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Improving Thermal Performance in the University Classrooms

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ABSTRACT

Universities are among spaces where it's important to ensure thermal comfort in indoor spaces, improving the occupants' well-being and productivity. The problem of the research was to study appropriate glazing systems for the spaces of the University of Baghdad because glazing systems are one of the most important elements of the indoor environments, and it has a major impact on the thermal performance of buildings. Glass is one of the most seasoned materials that are most utilized in the design. Since it is a diaphanous material, it allows sunlight to enter the building, increasing the space's temperature, cooling loads, and energy consumption in summer. The research followed the experimental method by studying and testing(conventional, advanced, and photovoltaic glazing)by Revit and Onyx Solar analysis in the Architectural Department classes to find the appropriate type of glazing in the spaces of hot, dry areas. The results showed that advanced glazing is the best by reducing the cooling loads andincreasingthermal performance quality. Photovoltaic glazing showed its efficiency in filling part of the electrical energy needs within the spaces of the Architectural department.

Keywords: Thermal performance, University classrooms, Glazing systems, Photovoltaic glazing.

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تحسين الاداء الحراري في الفضاءات التعليمية الجامعية

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الخلاصة

تعد الفضاءات التعليمية الجامعية من بين الفضاءات التي يتعين فيها تعزيز الراحة الحرارية، لكونها تنعكس ايجابا على صحة وانتاجية الشاغلين. تمثلت مشكلة البحث بدراسة واختبار نظم التزجيج المناسبة لفضاءات جامعة بغداد،لكون ان الزجاج احد اهم عناصر البيئة الداخلية، وله تأثير اساس على الاداء الحراري للأبنية، حيث يعد الزجاج من اقدم المواد التي صنعها الانسان وتم استخدامها في العمارة. نظرا لكونه مادة شفافة، فأنه يسمح بأختراق اشعة الشمس ودخولها الى المبنى، مما يؤدي بدورهِ الى زيادة درجات حرارة الفضاء ومن ثم زيادة استهلاك الطاقة المصروفةلاغراض التبريد صيفاً. اتبع البحث المنهج التجريبي وذلك بواسطةدراسة نظم التزجيج المختلفة والتي تمثلت بـ (نظم التزجيج التقليدية، ونظم التزجيج المتطورة، والتزجيج الكهروضوئي)، ومن ثم تم اختبارها من حيث احمال التبريد بواسطة استخدام الجانب البيئي من برنامج المحاكاة (Revit 2020) واداة من برنامج (Onyx Solar) في الفضاءات التعليمية لقسم هندسة العمارة، وذلك لأيجاد نوع التزجيج المناسب في فضاءات المناطق الحارة الجافة. اظهرت النتائج ان نظم التزجيج المتطورة هي الافضل بواسطة تقليلها لاحمال التبريد وتحسين الاداء الحراري، وكما اظهر التزجيج الكهروضوئيكفاءته في سد احتياج جزء كبير من الطاقة الكهربائية داخل فضاءات قسم هندسة العمارة.

الكلمات المفتاحية :الاداء الحراري، الفضاءات التعليمية الجامعية، انظمة التزجيج، التزجيج الكهروضوئي.

1. INTRODUCTION

The improvement of thermal performance with the rationalization of energy consumption is among the basic requirements that must be achieved in the building to enhance the thermal comfort of the occupants, as studies have confirmed that buildings are responsible for more than 40% of the total global energy consumption to improve thermal performance and provide thermal comfort. They also contribute 30% of greenhouse gas emissions, and therefore, government institutions in many countries take the necessary measures to reduce energy needs in the buildings without affecting their thermal performance **(Mansoor and Mohammed, 2018; Mostafa and Rashwan, 2022; Alsawaf and Albadry, 2022)**.

The thermal performance of the building is defined as the extent to which the design of the building, in its form and elements, responds to the changing climatic conditions daily and seasonally. The thermal performance of the building depends on the structural and design characteristics that respond or interact with external climate factors that play a role in determining the internal thermal environment. Thermal loads in buildings are one of the energy consumption problems due to external influences that affect indoor environmental spaces and the use of a mechanical cooling method to provide thermal comfort within the spaces **(Abdul Ghafour and Mahmoud, 2015)**. Thermal loads are divided into two main categories. The first is external heating loads, which are defined as the amount of thermal energy transferred from the hot external environment to the space, such as heat conduction

through walls, ceilings, and floors, as well as the transition of solar radiation through windows, doors and the air leakage from the external environment to the internal spaces **(Abd Alkadeer et al., 2017)**. The second is internal heating loads, defined as the amount of heat energy gained in the space due to the air conditioning system, electrical appliances, artificial lighting, and heat generated by the occupants **(Bhatia, 2006)**.
In addition, there are several design factors affecting the thermal performance of university educational spaces, as follows **(Kumar and Raheja, 2013)**:

- The shape of the building and its internal spaces.
- The orienting of the spaces in the buildings.
- The components of the building envelope (The research paper will focus specifically on the element of glazing within the building envelope and its effect on cooling loads within the educational spaces of the University of Baghdad).

Glazing systems have an important role in designing university educational spaces, as they affect the thermal performance of the interior spaces. Heat gain by glazing systems, especially in hot, dry climates, is a major source of increased cooling loads. This contributes to an increase in energy consumption, as the cooling load represents the highest percentage of energy consumption in buildings, so it is recommended to use multiple glazing systems or available natural shading means such as landscaping or artificial ones such as breakers, and as a result, it is possible to improve the thermal performance of the building, and reducing energy demand by employing the appropriate type of glazing **(Fasi and Budaiwi, 2015)**.
To improve the thermal performance in university educational spaces, the research will study the different glazing systems represented by (conventional glazing, advanced glazing, and photovoltaic glazing). Firstly, there are several conventional glazings, such as clear glazing, tinted glazing, reflective coating glazing, and low emissivity coating glazing **(Daqiqeh et al., 2017)**. Secondly, advanced glazing is represented by a double-glazing unit with insulating materials like (gas, vacuum, and aerogel) and a triple-glazing unit **(Walid and Abdelhady, 2021).** Thirdly, photovoltaic (PV) is the glazing technologyfavored in produces contemporary buildings and energy because of its aesthetic qualities **(Kamoona and Al Khafaji, 2015)**. Architectural and automotive windows use solar control glazing, one of the essential parts of photovoltaic panels, to reduce sunlight and heat inlet for comfort **(Ayead and Al-Tameemi, 2022)**. These solar panels lower energy consumption and improve thermal performance simultaneously **(Karasu et al., 2020)**.
This work aims to study and determine the appropriate glazing systems for the spaces of the University of Baghdad to improve thermal performance, reduce the capacity of air conditioners, reduce costs, protect the materials of the building from temperature changes, protect the furniture in the building, and increase comfort in indoor environmental spaces.

2. METHODOLOGY

The research adopted the experimental method to improve thermal performance in educational spaces. It focused on the internal environment system, specifically the element (glazing), to achieve the lowest cooling loads with the efficient use of electrical energy in spaces located in hot, dry areas. The research aims to choose the appropriate glazing system in the educational spaces of the University of Baghdad, so several types will be tested to see their efficiency. This will be done through the following steps:
1- Studying glazing performance factors.
2- Studying the different glazing systems.
3- Description of the climatic conditions and case study area

4- Acquaintance with the simulation program will be used to test the glazing systems.
5- Analyze the results.

2.1 Glazing Performance Factors

The ventilation, daylighting, solar heat gains, and aesthetic benefits of glass are essential. The solar heat gain coefficient, visible light transmission, and U-value, the following three factors, are the primary determinants of any glazing's thermal and aesthetic properties:

- Solar Heat Gain Coefficient(SHGC): It is the ratio between the amount of solar radiation penetrating from the material to which the amount of heat lost from its inner surface by convection and thermal radiation is added to the amount of solar radiation falling on its surface, as part of the solar radiation that is entered Through a window, door, or skylight - it is either directly transmitted or absorbed, and then released as heat inside the space, and the lower the SHGC, the less solar heat transferred by the glass and the greater its shading ability. Therefore, the SHGC is low in the summer to reduce cooling loads and high in the winter to collect solar heat **(Lu et al., 2017)**.
- Visible Light Transmission (VLT): It is the percentage of visible light that is measured when passing through the glazing system and a higher (VLT) ratio means more visible light passing, and a lower ratio means less visible light passing through the space through the glass **(Gündoğdu and Kunduraci, 2019).**
- The heat transfer coefficient (U) measures heat loss in a glazing unit. It measures how well the heat is transferred to parts of the building. This means that the higher the U value, the worse the thermal performance of the building envelope, as a low U value usually indicates high insulation levels **(Zhang et al., 2021)**.

2.2 Appropriate Glazing to Improve Thermal Performance

Different glazing systems will be discussed in the research, and knowing the appropriate type of glazing in the university educational spaces, depending on the thermal performance. These systems are represented by:

2.2.1 Clear glazing

It is a colorless glass, light passes through and spreads, with high hardness, resistance to friction or scratching, flat glass with a smooth surface, and comes in various thicknesses from 2 mm to 19 mm. It is the most widely used glass because it is the least expensive, and it transmits visible light at a rate of about 90%. Adding thickness to the glass panels also enhances their insulating qualities, as measured by the values of both (U-Value) and (SHGC) **(Aguilar-Santana et al., 2019)**. **Table 1.** shows the characteristics of transparent glazing systems and their relationship to increasing thickness.

2.2.2 Tinted glazing

It is made of clear glass with various mineral additions and chemical hues added to it to help maintain the glass's internal transparency while absorbing solar heat without impeding daylight. Also, it has a unique aesthetic quality. The dye alters the product's color, but the color is stable and doesn't deteriorate with time. The dye does not impact the (U-value) but does impact (SHGC) value. This effect can benefit the summer months **(Lawrence Berkeley National Laboratory, 2017)**.

Table 1. Characteristics of clear glazing systems and their relation to thickness increase **(Walid and Abdelhady, 2021)**

Thickness (mm)	Heat transfer coefficient (U-value)	Solar Heat Gain Coefficient(SHGC)	Visible Light Transmission (VLT)
2	5.8	0.89	0.91
6	5.7	0.82	0.88
10	5.6	0.77	0.87
12	5.5	0.74	0.85
19	5.3	0.66	0.81

Compared to other colors, green and blue tints on glazing allow for well-visible light penetration with less heat transfer. Bronze and gray colors can minimize glare but also lower the amount of natural sunshine that enters the interior area since the drop in visual light transmittance (VLT) is higher than the solar heat gain coefficient (SHGC) for these tints**(Daqiqeh et al., 2017). Table 2.** shows the characteristics of colored glazing systems and their relationship to increasing thickness.

Table 2. Characteristics of tinted glazing systems and their relation to thickness increase **(Daqiqeh et al., 2017)**

Color	Thickness (mm)	Heat transfer coefficient (U-value)	Solar Heat Gain Coefficient (SHGC)	Visible Light Transmission (VLT)
Bronze	4	5.8	0.68	0.60
	6	5.8	0.60	0.49
	8	5.7	0.53	0.40
	10	5.6	0.48	0.33
Green	4	5.8	0.63	0.79
	6	5.8	0.55	0.73
	8	5.7	0.50	0.68
	10	5.6	0.46	0.63
Grey	4	5.8	0.66	0.55
	6	5.8	0.57	0.43
	8	5.7	0.50	0.34
	10	5.6	0.45	0.26

2.2.3 Reflective glazing

It is glass that has a small layer of metal on top of it that may be placed to clear or tinted glass to create reflective glazing. The metallic layer can be different metallic hues (bronze, gold, or silver). Reflective glazing raises the surface reflectivity of the glass pane, reducing its (SHGC) value and possibly reducing its (VLT). When the applied reflective layer is tinted glazing, the decrease in (VLT) is more significant than the (SHGC). The degree to which the (SHGC) is lower depends on the location, thickness, and reflectivity. Because it works like a mirror, it is best applied on the exterior of the sun-facing glass **(Lawrence Berkeley National Laboratory, 2017)**.

2.2.4 Double and Triple Glazing Windows

It is a window with multiple glass panels (double or triple-glazed panels). The gaps between the glazing panels provide thermal insulation without severely impacting the illumination **(Radi, 2020)**, **Fig.1.**

One of the most important factors affecting the efficient performance of glazing systems is the selective control of light and direct solar radiation, which represents one of the challenges facing the design of the glazing system. For the system to be efficient, the following must be available **(Aguilar-Santana et al., 2019)**:

- The lower the U-value, the better it is to reduce heat loss in winter.
- The lower the value of (SGHC) the better to reduce the increase in heat in the summer.
- The higher the VLT value, the better the natural daylight transmittance.

The multi-panel glass system works naturally or mechanically to control ventilation and temperature. Solar energy is obtained in cold climates using that system to provide heating requirements. In hot climates, this system reduces solar radiation, controls it, and reduces cooling loads. The glass used in double or triple-glazing systems can be clear, tinted, or add different coatings, such as low-emissivity and reflective coatings **(Abd Alkadeer et al., 2017)**.

Double or triple-glazing systems have many benefits, as follows **(Brdnik, 2021)**:

1- Improving the thermal performance of the building by achieving thermal comfort in internal spaces.
2- Improving the energy performance of the building by reducing the costs of heating and cooling loads.
3- Provide 50% insulation.
4- Reducing greenhouse gases.
5- Reducing noise pollution in the interior spaces.
6- Reducing the long-term costs of the building.

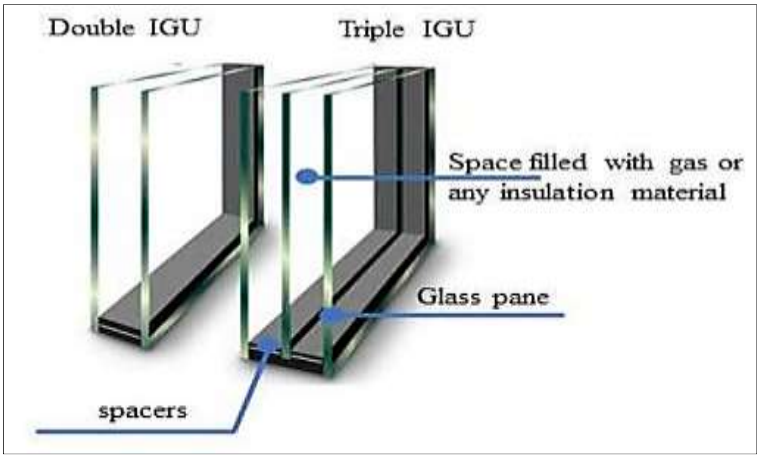

Figure 1. Insulated Glazing Unit **(Walid and Abdelhady, 2021)**

Double or triple glazing systems are divided into several types according to the difference in the style of insulating material filled in the space as follows:

- **Gas-Filled Glazing:** This glazing system has air as the insulating material. Nevertheless, the heat transmission between the two layers of glass will be lessened by utilizing a less conductive gas. Using noble or inert gases like argon, krypton, or xenon in the gaps between the glass panels would significantly enhance the glazing unit's thermal performance. Due to their lower thermal conductivity and heavier density than air, these gases diminish the amount of heat transmission through the IGU and the window's total U-value **(Bizonova and Bagona, 2019)**, **Fig. 2.**

Argon gas is the third most abundant gas in the world, and the gas used the most is the best choice among all inert or noble gases. It is non-reactive, non-toxic, clear, and odorless, like all inert gases, which makes it mostly used since it is less expensive. The ideal U-value at this spacing is 0.536 $W/m^2.K$, and the argon glass panes have a thickness of around (16) mm. Thermal conductivity for air is 2.496 x 10^{-2} W/m.K vs. 1.684 x 10^{-2} W/m.K **(Walid and Abdelhady, 2021)**.

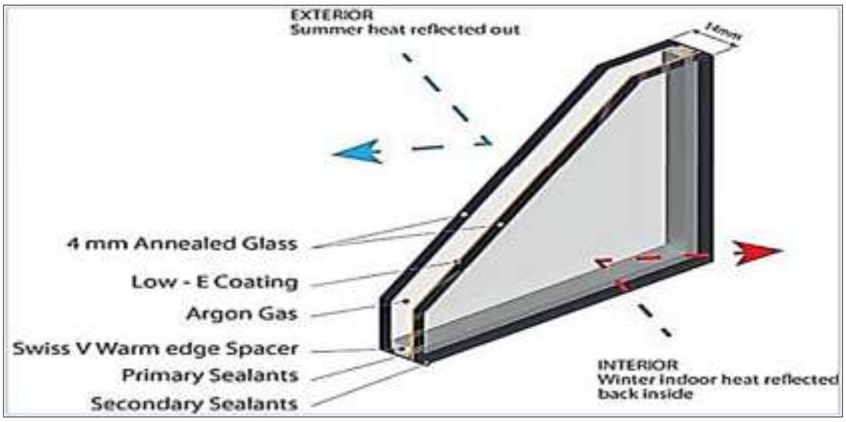

Figure 2. Structural details of argon filled double glazed windows **(Cuce, 2018)**

- **Vacuum Glazing:** This glazing system features reduced heat transfer due to the vacuum gap, where the air is drawn between the glass panels, creating a vacuum zone. Vacuum glazing consists of two glazing panels with a thickness of (3-4) mm and a narrow vacuum space ranging between (0.1-0.2) mm.

Glazing units with such a low internal cavity may get damaged by the stress exerted on them by atmospheric pressure. Applying small support pillars in a square grid will solve this issue. Edge sealing is carried out as indicated in **Fig. 3** to preserve the vacuum in the evacuated area's interior space.

To prevent radiative heat transfer, a low-E coating is applied to the inner surface of either one or both glass panes. Due to the decrease in the number of gas particles responsible for heat transfer, conduction and convection are minimal **(Ali et al., 2017)**.

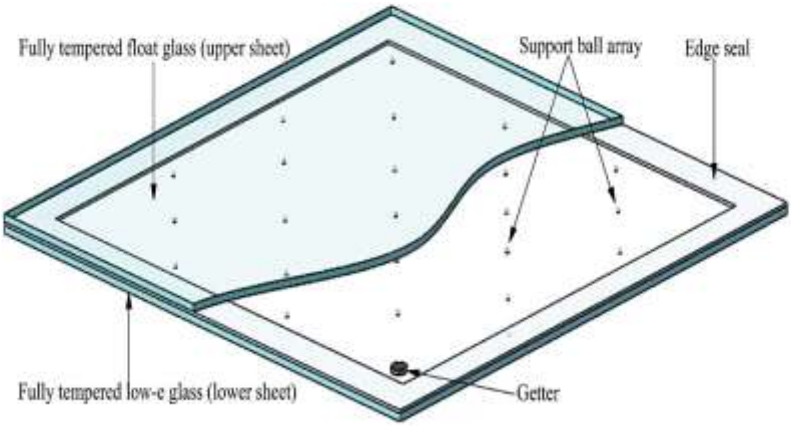

Figure 3. Structural details of vacuum-glazed windows **(Hu et al., 2018)**

2.2.5Photovoltaic glazing technique:

In the frame of zero-energy buildings, the integration of renewable energy sources along with energy-saving strategies must be the target **(Sadiq and Mussa, 2022)**. Photovoltaic glazing is an advanced technology for producing electrical energy and, as a result, reducing the consumption of depleted energy for cooling, heating, and lighting the interior spaces **(Skandalos and Karamanis, 2015)**.
A technique known as photovoltaic glass (PV glass) converts light into electricity. The glass has embedded transparent semiconductor-based photovoltaic cells, also known as solar cells. Two sheets of glass are positioned between the cells. Although photovoltaic glass is not completely transparent, some available light may pass through it, allowing buildings to utilize significant amounts of the material to generate part of their power via the windows. Due to its renewable source and lack of pollution, the electricity produced by photovoltaic panels is called green or clean electricity **(Mohammed and Hashim, 2019).** In addition to saving energy costs, using photovoltaic energy may also help facilities reduce their carbon footprint, advance sustainability, and improve their branding and public relations (PR) initiatives, **Fig. 4 (Willson et al., 2020)**.

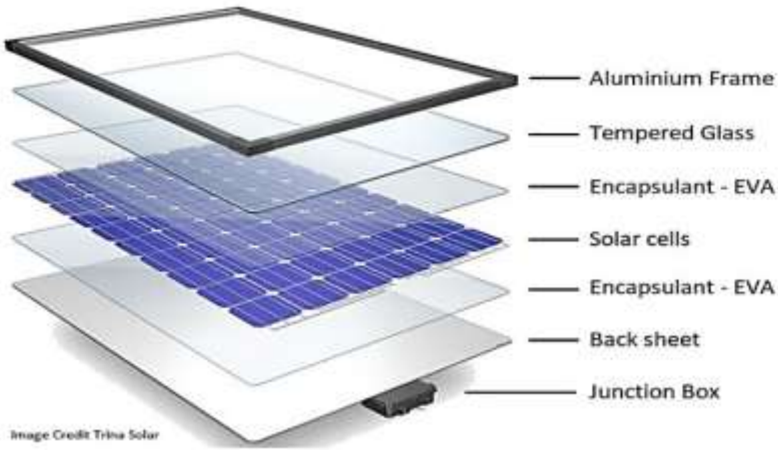

Figure 4. The parts of Photovoltaic glazing **(Willson et al., 2020)**

The effect of photovoltaic glazing will be explained in the following aspects **(Faal and Kamoona, 2021; Onyx Solar, 2022)**:

- **Thermal performance:** Photovoltaic glazing is a revolutionary technology that turns sunlight into electricity and decreases energy usage in cooling and heating.
- **Energy performance:** PV Glass generates free and clean electricity thanks to the sun, turning buildings into vertical power generators.

When integrating different types of PV modules into a building window or glazing façade, the variation of thermo-optical (e.g., emissivity, solar, and visible) transmittance of the glazing material will affect the fraction of absorbed, transmitted, and re-radiated solar radiation, as well as the amount of penetrating daylight. This will, in turn, affect the PV module's temperature and thus influence its electrical power generation **(Sun et al., 2018)**.
Solar photovoltaics are made with several parts:

- **Solar PV Cells:** Solar photovoltaic cells that turn sunlight into direct current (DC) electrical energy. The two primary silicon varieties, mono-crystalline and polycrystalline, affect a solar panel's performance. Cell type and silicon qualities determine how well a solar panel performs **(Irizarry et al., 2014; Kashan and Al-Qrimli, 2020)**.
- **Glass:** The front glass layer protects the solar cells from the elements, including hail and flying debris. In most cases, the glass is high-strength tempered glass, which has a 3.0 to 4.0 mm thickness and is designed to endure mechanical forces and extreme temperature changes. Additionally, photovoltaic glass can be customized for any project or design by changing its form, color, size, thickness, and degree of semi-transparency **(Irizarry et al., 2014)**.
- **Aluminum Frame:** The aluminum frame is essential because it protects the laminate section's edge where the cells are located and gives the solar panel a stable mounting platform. The extruded aluminum sections are made to be incredibly rigid, lightweight, and able to withstand severe wind and other external stresses. The corner sections of the aluminum frame can be bolted, pushed, or clamped together to offer varying degrees of strength and rigidity, depending on the manufacturer of the panel. The aluminum frame is available in silver or black anodizing **(Willson et al., 2020)**.
- **EVA Film**: It is the abbreviation for (ethylene vinyl acetate). A crucial component of conventional solar panel lamination is EVA films. The cells are laminated between sheets of EVA with the aid of a lamination machine under a compressed vacuum. This procedure is conducted under temperatures of up to 150°C. EVA films have the drawback of not being UV-resistant; hence, the protective front glass is needed for UV screening **(Irizarry et al., 2014)**.
- **Back sheet:** The rearmost layer of a common solar panel acts as a moisture barrier and final external skin to provide mechanical and electrical insulation. The material used for the back sheet is constructed of different polymers or plastics, including PP, PET, and PVF, which provide varying degrees of protection, thermal stability, and long-term UV resistance **(Xu et al., 2019)**.
- **Transparent solar panels use** titanium oxide (TiO_2) coated with a photoelectric dye and a tin oxide coating. Both infrared and ultraviolet photons are used by solar cells. The applications include windows for self-cleaning, self-generating power, lighting, and controlling temperature **(Willson et al., 2020)**.
- **Junction Box and Connectors:** It is a small, weatherproof enclosure on the panel’s rear side. The cables necessary to connect the panels must be firmly fastened. The junction box must be kept clean and dry as the hub where all the cell sets connect **(Willson et al., 2020)**.

2.3 Description of the Climatic Conditions and Case Study Area

Investigated for the current study were the classrooms on the University of Baghdad's campus in Baghdad. Al-jadiryia, an urban area, is where this campus is situated (33.16 N, 44.22 E). The summers are hot and dry, and the winters are cool in Baghdad. The average temperature in Baghdad varies from 9.5°C in January to 35°C in July, when highs can reach 44°C, with highs around 50°C in the summer and much sunshine. Baghdad is one of the hottest capital cities in the world. Days in winter are mild, but nights are frequently chilly, with temperatures occasionally falling to a few degrees below zero **(Abdulla, 2020; Khalil and Kamoona, 2022)**.

The Architectural Department of Engineering is a two-story building with having capacity of 350 students from the age group (18 to 22) years. The classroom will be tested in the Department of Architecture to determine the effect of glass type on thermal and energy performance.

The classroom is located on the ground floor of the building in a northeast direction. It had four windows and 56 plastic chairs, a blackboard for chalk, a display screen, flooring from mosaic tiles, and clear glazing with louvers. The research will deal with testing glazing systems, where the maximum effect of glazing systems on the cooling load’s purposes was calculated in the summer on the ninth of May, at (1:00) pm.

2.4 Tools Used to Perform the Simulation

The simulation program (Revit) was used, which represents one of the engineering simulation programs within the (Autodesk) group and allows architects to work easily in a three-dimensional (3D) environment, characterized by high flexibility in representing data for building design and applying all necessary strategies to design a sustainable building and energetically effective.

The Revit program is of great importance in the partnership between engineers of various architectural, structural, mechanical, electrical, and sanitary specializations, thus providing a high level of coordination in work, with fewer errors, due to the cooperation between engineering specializations in the early stages of the project.

Revit program is one of the important tools for applying the (Building Information Modeling (BIM)) methodology, which is a digital representation of a facility's physical and functional characteristics. It is a common source of knowledge that forms a reliable basis for making decisions during the life cycle of the building, starting from the stage of presenting design ideas for the building until its demolition **(Taif and Jandea, 2016)**.

The work of the program is to conduct a thermal simulation by using real weather data for the building site, with data on the materials constituting the building envelope, the nature of space occupancy, and the number of occupants, and then calculating the energy consumed in university educational spaces for cooling loads. Below are the detailed steps of the program’s working mechanism, **Fig. 5**:

1- Drawing the Department of Architecture / University of Baghdad in a two-dimensional (2D) and three-dimensional (3D) form using the (Revit) program

2- Entering the geographical data of the Department of Architecture / University of Baghdad / Al-Jadriya area, represented by the site coordinates data. It includes (latitude and longitude coordinates and the north angle of the building), to obtain realistic climate data for Baghdad.

3- Projecting the status of the structural materials used to envelop the building of the Department of Architecture, including (ceilings, walls, windows, doors, and floors), while providing them with the conductivity coefficient (K-value) for each material.
4- After completing the three-dimensional model of the Department of Architecture, the computer program begins the simulation process to calculate the amount of energy consumed by the cooling loads for each of the conventional and advanced glazings. Still, it is necessary to specify the official holidays, the number of occupants, the type of ventilation, and the air conditioning system. As a result, the analysis is done for the summer season.

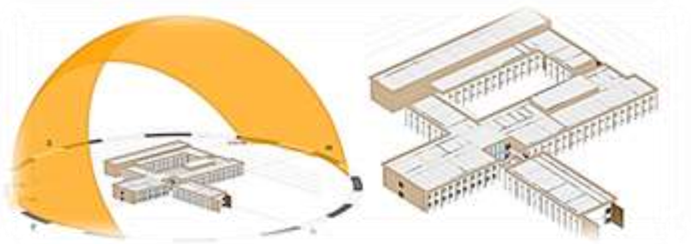

Figure 5. Drawing of the Department of Architecture in the (Revit) program**.**

Then, the photovoltaic glazing was tested by a tool belonging to (Onyx Solar company), which specializes in manufacturing photovoltaic glazing. The virtual test was done for the educational spaces in the Department of Architecture. This evaluation was based on several parameters (the location and direction of the educational spaces, the glazing area, and the type of photovoltaic glazing).

3. RESULTS AND DISCUSSION

The elements of the internal environment affect the thermal performance of the building, **Fig. 6, Table 3**. The research paper focused specifically on the(glazing) element, so each (clear glazing, tinted glazing, reflective glazing, double glazing, and triple glazing) was tested to know the effect of each type on cooling loads and their impact on thermal performance for the building**.** This was done by using Revit software, and the photovoltaic glazing systems were also tested to see how much electrical energy they would provide to the educational spaces by the ONYX Solar tool, as follows:

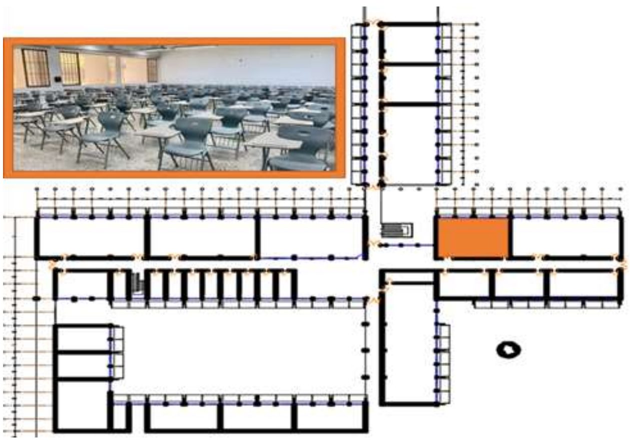

Figure 6. Selected classroom

Table 3. Description of the space

Space Type	No. of windows	Windows Areas	No. of doors	Spaces of Areas	No. of Occupants
Classroom	4	20.85 m^2	2	105.3 m^2	35

Accordingly, the types of glazing will be tested to find out their effect on thermal performance in university educational spaces, as shown in **Table 4.**

Table 4. Thermal performance of the glazings by Revit

Glazing Type	U-Value (Watt/m^2.^{o}C)	SHGC	VLT	Cooling loads (Btu/h)
Clear	5.2	0.62	0.54	39,984
Tinted (green)	3.2	0.60	0.76	38,144
Tinted (gray)	3.2	0.59	0.46	37,288
Reflective	3.2	0.19	0.080	33,723
Double(argon)	0.8	0.58	0.76	28,964
Double(vacuum)	1.10	0.49	0.47	32,451
Triple(argon)	0.5	0.46	0.65	27,877
Triple(vacuum)	0.8	0.61	0.70	32,231

Based on the results presented, it was found that among the conventional types of glazing, the reflective glazing system was the best. Then, the tinted (gray) glazing system consumed cooling loads in the environment of university educational spaces with a hot, dry climate. As for the advanced glazing, it was found that the double and triple glazing systems filled with argon gas are the best of the vacuum glazing systems, noting that all educational spaces in the University of Baghdad contain louvers, which were considered during the test.
The photovoltaic glazing was tested for its ability to provide electric energy to the spaces of the Department of Architecture, and the following results appeared in **Table 5**.

Table 5. Results of using photovoltaic glazing

Space type	Glazing Area (m^2)	Electricity Generated in 35 Years (kWh)	Total Lighting Points Operating (4) Hours Per Day	Avoided CO_2 Emission In 35 Years (ton)	Barrels of Oil Saved in 35 Years	Liters of Oil Saved in 35 Years	Trees saved
Classroom	20.8	132,584	260 Lights	89	78	12,405	21
Ground Floor	665.6	4,242,956	8,325 Lights	2,843	2,497	396,980	666
Building	1,331.2	8,485,912	16,650 Lights	5,686	4,993	793,960	1,331

The electrical energy of the glass was calculated after its dimensions were entered, so we find in the results the amount of electrical energy produced in the educational classroom, and on the ground floor, then in the building. The results showed that the amount of electrical energy produced by the glazing during the simulation process covered a part of the electrical energy needs and, at the same time, provided a large number of fossil fuels that could be consumed to produce electrical energy, as well as reducing carbon dioxide polluting the atmosphere and indoor spaces.

6. CONCLUSIONS

Based on the results of the research paper through its use of analysis tools by (Revit) and (ONYX Solar tool), the educational spaces are located in hot, dry areas, glazing plays an important role in the thermal performance of the building, and the higher the efficiency of glazing, the lower the cooling loads and the solar heat gain of glazing. Therefore, according to the educational space's direction and location, the appropriate type was the triple glazing filled with argon gas, as the cooling loads decreased from (39,984) to (27,877) Btu/h. The solar heat gain decreased from (0.62) to (0.46), and double glazing comes in the second degree. In the double glazing, the cooling loads decreased from (39,984) to (28,964) Btu/h, as well as the solar heat gain from (0.62) to (0.58). The educational spaces are located in a hot, dry area. The sun had a major role in the use of photovoltaic glazing and the exploitation of solar energy and its conversion into electric energy, and because the educational classrooms contain glazing of large areas, it had a role to generate electric energy, as we were able to provide (260) point electricity by solar energy in the space, and this will reduce carbon dioxide gas over several years of occupancy, as well as saving fossil fuels. Therefore, the research paper proved the significant role of glazing in generating electrical energy, reducing cooling loads, and improving the thermal performance of the building.

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