heat energy. When allowed to accumulate to above acceptable threshold levels, air contaminants lead to poor air quality within the poultry house. Contaminants include solid particles; microorganisms such as bacteria, fungi and viruses; and gases such as ammonia, hydrogen sulfide, and carbon dioxide. These contaminants are always present to some extent in poultry house air, but can be minimized with a well managed by the system.

II.5.3 Natural ventilation :

Natural ventilation, as the name implies, is a technology that uses natural forces to provide fresh air to poultry facilities. The air is exchanged through the structure's inlets and outputs. It's critical to grasp the differences between natural and mechanical ventilation systems. In mechanical ventilation structures, air exchange fans may be regulated to create the required air exchange rate. Both thermal buoyancy and wind are affected by unpredictably changing weather. Natural ventilation control is distinguished in this way [74].

Telle qu’elle fonctionne dans les bâtiments "ouverts sur un côté", "à rideaux latéraux", ou bâtiments "naturels". Des ventilateurs peuvent être utilisés à l'intérieur du bâtiment pour faire circuler l'air. Figure II.6

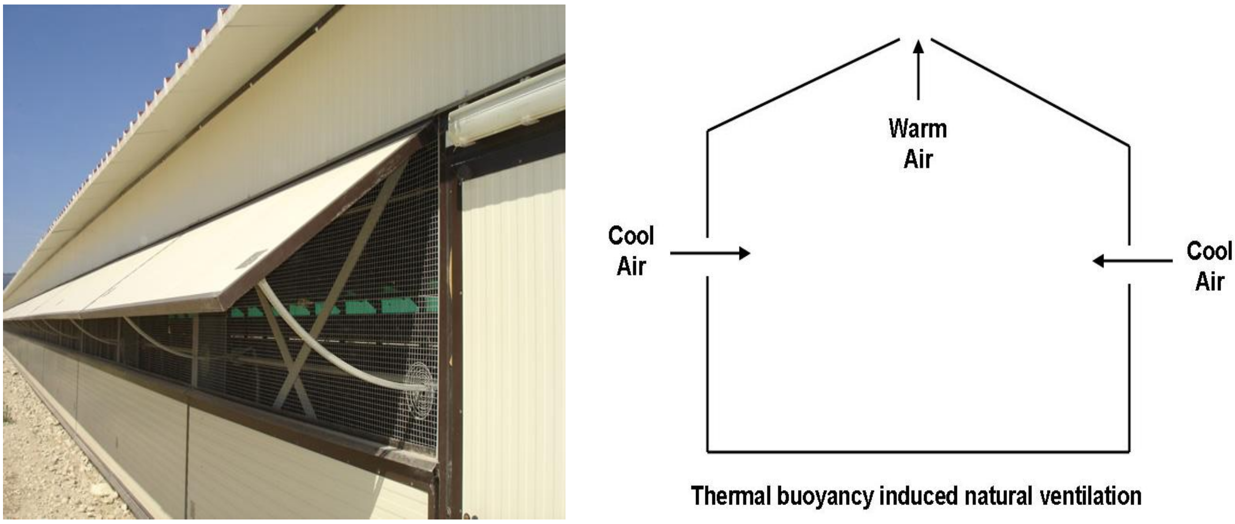


Figure II.6 : Ventilation Natural.

II.5.4 Electric ventilation :

Enclosed or climate controlled buildings These buildings usually have either solid side walls or curtains that are closed while the building is in operation. That is why electric ventilation and fans are used to pass the air inside the building. Figure 7

Figure II.7: Electric ventilation.

II.6 The main factors and ingredients in raising chickens :

II.6.1 temperature :

Chicks do need warmth, but these needs will gradually decrease as they grow.life. Table 2 presents the ideal temperature of the nursery according to the age of thechicks. There should be no greater than 2°C difference between the ideal temperature andthe actual temperature.

Table II.1: represents the optimum temperature for broiler chickens.

Chickage (number of days)	Temperature under the heater	Temperature in the poultry house
1	35 C °	27C °
2→10	32 C °	26C °
11→14	30 C °	25 C °
15→ 17	29 C °	24 C °
18→20	27C°	23C °
21→24	26 C °	22 C °

25→27	25 C °	22 C °
28→31	23 C °	21 C °
34→37	21 C °	20 C °
38→40	20 C °	19 C °
41→45	18 C °	18 C °

II.6.2 Humidity and litter :

The litter should always be clean and dry, because wet litter is dangerousBird health good droppings :

- consists of sawdust (ripe) or rice husk;
- It should be clean, dry and slightly elastic. It should not stick too much to the hands or on the shoes
- Its thickness should be 8 cm in the first week of a bird's life and about 6 cm in a weekdistance.
- It will get warm to the touch when the birds reach 11 days, their warmth is thatGarbage is heated.
- It should be clean and dry if the density of 10 birds / m2 is taken into account.
- If the litter is wet and/or sticky, in the whole house or in part of the house, there ishe has a problem.
- Remove litter near feeders if there is mixed food in the litter. Otherwise The chickens will eat the grain outside the feeder and at the same time they will eatLitter that will lead to digestive problems and diarrhea.

Figure II.8 : Wood carpentry in the poultry house.

The ability of air to charge more or less in water vapor, which is translated as relative humidity, is another significant component that mostly influences pathogen development and litter condition. Humidity, on the other hand, has no direct influence on Chicken behavior but might produce indirect problems. This explains the dry weather. It causes dust to accumulate, irritating the respiratory system and spreading bacterial illnesses. The knitted environment, on the other hand, makes the chicken crispier, especially when the temperature is low. Scales grow on the ground, increasing the risk of germs and parasites. The ideal relative humidity for rearing hens is between 40 and 75 percent; nevertheless, illnesses (such as respiratory ailments) may develop [75].

Table II.2: represents the optimum humidity for broiler chickens.

Chickage (number of days)	Humidity in the poultry house
1	62%-60%
7	60%-50%
14	50%-46%
21	46%-40%
28-45	40%

II.6.3 Lighting :

Light is an essential element that contributes to the growth of animals because they can always eat in the presence of light. It is essential to manage lighting in poultry houses well.

- From one to fifteen days: 3 to 5 W/m2 for 24 hours.
- 3–4 weeks: 1–2 W/m2 for 10–14 hours per day [76]. .

During the first two days, it is important to keep the chicks for a while.To promote water and food intake, maximum lighting (23–24 hours) with a power of roughly 5 W/m 2 is used. The lighting's aim is to assist the chicks to see. Feeders and drinkers: avoid very bright lighting in hot places to reduce stress. To maintain the proper amount of consumption, it must be lit at night during a colder time. To minimize activity and increase development, broilers should be maintained in semi-darkness. Several types of light sources can be used for broilers (Fig II.9). The most common types of lighting are incandescent, fluorescent, or LEDlighting. -Incandescent lamps provide a good spectral range but are not energy efficient [77]. Fluorescent lamps are more efficient than incandescent lamps, but they areThey lose their intensity over time and must be replaced before they really fail.LED lights (Light Emitting Diodes) are efficient and color fulSpecific lighting can be selected. The initial cost is high, but the bulbs lastmuch longer [78].

Lamp Halogen 45wlamp fluorescent 16wlamp LED 6w

Figure II.9 : Types of light sources that can be used for broilers.

Low light intensity during the day (opulence) can have a negative effect on Mortality CI, and growth Low light intensity can also lead to:

- Affects eye development.
- Increases the risk of foot injury.
- Reduce activity and resting behaviors (such as dusting and scratching).
- It has an effect on physiological rhythms because birds may not be able to discover the difference between night and day [79].

Table II.3 : Lighting Program Recommendations.

Chicken age (in days)	Duration of the light period
1 to 4	24 hour
5 to10	22 hour
10 to the end.	24 hour

II.6.4 Irrigation equipment:

II.6.4.1 Linear drinker(straw) :

Nipple watering makes it possible to dispense with starter drinkers provided that you begin in at least 40% of the breeding area and can begin with a High ambient temperature [80].

Figure II.10 : Poultry linear drinker.

II.6.4.2 Siphoid drinkers (round):

These systems are less expensive to build, however they pose issues such as floods, damp litter, seizures, and water hygiene concerns. Water purification using systems Animals often dump toxins in the reservoirs, making the open field difficult to maintain. Cleaning is required on a daily basis, which adds to the workload and wastes water. The efficiency of pressure modification may be monitored by looking at the litter quality. Drinkers that are too low, excessive pressure, or inadequate ballast are all symptoms of a moist litter under the source of supply. If the litter is extremely dry beneath the drinkers, the pressure may be too low [81].

Figure II.11 : Round poultry drinker.

II.6.4.3 Heating equipment:

II.6.4.3.1 Fuel brooder:

The air heated around the burner generates a confined convection current, which limits the losses to the building's overall volume, owing to the pavilion [82].

Figure II.12 :Gasoline heater for chickens.

II.6.4.3.2 Gas incubator :

Let's pretend that this heating is more expensive than coal heating and that getting the correct adjustment is more difficult [83].

Figure II.13 : gas heater for chicken.

II.6.4.3.3 Electric brooder :

It uses less fuel and has a wide range of applications, as well as being simple to modify and maintain.

Figure II.14 : Electric chicken heater.

II.6.4.3.4 Heating by radiation :

The linoleum is heated using radiant heat. Chicks may discover their comfort zone using this system. Food and water must be kept in the same location.

Figure II.15 : Heating by radiation.

II.6.4.3.5 Convection heating:

Convection is one of the methods of heating in poultry houses and is represented in the transfer of heat from one point to another by mixing part of a liquid fluid or gas with another fluid.

Convection can be natural, that is movement resulting from differences in density resulting from temperature differences, or forced movement, that is movement produced by mechanical means.

Figure II.16 : Convection heating.

II.6.4.3.5 Conduction heating:

It is heating and heat transfer by physical contact, without displacement of particles (Figure II.17).

Figure II.17 : Conduction heating.

II.7 The identification of traditional and modern poultry farmers :

It is no secret to some that poultry farming in Algeria receives a wide echo in all parts of the country. The methods of poultry farming differ from traditional to modern, and here is the point of difference, as the traditional methods of breeding lack the least modern and advanced means used in poultry houses such as heating, ventilation, air conditioning and lighting, In contrast to modern methods, it is characterized by modern technology in raising chickens, which allows farmers to produce higher and excellent quality compared to traditional breeding.

II.7.1 The location of the poultry house where the study was carried out :

The study state is located in the southeast of the country at a distance of 670 km from the capital, Algiers. It lies between latitudes 33° and 34° north and longitudes 6° and 8° east. It belongs to the northern desert of the eastern race, where the study was at the level of the municipality of **Oued El-Alanda**.

Its limits :

- Biskra and Tebessa in the north.
- Djelfa State in the northwest.
- Ouargla state in the south and southwest.
- The Tunisian border from the east.

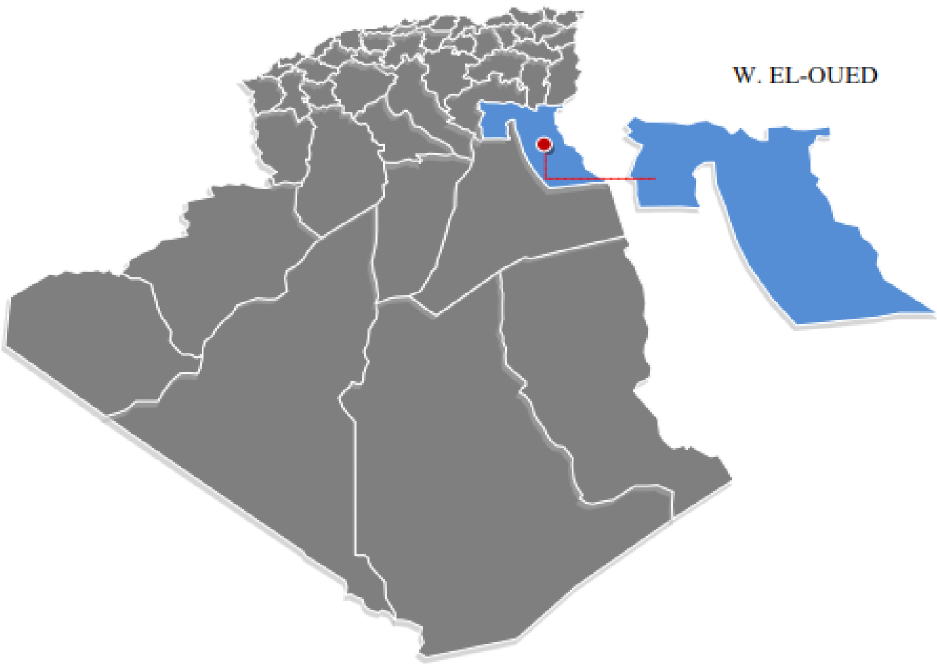


Figure II.18: Location of El-Oued Province in Algeria**.**

II.7.2Breeders' ages in Oued Souf :

It has been shown that 2% of traditional poultry farmers are 55 years old, while 13% of On the other hand, we note that most poultry farmers are at the ages of 28 years, 35 years, 44 years, 53 years, 65 years, and 70 years. 33% of breeders are over 45 years old [23].

II.7.2.1 level of poultry farmers :

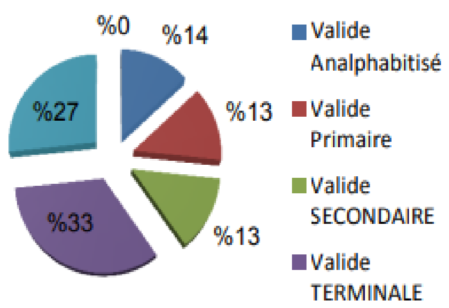


Figure II.19 : Traditional poultry farmers**.**

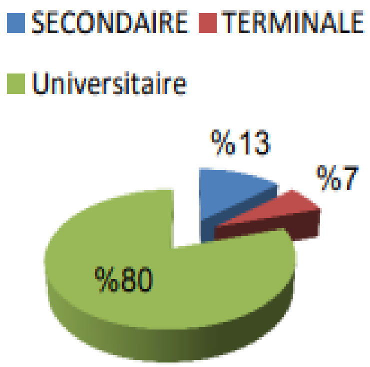
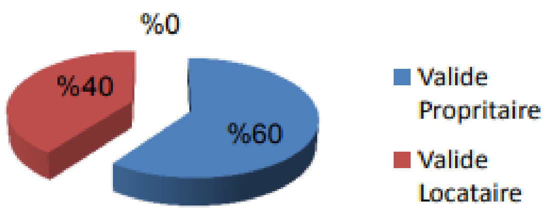


Figure II.20 : Modern poultry farmers**.**

From the figure above, it has been shown that (27% to 33%) of poultry farmers have a level terminal and a university degree. On the other hand, there is a percentage range of (14% to 13%) of poultry farmers illiterate, primary and secondary respectively. This figure II.2 shows that 80% of poultry farmers have a university level while 7% of poultry farmers have a terminal level.

II.7.2.2 Poultry farmer's adjectival :



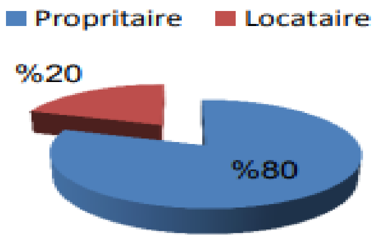
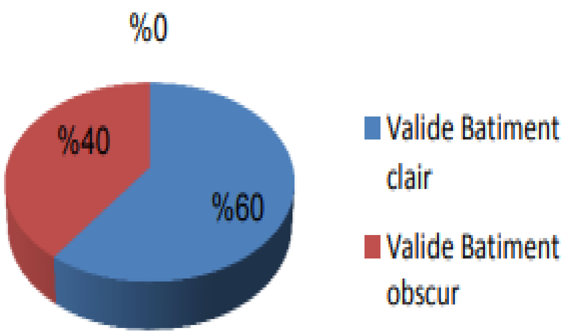


Figure II.21 : Traditional poultry farmers.**Figure II.22** :modern poultry farmers.

It can be seen that 60% of poultry farmers are owners of traditional poultry houses, whereas 40% of poultry farmers are tenants. It can be seen that 80% of poultry farmers are owners of modern poultry houses, whereas20% of poultry farmers are tenants.

II.8Poultry building characteristics :

II.8.1 Type of buildings:



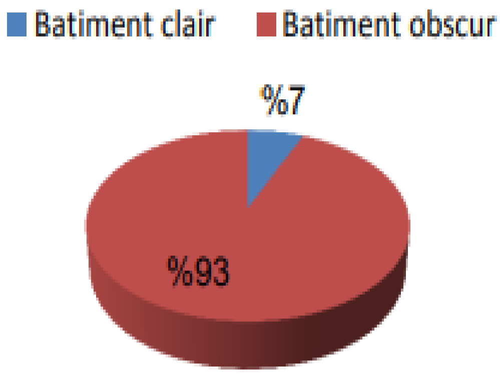


Figure II.23 : Type of traditional building. **Figure II.24 :** Type of modern building.

Figure II.23 shows that (60%) type of traditional buildings are dark than (40%) are light. The graph in Figure II.24 shows that 93% of typical modern buildings are dark.

II.8.1 Capacity of buildings:

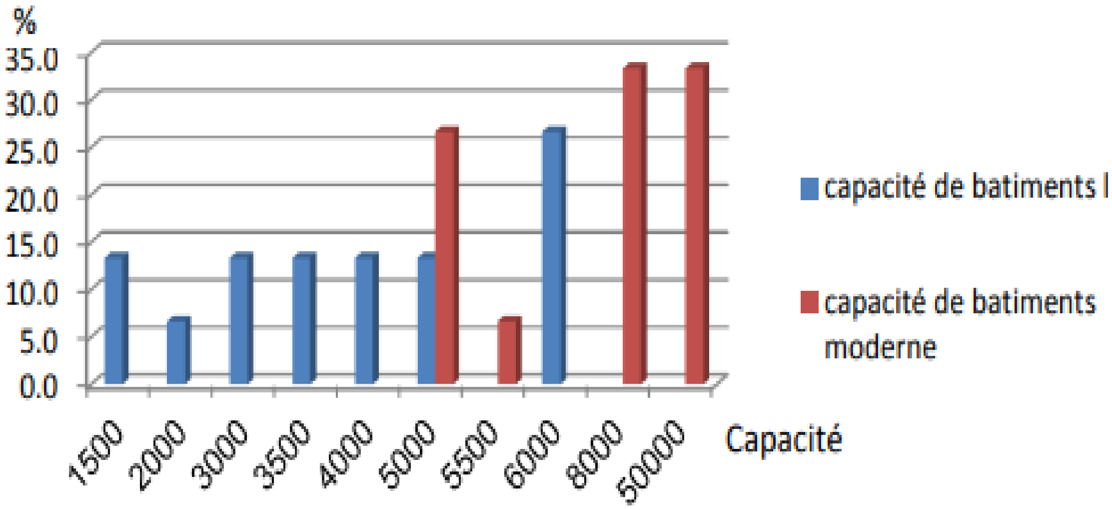


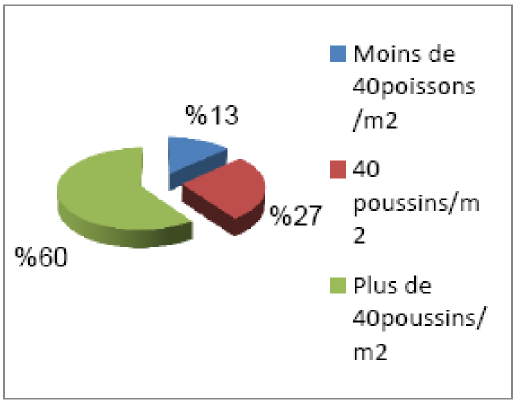
Figure II.25 : Capacity of buildings (traditional, modern).

We note that more than 26% of traditional buildings contain a capacity of 6000 subjects while more than 6% of others contain a capacity of 2000 subjects, with a majority of 13% being between cite 1500-5000 subjects. 33.3% of modern buildings contain a capacity of 8000 and 50000 subjects while more than 6.7% of others contain a capacity of 5500 subjects and others contain a capacity of 5000 subjects (26%) Figure II.25.

II.8.2 Chick density per m^2 :

In this graph shows that the greatest density recorded is more chicks / m2 with a percentage of 60%, the second density is 40 chicks / m2 while the last is 40 months, with percentages of 27% and 13% respectively Figure II.26.

In this graph shows that 47% a density of chicks in modern buildings of 40 chicks / m^2 with (20% to 33%) a density of chicks less than 40 chicks / $m^2$and more than 40 chicks / m2 Figure II.27.



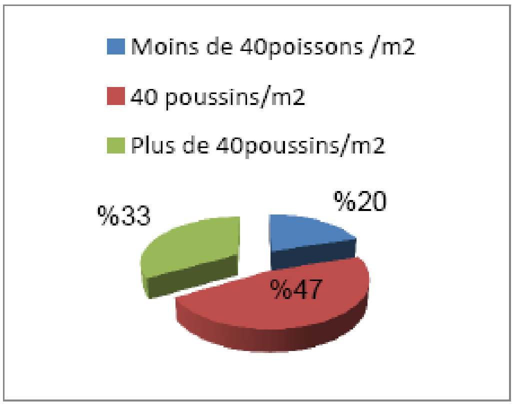


Figure II.26 : Chick density / m^2traditional. **Figure II.27 :** Chick density /m^2 modern.

II.8.3 Area of buildings :

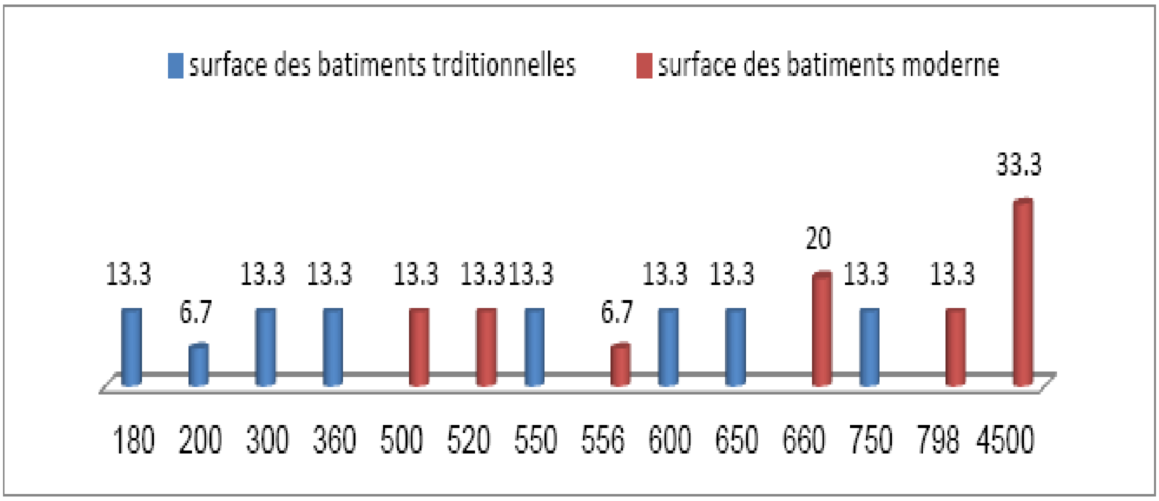


Figure II.28 :Surface area of traditional and modern buildings.

This graph shows that the majority of traditional buildings have the surface between (180m2 to 750 m2) while more than 6% have the surface (200m2) on the other hand we show that 33.3% the surface of modern buildings are 4500 m2 while 6 % the surface of the buildings have (556m2), and (13% to 20%) they have the surface between (500 to 798m2).

II.8.4 The number of chicks in buildings :

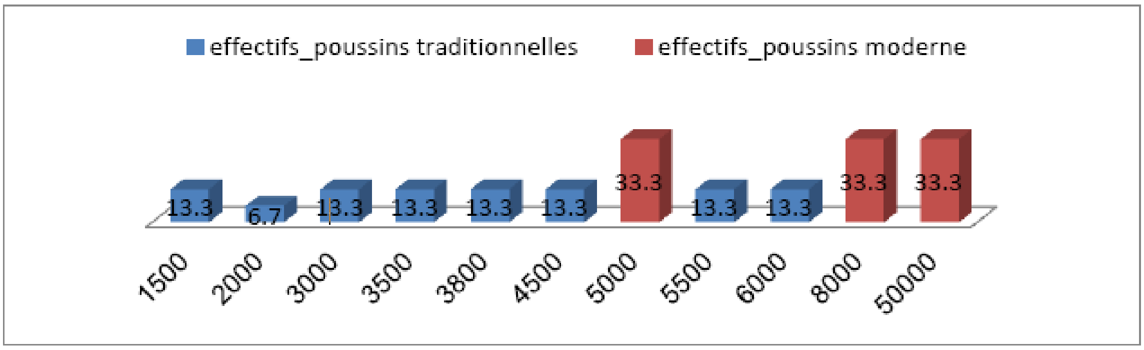
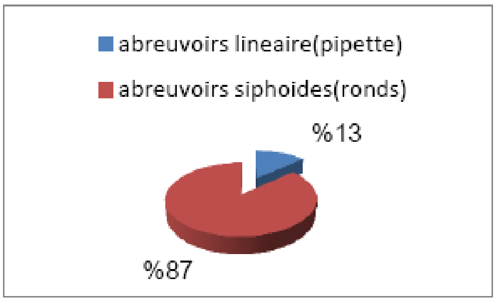


Figure II.29: Number of chicks in buildings (traditional and modern).

We show the majority of the traditional houses recorded the same percentage 13.3% they have the number of chicks between (1500 and 6000 subjects) while 6.7% of the houses have the number of chicks (2000 subjects). Figure: 11 On the other hand the majority of modern buildings recorded the same percentage 33.3% they have the number of chicks between (5000 a50000 subjects). Figure II.29

II.9 Building equipment and materials :

II.9.1 Type of drinkers :



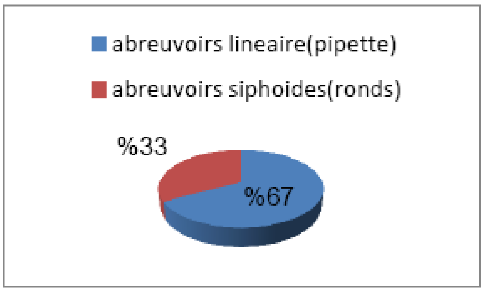
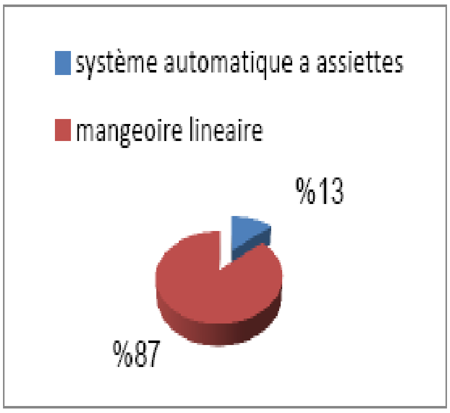


Figure II.30 :Type traditional drinkers. **Figure II.31**:Type modern drinkers.

It is shown that (87%) of traditional buildings used siphoid drinkers and 13% they used linear drinkers (nipple) Figure II.30 , on the other hand, we find that 67% of modern buildings used linear drinkers (nipple) while 33% used siphoid drinkers (round). Figure II.31

II.9.2 Type of feeders :



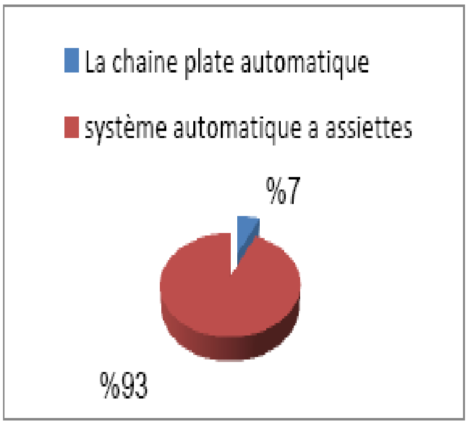
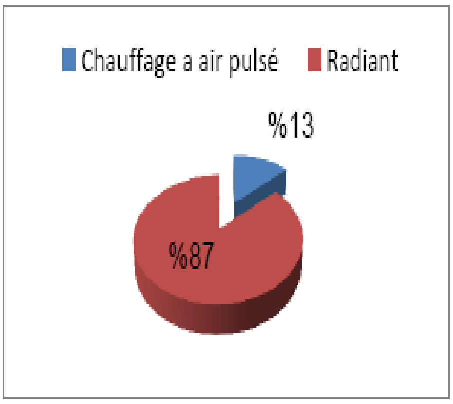


Figure II.32 : Traditional feeder type. **Figure II.33** : Modern feeder type.

This graph shows that (87%) in traditional buildings used linear feeders and 13% they used automatic plate feeders. Figure II.32 , on the other hand that 93% of modern buildings use automatic plate feeders. Figure II.33.

II.9.3 Type of heating :



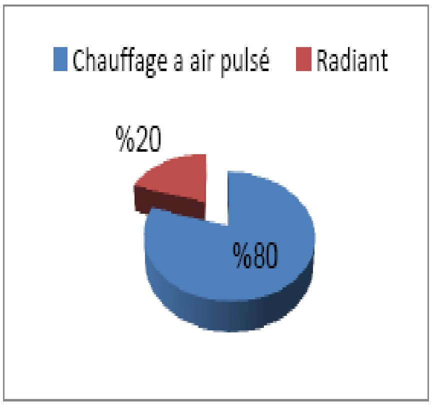


Figure II.34 : Type of traditional heating. **Figure II.35** : Type of modern heating.

It shows more than 80% of traditional buildings used radiant type heating and 13% they used forced air heating. Figure II.34 on the other hand we see that 80% of modern buildings use forced air heating and (20%) they have used radiant type heating. Figure II.35.

II.9.4 Starting temperature :

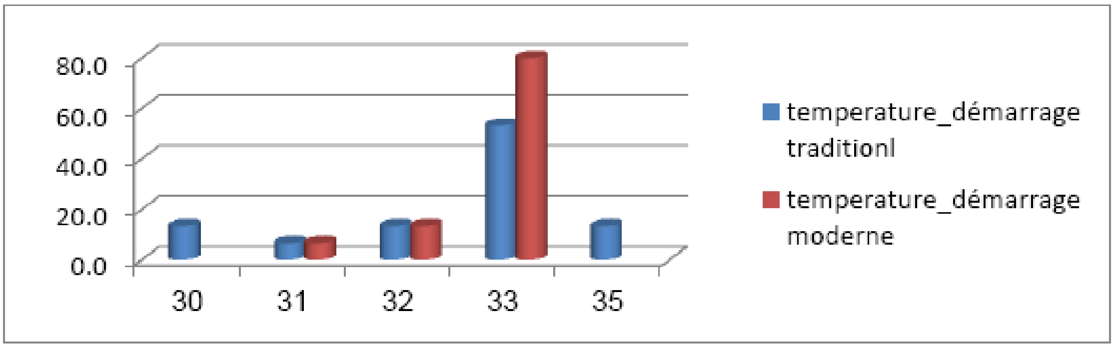
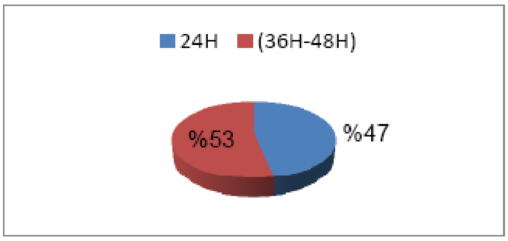


Figure II.36 : Starting temperature of traditional and modern buildings.

In this graph we can see that 53% of the traditional buildings use the T° = 33c° while more than 6% use the T°= 31c° with 13% some buildings use the T° between (30% to 35%) per against we have shown 80% of modern buildings used the T° = 33c° while between (7% to 13%) they used the T° = 31c° and 32c°. Figure II.36

II.9.5 Warm-up time :



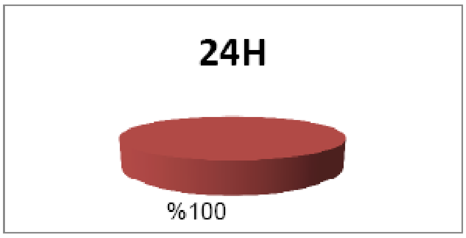


Figure II.37 : Traditional heating time.

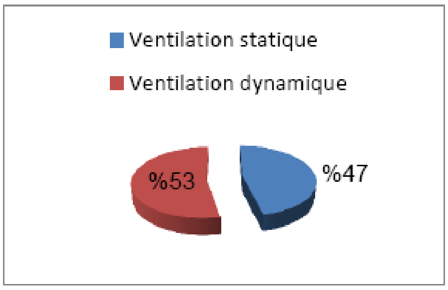
Figure II.38 : Modern heating time.

We note the heating time (preheating) achieved is 36h-48h by (47%) while the preheating time achieved in traditional buildings is 24h by (53%). Figure II.37, on the other hand, indicates 100% of modern buildings carry out 24 hours for preheating. Figure II.38.

II.9.6 The period of light :

It has been observed that 100% of buildings (traditional and modern) use the light period (23h-24h).

II.9.7 Type of ventilation :



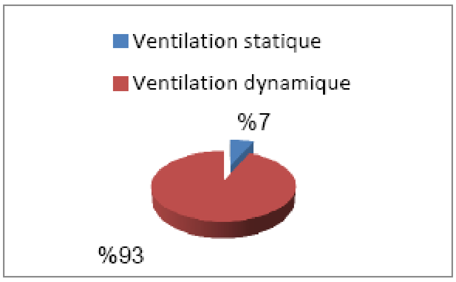


Figure II.39 : Type of traditional ventilation **Figure II.40** : Type of modern ventilation

It can be seen that 47% of traditional buildings have dynamic ventilation and a percentage (53%) of buildings have static ventilation. Figure II.39. On the other hand, it is indicated that (93%) of modern buildings use dynamic ventilation Figure II.40.

II.9.8 Number of mortalities in batch :

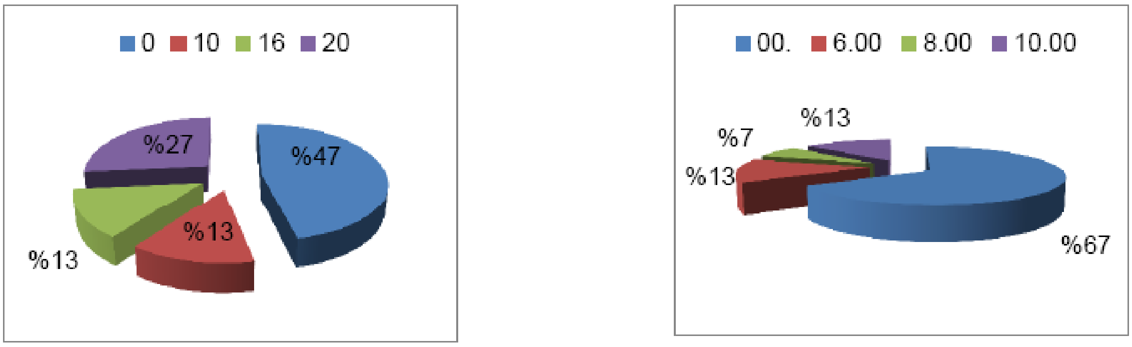


Figure II.41:Number of deaths in batch arrivals (traditional, modern).

In this graph of traditional buildings we have shown a (47%) cannot mortality with (13 to 27%) there are mortalities between (10 to 20 subject) but in modern buildings we indicate (67%) cannot mortality while between (7% to 13%) there are mortalities between (6a10subjet) Figure II.41

II.9.9 Weight of each day 1 chick :

This graph shows a (47%) in traditional breeding the weight of the chicks of the 1st day is 40g and with (13%a25%) are weight between (35 a62g) respectively. But in modern breeding, they are recorded that (33%) has the weight is 40g while (13%a17%) they are weight between (45and50g) Figure II.42.

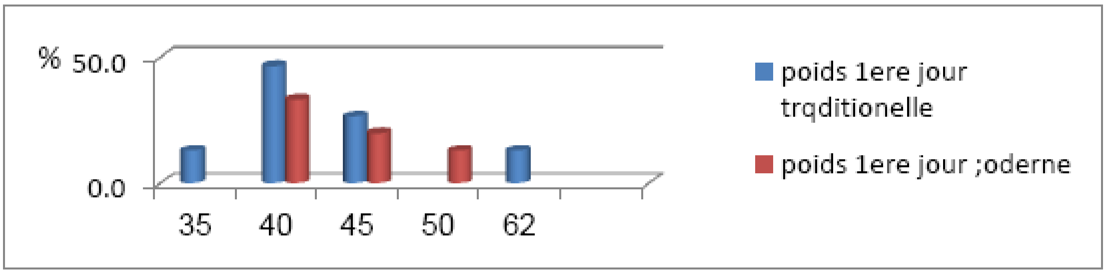


Figure II.42 : Weight of each day 1 chick (traditional, modern).

II.9.10 First week chick weight :

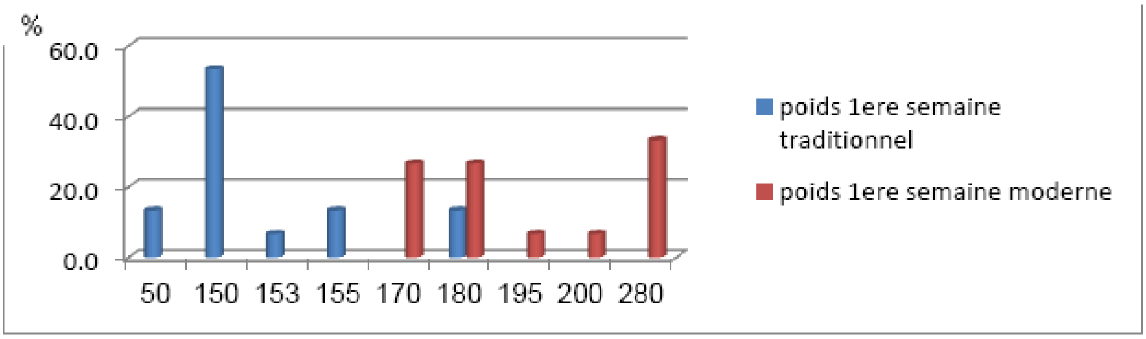


Figure II.43:Weight of each chick in the 1st week (traditional, modern).

In traditional breeding we see that the weight of the chicks during the 1st week is varied from 50g to 180g but in modern breeding we show that the weight is high from 170g to 280g. Figure II.43

Figure II.44 : Measuring chick weight 1st week.

II.9.11 Weight of each chick of the 2nd week :

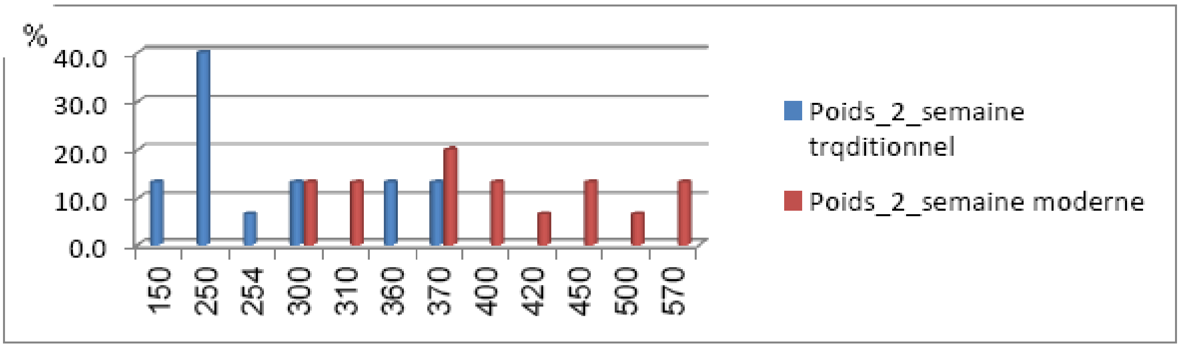


Figure II.45 : Weight of each chick of the 2nd week (traditional, modern).

In this graph we indicate (40%) of the chicks in traditional breeding have a weight of 250g and the same percentage 13% of the rest they have the following weight: 150,300,360 and 370g with (6%) they have the weight of 254g but in modern breeding we a note (20%) of the chicks of weight 370g with the same percentage (13%) of the rest they have weight between (300a 570g) whereas 6% they have weight between (420g a 500g) Figure II.45.

Figure II.46 : Measuring chick weight 2nd week.

II.9.12 Weight of each chick in the 3rd week :

In traditional buildings recorded only chicks weighing 700g (40%) and for the rest find the same percentage (13%) they have weight between 450 a720g with low percentage they have weight 723g but in modern buildings they find (20%) of the chicks weight 880g while even (13%) for the rest they have weight between 800g a945g and (6%) they have weight between 838a950g Figure II.47.

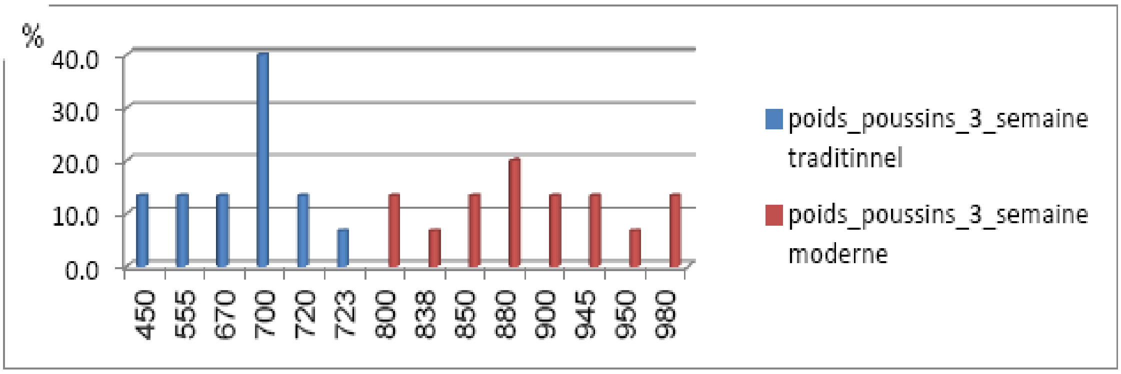


Figure II.47 : Weight of each chick of the 2nd week (traditional, modern).

II.10 Analysis and discussion :

Through the previous study that we did about traditional poultry houses and modern poultry houses, we conclude the following :

- Modern and advanced poultry houses produce higher number of chickens and of good quality compared to traditional poultry houses.
- The use of renewable energies to provide appropriate conditions (heating through geothermal energy) would reduce energy consumption and preserve the environment, unlike fossil fuels.
- Solar technology can achieve electrical cost savings of 30-85% for poultry farming.
- The adoption of poultry houses by the energy-saving HVAC system is not popular in **El-Oued** region due to the ignorance of the breeders of this technology.
- The ventilation technology and wind turbines can produce approximately 2,000 kWh/year of electricity and meet the energy demand of the entire poultry house, reducing greenhouse gas emissions by about 3.0 tons/year.
- Raising chickens by traditional methods is very expensive compared to modern methods that exploit renewable and clean energies.

II.9 Conclusion :

In this chapter, a study, analysis and comparison of the traditional and modern houses in the breeding of broiler poultry in the El Wadi region, the municipality of Oued El Alanda.

Through the study, we found that poultry farmers who use energy-saving HVAC system poultry houses that operate with renewable energy technology such as solar energy and geothermal energy reap higher profits at lower cost and produce large number of broiler chickens with good quality as a result of saving energy consumption unlike poultry breeders who use traditional poultry houses Those that run on gas and fossil fuels, the latter are harmful to the environment and broiler poultry farmers incur losses as a result of the high cost of fuel, gas and others.

Finally, it is no secret to everyone that renewable and sustainable energy technologies can replace the traditional HVAC system (fossil fuels, gas....) inside poultry houses. This can help reduce energy demand, operating expenses, and greenhouse gas emissions and boost farmers' profits.

CHAPTER 03

contribution of geothermal energy in poultry house

III.1 Introduction :

Global warming and climate change have been undeniable throughout the last century, and they are expected to continue if greenhouse gas emissions continue (GHGs). They have had negative effects on human civilization, animals and plants, the economy, and ecosystems all throughout the world, most of which are linked to climatic extremes [84]. Carbon dioxide (CO2) concentrations in the atmosphere are widely recognized as the primary cause of global warming. Due to dwindling energy sources, skyrocketing energy prices, and the rising importance of environmental concerns, energy conservation has become more important than ever [85].With the growing awareness of governments and individuals all over the world [86], it has been accepted that traditional methods based on fossil fuels have imposed a high cost on agriculture [87, 88], and as a result, they have begun to investigate novel renewable energy technologies in these fields, such as poultry houses [89–90], greenhouses [91–92]. GHG emissions from animal agriculture account for 22% of worldwide total emissions, with roughly 80% coming from poultry businesses involving livestock and feed transportation [99, 100].

The poultry business, particularly the broiler sector, is one of the most energy-intensive sectors in ALGERIA, consuming huge amounts of fuel. In order to maintain the correct temperatures for the rearing of the chicks, broiler chicken buildings need a lot of fuel—gas for their heating systems. The major sources of heating in poultry houses are currently conventional electricity and gas. Between 2010 and 2017, poultry farmers saw an increase in operating expenses owing to rising fuel prices. Fuel-derived energy has resulted in increased GHG emissions in the atmosphere, which has led to an increase in environmental pollution.

As a consequence, solar (55%), biomass (27%), geothermal (13%), and wind (5%) are generally regarded in the poultry production industry, as shown in Figure 1 [94–95]. Many research and applications have recently been offered, focusing mostly on solar energy [8996–97] and geothermal energy [98–101], and providing a simple, sustainable, and successful method for chicken homes. Heating is critical for the growth of chickens in poultry houses during the first week before they are able to regulate their own body temperature.

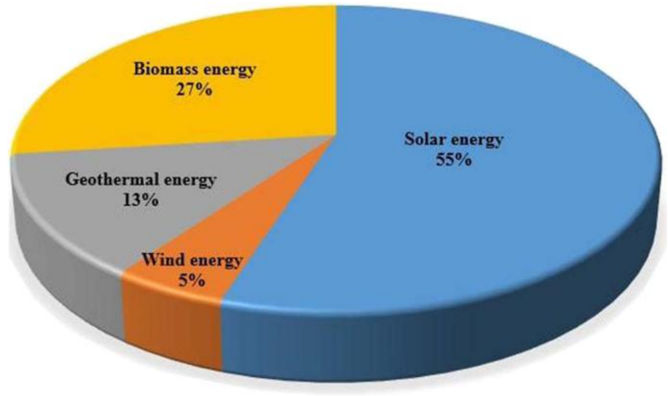


Figure III.1 : Different types of renewable energy sources for potential utilization in poultry houses [100].

Geothermal energy has the potential to be a cost-effective heat source for chicken buildings with high productivity.

Heat exchange between soil and chicken house is more efficient than previous alternatives since soil has a relatively constant temperature. Ground source heat pump (GSHP) systems are ecologically beneficial, consume a little amount of energy, assist maintain a consistent temperature in the poultry house, and reduce fossil fuel consumption and CO2 emissions.

III.2 Geothermal Energy :

Geothermal energy is heat that originates deep below the ground. Geothermal is derived from the Greek words geo (earth) and therme (heat). Because heat is constantly created inside the ground, geothermal energy is a renewable energy source. Geothermal heat is used for heating houses, and generating energy.

Figure III.2 : Geothermal energy.

Geothermal energy is now one of the most energy-efficient technologies accessible, providing the following benefits:

- can heat and cool sheds.
- almost zero carbon emissions.
- highly scalable.
- may slash energy costs by between 50% and 70% .
- base-load energy is not reliant on sunny skies or windy days.

Geothermal heating and cooling entails the use of steady heat (geothermal energy) that exists two to three meters under the surface for heating and cooling[103].

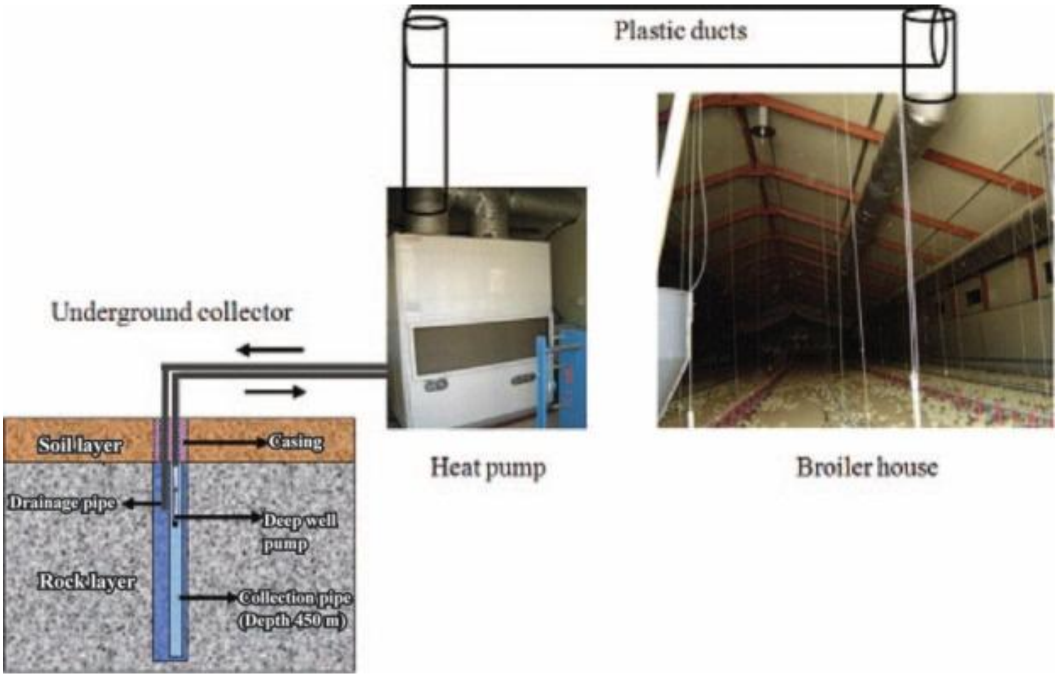


Figure III.3 : Schematic diagram of the geothermal heat pump (GHP) system for the broiler house[103].

III.3 Working principle of geothermal energy :

Depending on where you are in Algeria, the temperature of the soil two to three metres beneath the surface is reasonably stable all year at roughly 22° to 24°C. A loop system of fluid-filled subterranean pipes is used in a geothermal heating and cooling system to draw on this heat energy. The ground loop gathers heat energy and transports it to a heat pump. The heat pump compresses the heat and distributes it throughout the chicken house, drawing heat from the shed and returning it to the ground through the same loop system[105].

III.3 The main components of a geothermal energy system :

III.3.1 The heating and cooling pump :

A heat pump is an electrically powered device that extracts heat from a place with a lower temperature (source), and delivers it to a place with a higher temperature (poultry houses).The same working principle applies to the cooling pump, where it extracts heat from a place with a higher temperature (the ground) and delivers it to a place with a lower temperature[89].

A ground heat exchanger and a heat pump are the two primary components of ground-source heat pumps. Unlike air-source heat pumps, which have one heat exchanger outdoors, ground-source heat pumps have one heat exchanger within the residence[86].

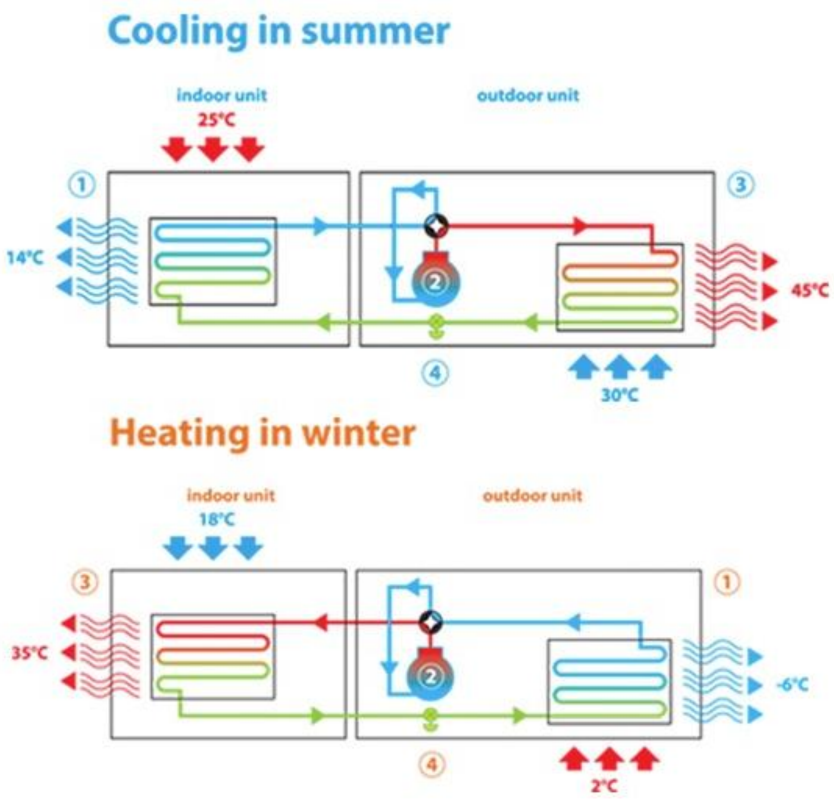


Figure III.4 : The heating and cooling pump[99].

III.3.2 Ground heat exchanger :

There are two types of ground heat exchanger designs:

III.3.2.1 Open Loop :

A groundwater bore is used as a heat source in an open loop system. The groundwater is pumped into the heat pump unit, which extracts heat and disposes of the water in an ecologically friendly manner. Bores are a great heat source since groundwater maintains a generally steady temperature throughout the year[101].

The heat trapped in an underground body of water is used in open systems. Water is drawn from the well and sent directly to the heat exchanger where it is removed. Then the water is released to a body of water above the surface of the earth, as shown in the Figure III.5.[101]

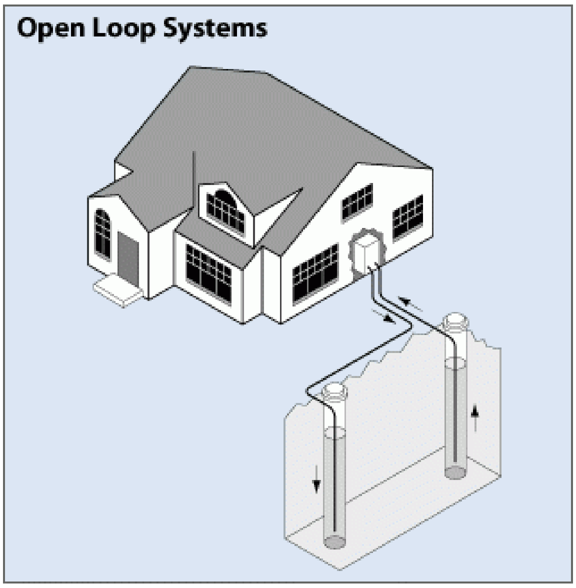


Figure III.5 :open loop system[101].

III.3.2.2 Closed Loop :

A continuous loop of underground polyethylene (poly) tubing is used in a closed loop system. The pipe connects to the internal heat pump to create a sealed subterranean loop that circulates an ecologically friendly anti-freeze and water solution. Unlike an open loop system that uses water from a bore, a closed loop system continually recirculates its heat-transferring solution in a pressurized chamber[80].

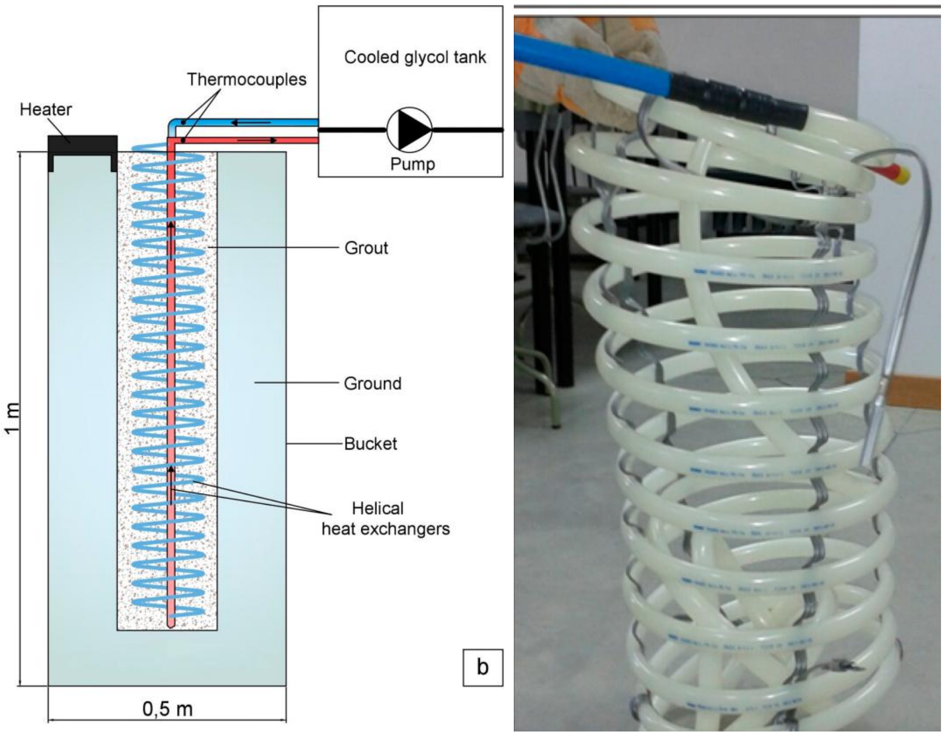


Figure III.6 :spiral closed loop system[80].

The temperature, available soil and ground conditions, and local installation costs all factor into the choice to use an external piping system.

III.3.3 heat distribution in geothermal energy hvac :

The geothermal unit and the distribution system are the most important parts of an HVAC system. The geothermal unit is in charge of moving heat from one location to another. The geothermal unit's energy is distributed throughout the poultry house using the distribution system[95].

Different configurations are allowed by the distribution system. The forced-air/ductwork system often utilized for air cooling is the most prevalent geothermal HVAC system. Radiators, radiant flooring, fan coils, and baseboard heaters are other effective heat distribution solutions[95].

The use of heating in poultry houses is necessary and very important in raising broiler chickens, for example in the Figure III.7.[95]

Figure III.7 : Heating distribution system in poultry house[95].

III.2 The Geothermal Pump Work :

A heat pump is a device that transfers heat from one spot to another by using a little amount of energy. Heat pumps are commonly used to extract heat from the earth to heat chicken houses, but they may also be used to cool them. In certain ways, if you understand how an air conditioner works, you'll understand how a heat pump works as well. Heat pumps and air conditioners are extremely similar in operation[105].

A note only if we consider that the earth temperature is about 20 to 25 degrees Celsius at a depth of 4 meters and the external temperature is from 38-40 degrees Celsius, taking into account the geographical directions and elevation angles in summer and winter here. Of course, poultry needs appropriate temperatures, whether lower or higher all season long[105].

Heat pumps raise the temperature from 20 to 38 degrees Celsius. Some commercial machines may achieve temperatures of 93°C. This is accomplished through a heat pump's evaporation, compression, condensation, and expansion cycle. A heat transmission medium called refrigerant flows within the heat pump[105].

The system starts when cold liquid refrigerant flows through a heat exchanger (evaporator) and absorbs heat from a low-temperature source, such as a ground loop fluid. The refrigerant absorbs heat as it evaporates into a gas. The gaseous refrigerant is then compressed into a compressor, raising the temperature to approximately 82°C. The hot gas is then pumped into the house at about 38°C after passing through a cooled air heat exchanger. The coolant becomes liquid when heat is lost.[105] When the fluid passes through the expansion valve, it cools down and the process repeats. The flow of the system is reversed to act as an air conditioner.

III.3 Scale of Heating and Cooling :

This system or technology is highly scalable, which means that systems are available to heat average poultry houses all the way to an 11,000 square meter building[87].

But this technique in southern Algeria (El-Ouedstate, for example) is rare and does not receive a wide response from poultry breeders due to their ignorance and knowledge of it on the one hand, and on the other hand, the effective use of thermal energy on a large scale in regions and countries. From poultry houses, hospitals, residential places, canopy and others[100].

III.4 How viable is geothermal heating :

The El-Oued area is characterized by a cold climate in winter and hot dry summer in the summer and the main source of energy in poultry farms there is fossil fuels and gas, which constitute a large part of the costs spent by farm owners, especially during the cold seasons[86].

Due to heating requirements, poultry farmers incur about **6%** of the total production cost in winter, and **4%** in summer and According to the study, the barns were heated by heat lamps and a diesel boiler, while ventilation relied on the principle of evaporative cooling that used fans[55].

Figure III.8 : Poultry houses in El-Oued state.

III.5 Efficiency of geothermal energy system in poultry houses :

Geothermal energy has the potential to be a cost-effective heat source for chicken buildings with high productivity. Heat exchange between soil and chicken house is more efficient than previous alternatives since soil has a relatively constant temperature[70].

A ground source heat pump (GSHP) is able to extract heat source from soil for heating the chicken shed to obtain the optimum production performance, which is conducive to guaranteeing a desired indoor temperature for poultry shed and decreasing fuel requirement and CO_2 emissions. To be more specific. [56] developed a GSHP system utilized to provide the heating for a poultry house in Algeria. It is concluded that the GSHP system could decline the operating cost since it could obtain more heating from ground for heating the shed. About 82% energy consumption could be saved in comparison to the conventional poultry houses during the operation period[99].

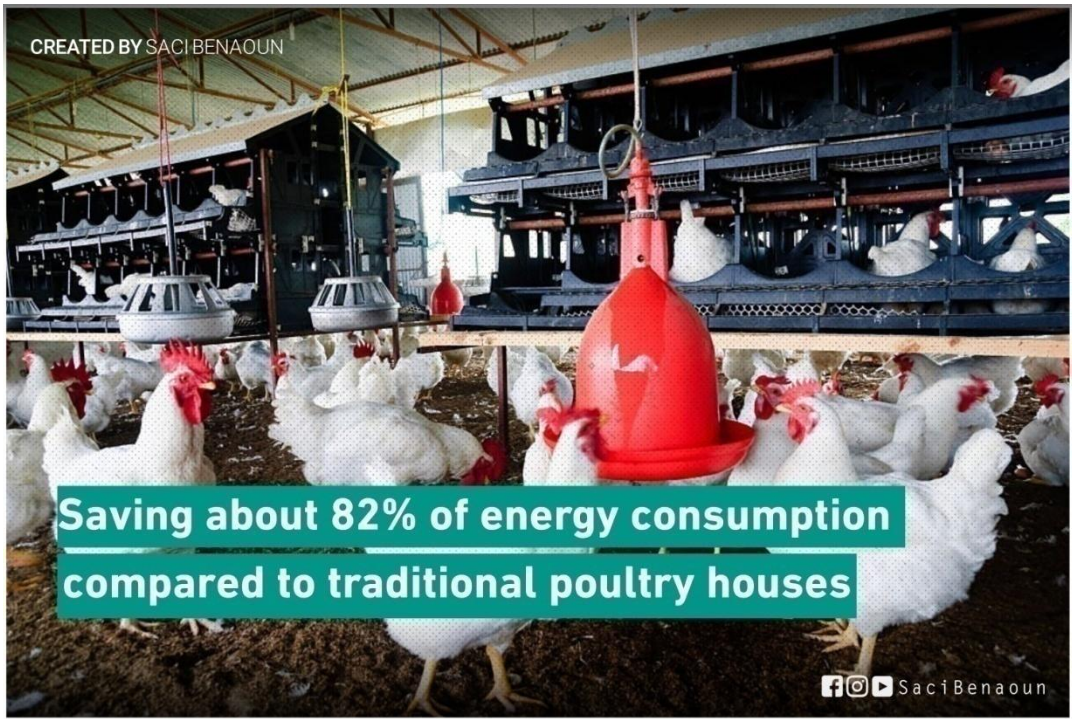


Figure III.9 : Saving consumption when using GHP.

In addition, the mortality rate of broilers when using the geothermal energy system reached 3% of the total number of poultry, compared to the traditional systems, which amounted to 6% of the total number of chicks.

Figure III.10 : Comparison of the mortality rate of poultry.

III.6 Conclusion :

In this chapter, the latest renewable and sustainable energy technologies (geothermal energy) are studied to replace the traditional heating and cooling system inside poultry houses. This can help reduce energy demand, operating expenses, and greenhouse gas emissions and boost farmers' profits, and From our study, the following conclusions were drawn :

- the energy consumption could be declined by 57% and has a payback time of about 6-year.
- It reduces the consumption of fossil fuels and gas by a significant percentage, thus increasing the profits of farmers
- the GHP system could increase the production performance of broiler chicks due to increased inside air.
- The GHP system contains less CO2 and NH3 emissions that are harmful to the environment.

- Geothermal energy is a renewable and sustainable energy unlike fossil fuels, gas...etc.
- A system that saves energy and consumption by 82% compared to conventional systems.
- Clean and eco-friendly heating system.

CONCLUSION

GENERAL CONCLUSION

Finally and a summary of what was studied in a graduation thesis on the HVAC system for poultry houses that provide energy in a desert area (Wilaya El-Oued, municipality of Oued Al-Alanda).

It can be said that the latest renewable and sustainable energy technologies can replace the traditional HVAC system inside poultry houses that use fossil fuels, gas, etc., and this can help reduce energy demand, operating expenses, greenhouse gas emissions and improve farmers' profits.

Solar and geothermal technology can achieve electrical cost savings of 30 to 85% for poultry farming. Moreover, the service life of solar energy technologies is able to maintain nearly 25 years with low maintenance cost for poultry houses.

Ventilation and wind turbine technologies may generate around 2000 kWh of electricity per year and meet the energy requirement of the whole chicken shed, resulting in a reduction of roughly 3.0 tons of GHG emissions per year.

The energy cost and average weight of chicks in a GSHP (Ground Source Heat Pump system) poultry shed can be saved about 92% and raised by about 6.8% compared with the ordinary poultry houses, and the payback period is less than 5 years. In addition, GSHP is relatively easy to install, and needs low maintenance cost.

To sum up, these renewable and sustainable energy technologies can help save up to 85% energy consumption compared to the conventional poultry houses, and have a payback time of 3–8 years.

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ABSTRACT

Abstract: The HVAC system, which is derived from renewable energy technologies such as solar energy, geothermal energy, etc., in broiler poultry houses, saves on the electrical cost, ranging by a large percentage for poultry farming. Moreover, the lifespan of renewable energies technologies is able to maintain approximately 25 years with low maintenance cost for poultry houses.

This can help reduce energy demand, operating expenses and greenhouse gas emissions and boost farmers' profits.

Keywords: HVAC system, ground-air heat exchanger, poultry houses, geothermal energy, energy-efficient ,Renewable energies,Arid zone.

Résume : Le système HVAC, qui est dérivé de technologies d'énergie renouvelable telles que l'énergie solaire, l'énergie géothermique, etc., dans les poulaillers à griller, permet d'économiser sur le coût de l'électricité, allant d'un pourcentage important pour l'aviculture. De plus, la durée de vie des technologies d'énergies renouvelables est capable de se maintenir à environ 25 ans avec un faible coût de maintenance pour les poulaillers.

Mots clés : Système HVAC, échangeur de chaleur sol-air, poulaillers, géothermie, économe en énergie, énergies renouvelables, zone aride.

الملخص :يعمل نظامHVAC المستمد من تقنيات الطاقات المتجددة مثل الطاقة الشمسية وطاقة حرارة الأرض ...الخ,في منازل الدواجن اللاحمة على توفيرًا في التكلفة الكهربائية يتراوح بنسبة كبيرة لتربية الدواجن. علاوة على ذلك،فإن عمر تقنيات الطاقات المتجددة قادر على الحفاظ على ما يقرب من 25 عامًا مع تكلفة صيانة منخفضة لبيوت الدواجن.

ويمكن أن يساعد ذلك في خفض الطلب على الطاقة ونفقات التشغيل و انبعاثات الغازات الدفيئة وتعزيز أرباح المزارعين.

الكلمات المفتاحية:نظام HVAC،مبادل حراري أرضي - هواء،طاقة شمسية ,طاقات متجددة, توفير الطاقة , حظائر دواجن،طاقة حراري أرضية،منطقة قاحلة.