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Feasibility Study of Geothermal Energy Earth Air Heat Exchanger in Poultry House: a case Study of Arid Zone of South Algeria-El Oued

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Dedication

Firstly, our research is dedicated to the sake of Allah, my creator and my Master, who give us the strength and the knowledge in everyday life.

This thesis is also dedicated to my both parents who are the reason of what I become today.

My late Father, Tedjani may Allah grant him the highest rank in jannah who did not only raise and nurture me but also taxed himself dearly over the years for my education and intellectual development, my Mother Aisha has been a source of motivation and strenght during of despair and discouragement and she is always beside me, I ask Allah to protect her for me.

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Nomenclature

EAHE	Earth Air Heat Exchanger
PVC	Polyvinyl chloride
PP	polypropylene
Qs	Building surface heat
A	Area of the building (m2)
R	Value of insulation for the wall material (m2C/W)
U	Thermal transmittance (W/m2C)
To	Exterior temperature (C)
Ti	Interior temperature (C)
Q_B	Bird heat (W)
S_h	Sensible heat (W/ kg)
W	Weight of the bird (kg)
Vc	Air capacity (m3/h)
Vfc	Tunnel fan capacity (m3/h)
V	Air velocity (m/s)
S	Cross-section area (m2)
DB	Dry bulb temperature, °C: is air temperature that is shielded from moisture and radiation.
MCWB	Wet bulb temperature, °C: is the temperature of air which is passed through a thermometer covered in water-soaked cloth
N_B	Number of Birds
Q	Heating Load or Heating Capacity (W)
Q_P	Saved Heating Capacity by EAHE (W)
Q_P (%)	The percentage of Saved heating capacity by EAHE (%).
N_{ex}	Number of Heat Exchangers
Q_s	The heating Capacity of single heat exchanger(W)
AVERAGE (Q (%))	The average percentage of saved heating capacity
∑ Q (%)	The sum of percentage of saved heating capacity (%).
S_m	S_m: The annual saved money (DA)
C_D	Total gas and diesel consumption (DA)

General Introduction

General Introduction

Nowadays, the food security has become a global concern because of the actual growth of the population that will reach at 9.2 billion in 2050.[1] The only sector that makes and expects to continue to make a major contribution to global food security and nutrition is the poultry sector.But this contribution faces many challenges related to climatic conditions and energy consumption which are due to the increasing consumption of fossil energy sources and its pollution, where the poultry sector also consumes energy for ventilation, lighting, heating, and cooling, which lead to a high-energy bill.On other side ,this challange leads to look for alternative sources that must be in abundance to fill the gap resulting from the replacement of fossil fuels.Also many types of alternative sources can help to reduce the pollution resulting from the fossil fuel, and these sources are called renewable energy sources. [2]

In Algeria, poultry industry is also considering the most important sector for food security and the growth of national economy and the public authorities are currently showing a clear desire to reduce energy consumption by encouraging the use of the renewable energy. [3]

Therefore, the only type of renewable energy that can be decrease energy consumption for heating and cooling system is geothermal energy with technique called the Earth-Air Heat Exchanger EAHE, with the knowledge that this technique is in the process of studying.

The aim of this project is to how to apply this technic in terms of thermal feasibility as well as financial feasibility.

Thus to achieve this work, we have summarized it into two parts:

Firstly, the part one is theoretical that is talking about generality of geothermal energy EAHE and poultry house design, secondly part is practical concerning the thermal and financial feasibility of geothermal energy EAHE in poultry house.

Chapter I: Generality of Geothermal Energy-Earth Air Heat Exchanger

I.1. Introduction

The requirement to reduce an energy consumption for heating and cooling loads improved through the past time that based on the energy saving,which can be produced by the renewable energies for example solar, wind and geothermal energy,therefore the geothermal energy EAHE can be suitable a source of energy for heating and cooling buildings which rely on the ground temperature at few meters depth , for example warmth source in the winter and as heat sink in the summer. [4]

I.2 Principal of Earth-Air Heat Exchanger

The earth-air heat exchanger is a geothermal system and it is a passive heating and cooling systems, which uses the energy of the ground to heat or cool the fresh air.

Depending on weather conditions, day and season, outside air temperature undergoes strong variations, in contrast the ground temperature of few meters below the surface varied slightly due to its high thermal inertia of the ground and to profit from this inertia we put in contact the outside air with ground through buried tubes.

The air from the outside moved by a fan and it traverses the heat exchanger tubes before being blown into the building, while the air flows withing the buried pipes, the heat is transferred from air to the contiguous soil through a summer period (known as "Provencal wells") and in the opposite in the winter season (known as "Canadian wells").

In addition, the feasible buried depth is 2 meters, the deeper depth is preferable but it cause extra cost.

Regarding the Materials of tubes are nonmetallic materials and the most used is polypropylene (PP) and PVC. [5]

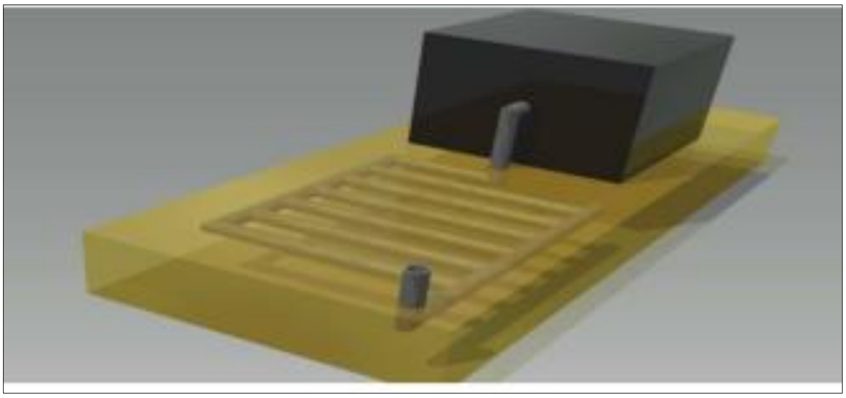


Figure 1: Earth–air heat exchanger principle. [5]

I.3. Types of earth air heat exchanger

I.3.1. Closed Loop System

In closed loop system, inside air from the home or structure is passed through a U-shaped with lenght of 30 to 150 m of tube where it is moderated to near earth temperature before distrubuting by ductwork to return home or structure .The closed loop system is more efficient than an open one, because it precools or preheat the same air again.

This system is subdivided into 03 types: closed loop (horizontal),closed loop(vertical),and closed loop (lake).[6]

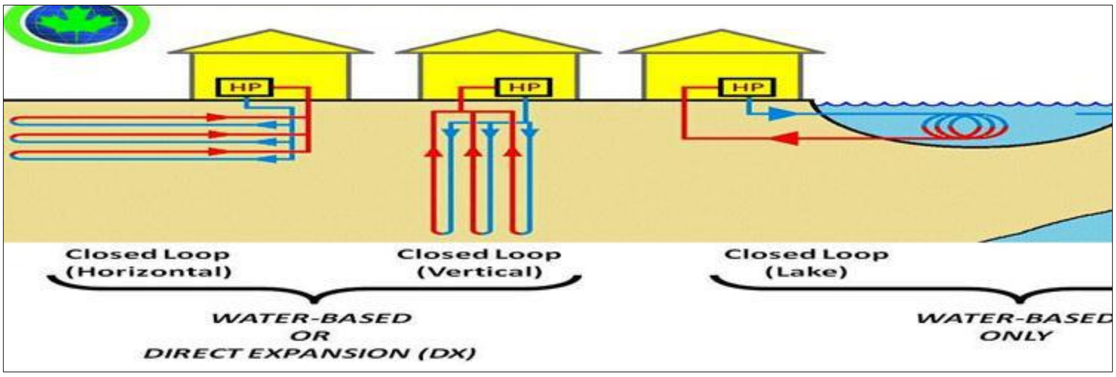


Figure 2:Types of closed loop system.[6]

I.3.2. Open Loop System

In open loop EAHE system,The fresh ambient air is aspirated by a fan and it flows through the buried pipes then it can gain the ground temperature before entering the building to match the heating/cooling requirements[6]. In addition, this system make sure that entering fresh air is filtred and tempered. [7]

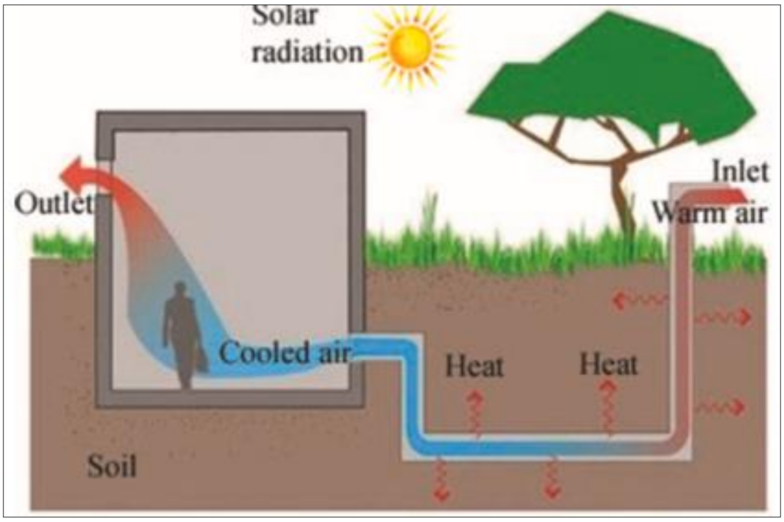


Figure 3:Types of open loop system.[7]

I.3.3. Miscellaneous Systems

Many ground systems cannot be classified as either open or closed such a system is the standing column well, in which water is pumped or coming from the well's bottom to the heat pump. In order to absorb heat, the leaving water percolates through gravel in the well's annulus. The Water used in mines and tunnels is also another source of heat. This water has a consistent temperature all year and it is easily accessible.[8]

I.4. Factors Affecting Operation and EAHE Performance

We mention many factors, which have impact on performance and operation of EAHE

- Depth of buried pipe.
- Space between the pipes.
- Roughness of the pipe
- Thermal insulation at the outlet of the pipe;
- Running time
- Sensitive and latent heat transfer
- Climatic condition
- Geographic location
- Composition and treatment of soil surface covering
- Physical properties of soil (moisture content, soil density, soil mineral composition, shape of soil particles, etc.)
- Thermal properties of soil (thermal conductivity, thermal diffusivity of the soil, penetration length)
- Floor gluing with pipes;
- Composition of the backfill material;
- Temperature and air velocity;
- Relative humidity of the air;
- Parameters related to the pipe: material (PVC, steel, etc.), pipe length, diameter, thickness. [9]

I.5.Advantages and disadvantages of Earth Air Heat Exchanger EAHE

The Earth Air Heat exchanger has the following advantages[10]:

- Simple design and easy installation
- It is suitable for different types of soil
- Less energy consumption.
- Less required maintance and lower cost
- It participle to minimize an air pollution
- It based on thenatural refrigerant such as water and air.
- It does not need a compresser for its operation
- It is not necessary to be located where is exposed to weathering
- Does not require energy for its operation in case of wind velocity high
- It provides fresh air such as open loop system.
- It has a lower cost than ISAHP and GSHPS.

In spite of these advantages, it has also the following disadvantages:

- Air outlet temperature is non-uniform.
- The cost of installation is high
- The phenomena of condensation within the pipes can participate to create microorganisms, which impact negatively on quality of air.
- High dependence on local climatic conditions in the upper parts of the exchanger above the ground, which influences the thermal performance of the system
- Convection of fan noise through the pipes to the far away living space.
- Condensed water vapor discharge problem however there is a solution, which is the pumping out a water inside the pipes where there is small submersible pump at lowest point, this solution will increase the total energy consumption of the system.

Chapter II: Poultry House Architectural Design

II.1 Introduction

The design of the poultry house plays an important role to determine the indoor climatic conditions for optimal health, growth and production performance of the birds.

Therefore, the type of poultry house system used by the proposed poultry farm depends on the prevailing climatic conditions of the farming regions. While the open poultry house system is a good system of housing in tropical countries due to its simplicity of construction, minimal running costs and ease of heat management, the controlled housing system is most popular in the temperate regions. [11, 12]

In this chapter, we have to know the required conditions for poultry house, which aid to calculate global heat energy released that is necessary for application geothermal energy EAHE on poultry house.

II.2. Climate Conditions for Poultry House

It is necessary to comprehend the influence of the poultry house's internal climatic conditions on the birds, how the birds react to them, and the consequences for heat control in poultry production. These informations help to determine criteria for poultry house architectural design, which reduce heat stress and enable optimal chicken production

The important climatic factors include temperature, relative humidity, air composition and velocity, and lighting condition.[13]

II.2.1. Temperature

There is a debate about the convenient temperature range, which is required for the differents age groups and class of chicken to obtain optimum production, this is related to other climatic factors like humidity and wind velocity that impact on temperature change and previous adaptation of chicken to climatic change. [12]

Usually, all class and age of chicken perform under a wide variety of temperature, but the exposure of chicken to excessive temperature preclude the performance of chicken production. It may also be compounded with the increase of relative humidity for its poor effect on evaporative cooling.[14]

The recommended temperature for day old chicks is 30–32°C [11],thereafter the temperature should be reduced by 3–4°C until the chicks at 4 weeks of age as shown in **Table1**.

It is reported that the required temperature range for growing broilers is 18–22°C [15]. In other reviews done, it was concluded that the comfortable temperature for the birds when environmental temperature vary between 18–24°C. [16] but, it should be notable that the optimal performance of chicken related to the market value of the product relative to the cost of feed .

It is a challenge to reach the ideal production temperature in the tropics regions consequently it is necessary that the poultry house designer pay considerable attention to temperature change.

Table 1: Recommended temperature values

Age of chicken	Temperature range
1	30-32
2	30-26
3	26-23
4	23-20
≥5	20

I.2.2. Relative Humidity

Internal temperature exceeding 26.7°C mixed with high relative humidity has a negative impact on feed efficiency, feathering, pigmentation, as well as weight gain in chicken [12]. Furthermore, at internal temperature range of 35–37.8 ° C, the birds' performances were poor regardless of the change in relative humidity, this means higher humidity with lower temperature can improve the performance of the birds but the humidity have to be controlled in order to avoid microorganisms, which cause dangerous diseases for birds [17, 18].

There is a strong relationship between Relative humidity and temperature change.
At the brooding stage, especially in the earlier weeks, the inside relative humidity can be low due to the needed warming of chicken at that age or when baby chickens hatch or thirsty at higher temperature.

Soon enough, the water vapour generated by the evaporative cooling lead to rise the inner relative humidity, which make the chicken regulate their body temperature as they grow [11]. As result, ages 3 weeks and above are very critical periods in chicken production whatever the class of chicken.

I.2.3. Air Composition

The decomposition of bird feces creates noxious and polluted gases such as ammonia, carbon dioxide, methane, and hydrogen sulphide.

These gases are of special imprtance due to the negative effects, which impact on performance of birds, cages, human poultry homes, and the environment itself. As a result, for optimum chicken production, ammonia and carbon dioxide concentrations are 25 ppm and no more than 2500 ppm respectively was recommended [11, 17, 19-23] .

For good bird health management , it was recommended that fecal material should be removed from the poultry house on a regular basis to limit the amount of gas emission [12].

II.2.4. Air Velocity

High interior temperatures can be regulated by adjusting the air velocity in addition, the air velocity is also significant in convectional cooling and air quality regulation for poultry house [17, 24] and it is recommended that ventilation capacity in hot climates should be at least "5m3 per chicken for each hour, with inlets equal to 1.5cm2 per 1m3 ventilation[11] .

it was shown that if the temperature stay stable between 25–30°C, the air velocity could be maintained from 0.1 to 0.2 m/s. [17] but according to other review that shows at the similar temperature conditions,the best growth rate for broilers is with an air velocity of 2 and 3 m/s respectively [25].

In order to better understand the effect of air velocity on the chicken,[26]it is considered that the age of the chicken in the temperature range of 25-30°C with a changeable air velocity.The study has shown that 6-week-old broilers benefited from increased air speed of 2 and 3 m/s compared to 4-week-old broilers. This is because of the high temperature needed by the young birds in the brooding stage.

II.2.5. Lighting

Lighting at an early age in birds has no influence on the hormone system, it only improves birds activeness, which includes feed intake, growth, physical and physiological activities [16, 27, 28] ,While an increase in lighting duration and intensity may lead to tiredness, cannibalism, immunological reactions, leg abnormalities, and even mortality [27, 29-33]

The most frequent lighting program is a continuous lighting of 16 hours of light and 8 hours of darkness, which has been demonstrated to be effective for overall chicken performance [16, 34-36] . However intermittent lighting, which alternates between brief periods of light and darkness lead to improve chicken performance [11, 37-40]

According to the continuous lighting program, it is recommended to maintain light intensity of 20 lux as minum value during the post hatch stage (1-7 days old) in order to aid the chick to fit their environment and aid feeding[27]. For this reason ,the light intensity should be decrease by 3–5 lux and introduce of intermittent lighting system to facility the control of the birds’ activeness in order to better performance and productivity [11, 27]. Birds bred under yellow, green, and blue light sources show that gain a weight more than those reared under red and orange light sources [41, 42].

It was found in a review that birds bred under blue light are docile, but those reared under red light are more energetic and aggressive. Furthermore, it was shown that red light increased sexual activity in birds. [41]

II.3. Poultry Housing System

The total energy released from poultry house is the total heat produced by the birds, the surrounding environment, and fecal material biodegradation[43, 44] .Therefore, the type of used housing system is an essential determinant element in the type of management to be adapt in poultry farm.

There are three common types of poultry housing system:

- Open housing system naturally ventilated
- Open housing system mechanically ventilated
- Environmentally Controlled House

II.3.1. Open housing system naturally ventilated

In the hot climate, the open poultry housing system is known for its economic implications, simplicity and ease of heat generation management inside the building through natural ventilation [11, 14, 45] .But, it is exposed to invasion by small predators animals, birds, insects, and rodents which can affect negatively on chicken productivity and performance.

As result, to alleviate this issue the dwarf sidewalls are raised to the eaves with corrugated wire mesh to keep animals away. Futhermore, the gutters filled with insecticides to preclude the attack of insects that surround the house. Consequently, it must take into account the design for open poultry house to obtain an optimal poultry performance and productivity.

II.3.1.1. Building orientation

The chicken house should be oriented east west in order to decrease the exposure of the sidewalls to direct solar radiation[44, 45] . This is critical because the heat stress in birds can be accelerated when they are exposed to direct sun radiation.

Deep litter breeding may enable the birds to avoid direct sunlight, but it may also cause bird clustering or crowding in a specific section of the house. As a result, the cooling becomes hard, and in severe circumstances that can lead to a panic and possibly death [45].

II.3.1.2. House width, length and height

A poultry house's east-west orientation may diminish the benefit of predominant winds moving east or west. As a result, it is advised that the building's breadth not exceed 12 m in order to avoid this problem. Furthermore, the issue of irregular air exchange rate and temperature within the house is eliminated. [45]

Moreover, the activities and services provided by poultry farmers and professional inside the building must be included in the design and where these activities may include chicken transfers, waste management, de-pecking, feeding and immunization.

According to Qureshi[14] , it is preferable to consider the number of levels to be used in the design of battery cages.

A two–tier cage system allows easy air exchange inside the poultry house; however a three–tier or four–tier cage system might be difficult for air exchange. As a result, it is preferable that cage rows do not exceed three with center aisles not less than 1.2 m with a minimum height difference of 1m from the ceiling.

II.3.1.3. Roof slope

It was was recommended that the inclination of roof is 45° was due to the angle reduces heat quantity on the roof which is produced from direct solar radiation, increases the distance of the bird from the heat gained under the roof, rapid escape of the heat received under the roof through ridge opening, increases air space to enhance air exchange rate and open space above for equipment installation[44-46]. On other side, the inclination of insulated roof is related to the insulation quality.

II.3.1.4. Overhang of Roof

The roof overhang play a vital role in the solar shading because it participate to shade the sidewalls of house from indirect and direct solar radiation. but, the roof overhang length mainly depend on the height of the sidewalls[45] . the use of overhang roof with slope of 45°aid to reduce heat gain by 30 % [44].

II.3.1.5. Ridge opening

Due to the difference of air density, hot air naturally rises above colder air.
In poultry house, the placement of ridge opening can help the ventilation through stack effect.

It is essential the use of an appropriate setback between structures in order to avoid circulation and inappropriate airflow [45, 47] . However, due to the uniformity of temperature within insulated poultry houses, ridge opening has been noted to be inefficient [48].

II.3.1.6. Sidewall openings

The sidewall is composed of a dwarf wall that extends up to the roof eave with a permeable membrane like corrugated wire mesh and an adjustable curtain.

To protect the poultry house from direct and indirect solar radiation, water seepage, predators, and pests, it is recommended that the minimum height is 0.4 m to avoid this issue [45].

The corrugated wire mesh permits an easy ventilation both within and outside the house, whereas the adjustable curtain adjusts air velocity and flow,on other side, the curtain may be translucent or of different colours to help in the management of intermittent lighting schemes [16, 45, 48] .

II.3.1.7. Building obstruction

To avoid insufficient air exchange rates in structures, appropriate setback between buildings is necessary. Topography, Wind speed and direction are all important factors to consider in identifying the ideal housing spacing. Moreover the distance between buildings, may be calculated using the formula below [48]

$$D = 0.4HL0.5 \qquad (01)$$

Where D: is the building spacing (the ridge of the next house's closest wall).

H: is the height of the next building.

L is the length of the adjacent structure.

II.3.1.8. Roof, sidewall insulation and end-wall

In the tropic region, naturally ventilated poultry houses have successfully the using of locally materials like bamboo and thatched roof as roofing materials in the construction [14] but in naturally ventilated poultry house, the minimum recommended R-value for ceiling insulation is 1.25 m2 C/W. The required minimum R-value for environmental temperature higher than 40°C is 2.25 m2 C/W. The different methods of insulating poultry house ceiling include dropped ceiling, rigid board insulation, spray polyurethane insulation and reflective insulation[45]

II.3.1.9. Cooling system

Rooftop sprinklers demonstrate to be effective in cooling the roof however in, the material of choice must be able to resist continual exposure to water.

In hot conditions, evaporative cooling in birds can be subdued by utilizing a fogger system where the water pressure rises producing a mist which helps the birds to cool off.

But, the level of humidity inside the house must be controlled because it can harm the health of the birds when the temperature rises. The increase of air velocity from a circulation fan increases convection cooling, which alleviate heat stress. In addition ,circulation fans typically produce air velocity of 0.5 m/s or higher and cover an area 15 times its horizontal diameter by five times the vertical diameter.Moreover, it should be positioned 1–1.5 m above the floor and inclined downward at angle of 5^o for optimal use of circulation fan [44, 45].

II.3.2. Open housing system mechanically ventilated

The ability to obtain optimal interior environmental conditions and maximum bird performance under severe weather conditions has led to use the mechanically ventilated housing systems, which is able to achieve this condition.

Furthermore, a mechanically ventilated house allows for maximum control over air exchange, wind direction and wind velocity[11, 45],the mechanically ventilated system involves the use of negative or positive pressure system.

The most typical negative-pressure system in mechanical ventilated buildings expels air out of the house via fans through an air inlet system for creating low pressure within the house and permit new air to flow in through the same air inlet system.In addition, the negative-pressure system can be applied via inlet or tunnel ventilation.

Regarding to the inlet ventilation system, the exhaust fans and air inlets are uniformy distributed throughout the poultry house while tunnel ventilation is known by the exhaust fans,which are positioned at one-end and inlet pipes are located at the other end,this gives tunnel ventilation the benefit of increased air speed, which contributes in more positive air exchange[45] .

II.3.2.1. House construction

The house must be well insulated and tightly constructed for optimum ventilation control. But instead of building a solid sidewall, the sidewall can be supplied with insulated adjustable curtains for usage during the cooler months of the year or in the case of power failure [45].

II.3.2.2. Air exchange

The temperature of the inside air is raised by the high exterior temperature and the heat created by the activities within the poultry house.

An efficient mechanical ventilation system must exchange air fast to maintain a difference of temperature no more than 2.8°C between the internal and exterior air temperatures.

The formula below may be used to calculate the suitable exhaust fan that is required for successful ventilation, which is related to building surface heat Qs [45].

$$Q_S = (A / R) \times (T_o - T_i) \quad (2)$$

Where, A: area of the building (m2), R: value of insulation for the wall material (m2C/W). To: exterior temperature (C); Ti: Interior temperature (C).

The value of T_o is the hottest outside temperature that is excepted of the exterior environment. But the calculation of heat gain for a roof in a building with attic space, the To value is considered to be 55°C while the To value for ceilings with insulation directly beneath the roof is supposed to be 65°C [2].In order to keep the birds comfortable, Ti should be considered 27°C. Thus, the value of R will be sum of the wall section's insulation value.

The commercial broiler produces 7.9 W/kg of total heat (sensible and latent), while broiler, pullets, and broiler breeders produce 5.1 W/kg [45, 49].The formula below is used to calculate heat produced by birds [45].

$$Q_B = S_h \times W \quad (3)$$

With: Q_B: Bird heat (W), S_h: Sensible heat (W/ kg), W: weight of the bird (kg)

Where: sensible heat, 50% of the total heat produced by birds.

Where the total heat is sum of building heat surface and heat bird.

$$\text{Total heat (W)} = Q_S + Q_B \quad (4)$$

However, the airflow capacity **Vc** required to maintain a temperature difference of 2.8°C between inlet and exhaust air which is expressed below.

$$V_c = \text{Total heat (W)} \times 3.4 / 2.8°C \quad (5)$$

Where: Vc: Airflow capacity (m3/h)

II.3.2.3. Air inlet system

Through the use a number of negative-pressure air inlet pipes, the internal climatic condition had been controlled by speed fresh air, direction and the entry location. In addition, the exhaust fan aid to determine how much airflow enters the building.

II.3.2.4. Inlet speed:

The entrance speed of fresh air is determined by the difference pressure between the interior and outside environments [45], but the pressure is related to the size and number of the air inlets.As result,the easy manipulation of differential pressure permits for more control of airflow pattern inside the building as well as a negative-pressure air inlet pipes used to control the internal climatic condition.

II.3.2.5. Inlet area

The exhaust fan must create a static pressure of around 12–25 Pa for simple control and distribution of air within the poultry house[45].

II.3.2.6. Air inlet control

For easy control of the air inlet, the recommended a static pressure of around 12–25 Pa because static pressures above or below that range might result in insufficient air velocity [45].

II.3.2.7. Types of inlet ventilation system

II.3.2.7.1. Cross ventilation

The exhaust fans are put on one side of the poultry house, whereas the air inlet pipes are installed on the opposite side ,which are suitable to narrow poultry houses (less than 10 m) since it causes differences in environmental conditions in larger houses [45].

II.3.2.7.2. Sidewall inlet ventilation

The exhaust fans are installed on both sides of the building walls below the air inlet pipes. However, the distance between the exhaust fans and the air inlet pipes should be at least double the diameter of the fan. The movement of air is oriented towards the centre by using exhaust fans. Furthermore, it is appropriate for narrow house with a width of no more than 12 m [45].

II.3.2.7.3. Attic inlet ventilation

This type of ventilation necessitates sufficient ceiling insulation and it is suitable for hot climates.

II.3.2.8. Tunnel ventilation system

The tunnel ventilation system is designed to match the air velocity and air exchange rate requirements but the needed air velocity is determined by the type of bird and the recommended air velocity for breeding various types of poultry birds is shown in (**Table 2)**

Table 2: Recommended air velocities in tunnel-ventilated houses.[45]

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

II.3.2.8.1. Tunnel fan capacity and air velocity

The tunnel fan's capacity is calculated using the same method as the inlet ventilation system, in contrary to the inlet ventilation system through which the apporiate air velocity is pushed by a circulation fan.therefore, the needed average air velocity within the tunnel house is determined using the formula below.

$$\mathbf{V\ (m/s) = Vfc/(\boldsymbol{S} \times 3600)} \quad \ldots\ldots \quad \mathbf{(6)}$$

Where Vfc: tunnel fan capacity (m3/h), V: air velocity (m/s), S: cross-section area of the house (m2).

However, It is crucial to note that the cross sectional area of the house has a negative impact on the air velocity within the house,as a result, it is preferable to construct a thin and long house with lower ceilings [45].The expression below may be used to calculate the appropriate air velocity.

$$\mathbf{Vfc = V\ (\boldsymbol{S} \times 3600)} \quad \ldots\ldots \quad \mathbf{(7)}$$

Where: Vfc: tunnel fan capacity (m3/h), V: desired air velocity (m/s), S: cross-section area of the house (m2).

II.3.2.8.2. Tunnel fan placement

The fans can be placed at the end-walls or at the end of the sidewalls, and this installation arrangement has no effect on the fan's performance.

II.3.2.8.3. Cool weather inlet system for tunnel ventilated houses

In hot weather, it is recommended that tunnel ventilated systems can be used because cool weather reduces the air exchange rate. As a result, it was recommended that a minimum of 60% of the tunnel fan capacity be controlled by the old intake system before converting to tunnel ventilation for simple switching during cooler weathers [45].

II.3.3. Environmentally Controlled House

This type of housing is provided by intelligent system, which controlled the inside conditions in order to maintain the bird's optimum needs. It is also characterised by a closed facility, longitudinally east to west, with large exhaust fans on the west side and evaporative cooling pads on the east side, automatic feeding and drinking systems which paraticipate to ensure optimal ventilation, temperature, relative humidity, and lighting program [50]

II.3.3.1. Climate control aims

Microclimate is defined as the local environment around the birds where the climate changes in the surrounding parts of the poultry house.

The microclimate carries oxygen for the animal's metabolism and it serves as a transport medium for excess heat, water vapour, and gases exhaled by the animals, as well as gases produced by the decomposition of manure and other particulate matter.

The most important microclimate parameters that impact on air quality are temperature, relative humidity, air velocity and gases (oxygen, carbon dioxide, methane, ammonia, hydrogen sulphide, and nitrous oxide) [50].

The common objectives of climate control are:

- Control the ventilation inside the poultry house
- Maintain relativity humidity
- Reduce temperature fluctuation
- Minimize the mortality of birds.

II.3.3.2. Ventilation

II.3.3.2.1. The Components of mechanical ventilation

They are 04 components: fans, openings, heaters.

The fans and openings are mentioned in the Open housing system mechanically ventilated

II.3.3.2.2. Heaters

In the winter, the poultry house needs the heating to reach the indoor required temperature.

II.3.3.2.3. Cooling system

There are 03 methods, which are commonly used for cooling system: Pad and fan system, Fog and fan system and High-pressure nozzel system.

II.3.3.2.4. Pad and fan system

Incoming air is drawn through a wet pad by exhaust fans in the poultry house, and the evaporation of moisture from the pad decreases the incoming air, this system divide in 02 types for cooling poultry buildings.

II.3.3.2.4.1. Pressurized system

Evaporative coolers are installed outside the house, and air is drawn through the coolers' evaporative pads before being pumped into the chicken houses.

II.3.3.2.4.2. Vacuum system

The evaporative pad is installed on one end of the house, while the exhaust fan is placed on the other end.

Air is pulled through the evaporative pad by the exhaust fans, which reduces the amount of entering air.

II.3.3.2.5. Fog and Fan system

It works similarly to a pad and fan system, except that the incoming air is pulled via a hood with high-pressure foggers. The temperature of the air was decreased when the air was dragged through the fog. In addition, airflow generated by fans within the shed increases considerably the cooling effect.

II.3.3.2.6. High-pressure Nozzel system

Generally, the Fogging systems participate to reduce the shed temperature.The Fogging is most effective in dry climates and typically consists of several rows of high-pressure nozzles that spray a fine mist through the house, which they based on the changing the liquid state to a gaseous state,this system eliminates wet pads and works in high-humidity environments [50].

II.3.3.3. Automatic controls system

Automatic controls system plays a significant role to manage indoor climate of poultry house.

Firstly, it keeps the indoor required temperature as well as provide air exchange when the weather changes hourly and seasonally, in addition it participate to set supplemental heating rate. [51]

Climate controller automatically controls temperature, humidity and ammonia concentration. Regarding the internal temperature, this system must based on the number of rearing days with required broilers temperature in order to control the temperature. On ther side, this system can ensure a water supply in the case of insufficient water, excessive and rapid water supply and it can controls lighting and the wet curtain system that is controlled by time, temperature and humidity. [52]

II.3.3.4. Feeding System

Broiler quality is determined by the broiler feeding system. Continuous feeding is used during the first week, it occurs as regularly as needed with small amounts at a time,in this period the broiler chicks are still learning and trying to adapt with surrounding environment , furthermore the feeding must be a small quantity in order to avoid the waste, as well as the feed is not be mixed with manure of broiler [53]. Broilers are typically fed 5 times per day, as broiler age increases, the feeding broilers frequency decreases till the sixth week where they are only fed 02 times per day.

The most important thing is the mealtime, Feeding must be done on time because the feeding at the same time every day can increase efficiency of production cost.

The right chosen of mealtime makes the chicken can eat well and not waste food[54] .
In addition, the feeding system have to be controlled like the automatic temperature and humidity regulation, which ensure a good quality of broilers produced , this is surely it is easy for the farmers to feed their broilers, on other hand the automatic system of feeding is expensive.

The automatic feeding system based on the use of screw conveyor system where it is 120 meter of screw conncted to motor as the screwdriver ,causing food to move forward to the entire container when the screw is turned [54]

II.4. Conclusion

The convection increases heat loss in birds when the volume and velocity of air are increased.

Furthermore, it must take account of architectural features such as building height, landscape, building orientation, roof overhang, building breadth, and roof slope in order to improve naturally ventilated buildings system for maximum chicken production. In addition, the use of cooling systems including fogging systems, sprinkling systems, and circulation fans in naturally ventilated systems has proven useful to enhance bird performance.

As a result, mechanical ventilated open housing systems have been introduced where the environmental temperature is extremely high and intolerable for birds.

In order to design mechanically ventilated house , it should take account of the heat generated by the birds, the fan capacity of the house, positioning of inlet pipes, sizes of inlet, level of installation, exhaust fan and the capacity of circulation fans required in inlet ventilated systems.[13]

The Environmentally Controlled closed House ensure a good performance of broiler production and lower energy consumption compared to the open house system [55].

Chapter III: Heating Load Calculation and Heating Capacity of Poultry House Using Hap 4.90 Software.

III.1. Introduction

The Heating, Ventilation, and Air Conditioning that are called HVAC systems which are one of the largest energy consumers in residential and commercial building, this system is defined as the simultaneous control of temperature, humidity, radiant energy, air motion and air quality within a space to meet requirements of comfort.[56]

They are the many methods for transferring air between indoor and outdoor spaces, with along cooling and heating.

These systems participate to keep you cool and fresh in the summer, warm in the winter and filter indoor air to keep you healthy and maintain appropriate humidity levels at ideal comfort levels.

In order to apply geothermal energy EAHE for the heating in the winter, it is necessary to calculate total heat load of poultry house, which allows knowing how much required heating capacity is produced from EAHE.

We need to organise the calculation into 03 following parts:

- The calculation of heating load.
- Required heating capacity of geothermal energy EAHE.
- Saved heating capacity from EAHE to supply poultry house.

III.2. Steps of calculation Heating Load by HAP 4.90

Firstly, to calculate the total Heating Load of poultry house in winter season, we can use **Hourly Analysis Program HAP 4.90** to simplify the calculation however, before the begging of calculation we should input the needed data, which as shown on the below Table 03

Table 3 : shows the needed data for HAP software

Design Parameters						
Latitude deg	Longitude deg	Elevation (m)	Summer DB (°C)	Summer WB (°C)	Summer Daily Range (K)	Winter DB (K)
33.5	6.8	62	41.7	22.1	13.9	4.1

Poultry House Dimensions				
Length (m)	Width (m)	Height (m)	Building Height (kg/m2)	Area (m2)
90	9	5	351.5	810

Internal Loads							
Miscellaneous Loads				Overhead lighting			
Number of Birds	Average Weight (Kg)	Sensible Heat (W)	Heat Load (W)	Number of lights	Light power (W)	Total Power (W)	Wattage (W/m2)
9000	2	4	72000	32	9	288	0.35

Envelope					
Walls			Roof		
Layers	Thickness (mm)	Density (Kg/m2)	Layers	Thickness (mm)	Density (Kg/m2)
Lw Concrete	40	640.7	CardBoard	40	99.3
Face Brick	150	2002.3	Polyster	40	35.0
Gypsum Plaster	40	720.8			

Secondly, the next **Figure04** illustrates the steps of heating Load calculation:

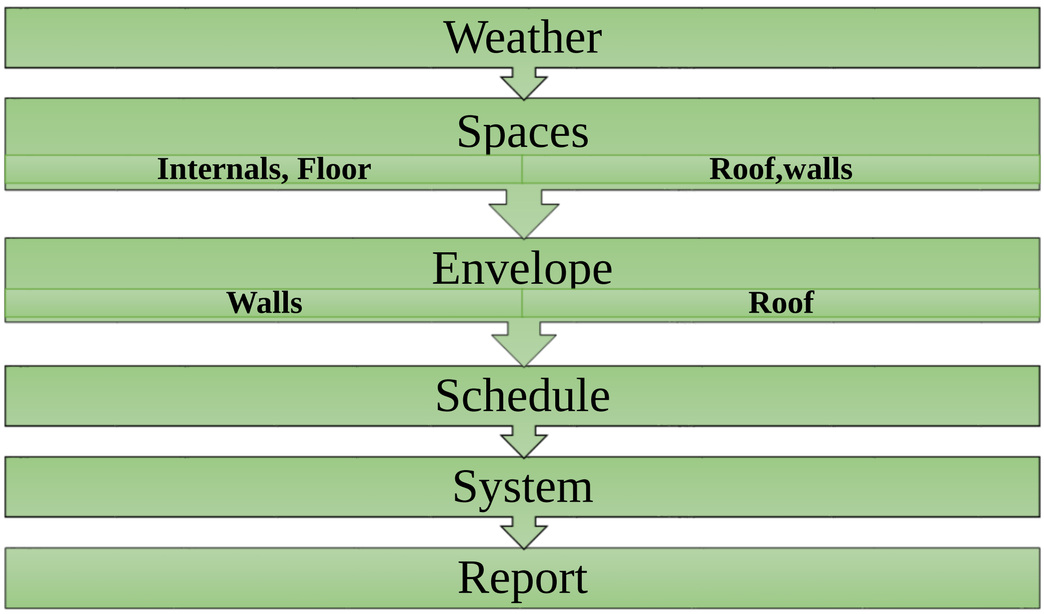


Figure 4:Steps of calculation Heating Load by Hap4.90

III.2.1. Weather

First of all, in this section we need to input weather data of the city of this project if it is available on HAP software, but in our case, Guemar El Oued weather data is not available, Therefore we have to access NASA site to import it and then choose and input design parameters that is required on weather section of HAP.

2017 ASHRAE Handbook - Foundamentals (SI)

GUEMAR, ALGERIA (WMO: 605590)

Lat:**33.511N**	Long:**6.777E**	Elev:**62**	StdP: **100.58**	Time zone:**1.00**	Period:**90-14**	WBAN:**99999**

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
1	**3.0**	**4.1**	**-5.1**	**2.5**	**14.3**	**-3.3**	**2.9**	**13.6**	**12.0**	**13.2**	**10.4**	**14.0**	**0.7**	**200**

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	**13.9**	**45.0**	**22.1**	**43.2**	**22.0**	**41.7**	**21.8**	**24.6**	**37.0**	**23.9**	**36.5**	**23.3**	**36.0**	**3.6**	**240**

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Extreme Max WB
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
21.6	**16.4**	**28.8**	**20.5**	**15.3**	**28.6**	**19.6**	**14.4**	**28.7**	**74.5**	**36.7**	**71.7**	**36.3**	**69.3**	**36.0**	**29.8**

Figure 5: NASA Weather data of Guemar-El oued city.

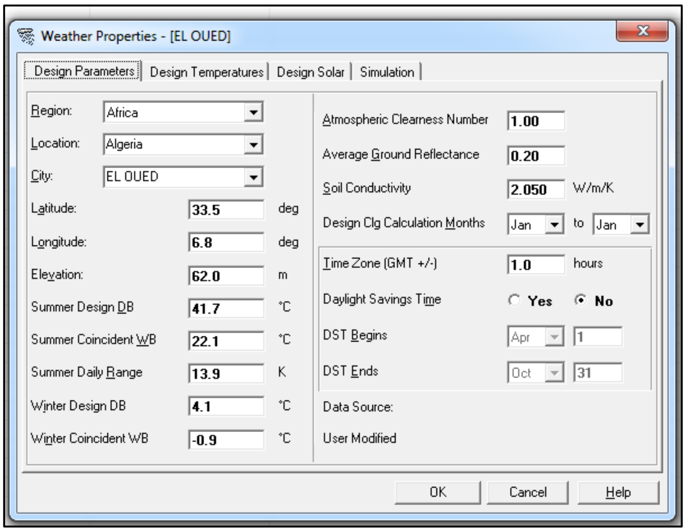


Figure 6:Weather properties of Guemar city.

DB: Dry bulb temperature, °C: is air temperature that is shielded from moisture and radiation.
MCWB: wet bulb temperature**,** °C: is the temperature of air, which is passed through a thermometer covered in water-soaked cloth (a wet-bulb thermometer).

III.2.2. Spaces:

In this section, we have to identify the dimensions of building, the internals loads, wall and roof area, walls direction of building

III.2.2.1. The Area of building:

Length: 90m

Width: 09m

Height: 05m

Area= L×W= 810 m2.

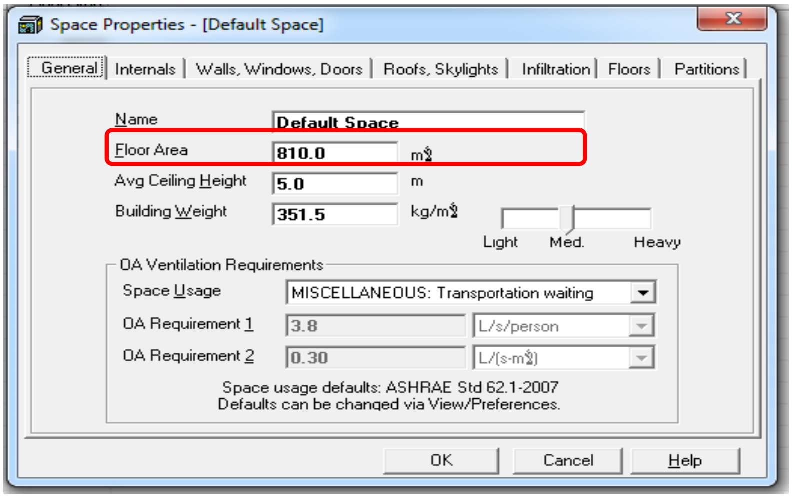


Figure 7: Space properties- Floor Area.

III.2.2.2. Internal loads

Internal loads of this poultry house consist of overhead lighting, sensible and latent of chickens

III.2.2.2.1. Miscellaneous Loads

Birds heat Q_B

$$Q_B = S_h \times W \times N_B \quad (8)$$

Where:

S_h : Sensible heat (W/ kg), W: weight of the bird (kg), N_B : Number of Birds.

Sensible heat = 4 watt/kg, Average weight =2 kg, Number of Birds=9 000

Birds heat (W) = 4 watt/kg × 2 kg ×9000 birds =72000 watt.

III.2.2.2.2. Overhead lighting

Power of single Light = 09 watt

Number of light = 32 lights and total power = 9 ×32 =288 watt

Wattage = (total power / floor area) = 288/910 = 0.35 watt/m2.

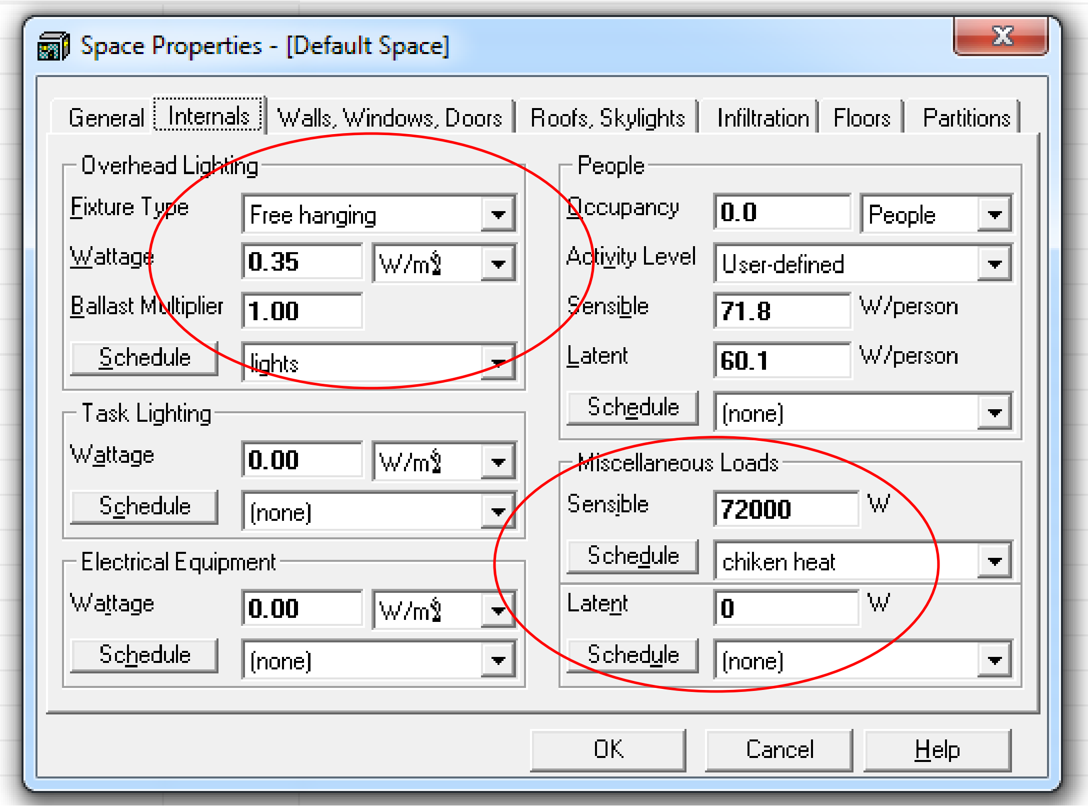


Figure 8:Space Properties-Overhead lighting and Miscelaneous load.

III.2.2.2.3. Walls and Roof

In this section, we input the Area of walls and the direction

The area of walls are oriented towards the South and the North are

(length × height) =90×5= 450 m2.

The area of walls are oriented towards the East and the West are

(length × height) =9×5 =45 m2.

The area of Roof = 90×9 =810 m2.

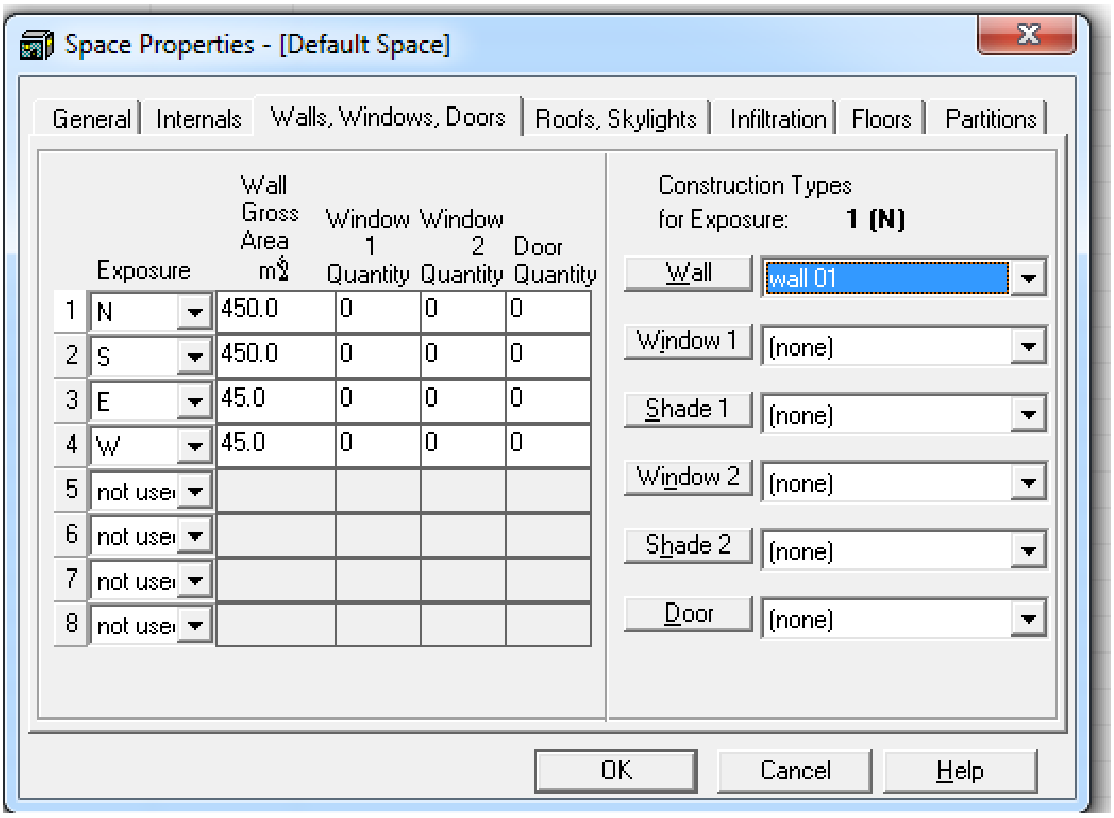


Figure 9: Space properties-Wall area.

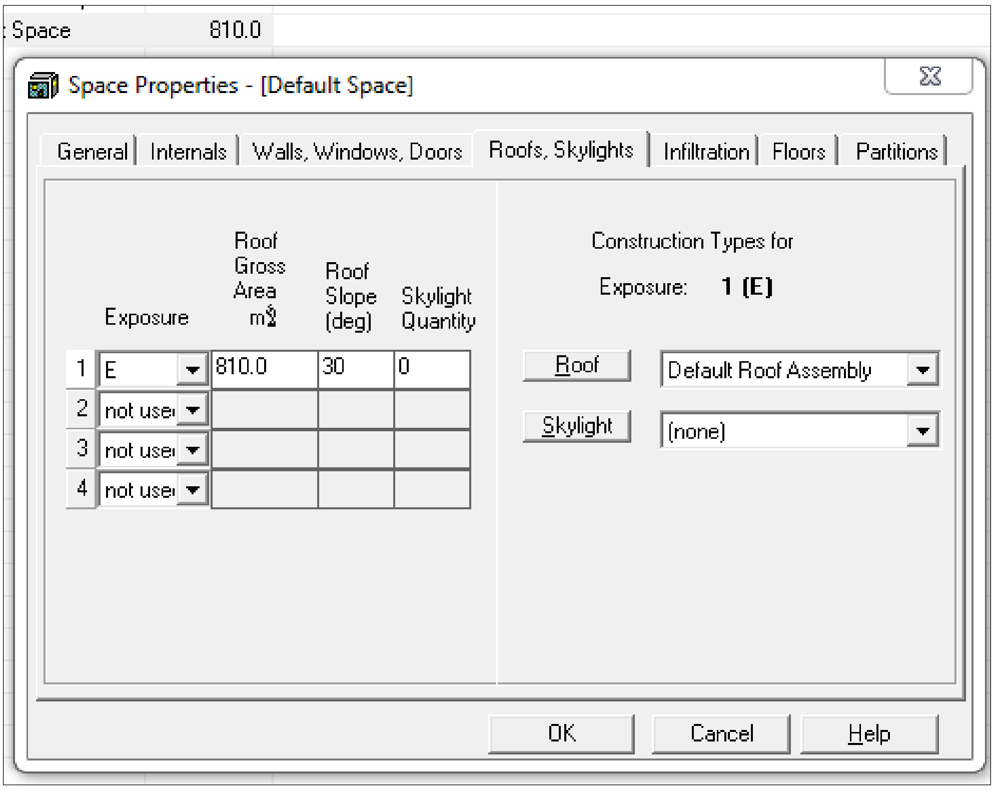


Figure 10: Space properties-Roof area.

III.2.3 Envelope

The figure 11 and **12** show the required parameters including Layers from inside to outside, Thickness, Density and specific heat to calculate the overall thermal transmittance (U-Value) of the Walls and the roof successively

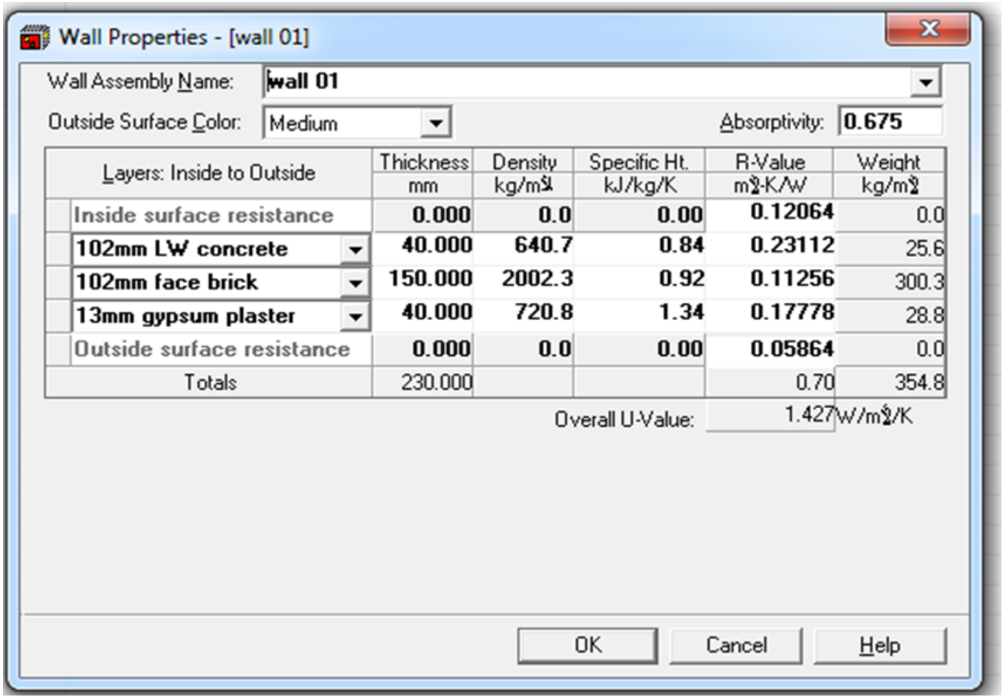


Figure 11: Wall properties- Thermal transmittance U

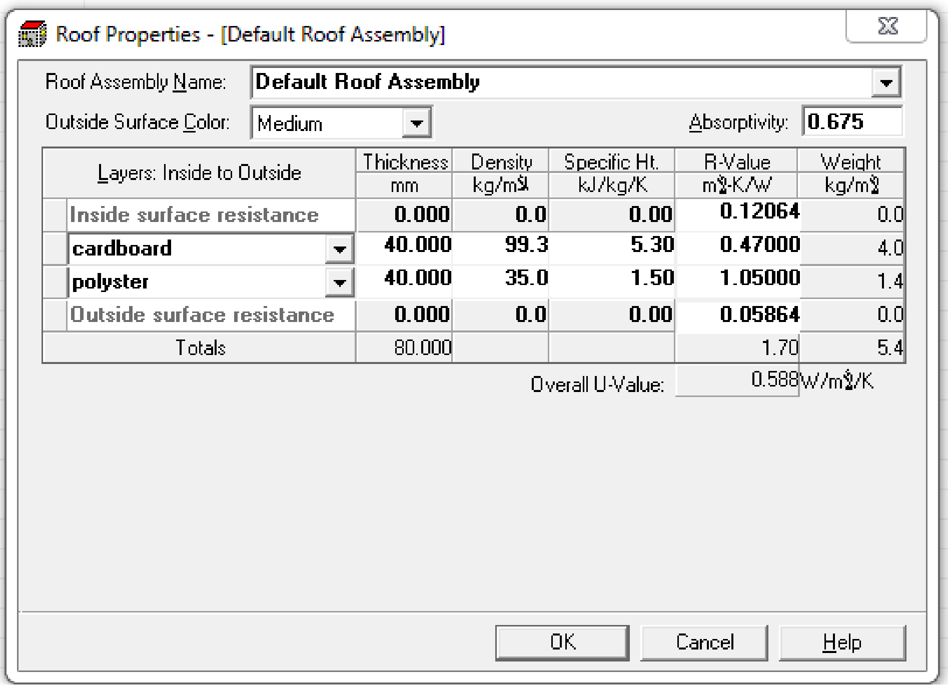


Figure 12: Roof properties- Thermal transmittance U.

III.2.4. Schedules

It should define hourly and daily schedules as percentages, which are the most used to describe the variation of internal heat gains.

III.2.4.1. Lighting

Depending on the lighting use for poultry house, we find that is used 50% of lighting durant the first 03 days of week and the rest days of week, it is used 100 % of lighting.**Figure 13**

- Profile one 01: shows the percentage of the lighting use that reach 50%.
- Profile two 02: shows the percentage of the lighting use, which reach 100%.

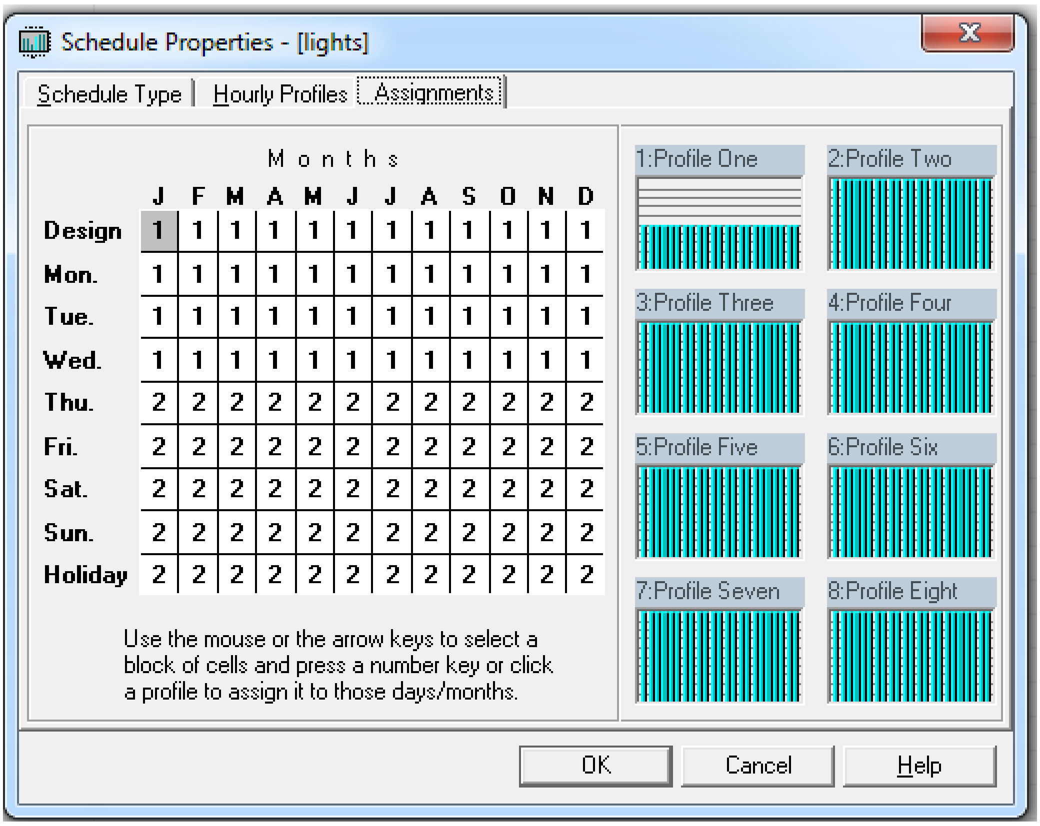


Figure 13: Schedule Properties- Lighting.

III.2.4.2. Ventilation

The schedule of ventilation presents the percentage of the ventilation use, which reach 100% for all days of week. **Figure 14.**

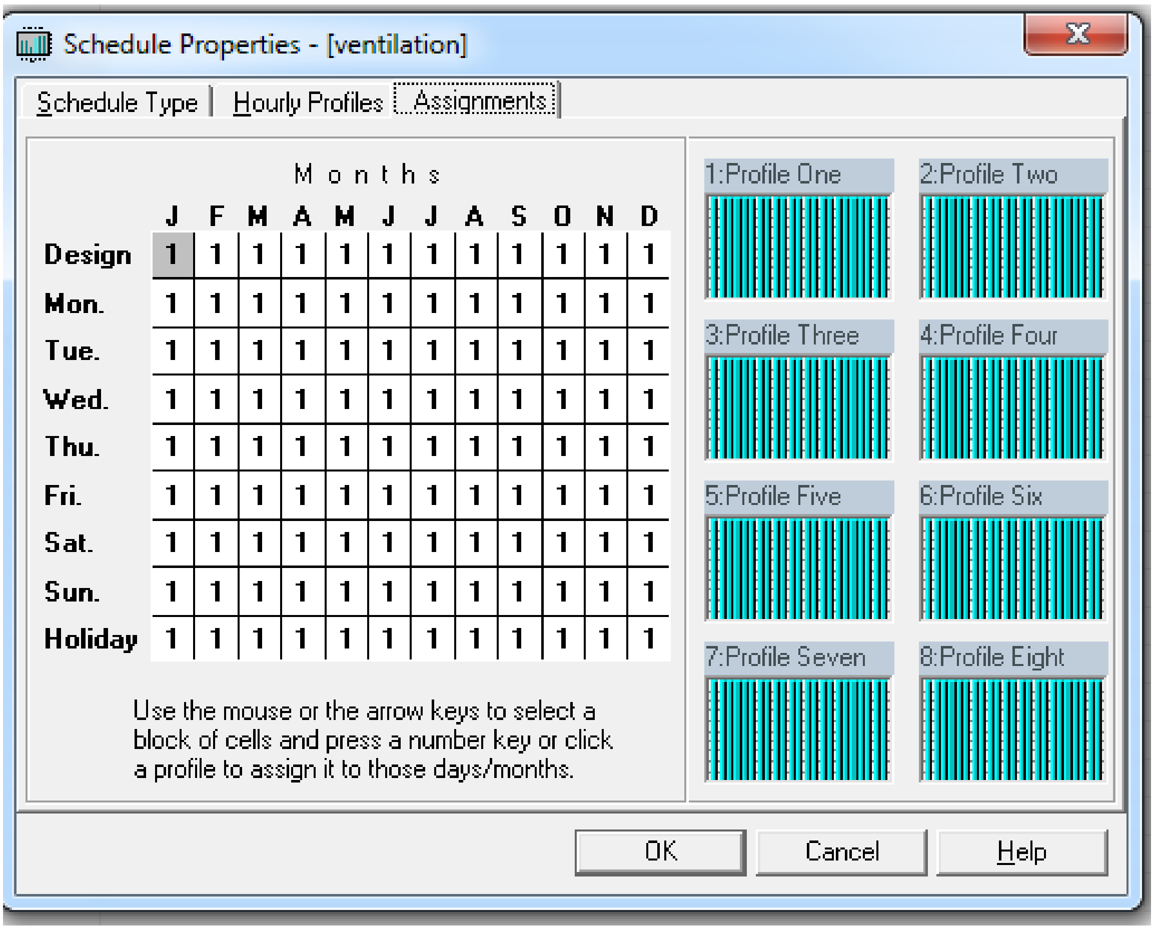


Figure 14:Schedule Properties- Ventilation.

III.2.4.3. Bird heat

According to the variation of internal heat gains from chickens, we can resume this variation in schedule **Figure 15**.

- Profile one 01: shows 50% of heat gain for 04 days per week.
- Profile two 02: shows 100% of heat gain or maximum heat gain for 03 days per week.

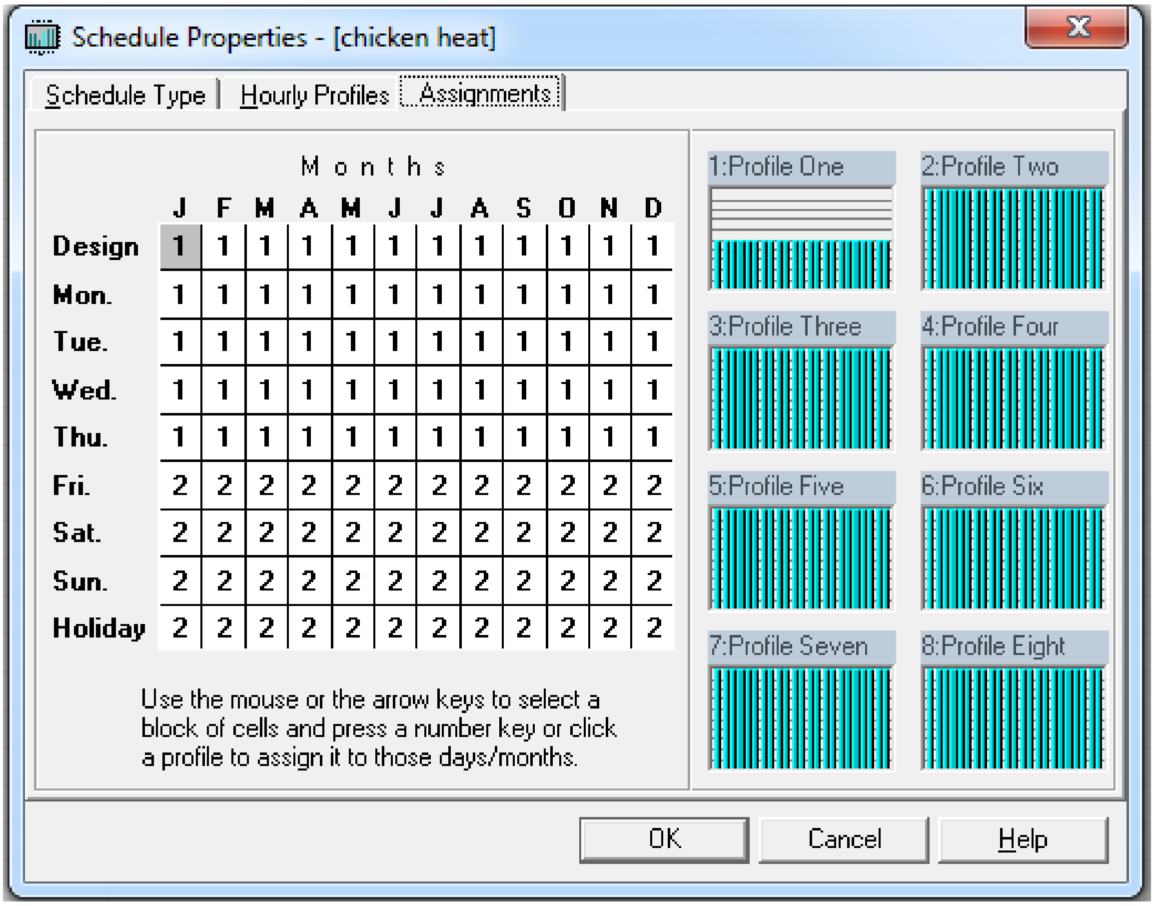


Figure 15: Schedule Properties- Chicken Heat gain.

III.2.5. Systems

In this section, we have to identify how many zone or area we want to study.

For example, if there is building contains rooms, so the program will show many area or zones for studying.

However, in our case we do not have any room, so the program will show only zone, which presents the dimensions of poultry house. **Figure 16**

Furthermore, in order to calculate heating load we have to set desired indoor temperature through using icon thermostat heating. **Figure 17**

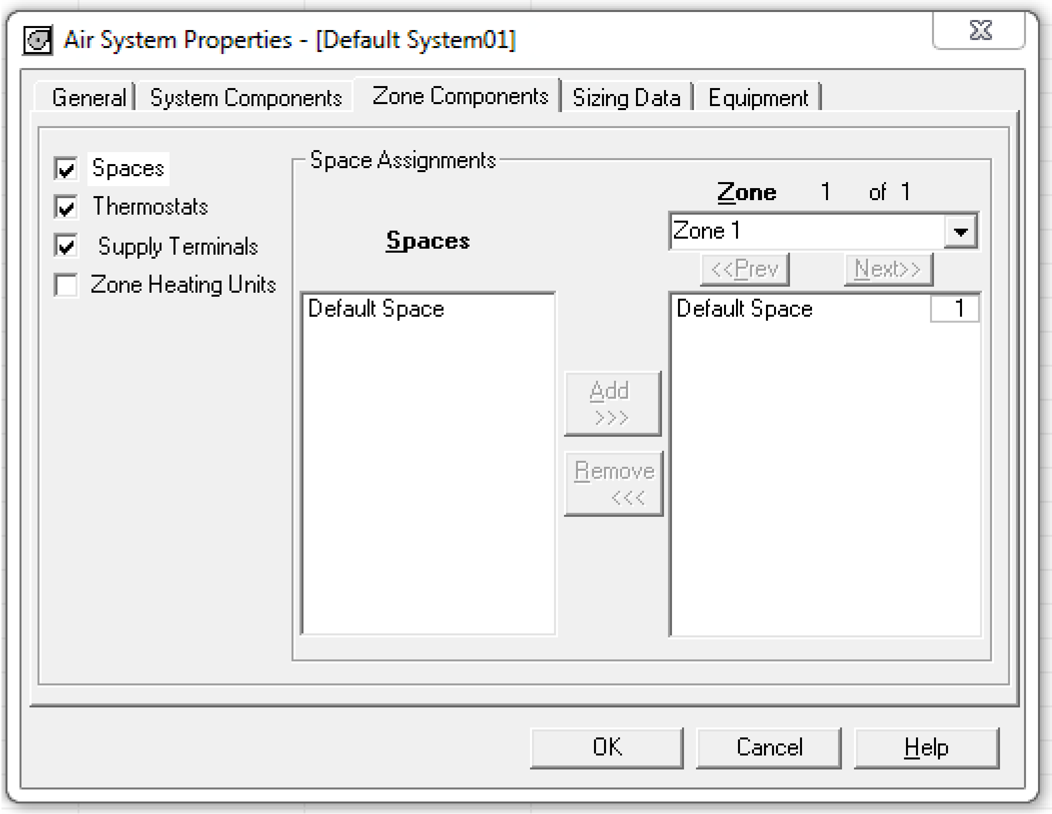


Figure 16: Air system properties-Zone components.

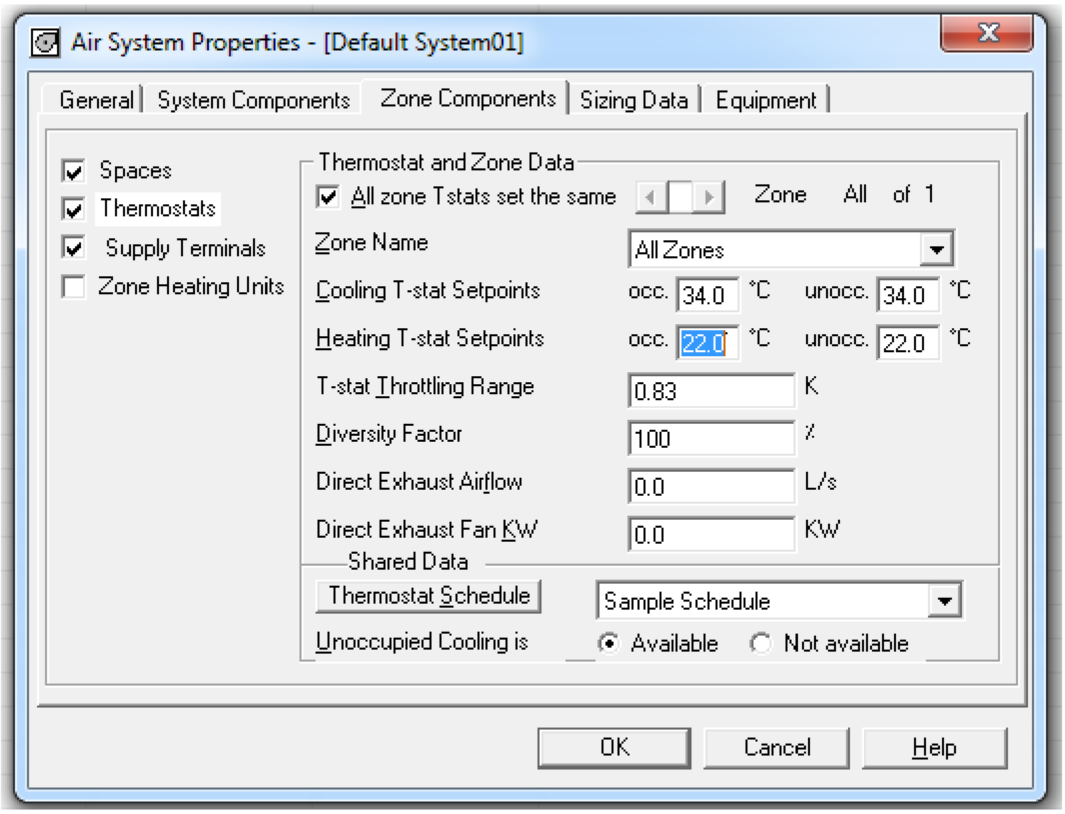


Figure 17: Air system properties-Thermostat and zone data.

III.2.6. Report

III.2.6.1. Required heating capacity from EAHE with a temperature of 22 °C

The result of report is calculated in extreme winter weather under outdoor temperature of 4.1 °C. Figure **18.**

Air System Design Load Summary for Default System01

Project Name: Poultry house
Prepared by: sh

05-13-2022
06:38ã

	DESIGN COOLING			DESIGN HEATING		
	NO COOLING DATA NO COOLING OA DB / WB			HEATING DATA AT DES HTG HEATING OA DB / WB 4.1 °C / -0.9 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	0 m²	-	-	0 m²	-	-
Wall Transmission	990 m²	-	-	990 m²	25288	-
Roof Transmission	810 m²	-	-	810 m²	8532	-
Window Transmission	0 m²	-	-	0 m²	0	-
Skylight Transmission	0 m²	-	-	0 m²	0	-
Door Loads	0 m²	-	-	0 m²	0	-
Floor Transmission	810 m²	-	-	810 m²	3215	-
Partitions	0 m²	-	-	0 m²	0	-
Ceiling	0 m²	-	-	0 m²	0	-
Overhead Lighting	-	-	-	0	0	-
Task Lighting	-	-	-	0	0	-
Electric Equipment	-	-	-	0	0	-
People	-	-	-	0	0	0
Infiltration	-	-	-	-	0	0
Miscellaneous	-	-	-	-	0	0
Safety Factor	0% / 0%	-	-	0%	0	0
>> Total Zone Loads	-	-	-	-	37036	0
Zone Conditioning	-	-	-	-	36195	0
Plenum Wall Load	0%	-	-	0	0	-
Plenum Roof Load	0%	-	-	0	0	-
Plenum Lighting Load	0%	-	-	0	0	-
Return Fan Load	-	-	-	30906 L/s	0	-
Ventilation Load	-	-	-	243 L/s	5083	53
Supply Fan Load	-	-	-	30906 L/s	0	-
Space Fan Coil Fans	-	-	-	-	0	-
Duct Heat Gain / Loss	0%	-	-	0%	0	-
>> Total System Loads	-	-	-	-	41278	53
Central Heating Coil	-	-	-	-	41278	-
>> Total Conditioning	-	-	-	-	41278	0
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		

Figure 18: Report of heating load calculation at an inside temperature of 22°C

According to this report**,** we can see that heating load is equal to heating capacity, we noticed also that the total heating load or required heating capacity that reached **41.278** kw,so this value presents the required heating capacity can produced from EAHE to maintain the temperature of **22 °C** inside of the poultry house.This calculation based on too the following formula.

Total heating load= **Q= AU (T_{in}-T_{out})** …………………………………………… **(9)**

T_{in}: Inside temperature of poultry house. (**°C**). **A:** Heating surface **(m2).**

T_{out}: Outside temperature (**°C**). **U:** Thermal transmittance (**W/m2/k)**

III.2.6.2. The Saved heating capacity producing from Geothermal EAHE

The table below presents the total heating load and the percentage of Saved heating capacity of EAHE for each required temperature of poultry house using HAP 4.90, which is based on the following simple formula

$$Q_p\ (\%) = (41278 / Q) \times 100 \quad (10)$$

Where:

Q_p (%): The percentage of Saved Heating Capacity of EAHE (%).

Q: Total Heating Load or Heating Capacity (W)

41278 watt: The Required Heating Capacity can produced from EAHE to maintain the temperature of **22 °C** inside of poultry house.

Table 4: Total heating load and the percentage of Saved heating capacity of EAHE as a function of indoor temperature

Days	Outside Temp °C	Required ndoor Temp °C	Total Heating Load (w)	The percentage of Saved heating capacity by EAHE (%)
1-2	4.1	33	67341	61.29
3-5	4.1	32	64919	63.58
6-10	4.1	31	62525	66
11-15	4.1	30	60150	68.62
16-21	4.1	29	57784	71.43
22-25	4.1	28	53385	77.32
26-30	4.1	27	51501	80.14
31-34	4.1	26	50383	81.4
35-40	4.1	25	48957	84.31
41-42	4.1	23	43637	94.59
43-45	4.1	22	41278	100

According to the **Table 04**, it is observed that when indoor temperature decreases, the total heating load decreases too, this means that there is a proportional relationship between heating load and the indoor temperature, which is defined by formula (9):

Furthermore, when a required temperature decreases, the percentage of saved heating capacity of EAHE increases.Therefore, at an indoor temperature of 33°C, geothermal energy EAHE can provide 61.29% for total heating capacity of poultry house and while the indoor temperature decrease to 22 °C, the geothermal energy EAHE can provide 100 % for total heating capacity (100 % saved heating capacity) this is because of the heating load at temperature of 22 °C is equal to heating capacity of EAHE that's why the saved heating capacity reach 100 %.

III.3. Conclusion

After calculation of the heating load in the winter season, the geothermal energy EAHE can produce heating capacity of 41.278 kW to maintain an indoor temperature of 22 °C (Required Heating Capacity).

According to results of the report, in extreme winter weather we can conclude that the geothermal energy EAHE can provide more than 60 % of heating capacity under indoor temperature of 33 °C.

When indoor temperature is equal to 22°C, the geothermal energy EAHE can provide 100 **%** of heating capacity of poultry house without the need for any additional heating,while the indoor temperature is superior than 22°C, the geothermal energy EAHE can only provide a heating capacity at temperature of 22°C and the rest part of heating capacity will be provided by heating system which heats from temperature of 22°C to required temperature.

.

Chapter IV: Sizing Earth Air Heat Exchanger, Financial Feasibility and Optimisation of Heating Capacity by using Movable Wall

IV.1. Introduction

This chapter is divided into 02 parts, the first one is talking about Sizing Earth Air Heat Exchanger and Financial Feasibility and the second one is about optimization of heating capacity in poultry house by using movable wall.

IV.2 Sizing Earth Air Heat Exchanger and Financial Feasibility

One of the most important project factor in the feasibility study to ascertain the likelihood of completing the project successfully is project cost.Thus in this part, we study the cost of this project compared to the annual bill of fuel and gas of poultry house, which allow to know the simple payback of this project

IV.2.1 Number of required heat exchangers

After the calculation of heating load, we have found that the poultry house needs a heating capacity of 41.278 kW ,which have to be provided by geothermal energy EAHE ,to maintain an indoor temperature of 22 °C in extreme winter weather under outside temperature of 4.1 °C, knowing that the capacity of single heat exchanger is 0.8 KW.[10]

$$N_{ex} = \frac{Q}{Qs} \quad (11)$$

Where:

N_{ex}: Number of heat exchangers.

Q_s: The heating capacity of single heat exchanger (W).

Q: The heating capacity of poultry house (W).

The Heating Capacity of single Heat Exchanger is 0.8 KW[10]

IV.2.2 Design of heat exchanger

Due to the soft hardness of sand formation in El Oued, the looped collector (horizontal) can be suitable design for poultry house.Therefore, to install the geothermal pipes by loop (horizontal) design we need an excavation of 3 metres on a surface of 540 m2

IV.2.3 Total cost of base case and proposed case

IV.2.3.1 The Cost of base case

It concerns the initial case before using geothermal energy EAHE where our study focus on exploiting a cold days of winter season that reach 135 day.

The following **Table05** shows details concern the base case cost, which reached 510000DA.

Table 5: shows the total cost of base case.

The cost of Gas consumption for furnace			
Number of days	Number of Gas bottles consumed per one day	The cost of single Gas bottle (DA)	Total cost (DA)
135	10	200	270000
The cost of Diesel consumption of 135 days for Boiler			
Number of liters Diesel consumption (L)		The cost of one liter of Diesel (DA)	Total cost (DA)
8000		30	240000
The Total cost of base case			
			Total cost (DA)
			510000

IV.2.3.2 The Cost of proposed case

It is the project cost, which is related to use of the geothermal energy EAHE that need to utilise the geothermal pipe of PVC type with diameter of 60 mm, which is the most commonly used in Earth Air Heat Exchanger as shown in the Table 06. [10]

Table 6 : Physical and thermal properties of Geothermal Pipe

Material	Density (kg/m3)	Thermal Capacity(J/kgK)	Thermal Conductivity (W/mK)
PVC Pipe	1380	900	0.16

The following Table 07 shows the cost of proposed case, which reach 998700 DA.

Table 7: shows the total cost of proposed case

Total cost of excavation and installation of Geothermal pipe					
Length (m)	Wide (m)	Depth (m)	Volume (m3)	The cost of 1m3 of Excavation (DA)	Total cost (DA)
60	9	3	1620	135	218700
Total cost of Geothermal pipe					
Number of heat exchangers		Length of pipes of one heat exchanger (m)		The cost of one meters of Geothermal pipe (DA)	Total cost (DA)
52		50		300	780000
Total cost of Geothermal pipe, Excavation and Installation					
					Total cost (DA)
					998700

IV.2.3.3 Annual Saved Money

In order to calculate annual saved money after the using geothermal energy EAHE, we should estimate the average percentage of saved heating capacity Average (Q (%)) for 135 days, which is define by the following simple formula:

$$\textbf{Average (Q (\%))} = \frac{\sum \mathbf{Q}\ (\%)}{\boldsymbol{N_d}} \quad \textbf{(12)}$$

Average (Q (%)) = 75 %

Where:

$\sum$ Q(%) : The sum of percentage of saved heating capacity

N_d : Number of days is 135 days

The annual saved money $\mathbf{S_m}$ that is defined by next formula:

$$\mathbf{S_m = C_D \times Average\ (Q\ (\%))} \quad \textbf{(13)}$$

$$\mathbf{S_m = 510000 \times 75\ \% = 382500DA.}$$

Where:

S_m: The annual saved money (DA)

C_D: Total gas and diesel consumption (DA)

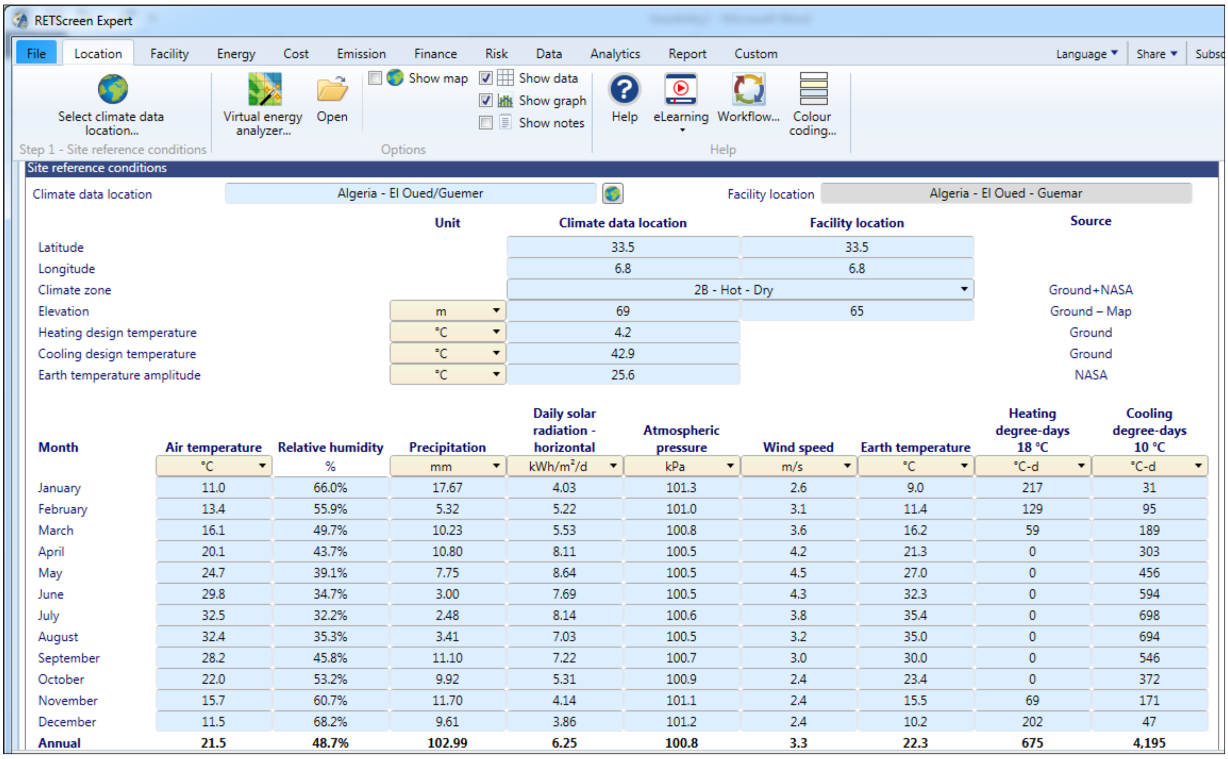
IV.2.4 Simple Payback

It measures duration, which it takes for a proposed project to recoup its own initial cost, out of the income, or savings it generates.[57]

In order to calculate the simple payback, we can use **RETScreen** Software by the following required steps

IV.2.4.1 Location and climate data

Firstly, in this section we need to locate the required city by cliquing climate data location. This picture shows climate data location of El oued city and exactly Guemar Airport. **Figure19**



	Unit	Climate data location	Facility location	Source
Latitude		33.5	33.5	
Longitude		6.8	6.8	
Climate zone		2B - Hot - Dry		Ground+NASA
Elevation	m	69	65	Ground – Map
Heating design temperature	°C	4.2		Ground
Cooling design temperature	°C	42.9		Ground
Earth temperature amplitude	°C	25.6		NASA

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	11.0	66.0%	17.67	4.03	101.3	2.6	9.0	217	31
February	13.4	55.9%	5.32	5.22	101.0	3.1	11.4	129	95
March	16.1	49.7%	10.23	5.53	100.8	3.6	16.2	59	189
April	20.1	43.7%	10.80	8.11	100.5	4.2	21.3	0	303
May	24.7	39.1%	7.75	8.64	100.5	4.5	27.0	0	456
June	29.8	34.7%	3.00	7.69	100.5	4.3	32.3	0	594
July	32.5	32.2%	2.48	8.14	100.6	3.8	35.4	0	698
August	32.4	35.3%	3.41	7.03	100.5	3.2	35.0	0	694
September	28.2	45.8%	11.10	7.22	100.7	3.0	30.0	0	546
October	22.0	53.2%	9.92	5.31	100.9	2.4	23.4	0	372
November	15.7	60.7%	11.70	4.14	101.1	2.4	15.5	69	171
December	11.5	68.2%	9.61	3.86	101.2	2.4	10.2	202	47
Annual	**21.5**	**48.7%**	**102.99**	**6.25**	**100.8**	**3.3**	**22.3**	**675**	**4,195**

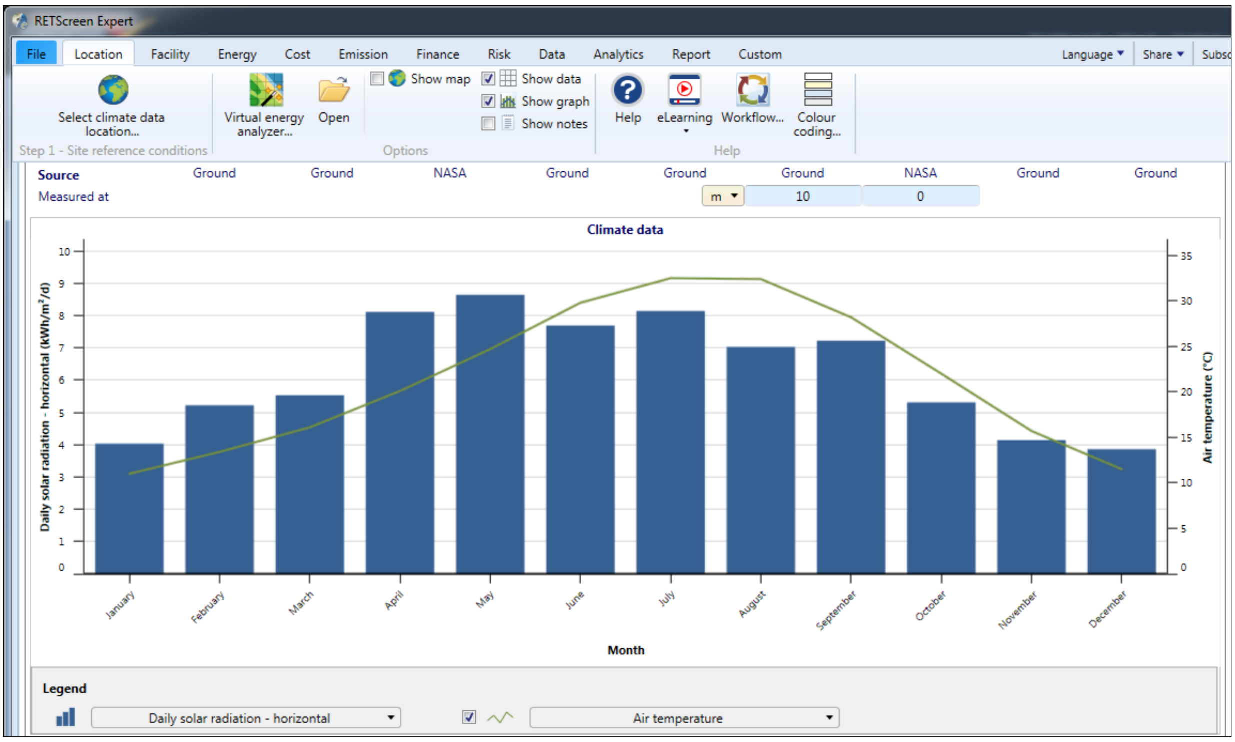


Figure 19:Location and climate data

IV.2.4.2 Currency

We can choose Algerian Dinar DZD by clicking button currency. **Figure 20.**

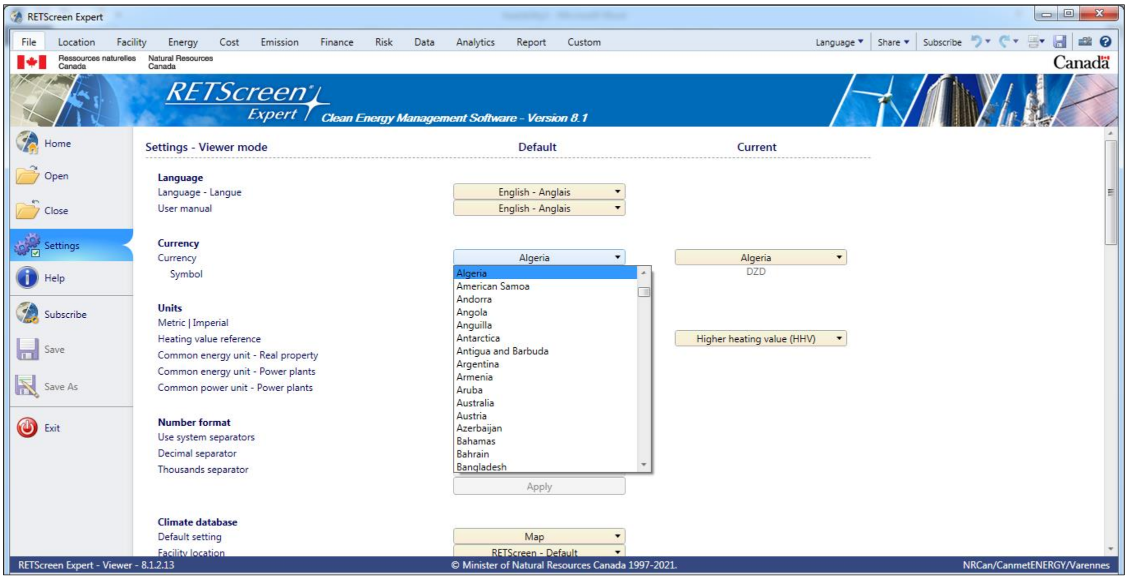


Figure 20: Changed currency from USD to DZD

IV.2.4.3 Feasibility

We click on the facility type and choose Agricultural, Poultry. **Figure 21**

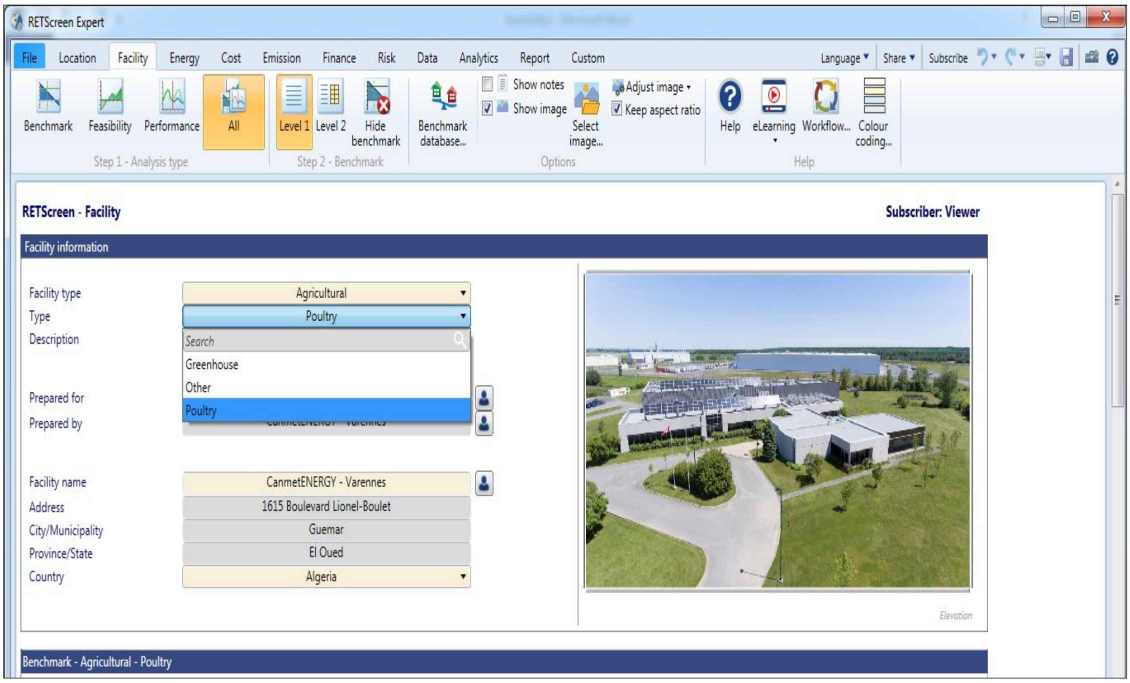


Figure 21: Facility type and type-poultry house.

IV.2.4.4 Energy

IV.2.4.4.1 Gas and Electricity cost

In this section, we should identify the rate of electricity which is 4.8 DZD/KWH and the natural gas is 0.48 DZD/m3 ,which are shown in **Figure 22**.

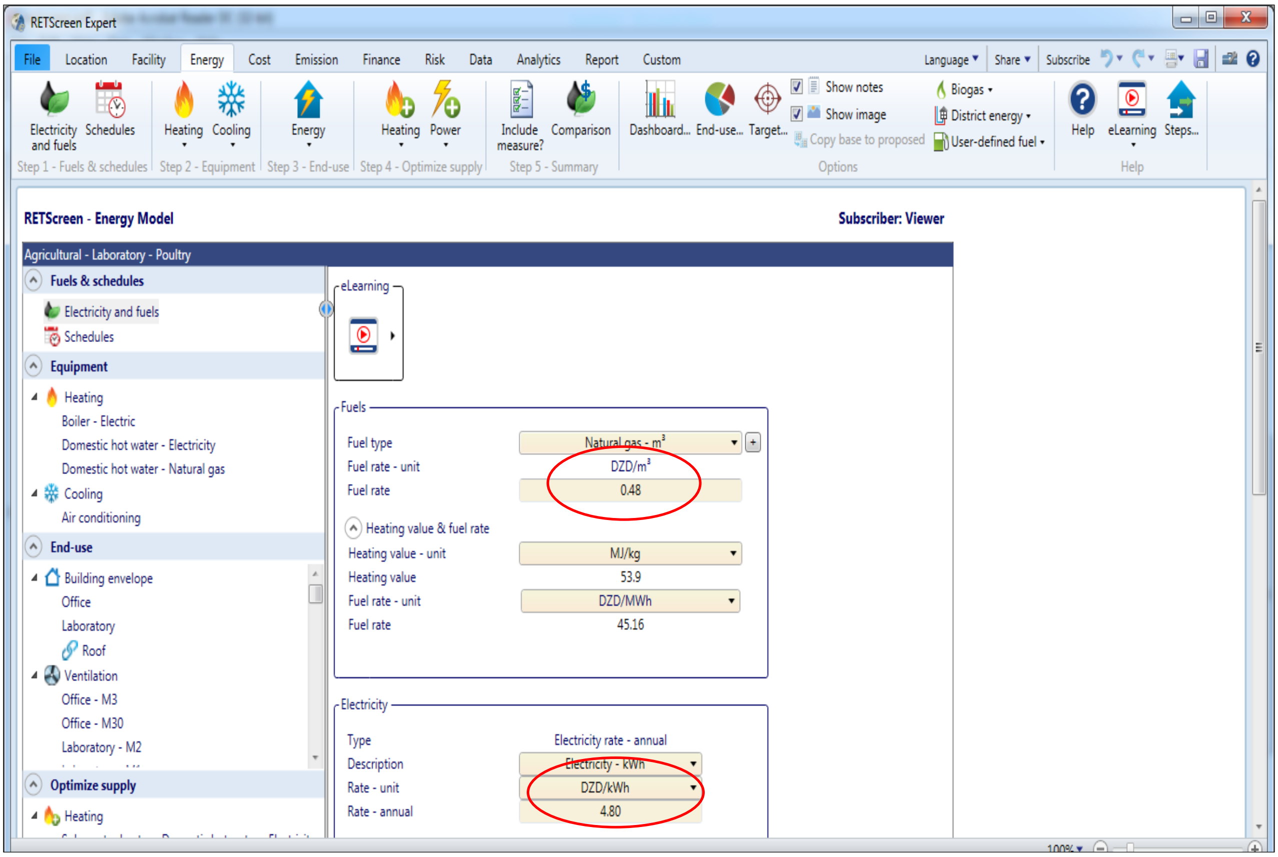


Figure 22: Gas and Electricity rate.

IV.2.4.5 The Heating

IV.2.4.5.1 Boiler

Our feasibility study focus on only the heating system that is why we choose the boiler. In this section, we need to input initial cost and the annual saved money for calculating a simple payback. Figure **23**

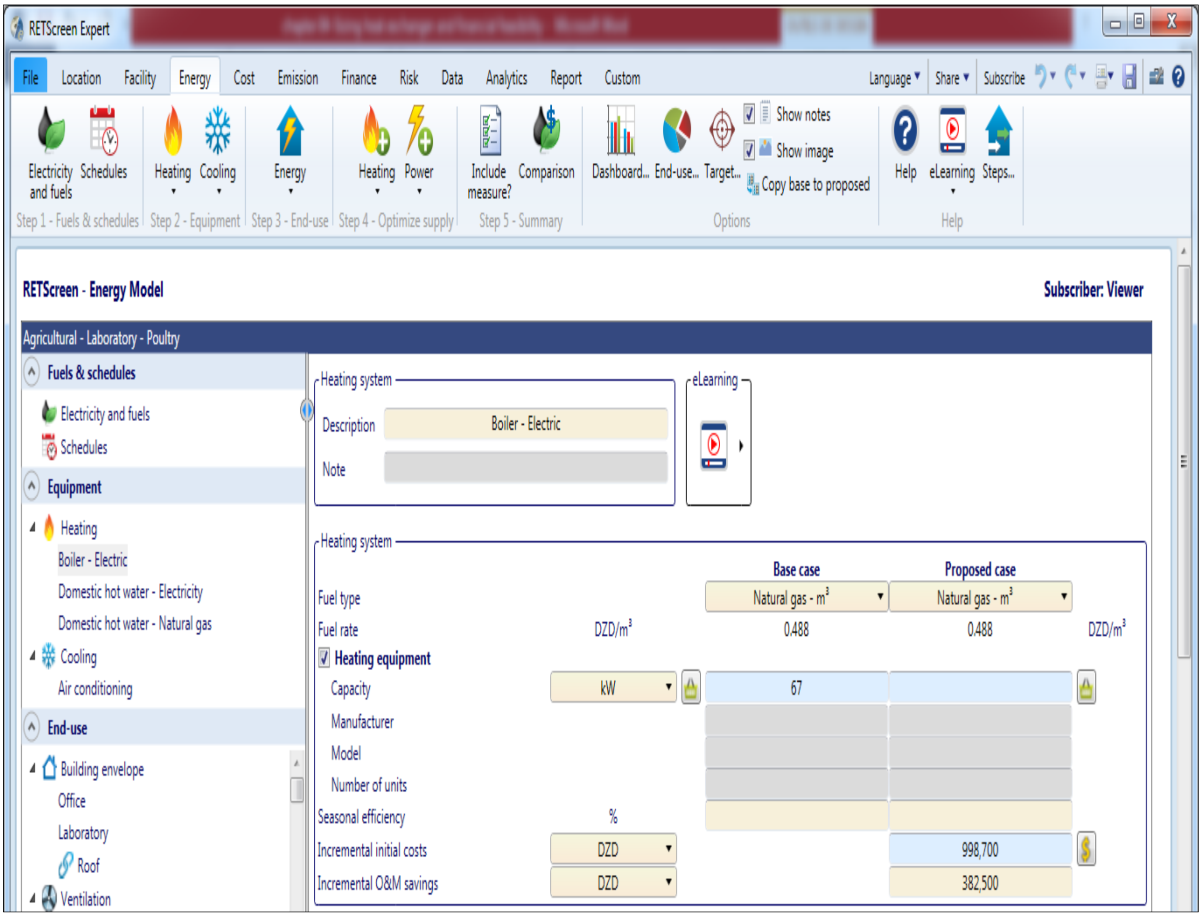


Figure 23: Base and proposed case of heating System–Boiler.

IV.2.4.6 Report

According to this table, the simple payback will take 2.6 year in order to recoup all spending (998700 DZD), which will be spent for applying this type of geothermal-Earth to Air Heat Exchanger in poultry house. **Figure 24**.

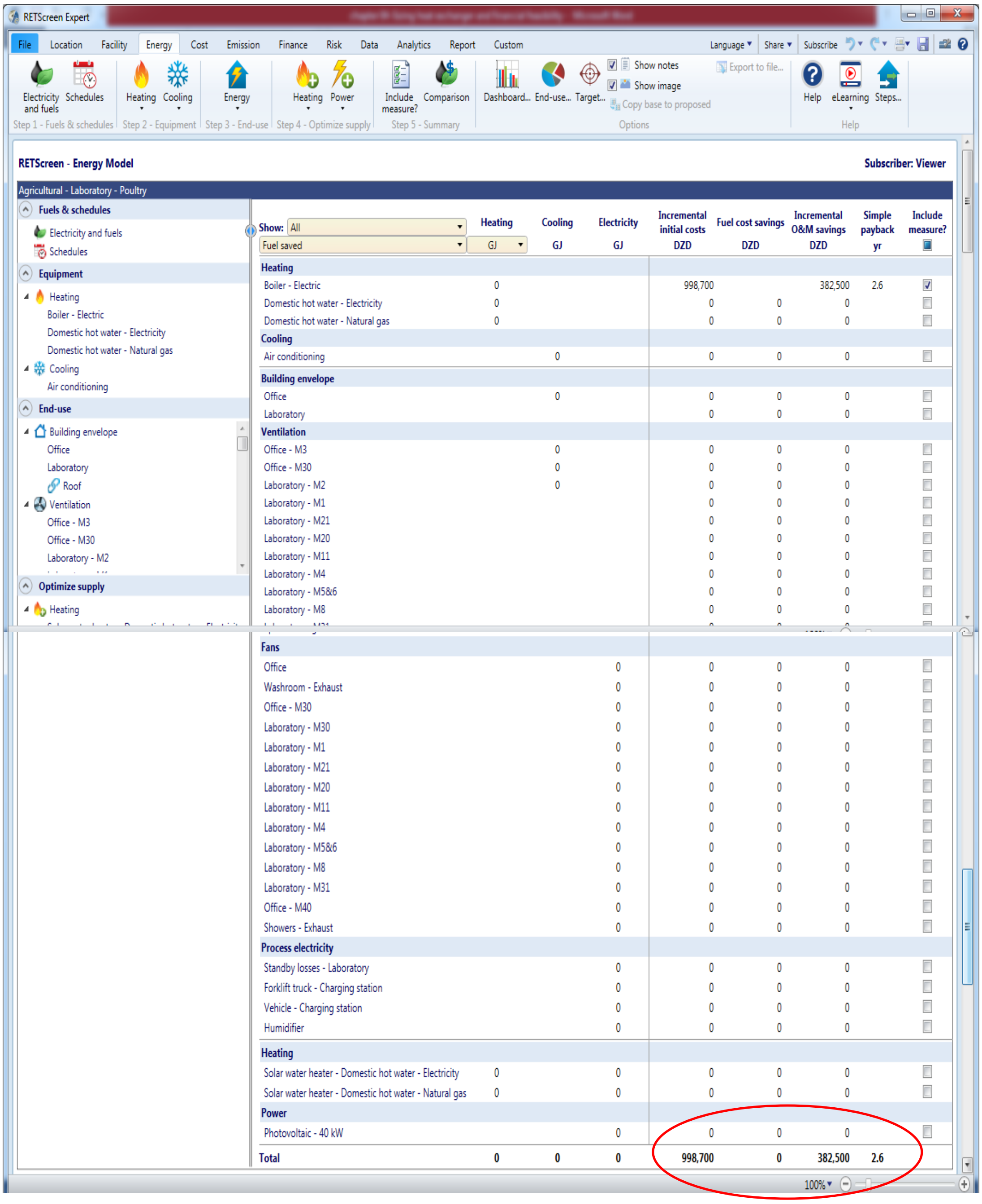


Figure 24 : Simple payback of feasibility study EAHE on poultry house

IV.3 Optimization of heating capacity in poultry house by using movable wall

Due to the high consumption of energy in poultry house, we suggest that the heating begins by 1/3 of the total heating surface, which is isolated by insulated movable wall.

In addition, for each 05 days we will expand the heating surface (needed surface) by 5 meters of length of poultry house using the movable wall as well as the same manner until the needed heating surface is equal to the total heating surface on thirtieth day.

We proposed this suggestion because the breeder use the boiler to heat total surface of poultry house rather than the heating by needed surface from the begging of breeding until the end.

In order to optimize the heating capacity, we should calculate the heating for total and needed surface and then comparison of its result.

This suggestion based on calculation that established by using Hourly Analysis Program HAP4.90.

IV.3.1 Heating load Comparison between total and needed surface

In this section, we use the HAP software in order to calculate the heating load for needed surface $\mathbf{Q_{NS}}$ and it is compared with the heating load of total surface $\mathbf{Q_{TS}}$ by using the next formula:

$$\mathbf{Q\ (\%) = \frac{(Q_{TS} - Q_{NS})}{Q_{TS}} \times 100} \qquad \mathbf{(14)}$$

Where:

Needed surface: the heating surface which occupied by chickens for the following surface (315,369,423,427,477,531,585 and 810 m2).

Total surface: the total heating surface of poultry house of 810m2.

Q_{TS} : the heating load calculated for total surface of 810 m2.

Q_{NS} : the heating load calculated for needed surface

Therefore, the following **Table 08 s**hows the all results Q_{NS} ,Q_{TS} and Q (%)

Table 8: shows the heating load for total surface and needed surface by HAP software

Days	Outside Temperature (°C)	Indoor Temperature (°C)	Heating load for total surface (w)	The percentage of saved Heating Capacity by EAHE (%)	Needed surface(m2)	Heating load for needed surface (w)	Percentage of Saved Heating capacity (%)
1	4.1	33	67341	61.29698104	315	28513	57.65878143
2	4.1	33	67341	61.29698104	315	28513	57.65878143
3	4.1	32	64919	63.58385064	315	27463	57.69651412
4	4.1	32	64919	63.58385064	315	27463	57.69651412
5	4.1	32	64919	63.58385064	315	27463	57.69651412
6	4.1	31	62525	66.01839264	369	30355	51.45141943
7	4.1	31	62525	66.01839264	369	30355	51.45141943
8	4.1	31	62525	66.01839264	369	30355	51.45141943
9	4.1	31	62525	66.01839264	369	30355	51.45141943
10	4.1	31	62525	66.01839264	369	30355	51.45141943
11	4.1	30	60150	68.62510391	423	32972	45.1837074
12	4.1	30	60150	68.62510391	423	32972	45.1837074
13	4.1	30	60150	68.62510391	423	32972	45.1837074
14	4.1	30	60150	68.62510391	423	32972	45.1837074
15	4.1	30	60150	68.62510391	423	32972	45.1837074
16	4.1	29	57784	71.43499931	477	35302	38.90696387
17	4.1	29	57784	71.43499931	477	35302	38.90696387
18	4.1	29	57784	71.43499931	477	35302	38.90696387
19	4.1	29	57784	71.43499931	477	35302	38.90696387
20	4.1	29	57784	71.43499931	477	35302	38.90696387
21	4.1	29	57784	71.43499931	531	38932	32.62494808
22	4.1	28	53385	77.32134495	531	37342	30.0515126
23	4.1	28	53385	77.32134495	531	37342	30.0515126
24	4.1	28	53385	77.32134495	531	37342	30.0515126
25	4.1	28	53385	77.32134495	531	37342	30.0515126
26	4.1	27	51501	80.1499	585	39088	24.10244461
27	4.1	27	51501	80.1499	585	39088	24.10244461
28	4.1	27	51501	80.1499	585	39088	24.10244461
29	4.1	27	51501	80.1499	585	39088	24.10244461
30	4.1	27	51501	80.1499	585	39088	24.10244461
31	4.1	26	50710	81.40011832	810	50710	0
32	4.1	26	50710	81.40011832	810	50710	0
33	4.1	26	50710	81.40011832	810	50710	0
34	4.1	26	50710	81.40011832	810	50710	0
35	4.1	25	48957	84.31480687	810	48353	0
36	4.1	25	48957	84.31480687	810	48353	0
37	4.1	25	48957	84.31480687	810	48353	0
38	4.1	25	48957	84.31480687	810	48353	0
39	4.1	25	48957	84.31480687	810	48353	0
40	4.1	25	48957	84.31480687	810	48353	0
41	4.1	23	43637	94.59403717	810	43637	0
42	4.1	23	43637	94.59403717	810	43637	0
43	4.1	22	41278	100	810	41278	0
44	4.1	22	41278	100	810	41278	0
45	4.1	22	41278	100	810	41278	0

According to the Table 07, at a temperature of 33°C we can see that the heating load value is high which reached 67.3 kW for total heating surface of 810 m2, while the heating load is equal to 28.5 kW for needed heating surface of 315 m2, it means that the use of movable wall on 1/3 of total heating surface will reduce a heating capacity by 57.65% and the same manner with each needed surface until it is equal to the total surface where the saved heating capacity null.

Note:

The decrease in the temperature does not impact on the heat load values because the variation between values of temperature is small (1°**C** between each change) compared to the significant variation in the surface, which reaches 54 m2, that is why the heat load increases despite the decreasing in temperature.

IV.4. Conclusion

In order to apply Geothermal energy EAHE on poultry house with surface of 810 m2 and height of 5 m, we need to install 52 heat exchangers on surface of 540 m2 with depth of 3 m.

The Geothermal energy EAHE can provide about 75 % of heating capacity of poultry house this means breeder can save about 75 % of annual cost of gas and diesel consumption.

To recoup all spending (998700 DZD) that will be spend for applying Geothermal energy EAHE, the simple payback will take 2.6 year.

Regarding the optimization of heating capacity by the movable wall , it conclude that the use of the heating by the needed surface, which isolated by movable wall ,it can reduce heating capacity by 57 to 24 % unless the needed surface is equal to total surface, the saved heating capacity will be null.

General Conclusion

General Conclusion

According to our study, which revolves around the feasibility study of geothermal energy Earth Air Heat Exchanger in poultry house in arid zone of south Algeria El oued, we can conclude that:

The calculation of the heating load of poultry house for the winter season using HAP Software demonstrates that the geothermal energy EAHE can produce heating capacity of 41.278 kW to maintain an indoor temperature of 22 °C (Required heating capacity).

In extreme winter weather, the geothermal energy EAHE can provide more than 60% of heating capacity under indoor temperature of 33 °C.

When indoor temperature is equal to 22°C, the geothermal energy EAHE can provide 100**%** of heating capacity of poultry house without need of the heating, when the indoor temperature is superior than 22°C, the geothermal energy EAHE can only provide a heating capacity of temperature 22°C and the rest part of heating capacity will be provided by heating system which heats from 22°C to required temperature.

In order to install geothermal energy EAHE on poultry house with surface of 810 m2 and height of 5 m, we need to install 52 heat exchangers of 0.8 kW on surface of 540 m2 with an excavation of 3 m depth.

The Geothermal energy EAHE may produce about 75 % of heating capacity of poultry house in one year this means breeder can save about 75 % of annual cost of gas and diesel consumption.

To recoup all spending (998700 DZD) which will be spent for applying geothermal energy EAHE, we will need a simple payback of 2.6 year.

The use of heating by needed surface that isolated by movable wall, it can reduce heating capacity by 57 to 24 % till the needed surface is equal to the total surface, the saved heating capacity is null

As long as the geothermal energy Earth Air Heat Exchanger produces about 75 % of total energy as clean energy, this leads also to decrease the percentage of CO_2 emissions.

Recommendations

In despite of satisfactory results, the research that is presented in this thesis can be further developed over time, thus there are improvements can be applied to this work:

The theoretical results for the feasibility study of geothermal energy in poultry house; it must be experimented with same facility in order to reveal the experimental results.

The model of theoretical calculation of this study can be utilised for other heating loads or another building.

According to this work that is based only on the calculation of heating capacity by HAP software, it can also calculate the cooling capacity for poultry house or another facility.

As long as the geothermal energy provide an important quantity of saved energy on which it may estimate the reduction percentage of CO2 emissions by the use of RETscreen software

References

[1] "How to Feed the World in 2050," Food and Agriculture Organization (FAO), United Nations2009.

[2] A. Laknizi, M. Mahdaoui, A. B. Abdellah, K. Anoune, and M. Bouya, "Energy Performance and Environmental Impact of an Earth-Air Heat Exchanger for Heating and Cooling a Poultry House," in *International Conference on Advanced Intelligent Systems for Sustainable Development*, ed: Springer, 2018, pp. 149-157.

[3] K. Hacini, A. Benatiallah, A. Harrouz, and D. Belatrache, "Efficiency assessment of an earth-air heat exchanger system for passive cooling in three different regions: The Algerian case," *FME Transactions*, vol. 49, pp. 1035-1046, 2021.

[4] M. I. Hasan and D. M. Muter, "A review of earth to air heat exchanger as a passive cooling and heating technique and the affecting parameters," *Al-Qadisiyah Journal for Engineering Sciences*, vol. 14, pp. 021-030, 2021.

[5] A. Laknizi, A. ElMaakoul, A. B. Abdellah, M. Bouya, S. Dhimdi, and S. Said, "Evaluation of earth-air heat exchanger for cooling and heating a poultry house: case study in Morocco," in *2015 3rd International Renewable and Sustainable Energy Conference (IRSEC)*, 2015, pp. 1-5.

[6] N. Bordoloi, A. Sharma, H. Nautiyal, and V. Goel, "An intense review on the latest advancements of Earth Air Heat Exchangers," *Renewable and Sustainable Energy Reviews,* vol. 89, pp. 261-280, 2018.

[7] S. Ahmed, G. Liu, M. Mofijur, A. K. Azad, M. A. Hazrat, and Y.-M. Chu, "Physical and hybrid modelling techniques for earth-air heat exchangers in reducing building energy consumption: Performance, applications, progress, and challenges," *Solar Energy,* vol. 216, pp. 274-294, 2021.

[8] G. Florides and S. Kalogirou, "Ground heat exchangers—A review of systems, models and applications," *Renewable energy,* vol. 32, pp. 2461-2478, 2007.

[9] N. Sakhri, Y. Menni, A. Chamkha, M. Salmi, and H. Ameur, "Earth to air heat exchanger and its applications in arid regions—an updated review," *Tecnica Italiana Ital J Eng Sci*, vol. 64, pp. 83-90, 2020.

[10] H. Abdessamia, "Etude de la faisabilité technique et économique de l'installation d'un échangeur de chaleur géothermique dans la région d'El Oued-Algérie," PhD Thesis Mechanical Engineering El Oued University

[11] E. Ketelaars and B. Gietema, *Lecture Notes on Chicken Farming in Warm Climate Zones*: STOAS human resource development worldwide, 2001.

[12] A. Oloyo, "The use of housing system in the management of heat stress in poultry production in hot and humid climate: a review," *Poultry Science Journal,* vol. 6, pp. 1-9, 2018.

[13] A. Oloyo and A. Ojerinde, "Poultry housing and management," *Poultry-An Advanced Learning,* 2019.

[14] A. Qureshi, "Open house tips for layers in hot climate zone," *World Poultry,* vol. 17, pp. 32-34, 2001.

[15] N. Daghir, "Nutritional strategies to reduce heat stress in broilers and broiler breeders," *Lohmann information,* vol. 44, pp. 6-15, 2009.

[16] V. Holik, "Management of laying hens under tropical conditions begins during the rearing period," 2015.

[17] J. Hulzebosch, "What affects the climate in poultry houses," *World Poultry,* vol. 20, pp. 36-38, 2004.

[18] R. G. Board and R. Fuller, *Microbiology of the avian egg*: Springer, 1994.

[19] A. Beker, S. Vanhooser, J. Swartzlander, and R. Teeter, "Atmospheric ammonia concentration effects on broiler growth and performance," *Journal of Applied Poultry Research,* vol. 13, pp. 5-9, 2004.

[20] H. Dong, J. Mangino, T. A. McAllister, J. L. Hatfield, D. E. Johnson, K. R. Lassey*, et al.*, "Emissions from livestock and manure management," *Embrapa Meio Ambiente-Capítulo em livro científico (ALICE),* 2006.

[21] H. H. Kristensen and C. Wathes, "Ammonia and poultry welfare: a review," *World's poultry science journal,* vol. 56, pp. 235-245, 2000.

[22] D. W. Kweku, O. Bismark, A. Maxwell, K. A. Desmond, K. B. Danso, E. A. Oti-Mensah, *et al.*, "Greenhouse effect: greenhouse gases and their impact on global warming," *Journal of Scientific research and reports,* vol. 17, pp. 1-9, 2018.

[23] D. Miles, S. Branton, and B. Lott, "Atmospheric ammonia is detrimental to the performance of modern commercial broilers," *Poultry science,* vol. 83, pp. 1650-1654, 2004.

[24] N. Daghir, "Poultry Production in the Hot Climates," *Poultry Production in the Hot Climates. 2nd ed. CABI Series. London, UK: CAB International,* 2008.

[25] M. Lacy and M. Czarick, "Tunnel-ventilated broiler houses: broiler performance and operating costs," *Journal of Applied Poultry Research,* vol. 1, pp. 104-109, 1992.

[26] J. Simmons, B. Lott, and D. Miles, "The effects of high-air velocity on broiler performance," *Poultry Science,* vol. 82, pp. 232-234, 2003.

[27] H. Olanrewaju, J. Thaxton, W. Dozier, J. Purswell, W. Roush, and S. Branton, "A review of lighting programs for broiler production," *International journal of poultry science,* vol. 5, pp. 301-308, 2006.

[28] A. S. Mendes, S. J. Paixão, R. Restelatto, G. M. Morello, D. J. de Moura, and J. C. Possenti, "Performance and preference of broiler chickens exposed to different lighting sources," *Journal of Applied Poultry Research,* vol. 22, pp. 62-70, 2013.

[29] H. Classen, C. Annett, K. Schwean-Lardner, R. Gonda, and D. Derow, "effects of lighting programmes with twelve hours of darkness per day provided in one, six or twelve hour intervals on the productivity and health of broiler chickens," *British poultry science,* 2004.

[30] H. Classen, C. Riddell, and F. Robinson, "Effects of increasing photoperiod length on performance and health of broiler chickens," *British Poultry Science,* vol. 32, pp. 21-29, 1991.

[31] M. P. Morris, "National survey of leg problems," *Pigs and Poultry,* vol. 6, p. 16, 1993.

[32] M. Petek, G. Sönmez, H. Yildiz, and H. Baspinar, "Effects of different management factors on broiler performance and incidence of tibial dyschondroplasia," *British Poultry Science,* vol. 46, pp. 16-21, 2005.

[33] C. Riddell and H. Classen, "Effects of increasing photoperiod length and anticoccidials on performance and health of roaster chickens," *Avian Diseases,* pp. 491-498, 1992.

[34] J. Davis, P. Thomas, and T. Siopes, "More evidence for light-dark growing. Broiler Industry, environments," *Appl. Anim. Behav. Sci,* vol. 44, pp. 229-243, 1997.

[35] S. Gordon, "Effects of daylength and increasing daylength programmes on broiler welfare and performance," *World's Poultry Science Journal (United Kingdom),* 1994.

[36] I. Rozenboim, B. Robinzon, and A. Rosenstrauch, "Effect of light source and regimen on growing broilers," *British Poultry Science,* vol. 40, pp. 452-457, 1999.

[37] H. Kritensen, J. Aerts, T. Leroy, D. Berckmans, and C. Wathes, "Using light to control broiler chickens," *Br. Poult. Sci,* vol. 45, pp. S30-31, 2004.

[38] S. Leeson, L. Caston, and J. Summers, "Performance of layers given two-hour midnight lighting as growing pullets," *Journal of applied poultry research,* vol. 12, pp. 313-320, 2003.

[39] S. Leeson, L. Caston, and J. Summers, "Potential for midnight lighting to influence development of growing leghorn pullets," *Journal of applied poultry research,* vol. 12, pp. 306-312, 2003.

[40] J. Renden, S. Bilgili, R. Lien, and S. Kincaid, "Live performance and yields of broilers provided various lighting schedules," *Poultry Science,* vol. 70, pp. 2055-2062, 1991.

[41] P. Lewis and T. Morris, "Poultry and coloured light," *World's Poultry Science Journal,* vol. 56, pp. 189-207, 2000.

[42] M. Kim, R. Parvin, M. Mushtaq, J. Hwangbo, J. Kim, J. Na, *et al.,* "Growth performance and hematological traits of broiler chickens reared under assorted monochromatic light sources," *Poultry Science,* vol. 92, pp. 1461-1466, 2013.

[43] M. Pattison, P. McMullin, J. M. Bradbury, and D. Alexander, *Poultry diseases*: Elsevier Health Sciences, 2007.

[44] J. A. Clark, *Environmental aspects of housing for animal production*: Elsevier, 2013.

[45] N. Daghir, "Feedstuffs used in hot regions," *Poultry Production in the Hot Climates. 2nd ed. CABI Series. London, UK: CAB International,* pp. 160-196, 2008.

[46] C. Guide, "The Chartered Institution of Building Services," *Delta House,* vol. 222, 1970.

[47] E. Ketelaars, "Lecture notes on chicken farming in warm climate zones," *Lecture notes on chicken farming in warm climate zones.,* 2001.

[48] M. Timmons, "Improving ventilation in open-type poultry housing," in *Proceedings of the 1989 Poultry Symposium*, 1989, pp. 1-8.

[49] H. Xin, I. L. Berry, G. T. Tabler, and T. A. Costello, "Heat and moisture production of poultry and their housing systems: broilers," *Transactions of the ASAE,* vol. 44, p. 1851, 2001.

[50] K. K. Verma, V. Singh, S. L. Gupta, J. Yadav, and A. K. Verma, "Environmentally Controlled House-In Poultry Production," *Poultry Line,* vol. 1, pp. 29-32, 2014.

[51] P. Bhadhauria, "Different types of poultry housing system for tropical climate," *Linkedin Corporation,* 2014.

[52] X. Company. *Breeding Equipements* Available: http://www.breeding-equipment.asia/

[53] I. R. Fadilah, *Sukses Beternak Ayam Broiler*: Agromedia Pustaka., 2007.

[54] P. Dewanto, M. Munadi, and M. Tauviqirrahman, "Development of an automatic broiler feeding system using PLC and HMI for closed house system," *American Academic Scientific Research Journal for Engineering, Technology, and Sciences,* vol. 58, 2019.

[55] M. Muharlien, E. Sudjarwo, D. L. Yulianti, A. A. Hamiyanti, and H. S. Prayogi, "Comparative production performance of broiler under opened house and closed house system," *Jurnal Ilmu-Ilmu Peternakan (Indonesian Journal of Animal Science),* vol. 30, pp. 86-91, 2020.

[56] R. W. H. PE and L. A. M. E. M. PE, *HVAC systems design handbook*: McGraw-Hill Education, 2010.

[57] (2021). *RETScreen Users Manuel.* Available: https://retscreen.software.informer.com/4.0

Abstract

Thesis title: Feasibility study of Geothermal Energy- Earth Air Heat Exchanger in Poultry House: a case study of Arid Zone of South Algeria-El Oued.
Master: Renewable energies in mechanics
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Keywords: poultry house, Earth Air Heat Exchanger, Geothermal Energy, Heating system.

Actually, due to the lack of innovation and optimization within poultry house especially the heating, which faces difficulties, and among them is the high fuel and gas consumption which is consumed by heating system in the winter season .so our project presents the feasibility study of geothermal energy Earth Air Heat Exchanger in poultry house of arid zone in the south of Algeria El Oued , which consist of calculation the heating load, the heating capacity can provided by EAHE, the number of needed heating exchangers ,the needed surface of installation and project cost. The purpose of this study aims to reduce the fuel consumption, which is accompanied by decreasing in CO_2 emissions too. the result of study demonstrate that in extreme winter weather at temperature of 4.1°C, the geothermal energy EAHE can provide more than 60% of heating capacity of poultry house under indoor high temperature of 33°C and the EAHE can produce heating capacity of 41.278 kW to maintain an indoor temperature of 22 °C and in term of the project cost, the simple payback of this project is 2.6 years.

الملخص

حاليا بسبب نقص الابتكار والتحسين داخل حظائر الدواجن خاصة التدفئة التي تواجه صعوبات ومن بينها ارتفاع استهلاك الوقود والغاز الذي يستهلكه نظام التدفئة في فصل الشتاء ,لذلك يقدم مشروعنا دراسة جدوى تطبيق الطاقة الحرارية الأرضية بتقنية المبادل حراري الأرضي في حظائر الدواجن في منطقة جنوب الجزائر الوادي حيث تعتمد هذه الدراسة على حساب الأحمال الحرارية لبيت الدواجن و سعة التدفئة التي يمكن ان توفرها المبدلات الحرارية الارضية وكذلك عدد المبدلات الحرارية الارضية اللازمة لذكلك ثم حساب المساحة اللازم لتمرير الانابيب تحت عمق 3 امتار من الارض واخيرا حساب تكلفة المشروع . كما تهدف هذه الدراسة إلى تقليل استهلاك الوقود والغاز، والذي يصاحبه أيضًا انخفاض في انبعاثات ثاني أكسيد الكربون.أظهرت نتائج الدراسة أنه في فصل الشتاء عند درجة حرارة باردة جدا تصل الى 4.1 درجة مئوية، يمكن للطاقة الحرارية الأرضية أن توفر أكثر من 60٪ من اجمالي قدرة التدفئة اللازمة لبيت الدواجن تحت درجة حرارة داخلية عالية تبلغ 33 درجة مئوية ويمكن لـلمبدلات الحرارية الارضية إنتاج سعة تدفئة تصل إلى 41.278 كيلو واط لحفاظ على درجة حرارة داخلية تبلغ 22 درجة مئوية. فمن حيث تكلفة المشروع، فإنه يمكن استرجاع الاموال المستثمرة في هذا المشروع خلال 2.6 سنة.

الكلمات المفتاحية: حظائر الدواجن ، المبادل الحراري للهواء الأرضي ، الطاقة الحرارية الجوفية ، نظام التدفئة.