KASDI MERBAH OUARGLA UNIVERSITY

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Presented by :

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Theme

Application of solar energy in heating/cooling of modern poultry farm

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In front of the jury :

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Dedication

I dedicate this study to Allah Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this study;

Our great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life;

Our great parents, who leads us through the valley of darkness with light of hope and support,

Our beloved brothers and sisters;

Our homeland algeria, the warmest womb;

The great martyrs, the symbol of sacrifice;

To all our family, the symbol of love and giving,

Our friends who encourage and support us,

All the people in our life who touch our hearts,

to teacher alaa bakkur thank you for teaching and guiding us we really appreciate your effort ,

we dedicate this research to love ones.

Appreciations

First of all, we thank ALLAH, the Almighty, for giving me

the courage and the will to accomplish this research work.

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Mrs Soumia Rahmouni, assistant professor at the University of Ouargla,

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made us complete this study and encourage us to continue and persevere.

We also thank the members of the jury for accepting our work :

Dr. N.Saifi Lecturer professor at university of ouargla

Dr. D.Messaoudi assistant professor at the University of Ouargla

I would like to thank all those who have contributed

directly or indirectly to the accomplishment of this work.

Application of solar energy in Heating/Cooling of modern poultry farm

Abstract:

This work studies air conditioning in a modern industrial chicken coop. The data are collected from the chicken coop for the Bayat complex. The heating and cooling capacity required for it was estimated by a regulatory technical document called DTR. We determined the feasibility of using solar energy to provide the electrical needs necessary to meet the needs of the poultry house. The results showed that the total thermal energy of the building is about 117.617 kW, while for cooling we need 553.922 kW. Determine the number of solar panels needed to provide electrical energy for one of the buildings (26 solar panels - an electric inverter - a charging regulator – 20 batteries for energy storage).

Keywords: poultry house, heat loss, heat gain, solar panels, inverter, charge controller, Cooling.

Application de l'énergie solaire dans le Chauffage/refroidissement d'une ferme avicole moderne

Résumé :

L'énergie solaire est l'une des énergies renouvelables les plus importantes qui enrichissent les combustibles fossiles. Ce travail étudie la climatisation dans un poulailler industriel moderne. Les données sont collectées au poulailler du complexe Bayat. La capacité de chauffage et de refroidissement nécessaire à celle-ci a été estimée par un document technique réglementaire appelé DTR. Nous avons déterminé la faisabilité d'utiliser l'énergie solaire pour fournir les besoins électriques nécessaires pour répondre aux besoins du poulailler. Les résultats ont montré que l'énergie thermique totale du bâtiment est d'environ 117,617 kW, tandis que pour le refroidissement, nous avons besoin de 553,922 kW. Déterminer le nombre de panneaux solaires nécessaires pour fournir de l'énergie électrique à l'un des bâtiments (26 panneaux solaires - un onduleur électrique - un régulateur de charge - 20 batteries pour le stockage de l'énergie).

Mots clés : poulailler, perte de chaleur, gain de chaleur, panneaux solaires, onduleur, contrôleur de charge, refroidissement.

تطبيق الطاقة الشمسية في تدفئة / تبريد مزرعة دواجن حديثة

الخلاصة

الطاقة الشمسية من اهم الطاقات المتجددة التي تغني الوقود الاحفوري، هذا العمل يدرس تكييف الهواء في حظيرة دجاج صناعية حديثة، البيانات مجمعة من حظيرة الدجاج لمجمع بيات تم تقدير قدرة التسخين والتبريد اللازمة لها، بواسطة وثيقة تقنية تنظيمية تسمى DTR. حددنا جدوى استخدام الطاقة الشمسية لتوفير الاحتياجات الكهربائية اللازمة لتلبية احتياجات المدجنة، أوضحت النتائج أن الطاقة الحرارية الكلية للمبنى تبلغ حوالي 117.617 kW، بينما للتبريد نحتاج 553.922 kW ، درسنا كمية استهلاك المزرعة للطاقة الكهربائية خلال فترة الصيف بقيمة 34.975 kW. حدد عدد الالواح الشمسية اللازمة لتوفير الطاقة الكهربائية لأحد المباني (26 لوح شمسي - عاكس كهربائي - منظم شحن - بطاريات لتخزين الطاقة) وبعد حساب تكاليف هذا النظام بعد معرفة عدد وعناصر النظام الشمسي وجدنا ان تكلفة انتاج المشروع 667M DA التي تعتبر جيدة مقارنة مدى حياة النظام.

الكلمات المفتاحية : حضيرة دواجن، ضياع الحرارة، مكتسبات الحرارة، الالواح الشمسية ، العاكس ، متحكم الشحن، تبريد.

Summary

Chapter two: thermal needs study of an industrial poultry house

Chapter three: results and discussions

Nomenclature

Symbols	Designation	Unit
D	Total heat losses	W/°C
Dli	losses through connections	W/°C
Dlnc	Losses through walls in contact with unheated rooms	W/°C
DR	Heat losses by air renewal	W/°C
dr	Losses by renewal of air in the unheated room	W/°C
DRs	Losses by additional air renewal due to wind	W/°C
DRv	Losses by air renewal due to ventilation	W/°C
Dsurf	Surface losses through parts in contact with the outside	W/°C
Ds	Losses through the walls in contact with the ground	W/°C
DT	Heat losses by transmission	W/°C
H	Coefficient of heat transfer by convection	W/m2.°C
He	External surface exchange coefficient	W/m2.°C
Hi	External surface exchange coefficient W/m2.°	
HSb,e	Basic specific humidity of outdoor air	g_{vap}/kg_{gas}
HSb,I	Basic specific humidity of indoor air	g_{vap}/kg_{gas}
It,b	Basic total radiation for month, latitude and orientation considered	W/m2
It,b (40)	Basic total radiation for the month of July, latitude 40° North and for the considered orientation	W/m2
K	Surface transmission coefficient	W/m2.°C
Kl	Linear transmission coefficient	W/m.°C
Ks	Linear transmission coefficient of the low floor or buried wall	W/m.°C
Mp	The mass of Chicken	kg
N	Hourly air change rate	h^{-1}
N	Number of occupants	-
Np	Number of chickens	-
Q	Heating power supplied by a boiler room	W
Qlat,oc	Latent gains of occupants	W
Qsen,oc	Perceptible gains of the occupants	W
Qv	Minimum ventilation rates	m3/h
R	Thermal resistance	m2.°C/W

Te (t)	Outside dry temperature per hour t	ºC
Te,b	Outdoor air base dry bulb temperature	ºC
Te,m	Mean dry outside air temperature	ºC
Ti,b	Base indoor air dry bulb temperature	ºC
Weff	Nominal power	-
ac	Contributions of heat from the various heated rooms to the unheated room	W/°C
Alat	Contributions latent calorific	W
Asen	Contributions sensible calorific	W
AIlat	Contributions internal latent	W
AIÉ	The contribution internal lighting	W
AIMÉ	The contribution internal due to the motor-machine assembly	W
AINFlat	Contributions latent due to air infiltration	W
AINFsen	Contributions sensitive due to air infiltration	W
AI sen	Contributions internal sensitive	W
APO	Contributions through the opaque walls	W
APOS	Contributions walls in contact with the ground	W
ARENlat	Contributions latent heat due to ventilation of premises	W
ARENsen	Contributions sensible heat due to the ventilation of the premises	W
ATlat	Contributions total latent calories	W
ATsen	Contributions sensible total heat	W
AV	Contributions through glass walls	W
Ccr	Percentage of residual heat corresponding to the share of energy remaining in the room	%
Cin	Overpower coefficient	-

Greek symbols

ϕlat	Latent gains of chickens	W
ϕsen	Sensitive Gains of Chickens	W
ϕtot	Total chicken gains	W

Δte	Equivalent temperature difference per hour t	ºC
Δtem	Equivalent temperature difference at time t for the orientation of the considered wall	ºC
Δtes	Difference in equivalent temperature at time t considering that the wall is in the shade	°C
η	Engine efficiency	
λ	Thermal conductivity	w/m.°C
ρ	Density	kg/m3

The clues :

A	Air
O	Outside
I	Interior
M	Mean
F	Floor
Th	Thermal

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General Introduction

General Introduction

The poultry sector in Algeria is witnessing its largest growth since the 1980s, thanks to government intervention aimed at improving this field. However, Algerian poultry farming still faces numerous constraints, such as outdated buildings and poor control of internal temperature, leading to high energy consumption, which in turn strongly affects growth and animal production [1.2] .

In addition, energy consumption in enclosed poultry production buildings constitutes a significant part of the overall energy consumed in poultry farming. The implementation of energy-saving techniques in broiler production has been effective in reducing total energy consumption throughout the sector.

There are two main solutions to improve the performance of broiler rearing and to maintain them at the right temperature and thermal comfort for the poultry. The first is to reduce the energy loss caused by the use of old buildings that lack insulating properties. The second solution is to use renewable energy sources to meet the thermal needs of poultry farms. Modern buildings are usually subject to appropriate insulation properties.

In order to improve the performance of broiler farming and maintain the appropriate temperature and thermal comfort for poultry, the thermal requirements for heating and cooling should be determined for large and small industrial poultry houses. This is to propose mathematical models to calculate the dimensions of the solar system specially designed for industrial poultry houses.

This work consists of three main chapters. The first chapter focuses on a general study of industrial poultry houses, including the requirements and thermal conditions necessary for poultry farming. Different ventilation systems are then identified, and the current heating and cooling methods used in poultry houses are presented. The chapter also presents the types of renewable energy used in the poultry sector.

The second chapter presents the equations that enable us to calculate the thermal requirements in winter and summer using regulatory documents such as DTR C 3-2 and DTR C 3-4, along with a step-by-step diagram explaining the calculation process.

The third chapter is divided into four main parts. Firstly, it determines the study area and examines the climate of the Ouargla province. Secondly, it calculates the thermal requirements for buildings in summer and winter with different dimensions. Thirdly, it sizes and determines the dimensions of the solar system, including the number of elements and the quantity required for the operation of the poultry houses. Finally, it calculates the cost of implementing this system in the study farm.

Finally, the work concludes with a general conclusion.

CHAPTER ONE

General information on industrial poultry house

I.1. Introduction:

The design and components of poultry houses, as well as the indoor climatic conditions within the buildings, play a crucial role in determining optimal health, growth, and productive performance of chickens. Understanding the basic principles of ventilation, insulation, and lighting is essential for proper building design and management. Throughout each growth period, the indoor air temperature requirements change according to the chickens' needs, resulting in a convective heating/cooling cycle that consumes a significant amount of energy resources to maintain these conditions.

I.2. Definition

A poultry farm is a facility where domesticated birds are raised. Poultry species include chickens, turkeys, ducks, and geese. These animals are primarily raised for their meat and eggs. Chickens are the most common bird raised for both meat and eggs. Chickens raised for meat production are referred to as broilers, while those raised for egg production are called laying hens or layers. Some poultry breeds are also raised on hobby farms for shows and competitions.

Table I-1: Temperature standards in broiler farming [3] .

Age (week)	Temperature (°C)
0 – 4 days	35 – 32 °C
5 – 7 days	32 – 30 °C
2nd week	30 °C
3rd week	28 °C
4th week	26 °C
5th week	21 °C
>5th week	21 – 18 °C

The following are some routine activities carried out on a poultry farm:

- Preparing the poultry house for the arrival of the birds.
- Feeding the birds
- Monitoring the conditions inside the poultry houses, including temperature, humidity, and air quality

- Checking and maintaining the feed and water lines to ensure a continuous supply of fresh water and feed for the birds.
- Monitoring the health of the birds, including observing their behavior, checking for signs of illness, and administering appropriate vaccinations or treatments
- Cleaning the poultry houses or coops regularly to maintain hygiene and prevent the spread of diseases
- Collecting eggs from laying hens and broiler breeders, ensuring proper handling and storage of eggs.
- Loading chickens or turkeys onto trucks for transportation to processing plants, in the case of meat chickens or turkeys [4] .

I.3. Building ventilation

Plays a crucial role in maintaining optimal conditions within poultry houses. There are two primary types of ventilation: natural ventilation and mechanical ventilation.

I.3.1. Natural ventilation: Natural ventilation, also known as "curtain ventilation," involves opening the building to allow exterior breezes and convection currents to circulate air into and through the structure. This is typically achieved by lowering side curtains, shutters, or doors. However, natural ventilation is effective only when external conditions closely match the desired conditions inside the poultry house. [5].

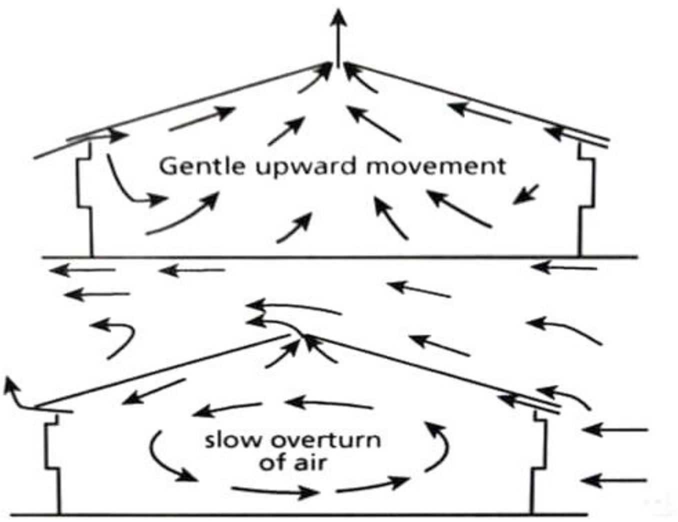


Figure I-1: Natural ventilation in a poultry house *[5]*.

- In hot weather, strong winds are necessary to achieve an acceptable air change rate.
- In cool weather, cold outside air may directly affect the chickens.

I.3.2. Mechanical ventilation:

"Dynamic ventilation" uses fans to bring air into and through the building. Power ventilation generally allows much greater control of air change rate and through airflow, depending on the configuration of the fans and air intakes as well as the type of control used it should only be used when transitional ventilation is not able to keep the chickens in a comfortable environment. It is used in hot to very hot weather and generally when the chickens are older. In this type of ventilation, large volumes of air are drawn down the entire length of the building, allowing the air to be replenished in a short period of time. This causes a high-velocity airflow over the chicken and creates a draft fresh air to cool them down. By varying the number of fans running, the speed of air entering the house and the cooling effect on the chickens can be varied [5].

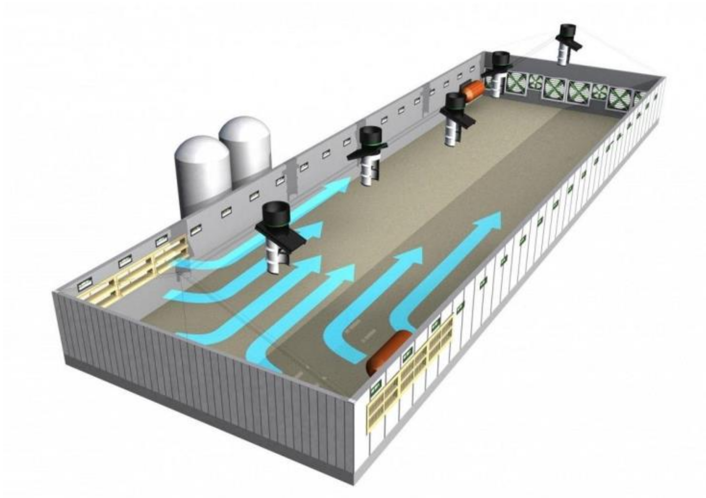


Figure I-2: Tunnel ventilation [5].

I.4. Heating Poultry Houses

I.4.1. Animal Requirements

Birds are homeothermic, which means they maintain a relatively constant internal body temperature regardless of changes in the environment. In cold weather, birds may increase their feed consumption to generate more body heat. However, if a significant portion of the feed is used for heat production, it can result in reduced weight gain, lower egg production, and overall decreased productivity. The impact of cold on productivity can vary considerably depending on factors such as bird weight, age, and species [5] .

Heat in the poultry barn is derived from three main sources: the birds themselves, the heating system, and the lights and motors present in the facility. Birds generate significant sensible heat, which contributes to maintaining the temperature inside the barn during cold weather. They also release latent heat primarily through respiration. Newly hatched chicks and poults are particularly susceptible to cold stress [6] .

According to the Code of Practice from the Canadian Agri-Food Research Council, the brooding temperature for chicks on their first day of life should range from 30 to 32°C at the chicks' eye level, depending on the housing type [6]. Subsequently, the temperature should be reduced by 2 to 3°C per week, reaching approximately 21 to 23°C by the age of 6 weeks. Afterward, it is preferable to maintain a relatively stable temperature within the range of 10 to 27°C [5].

Different chicken strains may have varying temperature requirements. Observing the behavior of chickens within a pen or brooding cage can serve as a reliable indicator of their thermal comfort. If the young chickens congregate outside the heating zone, it usually indicates a temperature that is too high. Conversely, if they gather close to the heat source, it suggests that the environmental temperature is too low. Optimal conditions are present when the chickens are evenly distributed throughout the entire brooding area. Most adult birds can tolerate a wide range of temperatures as long as the average environmental temperature is suitable. Temperatures ranging from 10 to 25°C are well-tolerated by layers. The optimal environmental temperature for layers largely depends on the specific diet used. Temperature fluctuations within a certain range are acceptable for layers, as there is no evidence that a constant temperature significantly enhances productivity [5.7].

Turkeys have slightly higher temperature requirements during the first two weeks of life. The turkey production handbook from the United States Department of Agriculture suggests that the temperature 8 cm above the floor should be 35°C for dark poults and 38°C for white poults. The temperature near the floor of the room outside the brooding area should be around 21°C [7].

I.4.2. Heating systems:

Two commonly used types of heaters in poultry farms are heating radiators and forced air heaters. In the poultry house, the heating radiator is the preferred type of heater [8].

Figure I-3: Schematic diagram illustrating the operation of the heating radiator used in the poultry house [8].

I.5. Cooling Poultry Houses

Controlled climate housing is widely practiced in modern poultry projects across many countries. However, in areas where it is not yet prevalent, there may be some confusion regarding its feasibility, principles, and practicality. The author thoroughly examines the subject, covering basic principles to practical implementation, particularly in hot and humid climates [5].

- **Objectives:**

The objectives of climate control in poultry houses are as follows:

- Removal of excess heat during hot seasons.
- Removal of excess moisture.
- Limiting the accumulation of harmful gases while ensuring sufficient oxygen for respiration.

These objectives can be accomplished by employing either of the following principles:

Tunnel ventilation or evaporative cooling methods, which may involve fogging or pad and fan systems Implementing a climate-controlled house that aims to create near-ideal conditions of temperature and humidity. Proper implementation of cooling systems in hot and humid climates can potentially lead to a significant improvement of up to 20% in productivity. Understanding the fundamental principles is crucial for the successful implementation of a cooling system in modern poultry houses [8].

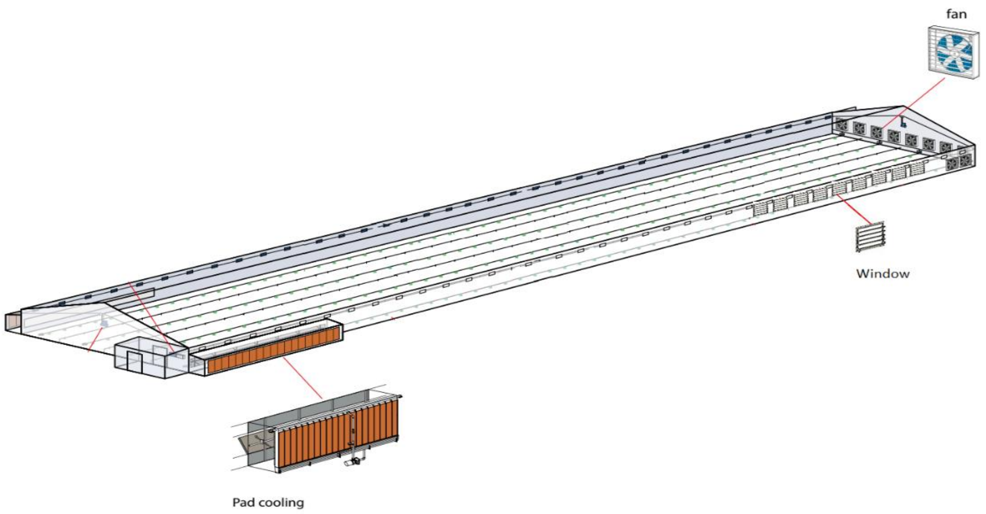


Figure I-4: Basic Cooling Systems [9] .

I.6. Types of renewable energies that can be used in modern poultry farm

I.6.1. Biomass Energy

Globally, photosynthesis converts solar energy into biomass at a rate approximately seven times higher than the current global energy consumption of 500 EJ/yr. However, less than 2% of this biomass is currently utilized for human energy consumption. Biomass resources are diverse, and the consumption of the largest biomass category (fuelwood in developing countries) is comparable to that of industrial roundwood [10].

When harnessed sustainably, biomass can be converted into modern energy carriers that are clean, convenient to use, and have minimal or no associated greenhouse gas (GHG) emissions over their life cycle. Various conversion technologies are available or being developed to utilize biomass as a renewable energy source. Sustainable bioenergy has the potential to contribute significantly to rural and economic development, enhance energy security, and reduce environmental impacts [10].

Projections from the International Energy Agency (IEA) and other organizations, as well as many national targets, anticipate increased production and use of biomass in the future. Factors related to sustainable feedstock production and estimates of available supplies up to 2050 [10].

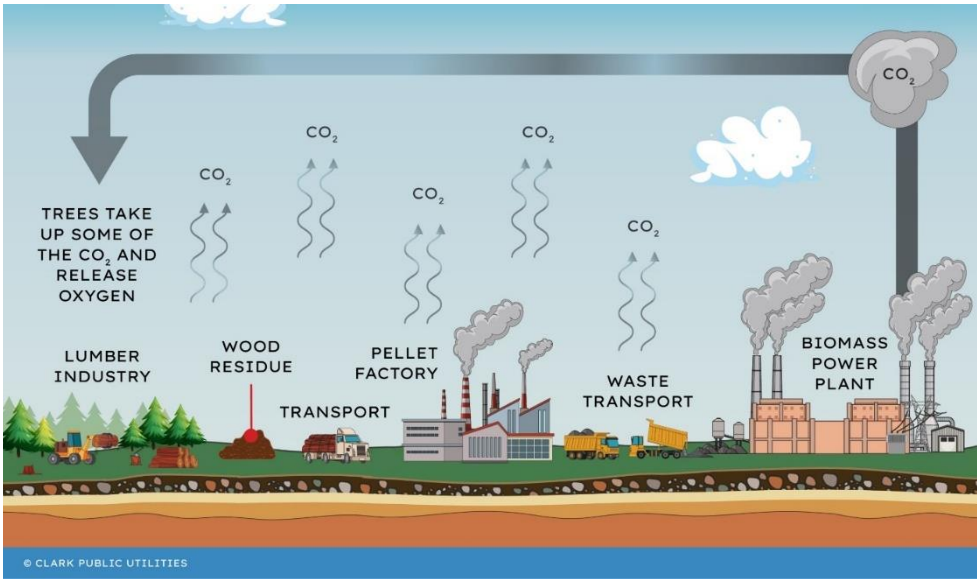


Figure I 5: The Biomass cycle [11]

I.6.2. Geothermal Energy

Geothermal energy has a long history of use, dating back thousands of years, for activities such as washing, bathing, and cooking. However, it was during the twentieth century that geothermal energy started to be harnessed on a larger scale for space heating, electricity generation, and industrial applications. The first significant implementation of geothermal district heating occurred in Iceland in the 1930s, and today it supplies geothermal heat to approximately 99% of Reykjavik's 200,000 residents [10].

The utilization of geothermal energy has experienced significant growth since the 1970s. In the first decade of the twenty-first century, the globally installed capacity for direct use of geothermal energy tripled from 15 to nearly 50 GWth (thermal capacity), while the installed capacity for electricity production increased from 8.0 to 10.7 GWth (electric capacity) [10] .

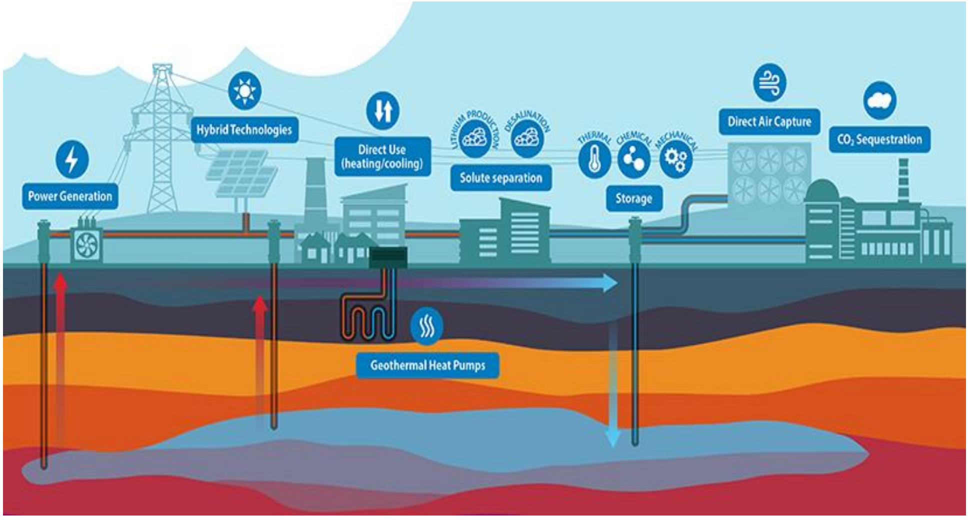


Figure I-6: The Power of Geothermal [11] .

I.6.3. Wind Energy

Wind energy has a long history of usage in various applications for thousands of years. However, it was overshadowed by other fuel sources for much of this time due to technical, social, and economic factors. The oil crises of the 1970s renewed interest in wind energy technology for grid-connected electricity production, water pumping, and powering remote areas. This section focuses on utility-scale, grid-connected wind technology deployed on land or offshore [10].

By 2009, wind power capacity had grown to meet nearly 2% of global electricity demand. Onshore wind power is currently one of the most cost-effective renewable energy generation technologies. In regions with favorable wind resources, generating electricity with wind turbines is already competitive, leading to rapid growth in installations. Offshore wind projects require higher capital investment compared to their land-based counterparts. However, some countries in Europe and Asia have set ambitious goals for offshore wind deployment. The experience gained from these projects is expected to drive cost reductions and improve performance [10].

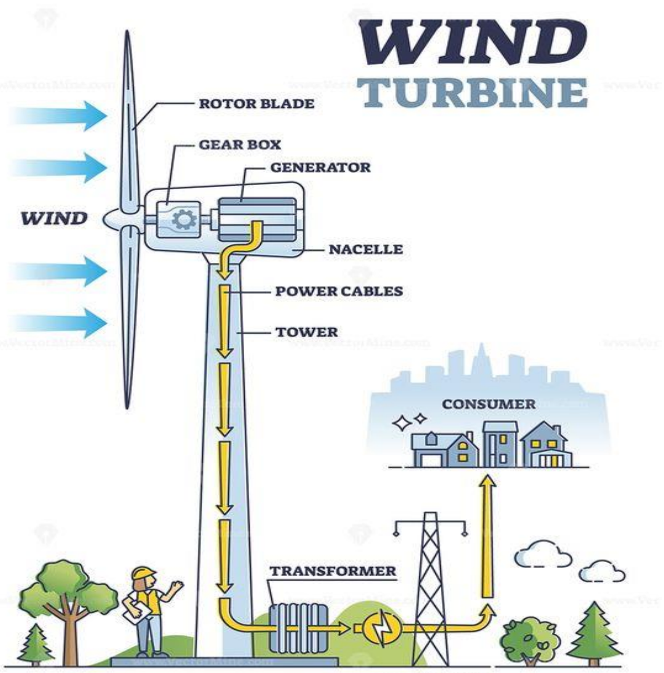


Figure I-7 : Wind energy [11] .

I.6.4. Photovoltaic Solar Energy

Photovoltaic (PV) technology, also known as solar electricity, directly converts sunlight into electricity. Solar electricity has been extensively used to power space vehicles and small electronics, as well as for rural and agricultural applications over the past three decades. In recent years, a strong market for solar electricity has emerged, particularly for grid-connected homes and buildings, driven by advances in solar technology and restructuring of the electric industry [10].

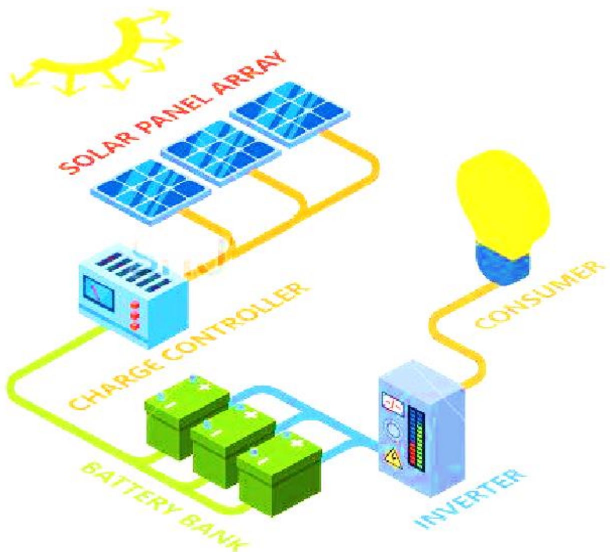


Figure I-8: Basic solar power system [11] .

I.6.4.1. Photovoltaic conversion

Indeed the word “photovoltaic” comes from the Greek word “photo” which means light and “voltaic” which originates from the name of an Italian physicist Alessandro Volta (1754 -1827) who contributed a lot to the discovery of electricity, then photovoltaics literally means “light electricity”.

The sun is a source of energy that. This energy makes it possible to produce electricity from photovoltaic panels or solar thermal power plants, thanks to sunlight captured by solar panels [12].

The possibility of directly transforming light energy, and in particular solar radiation, into electrical energy appeared in 1954 with the discovery of the photovoltaic effect. This effect uses the quantum properties of light allowing the transformation of incident energy into electric current, of which the solar cell or solar cell is the basic element of this photovoltaic conversion.

I.6.4.2. The photovoltaic effect

The photovoltaic effect is a process of transforming the energy emitted by the sun, in the form of photons, into electrical energy using a semiconductor component called a solar cell.

The photovoltaic effect can only occur if there is a potential barrier in the semiconductor before it is illuminated. Such a barrier exists, for example, at the interface between two differently doped volumes, i.e. where two different types of impurities with different concentrations have been introduced, for example of the P-N type. If this material is illuminated, the electric charges, made mobile by the light (the Photoelectric effect), will be separated by the barrier with on one side the positive charges and on the other side the negative charges . Among the most widely used semiconductor materials are silicon, germanium, gallium sulphide and gallium arsenide [13].

I.6.4.3. Principle of functioning

Photovoltaic cell is as follows: the “grains” of light called photons, penetrating very slightly into the silicon, displace a few electrons from the metal. The semiconductor metal only allowing the movement of electrons in one direction, the electrons moved by the light must pass through the external circuit to return to their place, which generates a current. The cells produce electricity every day even if the sky is cloudy: in this case, the efficiency is simply lower. The cells are assembled in the form of photovoltaic panels, panels which are embedded on or in the roof of the dwellings. Complex manufacturing requires excellent technical mastery to ensure the best performance over time. The assembly of these solar cells connected to each other [13].

I.6.4.4. Cell photovoltaic

The PV cell, also called solar cell, is the basic element of photovoltaic conversion. It is a semiconductor device that converts the light energy provided by an inexhaustible source of energy, the sun, into electrical energy. It exploits the properties of semiconductor materials used in the electronics industry: diodes, transistors and integrated circuits.

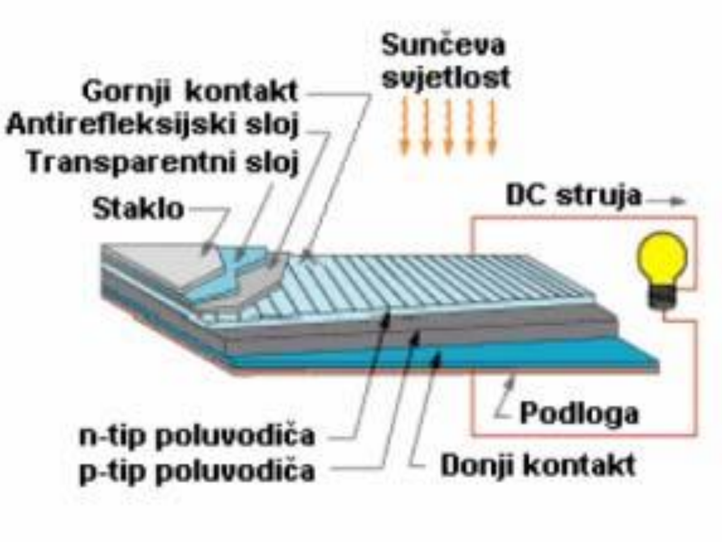


Figure I-9 : Typical cells [12] .

I.6.4.5. Different photovoltaic cell technologies

Photovoltaic cells can be made from various semiconductor materials. The semiconductor material used almost universally today is silicon, this is mainly due to its unlimited availability on earth. It is an extremely abundant, non-toxic and stable material, as Silicon is also found in very large quantities on our planet because it makes up about 28% of the Earth's crust. In fact, it is mainly found in the form of silicon dioxide (Sio2) and is the main component of sand. Therefore, they are plentiful and inexpensive [12.13] .

A. monocrystalline silicon

Monocrystalline silicon is the basis of this type of cell. Silicon cell manufacturing begins with the extraction of the silicon dioxide crystal. This material is deoxidized in large furnaces, purified and solidified. This process has reached a purity of 98 and 99% which allows a high energy yield. The silicon is then fused with a small amount of dopant, normally boron which is P-type and then cut into thin slices of around 300 µm. After cutting and cleaning impurities from the wafers, N-type impurities are introduced via a controlled diffusion process: the silicon wafers are exposed to phosphorus vapors in an oven where the temperature varies from 800 to 1000°C [12] [13] .

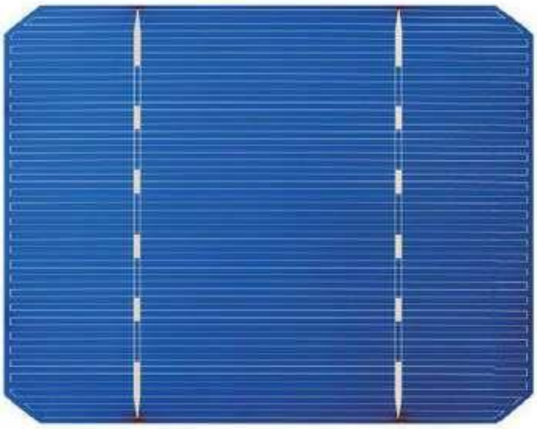


Figure I-10 : Monocrystalline photovoltaic cell [13].

- **Advantages**
  - Very good yield (17.2%).
- **Disadvantages**
  - High cost.
  - Poor performance under low light

B. polycrystalline silicon

The production process is similar to that previously presented in the case of silicon cell manufacturing, but with less rigorous control. As a result, the cells obtained are less expensive but also less efficient (12.5% yield on average).Their interest lies in the multiplicity of forms in which the coating can be presented: ingots to be cut, ribbon or wire to be deposited, each technique makes it possible to produce crystals with specific characteristics, including size, morphology and concentration of impurities [12.13] .

Figure I-11 : Polycrystalline photovoltaic cell [13].

- **Advantages**
  - Good efficiency (13%), but however less good than for monocrystalline;
  - Cheaper than monocrystalline.
- **Disadvantages**
  - The same as monocrystalline.
  - These are the most used cells for electricity production (best value for money).

C. Amorphous silicon

The amorphous silicon cells differ from the cells presented previously since their structure presents a high degree of disorder in the structure of the atoms. Using amorphous silicon for solar cells has shown great benefits

both in terms of the electrical properties and the manufacturing process (simple process, low energy consumption, inexpensive, possibility of producing cells with large sectors.

But, even with a reduced cost for production, the use of amorphous silicon has two drawbacks: the first is the low conversion efficiency compared to mono and poly crystalline silicon cells. The second is the fact that the cells are affected by a degradation process in the first months of operation, thus reducing their durability [13].

Figure I-12 : Amorphous silicon cell [12].

- **Advantages**
  - Operation with low illumination;
  - Cheaper than others.
- **Disadvantages**
  - Low yield in full sun (about 7%);
  - Performance decreases noticeably over time

Table I-2: comparison of different PV materials [14] .

Material	The yield	Longevity	Principal	Uses
Monocrystalline Silicon	12 to 18% (24.7% in laboratory)	20 to 30 years old	• High performance • W production stability • Production method costly and laborious.	Aerospace, modules for roofs, facades,
Polycrystalline silicon	11 to 15% (19.8% in laboratory)	20 to 30 years old	• Suitable for large scale production. • Production stability of W. • More than 50% of the world market.	Roof modules, facades, generators…
Amorphous	5 to 8% (13% in the laboratory)		• Can work under fluorescent light. • Operation if low light. • Operation in cloudy weather. • Operation if partial shade • Output power varies over time. At the	Electronic devices (watches, calculators…), building integration

			beginning of life, the power delivered is 15 to 20% higher than the nominal value and stabilizes after a few months.	

I.6.5. High-Temperature Solar Thermal Energy

High-temperature solar thermal technologies, also referred to as concentrating solar thermal, use mirrors that reflect and concentrate sunlight onto receivers. The receivers convert the solar energy to thermal energy, which is used in a steam turbine or heat engine to drive an electric generator. These concentrating solar power (CSP) systems might also allow the production of chemical fuels for transportation, storage, and industrial processes . CSP systems perform best in regions having a high direct-normal component of solar radiation [10].

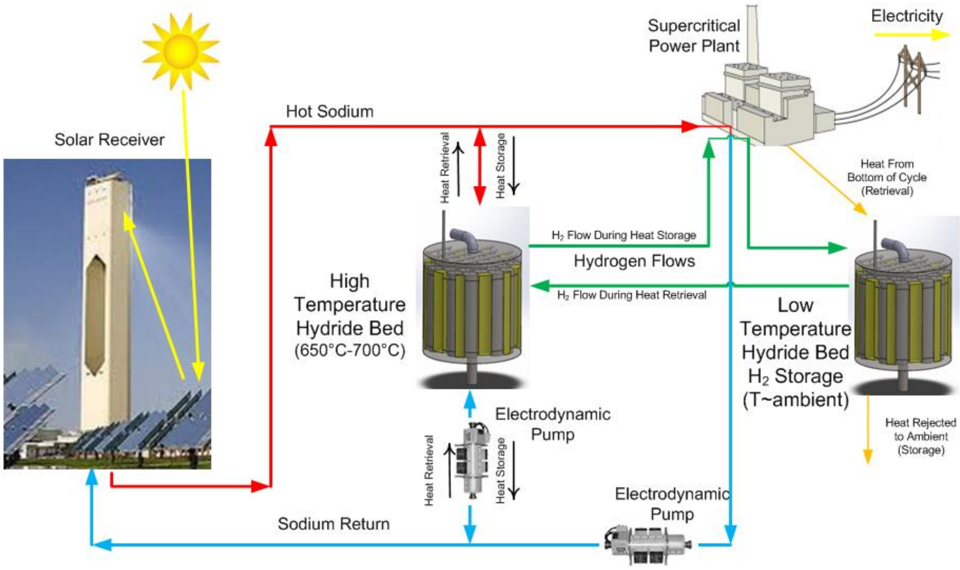


Figure I-13: High-Temperature Solar Thermal [11] .

I.6.6. Low-Temperature Solar Energy

Low-temperature solar energy technologies, with operating temperatures up to 100° C, are perhaps the simplest way to use solar resources. These systems can be active or passive. In active conversion systems, heat from a solar collector is transported to the end process by a heat transfer system. In passive systems, no active components are needed to use the solar resource for heating or lighting . This section is focused mainly on active systems that convert sunlight to thermal energy for water heating, space heating, space cooling, cooking, and crop drying [10].

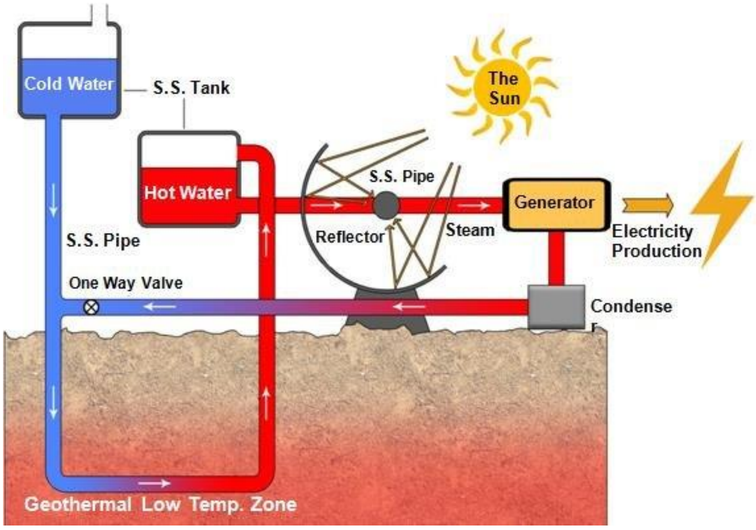


Figure I-14 : A scheme illustrates the use of solar energy with low temperature [11] .

I.7. Conclusion:

One of the most important factors that influence the growth and production of poultry is the internal temperature, ventilation, and lighting. Therefore, specialists in this field try to reduce the large consumption of energy by reducing the external heat through good insulation and good orientation of the building. Nevertheless, the building still consumes large amounts of fuel. Fossil fuels cause significant carbon dioxide emissions, which have negative effects on production and the environment .

CHAPTER TWO

Thermal Needs Study of an Industrial Poultry House

II.1. Introduction:

The objective of this chapter is to investigate the thermal requirements of an industrial poultry house modern ,The study is divided into two main parts:

Practical Study: data regarding the internal and external conditions of the building were gathered and orientation, dimensions, structure, etc.,.

Theoretical Study: In this part, the necessary formulas for calculating heat contributions and losses were determined. These calculations aided in determining the heating and cooling power required for the poultry house.

II.2. The steps for calculating Heating Energy required:

II.2.1. GENERAL EXPRESSION OF LOSSES

II.2.1.1. Total losses of a dwelling

The total losses D for a dwelling, containing several thermal volumes, are given by [15]:

$$D = \Sigma D_i \ [W/°C] \quad \text{(II.1)}$$

Where Di (W/°C) represents the total losses of volume (i)

II.2.1.2. Total losses of a volume D_i :

The total losses Di of a volume (i) are given by [15]**:**

$$D_i = (D_T)_I + (D_R)_I \ [W/°C] \quad \text{(II.2)}$$

D_T represents the losses by transmission of volume I, (W/°C)

D_R represents the air-renewal losses of volume i. (W/°C)

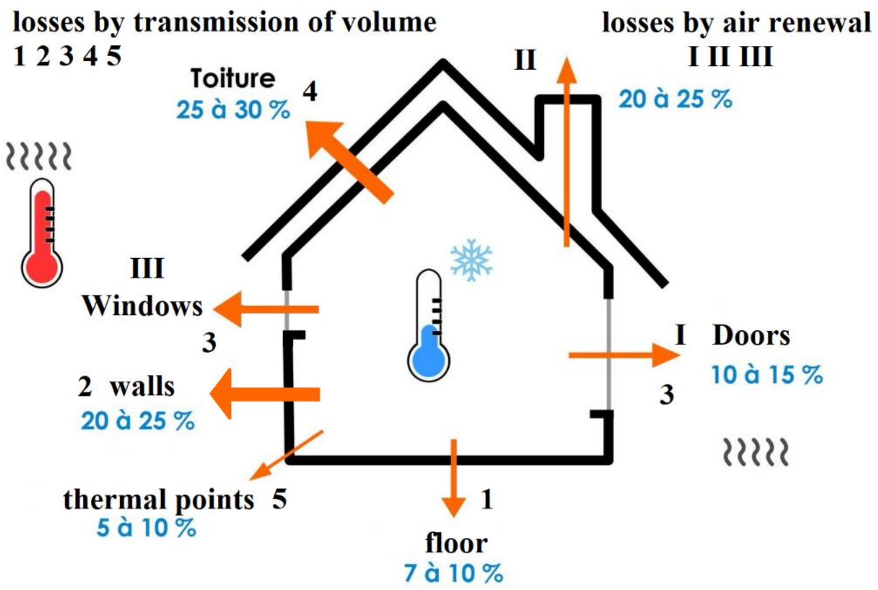


Figure II-1: Represents total losses in a certain size [16] .

A. Losses per transmission of a volume D_T:

The transmission losses (**DT**)$_I$ of a volume I are given by [15]:

$$(D_T)_I = (D_s)_I + (D_{li})_I + (D_{sol})_I + (D_{lnc})_I \quad [W/°C] \tag{II.3}$$

- $(D_s)_I$ (in W/°C) represents the surface losses through the common parts of the walls in contact with the outside
- (Dli)I (in W/°C) represents the losses through the links
- (Dsol)I (in W/°C) represents the losses through the walls in contact with the ground
- (Dlnc) (in W/°C) represents the losses through the walls in contact with the unheated

  rooms

- **Surface losses by transmission through a wall, D_s** [15]**:**

$$D_{surf} = K_{winter} \times S_I \quad [W/°C] \tag{II.4}$$

- S_I (in m²) is the interior surface of the wall.
- K_{winter} (in W/m^2.°C) represents the summer surface transmission coefficient and calculated by :

$$\frac{1}{K} = \sum R + \frac{1}{h_e} + \frac{1}{h_i} \; [m^2.°C/W] \qquad \textbf{(II.5)}$$

- **The losses through a link, or thermal bridge, D_{li} :**

Thermal bridges are junction points where the insulation is not continuous and which cause heat loss [15] .

Losses through thermal bridges are calculated by :

$$D_{li} = k_l \times L \;\; [W/°C] \qquad \textbf{(II.6)}$$

The losses by thermal bridges for the whole dwelling can be evaluated at 20% of the surface losses by transmission through the walls of the dwelling, by the formula : [15]

$$D_{li} = \Sigma(k_l \times L) = 0,20\ \Sigma(K_{winter} \times S_i) \;\; [W/°C] \qquad \textbf{(II.7)}$$

$$D_{li} = 0,20\ \Sigma\ D_{surf} \;\; [W/°C] \qquad \textbf{(II.8)}$$

- k_l (in W/m.°C) represents the linear transmission coefficient of the link.
- L (in m) represents the internal length of the connection.

- **losses by transmission through the walls in contact with the ground ,D_{sol} :**

The losses Dsol, for a low floor or a buried wall, are given by the formula: [15]

$$D_{sol} = k_{winter} \times P \qquad \textbf{(II.9)}$$

-P (in m) represents the interior perimeter for low floors.

- k_{winter} (in W/m.°C) is the linear transmission coefficient of the low floor or the wall.

The values of the coefficients ks are given according to the level difference z

For a low buried floor, the difference in level is the difference between the level of the upper face of the floor and the ground level. It is counted negatively when the floor is lower than the ground, and positively when it is not.

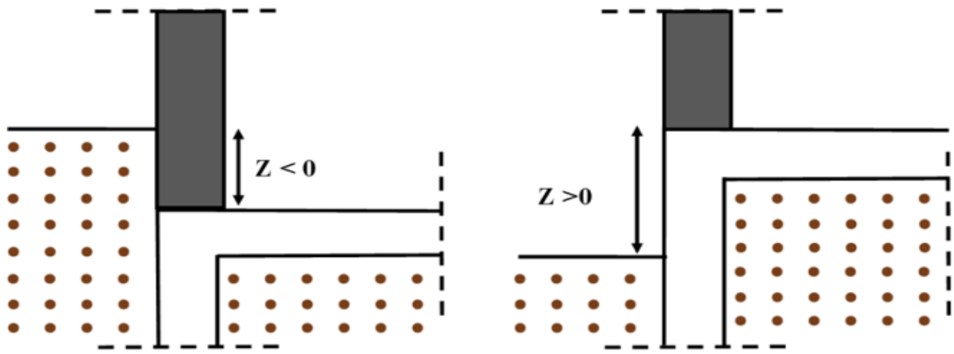


Figure II-2: Difference in the level of a floor from the ground *[15]*

- **Losses through walls in contact with unheated rooms,D** $_{lnc}$

The losses $\mathbf{D_{Inc}}$ by transmission per degree of difference through a wall in contact with an unheated room are given by the following formula [15] :

$$\mathbf{D_{Inc} = T_{au} \times [\Sigma(K_{winter} \times S_i) + \Sigma(k_l \times L)]\ [W/°C]} \quad \textbf{(II.10)}$$

Tau is the temperature reduction coefficient; It is [15] :

$$T_{au} = \frac{t_i + t_n}{t_i - t_e} = \frac{d_e}{d_e + a_c} \quad \textbf{(II.11)}$$

- t_i (in °C) is the interior temperature,
- t_n (in °C) is the temperature of the unheated space,
- t_e (in °C) is the outside temperature,
- a_c (in W/°C) represents the heat inputs from the various heated rooms to the unheated room and are calculated using the following formula [15]:

$$\mathbf{a_c = \Sigma(K_{winter} \times S_i) + \Sigma(k_l \times L)\ [W/°C]} \quad \textbf{(II.12)}$$

considering the dividing wall(s) between the unheated rooms and the heated rooms.
- d_e (in W/°C) represents the losses of the unheated room to the outside and are given by the following formula [15]:

$$\mathbf{d_e = [\ \Sigma\ (K_{winter} \times S_i) + \Sigma\ (k_l \times L)\ ] + dr\ \ [W/°C]} \quad \textbf{(II.13)}$$

- d_r (in W/°C) represents the losses by renewal of air in the unheated room, which are calculated differently according to the following formula [15]:

$$\mathbf{d_r = 0{,}34 \times N \times V\ [W/°C]} \quad \textbf{(II.14)}$$

- **V** (in m^3) is the volume of the unheated room.
- **N** (in h^{-1}) is the hourly air renewal rate of volume V of the unheated room.

B. Losses by air renewal of a volume D_r :

Heat losses by air renewal of a room represent heat losses from fresh air inlets and excess exhaust air, as well as air infiltration into the room in question of wall permeability [15].

$$(D_R)_I = (D_{Rv})_I + (D_{Rs})_I \ [W/°C] \quad \textbf{(II.15)}$$

D_{RV} (in W/°C) represents the losses due to the normal operation of the ventilation devices and is calculated using the following formula [17]:

$$D_{Rv} = 0.34 x\ Q_V\ [W/°C] \quad \textbf{(II.16)}$$

- Qv (in m3/h) the flow rate needed for broilers [17].

$$Qv = m_p\ x\ n_p\ x\ q_v\ [m3/h] \quad \textbf{(II.17)}$$

m_p= the mass of chicken.

N_p= Number of chickens.

Q_v= the ventilation flow rate of chicken.

D_{Rs} (in W/°C) represents the additional losses due to wind and calculate by the following formula

$$D_{Rs} = 0{,}34\ x\ Qs\ [W/°C] \quad \textbf{(II.18)}$$

- Qs (in m3/h) is the additional flow rate by wind infiltration

II.2.2. Verification and loss of reference

II.2.2.1. Regulatory verification

Losses by transmission D_T of the dwelling must verify [15]:

$$D_T \le 1{,}05 \times D_{réf}\ [W/°C] \quad \textbf{(II.19)}$$

- D_T represents the losses by transmission in (W/°C)
- $D_{réf}$ represents the reference losses in (W/°C)

II.2.2.2. Reference losses

The reference losses D_{ref} are calculated by the following formula [15]:

$$D\ réf = a \times S_1 + b \times S_2 + c \times S_3 + d \times S_4 + e \times S_5\ [W/°C] \qquad (II.20)$$

- The Si (in m²) represent the surfaces of the walls in contact with the outside, an attic, a crawl space, an unheated room or the ground. They concern respectively S1 the roof, S2 the low floor, including low floors on unheated premises, S3 the walls, S4 the doors, S5 the windows and the French windows. S1, S2, S3 are counted from inside the premises, S4 and S5 are counted by taking the dimensions of the perimeter of the opening in the wall
- The coefficients a, b, c, d and e, (in W/m².°C). They depend on the nature of the accommodation and the climatic zone.

II.2.3. Calculation of basic losses

II.2.3.1. Total Base Losses

The total basic losses for a $D_{B'}$ room, containing several thermal volumes, have the expression [15]:

$$D_B = \Sigma(D_B)_I\ [W] \qquad (II.21)$$

- where $(D_B)_I$ (in W) represents the basic losses of each thermal volume I .

II.2.3.2. Basic losses for a volume

The basic losses for a thermal volume (DB) are expressed as [15]:

$$(D_B)_I = D_i \times (t_{bi} - t_{be})\ [W] \qquad (II.22)$$

Or :

- D_i (in W/°C) represents the total losses of thermal volume i.
- t_{bi} (in °C) is the base interior temperature of the volume considered.
- t_{be} (in °C) is the basic outside temperature of the location of the construction .

II.2.4. Calculation of heating power

The heating power Q required for a dwelling is given by

$$Q = [t_{bi} - t_{be}] \times [[1 + Max\ (C_r\ ;\ C_{in})]\ D_T] + [(1 + C_r) \times D_R]\ [W] \qquad (II.23)$$

Or :

- tbi (in °C) represents the base interior temperature.
- tbe (in °C) represents the base outside temperature.
- DT (in W/°C) represents the losses by transmission of the dwelling.
- DR (in W/°C) represents the losses by renewal of air in the dwelling.
- cr (dimensionless) is an estimated ratio of heat losses due to the piping network possible.
- cin (dimensionless) represents an overpower coefficient.

Calculation Steps [13]**:**

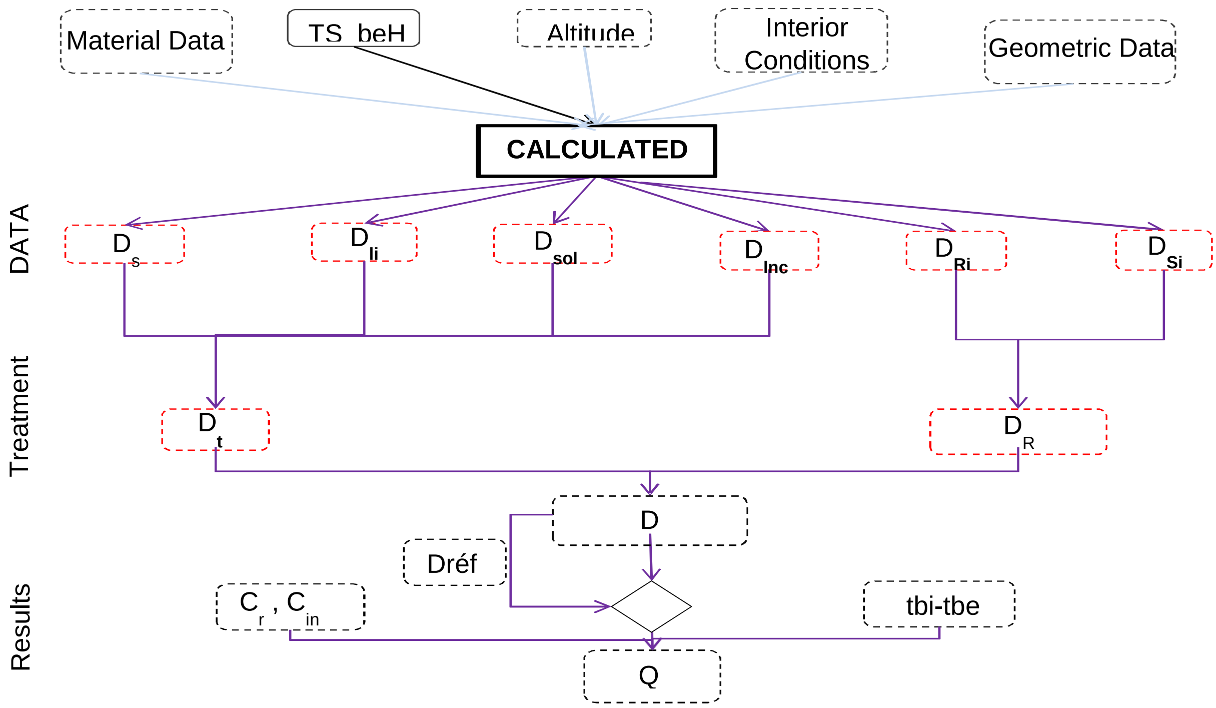


Figure II-3: Heating flowchart [13]

II.3. Steps for calculating cooling energy requirements

II.3.1. The contributions calorific:

The calorific contributions (also called gains) of a room are equal to the sum of the sensible and latent heat contributions, coming from an internal or external source of the room, for determined external and internal conditions [18].

II.3.1.1. Calculation of Contributions [18]:

$$Atot = \Sigma\ APO + AVE + AIocc + AI\ flash + AREN\ S + ARENL \quad \textbf{(II.24)}$$

- **Contributions calorific sensible As and latent Al are given by** [18]**:**

$$As = APO + AV + AI_s + AINF_s \ [W] \quad \textbf{(II.25)}$$

$$A_l = AI_l + AINF_l \ [W] \quad \textbf{(II.26)}$$

- APO (in W) represents the contributions by the opaque walls,
- AV (in W) represents the intakes through the glazed walls,
- AI_s and AI1 (in W) represent the sensitive and latent parts of the internal contributions,
- $AINF_s$ and AINF1 (in W) represent the sensitive and latent parts of the contributions due to air infiltration,

- **Contributions effective calorific sensible AEs and latent AEl are given by** [18]**:**

$$AE_s = (C_{\Delta as} \times A_s) + (BF \times AREN_s\ [W] \quad \textbf{(II.27)}$$

$$AE_l = (C_{\Delta al} \times A_l) + (BF \times AREN_l)\ [W] \quad \textbf{(II.28)}$$

- A_s (in W) represents the sensible gains,
- A_l (in W) represents the latent gains,
- $AREN_s$ and $AREN_l$ (in W) represent the sensitive and latent parts of the contributions due to the ventilation of the premises,
- BF or bypass factor expresses the part of the outside air (new air) not treated by the air conditioning installation (imperfection of the treatment device), and which reaches the room without modifications (BF=0.40)

- $C_{\Delta as}$ is a coefficient of increase of the sensitive gains which takes into account the additional gains (heating of the fan, network of air ducts crossing unconditioned rooms)
- $C_{\Delta al}$ is a latent gains increase coefficient which takes into account additional gains (such as those due to possible air leaks in air duct networks)

- **Contributions total sensible calorific ATs and latent ATi are given by** [18]**:**

$$AT_S = (C_{\Delta as} \times A_S) + AREN_S \text{ [W]} \quad \textbf{(II.29)}$$

$$AT_I = (C_{\Delta al} \times A_I) + AREN_l \text{ [W]} \quad \textbf{(II.30)}$$

- **Regulatory verification :**

The sum of the calorific contributions by the glazed walls and the overhead opaque walls must verify in the month of July at 3 p.m. TSV, for an interior dry temperature of 27°C, the relationship below [18]:

$$APO\ (15h) + AV\ (15h) \leq 1.05 \times A_{REF}\ (15h) \text{ [W]} \quad \textbf{(II.31)}$$

- APO (in W) designates the calorific contribution through the aerial opaque walls,
- AV (in W) designates the heat input through the glazed walls,
- A_{REF} (in W) designates the contributions reference calories,

The A_{REF} reference calorific intakes are given by [18]**:**

$$A_{REF} = A_{REF,PH} + A_{REF,PV} + A_{REF,PVI} \text{ [W]} \quad \textbf{(II.32)}$$

- $A_{REF,PH}$ (in W) designates the contributions reference heat values through the horizontal opaque walls,
- $A_{REF,PV}$ (in W) designates the contributions reference heat values through the vertical opaque walls,
- $A_{REF,PVI}$ (in W) designates the contributions reference calorific values through the glazed walls,

- **Contributions of reference for horizontal opaque walls ;**

Contributions reference calorific values of horizontal opaque walls AREF,PH are calculated using the following formula [18]:

$$A_{REF,PH} = \Sigma\ (a \times S_{INT} \times \Delta TS_{REF,PH}) \text{ [W]} \quad \textbf{(II.33)}$$

- a (in W/m².°C) is a coefficient related to the nature of the construction and function of the area climatic.
- S_{int} (in m²) designates the surface of the horizontal wall counted from the inside.
- $\Delta TS_{REF, PH}$ (in °C) is the reference temperature difference for horizontal walls .
- The value of the coefficient a is:
- equal to 1.90 W/m².°C for high floors (ceilings) in contact with an unconditioned room (regardless of the climatic zone);
- equal to 2.70 W/m².°C for low floors in contact with an unconditioned room (regardless of the climatic zone);
- given in table 1.3 for high floors in contact with the outside (roof).

Climate zone	Individual Housing	Housing in collective buildings, offices, premises for accommodation use
A	1,10	1,10
B	1,10	0,90
B'	1,10	0,90
C	1,10	0,85
D1, D2 et D3	2,40	2,40

Table II-1: Values de **a** [18].

- **Contributions of reference for vertical opaque walls:**

Contributions reference heat values of the vertical opaque walls A_{ref}, PV are calculated using the following formula [18]:

$$A_{REF,PV} = \Sigma (c \times S_{int} \times \Delta TS_{REF,PV}) \text{ [W]} \quad \textbf{(II.34)}$$

- c (in W/m².°C) is a coefficient related to the type of construction and function of the climatic zone,
- S_{int} (in m²) designates the surface of the vertical wall counted from the inside,
- $\Delta TS_{REF, PV}$ (in °C) is the reference temperature difference for the vertical opaque wall

II.3.1.2. External contributions:

A. Contribution through the walls Opaque:

Contributions of heat through an opaque wall at a time t, APO(t) are typically of sensible heat nature and are given by the following formula [18]:

$$\mathbf{APO(t)= 1.2 \times K_{summer} \times S_{int} \times \Delta te\ (t)\quad [W]} \qquad \textbf{(II.35)}$$

Where 1.2 is a coefficient of increase taking into account the linear lateral contributions (through thermal bridges) and K summer is the transmission coefficient in the current part of the wall, S int is the total interior surface of the wall considered, Δte (t) is the equivalent temperature difference at time t [18] .

- 1,2 is an increasing coefficient taking into account linear lateral inputs (through thermal bridges),
- K summer (in W/m².°C) is the transmission coefficient in current part of the wall considered for the summer
- S_{int} (in m²) is the total inner surface of the wall considered; for sloping roofs, we will take the horizontal projection of the surface;
- Δte(t) (in °C) is the equivalent temperature difference at time t
- The coefficient K summer of the opaque walls is given by the following formula [18]:

$$\frac{1}{K} = \sum R + \frac{1}{he} + \frac{1}{hi} \quad [m^2.°C/W] \qquad \textbf{(II.36)}$$

- The equivalent temperature difference Δte(t) is given by [18]:

➢ **sunny wall**

$$\Delta te(t) = \Delta tes(t) + C\Delta te + \frac{\alpha}{0.9} \times [\Delta tes - \Delta tem] \times \frac{It,b}{It,b(40)} \quad [°C] \qquad \textbf{(II.37)}$$

➢ **shaded wall 24 hours a day**

$$\Delta te(t) = \Delta tes(t) + C\Delta te \quad [°C] \qquad \textbf{(II.38)}$$

- $\Delta t_{es}(t)$ (in °C) is the equivalent temperature difference at time t considering that the wall is in the shade
- $C\Delta t_e$ (in °C) is a correction factor due, on the one hand, to the maximum difference
- α is the absorption factor of the wall
- $\Delta t_{em}(t)$ (in °C) is the equivalent temperature difference at time t for the orientation of the wall considered;

- $I_{t,b}$ (in W/m²) is the basic total radiation for the month, latitude and orientation considered .

- $I_{t,b}(40)$ (in W/m²) is the total basic radiation for the month of July, latitude 40° North and for the orientation considered

- The absorption factor α of the exterior walls is given below depending on whether the wall is painted or not. The absorption factor α of a painted exterior wall is given according to the color of the exterior face of the wall:

- Outer face of dark color (dark blue, dark red, dark brown), α = 0.90;
- Outer face of medium color (light green, light blue, light grey), α = 0.70;
- light-coloured outer surface (white, cream), α = 0.50;

B. Contributions through a floor in contact with the ground [18]**:**

$$APO_S = K_{summer} \times Si \times (Tm - Ti,b)\ [W] \qquad \textbf{(II.39)}$$

K_{summer}: Transmission coefficient in the current part of the wall considered in summer; W/m²°C

Tm: Mean dry outside air temperature; °C

C. **Internal contribution**:

The internal gain represents the amount of heat potentially or specifically released in an air-conditioned room : [18]

- **Increase in the heat of the chickens :**

The total calorific value of chicken is given by [18]:

$$\phi_{tot} = \phi_{sen} + \phi_{lat} \qquad \textbf{(II.40)}$$

To calculate the latent heat and sensible heat production of chickens, the equation developed by Pedersen & Thomsen (2000) was used as shown below [18]:

$$\phi tot = 9.84 \times m_P^{0.75}(4.\ 10^{-5} \times (20 - Ti,b)^3) \qquad \textbf{(II.41)}$$

$$\phi s = 0.83 \times \phi tot(0.8 - 1.85.\ 10^{-7}(Ti,b + 10)^4) \qquad \textbf{(II.42)}$$

Where :

mp (in kg) is the mass of the chicken

The gains due to the occupants are a source of sensible and latent heat [19].

- **Occupants sensibles gains** [19] **:**

$$Q_{sen,oc} = nC_{sen,oc} \quad \textbf{(II.43)}$$

- **Occupants latents gains** [19] **:**

$$Q_{lat,oc} = n_{Clat,oc} \quad \textbf{(II.44)}$$

Where:

n is the number of occupants.

$C_{sen,oc}$ Et $C_{lat,oc}$ (in W) the sensible and latent heat of the occupants.

- **Gains due to machines driven by an electric motor :**

Electric motors and machines powered by these motors are important sources of profit. If the engine and the working machine are in the same air-conditioned room, all the energy absorbed is dissipated as heat in the air-conditioned room. The contribution of the engine and machine assembly AI is given by [18] .

$$A_{Mè} = W_a = \frac{W_{eFF}}{\eta} [W] \quad \textbf{(II.45)}$$

W_a: Power absorbed; W
W_{eff}: Power nominal; W
η: Motor efficiency;

- **Gains due to lighting:**

Light fixtures are a source of heat. If the installed lighting power is known, the lighting gain can be calculated using the following formula [18] :

$$A_{è} = \sum(W_n . C_{me} . C_{cr}) [W] \quad \textbf{(II.46)}$$

W_n: Power rating of the bulb or fluorescent tube; W
C_{me}: Coefficient increase.

C_{cr}: Percentage of residual heat corresponding to the share of energy remaining in the room.

D. Contributions of heat by introduction of outside air

We are talking about admission by supply of fresh air. When outside air enters directly, i.e. H. This air enters through an undesired air inlet without passing through the air handling unit (to AINF infiltrations) or desired (to renewal of air AREN) .

When the outdoor air supply from the outside is mainly the height of the ventilation unit. This last supply of fresh air from outside is indirect and should not be taken into account in the load of the room

The significant gains due to the renewal of the ARENsen air, and due to the AINFsen infiltrations are given by the formulas given below:

$$\mathbf{AREN_{sen}(t) = 0.320 \times qv \times (T_e(t) - T_{b,i})\ [W]} \qquad \textbf{(II.47)}$$

$$\mathbf{AINF_{sen}(t) = 0.320 \times qv_{inf} \times (T_e(t) - T_{b,i})\ [W]} \qquad \textbf{(II.48)}$$

0.320 (In j/m3 °C) represents the product of the specific heat of the air (1004 j/Kg °C) by the density of the air (1.15 kg/m3) and by a conversion factor (1 /3600).

- Te(t) (in °C) represents the dry temperature of the outside air at time t and is calculated by:

$$\mathbf{T_e(t) = T_{b,e} - (C_{Ts}(t) \times Eb)\ [C°]} \qquad \textbf{(II.49)}$$

- **CTs(t):** Correction coefficient;

- **Eb:** Basic diurnal deviation; °C

The latent gains due to the renewal of the ARENlat air, and due to the AINFlat infiltrations are given by the formulas given below [18]:

$$\mathbf{AREN_{lat}(t) = 0.797 \times qv \times Max.\ [(HS_{b,e} - HS_{b,i})]\ [W]} \qquad \textbf{(II.50)}$$

$$\mathbf{AINF_{lat}(t) = 0.797 \times qv_{inf} \times Max.\ [(HS_{b,e} - HS_{b,i})]\ [W]} \qquad \textbf{(II.51)}$$

0.797 (In j/Kgair / Kgvap. m3.) represents the product of the average density of air (1.15 Kg/m3) by the heat of vaporization of water (2498 j/Kg) and by a factor of conversion

(1/3600) [20].

- **The calculation steps power cooling** [13] .

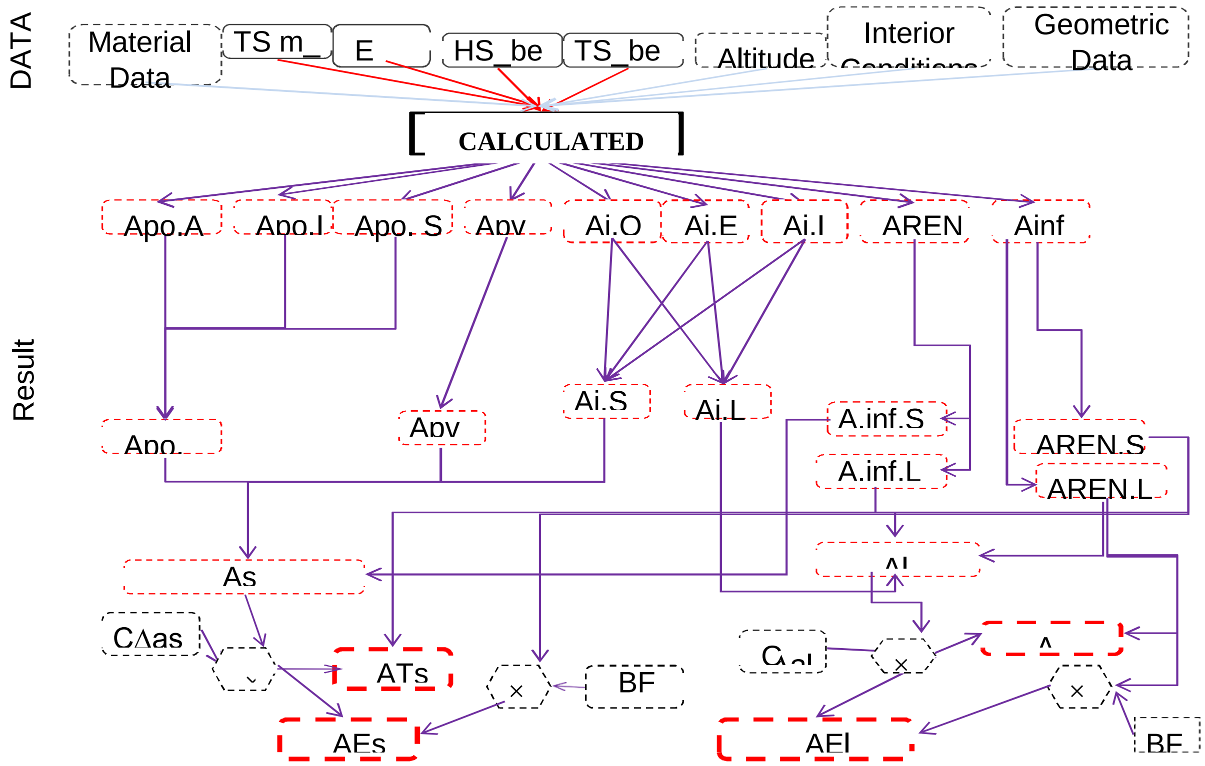


Figure II-4 : General air conditioning flowchart

II.4. Conclusion:

Through the foregoing, we got acquainted with a set of important equations in the field of heat loss for buildings and to determine the thermal energy required to heat or cool the building under study (domesticated), according to the two regulatory documents **DTRC 3-4** and **DTRC 3-2** of the document Regulatory technical related to thermal buildings.

Where these equations enable us to calculate the lost heat and the heat gained for the poultry house, according to what was previously mentioned in this chapter.

CHAPTER THREE

Results and discussions

III.1. Introduction

In this chapter, we will first present an overview of the study region, which is the Wilaya of Ouargla, including its climate. We will then provide a brief description of the visited company, the BAYAT poultry complex located in the town of Ain Al beida. Furthermore, we will provide a detailed mathematical modeling of the BAYAT chicken coop using the DTR.

III.2. Presentation of the Study Area

III.2.1. Geographical Location:

Ouargla is located in Algeria, specifically in the southeastern region of the country. The geographical coordinates of the Wilaya of Ouargla are as follows:

- Latitude: 32.3833° N
- Longitude: 3.8000° East

The Wilaya of Ouargla covers a total area of approximately 200,000 square kilometers and is characterized by numerous tourist sites, important archaeological sites, and historical monuments.

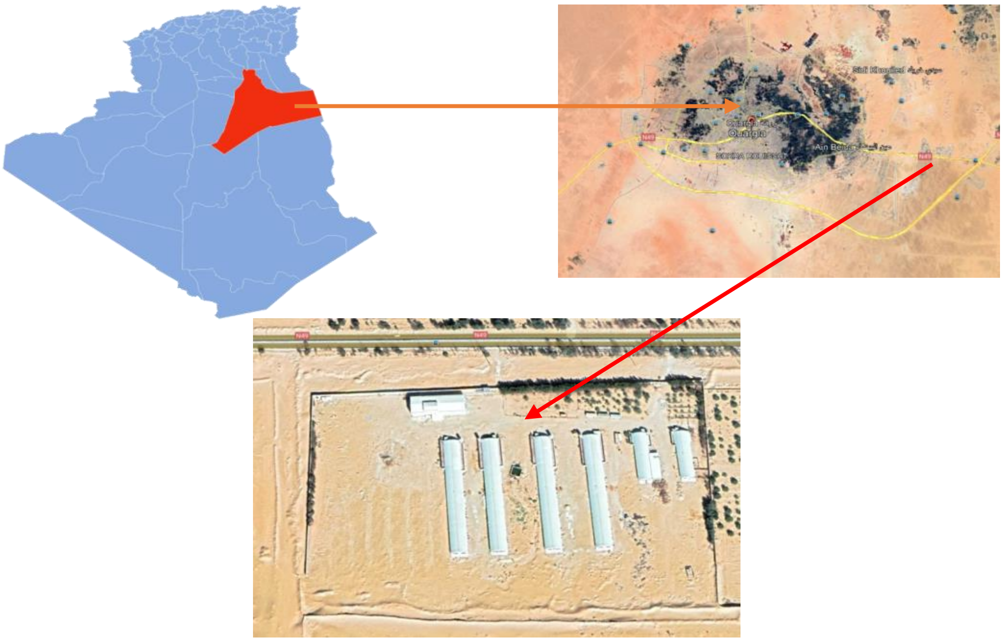


Figure III-1: Photo of BAYAT poultry complex site provided by Google Maps [21] .

III.2.2. Natural resources

- Agricultural Land: The region has significant soil potential, with approximately 60,000 hectares of land being exploited for development.
- This potential is mainly located in the northwest of the Wilaya (Ouargla-El Hadjira-Dzioua), in the Oued Righ valley, and along the Hassi Messaoud-Gassi Touil axis.
- Water Resources: The region's water resources consist of groundwater from four large Albian aquifers.
- The depth of these aquifers varies between 100 and 1800 meters, requiring substantial investment for their exploitation.
- Solar Energy: Solar energy can be utilized in various sectors in the future, including solar power plants, photovoltaic lighting, photovoltaic pumps, humidifiers, and extractors [21].

III.3. Climate Study of the Wilaya of Ouargla

III.3.1. Temperature in Ouargla

The hot season lasts for approximately 3.3 months, from June 4th to September 14th, with an average daily high temperature above 38°C. The hottest month in Ouargla is July, with an average maximum temperature of 42°C and a minimum of 28°C. (See figure III**-2**)

The cool season lasts for approximately 3.5 months, from November 19th to March 3rd, with an average daily high temperature below 23°C. The coldest month in Ouargla is January, with an average minimum temperature of 6°C and a maximum of 18°C.

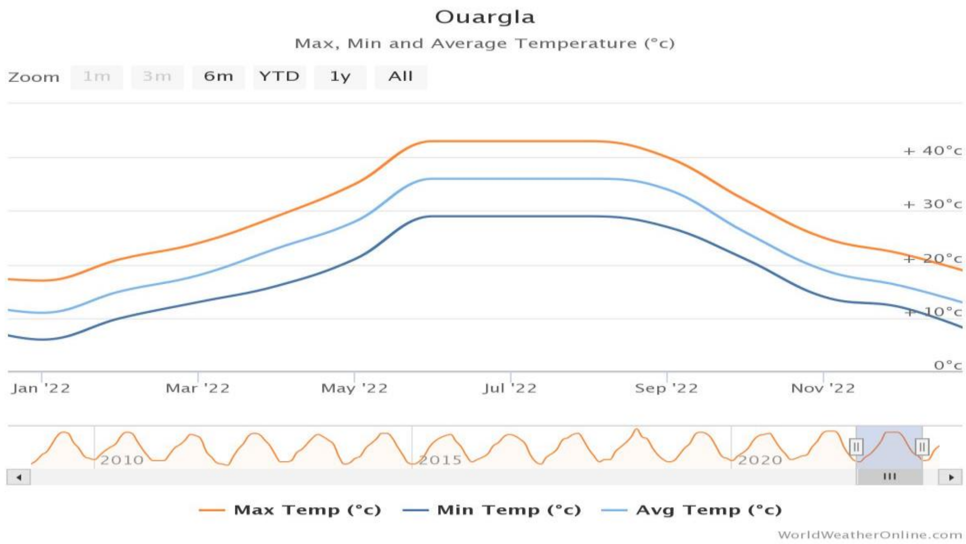


Figure III-2: Average Temperature In Ouargla In 2022 [22].

III.3.2. Humidity

We estimate the level of comfort according to the humidity on the dew point, because it determines if perspiration will evaporate from the skin, thus causing a cooling of the body. Lower dew points are experienced as a drier environment and higher dew points as a more humid environment. Unlike temperature, which usually varies greatly between day and night, dew points vary more slowly. So, although the temperature may drop at night, a muggy day is usually followed by a muggy night.

The perceived humidity level in Ouargla, as measured by the percentage of time in which the humidity comfort level is muggy , oppressive , or miserable , does not vary significantly over the course of the year, staying within *2% +/- 2%* [23].

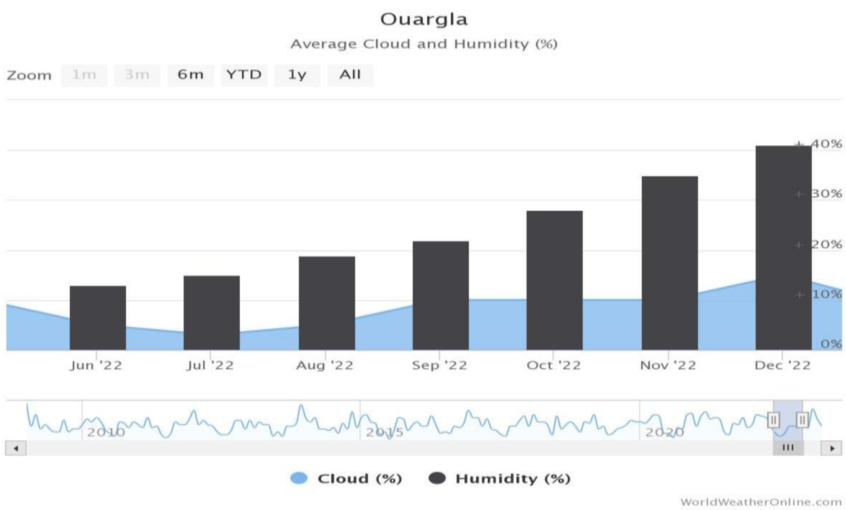


Figure III-3 Annual Cloud and Humidity Averages in 2022 at Ouargla [24] .

III.3.3. Wind

This section deals with the extended hourly mean wind vector (speed and direction) at 10 meters above the ground. The observed wind at a given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more than hourly averages.

The average hourly wind speed in Ouargla experiences mild seasonal variation over the course of the year.

The windiest time of year lasts for 4.8 months, from March 2 to July 26, with average wind speeds of over 4.0 meters per second. The windiest month of the year in Ouargla is May, with an average hourly wind speed of 4.5 meters per second.

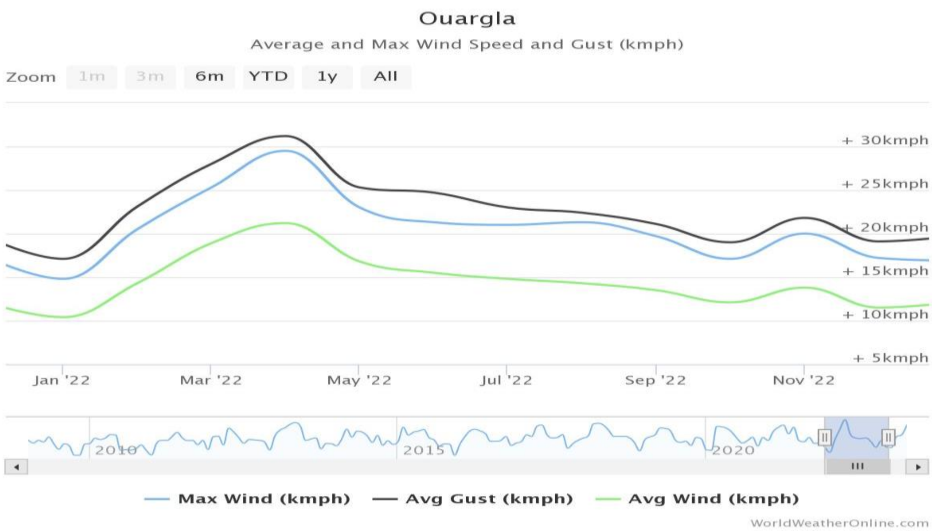


Figure III-4: Annual Wind Speed and Wind Gust Averages in 2022 at Ouargla [24] .

III.3.4. Sun

The length of the day in Ouargla varies significantly over the course of the year. In 2022, the shortest day is December 22, with 10 hours, 4 minutes of daylight; the longest day is June 21, with 14 hours, 15 minutes of daylight.

The earliest sunrise is at 5:32 AM on June 12, and the latest sunrise is 2 hours, 8 minutes later at 7:40 AM on January 9. The earliest sunset is at 5:34 PM on December 4, and the latest sunset is 2 hours, 15 minutes later at 7:48 PM on June 30.

From bottom to top, the black lines are the previous solar midnight, sunrise, solar noon, sunset, and the next solar midnight. The day, twilights (civil, nautical, and astronomical), and night are indicated by the color bands from yellow to gray [24].

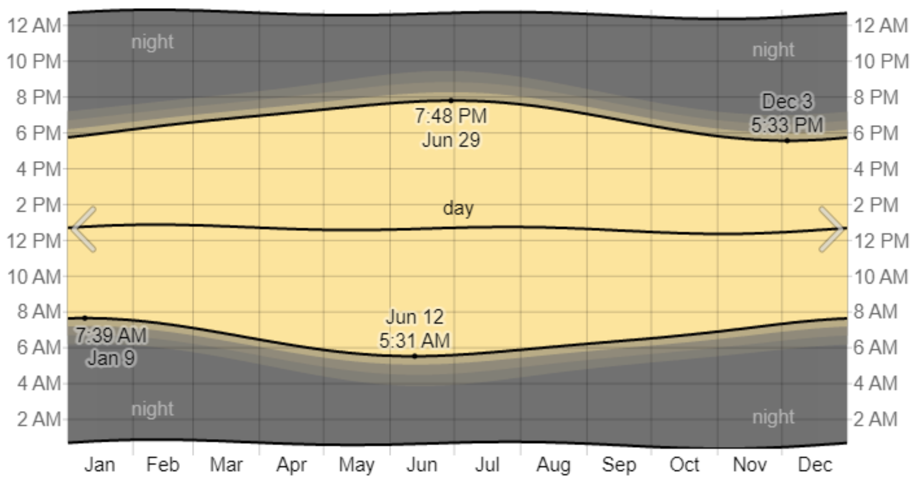


Figure III-5: The solar day over the course of the year 2022 at Ouargla [24] .

III.4. Dimensions and structure of the building:

The studied building has a length of 120 m, a width of 14 m, and a wall 5 m high (Fig. III.6).

The walls of the building were constructed of 5 cm thick insulated panels, and the roof consisted of three layers of 5 cm thick insulated panels and a 20 cm thick air void with a layer of glass wool in the middle with a thickness of 10 cm and the reinforced concrete floor with a thickness of 15 cm.

The (east) and (west) walls have 9 windows [0.4m x 1.2m] and a door [1.9m x 0.9m]. The (north) and (south) wall contain a door [3m x 4m].

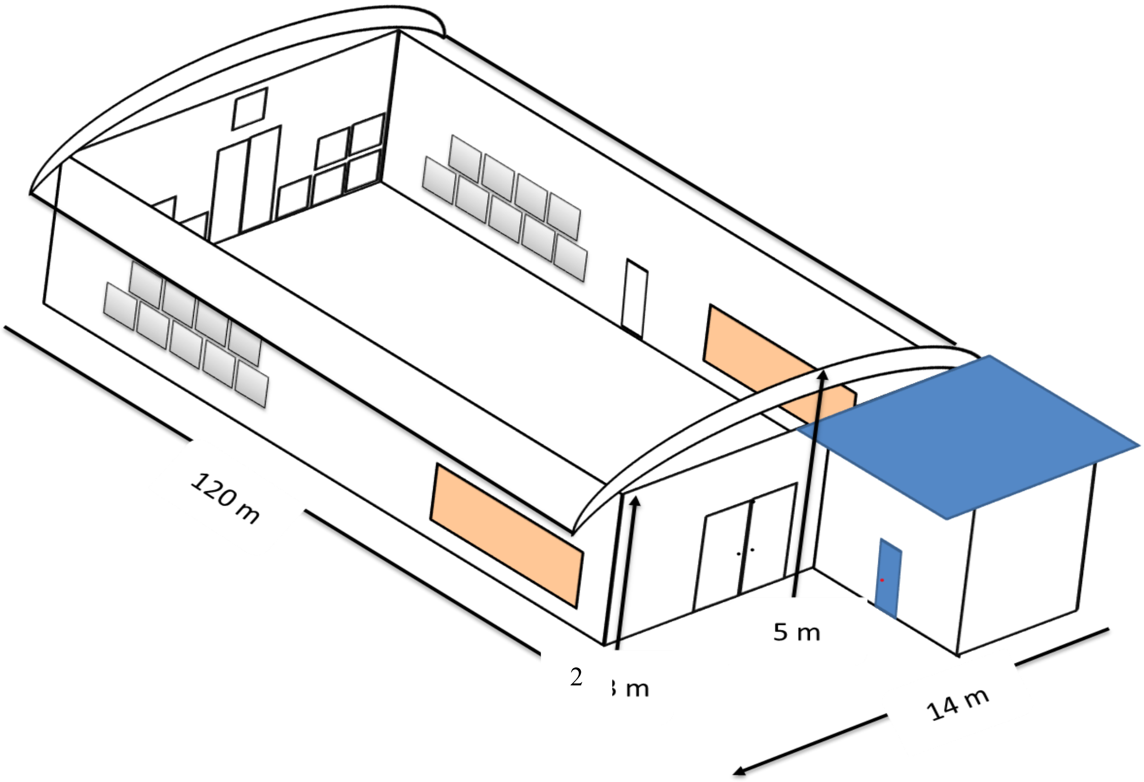
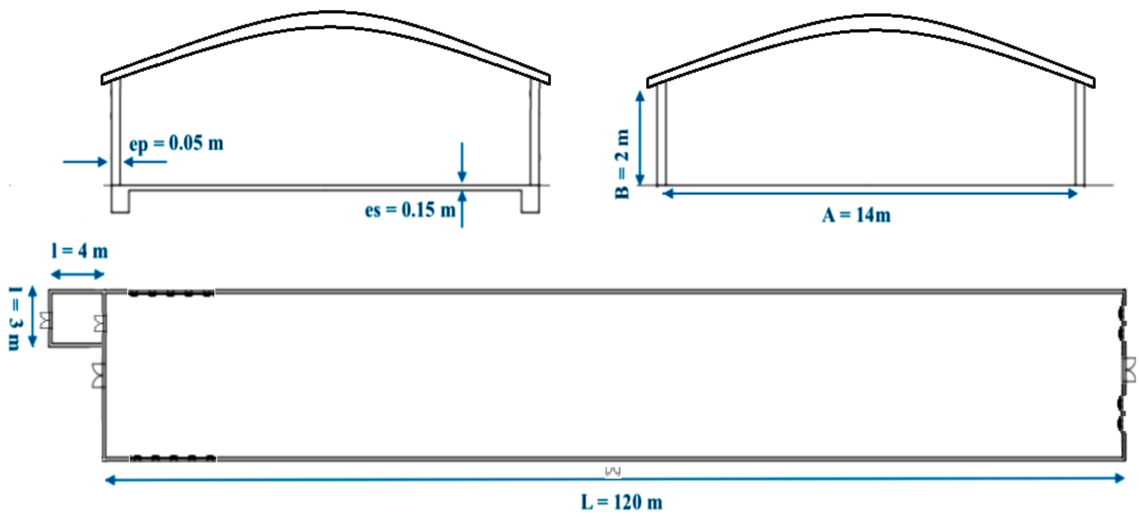


Figure III-6: 3D drawing of a chicken house

In this study, we have two cases that differ in size and number of chickens.

III.4.1. Case N° 1 (Large Building) :



The previous figure represents the external dimensions of the large building .

Figure III-7 : Diagram of the large chicken house.

As we can see in the previous figure, the dimensions and shape of the large building, which were taken after examining the poultry house for calculation

Table III-1: The surfaces and orientation of the large building

This table represents the area of each element of the building as well as determining its direction of the large building .

	direction	Surfaces (m^2)				
		wall	door	Window	Cooling carton	clean wall
Wall 1	North	35.5362	12	-	-	23.5362
Wall 2	East	240	-	4.32	60	175.68
Wall 3	west	240	1.71	4.32	60	173.97
Wall 4	South	35.5362	12	-	-	23.5362
Floor	1680					
Roof	1860.95					

The following table represents the area of each of the walls, windows, ceiling, floor, and doors, with determining the direction of each of the elements mentioned in the large building .

III.4.2. Case N° 2 (Small Building) :

The previous figure represents the external dimensions of the small building .

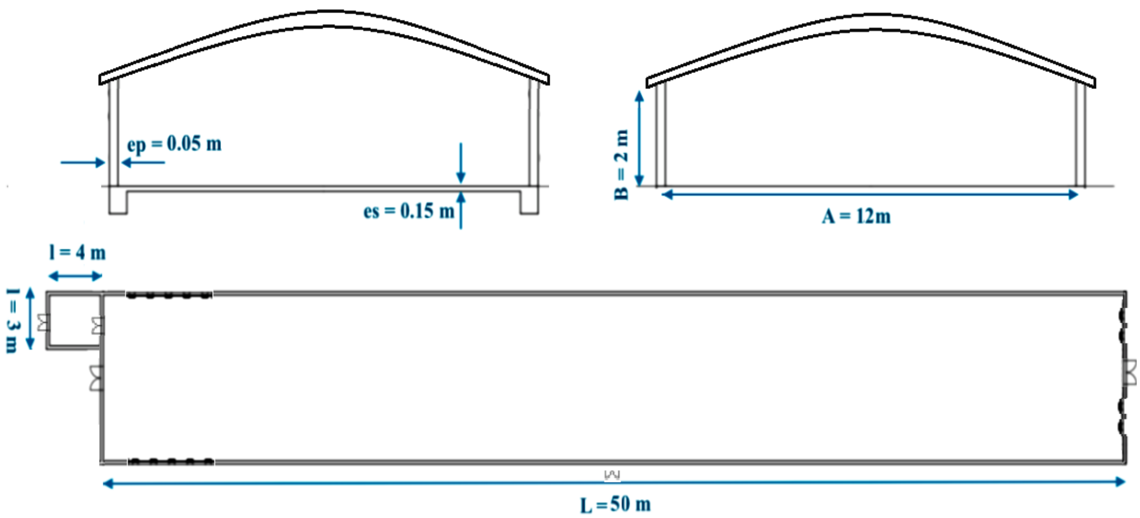


Figure III-8 : Diagram of the small chicken house.

As we can see in the previous figure, the dimensions and shape of the small building, which were taken after examining the poultry house for calculation **.**

Table III-2 : The roofs and orientation of the small building

This table represents the area of each element of the building as well as determining its direction of the small building .

	direction	Surfaces (m^2)				
		wall	door	Window	Cooling carton	clean wall
Wall 1	North	31.1603	12	-	-	19.1603
Wall 2	East	100	-	4.32	25	70.68
Wall 3	west	100	1.71	4.32	25	68.97
Wall 4	South	31.1603	12	-	-	19.1603
Floor	600					
Roof	695.47					

The following table represents the area of each of the walls, windows, ceiling, floor, and doors, with determining the direction of each of the elements mentioned in the small building

III.5. Calculation of heating power winter:

This is the sum of the three losses. The surface passes through walls in contact with the outside, walls in contact with the ground and walls in contact with an unheated space. The transmittance is calculated by equation (**II.5**) as follows (see Table **III.3**):

Table III-3: Transmission coefficient K_{winter}

	Material	e (m)	λ(W/m.°C)	R (m.°C/W)	$1/h_e+1/h_i$ (m2.°C/W)	K_{winter} (W/m2.°C)
Walls N	Sandwich panel	0.05	0,0255	1.9608	0,22	0.4585
Walls S	Sandwich panel	0.05	0,0255	1.9608	0,17	0.4693
Walls E	Perforated brick Sandwich panel	0.15 0.05	0.7 0.0255	2.1751	0,17	0.36977
Walls W	Perforated brick Sandwich panel	0.15 0.05	0.7 0.0255	2.1751	0,17	0.36977
Roof	Sandwich panel air sec Glass wool Sandwich panel	0.05 0.2 0.1 0.05	0,0255 0.024 0.04 0,0255	14.7549	0,14	2.0657
Floor	Concrete	0.15	1.5	0.1000	0,22	0.0222
Door N	Sandwich panel	0.05	0,0255	1.9608	0,17	0.4693
Door N	Sandwich panel	0.05	0,0255	1.9608	0,22	0.4585
Door S	Sandwich panel	0.05	0,0255	1.9608	0,17	0.4693
Door W	Sandwich panel	0.05	0,0255	1.9608	0,17	0.4693
Window	Formica	0.003	0,937	0.0032	0,17	5.7737

III.5.1. Heating Power Calculation in large building

All calculations are performed using an Excel spreadsheet. Surface exchange resistances for winter are classified in DTR [15]. The basic data are summarized in the following table III.4:

Table III.4. The surface loss through the walls touching the outside

The roof loss is calculated by touching the walls with the outside in order to determine the total .

Basic data				
L (m)	**l (m)**	**H (m)**	**Te,b (°C)**	**V(m^3)**
120	14	3	5	5940.052
Cr	**Cin**	**Ti,b (°C)**	**Hri,b (%)**	**N (h^{-1})**
0	0,15	27	50	0,5

The transmission losses DT (W/°C)			
Walls	**S(m^2)**	**K_{winter} (W/m^2.C)**	**Ds (W/°C)**
Wall			
N	23.5362	0.4585	10.7913
E	175.68	0.36977	64.96119
W	173.97	0.36977	64.32889
S	23.5362	0.4693	11.04553

Window			
E	4.32	5.7737	24.942384
W	4.32	5.7737	24.942384
Doors			
Door N	12	0.4693	5.6316
Door N	1.71	0.4585	0.784035
Door S	12	0.4693	5.6316
Door W	1.71	0.4693	0.802503
Roofs			
Roof	1860.95	2.0657	3844.1389
The total surface losses **Ds (W/°C)**			4058.00032

*The total surface losses **Ds= 4058.00032 (W/°C)***

Table III.5. The losses through the walls in contact with the ground **D_{SOL}**

It is the losses that are through the contact of the walls with the ground

Walls	**P(m)**	**k_s (W/m^2. °C)**	**D_{SOL} (W/°C)**
Floor	268	1.75	469
The losses through the walls in contact with the ground		**D_{SOL}**	469

*The total losses through the walls in contact with the ground D_{SOL} = **469 (W/°C)***

Table III.6. Losses through walls in contact with unheated rooms

It is the losses that are caused by the walls that touch the unheated rooms .

Wall	**S(m^2)**	**K_{hiver} (W/m^2.C)**	**D_s (W/°C)**
Wall N	**6**	0.4585	**2.751**
door	**1.71**	0.4585	**0.7840**
Parois	**T_{au}**	**D_{si} (W/°C)**	**D_{Inci} (W/°C)**
wall	**0.036841**	**2.751**	**0.101351**
door	**0.036841**	**0.7840**	**0.028884**
Losses through walls in contact with unheated rooms **D_{Inc}**			**0.130235**

The total Losses through walls in contact with unheated rooms

D_{Inc} = 0.130235 (W/°C)

Table III.7. Losses through thermal bridges **D_{LI}**

These are the losses that are caused by thermal bridges through which buildings are formed.

	L	K1	D_{li} (W/°C)
Floor	**268**	**0.36363636**	**97.454544**
Losses through thermal bridges **D_{LI}**			**97.454544**

The total Losses Through Thermal Bridges ***Dli* = *97.454544*** **(W/°C)**

From **Equation II.3** we get:

(DT) = 4058.00032 + 469 + 0.130235 + 97.454544 =4624.584

The total Losses by total transmission ***4624.584 (W/°C)***

Table III.8. Loss by renewal air

They are the losses that are due to the renewal of air through ventilation.

q_v	$(\rho * c_p)/3600$	**D_R**
1784.16	**0.34**	**606.61**

Table III.9. Calculation of heating power

$Q = [t_{bi} - t_{be}] * [[1 + Max(c_r ; c_{in})] D_T] + [(1 + c_r) * D_R]$

The Total Heating Power (W) ***117617 W***

The thermal balance of this large poultry house in winter makes it possible to observe the heat losses in different parts of the chicken coop. Here you can see that:

- Most heat loss is due to transmission loss, which is about 83%, and area loss accounts for the majority (76%) of this loss.
- Since only two walls are insulation and the other two walls are brick, the heat loss through the walls is high.
- Heat loss through the floor represents 14% and this value can be reduced by insulating the floor.

• Heat losses from unheated rooms and thermal bridges are almost negligible at a rate of 3%.

• This also helps determine the total heat output required to provide the proper heat in that farm. This is estimated at approximately 117.617 kW.

III.5.2. Heating Power Calculation In Small Building

All calculations are performed using an Excel spreadsheet. Surface exchange resistances for winter are classified in DTR [15]. The basic data are summarized in the following (table **III.10**)

Table III.10: The surface loss through the walls touching the outside

The roof loss is calculated by touching the walls with the outside in order to determine the total .

Basic data				
L (m)	**l (m)**	**H (m)**	**Te,b (°C)**	**V(m³)**
50	12	3	5	2156.696
Cr	**Cin**	**Ti,b (°C)**	**Hri,b (%)**	**N (h⁻¹)**
0	0,15	27	50	0,5

The transmission losses **DT (W/°C)**			
Walls	**S(m²)**	**Khiver (W/m².C)**	**Ds (W/°C)**
Wall			
N	19.1603	0.4585	8.78499755
E	70.68	0.36977	26.1353436
W	68.97	0.36977	25.5030369
S	19.1603	0.4693	8.99192879
Window			
E	4.32	5.7737	24.942384
W	4.32	5.7737	24.942384
Doors			
Door N	12	0.4693	5.6316
Door N	1.71	0.4585	0.784035
Door S	12	0.4693	5.6316
Door W	1.71	0.4693	0.802503
Roofs			
Roof	695.47	2.0657	1436.632379
			1568.78

The total surface losses ***Ds = 1568.78(W/°C)***

Table III.11. The losses through the walls in contact with the ground **D_{SOL}**

It is the losses that are through the contact of the walls with the ground.

the losses through the walls in contact with the ground D_{SOL}			
Walls	**P(m)**	**ks (W/m². °C)**	**D_{SOL} (W/°C)**
Floor	124	1.75	217
			217

The total the losses through the walls in contact with the ground ***d_{sol}**= 217*

Table III.12. Losses through walls in contact with unheated rooms

It is the losses that are caused by the walls that touch the unheated rooms .

Wall	S(m2)	K_{hiver} (W/m2.C)	Ds (W/°C)
Wall N	6	0.4585	2.751
door	1.71	0.4585	0.7840
Parois	Tau	D_{si} (W/°C)	D_{lnci} (W/°C)
wall	0.036841	2.751	0.101351
door	0.036841	0.7840	0.028884
Losses through walls in contact with unheated rooms			0.130235 W/°C

The total Losses through walls in contact with unheated rooms ***D_{lnc} 0.130235(W/°C)***

Table III.13. The Losses Through Thermal Bridges D_{li}

These are the losses that are caused by thermal bridges through which buildings are formed.

	L	**K1**	**D_{li}** (W/°C)
Floor	124	**0.36363636**	**45.0909**
Losses through thermal bridges **D_{LI}**			45.0909 (W/°C)

The total Losses Through Thermal Bridges ***D_{li} = 45.0909* (W/°C)**

From **Equation II.3** we get:

$$(D_T)_i = 1568.75 + 217 + 0.130235 + 45.0909 = 1831.01135$$

The total Losses by total transmission ***D_T = 1831 W***

Table III.14. The Loss By Renewal Air **D_r**

They are the losses that are due to the renewal of air through ventilation.

qv	$(\rho * c_p)/3600$	D_R
1784.16	**0.34**	**606.61**

The total Loss By Renewal Air ***D_r =606.61***

Table III.15. Calculation of heating power

$$Q = [t_{bi} - t_{be}] * [[1 + Max(c_r ; c_{in})] \ D_T] + [(1 + c_r) * D_R]$$

The Total heating power = ***46930.93872 (W)***

The thermal balance of this small poultry house in winter makes it possible to observe the heat losses in different parts of the chicken coop. Here you can see that:

• Most heat loss is due to transmission loss, which is about 81%, and area loss accounts for the majority (75%) of this loss.

• Since only two walls are insulation and the other two walls are brick, the heat loss through the walls is high.

• Heat loss through the floor represents 19% and this value can be reduced by insulating the floor.

• Heat losses from unheated rooms and thermal bridges are almost negligible at a rate of 3%.

• This also helps determine the total heat output required to provide the proper heat in that farm . This is estimated at approximately 46.930 kW.

III.5.3. Calculation of Summer cooling power

The transmittance is calculated using equation (II.36) as shown in the following table (see Table III.16).

Table III.16. Transmission coefficient K summer.

	R (m.°C/W)	$1/h_e+1/h_i$ (m^2.°C/W)	K_{summer} (W/m^2.°C)
Walls N	1.9608	0,21	0.4607
Walls S	1.9608	0,14	0.4760
Walls E	2.1751	0,14	0.4319
Walls W	2.1751	0,14	0.4319

Roof	14.7549	0,20	0.0669
Floor	0.1000	0,21	3.2258
Door N	1.9608	0,14	0.4760
Door N	1.9608	0,21	0.4607
Door S	1.9608	0,14	0.4760
Door W	1.9608	0,14	0.4607
Window	0.0032	0,14	0.4760

All calculations are performed using an Excel spreadsheet. Surface exchange resistances for summer are classified in DTR [18]. The basic data is summarized in the following table **III.18:**

Table III.17. Basic data for calculating the cooling capacity

TSV (h)	$T_{i,b}$ (°C)	$Hr_{i,b}$ (%)	$T_{e,b}$ (°C)	$HS_{b,i}$ (g_{vap}/kg_{gaz})	$HS_{b,e}$ (g_{vap}/kg_{gaz})	Tsm (°C)	Eat (°C)
15	22	50	44	6.5	99	33	38

Table III.18: The Contributions through the aerial walls

Walls	ΔTes(°C)	ΔTem(°C)	$C\Delta$te(°C)	IT,b(W/m²)	$I_{T,b}$(40°) (W/m²)	a
Wall						
N	6.28125	**6.7**	11.9	50.9	47	0.5
E	6.28125	**15.6**	11.9	517	516	0.75
W	6.28125	**7.2**	11.9	517	516	0.75
S	6.28125	17.8	11.9	93.36	217	0.5
Window						
E	6.28125	7.2	11.9	517	516	0.75
W	6.28125	17.8	11.9	517	516	0.75
Doors						
Door N	6.28125	6.7	11.9	50.9	47	0.5
Door N	6.28125	6.7	11.9	50.9	47	0.5
Door S	6.28125	15.6	11.9	93.36	217	0.5
Door W	6.28125	17.8	11.9	517	516	0.5
Roofs						
Roof	7.3125	21.1	11.9	769.93	734	0.5

Table III.19: The Contributions through the opaque

Contributions through the aerial walls				
Walls	ΔTe (°C)	S (m^2)	K_{summer} (°C)	APO(W)
Wall				
N	18.6	23.5362	0.4607	242.0186
E	27.5	175.68	0.4319	2503.914

W	19.1	173.97	0.4319	1722.155
S	29.7	23.5362	0.4760	399.2832
Window				
E	19.1	4.32	0.4760	47.13085
W	29.7	4.32	0.4760	73.28724
Doors				
Door N	18.6	12	0.4760	127.4918
Door N	18.6	1.71	0.4607	17.58363
Door S	27.5	12	0.4760	188.496
Door W	29.7	1.71	0.4607	28.07709
Roofs				
Roof	33	1860.95	0.0669	4930.103
Contributions through the aerial walls				**10279.54 W**

*The Total Contributions Through The Aerial Walls Equal **10279.54 W***

Table III.20: Contributions through a floor in contact with the ground

Wall	$\boldsymbol{T}$ m(°C)	S ($\boldsymbol{m}^2$)	K $_{summer}$ (°C)	APO(W)
floor	33	1680	3.2258	59612.7840 w
Contributions through a floor in contact with the ground equal				59612.7840 w

The Total contributions Through a Floor In Contact With The Ground

*Equal = **59612.7840 W***

$$APO = \boldsymbol{10279.54 + 59612.7840 = 69892.3247\ w}$$

*The contributions through the opaque walls APO are equal = **69892.3247 w***

Table III.21: The Contributions Internal Al

Chicken				
mp(kg)	N°	**Aptot (W)**	**APs (W)**	**APl (W)**
3	16000	298763,8369	147967, 2382	150796.5987
electric motor				
N°	Weff (W)	η	**AÉ (W)**	
3	412.5	0.72	1718.75	
Lighting				
N°	**Wn (W)**	**Cme**	**Ccr**	**AIei (W)**
30	16	1.2	1	576
Contributions Internal sensitive				
The sources	**Cs**	**NAI**	**As (W)**	**AIs (W)**
Chicken	1	1	147967, 2382	147967.2382
electric motor	0.85	1	1718.75	1460.9375
Lighting	0.85	1	576	489.6
Contributions Internal sensitive equal				**149917.7757**

*The total Contributions Internal sensitive equal **149917.7757 W***

Table III.22: The Contributions internal latent

The sources	C_s	A_s (W)	AI_s (W)
Chicken	1	147967, 2382	147967.2382
Contributions internal latent equal			**147967.2382**

The total Contributions internal totals 297885.0139 W

Table III.23: The Cooling Power

$C_{\Delta as}$	$C_{\Delta al}$	AT_S (W)	AT_L (W)
1.15	1.1	381944.9497	171977.7133

The total cooling power ***(w) = 553922.6630 w***

We can notice the increase in heat that affects the large chicken house, whether it is heat gain external entering through the house structure (heat, sun...) or internal (lost heat by chickens, machines, etc.), where we find that:

- The internal thermal contributions represent 79% of that which enters through the structure of the building.

- The thermal contributions emitted by the chickens represent the greatest source of heat, 76%. Because the heat produced by animals in hot weather is emitted under forms water vapor in the air, and this causes heat stress in the building.

- The thermal gains emitted by the machines, the lighting and the occupation are negligible compared to other heat sources.

- The thermal gains entering through the walls and the roof of the building are low compared to the thermal gains entering through the ground because the roof and the walls are made of insulating materials.

- The cooling power needed to provide the appropriate heat in this large chicken house is estimated at approximately **553.922 kW**.

All calculations are performed using an Excel spreadsheet. Surface exchange resistances for summer are classified in DTR [18]. The basic data is summarized in the following table III.24**:**

Table III.24: The Contributions through the aerial walls

Walls	ΔTes(°C)	ΔTem(°C)	$C\Delta te$(°C)	IT,b(W/m²)	$I_{T,b}$(40°) (W/m²)	a
			Wall			
N	6.28125	**6.7**	11.9	50.9	47	0.5
E	6.28125	**15.6**	11.9	517	516	0.75
W	6.28125	**7.2**	11.9	517	516	0.75
S	6.28125	17.8	11.9	93.36	217	0.5
			Window			
E	6.28125	7.2	11.9	517	516	0.75
W	6.28125	17.8	11.9	517	516	0.75
			Doors			
Door N	6.28125	6.7	11.9	50.9	47	0.5
Door N	6.28125	6.7	11.9	50.9	47	0.5
Door S	6.28125	15.6	11.9	93.36	217	0.5
Door W	6.28125	17.8	11.9	517	516	0.5
			Roofs			
Roof	7.3125	21.1	11.9	769.93	734	0.5

Table III.25: The Contributions through the opaque

Contributions through the aerial walls				
THE DATA				
Walls	ΔTe (°C)	S (m^2)	K_{summer} (°C)	APO(W)
		Wall		
N	18.6	19.1603	0.4607	197.022
E	27.5	70.68	0.4319	1007.381
W	19.1	68.97	0.4319	682.7442
S	29.7	19.1603	0.4760	325.0476
		Window		
E	19.1	4.32	0.4760	47.13085
W	29.7	4.32	0.4760	73.28724
		Doors		
Door N	18.6	12	0.4760	127.4918
Door N	18.6	1.71	0.4607	17.58363
Door S	27.5	12	0.4760	188.496
Door W	29.7	1.71	0.4607	28.07709
		Roofs		
Roof	33	695.47	0.0669	1842.467
Contributions through the aerial walls				**4536.728254 W**

The Total Contributions Through The Aerial Walls Equal ***4536.728254 W***

Table III.26. Contributions through a floor in contact with the ground

Contributions through a floor in contact with the ground.				
Wall	T m(°C)	S (m^2)	K_{summer} (°C)	APO(W)
floor	33	600	3.2258	21290.2800 w
Contributions through a floor in contact with the ground equal				**21290.2800 w**

*The Total contributions Through A Floor In Contact With The Ground Equal =****21290.2800 w***

APO = ***21290.2800 + 4536.728254 = 25827.0083w***

The contributions through the opaque walls APO are equal = ***25827.0083w***

Table III.27: The Contributions Internal AI

Chicken				
mp(kg)	N°	**Aptot (W)**	**APs (W)**	**APl (W)**
3	7000	130709.1786	64735.66671	65973.5115
electric motor				
N°	Weff (W)	η		**AÉ (W)**
3	412.5	0.72		1718.75
Lighting				
N°	**Wn (W)**	**Cme**	**Ccr**	**AIei (W)**
30	16	1.2	1	576
Contributions Internal sensitive				
The sources	**Cs**	**NAI**	**As (W)**	**AIs (W)**
Chicken	1	1	64735.66671	64735.66671
electric motor	0.85	1	1718.75	1460.9375
Lighting	0.85	1	576	489.6
Contributions Internal sensitive equal				66686.20421

The total Contributions Internal sensitive equal = ***66686.20421 W***

Table III.28. The Contributions internal latent

The sources	**Cs**	**As (W)**	**AIs (W)**
Chicken	1	64735.66671	64735.66671
Contributions internal latent equal			64735.66671

The total Contributions internal ***131421.8709 W***

Table III.29. The Cooling Power

CΔas	**CΔal**	**ATS (W)**	**ATL (W)**
1.15	1.1	210819.9155	90524.759

COOLING POWER (W) 301344.6745

We can notice the increase in heat that affects the small chicken house, whether it is heat gain external entering through the house structure (heat, sun...) or internal (lost heat by chickens, machines, etc.), where we find that:

- The internal thermal contributions represent 80% of that which enters through the structure of the building.

- The thermal contributions emitted by the chickens represent the greatest source of heat, 76%. Because the heat produced by animals in hot weather is emitted under forms water vapor in the air, and this causes heat stress in the building.

- The thermal gains emitted by the machines, the lighting and the occupation are negligible compared to other heat sources.

- The thermal gains entering through the walls and the roof of the building are low compared to the thermal gains entering through the ground because the roof and the walls are made of insulating materials.

- The cooling power needed to provide the appropriate heat in this small chicken house is estimated at approximately **301.344 kW.**

III.6. Sizing a photovoltaic system for a chicken coop

"Renewable energies are energy sources that renew at a fast enough rate to be considered practically inexhaustible within the human time scale"

The expression renewable energy is the short and usual form of the expressions “renewable energy sources” or “energies of renewable origin” which are more correct from a physical point of view. Photovoltaic energy resulting from the direct transformation of sunlight into energy

electricity by means of cells generally based on crystalline silicon which remains the most technologically and industrially advanced sector, in fact silicon is one of the most abundant elements on earth in the form of non-toxic [12].

III.6.1. Sizing the photovoltaic system

Each building consumes electrical power through the used equipment, which is sufficient to meet the thermal needs of the building, according to the performance of the work of each system, whether cooling or heating. Therefore, we calculate the electrical consumption of the machines in order to determine the electrical power of the building [13].

Figure III-9: photovoltaic system Component

III.6.2. PV System Sizing:

Sizing a photovoltaic system is essential for its proper operation and user satisfaction. Scaling methods differ mainly according to the type of connection, i.e. whether the system is connected to the electricity grid (Sonelgaz public network) or is independent or "isolated" from it [13].

Case study: complex Bayat avicul located in Ain El Beida, Ouargla Province, which consists of four large buildings and two small buildings [13].

To determine the size of the PV system, we need to determine [13]:

- Ec needs in [Wh/d]
- The radiation Ei to consider [kWh/d.m²]
- The peak power Pc in [Wc]
- The installation voltage U in [V]
- Size of inverter, regulator and batteries [Ah]

Calculate the amount of electrical energy consumed by electrical appliances in the two tables III.30 and III.31 :

Tableau III.30. The machines in single large chicken coop

	Number of engines	U: tension en volt	I: intensité en ampère	Single power w	Operating time per day	The power of all units w/h
Engine feeds	5	400	2.75	1100	1/4 h	1375
Pump	4	230	3.26	750	2/3 h	2000
Lighting	60	230	0.06	16	12 h	11520
Fans	11	400	1.40	560	2 h	12320
Air conditioning	1	230	4.21	970	8 h	7760
The total power w **(Ec)**						34975 w

Tableau III.31. The machines in single small chicken coop

	Number of engines	U: tension en volt	I: intensité en ampère	Single power w	Operating time per day	The power of all units w/h
Engine feeds	5	400	2.75	1100	1/4 h	1375
Pump	4	230	3.26	750	2/3 h	2000
Lighting	30	230	0.06	16	12 h	5760
Fans	5	400	1.40	560	2 h	5600
Air conditioning	1	230	4.21	970	8 h	7760
The total power w **(Ec)**						22495 w

Ec = is the total daily energy consumed by electrical appliances.

III.7. The daily energy consumed:

The daily energy expressed in Wh / day refers to part or all of the electrical energy needs that should be met by photovoltaic panels. This energy is given by the following formula [12]:

$$Ep = Ec + (Ec * 25\%) \quad \textbf{(Wh/d)} \qquad \textbf{[III-1]}$$

Or

Ec = is the total daily energy consumed by electrical appliances.

(Ec*25%) = Safety factor for power loss during connection or through loss of performance of devices

For the case of our installation, the energy consumed it is:

- In the large chicken house is equal to **Ep= 43718.75 Wh/d**
- In the small chicken house is equal to **Ep= 28118.75 Wh/d**

III.8. Daily global radiation Ei:

The daily global radiation **E_i** is the daily solar irradiation, expressed in kWh/m²/day, received by the photovoltaic field.

For the case of the city of Ouargla, we will take the average solar radiation over an entire year equal to the highest value plus the lowest value of the divide by 2 , Equal 5.7 kWh/j. m² .(figure III.10)

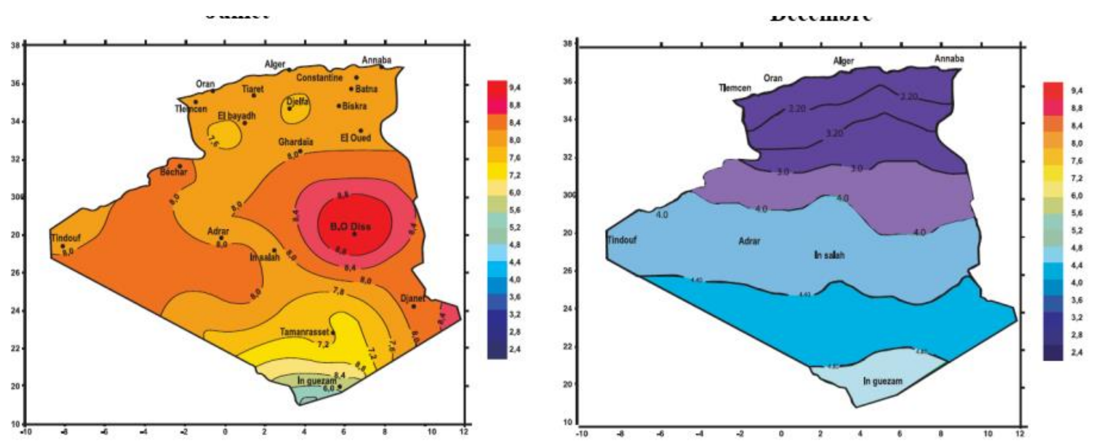


Figure III.10: Global daily irradiation received on a horizontal plane in the months of July and December [26]

$$(8.4+3)/2 = 5.7 \text{ kWh/d. m}^2$$

III.9. The voltage of the installation U:

The voltage necessary to ensure the total peak power of our installation is U= 48 Volts, because this peak power exceeds 2000Wc [12].

- Pc > 2000 W
- So U=48V

III.10. Battery Type

To determine the type of batteries needed for energy storage and subsequent utilization, we will consider their capacity. In other words, we will determine the appropriate battery type based on its capacity [12.25] .

$$c = \frac{Ep*N}{D*U} \quad \text{(Ah)} \qquad \text{[III-2]}$$

$$c = \frac{Ep * 1}{0.8 * 48}$$

D: The percentage of battery discharge, i.e. leave it at 20%
N: The number of days the batteries are not charged

- In the large chicken house is equal to **C=1138.48 Ah ≈ 1138 Ah**
- In the small chicken house is equal to **C=732.25 Ah ≈ 732 Ah**

III.10.1. The number of batteries and how to connect them :

When it comes to solar batteries, many experts will debate the merits of gel batteries and AGM batteries. No two solar installations are identical, and factors such as climate and discharge demands can have a big impact on what type of batteries you need. However, we believe that gel batteries provide a number of benefits to solar users for long term energy storage.

- **Advantages of Gel batteries :**

Gel Batteries are becoming increasingly popular for solar systems due to the following reasons:

- Best suited for Deep cycle applications and their life is generally in the 500 to 5000 cycles range
- Maintenance free
- Minimal corrosion therefore compatible with sensitive electronic equipment
- Rugged and vibration-resistant
- Very safe as less risk of sulphuric acid burns

- Lowest cost-per-month (cost / months of life)
- Lowest cost-per-cycle (cost / life cycles)

- **Disadvantages Gel batteries**
  - High initial cost
  - In case of overcharging water cannot be refilled
  - Special chargers and regulators are required
  - Hot temperatures can affect adversely acid can turn the gel hard and may shrink away from plates

So we choose Gel Battery with a voltage of 12 V and a capacity of 250 Ah [27].

Tableau III.32: Characteristic of Gel battery

	**Nominal Voltage**		12V
	Nominal Capacity (10 hour rate)		250Ah
	Capacity 25℃(77°F)	20 hour rate (13.9A)	278Ah
		5 hour rate (45.7A)	228Ah
		1 hour rate (184.8A)	184.8Ah
	Internal Resistance	Full Charged Battery	25℃≤2.0mΩ
	Capacity affected by Temperature (10 hour)	40℃ (104°F)	102%
		25℃ (77°F)	100%
		0℃ (32°F)	85%
		-15℃ (5°F)	65%
	Self-Discharge 25℃(77°F) Capacity	after 3 month storage	90%
		after 6 month storage	80%
		after 12 month storage	62%

- **Series number** [12]

number of batteries $= \frac{\text{The voltage of the installation U}}{\textit{Selected battery voltage}} = \frac{48}{12} = 4\ batteries$

large building : $n = \frac{1138}{250} = 4.55\ \approx 5\ series$

small building : $n = \frac{732}{250} = 2.92\ \approx 3\ series$

- Four batteries in series in each row, and five rows, and each row is connected to the next row in parallel to the large building.
- Four batteries in series in each row, and three rows of each row connected to the next row in parallel for the small building.

Specification	
Maximum power of the solar panel in case of 48V battery charge	2000W
Rated charging current	35A
Dimensions	130 x 186 x 70 mm
Weight	1.25 Kg
Warranty	5 years
Manufacturer	Victron Energy (Netherlands)
Victron product reference	SCC02003500

Table III.33. Solar regulator mppt 150/35

III.11. Peak power:

The peak power Pc of the photovoltaic field designates the total power of the PV panels installed to ensure the production of solar energy sufficient for the sizing of the electrical appliances powered, given by the equation

$$Pc = \frac{\mathbf{Ec}}{\mathbf{k*Ei}}$$

Where k=0.6 is the correction factor.

So: large building Pc = 34975/(5.7*0.6) = 10226 Wc

So: small building Pc = 22495/(5.7*0.6) =6577 Wc

III.12. Characteristics of components used for sizing PV systems

The characteristics of the basic components used for the design of photovoltaic systems are presented in the following table III.34 :

Table III.34: Characteristics of components used for sizing PV systems [22]

Specification	
Dimensions	1967 x 992 x 40
Maximum power P(max)	385
Voltage V(mp)	40.8
Current Pmax (Imp)	9.47
Short circuit current (Isc)	10
Open circuit voltage (Voc)	47.6
Temperature coefficient of Isc(%)	0.060%/C°
Temperature coefficient of Voc(%)	-0.30 %/ C°

Rated power temperature coefficient (Pmax)	45 C°

III.13. Estimation of number of PV panels

III.13.1. Number of modules required

After calculating the peak power required, the total number of modules N_m constituting the photovoltaic generator is determined by the following formula [12] [14] .

$$N_m = \frac{PWER\ TOTAL}{PWER\ DU\ MODULES}$$

In order to reduce energy loss and the use of a small number of batteries and the use of a small reflector, so we install on each building its own panels and not all buildings together in order to reduce electrical losses and to reduce the area consumed by the panels combined and to reduce the size of the reflector for the panels combined

- One large chicken coop

Nm = $\frac{10226}{385} = 26.56 \approx 26$ panels

- One small chicken

Nm = $\frac{6577}{385} = 17.08 \approx 17$ panels

A. Inverter size is to be for the large chicken coop:

- Total connected load to PV panel system = 10.226 kW .

Tableau III.35. Characteristics of the selected inverter [28] .

Model		**HopeSun 12KTL**
	Rated output	12kW
	Maximum active power(cosθ=1)	13.2kW
	Rated grid voltage	400V(3 phase)
	Allowable voltage range	400v+/-20%
	Rated output voltage	17A
	Maximum output voltage	19A
	Rated network frequency	50HZ/60HZ

	power factor	0.8(sensibility)-
	Maximum total harmonic distortion(THD)	<3%

B. Inverter size is to be for the small chicken coop:

- Total connected load to PV panel system = 6.577 KW

Tableau III.36. Characteristics of the selected inverter [28]

Model		**HopeSun 10KTL**
OPEWIND 10 Kw 	Maximum Dc voltage	1100V
	start voltage	250V
	MPPT voltage range	250V-1000V
	Full load MPPT voltage range	540V-880V
	Maximum input current per MPPT channel	13A
	Maximum input Number	2
	Number of MPPT	2

III.14. Assessment of the initial investment cost:

For the calculation of the cost price of the installation, the prices of each equipment or accessory used are summed when the sizing of the system is completed to know the number of modules and that of the batteries as well as the various equipment involved during the installation of the installation.

III.14.1. Gross cost:

A. Cost of PV modules:

The total cost of the modulus is given by:

$$\mathbf{C\ mod = N\ mod \times Cost\ modules}$$

And:

N $_{mod}$**:** is the number of modules.

B. Cost of inverters:

The total cost of inverters is given by:

$$C_{inv} = N_{inverter} \times \text{cost of inverter}$$

And:

N inve : is the number of inverters.

C. c. Cost of battery :

$$C_{batt} = N_{battery} \times \text{cost of battery}$$

And:

N batt : is the number of battery

D. Cost of solar regulator :

$$C_{regu} = N_{regu} \times \text{cost of regu}$$

And:

N cont : is the number of solar regulator

E. Total cost of the system:

The overall cost of the PV system is the sum of all the fixed costs mentioned above

$$C_{totale} = C_{mod} + C_{inve} + C_{batt} + C_{regu} + BOS$$

C_{mod} : cost of modules PV

C_{inv}: cost of inverter

C_{batt} : cost of battery

C_{regu} : cost of solar regulator

BOS : Additional costs (such as transport, planning, engineering studies and assembly of the installation, etc.)

Tableau III.37. Total cost of the system

	The total number	The price in hard currency	unit price in DA	Price per number of items
Solar Panels	138	//	26000	3588000
solar regulator	6	$ 215	29344.23	294978.84
Inverter	6	$ 628	85947.45	515684.70
battery	104	$ 169	23065.93	2398856.72
total price				6678606.80 DA

In fact, there may not be a time when all poultry houses use the electrical appliances of the cooling or lighting system at the same time.

Therefore, we can reduce the number of panels and batteries if we make sure that electrical appliances are not used at the same time in all poultry farms, in order to reduce the value of the cost of the solar energy system.

The goal of calculating the total cost of the used system is to know the difference between the use of this system or the use of fossil electric energy

III.14.2. Approximate cost calculation

In this system, it consists of three basic elements: solar panels, inverter, batteries and their prices

The number of elements of each basic element was calculated, and the total cost of the project was estimated at **6,678,606.80 DZD**

III.15. Conclusion

With the data of the first stage, it is possible to know the quantity of photovoltaic modules necessary for the supply of electrical energy in the installation considered. In this chapter, devoted to the sizing method for stand-alone installations, we have integrated the essential data concerning the characteristics of the installation site and the solar energy received on the site itself.

The first step also allows you to calculate the number of batteries. The energy that must be stored depends directly on the periodicity of consumption. In other words, you will need far fewer batteries if you consume a little electricity every day (regular consumption) than if you consume everything in a few days (for example during the holidays), and this even if in both cases you have consumed the same amount.

Finally, the dimensioning of the autonomous photovoltaic installation is completed when the calculation of the section of the electric cables carrying the energy is carried out. Too small a section increases the resistance and temperature of the cable, which reduces the power of the facility

General Conclusion

General Summary:

In this study, the heating and cooling requirements for a poultry house with a capacity of 16,000 chickens were calculated for COMPLEXE BAYAT AVICOL company located in Ain El Beida, Ouargla, Algeria.

The maximum heating requirements for this poultry house were calculated considering the harsh winter working conditions, which correspond to the maximum external conditions (coldest day). The maximum internal conditions were also taken into account, considering the age of the chickens (higher heating requirements during the early weeks).

Similarly, the maximum cooling requirements were calculated for the harsh summer working conditions, which correspond to the maximum external conditions (hottest day). The maximum internal conditions related to the age of the chickens (cooling requirements are highest beyond three weeks of age) were also considered.

To conduct this study, meteorological and geographical information for the region, as well as detailed internal and external information about the building and its structure and area, were collected. All heat gains and losses were calculated using the regulatory technical document (DTR) "DTR C 3-2" and "DTR C 3-4".

The results indicate that the large house requires heating energy with a calculated value of 117,617 watts, and it also requires cooling energy with a calculated value of 553,992 watts. It is worth noting that the cooling requirements are four times the heating requirements, which, in turn, consume electrical energy to meet the house's needs using a set of cooling devices totaling 34,975 watts.

On the other hand, the small house requires heating energy with a calculated value of 46,930 watts, and it also requires cooling energy with a calculated value of 301,344 watts. The cooling requirements are four times the heating requirements, which, in turn, consume electrical energy to meet the house's needs using a set of cooling devices totaling 22,495 watts.

After calculating the heating and cooling requirements for these chicken houses, a solar energy system was designed to meet these demands using cooling and heating devices that satisfy these requirements. The study results demonstrate that it is possible to eliminate the use of fossil fuel electrical energy and replace it with a renewable energy source that supplies the heating needs of the poultry house.

To meet the needs of the large building, 26 solar panels, a 10-kilowatt electric inverter, a charge controller, and 20 gel batteries with a voltage of 12 volts and 250 amperes, are required. The same applies to the small building, which requires 17 solar panels, a 12-kilowatt electric inverter, a charge controller, and 12 gel batteries with a voltage of 12 volts and 250 amperes.

This system occupies an area of 276 square meters with 385-watt monocrystalline solar panels, requiring 104 gel batteries with a voltage of 12 volts and 250 amperes, 6 inverters (4 with a capacity of 12 kilowatts and 2 with a capacity of 10 kilowatts), and 6 MPPT charge controllers to serve four large houses and two small houses.

Considering the high cost of the system but its long lifespan of approximately 25 years for the panels and 5 years for the other devices, it can be considered very good in terms of the number of years the system operates.

Recommendations:

Based on the above, it is possible to consider other types of renewable energy sources that may be better suited for the nature of the study area. For example, using geothermal energy to meet part of the building's heating requirements or using wind energy to provide electrical energy.

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Annex

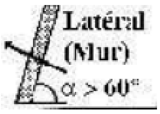
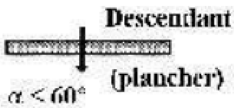
Annex I: The climatic zone in the winter period [15] .

Table A.1. List of municipalities for winter zoning (HEATING).

Wilaya	Communes	Zone
30 OURAGLA	Toutes les communes	D

The value of the winter surface thermal resistance varies with the position of the horizontal or vertical wall and the thermal resistances of surface exchanges:

Table A.2. Winter superficial thermal resistances.

$\frac{1}{h}$ en m².°C/W	Paroi en contact avec : - l'extérieur, - un passage ouvert, - un local ouvert.			Paroi en contact avec : - un autre local, chauffé ou non chauffé, - un comble, - un vide sanitaire.		
	$1/h_i$	$1/h_e$	$1/h_i + 1/h_e$	$1/h_i$	$1/h_e$	$1/h_i + 1/h_e$
 Latéral (Mur) $\alpha > 60°$	0,11	0,06	0,17	0,11	0,11	0,22
 Ascendant (toiture) $\alpha < 60°$	0,09	0,05	0,14	0,09	0,09	0,18
 Descendant (plancher) $\alpha < 60°$	0,17	0,05	0,22	0,17	0,17	0,34

The basic outside temperature according to the altitude and the climatic zone:

Table A.4. Base outdoor temperatures.

ZONE	Altitude (m)	t_{be} (en °C)	ZONE	Altitude (m)	t_{be} (en °C)
A	< 300 300 à 500 500 à 1000 ≥ 1000	6 3 1 -1	C	500 à 1000 ≥ 1000	- 2 - 4
B	< 500 500 à 1000 ≥ 1000	2 1 -1	D	< 1000 ≥ 1000	5 4
B'	<500 ≥ 500	0 voir Zone B	D'	< 1000	5

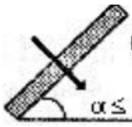
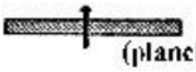
The values of C_{in} and Cr:

- The coefficient Cin takes the following values:
  - 0.10 in case of continuous heating.
  - 0.15 in the event of discontinuous heating, and in the case of a construction whose inertia class is "low" or "medium".
  - 0.20 in the event of discontinuous heating, and in the case of a construction whose inertia class is "high".
- The Cr coefficient takes the following values:
  - 0 for "individual heating" type installations.
  - 0.05 for "central heating" type installations in which all the pipes are insulated,
  - 0.10 for "central heating" type installations in which the pipes are insulated only in the unheated areas,
  - 0.20 for "central heating" type installations whose piping network is not insulated.[31]

The value of the summer surface thermal resistance varied with the position of the horizontal or vertical wall and the thermal resistances of surface exchanges:

Annex II: The climatic zone in the summer period [18] .

Table B.2 Summer surface thermal resistances.

$\frac{1}{h}$ en m².°C/W	Paroi en contact avec : - l'extérieur, - un passage ouvert, - un local ouvert.			Paroi en contact avec : - un autre local, conditionné ou non conditionné, - un comble, - un vide sanitaire.		
	$1/h_i$	$1/h_e$	$1/h_i + 1/h_e$	$1/h_i$	$1/h_e$	$1/h_i + 1/h_e$
 Latéral (Mur) α > 60°	0,10	0,04	0,14	0,10	0,11	0,21
 (toiture) α ≤ 60°	0,16	0,04	0,20	0,16	0,17	0,33
 (plancher)	0,08	0,04	0,12	0,08	0,09	0,17

Basic diffuse radiation:

Table B.3. Basic Radiation.

Rayonnement total de base $I_{t,b}$ et diffus de base $I_{d,b}$ (en W/m²)										
Latitude Nord	Mois	ORIENTATION								
		N	NE	E	SE	S	SO	O	NO	Horiz.
20°	Juillet	59	435	514	267	44	267	514	435	791
	Août	34	372	520	356	81	356	520	372	788
	Septembre	31	273	514	441	205	441	514	273	733
30°	Juillet	50	413	516	315	94	315	516	413	776
	Août	34	340	520	406	198	406	520	340	741
	Septembre	28	284	498	479	330	479	498	284	668
40°	Juillet	47	400	516	394	217	394	516	400	734
	Août	34	321	511	459	321	459	511	321	675
	Septembre	28	183	470	511	441	511	470	183	577

The values of the basic climatic characteristics of the outside air:

Table B.4. Basic external conditions.

Zone climatique	Température sèche $TS_{b,e}$ (°C)	Humidité spécifique $HS_{b,e}$ (g_{vap}./kg_{as})	Ecart diurne E_b (°C)	Température moyenne TS_m (°C)	Ecart annuel de température EAT (°C)
A					
alt < 500 m	34	14,5	9	25,5	31
500 ≤ alt < 1000 m	33,5	13	10	25	32,5
alt ≥ 1000 m	30,5	13	9	22,5	31,5
B					
alt < 500 m	38	12,5	15	26,5	36
500≥ alt < 1000 m	37	11	15	26,5	36
alt ≥1000 m	35	10	14	25	36
B'					
alt < 500 m	41	11	18	29	41
alt ≥ 500 m	voir zone B	voir zone B	voir zone B	29	
C					
alt < 1000 m	39,5	8,5	20	27	41,5
alt ≥ 1000 m	36	8,5	18	25	40
D1	44	6,5	15,5	33	38
D2	48	5,5	16,5	36,5	43
D3	39	5,0	12,0	29,6	35

Equivalent temperature difference for exterior walls and roof:

Table B.5. Equivalent temperature difference for exterior walls.

Déférence équivalente de température $\Delta t_{es}(t)$ ou $\Delta t_{em}(t)$ - Murs ensoleilles ou à l'ombre				
Orientation	m_{surf} (kg/m^2)	Temp Solaire Vrais		
		16	17	18
NE	≤100	7,8	7,8	7,8
	300	6,7	7,2	7,8
	500	5,5	6,1	6,7
	≥700	7,8	6,7	5,5
E	≤100	7,8	7,8	7,8
	300	6,7	7,2	7,8
	500	10,0	8,9	7,8
	≥700	10,0	9,4	8,9
SE	≤100	8,9	8,3	7,8
	300	10,0	8,3	7,8
	500	10,0	9,4	7,8
	≥700	8,9	10,0	8,9
S	≤100	14,4	11,1	8,9
	300	14,4	12,8	11,1
	500	8,9	10,0	10,0
	≥700	5,5	7,2	7,8
SO	≤100	22,2	22,8	23,3
	300	17,8	19,4	20,0
	500	7,8	10,6	12,2
	≥700	4,4	5,0	5,5
O	≤100	22,2	25	26,7
	300	14,4	18,9	22,2
	500	6,7	9,4	11,1
	≥700	5,5	6,1	6,7
NO	≤100	13,3	18,3	22,2
	300	6,7	11,7	16,7
	500	3,3	5,0	6,7
	≥700	3,3	3,9	4,4
N (à l'ombre)	≤100	7,8	7,2	6,7
	300	5,5	6,1	6,7
	500	2,2	2,8	2,8
	≥700	1,1	1,7	2,2

Table B.6. Equivalent temperature difference for exterior roofs.[31]

Déférence équivalente de température $\Delta t_{es}(t)$ ou $\Delta t_{em}(t)$ - Toits ensoleilles ou à l'ombre				
Condition	m_{surf} (kg/m^2)	Temp Solaire Vrais		
		16	17	18
Ensoleillé	≤50	23,9	25,6	25
	≤100	22,8	23,9	23,9
	200	21,1	22,2	22,8
	300	19,4	21.1	21,7
	≥400	17,8	19,4	20,6
A l'ombre	≤100	7,8	7,2	6,7
	200	6,7	7,2	6,7
	300	4,4	5	5,5

If the roof is insulated (i.e. the insulation function is ensured by a sheet of insulating material whose thermal conductivity is less than 0.12 W/m.°C, and the thickness of the insulating sheet provides thermal resistance greater than 0.5 m2

.°C/W), we will take for Δtem(t) and Δtes(t) 75% of the values given in the previous table

Correction factor CΔte:

Table B.7. Correction factor CΔte.

Valeurs de $C_{\Delta te}$ (en °C)		
$\Delta ts_{max} = TS_{b,e} - TS_{b,i}$	Ecarts diurnes de base E_b(en °C)	
	15	16
22	11,9	11,4

The increase coefficient of sensible gains CΔas of latent gains CΔal:

Table B.11. Value of the increase coefficients of sensible and latent gains.[31]

Disposition des conduits d'air	$C_{\Delta as}$	$C_{\Delta al}$
Installation dont les conduits d'air sont à l'extérieur des locaux climatisés, ou traversant des locaux non climatisés	1,15	1,10

Annex III: proforma facture for product pricing

SOLED ENERGIE
Route National N°49 MEKHADMA,OUARG
Tel: 06 61 89 79 62
Mail: ma.benkrima@gmail.com
BANK: BNA / 00100 946 0300 001 154 / 16
AP OUARGLA 946

Client	Proforma	
Nom Client	Numéro de Proforma	001-2023
NRC:	Date de Proforma	6/5/2023
MF :	Conditions de paiement (jours)	
N° ART:	Date d'échéance	
Tel:	**Total à payer en DA**	
Adresse:		

Description	Unité	Prix
Solar Panel 385W	1	26000.00 DZD
GEL battery 12V 250AH	1	23065.93 DZD
Inverter	1	85947.45 DZD
solar regulator	1	29344.23 DZD