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MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

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INSTITUE OF ARCHITECTURE AND URBAN PLANNING

Architecture Department

<u>Architecture Master Degree Thesis.</u>

Option : Architecture, Environment and Technology.

Sustainable Student Housing : A Study on Energy-Efficient Design for Residences in Blida

Graduation Project :

Design of Sustainable Student Housing

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الإهداء

بسم خالقي وميّسر اموري وعصِمتُ أمري،

لك كل الحمد والامتنان

.الحمد الله حُباً وشكراً وامتناناً على البدء والختام

(وَ آخر دَعْوَاهُمْ أَنِ الحَمِدُ لله رَبّ العَالَمين)

إلى والدي (حفظهم الله)، إلى من بهم استندت وحاولت الوصول، الى من كانوا دواء قبل ان يكون لي داء ... كنتم أرضي الصلبة وجداري المتين، ويضيق الكلام عند شكركم، إلى من بهم أسقيت حتى أثمرت، وأهديكم ثمرة سقياكم. لطالما تمنيت أن اقّر عينكم ...بنجاحي

الى من كلل العرق جبينه وعلمني ان النجاح لا ياتي إلا بالصبر والأصرار ، الى النور الذي انار دربي والسراج الذي لا ينطفي نوره بقلبي أبدأ ، من بذل الغالي والنفيس واستمديت منه قوتي واعتزازي بذاتي

(عياط بوبكر ،والدي العزيز)

الى من جعل الله الجنة تحت اقدامها وسهلت لي الشدائد بدعائها، الى الانسانة العظيمة التي طالما تمنت أن تقر عينها برؤيتي في يوم كهذا

(قودة نصيرة ،والدتي الحبيبة)

الى خيرة أيامي وصفوتها كانوا لي سندا وداعمين ومشجعين دائما أزاحوا عن طريقي المتاعب ممهدين الطريق زارعين الثقة والاصرار بداخلي سندي وكتفي الذي استند عليه دائما الى الذين غمروني بالحب والتوجيه امدوني بالقوة إلى الذين لطالما كانوا الظل لهذا النجاح

اخواني وأختي حفظهم الله

دنيا، ايوب و**مهدي.**

أود أن أعرب امتناني وتقديري العميق لمشرفتي الأساسية، التي وجهتني طوال المشروع، وكلمات الثّناء لا توفيك حقك، ولا ينبغي أن أنسى مشرفاي الثانويان ممن كان لهم الدور الاكبر في مُساندتي ومدَي بالمعلومات القيّمة.

لكل من كان عوناً وسندا في هذا الطريق ... للأصدقاء الأوفياء **لينة، بسمة، سعاد** و**منال**. رفقاء المواقف والسنين وأصحاب الشدائد والأزمات، الى من أفاضني بمشاعره ونصائحه المخلصة إنكم **عائلتي الثانية.**

أهديكم هذا الإنجاز وثمرة نجاحي الذي لطالما تمنيته، ها أنا اليوم أتممت أول ثمراته بفضل من الله عز وجل، فالحمد لله على ما وهبني، .وأن يعينني ويجعلني مباركة أينما كنت

.داعيًا المولى - عزَّ وجلَّ - أن يُطيل في أعماركم، ويرزقكم بالخيرات

Abstract :

This thesis, titled *Sustainable Student Housing : A Study on Energy-Efficient Design for Residences in Blida*, explores the development of an off-campus student residence in Ouled Yaich, near the University of Blida 1. The project responds to the urgent need for quality student housing by addressing key issues such as energy efficiency, acoustic comfort, and integration with the urban context. A central objective is to reconnect the city of Blida with its university, bridging the gap between academic life and urban life. The architectural approach integrates environmentally responsible strategies, including a deep climatic analysis to ensure the building responds effectively to local environmental conditions. The project also proposes the use of photovoltaic panels to enhance energy performance and reduce reliance on non-renewable resources. A detailed simulation study compares different types of glazing to determine the most efficient solutions in terms of thermal performance and natural lighting. In addition, the project addresses nearby noise pollution through thoughtful spatial and material design. This work combines environmental theory, digital technology, and urban sensitivity to propose a sustainable, energy-efficient student residence tailored to its context, enriching both the academic and social experience of its users.

Keywords:

Sustainable architecture, student housing, energy efficiency, photovoltaic panels, climatic analysis, thermal comfort, glazing simulation, urban integration, Blida, Algeria.

Résumé:

Ce mémoire, intitulé *Habitat étudiant durable : étude sur la conception éco-énergétique des résidences à Blida*, porte sur la conception d'une résidence étudiante hors campus située à Ouled Yaich, à proximité de l'Université de Blida 1. Le projet répond au besoin croissant de logements étudiants adaptés, en abordant des problématiques essentielles telles que l'efficacité énergétique, le confort acoustique, et l'intégration urbaine. L'un des objectifs majeurs est de recréer une connexion entre la ville de Blida et son université, en rapprochant vie académique et environnement urbain. L'approche architecturale s'appuie sur des stratégies durables, incluant une analyse climatique approfondie afin d'adapter le bâtiment aux conditions locales. L'intégration de panneaux photovoltaïques est également proposée pour améliorer les performances énergétiques et limiter la consommation d’énergies non renouvelables. Une étude de simulation permet de comparer différents types de vitrages afin d’optimiser le confort thermique et l’éclairage naturel. Le projet traite aussi la question de la pollution sonore par des choix spatiaux et matériels appropriés. Ce travail combine réflexion environnementale, outils numériques et sensibilité urbaine pour proposer une résidence étudiante durable, performante et bien ancrée dans son contexte local.

Mots-clés:
Architecture durable, logement étudiant, efficacité énergétique, panneaux photovoltaïques, analyse climatique, confort thermique, simulation de vitrage, intégration urbaine, Blida, Algérie.

ملخص:

تتناول هذه المذكرة، بعنوان *السكن الطلابي المستدام: دراسة حول التصميم الموفر للطاقة للمساكن في مدينة البليدة*، مشروع إقامة طلابية خارج الحرم الجامعي في أولاد يعيش، بالقرب من جامعة البليدة 1. يهدف المشروع إلى تلبية الحاجة المتزايدة لسكن طلابي مستدام ومريح، من خلال التركيز على الكفاءة الطاقية، الراحة الصوتية، والتكامل مع النسيج العمراني. يسعى التصميم إلى إعادة ربط المدينة بالجامعة من خلال خلق تواصل حضري بين الحياة الجامعية والمحيط المدني. يعتمد المشروع على استراتيجيات تصميم مسؤولة بيئياً، تشمل تحليلاً مناخياً معمقاً لفهم تأثير الظروف المناخية المحلية على الأداء المعماري. كما يقترح إدماج الألواح الكهروضوئية لتعزيز كفاءة الطاقة وتقليل الاعتماد على المصادر غير المتجددة. وتم إجراء دراسة محاكاة تقنية لمقارنة أنواع التزجيج المختلفة وتحديد الأكثر فاعلية من حيث العزل الحراري والإضاءة الطبيعية. بالإضافة إلى ذلك، تم اقتراح حلول تصميمية ومعمارية لمعالجة التلوث الصوتي من المحيط الخارجي. يجمع هذا العمل بين النظرية البيئية، والتحليل التكنولوجي، والوعي الحضري لتقديم إقامة طلابية مستدامة وفعالة تلبي احتياجات الطلبة وتعزز تجربتهم الجامعية والاجتماعية.

الكلمات المفتاحية:
العمارة المستدامة، السكن الطلابي، كفاءة الطاقة، الألواح الكهروضوئية، التحليل المناخي، الراحة الحرارية، محاكاة التزجيج، الاندماج الحضري، البليدة، الجزائر.

Contents :

Workshop Theme : Architecture, Environment, and Technologies :

The Architecture, Environment, and Technologies workshop in the Master 2 program primarily aims to train architects capable of addressing contemporary challenges in the field of construction and urban planning, while considering environmental, energy, and technological issues. It must support the societal transition we are experiencing today.

Evolving technical means, communication tools, knowledge, and the emergence of new socio-economic needs require the practice and missions of the architect to evolve. In a context of global energy transition and increasing urbanization, it is essential that future architects integrate sustainable, environmentally friendly solutions adapted to local realities.

The pedagogical goal of the M2 workshop program is to integrate environmental theory/practice with reflection/technology in all design projects. This program draws heavily on the study of the needs of local communities and applies an approach that integrates construction systems adapted to the climatic conditions of Algeria. Thus, ensuring comfort in community projects, climate-conscious design, and the possibility of expanding skills in digital technologies and building energy performance to achieve energy efficiency are three key areas of study in the Master 2 work.

Workshop Objectives :

The workshop aims to :

- Train architects capable of designing **innovative**, **sustainable** projects **adapted** to Algerian realities.
- Raise awareness of **environmental issues** in the housing sector.
- Integrate **digital technologies** and skills in **bioclimatic strategies** and **energy performance** into architectural design.

- Address the specific needs of housing projects in Algeria by offering solutions to improve thermal comfort and energy efficiency in architecture.

Teaching Team :

Dr. KHELIFI.L / Mr. Bouadi.M / Ms. Kassa.S

<u>Chapter I :</u> INTRODUCTION.

Chapter I : INTRODUCTION

General introduction :

"This recent discovery that the world is fragile is going to be probably the single most inspiring element for the new century for architecture. Not in terms of morality or consuming less energy but finding a new language that is actually the language of building that breathes..."[1]
***Renzo Piano interview by Charlie Rose**, June 5, 2008 .*

The Earth's climate has been undergoing significant changes, primarily driven by the excessive accumulation of greenhouse gases in the atmosphere. These gases, such as carbon dioxide and methane, trap heat from the sun, leading to a warming planet. This phenomenon, known as global warming, has far-reaching consequences for ecosystems, economies, and societies worldwide.

The Intergovernmental Panel on Climate Change (IPCC.2022)[2], the leading international body for assessing the science related to climate change, has unequivocally stated that human activities are the primary cause of global warming. The burning of fossil fuels, deforestation, and industrial processes release vast amounts of greenhouse gases, disrupting the delicate balance of the Earth's climate system. [3]

The impacts of climate change are already being felt across the globe. Rising global temperatures are causing sea levels to rise, leading to coastal erosion and flooding. Extreme weather events, such as heatwaves, droughts, and storms, are becoming more frequent and intense. These events can have devastating consequences, including loss of life, property damage, and disruptions to agriculture and infrastructure.

Algeria, a North African nation, is particularly vulnerable to the effects of climate change. The country's arid and semi-arid climate, coupled with its reliance on agriculture and water resources, makes it susceptible to water scarcity, desertification, and heatwaves.

[1] ***Renzo Piano interview by Charlie Rose**, June 5, 2008*

[2] **Intergovernmental Panel on Climate Change (IPCC):** The IPCC's Assessment Reports provide comprehensive scientific assessments of climate change.

[3] *Intergovernmental Panel on Climate Change (IPCC). 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment [1] Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Cambridge, UK and New York, [2] NY, USA.*

The projected increase in temperature and decrease in rainfall could exacerbate these challenges, impacting food security, water availability, and economic growth.

To mitigate the effects of climate change and build a sustainable future, it is imperative to adopt innovative and eco-friendly solutions. One such solution is the concept of **energy-efficient buildings**. These buildings are designed to minimize energy consumption while maintaining comfort and functionality, significantly reducing their carbon footprint.

Energy-efficient buildings employ a variety of strategies to achieve reduced energy use and enhanced performance. These strategies include:

- **Energy-efficient design**: Optimizing building orientation, insulation, and airtightness to minimize energy loss.
- **High-performance building materials**: Using materials with superior thermal and acoustic properties to lower energy demand.
- **Efficient systems**: Installing advanced heating, ventilation, and air conditioning systems that consume less energy.
- **Renewable energy integration**: Incorporating solar panels, wind turbines, or other renewable sources to supplement energy needs with clean electricity.
- **Energy-efficient appliances and lighting**: Utilizing energy-saving appliances and LED lighting to further reduce electricity use.
- **Smart building technologies**: Implementing automation systems and intelligent controls to monitor and optimize energy consumption.

By promoting energy-efficient building standards, Algeria can significantly reduce its greenhouse gas emissions, conserve energy resources, and enhance the resilience of its built environment to climate change. These buildings can help mitigate the impacts of rising temperatures, water scarcity, and extreme weather events, ensuring a more sustainable and adaptive future for the country.

The University of Blida, like many institutions worldwide, is experiencing the direct consequences of climate change. Rising temperatures and extreme weather events have led to infrastructure damage, disruptions to academic activities, and increased energy consumption. The university's campus, situated in a region vulnerable to climate change, faces challenges such as water scarcity, heat stress, and potential flooding. Additionally, the increasing urbanization surrounding the campus has led to noise pollution and traffic congestion, further disrupting the academic environment. As the American Planning Association has noted, urban expansion often leads to increased noise pollution and traffic congestion, which can negatively impact educational institutions.[4]

General Research Questions:

The University of Saad Dahleb in Blida was originally conceived as an oasis of tranquility, a secluded academic haven shielded from the bustling urban environment. Its sprawling campus, characterized by vast green spaces, winding pathways, and modern architectural structures, was designed to foster a serene and conducive learning atmosphere. The university's founders envisioned a space where students and faculty could immerse themselves in their studies, free from the distractions of city life.

However, the rapid urban expansion of Blida in recent years has begun to encroach upon this carefully crafted isolation. New residential and commercial developments are creeping closer to the campus boundaries, blurring the lines between the university and the city. The once-distant hum of traffic now permeates the quietude of the campus, and the skyline is increasingly dotted with high-rise buildings. This encroachment threatens to undermine the university's original purpose and compromise the serene environment that has long been its hallmark. While the university continues to strive for academic excellence, the erosion of its intended isolation poses a significant challenge to its future development and the well-being of its community.

The University of Saad Dahleb was meticulously designed to be an isolated academic haven, shielded from the distractions of urban life. However, the relentless march of urban expansion is eroding this carefully crafted seclusion. As the city of Blida grows ever closer, the university's tranquil environment is being compromised by noise pollution, traffic congestion, and other urban disturbances.

For instance, the University of California, Berkeley, has seamlessly integrated itself into the city, fostering a strong community bond through collaborative projects, student engagement, economic contributions, and cultural exchange. This successful model

[4]American Planning Association. (2023). *Planning for a Sustainable Future: A Guide to Creating Livable Communities.* Chicago: APA Press.

demonstrates the potential for universities to enhance their impact by actively participating in the urban environment[5].

This raises a critical question:

- **How can the university adapt to this changing landscape while preserving its core mission of academic excellence and fostering a serene learning environment and create arelation between the university and the city of blida ?**

Specific Research Questions:

The University of Saad Dahleb, like many Algerian universities, has traditionally relied on on-campus housing to accommodate its student population. This model, centered around university-owned and operated dormitories, offers certain advantages such as centralized administration, security, and communal living experiences. However, it also presents limitations that can hinder students' holistic development and limit the overall university experience.

Firstly, the scarcity of on-campus housing often results in a competitive and selective allocation process, leaving many students without adequate accommodation. This can lead to overcrowding, discomfort, and potential academic disruptions. Secondly, the limited availability of on-campus housing restricts students' choices and can stifle their personal growth. By confining students to a controlled environment, universities may inadvertently impede their development of essential life skills, such as independent living, budgeting, and decision-making .

The absence of off-campus housing options, such as student residences and private rentals, further exacerbates these issues. Student residences, in particular, offer a valuable middle ground between on-campus dorms and private rentals. They provide a supportive living environment with amenities like common areas, study rooms, and recreational facilities. Additionally, they often offer security, maintenance services, and social activities, fostering a sense of community among residents. As the International Association of

[5] https://www.berkeley.edu/map/

Universities (IAU) has noted, off-campus housing can provide students with a more diverse and flexible living experience[6].

By expanding access to off-campus housing options, Algerian universities can offer a more diverse and flexible living experience for their students. This would not only improve student satisfaction and well-being but also contribute to the local economy by stimulating demand for housing and related services. Moreover, it would align Algerian universities with international best practices, where off-campus housing is a common and integral part of the student experience.

Maximizing the energy efficiency of a student housing project is crucial for both environmental sustainability and cost-effectiveness. Passive design techniques offer a powerful approach to harness natural resources and minimize energy consumption. By carefully orienting buildings to optimize solar exposure and natural ventilation, architects can significantly reduce the need for artificial heating and cooling. Additionally, the strategic use of shading devices, such as overhangs and blinds, can further mitigate solar heat gain during peak periods.

The selection of appropriate building materials plays a vital role in energy performance. High-performance insulation materials can significantly reduce heat loss in winter and heat gain in summer. Moreover, the use of locally sourced and sustainable materials can minimize the embodied energy associated with construction and transportation. Incorporating renewable energy technologies, such as solar panels or wind turbines, can further enhance the project's energy efficiency and reduce reliance on traditional energy sources.

Furthermore, integrating smart technologies into the design can optimize energy consumption. Advanced building automation systems can control lighting, heating, and cooling systems based on occupancy and weather conditions, minimizing energy waste. Energy-efficient appliances and lighting fixtures can also contribute to significant savings. By carefully considering these factors, it is possible to create a student housing project that is not only energy-efficient but also comfortable, affordable, and environmentally responsible.

[6] International Association of Universities (IAU). (2023). *Higher Education in a Changing World: Trends, Challenges, and Opportunities.* Paris: IAU Press.

- **What are the strategies that we schould choose to design a sustainable student housing project balancing on-campus and off-campus options and reaching energy efficiency in architecture ?**

Revised Research Hypothesis :

Hypothesis 1: Strategic urban planning can foster a symbiotic relationship between university campuses and surrounding urban areas by creating a off-compus near to the university in the city of blida .

Hypothesis 2: Off-campus student housing, when integrated with sustainable design principles, can enhance the overall student experience and improve the energy efficiency of student housing projects.

Research Objectives:

- To assess the climatic conditions in Blida and their suitability for energy efficiency design.
- To evaluate the potential energy savings and environmental benefits of energy efficiency student housing in Blida.
- To identify the key challenges and opportunities for implementing energy efficiency-[2]design in this context.
- To develop strategies for promoting energy efficiency student housing in Algeria.

Methodological Approach:

In this study, we use the hypothetico-deductive methodology. As Kumar (2014) suggests, the hypothetico-deductive method is a suitable approach for this research.[7]

This methodological approach is a scientific method used for studying occurrences. Acquiring new knowledge or integrating old knowledge involves observation, background study, hypothesis generation, deductive reasoning, and design. We do experiments, collect

[7] Kumar, R. (2014). Research Methodology: A Step-by-Step Guide for Beginners. Sage Publications.

data, analyze it, compare it to the hypothesis, and reach a conclusion that either supports or refutes it.

This work consists of two major parts which are: the theoretical part and the practical part.

-The theoretical part:

this section relies on documentation: We will provide a comprehensive understanding of the subject through an extensive bibliographical search of books, theses, reports, articles, and more. This step will also involve identifying the key theoretical aspects related to our research theme, sustainable development, sustainable architecture, renewable energies,, energy efficiency buildings ,students housing …

-The practical part:

this section contains, different scale analysis, urban intervention students housing project, and finally the dynamic thermal simulation. The different scale analysis consists of: project example analysis, our study area urban analysis including the swot analysis and sensory analysis.

The softwares that we will be using are the following:

For the graphical part: revit, AutoCAD, Sketchup,Enscape and photoshop.

For the simulation part: meteonormes , climate consultant and Design builder.

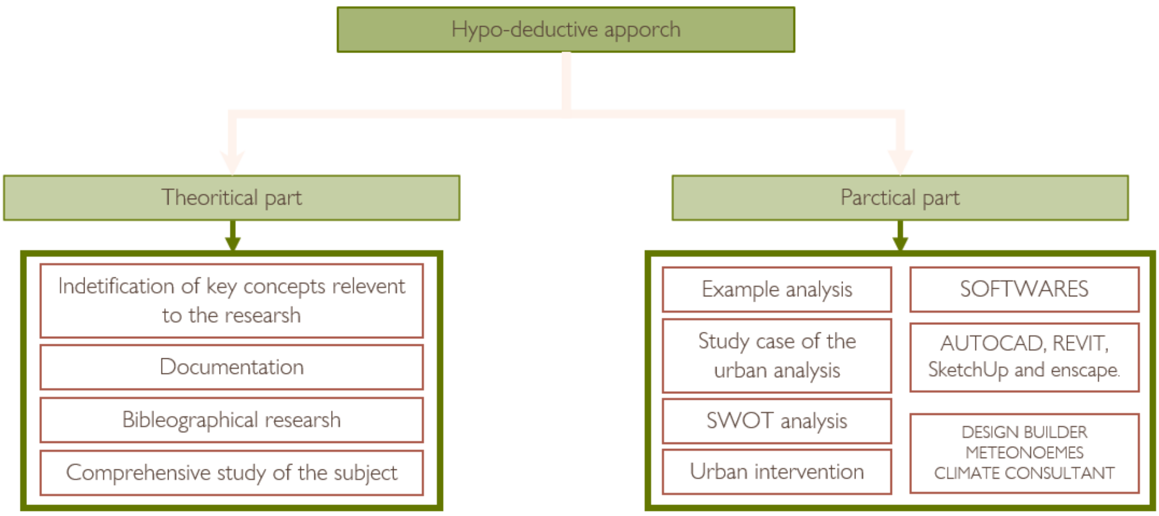

Figure 1 an illustration showing the applied methodological approach, source : author.

Dissertation Structure:

In this thesis, we aim to provide comprehensive information to help achieve our objectives. The thesis is structured into four parts: the first part is the introductory chapter, the second covers the state of the art, the third focuses on the case of study, and the fourth is dedicated to the simulation and discussion of the results.

CHAPTER 01: The introductory chapter: The introductory section of this thesis outlines the overall theme and concept, addresses the general and specific research questions, and discusses the objectives, issues, and various methodological approaches.

CHAPTER 02: State of the art: This chapter consists of two parts. The first part covers the key concepts related to the project theme energy efficients builiding and the architectural project to provide a comprehensive understanding. The second part includes an analysis of student housing project examples to fully grasp their distinct features and operations.

CHAPTER 03: Case of study: This section focuses on the urban aspects, including an analysis of the study area's urban environment, an swot analysis, and a sensory analysis. The goal is to identify the challenges faced by the study area and develop an action plan. This will be followed by an urban intervention to address the identified issues, and finally a site analysis where our project will be implemented.

CHAPTER 04: Simulation result and discussion: This chapter covers an introduction to the thermal dynamic simulation where the meaning of it and its purpose are explained, followed by dynamic thermal software examples, the choice of using design builder, the software operating method.

Chapter II : STATE OF THE ART.

Introduction :

The objective of this chapter is to objectively analyze the many interpretations of "ideal energy-efficient building" status while recognizing the considerable difficulties in defining and attaining it. The chapter explores the various viewpoints and underlying presumptions that influence these definitions in light of the inherent constraints of static definitions, which find it difficult to keep up with the quick changes in building technology and changing energy landscapes. The chapter aims to shed light on these complications in order to address the reality of modern energy use and go beyond strict frameworks to a more dynamic and nuanced understanding of energy-efficient buildings. The variety of regional climates, grid infrastructure, and legislative frameworks that affect the viability and interpretation of energy efficiency goals will also be taken into account in this analysis. Additionally, it will examine the consequences of various energy performance measures and assessment parameters, including operational carbon emissions, source energy usage, and site energy use intensity, and how these decisions affect a building's perceived performance.

1. Sustainable Architecture :

Definition :

It is a design approach that seeks to minimize the negative impact of buildings on the environment and enhance their positive contributions to society. It prioritizes resource efficiency, Energy conservation, and environmental protection while considering social and economic factors. Sustainable architecture aims to create buildings that are not only functional and aesthetically pleasing but also contribute to a more sustainable future.

The building process uses huge quantities of materials, produces tons of debris and sets out gases and pollutants of the environment. It also requires a huge power during operating and along the lifetime of the building. So, if architecture in the past sought the Vitruvius trilogy: strength, function and beauty, nowadays it is seeking to have an effective role to develop the environment level not only in the site, but also on the regional and global levels (Earth Pledge Organization, a website). James Steel showed that sustainable architecture is the architecture which aims to fulfill the requirements of the society at the present time in a way that saves the potentials for the upcoming generation's needs (Steel, 1997, p. 3). Another definition recognized by the Organization of Economical Cooperation and Development) OECD; where it defined sustainable architecture as the architecture with the least negative impacts on the natural and the constructed environment whether on the level of the local environment or the regional and the global levels. Also, it is the one that involves the quality integration of the economical, environmental and social performance (OECD, Websites). The goals of the sustainable architecture are to enhance the effectiveness of Resources, Energy efficiency and nature compatibility (Ibraheem, Mohsen, 2006, p. 5).

a) Sustainable Architecture Principles and Entries :

Fisher identifies five basic principles of the sustainable environmental architecture:

- The healthy inner environment.
- Energy efficiency.
- Good structural materials.
- The environmental shape; clarifying the relation between the shape and the designing process with the location.
- Good design. (SABD 2002, p. 7).

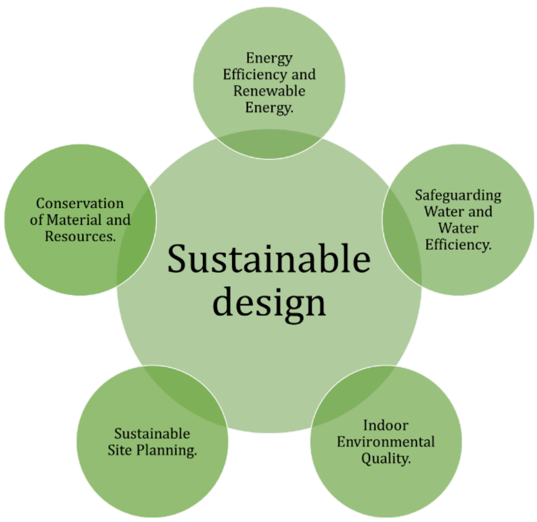

Figure 2 illustration for the Environmental sustainable design principles source :Fisher 2001

The entries for sustainable architecture are represented by the cultural and social factors, in addition to health and environmental considerations. Some of these factors are linked to the environment and some others are linked to the human being as an effective element in the motion of the environment and in its continuity (Kunszt, 2003, p. 7). In order to achieve the concept of sustainability in the scope of architectural work, two basic points should be concentrated on :

1- working on re-qualifies old architectural productions and raising its performing efficiency for certain purposes.
2- producing new models that are considered successful in the standards of modern time, but their main goal remains directed to the future, and establishing what could be called (sustainable future) (Corcoran, 2001, p. 1,2).

The steps of the designing process depend on three basic levels, coming subsequently from top to bottom like this : Principles, Strategies and Means.

Figure 3 Illustration of Design for Social Sustainability Framework, Young Foundation.

Source: S. Woodcraft, T. Hackett & L. Caistor-Arendar (2011) .

4- Bioclimatic architecture :

definition:

Bioclimatic architecture integrates environmental conditions into building design to cater to the occupants' needs. It examines the climate of the building's location and considers various elements to optimize resource utilization and minimize environmental impact. The goal is to ensure occupants' comfort while minimizing resource consumption.

Bioclimatic architecture building strategies :

➢ Soil: In bioclimatic architecture, the soil's climatic effects are utilized to moderate temperature fluctuations throughout the day. Buildings are often partially embedded in the ground to harness the heat released by the soil, providing insulation and stability. Geothermal energy, a renewable resource, is commonly employed to maximize this benefit.

➢ Orientation : Proper orientation of buildings is crucial in bioclimatic architecture for effective emperature regulation and energy efficiency. Strategic placement and the use of shading devices, such as blinds or vegetation, enable precise control over temperature variations throughout the day and across seasons.

➢ Insulation : Sustainable insulation materials are prioritized to minimize environmental impact. Bioclimatic architecture favors external thermal insulation and materials with high thermal inertia, such as stone, brick, or concrete. These choices ensure efficient thermal regulation while respecting environmental principles.

➢ Ventilation : Adequate ventilation plays a key role in maintaining thermal comfort within bioclimatic buildings. Mechanical ventilation systems are often employed to ensure air quality and optimal temperature levels while promoting energy efficiency.

➢ Morphology: the morphology of the building has a great impact on the thermal comfort, if the indoor spaces are compact, their morphology helps in preserving the heat, and if they are open spaces with high ceilings for example, their morphology contributes to heat loss.

Bioclimatic architecture conception principles:

Bioclimatic design focuses on harnessing solar energy effectively. During winter, buildings aim to capture, diffuse, and retain solar energy to maximize warmth. Conversely, in summer, the focus shifts to shielding the building from excessive solar radiation and dissipating built-up heat. Bioclimatic design centers around three key principles:

➢ Capture/Protect from heat :

➢ Transform, diffuse heat :

➢ maintain heat or freshness :

b) Bioclimatic strategies :

Urban strategies :

Maximize daylighting: Design buildings with large windows and clerestories to maximize natural light and reduce the need for artificial lighting.

Encourage natural ventilation: Utilize operable windows, doors, and vents to allow for natural airflow and improve indoor air quality.

Urban Agriculture: Incorporate urban farms and gardens to provide local food sources, improve air quality, and create green spaces.

Thermal Mass: Thermal Mass: Incorporate materials like concrete, stone, and brick that store heat during the day and release it slowly at night, regulating indoor temperatures.

Figure7Maximize daylighting:

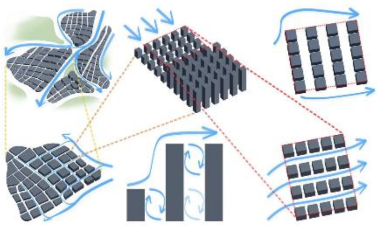

Figure 6 Encourage natural ventilation:

Figure5Urban Agriculture:

Figure 4Thermal Mass:

Architecturale strategies :

Natural lighting :

- **Maximize Winter Sun:** Orient the building to capture winter sunlight for passive heating. Large south-facing windows allow sunlight to penetrate deep into the building.
- **Minimize Summer Sun:** Utilize overhangs, shading devices (louvers, blinds), and deciduous trees to block direct summer sun and prevent overheating.

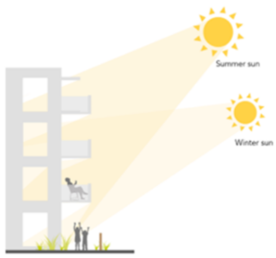

Figure 8 illustration of natural lighting

Figure 9 illustration of the natural shading

Natural Ventilation

- **Cross-ventilation:** Design the building with openings on opposite sides to allow prevailing winds to flow through, cooling the interior naturally.
- **Stack Effect:** Utilize the natural rise of warm air to create a chimney effect, drawing cool air in from lower levels and expelling warm air through vents or openings higher up.

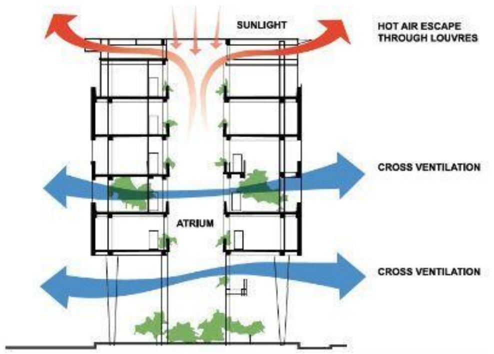

Figure 10 Vertical Farm Design with Natural Ventilation ; source: Pinterest

Thermal Mass

- **Incorporate materials:** Utilize materials like concrete, stone, and brick that store heat during the day and release it slowly at night, regulating indoor temperatures.
- **Strategic placement:** Position thermal mass elements, such as concrete walls or floors, to absorb heat during the day and release it at night when temperatures cool down.

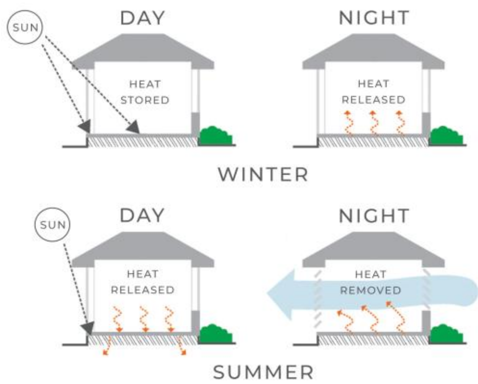

Figure 11 illustration of the thermal mass

5 . energy efficiency of a building:

Definition :

Energy efficiency in a building means how well the building uses energy compared to what is expected for that kind of building. It looks at how much energy is used for each square metre of space and compares it to standard values made for similar buildings in similar weather conditions.

These standard values are called energy benchmarks. They help us understand if a building is using more or less energy than it should, based on what's typical for that type of building.

Energy benchmarks are created by studying data from different building types in a country. A typical benchmark is based on the *middle* performance (called the median), and good performance is based on the *top 25%* of buildings in that category. By comparing a building's annual energy use per square metre (measured in kWh/m^2 per year), we can figure out how energy-efficient it is and where improvements are needed.

Benchmarks mainly apply to things like heating, cooling, air-conditioning, ventilation, lighting, fans, pumps, controls, office equipment, and outdoor lighting. These benchmarks can vary depending on the country and building type.

Another way to measure energy efficiency is by looking at the U-value, which tells us how easily heat passes through a material. The lower the U-value, the better the material keeps heat in (or out), meaning it's more energy-efficient. U-values are used in building codes to set minimum efficiency standards for windows, doors, walls, and other exterior parts of a building. These parts can affect how much energy is needed for heating or cooling, so it's important that they meet certain efficiency levels.[8]

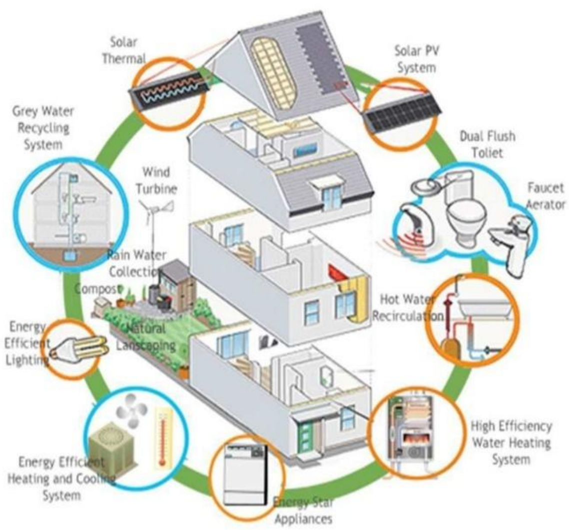

Figure 12energy-efficient strategies and technologies that directly contribute to that goal ;source: https://greendiarybe.blogspot.com/2018/01/energy-efficient-solutions-in-buildings.html

The importance of energy efficiency :

Energy efficiency in buildings is crucial, especially in developing countries, where energy demand is growing quickly but supply is limited. Governments need to ensure enough energy is available to support economic growth. Instead of always investing in expensive

[8](UNIDO),2009 ,SUSTAINABLE ENERGY REGULATION AND POLICYMAKING TRAINING MANUAL .

new power plants, it's often cheaper and faster to reduce energy demand through energy-efficient buildings. (CARICOM BEEP, 2017)

Investing in energy efficiency usually costs less than increasing energy supply, and it doesn't come with extra operating costs. Plus, these improvements can be done faster, which is helpful when energy demand is rising fast.

By encouraging buildings to use less energy—through better lighting, heating, cooling, and appliances—governments can reduce pressure on the power grid. One way to do this is by offering low-interest loans to help people make their homes more efficient, with repayments based on the money they save on energy bills.

Benefits of Energy Efficiency in Buildings:

- Lower energy bills
- Less electricity needed for heating, cooling, lighting, and appliances
- Lower maintenance costs
- Improved comfort and indoor environment
- Higher property value

In places where electricity is unreliable, reducing energy needs also reduces the cost of backup systems like diesel generators. In developed countries, energy efficiency is driven by climate policies, incentives, and the desire for a greener image. These include:

- Energy audits
- Building energy labels and certifications
- Tax breaks for efficient buildings
- Loans and grants for improvements

Lastly, changing weather and droughts reduce hydro power in some countries, leading to energy shortages. To cover the gap, governments often rely on petroleum-based energy, which is expensive and makes countries vulnerable to oil price changes. Efficient buildings help avoid this problem by using less energy in the first place.

What makes buildings energy efficient :

The development of "Energy Efficient Buildings" (EE Buildings) is a critical component of sustainable development, encompassing a range of integrated design and technological approaches to minimize energy consumption. As illustrated in the accompanying diagram (Figure 5), key factors for achieving energy efficiency include optimizing building design through bioclimatic principles, which leverage natural climate conditions to reduce energy demands for heating, cooling, and ventilation [9]. Maximizing natural lighting and utilizing efficient fenestration, along with advanced artificial lighting systems, significantly reduce electricity use for illumination [10].

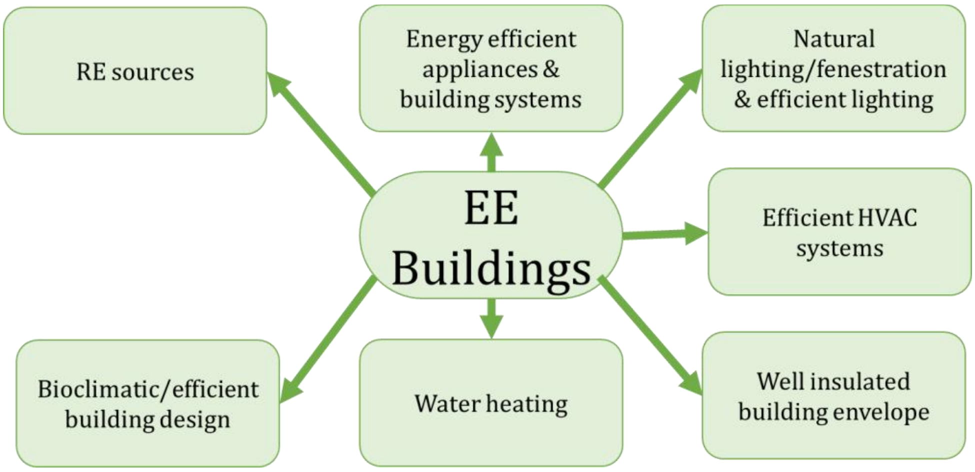

Figure 13 :Key Components of Energy Efficient Buildings, source :CCREEE

A robustly insulated building envelope is essential for mitigating heat transfer, thus lowering the energy required for maintaining comfortable indoor temperatures . Furthermore, the integration of efficient HVAC (Heating, Ventilation, and Air Conditioning) systems optimizes energy use for climate control Beyond the building's inherent structure, the incorporation of Renewable Energy (RE) sources, such as solar or wind power, directly contributes to a building's overall energy independence and reduced carbon footprint . Finally, the deployment of energy-efficient water heating solutions and

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[9] U.S. Department of Energy. (n.d.). *Energy-efficient buildings and appliances*. Retrieved from https://www.energy.gov/ (General reference for multiple aspects of energy efficient buildings).
[10] International Energy Agency (IEA). (n.d.). *Buildings - Energy System*. Retrieved from https://www.iea.org/energy-system/buildings (General reference for various building energy efficiency measures).

high-performance appliances further enhances the building's energy-saving potential . These interdependent elements collectively define the pathway toward energy-efficient buildings, a goal actively pursued by organizations like the Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE), which works to advance sustainable energy initiatives, particularly in the Caribbean region [11].

4. Principles for Energy Efficient Buildings:

The principles for defining and implementing energy-efficient buildings should take into account all financial, legal, technical, and environmental aspects, and should address present and future challenges and benefits. Hence, an appropriate and workable definition of energy-efficient buildings should have the following characteristics:

Clarity: Be clear in its objectives and terms to avoid misunderstandings and implementation failures.

Feasibility: Be technically and financially feasible within the current technological and economic landscape.

Flexibility and Adaptability: Be sufficiently flexible and adaptable to diverse local climate conditions and building traditions.

Continuity: Build upon existing low-energy standards and practices, promoting a progression towards higher efficiency.

Technological Neutrality: Allow and even foster open competition between different energy-saving technologies and solutions.

Ambitious and Evolving: Be ambitious in terms of environmental impact and be elaborated as an open concept, capable of keeping pace with technological advancements.

Stakeholder Consensus: Be elaborated based on a wide agreement of the main stakeholders (politicians, designers, industry, investors, users, etc.).

[11] Caribbean Centre for Renewable Energy and Energy Efficiency (CCREEE). (n.d.). *About Us*. Retrieved from https://www.ccreee.org/about-us/ (General reference for CCREEE's mission and role).

Inspiration and Adoption: Be inspiring and stimulate the appetite for faster adoption across the building sector.

Therefore, there are three basic principles responding to the three main reasons and objectives of regulating the building sector: reduction of energy demand, efficient use of energy, and the reduction of associated GHG emissions

Algeria Power Consumption :

Electricity consumption increased by 4% in 2022 to 69 TWh after 7% growth in 2021. It had been increasing very rapidly over 2009-2019 (8%/year) and decreased by 3% in 2020 due to the activity slowdown caused by the COVID pandemic. The electrification rate is close to 100%.

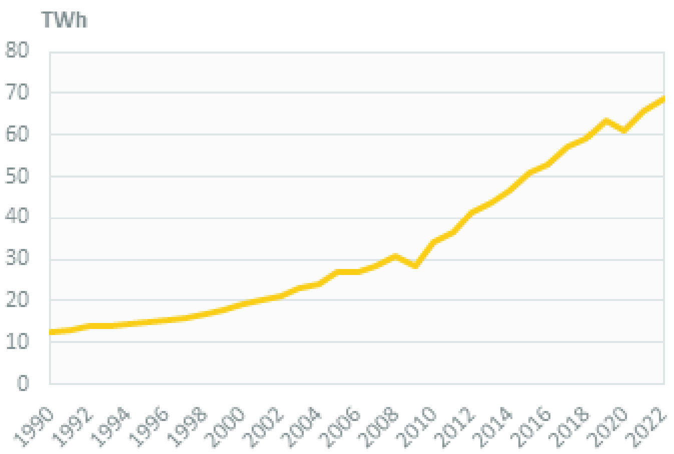


Figure 14 Graph: ELECTRICITY CONSUMPTION , ALGERIA (TWh)

The residential sector accounts for 38% of electricity consumption, followed by industry with 35% and services with 19% (2022).

Design Concepts of Energy Efficient Buildings for Mediterranean Climates

By default, buildings in Mediterranean climates benefit from abundant renewable energy sources such as direct solar radiation, wind, and the earth's thermal storage capacity. Implementing design strategies that take advantage of these natural energy sources in building design contributes to lowering energy consumption and reducing overall energy needs(Torcellini,2008) [12]. This section reviews design solutions for residential buildings in Mediterranean climates and lists multiple passive and active climate-responsive strategies and solutions for enhanced energy efficiency.

In Mediterranean climates, it is always necessary to avoid sensible and latent heat gains in every possible way and to achieve comfort conditions while minimizing energy consumption. Therefore, passive design solutions couple two major strategies: heat rejection and heat release (Givoni, B. 1992) , (Fathy, H. 1986). [13] [14]. Heat rejection strategies are environmentally protective and include solar and thermal control in addition to thermal zoning or buffering concepts (Harriman, L. 2008)[15]. Heat release strategies are environmentally reversing the heat effect through cooling and include passive cooling techniques.

Similarly, active design solutions aim to reject and release heat but mechanically. However, the difference between active and passive design strategies is not only the mechanical intervention but also the potential for on-site generation of thermal and electric needs to offset consumption. These main differences in the following paragraphs.

Thermal Control: Thermal and humidity control are essential for the building skin in Mediterranean climates. The thermal exchanges between buildings and the outdoor micro-climate depend on the temperature difference between inside and outside, as well as on the exposure and thermal properties of external building elements. The use of wall cavities, thermal mass, thermal insulation, and external reflective materials can help prevent heat gains and suppress these exchanges (Torcellini,2008).

Thermal Zoning : The positioning of the building spaces with regard to the path of the sun, prevailing winds, openings locations, and landscape design can lead to improved thermal comfort in relation to the functions and climatic requirements, thereby contributing to overall energy efficiency (Torcellini,2008).

[12] Torcellini, P., Pless, S., Deru, M., & Crawley, D. (2008). *Zero Energy Buildings: A Critical Look at the Definition, Energy, and Performance of Highly Efficient Buildings*. National Renewable Energy Laboratory.
[13] Givoni, B. (1992). *Passive and Low Energy Cooling of Buildings*. Van Nostrand Reinhold.
[14] Fathy, H. (1986). *Architecture for the Poor: An Experiment in Rural Egypt*. University of Chicago Press.
[15] Harriman, L. (2008). *The Thermal Envelope: An Overview of Building Enclosure Design and Thermal Performance*. ASHRAE Journal.

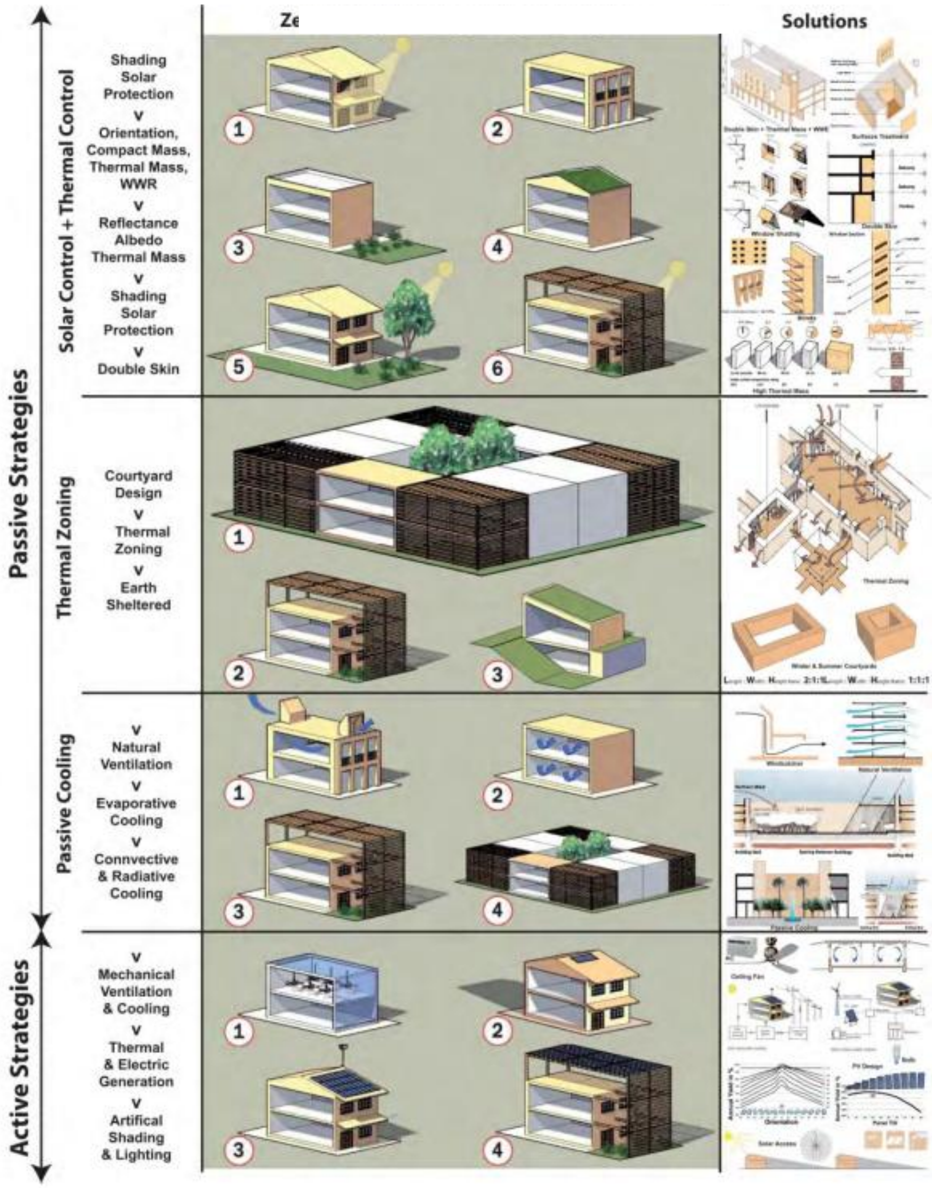


Figure 15 Inventory of passive and active solution sets for energy efficient hot-humid climates

In Mediterranean climates, the concept of thermal zoning or heat buffering entails creating intermediate semi-controlled outdoor zones that serve as an active double skin or even triple skin using bioclimatic landscape design strategies. These outdoor zones serve to block heat transfer to the main mass of occupied spaces and include courtyards, deep verandas, porches, and earth-sheltered partitions of buildings (Attia, S. 2011)[16][17]. A combination of shade and natural ventilation also plays a key role in the process of thermal zoning, aiming to improve internal temperatures and contribute to overall energy efficiency.

[16] Attia, S. (2009). *Green Buildings and Passive Design Strategies in Hot Climates: A Review*.
[17] Attia, S. (2011). *Bioclimatic Design for Sustainable Buildings in the Mediterranean Region*.

Passive Cooling: The application of passive cooling is most appropriate to release heat from buildings in Mediterranean climates. This includes evaporative cooling of outdoor air supplied to a building for ventilation, or radiative and convective cooling to cool the building's structure. Passive cooling also encompasses ventilation. Ventilation is the provision of a fresh air supply necessary for occupant health and hygiene in buildings. The ventilation process consists of a rate of air exchange that can vary as a function of fresh air requirements, as well as the mechanism of air supply [18].

In Mediterranean climates, where external heat gain from solar radiation is significant, and where outdoor summer temperatures are high (due to the climate type, global warming, or the urban heat island effect), passive and low-energy cooling strategies may sometimes be insufficient to maintain indoor comfort conditions while achieving optimal energy efficiency [19].

5- Passive, Low Energy, and Hybrid Cooling Strategies

Both passive and low-energy cooling strategies employ natural phenomena to exchange heat with the surrounding environment using architectural elements and natural heat sinks (Voss et al. 2007, Santamouris 2007). The effectiveness of these cooling strategies is therefore mainly dependent on the climate and some building fabric components. Since the building is not well-defined in the early stages of the design process, the selection of effective cooling strategies depends mainly on the Mediterranean climate.

Five main passive cooling strategies are commonly adopted: natural ventilation, nocturnal/night ventilation, direct evaporative cooling, indirect evaporative cooling, and ground cooling (Givoni 1994). Night ventilation and direct evaporative cooling are suggested for hot-dry Mediterranean climates, while natural ventilation and indirect evaporative cooling may be suitable strategies for hot-humid Mediterranean climates (Szokolay 2003). Passive designs are very energy-efficient and are expected to consume the least energy of the many different cooling strategies. However, the cooling potential of these strategies is sometimes insufficient to satisfy the cooling requirements of all the

[18] Givoni, B. (1996). Passive Low Energy Cooling of Buildings. Wiley.
[19] Florides, G. A., Kalogirou, S. A., Tassou, S. A., & Wrobel, L. C. (2002). "Measurements and simulation of the thermal performance of a dwelling in Cyprus." *Energy Conversion and Management*, 43(18), 2563-2581.

building zones, especially at extreme weather conditions. Moreover, the performance of some passive strategies – evaporative and ground cooling – could hardly be controlled.

Low-energy cooling strategies integrate some active cooling components to improve the cooling potential, control the cooling performance, and satisfy the majority of cooling needs of the building. Examples of these applications include slab radiant cooling with embedded chilled pipes, evaporative coolers, and geothermal borehole heat exchangers (Florides et al. 2002, Liddament 2000, Tassou 1998, Santamouris 2007). Low-energy cooling strategies are expected to provide more controllable cooling potential than passive designs but with higher associated energy consumption. This energy consumption is expected to be lower than conventional active systems since these strategies exploit natural energy sources: solar energy, geothermal energy, wet-bulb depression, and material properties (Santamouris 2007).

High thermal mass is usually used in conjunction with these passive and low-energy cooling strategies to act as a heat sink that controls the heat absorption and discharge heat transfer mechanisms. At the same time, thermal mass reduces the fluctuation of the indoor environment and so protects it from the severe dry outdoor climate and the large temperature swings (Abanomi et al. 2005, Zhou et al. 2006, Antinucci et al. 1992). The effectiveness of the thermal mass depends on the exposed surface, material properties, and the diurnal dry-bulb temperature variation (Givoni 1998). Since passive strategies should satisfy part of the cooling demands and consume the least energy consumption, the research focuses more on the five different passive strategies (below) together with possible improvements using low-energy cooling technologies.

6- Definition of student housing :

Student housing is a form of accommodation that university or college students can choose as an alternative to on-campus housing. Typically, student housing can be found in close proximity to the college campus or it can be found in parts of a city that is known to offer affordable housing.

Often, there is an assumption that student housing is offered through homes that are falling apart, that are either crammed or are luxurious and unaffordable. The reality is, student housing can be whatever the investor chooses it to be, but the key thing that differentiates it from other housing is that it caters and targets students specifically.

7- On-Campus Housing vs. Off-Campus Hosing

When it comes to determining on-campus housing and off-campus housing, there are factors that should be considered, especially if you are considering investing in a property for your real estate portfolio.

When it comes to off-campus student housing, it is a great way to provide more privacy and more independence for the scholar. Oftentimes as well, this choice of a housing alternative is because they have experienced on-campus housing and want to now live a less college or resident life.

Having attractive off-campus apartments means catering to both those either in their first year or in their later years.

On the other hand, with on-campus, there is little to no risk for the students. Their dorm is close to everything, they are able to get support on campus, they can walk to class, what more would a college student want? On-campus dorms are perfect for anyone looking for a housing option that is easy and no fuss to them or their wallets.

8- Benefits of Off-Campus Housing?

Owning a rental property that caters to off-campus housing, or rather student residents can be a lucrative field to get into. Why?

Firstly, most college towns offer a form of student housing, some are affiliated with the college while others are not. These student apartments that are privately owned and operated, typically cater to those who are pursuing higher education, for example, their Masters or Doctorate. The number one reason for them to choose this form of housing is because it provides an escape from the typically chaotic and frenzied dorm life. They can focus on their studies and not be distracted.

As a homeowner or company looking to provide housing options to students, off-campus housing is a great choice. This is especially true if you own an apartment that features multiple dorms. Each unit or apartment could have multiple renters or a single renter occupancy.

Students today want more freedom and one of the best ways of achieving this is through rental apartments.

9- What to Consider in Housing for College Students

When it comes to offering housing options to students, especially an apartment, there are a few things one should consider. These are the top three factors one looking to provide off-campus housing options.

Amenities

When a student makes the choice to sign a lease for renting off-campus, they want to make sure that the space they are renting offers an array of amenities that are going to suit their needs.

The number one reason that amenities are important to a student renting in a house or apartment off-campus is that, if they were to choose to live on-campus, they would have the resources and support they need right outside their door. Whereas, student housing or non-student residents would have to deal with matters on their own, without the input of the school.

As someone looking to provide student housing, you want to make sure that your rent entices the student. You want to include in the lease the added features of your apartment because the student wants to feel that they are getting what they pay for.

In order for a student to consider your accommodation, and to be competitive with most markets that cater to student housing, you can ensure the following :

Kitchen Appliances

Though there is a notion that students eat out more often than they cook, having the space and the proper equipment to cook or prepare meals can be appealing because most university dorms do not offer such a luxury.

Sense of Community

Despite students wanting to live off-campus, they don't want to be so far away from their universities that they miss out on the college life experience. Invest in student housing that is close to colleges and universities, as this can provide that feeling of community.

Security

Students who choose to live off-campus may have never lived away from comforts before; therefore, establishing and demonstrating a sense of security and easy access to the school, stores, and yourself, as the landlord can be a comfort. Students want to know that they can call their landlord and have them on-site if there is an emergency.

10- Furnished vs. Non-Furnished

There is no denying that there is a demand for international students who are looking to get a foreign education, and because of this, they may make a great candidate for your property. Nonetheless though, determining whether you offer furnished or non-furnished accommodation may be a deal-breaker for some students.

This is because they may not have the resources or means to furnish their place and want a residence that has everything they need. If you are going to furnish the accommodation, make sure to factor in any potential damage and use it through a security deposit.

Location

Many colleges offer some form of a housing community, the community can be off or on campus. As these are accommodations that are found off-campus, they don't provide students with a meal plan which is often provided to on-campus housing.

It is for this reason that location is an important factor to consider when looking to invest in off-campus housing. Student housing should be close to the campus, at least enough so that they can either walk or easily take public transportation. Most colleges are on a major transit route; therefore, it is important that when you start looking at the real estate market you find one that is easily accessible.

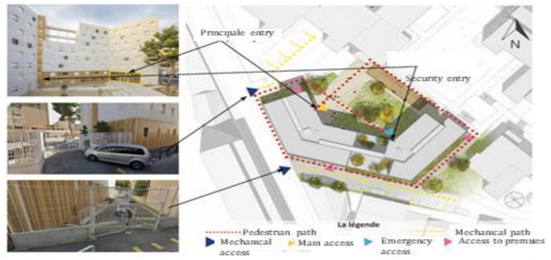
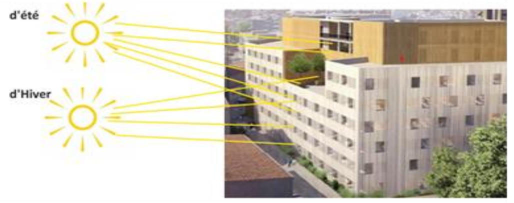
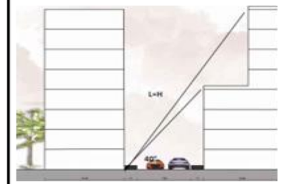
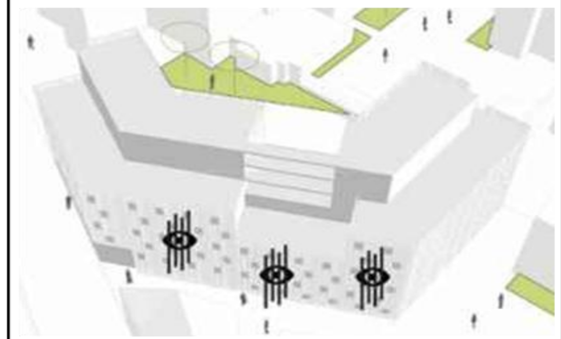
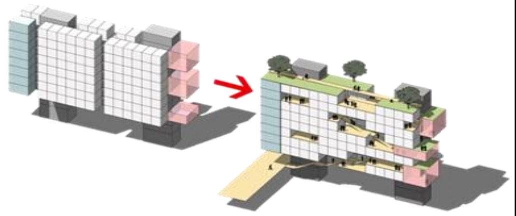
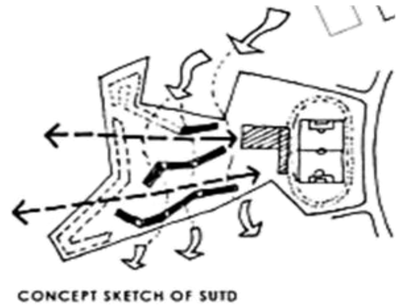
Students determining whether or not to rent a property are going to look at the location. They are going to see whether or not it is worth it to embark on off-campus student housing or to choose to live within the campus confines.

One way of determining where your rental property lies or if it is going to draw in renters is to pay attention to rent boards. These are typically posted around traditional residence halls within universities and they provide a listing of houses and apartments close by.

types of student housing :

Student housing encompasses a diverse range of options, each with its own unique characteristics and advantages. Here are some of the most common types:

- **On-Campus Dormitories (Residence Halls):**
  - **Traditional:** Often feature shared rooms, bathrooms, and common areas.
  - **Suite-Style:** Offer more privacy with private bedrooms and shared bathrooms within a suite.
  - **Apartment-Style:** Provide more independence with individual bedrooms, bathrooms, and kitchenettes within an apartment unit.
- **Off-Campus Apartments:**
  - **Privately Owned:** Rented from individual landlords or property management companies.
  - **Purpose-Built Student Housing:** Professionally managed complexes specifically designed for students, offering amenities like fitness centers, study lounges, and social spaces.
- **Other Options:**
  - **Fraternities/Sororities:** Social organizations that provide housing for members.
  - **Homestays:** Living with a host family.
  - **Co-ops:** Student-run housing where residents share responsibilities like cooking and cleaning.

	Project profile :	Urban implantation	Climate stategies	general concepts
Project Name: Lucien Cornil Student Residence 	• **Architects:** A+Architecture • **Location:** Marseille, France • **Area:** 12000.0 m2 • **Project Year:** 2017 • **Floors:** r+7 • **Manufacturers:** SFA Peinture, Rondy Forestier, ARCADE, ARBONIS, CIBETANCHE, Schindler, ART DECO, ARBONIS and CHIRI	Urban implantation :  Accessibility :  Floors levels : 	passive design : **Cross Laminated Timber (CLT) Construction:** Provides excellent natural insulation, reducing heating/cooling needs and lowering the carbon footprint. **Strategic Facade & Orientation:** Perforated cladding offers solar shading, and most rooms face an interior garden for a cooler microclimate. Window placement considers both light and noise. **Interior Green Courtyard:** Acts as a passive cooling element for adjacent spaces.  	The architect cut out a part in the two upper floors to respect the prosect law H=L.  
Project Name: Singapore University of Technology and Design student housing 	• **Architects:** LOOK Architects, in collaboration with Surbana International Consultants • **Location:** Singapore • **Client:** Singapore University of Technology and Design • **Floors:** r+11 • **Site Area:** 74,928 m² • **Gross Floor Area:** 74,928 m² • **Status:** Under Construction	Urban implantation :  Accessibility : 	**Social Interaction:** The horizontal voids ceate spaces for community building. **Ventilation:** The perforations improve air circulation and quality. **Natural Light:** The voids bring in more natural light. **Security:** The communal spaces act as natural surveillance points 	**General concepts:** the design approach aims to transform the traditional housing model into a more dynamic and engaging living environment, promoting social interaction, environmental sustainability, and overall well-being for residents. 

Conclusion :

- Dynamic Definition of Energy Efficiency : Defining optimal energy efficiency is a complex, evolving task that demands a nuanced understanding beyond static definitions, accounting for varied climates, infrastructure, and policy frameworks.
- Integrated Design for Efficiency : Achieving energy-efficient buildings fundamentally relies on an integrated approach, deeply embedding sustainable and bioclimatic design principles to leverage natural resources and optimize building performance.
- Strategic Benefits of Efficiency : Energy efficiency offers indispensable strategic advantages, particularly for growing economies like Algeria, by reducing energy demand, lowering costs, enhancing comfort, and bolstering energy security and sustainable development.

Chapter III : Study case.

Introduction :

This chapter presents a detailed case study exploring the design and development of a sustainable student housing complex in Blida, ~~Algeri~~a. Recognizing the growing need for modern and environmentally conscious living spaces for students, this case study aims to demonstrate a holistic approach to student housing design that prioritizes sustainability, comfort, and community. To reach our objective, we used analytical and conceptual approaches at urban and architectural scales.

I. Introduction :

1. City Presentation:

Blida, Known affectionately as "The City of Roses," derives its name from "boulayda," an ancient Arabic term for "a little town or district." This is a diminutive of "Bilad," meaning "country" or "region." Over time, particularly during the French occupation, the pronunciation evolved into the familiar "Blida" in everyday Arabic.

2. .Blida Geographical Location:

a) the national scale:

The municipality of Blida is located in the northern part of the country in the geographical area of the central Tell, situated in the north of Algeria, 50 km southwest of Algiers .

b) the regional scale:

Blida is situated in the coastal zone and borders Médéa Wilaya to the south. The wilayas of Boumerdes, Tipaza, and Algiers abut it to the north. Blida is bounded to the east by the wilaya Of Bouira and to the west by Ain Defla.

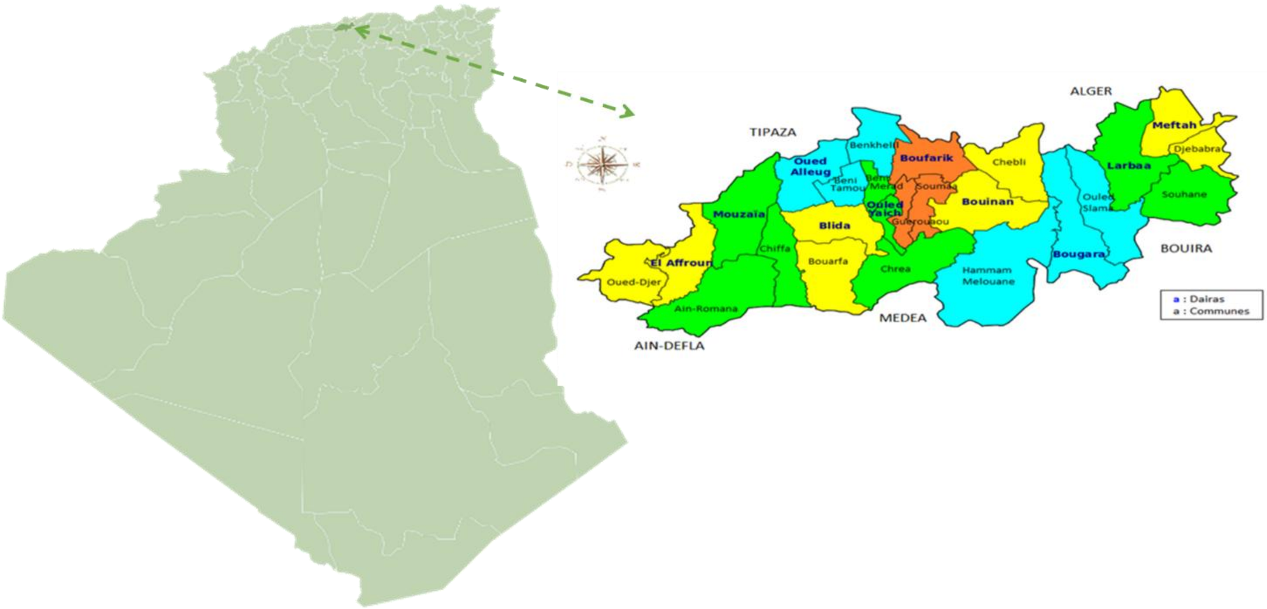


Figure 16 Blida Geographical Location source: https://fr.wikipedia.org/wiki/Communes_de_la_wilaya_de_Blida

c) Blida's accessibility :

Blida enjoys excellent accessibility due to its strategic location in the Tell region and its well-developedroad network. Major routes connect Blida to major cities like Algiers, as well as surrounding towns and scenic areas like Bouinan, Koléa, Attatba, and Chréa.

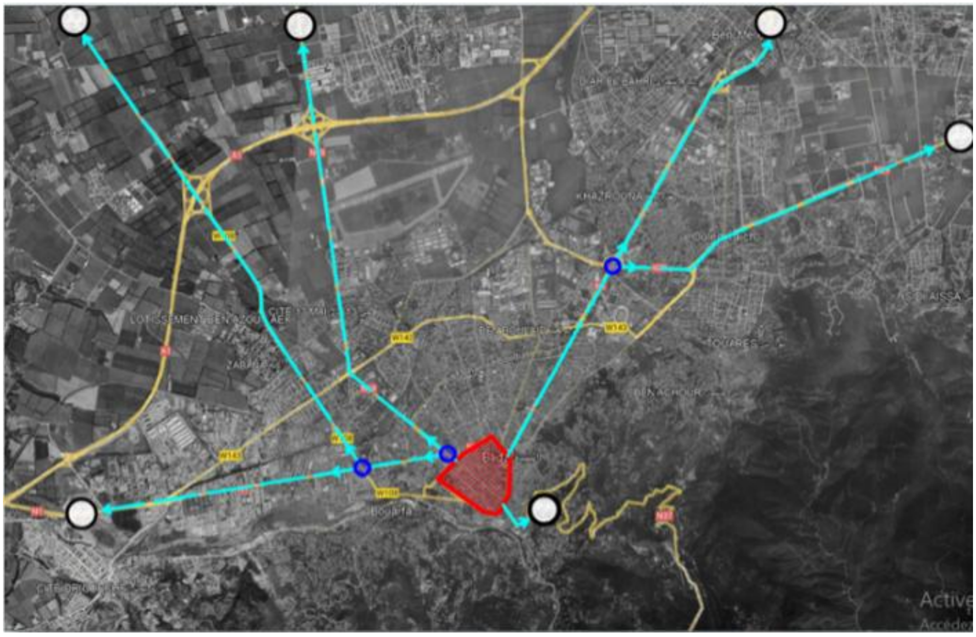


Figure 17 Blida's accessibility source :auther

d) the vocation of the city of Blida :

Blida has an agricultural, commercial, and industrial vocation; it is situated between economic, industrial, tourist, and agricultural hubs that maintain significant exchange and complementarity relations among themselves. The functions it possesses allow it to acquire the status of an active metropolis.

II- Urban Analysis of the City: Formation and Transformation Processes :

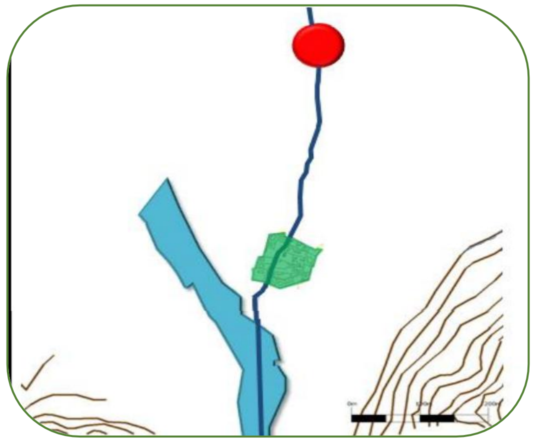
1. Diachronic analysis :

Like cities around the world, Blida has experienced a profound transformation in its growth and development. It is crucial to examine the city's beginnings throughout different historical eras in order to obtain a better understanding of this development. We can determine the elements influencing its development and the enduring traits that have molded its identity over time by looking at the origins of Blida across its many eras.

The chronological historical eras that influenced Blida City are as follows:

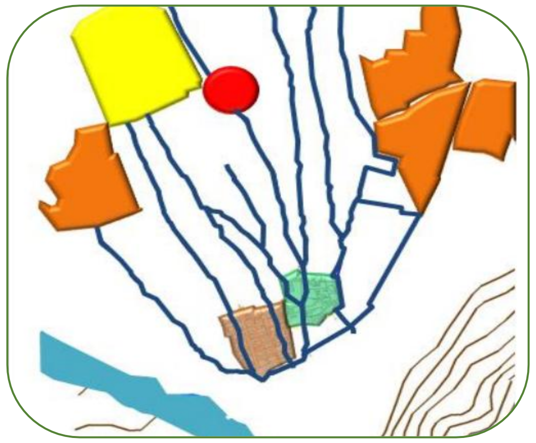
1. BIRTH OF THE CITY OF BLIDA

- Around 1519, Sidi Ahmed El Kebir, a marabout (Muslim scholar), settled in a strategic location.
- This location is the confluence of two watercourses: the Oued Taberkachent and Chabet Arromain (now Oued Sidi El Kebir).
- The establishment of Sidi Ahmed El Kebir marks a turning point in the history of Blida.



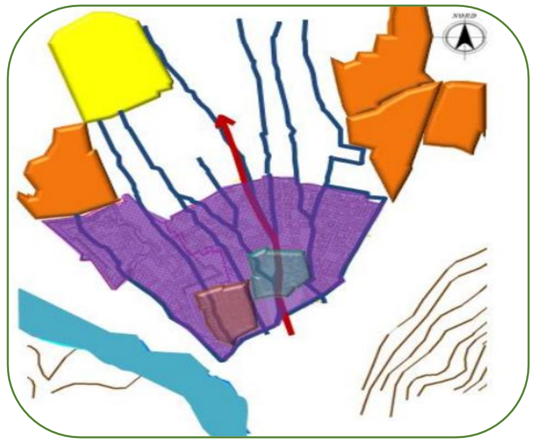
2. ANDALUSIAN PERIOD

- In 1533, a group of Moors expelled from Spain settled in Blida with the protection of the great marabout "Sidi El Kebir" and the support of "Pacha Khair-Eddine".
- The Ouled Sultane ceded the southern part of their village in the southern part of the alluvial cone of the wadi.



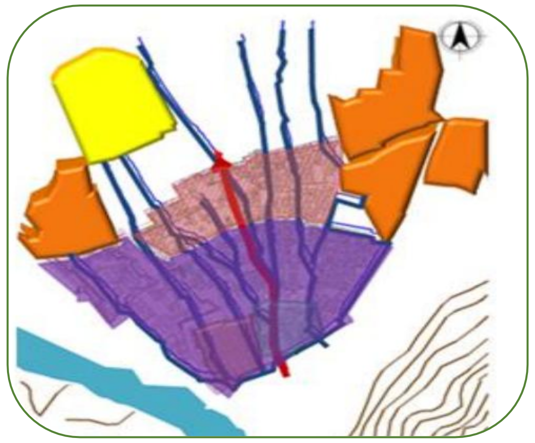
3. OTTOMAN PERIOD

Blida was founded in 1535 as a strategic alliance between the Ottoman Empire and local religious authority. Blida also played a crucial role in trade and communication between Algiers and the Titteri region.



4. PRECOLONIAL ERA

Some boundaries have been determined based on reconstructions prior to 1842. The interior of the blocks remains unchanged due to their character. Other boundaries have been discovered, but this time they are houses with ramparts.



5. COLONIAL PERIOD

- During the colonial period, Blida lost its historical character as it was transformed to serve the interests of the colonial power. The colonial authorities remodeled the city, imposing a grid pattern over the existing layout.
- The city walls were demolished in 1926 to create a new road.

6. POST-COLONIAL PERIOD

Following Algerian independence, Blida experienced rapid and uncontrolled urban growth, fueled by rural migration and a lack of proper planning. This led to land fragmentation, illegal construction, and the deterioration of the historic center. Despite subsequent housing projects, urban development in Blida faced significant challenges..

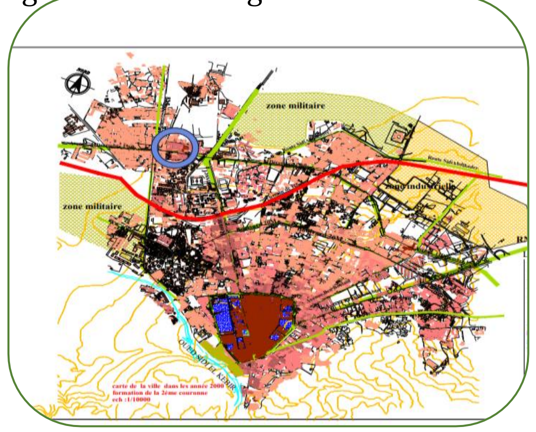


Figure 181. Diachronic analysis of the city of blida

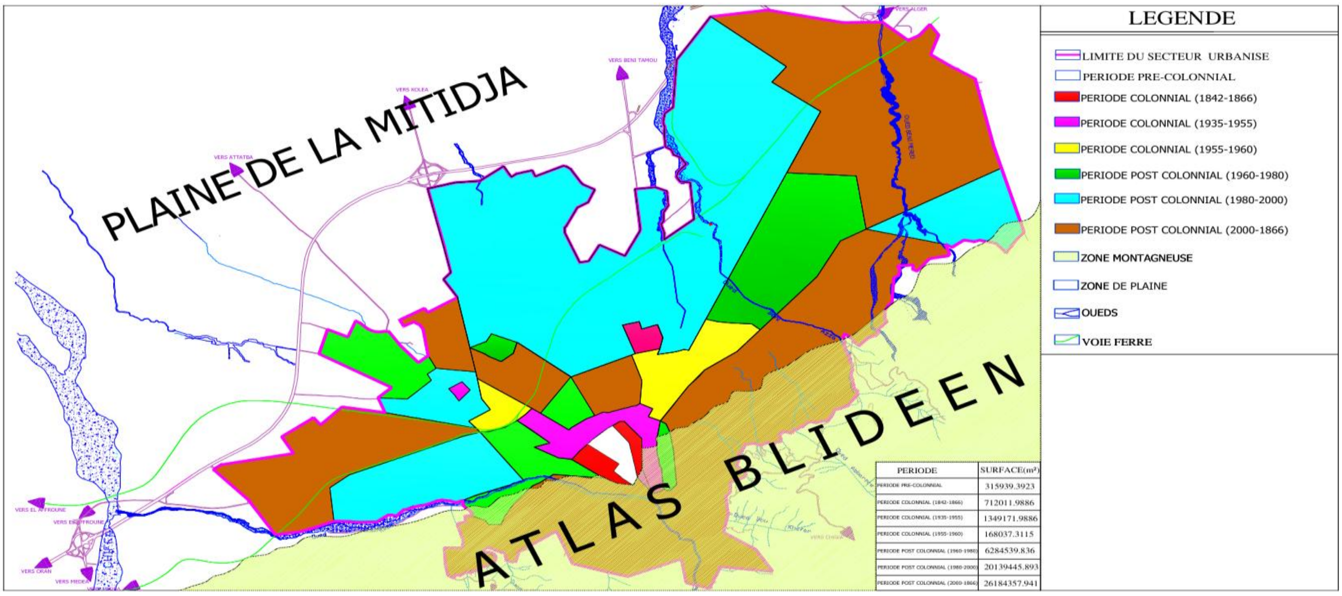


Figure 19 the sythises carte of the history of blida

SYNTHESIS :

During the development of Blida, the city underwent transformations whose major characteristics can be summarized as follows :

1) Continuous growth :

- The development of the city occurred through successive additions of new parts in the direction of the north-south axis.
- The urban fabric developed uniformly, all surrounded by a protective wall.
- Blida's growth was polar, centered around Sidi Ahmed El Kebir's core, constrained by the Chrea Mountain to the south.

2) Regulatory elements:

A/ Regulator and barrier: The geomorphology of the site (topography, Oued Sidi el Kebir) acts as a natural regulator for the establishment and development of the city towards the north, while the mountain range to the south will limit, orient, and manage the formal aspect of the city.

B/ Growth line: The territorial routes (ALGER - BLIDA and BLIDA - KOLEA) and the development pathways (seguias) have organized the growth of the city towards the North throughout.

2. Morphological analysis of the city according to the 4 systems

Danieul and Borie's urban morphological analysis offers a foundational framework for understanding the city's structure by dissecting the urban fabric into four interdependent systems :

- **Path System :** The network of streets and pathways, defining circulation, accessibility, and the city's skeletal framework.
- **Plot System :** The subdivision of land into individual units, revealing patterns of ownership and development potential.
- **Built System :** The buildings and structures themselves, encompassing their footprints, volumes, and typologies, which define the urban mass.
- **Open Space System :** The unbuilt areas like parks and plazas, crucial for understanding breathable spaces, recreation, and the interaction of voids and solids.

Land parcel system :

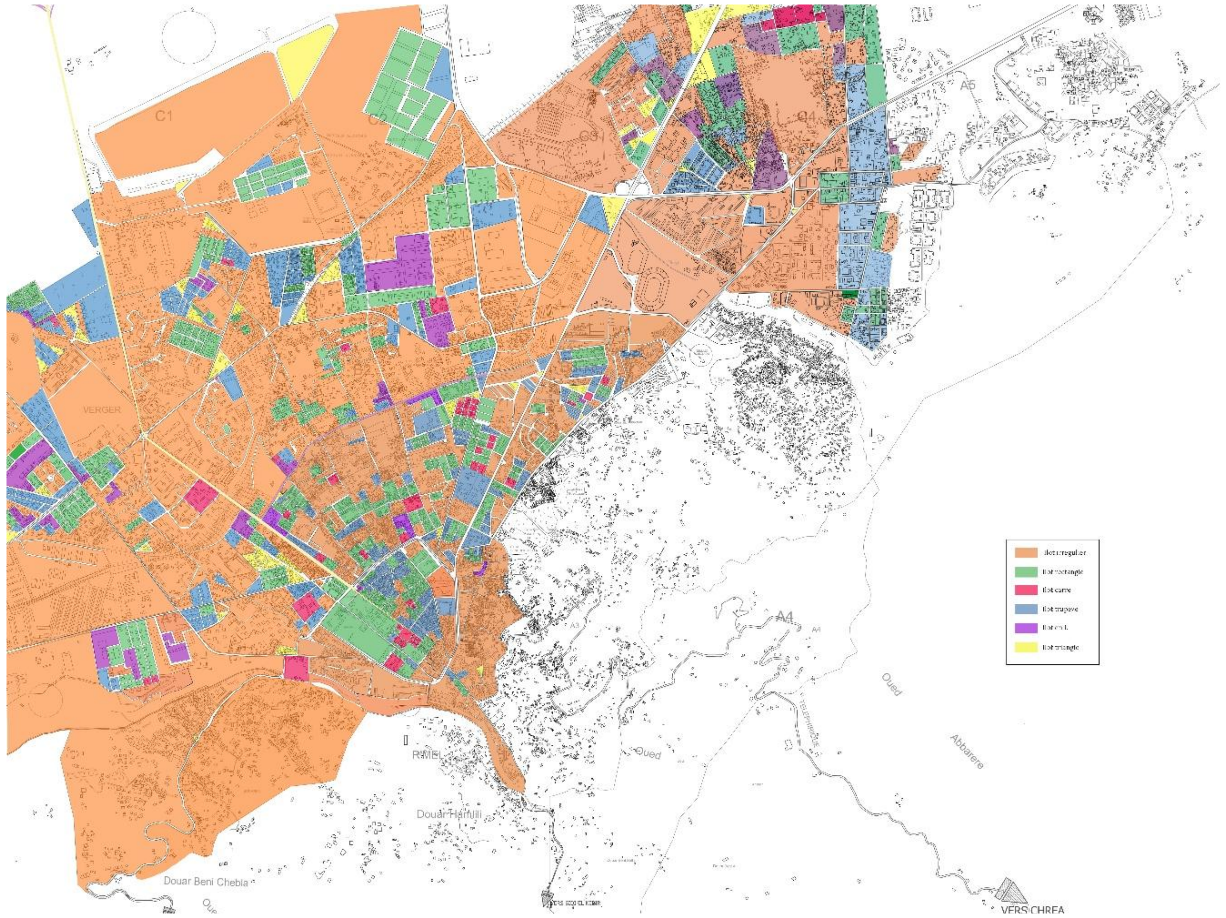


Figure 21 land parcel analysis

Viare system : road network

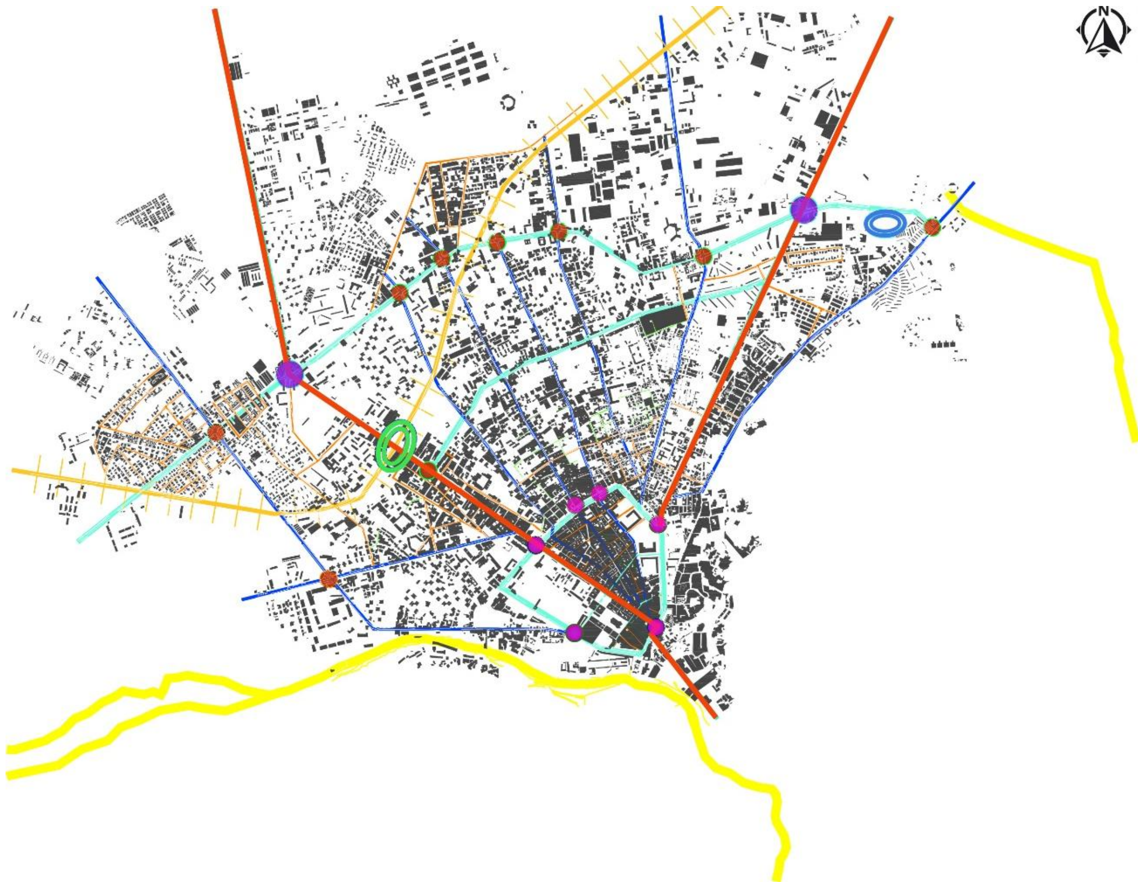


Figure 20viare system network road

Non-built system :

Figure 22 built / non-built system

Built system :

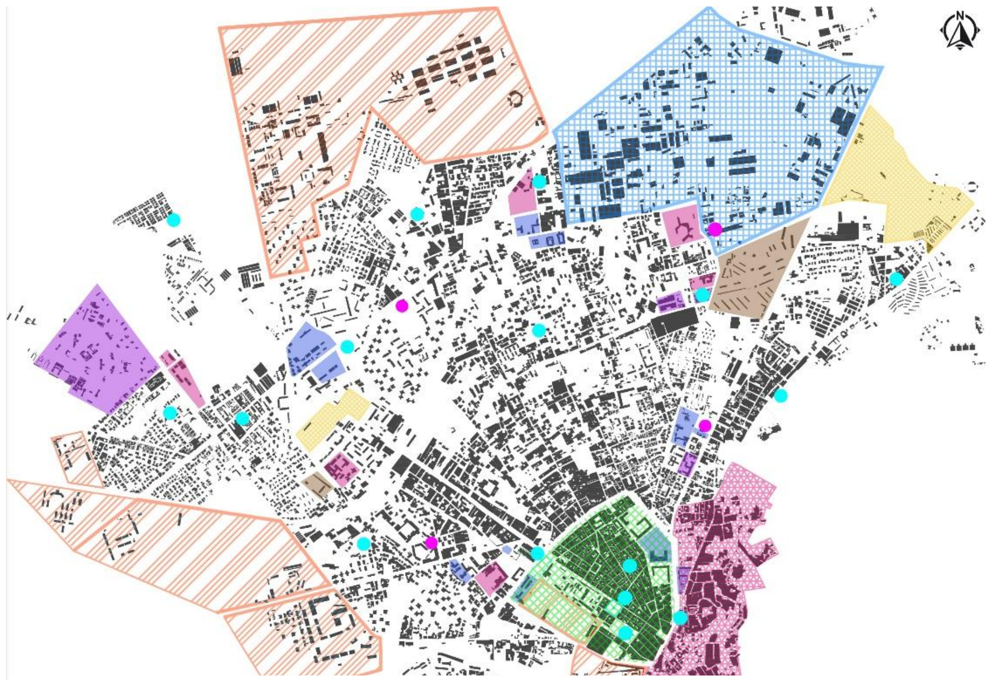


Figure 23 built analysis system

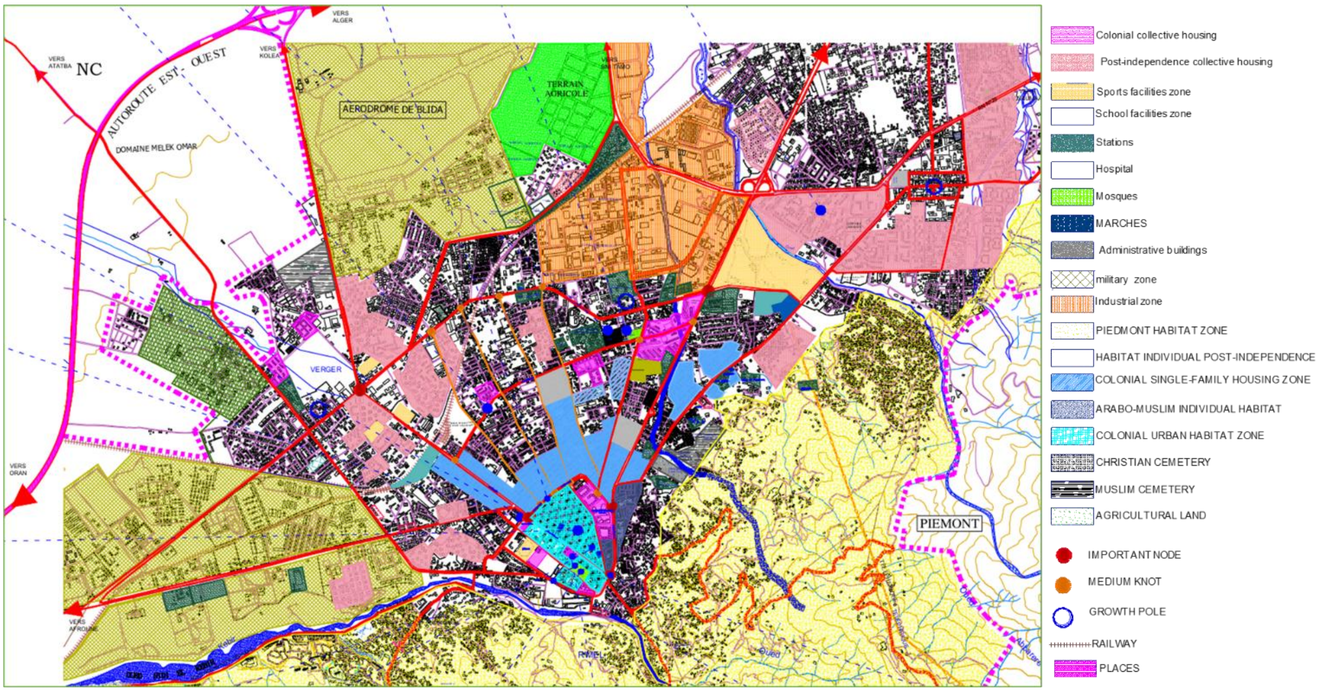


Figure 24 synthesis carte

Synthesis :

Searching throughout Blida city history and understanding the different architectural styles, and urban plannings that have been introduced to the city during the different epochs that it has been through, helped us understand and value of the city’s architectural identity, by reminiscing it into future project

Ouled Yaich Presentation :

Ouled Yaïch, once a small village in the 1970s, has grown into the largest urban area in Blida province, now home to over 100,000 residents. Named after its earliest settlers, the Aïchi, the town developed through neighborhoods like Touarès, Ben Amour, Meliani, and the Russian and Spanish quarters. Major urban growth began in the 1980s with large-scale housing projects, including 1,000 rental social units. However, rapid expansion without thoughtful urban planning has turned Ouled Yaïch into a dense, characterless dormitory town. While the old colonial center retains some charm, the city suffers from a lack of architectural identity, green spaces, and environmental consideration.

Figure 25 birdeye imageof ouled yaich ; source:https://www.lnr-dz.com/2023/08/23/commune-douled-yaich-une-ville-anarchique

Commune of Ouled Yaich choice criteria:

- University center commune.

Ouled Yaich geographical Location :

The commune of Ouled Yaïch is centrally located in the Blida province, about 4 km northwest of Blida, 42 km southwest of Algiers, and 29 km northwest of Médéa. It shares borders with Beni Mered to the north, Blida to the east, Guerouaou to the west, and Chréa to the south.

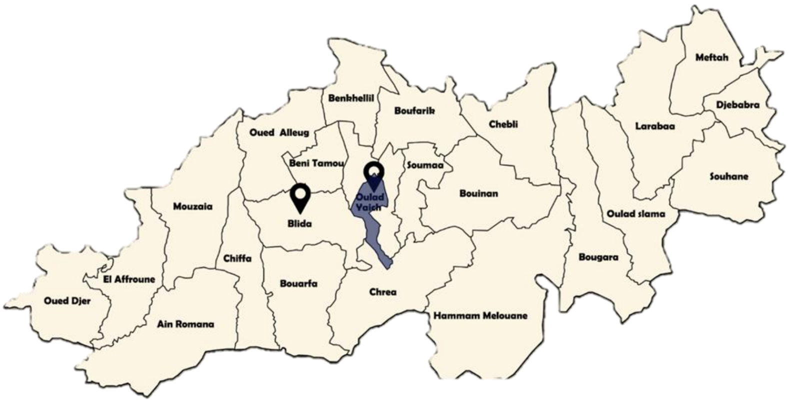


Figure 26: Ouled Yaich situation, in Blida city, source : Wikipédia

3. Morphological analysis of the study area: the site and immediate environment according to the 4 systems :

Delimitation:

The recommended student housing location:

Generally speaking, student housing is found adjacent to universities, either on the campus or close to the university center. In terms of aesthetic appeal, enhancing the neighborhood and raising its value, the pinned site is most suited for student housing.

Figure 27 an image showing the study area delimitation source : Google earth, edited by author

The following services are available in our research area :

Figure 28 An image showing the study area different services. Source: Google earth, edited by author.

The study area has the following services:

1. Residential buildings .
2. University dorms.
3. University.
4. bus station (under constructions)

The university of Blida occupies a huge portion of land in our study area.

Accessibility and means of transportation:

Figure 29 1: 1: A map showing the different bus stops in our study area Source: Google earth, edited by author

The study area is accessible by two main modes of transportation: mechanical and pedestrian. The mechanical access includes both cars and buses, with four key bus stops located along the west–east axis:

- DNC bus stop
- First university entrance bus stop
- Second university entrance bus stop
- Third university entrance bus stop

This multi-accessibility enhances connectivity within the area and supports its integration into the broader urban fabric.

Morphological approach :

a-Map of the road network: Hierarchy of roads:

Figure 30 road system map, Source: Author

The study area is served by 2 types of roads of different importance :

The national road RN 29 that links the commune of 'OULED YAICH' with the commune of 'SOUMAA'

Secondary roads structuring and serving the islands .

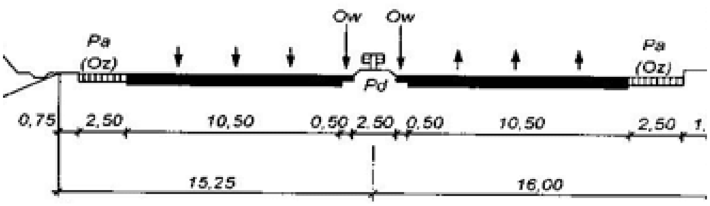


Figure 31section of the main road

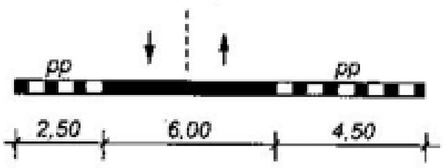


Figure 32 section of the secondary roads

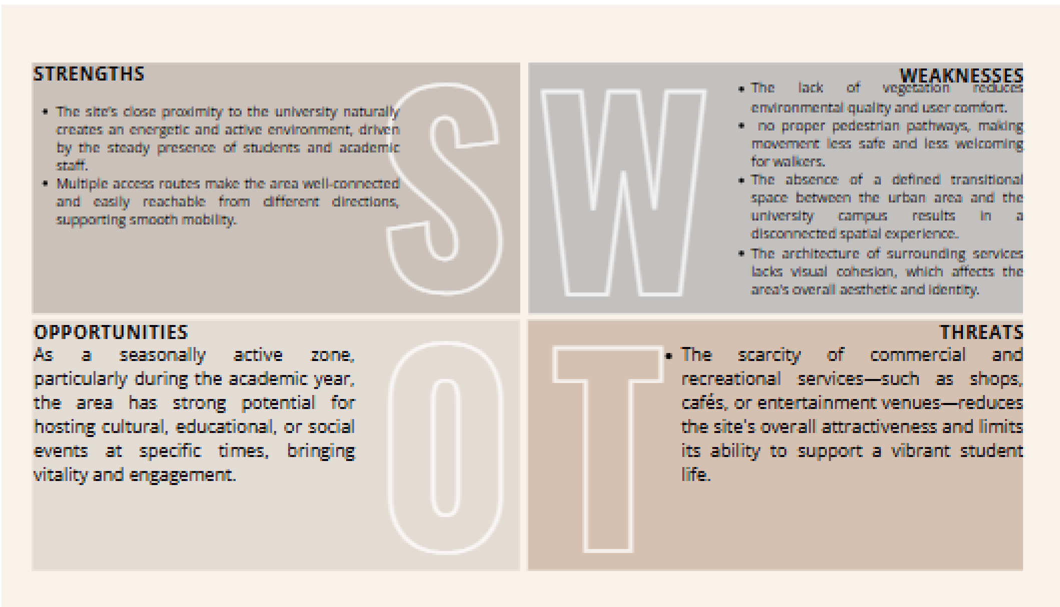
-Map of the Built/ NON-Built spaces:

Figure 33 built and non build spaces system

Our study lacks of Urban parcs, green spaces surrounding buildings and a development with urban furniture throughout the river.

It also consists of the following services: Residential services,and educational services, consisting of the APC headquarters and 2 leisure services .

SWOT Analysis :



Critique of the Local Land Use Plan: POS

sensory approach:

The study area is located within POS C5, according to the updated PDAU of 2015, placing it strategically at the eastern entrance of the municipality of Ouled Yaïch. This site was selected based on several key factors:

1. the proximity from the University of Saad Dahleb.
2. the promising availability of land resources.

Sensory and Sequential analysis:

Sequential analysis links urban morphology to human sensory perception to assess the concept of *imageability*—the ability of individuals to orient themselves and form a mental image of a space. By immersing ourselves in the study area, we identified distinct urban sequences, each evoking different spatial experiences. For detailed visualization, refer to the sequential analysis map below.

The study area is divided into two main sequences based on the contrasting sensations they evoke:

1. Sequence one : Very calm but insecure:

   This zone is characterized by a quiet atmosphere but feels insecure due to its physical fragmentation and limited building density compared to surrounding areas. And it could be studied and urbanized
2. Sequence two: University Campus

   This sequence includes the university campus, marked by a high seasonal flow of pedestrians and vehicles. While it becomes vibrant during academic periods, the transient crowding also contributes to a perceived lack of security.

Figure 34 A map showing the different sequences of our study area source: Google earth, edited by author

Synthesis: Urban planning recommendations and principles, Include a land use and occupancy scheme :

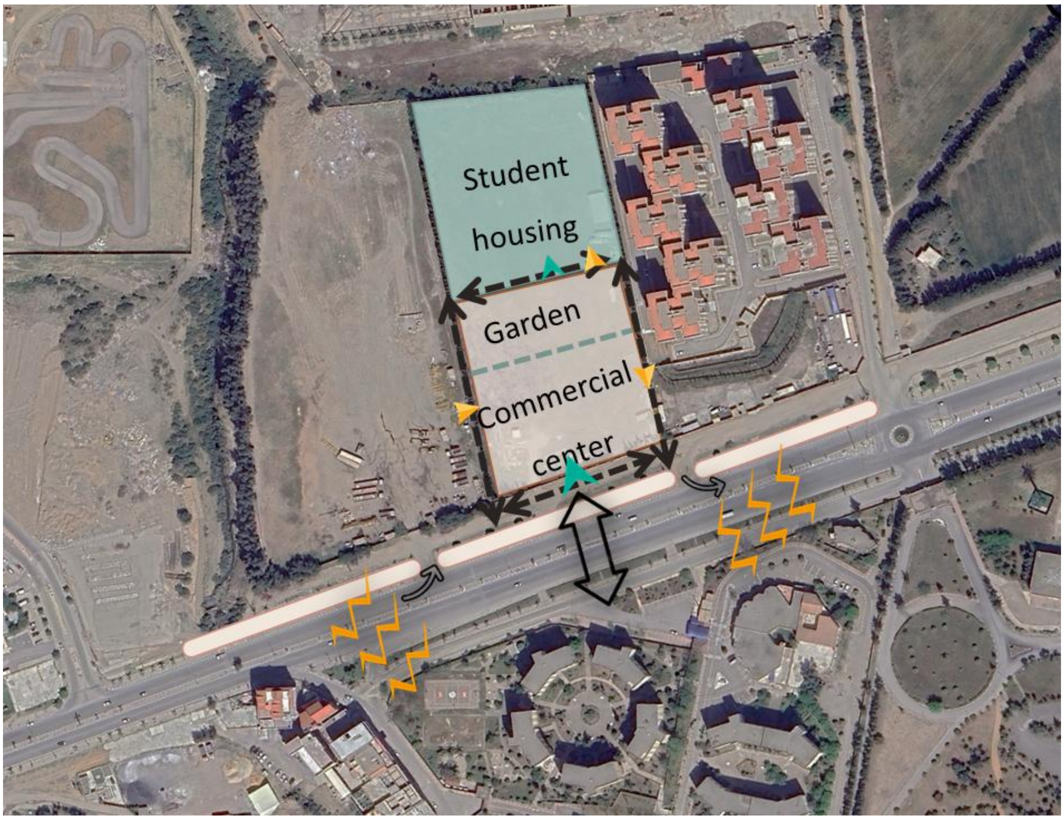


Figure 35 representation of the intervention area , Sources : GOGLE EARTH edited by author .

Ouled Yaich environnemental analysis:

1- Climatic analysis

In this analysis we will develop a climatic analysis, presentation of climatic data to have an overall idea of the climatic stage of our case study through two software Meteonorm 8 and Climate Consultant V6 developed by the University of California.

we will delve into a detailed climatic analysis of Oulad yaich , Blida. This analysis will utilize the psyconometric diagram, enabling us to select bioclimatic strategies that are well-suited to the specific climatic conditions of the study area .

PERCIPITATION

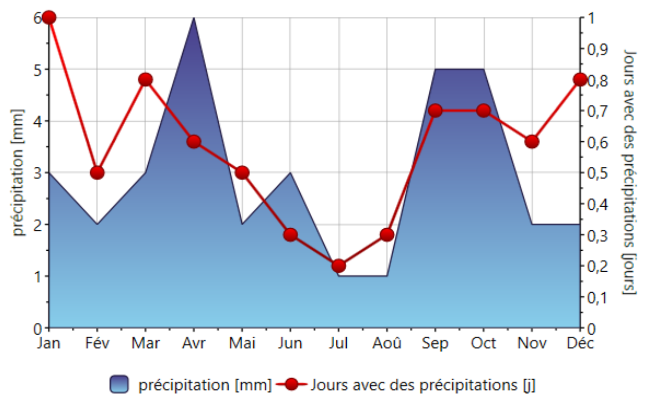


Figure 40Precipitation Graph (Source: Meteonorm 8)

clear seasonal pattern, with peak precipitation occurring in March and September, and a dry period during the summer months.

TEMPERATURE

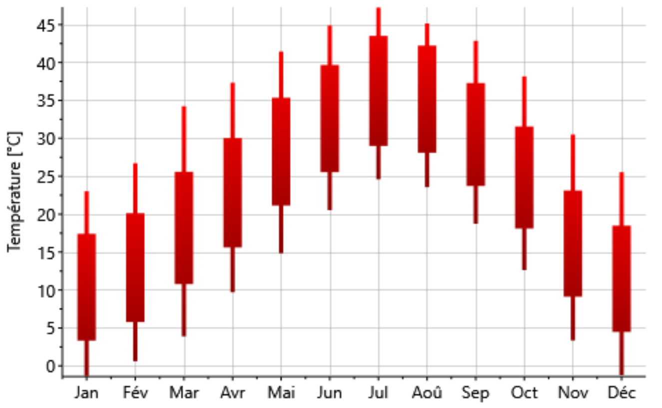


Figure 39 Temperature Graph (Source: Meteonorm 8)

a clear seasonal trend with higher temperatures during the summer months (June to August) and lower temperatures during the winter months (December to February).

SKY COVER

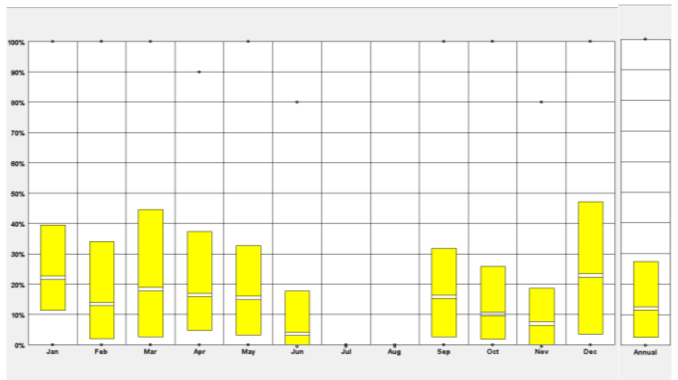


Figure 38 Sky Cover Graph (Source: Climate Consultant)

higher cloud cover during the winter months (December to February) and lower cloud cover during the summer months (June to August).

RADIATION

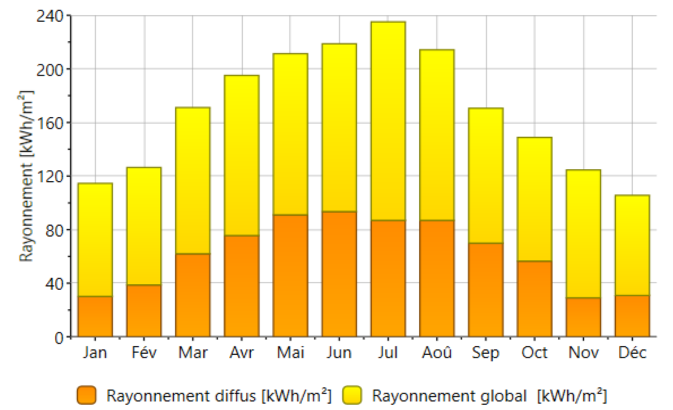


Figure 41Radiation Graph (Source: Meteonorm 8)

global and diffuse radiation exhibit are highest during the summer months (June-August) and lowest during the winter months (December-January).

SUNSHINE

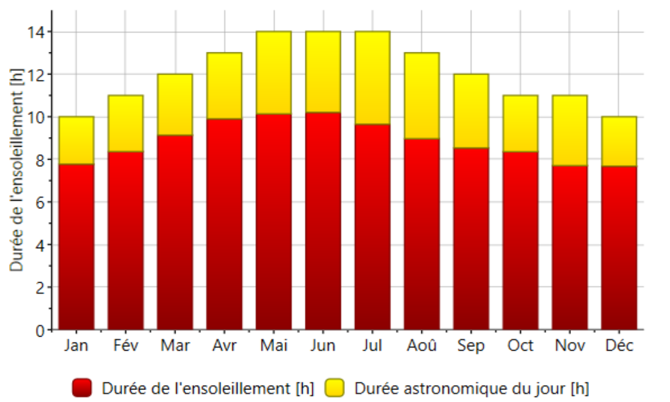


Figure 37Sunshine Graph (Source: Meteonorm 8)

sunshine duration and astronomical day length peak during the summer months (June-August) and reach their minimum during the winter months (December-January).

HUMIDITY

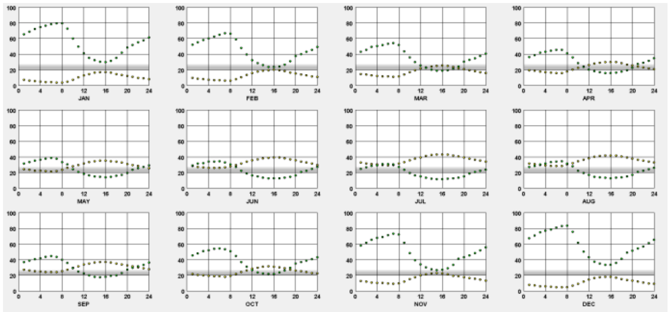


Figure 42Humidity Graph (Source: Climate Consultant)

Humidity likely peaks in winter due to increased rainfall and lower temperatures, while summer experiences lower humidity due to higher temperatures and evaporation.

WIND WHEEL "WINTER"

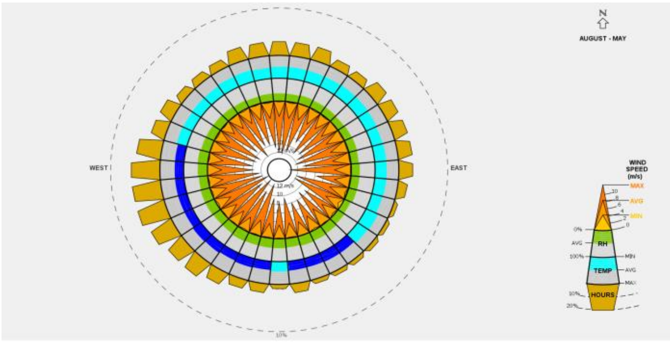


Figure 43Wind Wheel Winter (Source: Climate Consultant)

The wind rose reveals that prevailing winds in Blida during August blow predominantly from the West. Moderate to strong winds are frequent during this month.

WIND WHEEL "SUMMER"

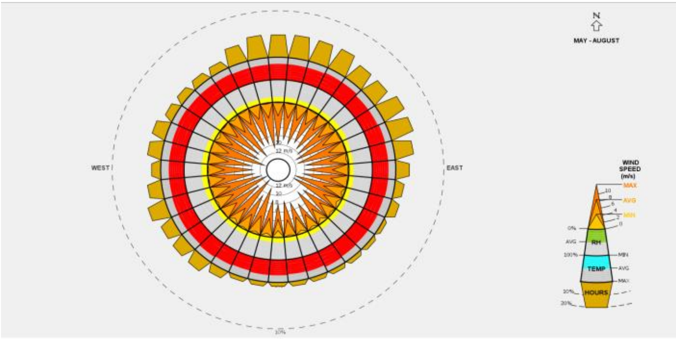


Figure 44Wind Wheel Summer (Source: Climate Consultant)

The wind rose for May-August shows prevailing winds from the West and Northwest in Blida. Moderate to strong winds are common during these months.

Figure 36 Table showing Ouled yaich climate analysis

ANNUAL PSYCHOMETRIC DIAGRAM

Blida, Algeria, experiences a Mediterranean climate with hot, dry summers and mild, wet winters. An analysis of it's psychrometric chart, spanning January through December, reveals :

- **Comfort :** Only 19.3% of the year is considered comfortable (1689 out of 8760 hours).
- **Cold :** Temperatures dip below the comfort zone primarily during **December, January, and February**, requiring heating. Humidification wasn't deemed necessary within the analyzed period.
- **Hot :** Summers are significantly hot, with temperatures exceeding the comfort zone from **June through September**, necessitating cooling strategies. While some strategies are listed (thermal mass, etc.), many show zero hours of use, suggesting potential for optimization.

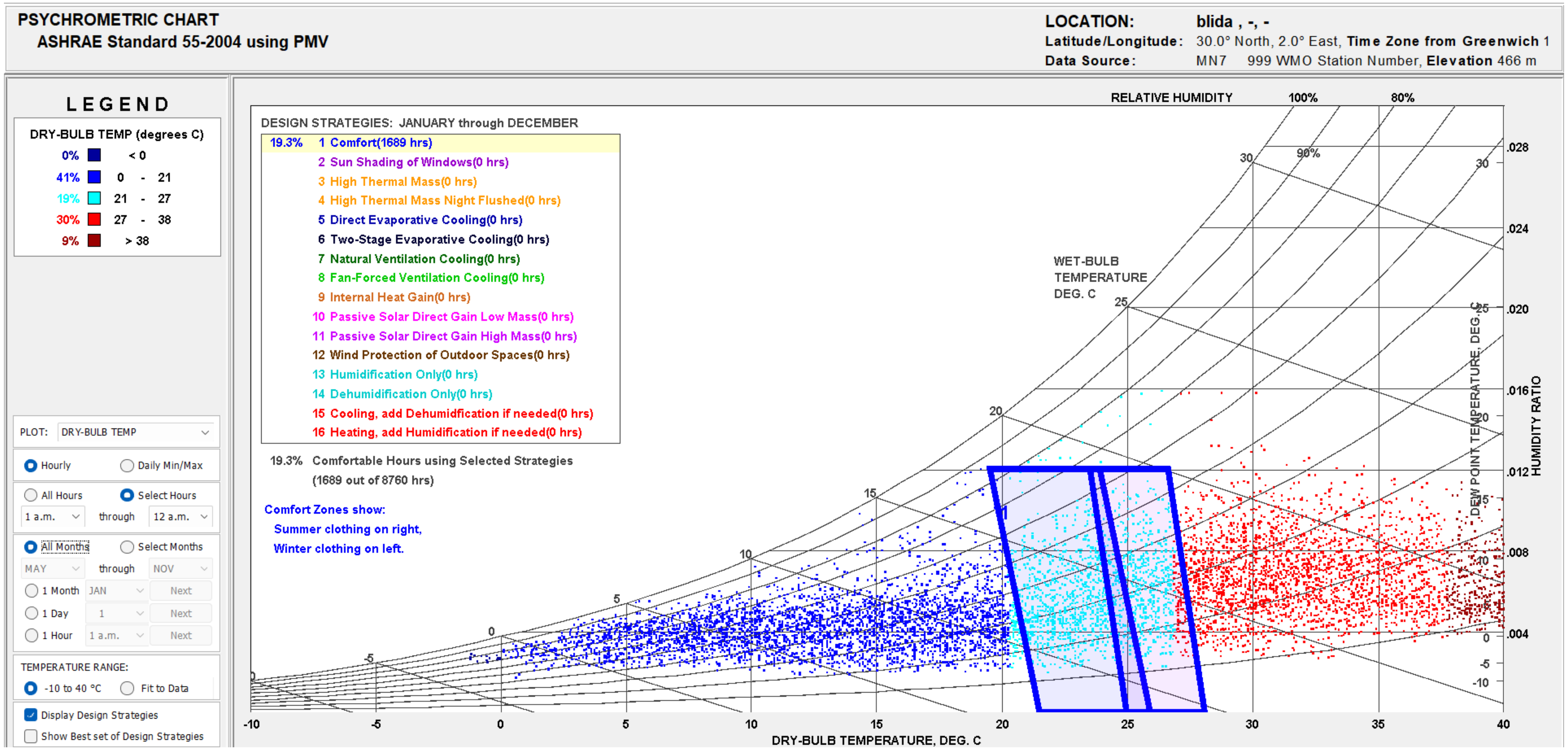


Figure 45 psychometric chart annual , climat consultant 2025

Based on the climatic analysis, Blida exhibits a typical Mediterranean climate, categorised as a dry bioclimatic stage. This is characterized by hot, arid summers and cold, humid winters.

Bioclimatic analysis using psychometric diagram (Sozoklay):

SUMMER SEASON PSYCHOMETRIC DIAGRAM :

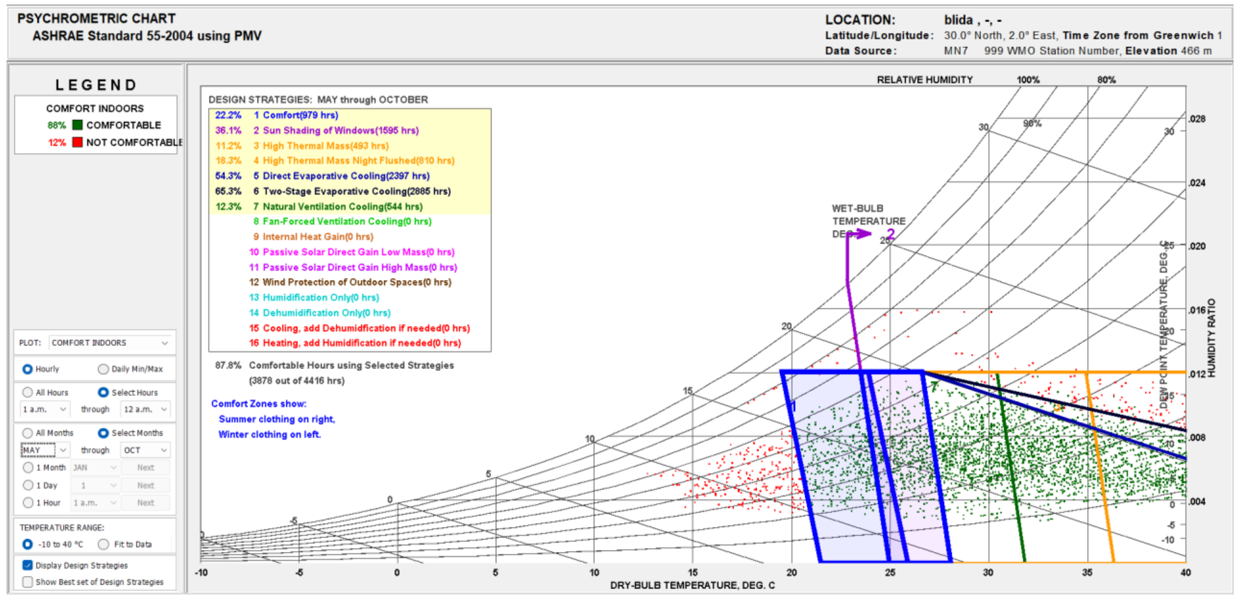


Figure 47 psychrometric chart summer season , climat consultant 2025

psychrometric chart for Blida, Algeria (May-October), shows indoor comfort based on ASHRAE Standard 55-2004. Key findings:

- **High Comfort:** 87.8% of the hours (3878 of 4416) are comfortable using selected strategies.
- **Effective Strategies:** Sun shading, evaporative cooling (both direct and two-stage), and natural ventilation are heavily utilized.
- **Warm Climate Emphasis:** The focus on cooling strategies highlights the warm climate during these months.
- **Potential Optimization:** While comfort is high, further analysis could explore optimization opportunities.

WINTER SEASON PSYCHOMETRIC DIAGRAM :

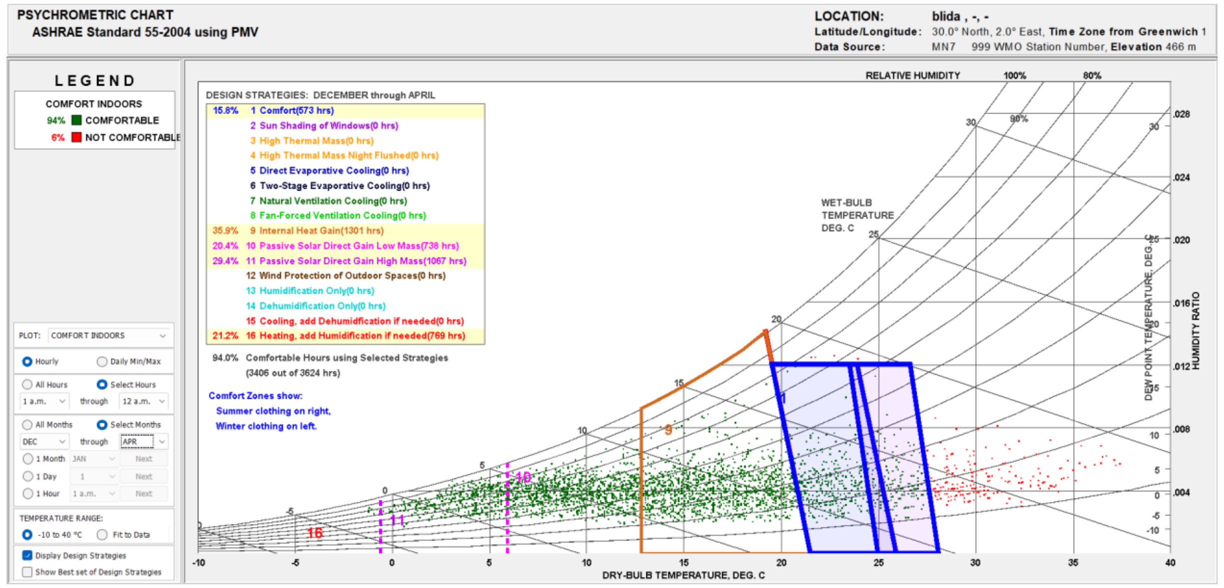


Figure 46 psychrometric chart winter season , climat consultant 2025

psychrometric chart for Blida, Algeria (Dec-Apr), shows indoor comfort. Key points:

- **High Comfort:** 94% of te hours (3406 of 3824) are comfortable with selected strategies.
- **Key Strategies:** Passive solar gain (both low and high mass) and internal heat gain are heavily utilized. Heating is also employed.
- **Cool Season Focus:** The emphasis on heating strategies reflects the cooler months.
- **Effective Design:** The strategies are well-suited for Blida's mild winter climate.

Figure 48 Table showing bioclimatic analysis

Synthèse : recommandations et principes climatiques

Maximize daylighting:

Design buildings with large windows and clerestories to maximize natural light and reduce the need for artificial lighting.

Figure 52 Daylight in the Downtown Area source : https://www.mdpi.com/2071-1050/14/2/774

Encourage natural ventilation:

Utilize operable windows, doors, and vents to allow for natural airflow and improve indoor air quality.

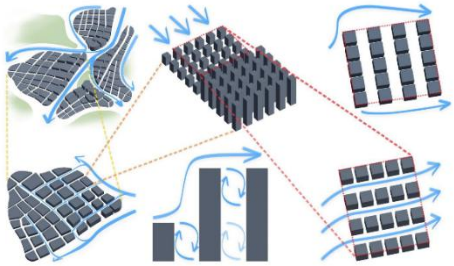


Figure 51urban ventilation at various levels of urban planning and design source : https://www.researchgate.net/figure/Impact-of-urban-form-on-urban-ventilation-at-various-levels-of-urban-planning-and-design_fig1_362540838

Urban Agriculture:

Incorporate urban farms and gardens to provide local food sources, improve air quality, and create green spaces.

Figure 50 Urban Agriculture source : Guidelines on Integrating Nature-based Passive Cooling Options into Urban Planning and Design2022

Water Features:

Incorporate ponds, fountains, and other water features to provide evaporative cooling and increase humidity.

Figure 53 water features source : Guidelines on Integrating Nature-based Passive Cooling Options into Urban Planning and Design 2022

Thermal Mass:

Incorporate materials like concrete, stone, and brick that store heat during the day and release it slowly at night, regulating indoor temperatures.

Figure 54 thermal mass source : youtube

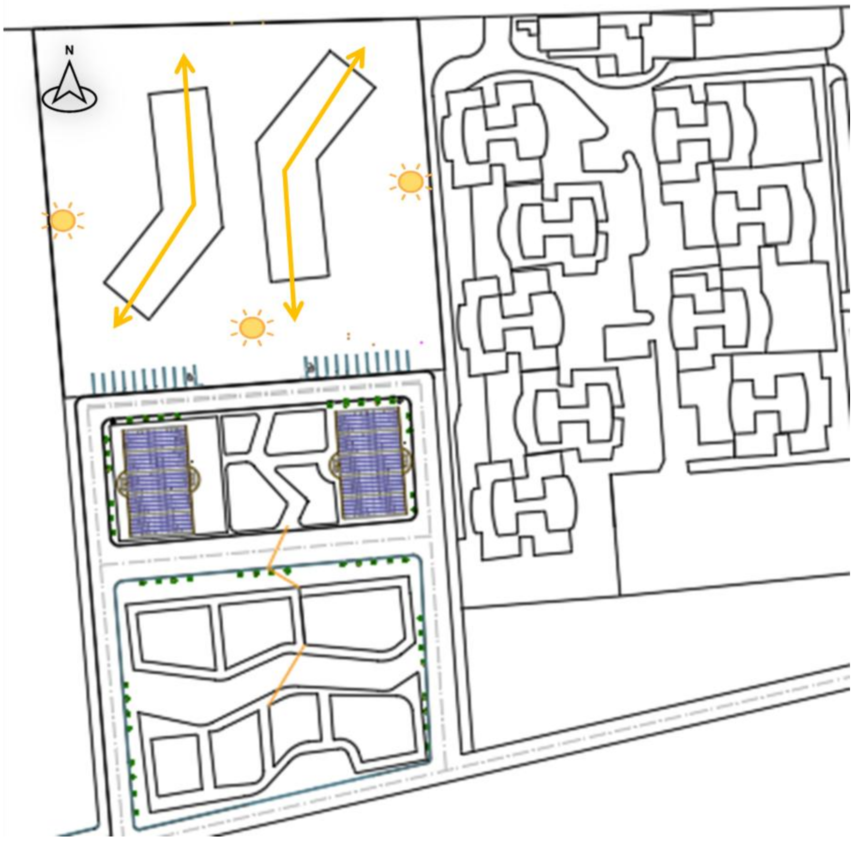


Figure 55 sunlight exposure

two parallel buildings oriented to maximize the exposure of their longest facades to sunlight.

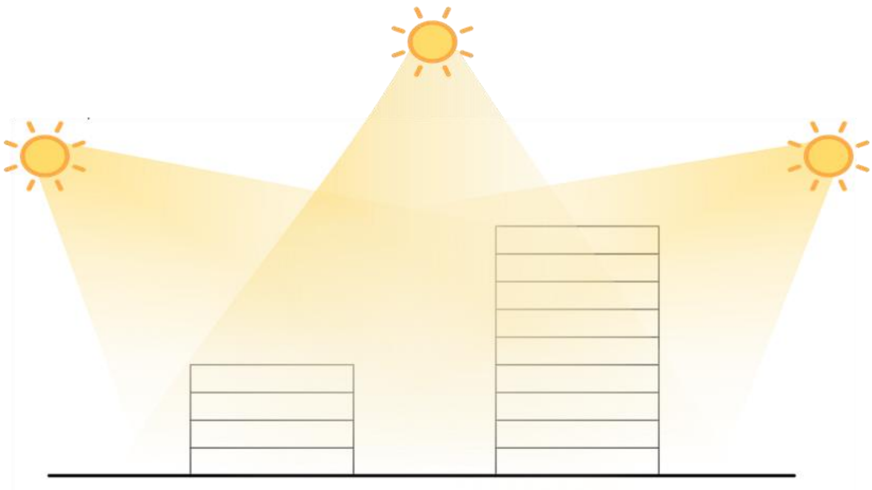


Figure 56Solar Path and Shading Analysis of Building Massing illustration   sourbe auther 2025

Figure 58wise wind effect

The association of buildings of different sizes and positioned parallel to each other creates a vertical vortex resulting from the downstream vortex effect

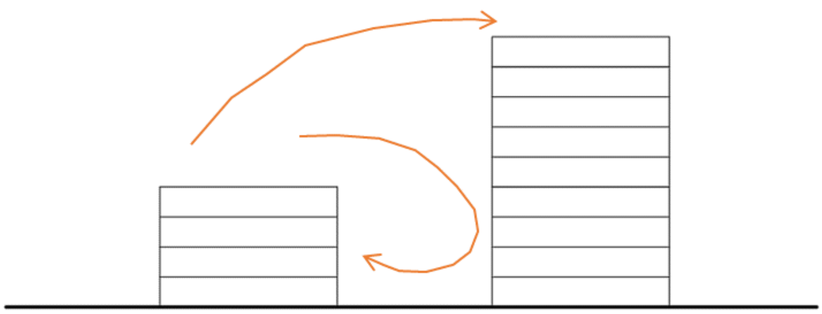


Figure 59wise effect wind illustration source auther 2025

I. Soft Mobility :

- **Maximize Distance from Mécanisa Routes :** Locate noise-sensitive areas away from roads ; utilize vegetation buffers.
- **Prioritize Ecological Movement:** Design a connected network of safe and shaded pedestrian pathways with permeable materials.
- **Peripheral Parking :** Locate parking on the site's edges to minimize vehicle-pedestrian conflict and encourage walking.
- **Integrated Site Map:** Clearly delineate mechanical circulation, pedestrian paths, and parking areas on the site plan.

II. Vegetation :

- **Strategic Windbreaks :** Plant wind-resistant native vegetation to reduce wind impact on buildings and outdoor spaces.
- **Noise-Buffering Green Barriers :** Implement dense vegetation along site boundaries to absorb and deflect noise pollution.
- **Passive Solar Shading :** Utilize deciduous trees and vegetated structures to provide shade in summer and allow winter sun.
- **Enhance Landscape Quality:** Incorporate diverse, native, and drought-tolerant plantings for aesthetics and ecological benefits.
- **Integrated Vegetation Map :** Clearly position vegetation types on the site map, indicating their primary protective function (wind, noise, shade).

III. Waste Management :

- **Strategic Waste Collection Points :** Locate accessible and clearly marked bins for different waste streams (general, recyclables, organic).
- **Facilitate Source Separation :** Provide color-coded recycling bins at all collection points.
- **Implement On-Site Composting (If Applicable) :** Designate a suitable area for composting organic waste.

- **Integrated Waste Management Map :** Clearly show the location of all waste collection points and composting areas on the site plan.

IV. Stormwater Management :

- **Utilize Permeable Paving :** Employ permeable materials for pathways and parking to encourage infiltration.
- **Implement Rain Gardens and Bioretention :** Design vegetated 1
- **Create Vegetated Swales :** Use planted channels to convey and filter stormwater.
- **Incorporate Infiltration Basins/Trenches :** Design areas for temporary stormwater storage and infiltration.
- **Explore Green Roof Technology :** Implement vegetated roofs to absorb Rainwater and provide insulation.
- **Consider Rainwater Harvesting :** Collect and store rainwater for non-potable uses.
- **Optimize Site Topography :** Grade the site to direct stormwater towards infiltration features.
- **Integrated Stormwater Management Map :** Clearly indicate the location of all stormwater management features and flow directions on the site plan.

V. Integration (Implicit in all strategies) :

- **Reduce Reliance on Mechanical Systems :** Soft mobility and passive cooling through vegetation minimize energy use.
- **Minimize Waste-Related Energy :** On-site composting and efficient recycling reduce transportation and processing energy.
- **Conserve Water Resources:** Permeable paving and rainwater harvesting reduce reliance on municipal water

IV The Architectural Project :

It's important to highlight that each architectural project is defined by its own unique set of needs. These needs are influenced by various factors, including the project's goals, its surrounding context, and the constraints set by stakeholders — all of which play a crucial role in shaping the design process.

1- The user category :

User Categories	**Qualification :**	**Quantification:**
Students	The primary residents, likely undergraduates, graduates, or international students. **Female student**	Number of beds, number of units, mix of single/double.
Staff	Resident assistants (RAs), maintenance personnel, cleaning staff, administrative staff.	Number of staff members
Visitors	Family members, friends visiting students.	Estimated visitor flow, especially during move-in/move-out, holidays
Faculty/Guest Lecturers	May stay temporarily in guest suites.	Number of guest suites

2- Functional Logic and Concepts Related to the Program :

Zoning Strategy :

The core logic revolves around a clear and hierarchical zoning of spaces :

- **Public Zone :** Easily accessible to all residents and potentially visitors. This includes entrance lobbies, common rooms, study areas, multi-purpose halls, circulation spaces (main corridors, stairwells near public areas), and potentially shared outdoor spaces.
- **Semi-Public/Semi-Private Zone :** Transitional spaces that might be shared by a smaller group of residents (e.g., within a floor or a cluster of rooms). This could

include shared kitchenettes, small lounges on each floor, or shared balconies accessible from a few rooms.

- **Private Zone :** Spaces dedicated solely to individual residents or small groups (e.g., individual dorm rooms, shared apartments for a few students). Access to these areas should be controlled and clearly defined.

the absolute *most* essential functions for student housing, the core three are:

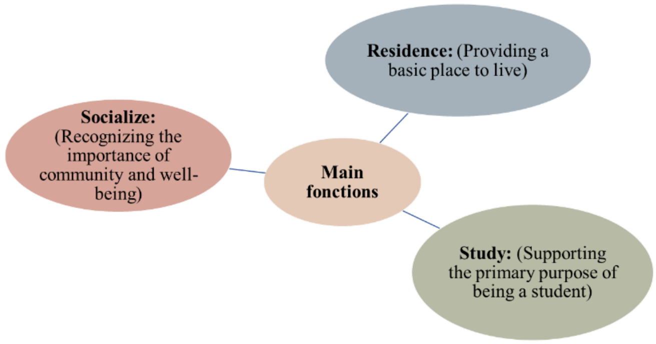


Figure 60 an image that shows the most important main function of the student housing

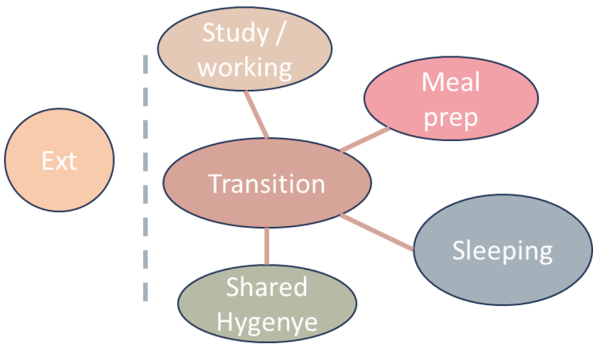


Figure 61 fonction the residential unit ,source: auther 2025

The residential unit was divided to be a space that would respond to the students' all needs, while studying and attending university at the same time. so the students don't have the need to leave the room to get things done

3- Spatial Organization of the Project :

The spaces on the all project are divided to go from public to semi-public then private to keep the same concept going on, so the first spaces would be such as the welcoming area that is for all the people that enter the building and from there the spaces get more private that only group of student use , as we get to the residential unit that would be just accessible just for for the students that lives in the room .

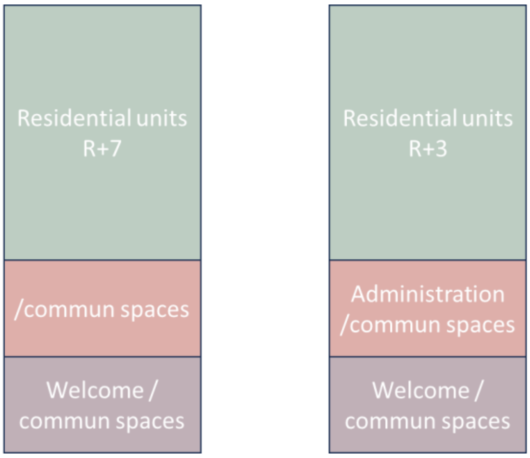


Figure 63 General Spatial organisation section of the student housing , source : auther 2025

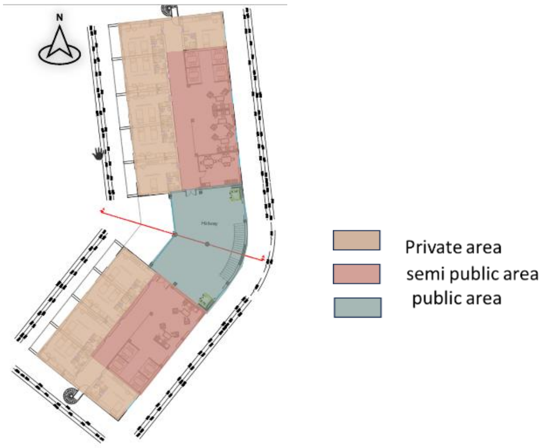


Figure 62General Spatial organisation plan of the student housing

4- Concepts Related to the Site

The noise pollution that is a main issue in the site and was the essential part to take into consideration in the site division whereas it showed in (figure 45) the need to create a secondary space that would work as a barrier for the noise .

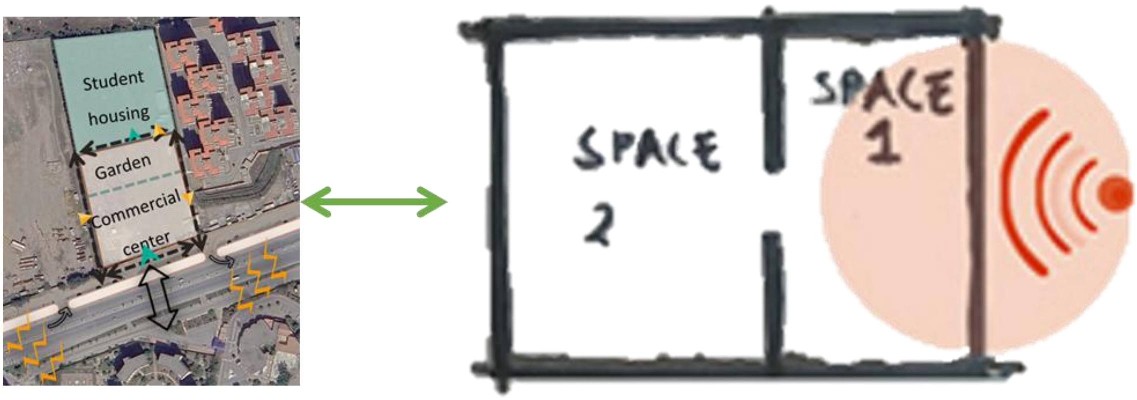
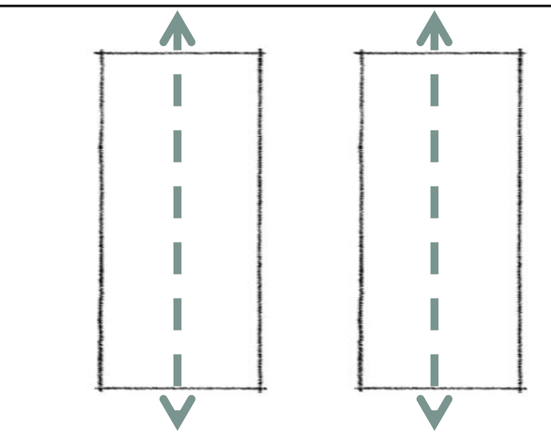
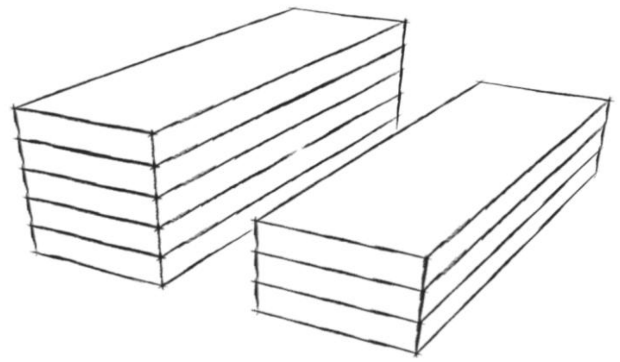
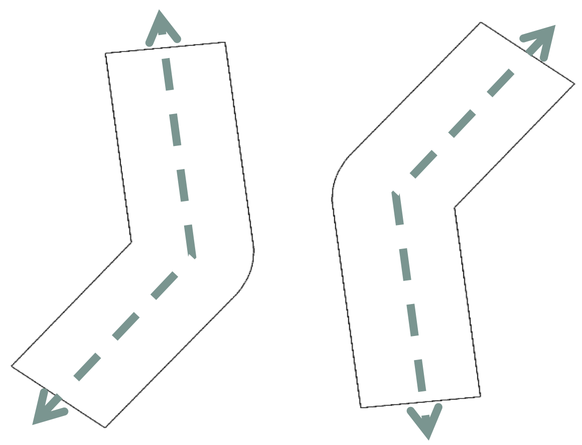
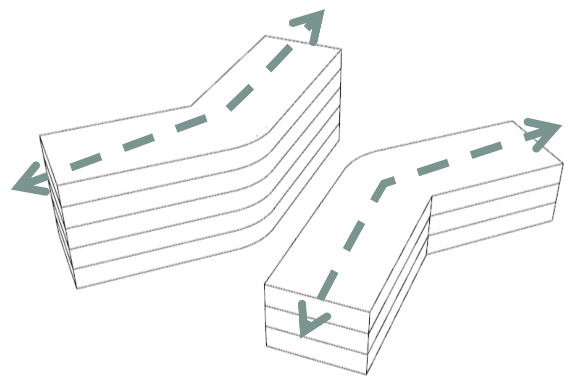
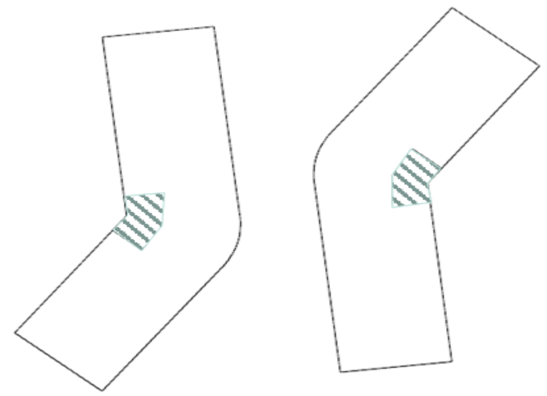
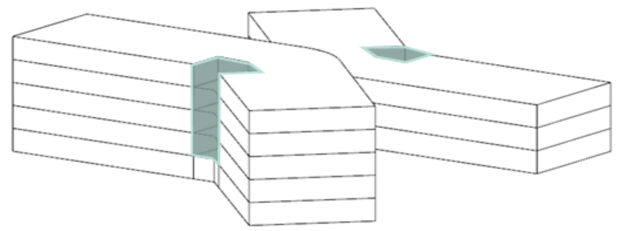
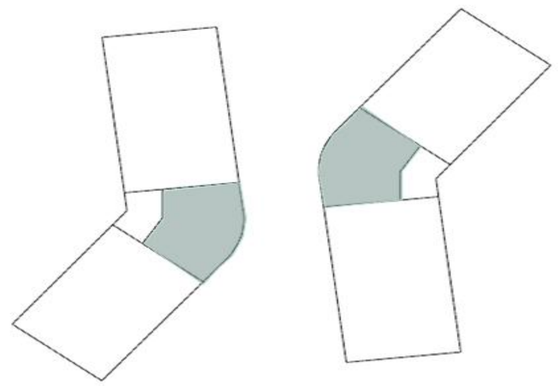
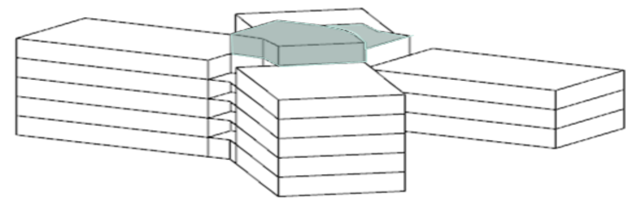


Figure 64illustration of the answers of the noise poluution in the site area

5- Genesis of the Project

The architectural design of this student residence emerges from a rigorous generative process, directly responding to site constraints, functional requirements, and the ambition for optimal environmental performance. The building's form results from logical manipulations of simple elements, optimizing habitability, natural light, ventilation, and contextual integration.

Genesis of the Project Form	Description :	2D	3D
The Elementary Module and Initial Flexibility:	Our formal starting point is the adoption of simple rectangular volumes. These modular blocks offer an efficient, repeatable, and pragmatic base for organizing residential units and ensuring high construction efficiency.		
Inflection and Contextual & Environmental Adaptation:	The initial rigidity of these blocks is softened by an inflection, where volumes are bent or articulated. This curvature directly addresses: •**Bioclimatic Orientation:** Optimizing façade orientation in Ouled Yaich to maximize passive solar gain in winter and minimize summer overheating, thereby contributing to the building's **energy efficient** performance. •**Natural Ventilation:** Creating openings and recesses that promote cross-ventilation and the stack effect, crucial for thermal comfort in the Algerian climate. •**Spatial Definition & Site Response:** Defining semi-private outdoor spaces or courtyards, structuring the site, and adapting to Ouled Yaich's topographical or urban context.		
Interconnection and the Creation of Active Voids:	The building's articulated blocks form complex interconnections, creating **junction points** and **carved-out voids** that serve as active elements: **Light and Ventilation Shafts:** These optimize natural light and ventilation across five levels, reducing the need for artificial lighting and mechanical conditioning. **Transition and Socialization Spaces:** Voids house vertical circulation, enlarged landings, or indoor gardens, fostering informal meetings and transitions between units and common areas, thus supporting student socialization. **Differentiation and Identification:** These elements give the building a unique identity and help users with orientation..		
Materialization of the Functional Program:	The form's genesis is intrinsically linked to the functional program. Each formal manipulation serves a programmatic intention: •Arranging modules for residential units. •Creating folds to frame common areas and internal courtyards for student social life and group activities.		

6- Facade Composition

The facade leans towards a **Contemporary** and **Modernist** style with elements of Biophilic design and Functionalism.

Contemporary/Modernist: the use the clean lines, geometric forms, large windows, and the use of modern materials. The emphasis is on simplicity, efficiency, and a lack of excessive ornamentation.

Biophilic Design: The integration of greenery on the facade (vertical elements, likely planters or climbing systems) and the visible green spaces in the foreground strongly suggest a connection to nature, which is a core principle of biophilic design.

Functionalism: The design prioritize the practical aspects of the building, that shows in natural light (large windows), outdoor spaces (balconies/terraces, rooftop), and potentially ventilation, which aligns with functionalist principles.

Figure 65 3d view of the facade

7- Structural System and Construction Technologies

A dilatation joint, also known as an expansion joint, is a critical component in various structures, particularly those constructed with materials susceptible to dimensional changes due to thermal expansion and contraction. Its primary function is to create a controlled break in the continuous material, allowing for movement without inducing damaging stresses or cracks in the structure.

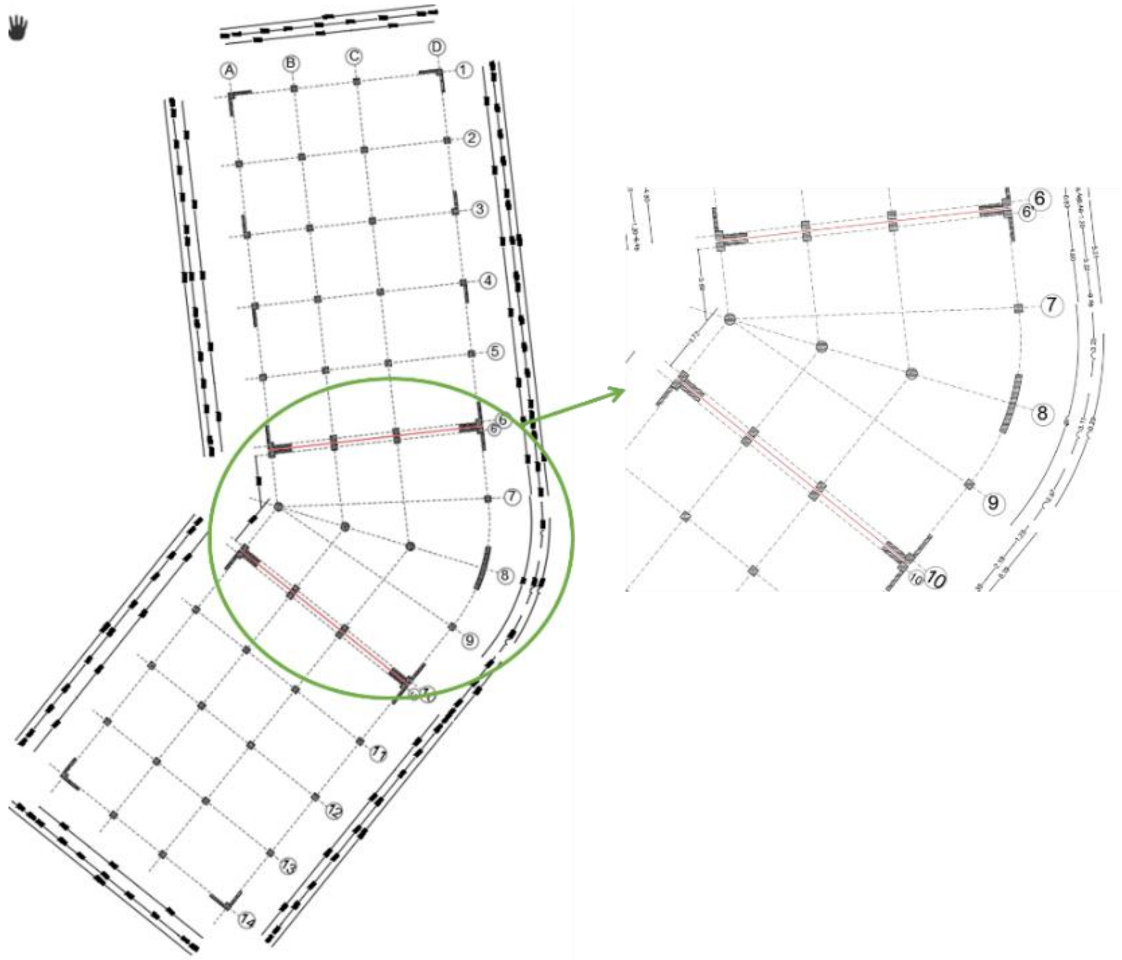


Figure 66 structural plan to show the joints of the building , source autocad 2025

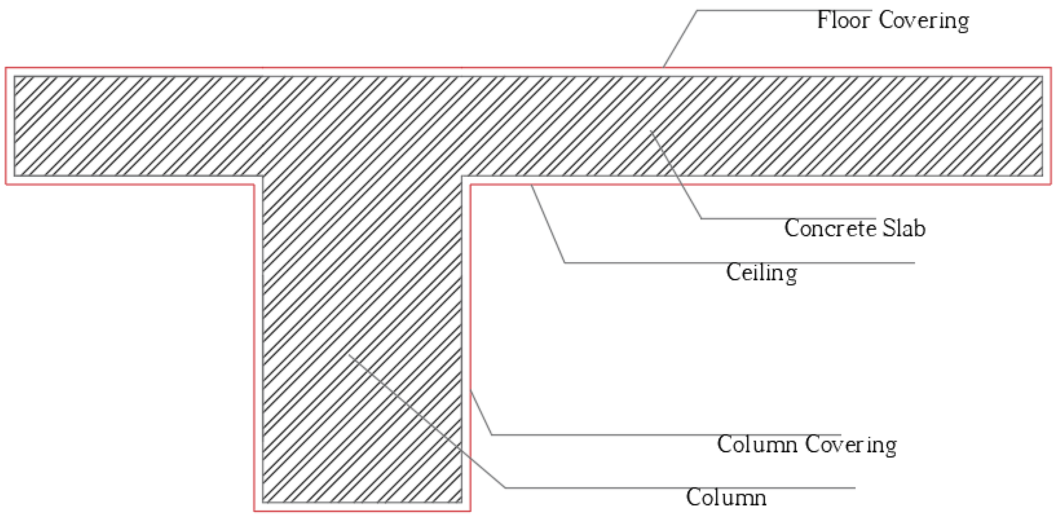


Figure 67 Cross-Sectional Detail of full Concrete Slab and Column Connection source : autocad 2025

The structural floors and roof of the project were constructed using a full slab concrete method. A solid concrete slab is positioned between supporting components, usually beams or columns, in this design. The cross-sectional detail demonstrates the continuity of the concrete material for both the horizontal slab and the vertical support, demonstrating how the concrete slab integrates with a supporting column. The building's structural system is strong and monolithic thanks to the full slab construction.

The action final plan :

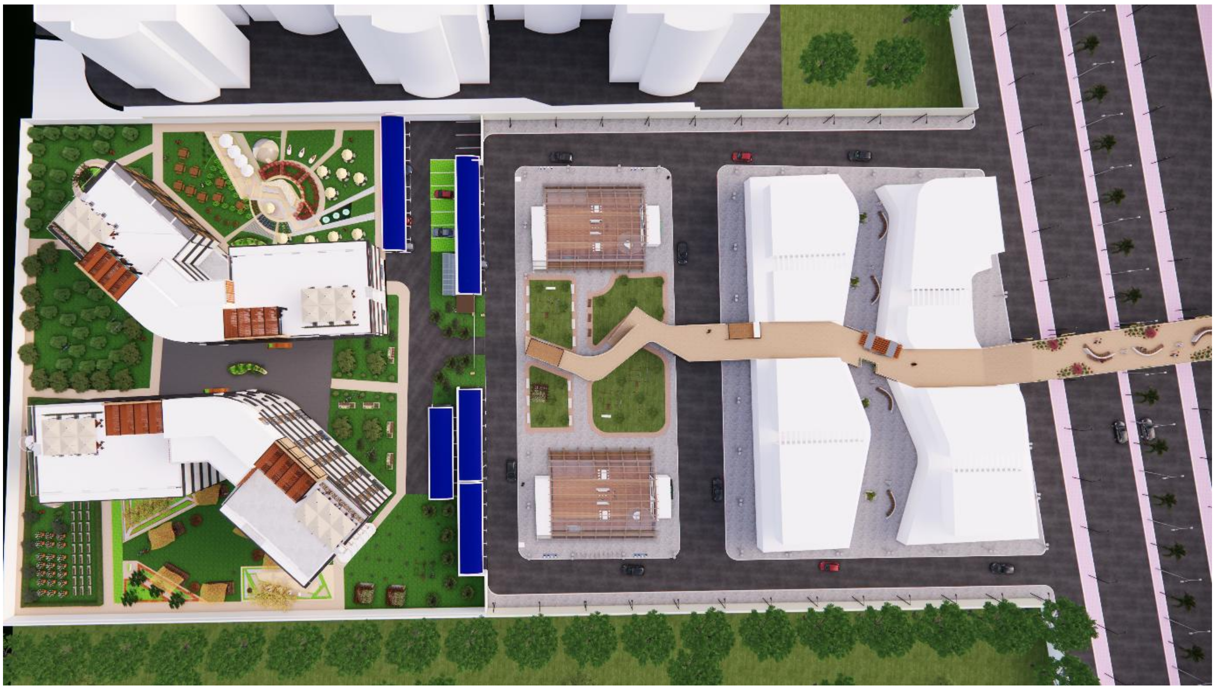


Figure 68 3d representation of the action plan

Figure 69 the exterior spaces and the mass plan of projet

Conclusion :

This case study details the design of a sustainable Female student housing complex in Blida, Algeria, addressing the growing need for modern, eco-conscious living spaces for students.

Blida, a strategically located city, has experienced significant urban development, though often uncontrolled, leading to challenges like a lack of architectural identity and green spaces, particularly in the Ouled Yaïch area. Analyses of the site revealed good connectivity but also deficiencies in vegetation and pedestrian infrastructure. Climatic assessment identified Blida's Mediterranean climate as challenging, with natural comfort achieved only 19.3% of the year, necessitating bioclimatic strategies for cooling in summer and heating in winter.

The architectural design was developed through a rigorous process, aiming for optimal environmental performance, habitability, and contextual integration. Key design concepts included hierarchical spatial zoning to meet student needs and sustainable site integration strategies such as promoting soft mobility, strategic vegetation, waste management, and stormwater control. The structural system utilized a full slab concrete method for a robust build.

This project demonstrates a comprehensive approach to creating environmentally conscious and comfortable student living environments, tailored to Blida's specific urban and climatic context.

Chapter IV : SIMUATION.

Chapter IV : simulation.

4.1. Introduction :

4.2. General Information on Dynamic Thermal Simulation (DTS).

4.2.1. Definition of DTS:

Dynamic thermal simulation (DTS) is a computer based modeling technique that simulates and predicts building thermal performance. This simulation considers aspects like building materials, room arrangement, and ventilation, heating, and cooling systems, as well as the weather outside.

4.2.2. Objectives of DTS :

Dynamic Thermal Simulation (DTS) is a sophisticated computational modeling technique that provides a comprehensive understanding of a building's transient thermal behavior under dynamic environmental and operational conditions. The primary objectives for employing DTS in architectural and building science research and practice are to:

- Benefits and Objectives of Building Performance Simulation:

1. Quantify and Optimize Building Energy Performance:

- Accurately predict and analyze building heating, cooling, and overall energy consumption.
- Evaluate the energy impact of design choices (orientation, envelope, windows, thermal mass, shading).
- Optimize designs for enhanced energy efficiency, reducing costs and carbon footprint. Demonstrate compliance with energy codes and regulations.

2. Assess and Enhance Indoor Environmental Quality (IEQ) with a Focus on Thermal Comfort:

- Predict internal air temperatures, radiant temperatures, and humidity for detailed thermal comfort analysis (e.g., PMV/PPD).
- Identify and mitigate overheating risks through heat gain analysis and cooling strategies.
- Inform optimal thermal comfort strategies via passive design and mechanical system integration.

3. Evaluate and Integrate HVAC System Performance:

- Determine appropriate HVAC sizing and selection based on dynamic building loads.
- Simulate and optimize HVAC system performance, control strategies, and operational schedules.
- Analyze the synergistic relationship between the building envelope and HVAC efficiency for integrated design.

4. Inform and Validate Design Decision-Making:

- Provide data-driven insights into the impact of architectural design on thermal performance.
- Quantify benefits of passive strategies (shading, daylighting, thermal mass) to reduce active system reliance.
- Serve as an analytical tool for comparing design iterations and facilitating optimization.

5. Support Sustainability and Resilience Initiatives:

- Estimate operational carbon emissions for environmental impact assessments and reporting.
- Support green building certifications through verifiable performance data.
- Assess building resilience to future climate change scenarios and extreme weather events.

4.2.3. Selection of DTS Tools (Software):

4.2.3.1. Presentation of DesignBuilder.

DesignBuilder is a software that provides a graphical interface for the EnergyPlus calculation engine. It's a comprehensive tool for energy analysis and building design, offering features like calculating heat loss/gain, sizing heating and cooling systems (including natural ventilation), and performing dynamic simulations for assessing comfort, thermal balance, and ventilation. The software includes 3D modeling with shadow visualization, a building modeler with wizards, and detailed management of building operations. It also incorporates energy-saving functions and provides a library of materials, natural lighting calculations, and RT2012 compliance. In essence, DesignBuilder is a complete solution for designing energy-efficient buildings.

4.2.3.2. Presentation of Meteonorm:

PMV/PPD The global climatological database Meteonorm (www.meteonorm.com) is widely used as meteorological input for simulation of solar applications and buildings. It's a combination of a climate database, a spatial interpolation tool and a stochastic weather generator. Like this typical years with hourly or minute time resolution can be calculated for any site. (J. Remund ,2010)

4.3. Simulation Process using DesignBuilder :

4.3.1. Simulation Method.

This research embarks on a detailed investigation into the thermal performance of a student residence unit through a robust simulation methodology. The primary objective is to systematically evaluate the distinct impacts of various glazing systems on both the thermal comfort experienced by occupants and the overall energy consumption of the unit. Given the increasing global emphasis on sustainable building practices and the significant role of the building envelope in energy efficiency, understanding how different window technologies influence indoor conditions is paramount. This study aims to quantify these effects, providing data-driven insights into how strategic glazing choices can contribute to creating more comfortable living environments for students while simultaneously minimizing the operational energy demand associated with heating and cooling. By employing advanced simulation techniques, this research seeks to identify optimal glazing solutions that balance indoor environmental quality with energy efficiency goals, thereby informing future design and construction decisions for similar residential facilities.

1.3.1. Presentation of Case Study:

1.3.1.1. Division of the Project into Thermal Zones.

The chosen residentiel is conciderd like the least favorabale residential unit , For precise thermal simulation, the student residential unit is separated into distinct thermal zones based on function and thermal properties. This segmentation enables precise modeling of heat transmission and comfort assessments in each location.

The unit logically divides into three basic heat zones :

- The main living/sleeping area is the largest and most occupied zone, with high external exposure and continuous internal heat gains.
- Kitchenette : A discrete zone created by intermittent, high internal heat increases from cooking appliances.
- Bathrooms are distinguished by transient high humidity and temperature changes caused by hot water use, necessitating specialized ventilation.

Figure 71: Typical Student Residence Unit Layout (26m^2) source : SketchUp, author 2025 .

Figure 70 : Thermal Zoning Diagram of the Student Residence Unit ;source : design builder , auther ,2025

1.3.1.2. Thermal Propities of Materials :

The wall's opaque portions would be simple and would probably include:

An outside layer, like plaster or a basic weatherproof finish.

- **An Outer Layer:** Such as plaster or a simple finish for weather protection.
- **A Core Material:** This could be a solid, medium-density material like brick, providing some thermal mass to absorb and slowly release heat.
- **An Inner Finish:** A simple plaster or drywall for the interior surface.

The main thermal control mechanism moves to the thoughtful positioning and kind of glazing, even though some simple insulation may be incorporated into the core material or applied as a thin coating. For instance, even in the absence of highly insulated opaque walls, **double or triple-pane windows** would be essential to reducing heat intake in the summer and loss in the winter.

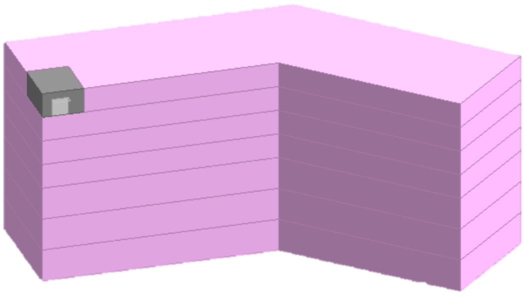


Figure 73 3D image that shows the studied area , source : design builder 2025

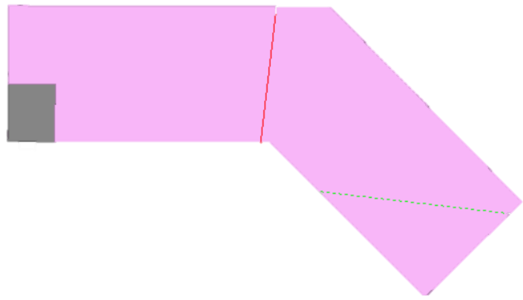


Figure 72 2D image that shows the studied area , source : design builder 2025

Layer Position	Material	Thickness (m)
Outermost	Brickwork	0.1000
Layer 2	XPS Extruded Polystyrene - CO2 Blowing	0.0795
Layer 3	Brickwork	0.1000
Innermost	Gypsum Plastering	0.0130

Tableau 1 Thermal Properties of Multi-Layered Wall Materials, source : design builder 2025

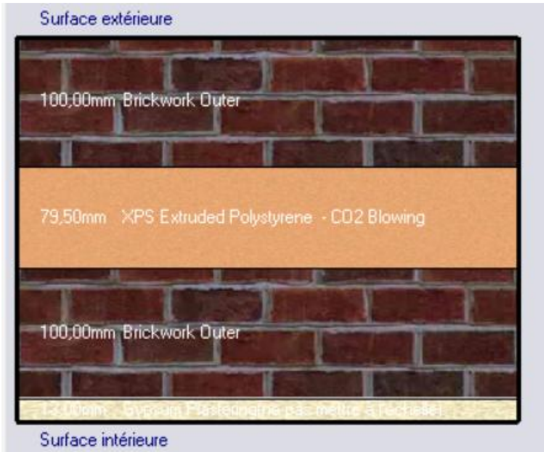


Figure 74 Brick Material Thermal and Surface Properties, source: design builder 2025

This brick and concrete block material's characteristics include its thermal properties, vapor and humidity transfer data, and surface attributes. Key figures are a conductivity of 0.8400 W/m-K, specific heat of 800.00 J/Kg-K, and density of 1700.00 kg/m^3. It also features a vapor resistivity of 40 MNs/g.m and strong absorption across thermal, solar, and visible light spectra (all 0.700 or higher), presented with a "Red brick with light grout" color and a rough finish. These details are vital for assessing its suitability in construction applications.

1.3.2. Definition and Integration of Operational Scenarios.

4.3.3. Studied Variants:

This study defined three operational scenarios to assess project performance under various conditions, enabling robust analysis of system behavior, efficiency, and adaptability.

4.3.3.1. Selection of Studied Variants :

This study systematically investigates three distinct glazing options—simple, double, and triple glazing—each with varying properties. These different glazing configurations were integrated as operational scenarios to rigorously assess their individual impacts on the building's thermal performance, energy consumption, and overall efficiency, providing a comprehensive understanding of their suitability for various building designs and climates.

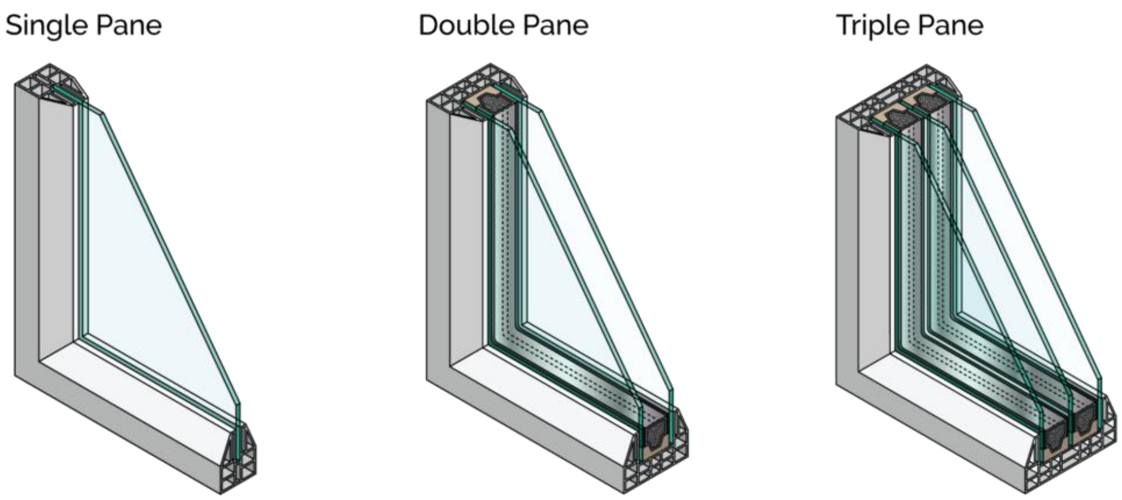


Figure 75 types of glazing glass, source : https://efficientwindows.org/window-glazing/

4.3.3.2. Presentation of Studied Variants.

a) Studied Variant num 01 : **Simple Glazing**

Single glazing refers to a single pane of glass, which is the most basic and least insulated type of glazing. According to the provided data for a specific glazing material, it has a thickness of 0.006 meters (6 mm) and a conductivity of 0.090 W/m-K.

In terms of solar properties, it has a solar transmission of 0.48, with both exterior and interior solar reflection factors of 0.05. For visible radiation, it exhibits a transmission of

0.57, and both interior visible solar reflection factor and interior solar reflection factor are 0.06. Infrared transmission for this single glazing is 0.00, and both exterior and interior emissivity are 0.84.

Category	Property	Value
Thermal Properties	**Thickness (mm)**	**06,00**
	Conductivity (W/m-K)	**00,90**
Solar Properties	**Solar Transmission**	**00,48**
	Exterior Solar Reflection Factor	**00,05**
	Interior Solar Reflection Factor	**00,05**
Visible Radiation Properties	**Visible Radiation Transmission**	**00,57**
	Interior Visible Solar Reflection Factor	**00,06**
	Interior Solar Reflection Factor	**00,06**
Infrared Properties	**Infrared Transmission**	**00,00**
	Exterior Emissivity	**00,84**
	Interior Emissivity	**00,84**

Tableau 2single Glazing Material Thermal, Solar, and Radiation Properties, source : design builder 2025

Simulation results of operative temperature:

	Jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
air tempreture (°C):	15,08	16,37	19,69	22,97	26,11	31,34	34,6	34,69	30,23	26,41	19,69	16,18
Radiant Temperature (°C)	15,04	16,41	19,83	23,26	26,4	31,83	35,07	35,15	30,58	26,63	19,73	16,14
Operative Temperature (°C)	15,06	16,39	19,76	23,12	26,26	31,59	34,84	34,92	30,4	26,52	19,71	16,16

Tableau 3 Monthly Air, Radiant, and Operative Temperatures, source :design builder 2025

This table analyzes monthly air, radiant, and operative temperatures. All 3 shows clear seasonal trends, with peak operative temperature at 34.92 °C in August and lowest at 15.06 °C in January. Temperatures remain very close, with radiant often slightly above air (e.g., in August, radiant is 35.15 °C vs. Air 34.69 °C), and operative temperature consistently falling in between, reflecting perceived comfort.

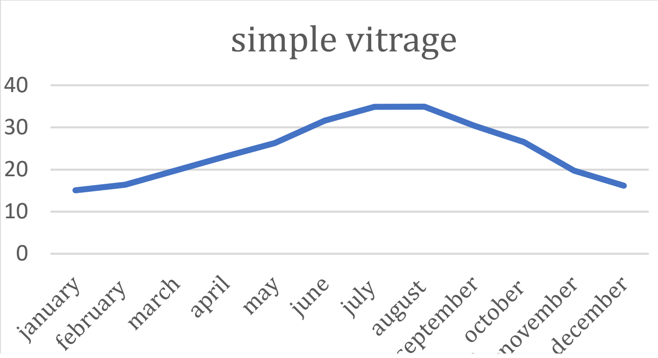


Figure 76 The graph shows a clear seasonal pattern for operative temperature with simple glazing , excel 2025

The graph shows a clear seasonal pattern for operative temperature with simple glazing. Temperatures start low in winter, gradually increase through spring, reach their peak in summer (July and August), and then decline through autumn into winter again. The highest operative temperatures appear to be around 34-35 °C in July and August, while the lowest are around 15-16 °C in January and December.

b) Studied Variant num 02 : **double Glazing :**

Double glazing refers to an insulated glass unit (IGU) consisting of two panes of glass separated by a sealed gap. According to the provided data for a specific double glazing unit named "Double Glazing Unit: Solar Control Silver (Outer) with Argon 6mm Gap and Arctic Blue (Inner)", it comprises an outermost pane of PFG Building Glass SolarShield S30 Silver and an innermost pane of Pilkington 6mm Arctic Blue, separated by a 6mm Argon gas gap.

The properties of its individual glass panes are as follows:

Outer Pane (PFG Building Glass SolarShield S30 Silver):

- **Thermal Properties:** Thickness of 6.13600 mm and conductivity of 0.81300 W/m-K.
- **Solar Properties:** Solar transmission of 0.28000, exterior solar reflection factor of 0.18000, and interior solar reflection factor of 0.17500.
- **Visible Radiation Properties:** Visible radiation transmission of 0.35100, interior visible solar reflection factor of 0.19500, and interior solar reflection factor of 0.18000.

Inner Pane (Pilkington 6mm Arctic Blue):

- **Thermal Properties:** Thickness of 5.95000 mm and conductivity of 1.00000 W/m-K.
- **Solar Properties:** Solar transmission of 0.34500, and both exterior and interior solar reflection factors of 0.05000.

- **Visible Radiation Properties:** Visible radiation transmission of 0.54000, and both interior visible solar reflection factor and interior solar reflection factor of 0.05700.

Layer Position	Material	Gas Gap (Thickness)
Outermost Pane	PFG Building Glass SolarShield S30 Silver	6MM
Gap	ARGON	6MM
Innermost Pane	Pilkington 6mm Arctic Blue	6MM

Tableau 4double Glazing Unit: PSGilding SolarShield Details ,source: design builder 2025

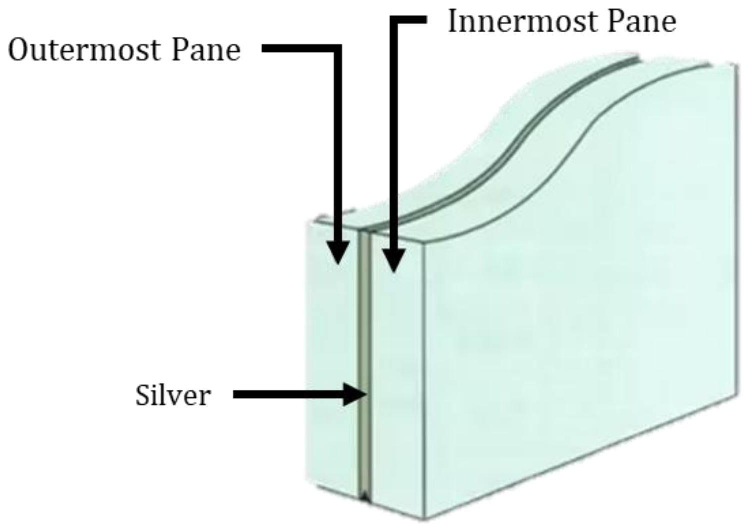


Figure 77 schema double Glazing Unit: PSGilding SolarShield Details ,source: auter 2025

This triple glazing unit's structure is detailed by its components and their specific thicknesses. It comprises an outermost pane of "PFG Building Glass SolarShield S30 Silver," an internal "Gap" filled with "ARGON" gas, and an innermost pane of "Pilkington 6mm Arctic Blue" glass. All three elements, including both glass panes and the gas gap, are consistently 6mm thick.

Property	Pilkington 6mm Arctic Blue Value	PFG Building Glass SolarShield S30 Silver Value
Thermal Properties		
Thickness (mm)	5.95000	6.13600
Conductivity (W/m-K)	1.00000	0.81300
Solar Properties		
Solar Transmission	0.34500	0.28000
Exterior Solar Reflection Factor	0.05000	0.18000
Interior Solar Reflection Factor	0.05000	0.17500
Visible Radiation Properties		
Visible Radiation Transmission	0.54000	0.35100
Interior Visible Solar Reflection Factor	0.05700	0.19500
Interior Solar Reflection Factor	0.05700	0.18000
Infrared Properties		
Exterior Emissivity	0.84000	0.84000
Interior Emissivity	0.84000	0.84000

Tableau 5 double Glazing Material Thermal, Solar, and Radiation Properties, source : design builder 2025

Simulation results of operative temperature:

	jan	feb	mar	Apr	may	jun	jul	aug	sept	oct	nov	dec
air tempreture (°C):	14,43	15,4	18,4	21,41	24,4	29,23	32,41	32,66	28,74	25,23	18,93	15,51
Radiant Temperature (°C)	14,29	15,3	18,37	21,46	24,45	29,48	32,66	32,91	28,91	25,29	18,86	15,36
Operative Temperature (°C)	14,36	15,35	18,38	21,46	24,42	29,36	32,53	32,78	28,82	25,26	18,89	15,44

Tableau 6double glazing Monthly Air, Radiant, and Operative Temperatures, source :design builder 2025

This table analyzes monthly air, radiant, and operative temperatures. All three exhibit seasonal trends, peaking at around 32-33 °C in July/August and dropping to about 14-15 °C in January. Temperatures stay very close, with radiant slightly above air, and operative temperature between the two, indicating perceived comfort.

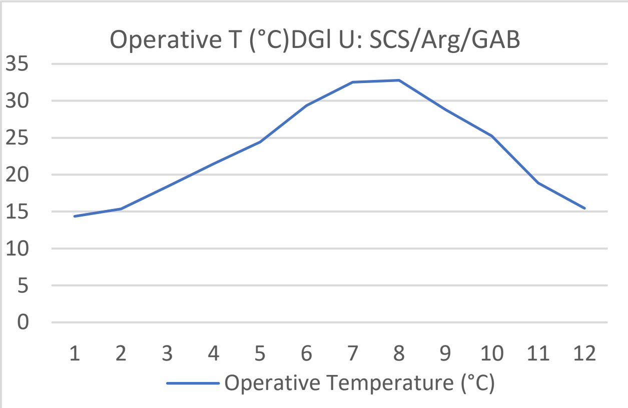


Figure 78The graph shows a clear seasonal pattern for operative temperature with double glazing, excel 2025

The graph "Operative T (°C) DGI U: SCS/Arg/GAB"[20] shows monthly operative temperatures for a double glazing unit. Temperatures exhibit seasonal variation, peaking around 32-33°C in July/August and dropping to 14-18°C in winter months (1-3, 11-12).

c) Studied Variant num 03 : **triple Glazing :**

Triple glazing refers to an insulated glass unit (IGU) composed of **three panes of glass**. These panes are separated by two sealed gaps, which are typically filled with an inert gas to enhance thermal insulation. For instance, a specific triple glazing unit, "SageGlass Climatop Blue No Tint," utilizes two 12mm Krypton gas gaps.

This type of glazing significantly improves thermal performance by reducing heat transfer compared to single or double glazing. It often incorporates specialized glass types for specific functionalities. For example, the "SageGlass Climatop Blue No Tint" unit includes an outermost pane of SAGE Electrochromics Inc. SageGlass Blue 9mm laminated glass, a middle pane of Cardinal Glass Industries Float Glass - 4mm, and an innermost pane of Cardinal Glass Industries LoE 180 on 4mm Clear.

Layer Position	Material	Gas Gap (Thickness)
Outermost Pane	SAGE Electrochromics Inc. SageGlass Blue 9mm	9mm
Window Gas 1	KRYPTON	12MM
Pane 2	Cardinal Glass Industries Float Glass	4mm
Window Gas 2	KRYPTON	12MM
Innermost Pane	Cardinal Glass Industries LoE 180 Clear	4mm

[20] Double Glazing Unit: Solar Control Silver (Outer) with Argon 6mm Gap and Arctic Blue (Inner)

property	SAGE Electrochromics Inc. SageGlass Blue 9mm lami full clear Value	Cardinal Glass Industries Float Glass - 4mm <Clr-4.CIG> Value
Thermal Properties		
Thickness (mm)	8.76000	3.90000
Conductivity (W/m-K)	0.72700	1.00000
Solar Properties		
Solar Transmission	0.25600	0.82400
Exterior Solar Reflection Factor	0.05900	0.07400
Interior Solar Reflection Factor	0.11800	0.07400
Visible Radiation Properties		
Visible Radiation Transmission	0.45300	0.90100
Visible Reflection Factor (Exterior)	0.04800	0.08200
Visible Reflection Factor (Interior)	0.02800	0.08200
Infrared Properties		
Infrared Transmission	0.00000	0.00000
Exterior Emissivity	0.83900	0.84000
Interior Emissivity	0.14000	0.84000

Tableau 7triple Glazing Material Thermal, Solar, and Radiation Properties, source : design builder 2025

This table compares two glass types: "SAGE Electrochromics Inc. SageGlass Blue 9mm lami full clear" and "Cardinal Glass Industries Float Glass - 4mm <Clr-4.CIG>". SageGlass is thicker (8.76000 mm vs. 3.90000 mm) and has lower conductivity (0.72700 W/m-K vs. 1.00000 W/m-K), making it a better insulator. Cardinal Glass has higher solar (0.82400 vs. 0.25600) and visible light (0.90100 vs. 0.45300) transmission. SageGlass also features significantly lower interior emissivity (0.14000 vs. 0.84000), enhancing its thermal performance.

Simulation results of operative temperature:

	jan	feb	mar	apr	may	jun	jul	aug	sept	oct	nov	dec
air tempreture (°C):	14,85	16,01	19,11	22,2	25,22	30	33,45	33,63	29,51	25,92	19,4	15,96
Radiant Temperature (°C)	14,78	16	19,19	22,41	25,41	31	33,83	34,01	29,79	26,09	19,41	15,89
Operative Temperature (°C)	14,82	16,01	19,15	22,31	25,31	30	33,64	33,82	29,65	26	19,41	15,93

Tableau 8 triple glazing Monthly Air, Radiant, and Operative Temperatures, source :design builder 2025

The table analyzes monthly air, radiant, and operative temperatures. All 3 shows seasonal trends, peaking around 33-34 °C in July/August and dropping to about 14-15 °C in January. Temperatures stay very close, with radiant slightly above air, and operative temperature between the two, indicating perceived comfort.

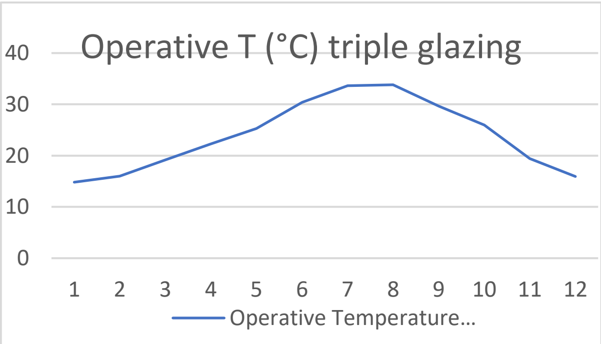


Figure 79 The graph shows a clear seasonal pattern for operative temperature with triple glazing, excel 2025

The graph "Operative T (°C) triple glazing" shows monthly operative temperatures for triple glazing. Temperatures follow seasonal trends, peaking around 34°C in July/August and dropping to about 15°C in January/December.

4.4. Results Obtained and Discussion.

	jan	feb	mar	apr	may	jun	jul	aug	sept	oct	nov	dec
Operative T (°C) simple glazing	15,06	16,39	19,76	23,12	26,26	32	34,84	34,92	30,4	26,52	19,71	16,16
Operative T (°C) double glazing	14,36	15,35	18,38	21,46	24,42	29	32,53	32,78	28,82	25,26	18,89	15,44
Operative T (°C) Triple Glazing	14,4	15,5	18,64	21,77	24,78	30	33,08	33,22	29,15	25,5	19	15,5

Tableau 9 Monthly Operative Temperature Comparison for Simple, Double, and Triple Glazing source : excel 2025

1. **Seasonal Trend:**

All three glazing types exhibit a clear seasonal pattern in operative temperatures. Temperatures are lowest in winter months (January, February, December), gradually increase through spring, peak in summer (July, August), and then decrease through autumn.

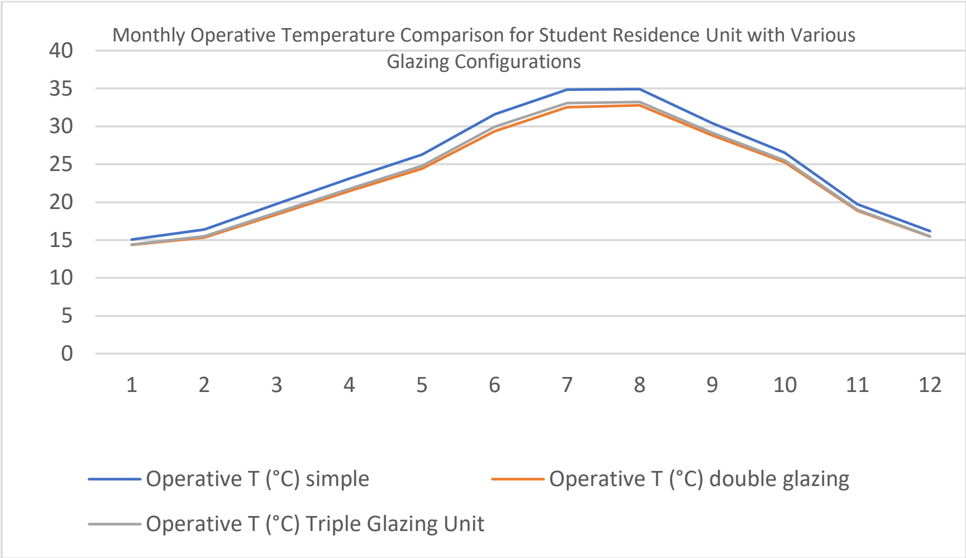
2. **Performance Comparison:**

- **Simple Glazing:** Consistently shows the highest operative temperatures during the warmer months and the highest overall operative temperatures. For example, in August, it peaks at 34.92 °C. In cooler months like January, it records 15.06 °C. This indicates poor insulation and high heat gain/loss.
- **Double Glazing:** Demonstrates a reduction in operative temperatures compared to simple glazing, particularly during the peak summer months. Its peak in August is 32.78 °C, which is lower than simple glazing's 34.92 °C. In January, it shows 14.36 °C. This suggests improved thermal performance and better control over temperature fluctuations.
- **Triple Glazing:** Generally maintains the lowest operative temperatures across the board, especially during summer. Its August peak is 33.22 °C, which is slightly higher than double glazing, but overall offers a more stable profile. In January, it records 14.4 °C. The differences between double and triple glazing are less pronounced than between simple and double, especially in cooler months, suggesting that while triple glazing offers superior insulation, its impact on operative temperature might be more significant in extreme conditions or for very precise comfort requirements.

5. **Temperature Range:**

- Simple Glazing: Ranges from 15.06 °C (Jan) to 34.92 °C (Aug), a range of 19.86 °C.
- Double Glazing: Ranges from 14.36 °C (Jan) to 32.78 °C (Aug), a range of 18.42 °C.
- Triple Glazing: Ranges from 14.4 °C (Jan) to 33.22 °C (Aug), a range of 18.82 °C.

Final Result :



Operative T (°C) simple	15,06	16,39	19,76	23,12	26,26	32	34,84	34,92	30,4	26,52	19,71	16,16
Operative T (°C) double glazing	14,36	15,35	18,38	21,46	24,42	29	32,53	32,78	28,82	25,26	18,89	15,44
Operative T (°C) Triple Glazing Unit	14,4	15,5	18,64	21,77	24,78	30	33,08	33,22	29,15	25,5	19	15,5

Double glazing emerges as a better option. It significantly moderates operative temperatures, with an August peak of 32.78 °C and a January low of 14.36 °C. The use of an Argon gas gap and specialized panes like Solar Control Silver (outer) and Arctic Blue (inner) contributes to improved thermal performance and solar control. This balance of enhanced performance and potentially lower cost makes double glazing a practical and effective upgrade.

Solar Panel Material for Sunlight Capture: Monocrystalline Silicon

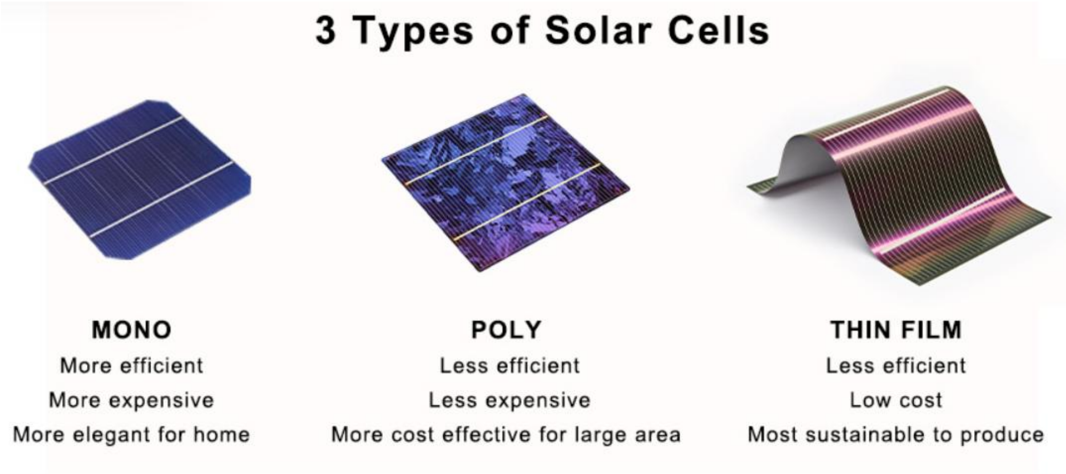


Figure 80 types of solar cells ,source : https://www.maysunsolar.com/solar-panel-types-and-differences-monocrystalline-silicon-polycrystalline-silicon-and-amorphous-silicon-solar-panels/

- **Higher Efficiency:** Monocrystalline panels are generally more efficient at converting sunlight into electricity (typically 18-24% efficiency, sometimes higher) compared to polycrystalline panels (typically 15-17%). This higher efficiency means they can generate more power from a smaller footprint, making them ideal when space is limited or when you want to maximize energy capture.
- **Aesthetics:** They have a uniform, dark black appearance due to the single crystal structure, which can be more aesthetically pleasing.
- **Performance in Low-Light Conditions:** While all panels perform best in direct sunlight, monocrystalline panels tend to perform slightly better in low-light conditions (e.g., cloudy days, early morning/late afternoon) than polycrystalline panels.
- **Durability:** They are known for their longevity and reliability. (Brian, 2022)

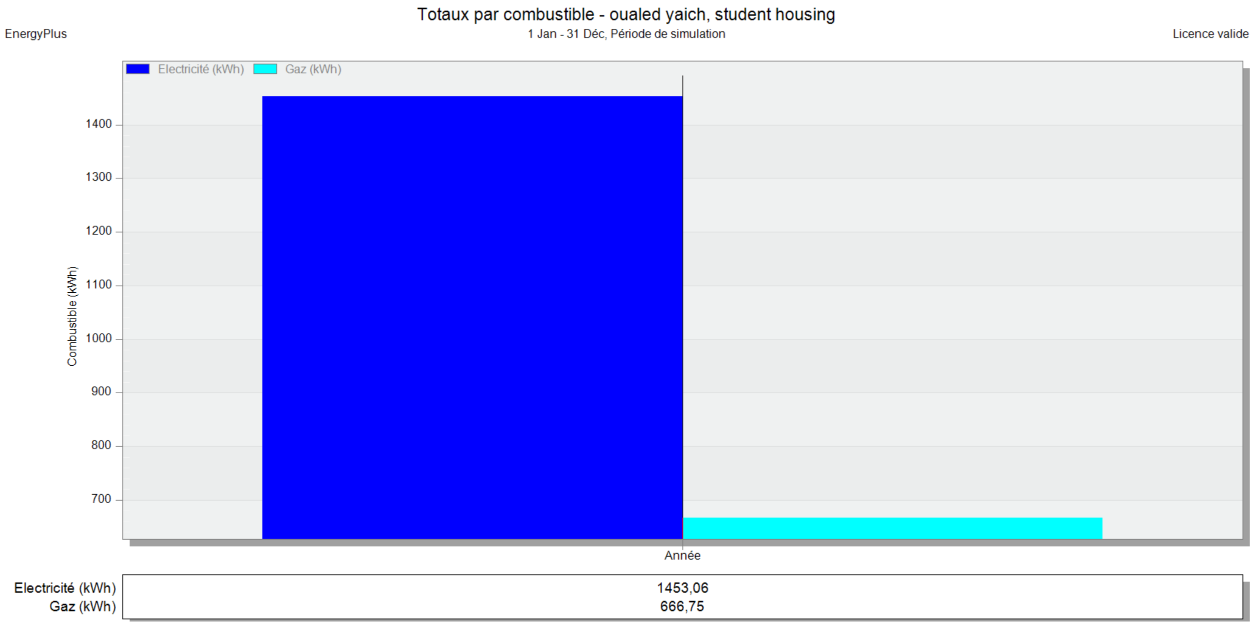


Figure 81 annual Energy Consumption , source design builder 2025

Reducing 159,840 kWh Annual Consumption with Monocrystalline Solar Panels for 110 residetial unit :

The most effective strategy combines maximizing building energy efficiency with a high-performance solar PV system. **Monocrystalline Silicon**

3.0 Energy Consumption Reduction Strategy

To effectively reduce an annual electricity consumption of 159,840 kWh, a two-pronged strategy focusing on maximizing building energy efficiency and optimizing solar photovoltaic (PV) panel implementation is proposed.

3.1 Maximize Building Energy Efficiency

The initial and crucial step involves significantly reducing the building's electricity demand, primarily for heating and cooling, through comprehensive energy efficiency upgrades.

3.1.1 Glazing Enhancement

Current State: If the building currently utilizes simple glazing, it experiences wide operative temperature fluctuations. For instance, temperatures can range from approximately 15.06 °C in January to 34.92 °C in August, directly contributing to high energy consumption for climate control.

Recommended Upgrade:

Double Glazing: For a balanced and effective load reduction, an upgrade to double glazing is recommended. An example of such a unit is the "Double Glazing Unit: Solar Control Silver (Outer) with Argon 6mm Gap and Arctic Blue (Inner)".

Impact:

Implementing this double glazing upgrade, in conjunction with other energy efficiency measures (e.g., improved insulation, LED lighting, efficient appliances), will significantly reduce heating and cooling loads, thereby lowering the total annual electricity consumption. Operative temperatures will show a noticeable improvement compared to simple glazing, with summer peaks around **32.16 °C in August** and winter lows around 14.36 °C in January. This leads to less energy consumption for climate control while offering a cost-effective solution.

3.1.2 Illustrative Consumption Reduction Calculation

Assuming a comprehensive energy efficiency upgrade (including double glazing, better insulation, efficient appliances, LED lighting) leads to a **30% reduction** in annual electricity consumption:

- **Original Annual Consumption:** 159,840 kWh
- **Reduced Annual Consumption:** 159,840 kWh×(1−0.30)=111,888 kWh
- **Reduced Daily Consumption:** 111,888 kWh/365 days≈306.54 kWh/day

3.2 Solar Photovoltaic (PV) System Sizing

Following the energy efficiency enhancements, a solar PV system can be sized to offset the remaining electricity demand. Monocrystalline silicon solar panels are selected for optimal sunlight capture due to their higher efficiency.

3.2.1 System Design Parameters

- **Peak Sun Hours (PSH):** An average of 5 hours/day is assumed for a well-sited system ina sunny region.
- **System Efficiency Factor:** A factor of (80%), accounting for various system losses (e.g., inverter efficiency, wiring, temperature, shading, dust).

- **Solar Panel Power (Monocrystalline):** High-efficiency 400 W (0.4 kW) monocrystalline panels.

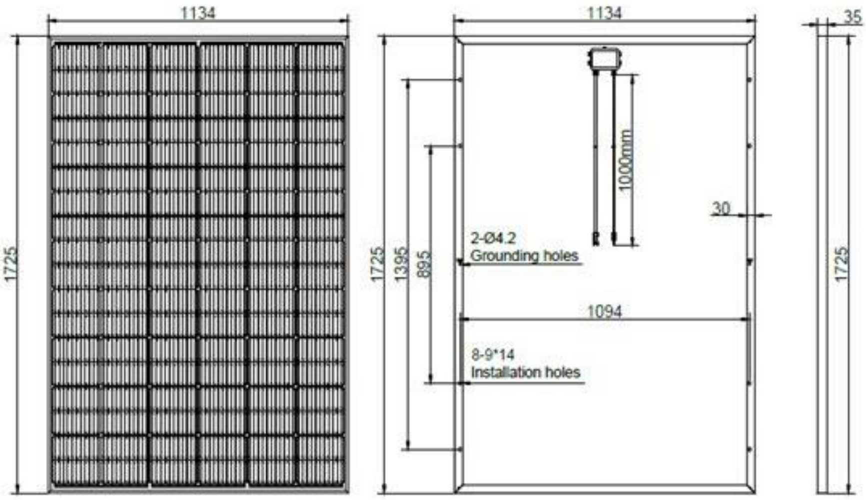


Figure 82 Monocrystalline 400W Solar Panel (Illustrative) source : https://www.jensysenergy.com/solar-panels/monocrystalline-solar-panels/400wp-high-efficiency-monocrystalline-solar.html

3.2.2 Required System Size Calculation

The required system size is calculated using the following equation:

$$\text{System Size (kWp)} = \frac{\text{Consumption (kWh/day)}}{\text{PSH (hours/day)} \times \text{System Efficiency FactorDaily}}$$

Substituting the reduced consumption values:

$$\text{System Size } = \frac{306.54 \text{ kWh/day}}{2a5\ hours/day \times 0.80} = 76.64 \text{ kWp}$$

1.2.3 Number of Monocrystalline Solar Panels

1.2.4 The number of panels required is determined by:

$$\text{Number of Panels} = \frac{\text{System Size (kWp)}}{\text{Power per Panel (kWp)}}$$

$$\text{Number of Panels} = \frac{76.64 \text{ kWp}}{0.4 \text{ kW/panel}} = 191.6 \text{ panels}$$

- Rounding up, approximately **192 monocrystalline solar panels** would be needed.

3.3 Conclusion

The most effective strategy for significantly reducing a 159,840 kWh annual electricity consumption, and subsequently optimizing solar PV implementation, is a two-pronged approach. Firstly, a substantial investment in building energy efficiency, particularly by upgrading to **double glazing for improved thermal control**, is paramount. This measure will significantly reduce the baseline electricity demand for heating and cooling. Secondly, for electricity generation, the utilization of high-efficiency **monocrystalline silicon solar panels** is recommended. This comprehensive strategy enables a reduction in the required number of solar panels from an initial estimate of approximately **274** (without upgrades) to **192 panal** , thereby lowering the overall investment in renewable energy infrastructure while contributing to enhanced indoor comfort and long-term energy independence.

Taking on considiration the study was based on the least favorable residentiel unit .

4.6. conclusion :

The existing urban landscape of Blida, characterized by pervasive **urban sprawl** and fragmented, **disconnected urban spaces**, underscores a pressing need for integrated and strategic planning. By intentionally focusing on the development of a concentrated **off-campus hub** situated in close proximity to the University of Blida, urban planning can serve as the pivotal link, transforming a mere geographic adjacencyànto a truly **symbiotic relationship** between the academic institution and its urban surroundings. Such a hub offers more than just crucial amenities like student housing, social spaces, and services; it acts as a powerful catalyst for broader **urban regeneration** within Blida. This strategic intervention has the potential to invigorate local economies, foster business growth, diversify the city's economic base, and importantly, integrate principles of **energy efficiency** into its very design and operation, thereby enhancing Blida's overall appeal as a dynamic educational, sustainable, and residential center. Furthermore, by drawing university life into the urban core, this initiative would significantly increase interaction between the academic community and local residents, fostering invaluable **knowledge exchange**, enriching **shared cultural experiences**, and cultivating a stronger sense of **collective identity** across the city. Consequently, the implementation of such a well-integrated and energy-efficient off-campus hub moves beyond theoretical urban design, representing a practical and impactful strategy for mutually beneficial growth, enriching both the university experience and the comprehensive urban development of Blida.

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Figures list :

Table List :

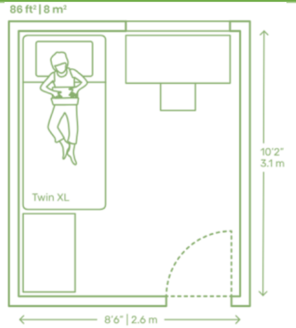
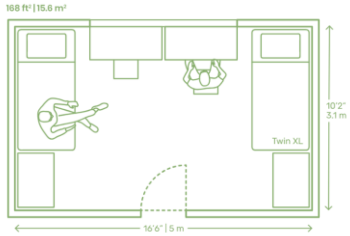
The annexes.

4- Ergometric Study of student housing :

Introduction:

The ergometric study aims to determine the optimal surfaces and layouts for various spaces within this residential building, taking into account the needs and activities of the occupants. The study will consider anthropometric data, furniture dimensions, and circulation requirements to ensure efficient and comfortable use of each space.

1. Living/Residential Spaces

<table>
<tr><th></th><th>Purpose:</th><th>Furnishing:</th><th>Optimal Surface:</th><th>Considerations:</th><th>Figure</th></tr>
<tr><td>Single Room:</td><td>Provides a private space for individual residents to sleep, study, and relax.</td><td>Bed, desk, chair, wardrobe, shelves.</td><td>9 - 12 m^2 (depending on furniture configuration and inclusion of in-room study area).</td><td>Adequate natural light, ventilation, and access to power outlets. Efficient use of space for both living and studying.</td><td>
Figure: Example of a well-designed single room

</td></tr>
<tr><td>Double Room:</td><td>Similar to a single room, but accommodates two residents.</td><td>Two beds, two desks, two chairs, wardrobes, shelves.</td><td>14 - 18 m^2 (depending on furniture configuration and inclusion of in-room study areas).</td><td>Privacy for each resident, sufficient storage, and designated individual study areas.</td><td>
Figure: Example of a double room with designated study zones

</td></tr>
</table>

2. Study Spaces

- **2.1 Dedicated Study Rooms/Library Spaces:**
    - **Purpose:** Provides quiet, focused environments for individual and group study.
    - **Furnishing:** Desks, chairs, tables, bookshelves, computer workstations, printers.
    - **Optimal Surface:**

      Allocate 2-3 square meters per person, including desk, chair, and circulation space.

      A table for 4-6 people needs 6-10 square meters.
    - **Considerations:** Good lighting, acoustics, access to power outlets and technology.
- **2.2 Quiet Zones within Common Areas:**
    - **Purpose:** Offers designated quiet areas within larger social spaces for individual study or focused work.
    - **Furnishing:** Comfortable seating, individual tables or desks.
    - **Optimal Surface:** Allow 2-3 square meters per person for comfortable seating.
    - **Considerations:** Visual and acoustic separation from the more active zones in the common area.
-
- **2.3 Study Lounges (with a social zone):**
    - **Purpose:** Combines study areas with social spaces, allowing for both individual work and collaborative learning.
    - **Furnishing:** Mix of individual study desks, group work tables, comfortable seating, and potentially whiteboards or presentation screens.

- **Optimal Surface:** Balance individual study desks (2-3 sq m per person) with group tables (6-10 sq m per table) and social seating (6-8 sq m for 4 people).
- **Considerations:** Zoning to separate quiet study areas from more social spaces.

3. Social/Recreational Spaces

- 3.1 Common Lounges:
  - Purpose: Provides comfortable and versatile spaces for residents to relax, socialize, and interact.
  - Furnishing: Variety of seating options (sofas, armchairs, beanbags), coffee tables, potential for games or entertainment systems.
  - Optimal Surface per person: 2-3 square meters.
  - Considerations: Welcoming atmosphere, good lighting, and access to amenities.
- 3.2 Game Rooms:
  - Purpose: Offers a dedicated space for recreational activities and games.
  - Furnishing: Game tables (billiards, table tennis), video game consoles, board games, comfortable seating.
  - Optimal Surface per person: 3-4 square meters for active games, 2-3 square meters for less active games.
  - Considerations: Durable surfaces, good lighting, and potentially sound absorption to manage noise levels.
- 3.3 TV Rooms/Media Rooms:
  - Purpose: Provides a space for residents to watch movies, TV shows, or engage with other media.
  - Furnishing: Comfortable seating, large screen TV, sound system.

    - Optimal Surface per person: 1.5-2 square meters.
    - Considerations: Good acoustics, comfortable seating arrangement for viewing.

4. Dining/Kitchen Spaces

- 4.1 Communal Kitchen:
    - Purpose: Allows residents to cook their own meals and share a dining experience.
    - Furnishing: Multiple cooking stations with ovens, stoves, sinks, refrigerators, ample counter space, dining tables and chairs.
    - Optimal Surface per person: 2-3 square meters.
    - Considerations: Efficient layout for multiple users, ample storage, and good ventilation.
- 4.2 Kitchenette (in a suite):
    - Purpose : Provides basic cooking facilities within a suite.
    - Furnishing: Compact refrigerator, sink, microwave/cooktop, limited counter space and storage.
    - Optimal Surface : Typically integrated within the suite layout.
    - Considerations: Efficient use of space, adequate ventilation, and easy-to-clean surfaces.
- 4.3 Shared Dining Area:
    - Purpose: Offers a dedicated space for residents to eat meals together.
    - Furnishing: Dining tables and chairs, potentially a serving area or buffet counter.
    - Optimal Surface per person: 1.5-2 square meters.
    - Considerations: Comfortable seating, good lighting, and potentially access to outdoor dining areas.

- 4.4 Cafeteria/Dining Hall (if applicable):
    - Purpose: Provides a large-scale dining facility for residents, potentially with prepared meals or buffet options.
    - Furnishing: Extensive dining tables and chairs, serving counters, food display areas.
    - Optimal Surface per person: 1-1.5 square meters.
    - Considerations: Efficient flow for serving and seating, noise control, and comfortable seating.

5. Staff/Administrative Spaces

- 5.1 Staff Offices:
    - Purpose: Provides workspace for administrative staff and support personnel.
    - Furnishing: Desks, chairs, computers, filing cabinets, meeting tables.
    - Optimal Surface per staff member: 10-15 square meters.
    - Considerations: Ergonomic workstations, privacy for confidential work, and access to necessary equipment.

5.2 Meeting Rooms:

- Purpose: Facilitates meetings and collaborative work among staff or with residents.
- Furnishing: Conference table, chairs, presentation screen, whiteboard.
- Optimal Surface per participant: 2-3 square meters.
- Considerations: Good acoustics, comfortable seating, and access to technology.

- 5.3 Storage Rooms (for maintenance):
    - Purpose: Provides secure storage for maintenance equipment and supplies.
    - Furnishing: Shelving, racks, storage bins.

    - Optimal Surface: Depends on the amount of equipment and supplies to be stored.

Considerations: Organized and accessible storage, potentially with designated areas for different types of equipment.

- 5.4 Maintenance Workshops:
    - Purpose: Provides a dedicated space for maintenance and repair work.
    - Furnishing: Workbenches, tools, equipment for repairs.
    - Optimal Surface: Depends on the types of maintenance tasks performed.

Considerations: Good ventilation, adequate lighting, and safe work practices.

6. Other/Support Spaces

- 6.1 Laundry Rooms:
    - Purpose: Provides residents with facilities for washing and drying clothes.
    - Furnishing: Washing machines, dryers, folding tables, ironing boards.
    - Optimal Surface per resident: 1-2 square meters.

Considerations: Good ventilation, durable flooring, and adequate space for circulation.

- 6.2 Restrooms:
    - Purpose: Provides accessible restrooms for residents and visitors.
    - Furnishing: Toilets, sinks, mirrors, hand dryers.
    - Optimal Surface: Varies depending on the number of fixtures and accessibility requirements.

Considerations: Hygiene, accessibility, and adequate ventilation.

- 6.3 General Storage Areas:
    - Purpose: Offers storage space for residents' belongings or building supplies.
    - Furnishing: Shelving units, lockers, storage bins.

- Optimal Surface: Depends on the storage needs of the residents and the building.

Considerations: Secure and accessible storage, potentially with different sizes of units to accommodate various needs.

- 6.4 Utility Rooms:
  - Purpose: Houses building systems and equipment, such as water heaters, HVAC systems.
  - Furnishing: Equipment specific to the building's systems.
  - Optimal Surface: Depends on the size and type of equipment.

Considerations: Accessibility for maintenance, adequate ventilation, and safety measures.

- 6.5 Mechanical/Electrical Rooms (for Zero Net Energy - ZNE systems):
  - Purpose: Houses specialized equipment for ZNE systems, such as solar panels, battery storage, and energy management systems.
  - Furnishing: Equipment specific to the ZNE systems.
  - Optimal Surface: Depends on the scale and complexity of the ZNE systems.

Considerations: Accessibility for monitoring and maintenance, adequate ventilation, and safety protocols.

- 6.6 Lobby/Waiting Area (for visitors):
  - Purpose: Provides a welcoming space for visitors and guests.
  - Furnishing: Comfortable seating, reception desk (if applicable), information displays.
  - Optimal Surface per person: 2-3 square meters.

Considerations: Creating a positive first impression, clear wayfinding, and access to restrooms.

- 6.7 Circulation (Hallways, Stairwells, Elevators):
  - Purpose: Ensures safe and efficient movement throughout the building.

- Furnishing: Handrails, signage, emergency lighting.
- Optimal Dimensions: Comply with building codes and accessibility standards for corridors, stair widths, and elevator capacity.

Considerations: Clear wayfinding, fire safety, and accessibility for people with disabilities.

- 6.8 Outdoor Spaces (Courtyards, Patios, Rooftop Terraces):
  - Purpose: Provides access to fresh air, natural light, and opportunities for recreation and relaxation.
  - Furnishing : Outdoor seating, landscaping, shading devices, potentially play equipment or exercise areas.
  - Optimal Size and Design : Depends on the intended use and the surrounding environment.

Considérations : Connection to indoor spaces, accessibility, and integration with the building's design.

- 6.9 Multi-purpose rooms (for events, meetings, etc.) :
  - Purpose: Offers flexible spaces for a variety of activities, such as meetings, events, or recreational activities.
  - Furnishing : Movable tables and chairs, presentation equipment, potential for a stage or performance area.
  - Optimal Surface per person: 2-3 square meters.

Considerations: Acoustic separation, adaptable lighting, and access to storage for furniture and equipmen