

Cooling System for Solar Housing in the Iraqi Buildings

Dr.Kareem K.Jasim

Dr.Jaffer A.Kadhim

Eng.Mahdi Sarhan

Energy and Renewable Energy Technology Center

University of Technology

ABSTRACT:

In response to the fact that most of residential buildings in Middle East region designed far away to be effectively efficient, and also the fact that a significant amount of the energy produced within these countries is consumed by the buildings, this research trying to develop standards can be used in the future on residential buildings for this region from energy point of view, with additional suggestions for other optimization measure may overall efficiency, finally, the payback period of the project to be reduced.

This study aims to identify an appropriate solar driven cooling system configuration and size with respect to fulfill target values in primary energy savings, solar thermal system exploitation and economics.

This paper presents two different techniques to design an efficient building able to comply with different climate conditions in IRAQ. In the first technique, the research focusing on estimating the Energy demand of a reference building by using advanced simulation tools. The second technique proposed to simulate an absorption machine solar thermal driven, which can be used with HVAC system to cover the cooling load during summer period by using dynamic modeling tool.

1.INTRODUCTION:

The application of solar energy technology to heat transfer is important. Although good heat buildings often depends on its ability to be transfer (passive or even active) is preferable, integrated into common building structures, such installation and mounting costs also have to be as facade elements. Costs of planning, manufacture into consideration for PV facades. Four turning and installation may be reduced if co different kinds of PV facades, i.e., passively and components such as substrate, weather protection, actively cooled, and in combination with an photovoltaic (PV) generator, solar thermal collecting integrated thermal insulation for the building, tor, thermal insulation and mounting elements have been investigated. One part of the invest could be combined. In particular, the thermal ligation (forced backside convection by fans) was behavior of the

PV generator has been investigation carried out at a test facility of the 'Companies gated for different configurations of the products in the structure.

Some researchers further testing took place at Increased cell temperatures of PV modules. Earlier work predicts the power output of typical crystalline 21 duct ion of the cell operating temperature of 3–4 K silicon PV power plants by 20.3 to 20.5% K only for passive cooling by natural convection on . Therefore, as electrical-higher values reports on thermal performance of certain given facades, making it difficult to compare results. [1]

The following investigation has been undertaken to achieve more accurate results in a direct comparison of four very different thermal layouts under static conditions. This was carried out as a prerequisite for an economic evaluation of a new combined facade element that serves as a building insulation, generates electrical power at a high photovoltaic conversion efficiency and allows the use of solar thermal energy as well. Fig. 1. Current–voltage characteristics of the PV modules used during the experiments.[2]

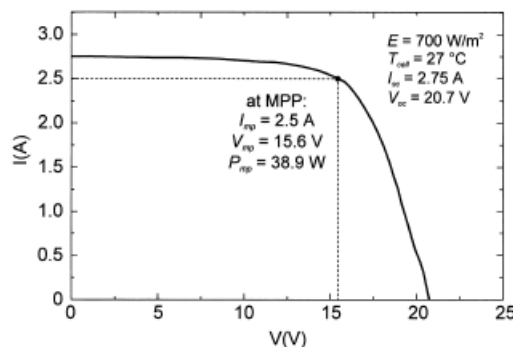


Fig.(1) IV characteristics of PV module

among middle east countries, made some kind of complexity to decide what is the optimum building characteristics should be to build an efficient building able to minimize the energy consumption during the year with a good indoor climate for the occupants. Therefore we cannot set a unite standard for all states and then follow it without taking into consideration the differences in temperature, humidity, solar radiation and solar altitude, thus this research was structured to find and assess the behavior of building (reference building) and how does it react with different climate conditions especially with solar radiation, which has the most influencing factor on energy demand and energy balance, and in turn leads to specify the appropriate HVAC systems capacity should be used in such building.[3]

The aims of this dissertation are:

1. to assess the energy demand of the reference building by using modeling tools for this purpose.
2. to present a method to simulate an absorption machine (for the HVAC system), as a way to rise the overall efficiency of the building.

The paper objectives are:

3. to provide a comprehensive understanding how different climates and different places, affect the energy balance and energy demand of buildings.
- 4.to present how the passive (orientations, window type, shading) and active (absorption chiller) measures which may existed, are contributing in optimizing the energy consumption in the buildings.[3,4]

2. REFERENCE BUILDING AND CLIMATE IN IRAQI REGION :

2.1 Description of Reference building:

the construction of reference building has been built in U-values standards for opaque partitions and glazing exceeded even the ones of U.S. and Germany as shown in the figure below which have strict regulations for efficient building designs. Figure 2 shows the U-values that applied on the structure of building during the construction:

Country Energy Building Codes

Country	Maximize thermal conductivity coefficient (roof)	Maximize thermal conductivity coefficient (flooring)	Maximize thermal conductivity coefficient (external walls)	Maximize thermal conductivity coefficient (windows)	Unit (W/m ² . K)
UAE	0.44	-	0.57	2.5 - 3.18	(W/m ² . K)
USA	R-38	R13-R25	R11-R22	1.99 - 2.56	(W/m ² . K)
Germany	0.25	0.4 - 0.5	0.35 - 0.45	1.7 - 2.0	(W/m ² . K)
France		1.0 1.35	0.4 0.6	2.7 3.5	(W/m ² . K)
Belgium	0.4	0.9	0.6	2.5 - 3.5	(W/m ² . K)
UK	0.25	0.35 - 0.45	0.45	2.2 - 4.2	(W/m ² . K)
Spain	0.7 - 1.39	0.7 - 1.39	1.2 - 1.8	3.48 - 5.2	(W/m ² . K)
Syria	0.5	1.0	0.8	3.5	(W/m ² . K)
Egypt	2.7		0.70	4.0	(W/m ² . K)

Fig.(2) Standard for Building Envelope[5]

2.2 Building envelope:

Centre of Excellence© consists of two floors connected by internal stair, each floor has an area of 68 m² and high of 3.1 m. Ground floor contains entrance, living room, kitchen and bathroom. First floor contains two bedrooms, kitchen, bathroom, and small balcony. Figure 3. Vertical Plan.[6]

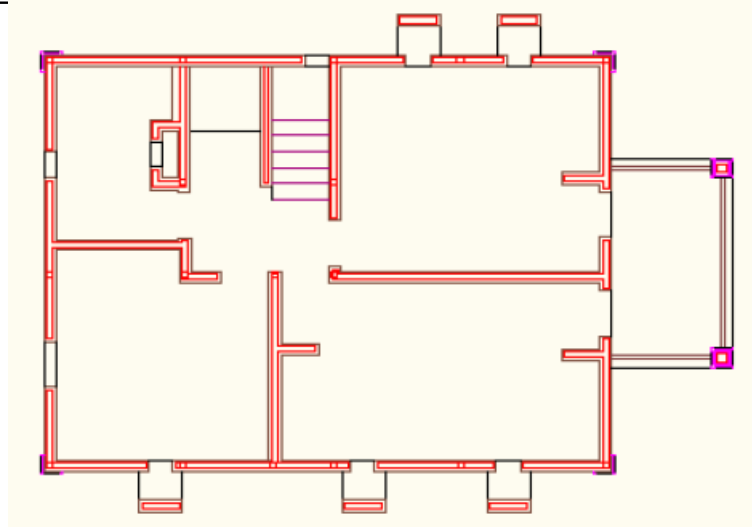


Fig.(3) Vertical Plan of First

2.3 Building Structure:

The construction of proposed buildings based on steel beams structure, The high thermal insulators with impermeable building envelope has been used during the construction. Figure 4 shows a proposed middle east and Iraqi house building.



Fig.(4) Middle East and IRAQI house Contracture

2.4New Window design:

The suggested building constructed a new design for placing the external window on the building envelope. This design own a shape of cuboids, attached to the external surfaces of the building and has two identical parallel transparent openings (glazings). [7]

Each one of these transparent openings has an area of 0.88 m² (Length=1.76 m, Width= 0.5 m). Furthermore, each one of these windows

are connected to the inside of building by “Rectangular Opening” has an area of 0.71 m² and its lower rib located 0.65 m away from the floor’s ground. Each floor contains five of those windows and distributed on two parallel facades. Figure 5 shows new window design configuration.

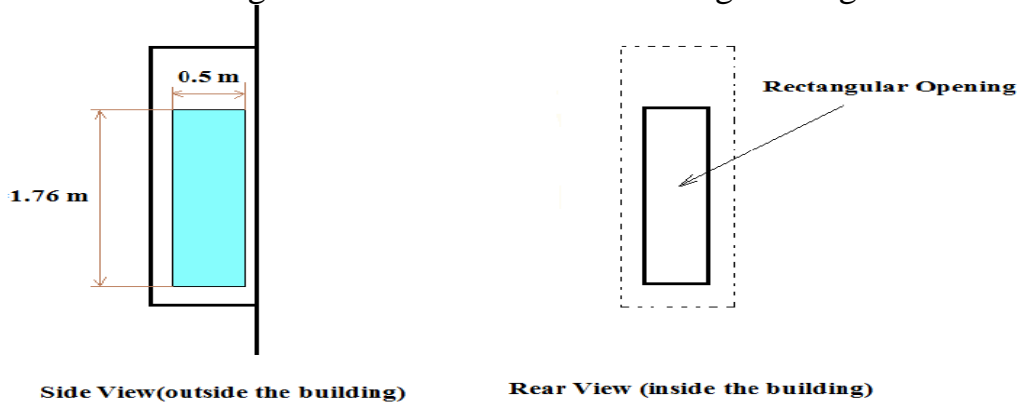


Fig.(5) New Window Design configuration

Additionally, the building contains normal design of windows, i.e. built directly on the external surfaces and they presence mostly on the main building designed.

In First floor, the total glazing’s area -except the areas of new window design- are assumed to be around 5.75 m² distributed on three identical openings on the building envelope. Two of them are located on the main façade, while the third one located on the back side of building, in addition there is a small window has an area assumed to be 0.65 m² for the bathroom on the backside of building. [8]

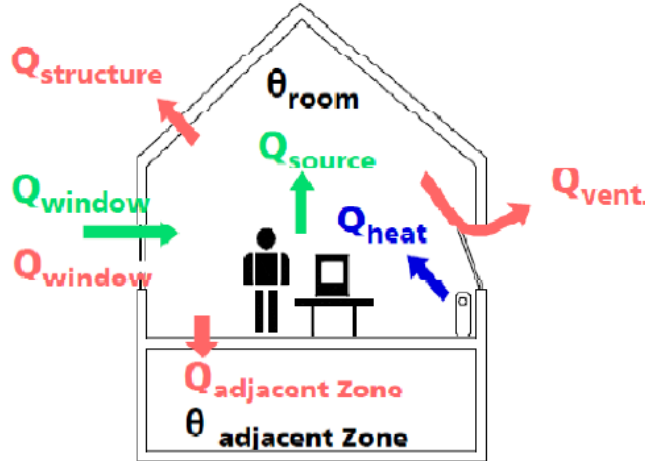
In ground floor, the total glazing’s area -except the areas of new window design- assumed to be around 8 m² distributed on four windows. Three of them (6 m²) located on the front building’s façade (main façade), while the fourth one (2 m²) located on the back side of the building. (Figure 4)

The room climate model which connects the energetic building simulation and the hygrothermal component calculation. With the building simulation software the hygro and thermal ratios in a building, in its perimeter and their interaction can be calculated and quantified as well as the energy demand and consumption of system engineering. [9]

The simulation building can be modeled easy with aid of the Building Wizard. Numerous assemblies and materials are already deposited in the accordant databases and can be assigned to the components of the simulation building. [4,10]

2.5 Mathematical Model Description:

Heat Balance:



Fig(6) heat flow into and out of thermal zone

Figure (6) shows the heat flow into and out of the thermal zone. These flows are balanced as in this equation [1]:

$$\rho \cdot c \cdot V \cdot \frac{d\theta_i}{dt} = Q_{component} + Q_{window} + Q_{IWQ} + Q_{vent} + Q_{RLT} \dots\dots\dots[1]$$

Where:

$Q_{component}$: heat exchange through opaque partitions.

Q_{window} : heat exchange through windows.

Q_{IWQ} : heat gain from people, equipment,.... etc.

Q_{vent} : heat flow ventilation (include natural and mechanical ventilation, and infiltration).

Q_{RLT} : heat flow from HVAC systems.

Heat Transport through walls:

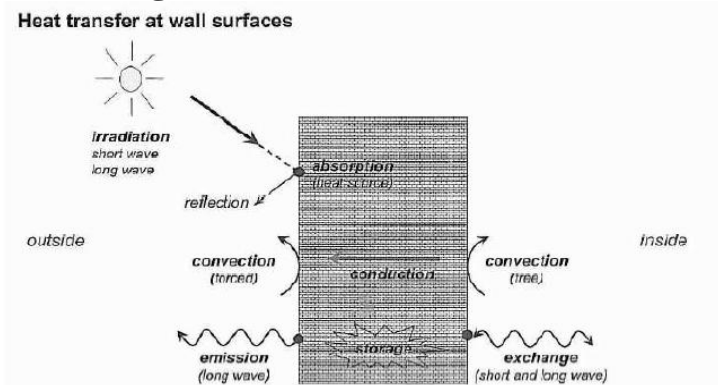


Fig.(7) Wall Heat transfer model

Heat exchanged through the opaque partitions of building envelope is given by equation[2]:

$$Q_{component} = \sum A \cdot U \cdot (T_a - T_i) \dots\dots\dots[2]$$

It should be noted that the overall heat transfer coefficient (U) will not have a constant value during the simulation. Every time step, a new U -value will generate according to the real values of surface and ambient temperature and other parameter depending on the surface's material.[11]

3.HEAT TRANSFER:

Window modeling

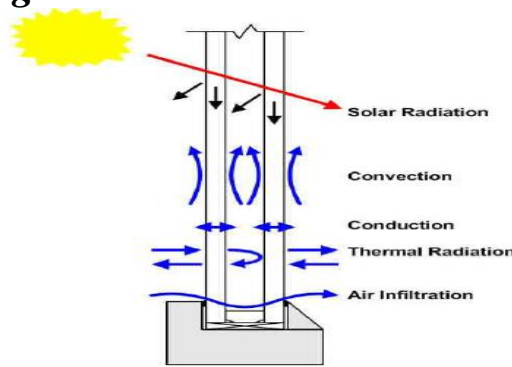


Fig.(8) Window model

The net heat flux flows through the window computed in a simplified way, taking into consideration transmission loss, because of the temperature difference between inner zone temperature and ambient temperature.

Transmission loss (or gain) through window is given by equation[3]:

$$Q_T = A_W \cdot U_W \cdot (T_a - T_i) \dots\dots\dots[3]$$

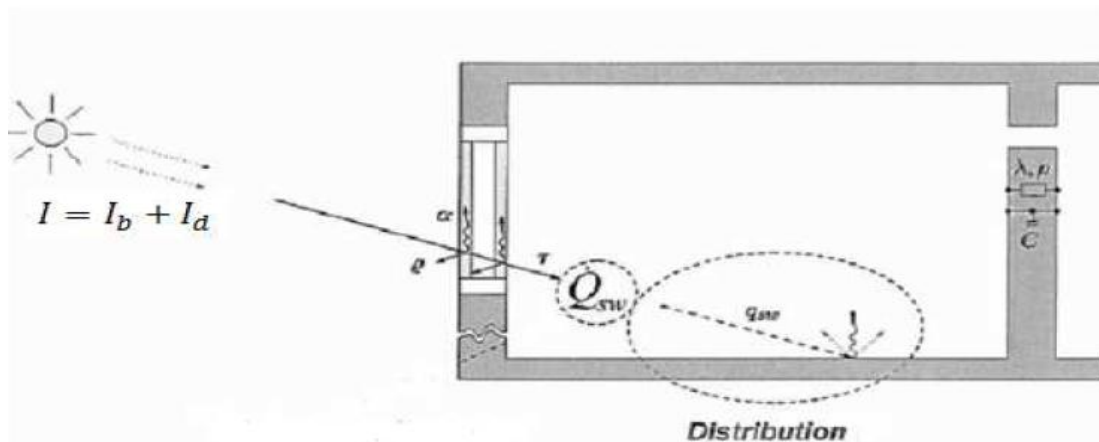


Fig.(9) Internal Distribution of short-wave radiation (Beam solar radiation)

The window model consists of two panes (Figure 9), each glazing contributes in a part of reflection, and absorption of solar radiation and also influenced the short-wave being transmitted into the thermal zone (this reduction take place in visual band of light and thermal gain). “g-value” determines the amount of total solar radiation (Beam & Diffuse) being inside the zone, this value strongly dependent on inclination angle of solar radiation on the window pane, which could be defined as constant or angle depended (user define). [12] Zone gain from solar radiation is given by equation(4):

$$Q_I = \gamma (f_{frame} \cdot SHGC \cdot A_w \cdot I) \dots\dots\dots [4]$$

Where:

γ solar gains direct to inner air. This factor ranges between (0-1), and it specify the percentage of solar gain directly contributed in rising the indoor temperature of the zone.

SHGC Solar Heat Gain Coefficient.

f_{frame} the ratio of the frame area to the total window area (*A_w*).

Finally, net heat flux flows through window (in two directions depends on inner and outer temperature)[5]:

$$Q_{window} = Q_T - Q_I \dots\dots\dots [5]$$

3.1 Absorption chiller system characteristics:

We will focus on the analyses of the energetic and economical performance of solar

powered absorption chiller system used to cover the previous investigated building. The goals are to calculate the solar contribution to the total energy demand of the thermal chiller system and to specify the associated costs.[13]

The chilled water system is consisting of the following elements. The system layout is given in Figure (10).

- Solar collector field
- Hot water buffer storage
- Absorption chiller.
- Wet cooling tower
- Cold water buffer storage
- External backup heater.
- Circulation pumps

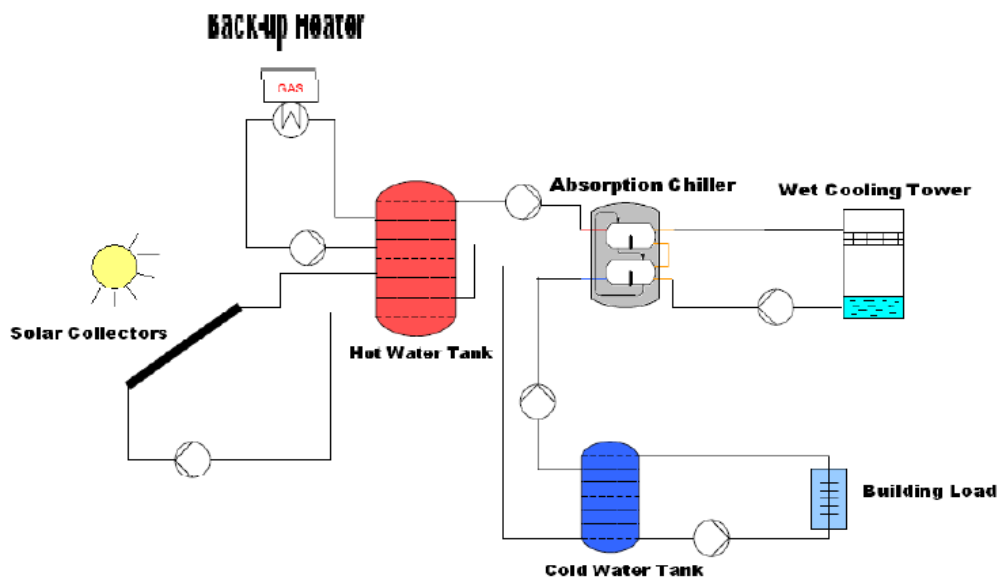


Fig.(10) The chilled water system.

The solar circuit are separated by a heat exchanger in hot storage tank. Hot water from the hot water storage tank is feeding to the absorption chiller generator to provide cooling.

In case the cooling load cannot be met by solar means alone, an external backup heater is foreseen for supplementary heating of the hot water loop to the generator.

Heat rejection is obtained by means of a wet cooling tower. For reasons of simulation simplification the heat rejection unit, it assumed that in case of no adequate outlet cool water temperature; a constant cooling water inlet temperature of 26°C to the absorption chiller will be supplied. Also for reasons of simulation simplification, it has been assumed that return temperature from cold distribution system of building always constant and equal to the set-point temperature cooling minus three degree °C.[14]

4. RESULTS AND DISCUSSION:

4.1 Building Modeling

4.1.1 Simple model testing results:

In this stage, two window designs were analyzed. The two model were tested under the weather of Baghdad. The term “Design A” refers to normal window design. The term “Design B” refers to the prominent design of the windows of reference building (The geometry and the characteristic of these two Designs).

Figure(11) shows the vertical view of “Design A” and “Design B” models which are used.

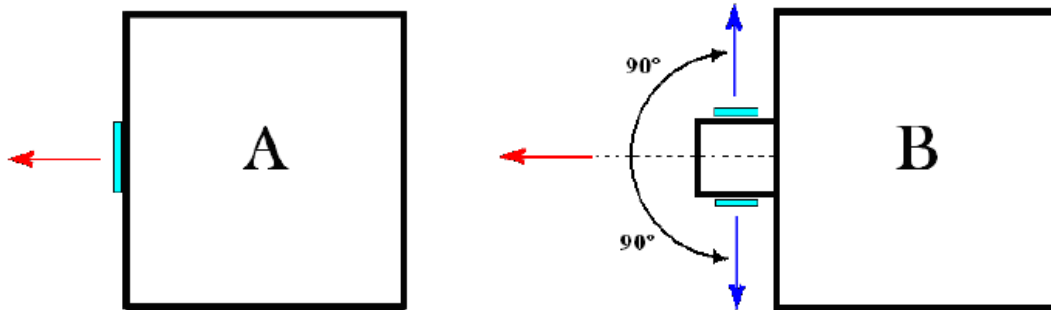


Figure (11). Design A (left) and Design B (right) Models

Figure(11) represents the monthly solar energy gained at West direction for both designs.

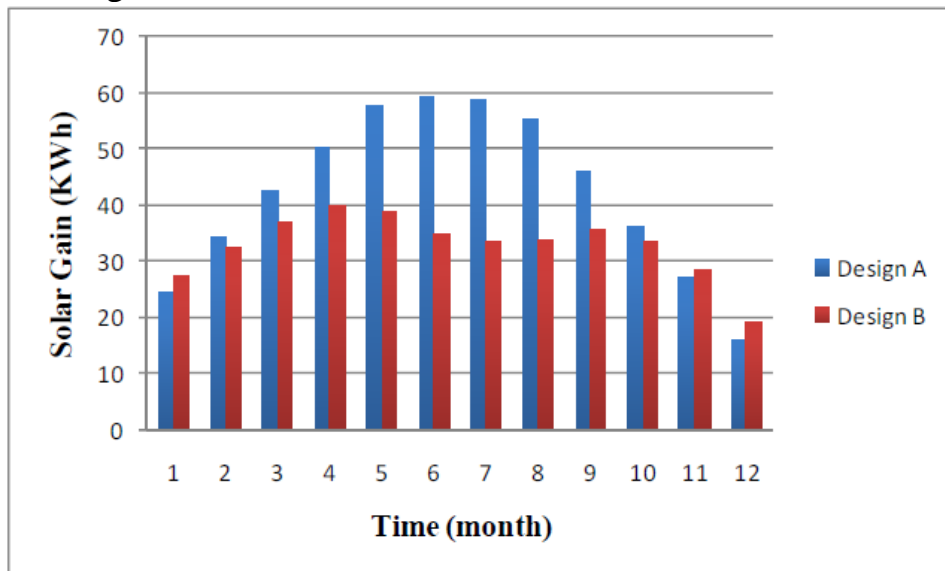


Fig.(12) Monthly Solar energy Gain Distribution – West Orientation

Figure(12) above shows the monthly solar energy gain distribution due to the west orientation. It appears that the highest solar gain is during the middle time of the year.

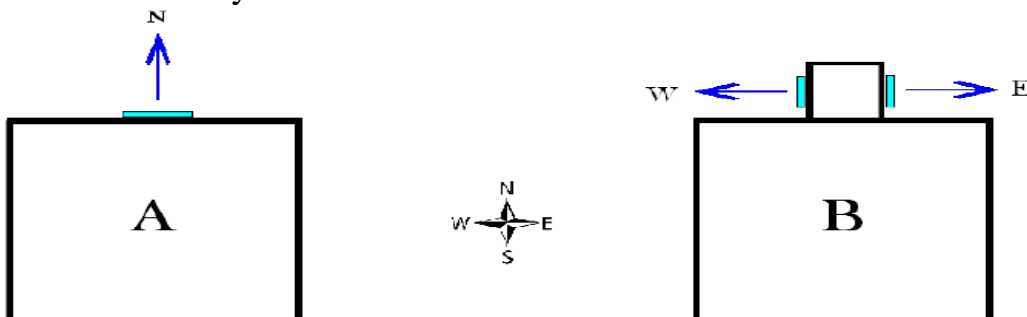


Fig.(13) Design A (left), Design B (right) North orientation
 Taking the North orientation case. Here the two glazings of “Design B” oriented West and East.(see Figure 13)

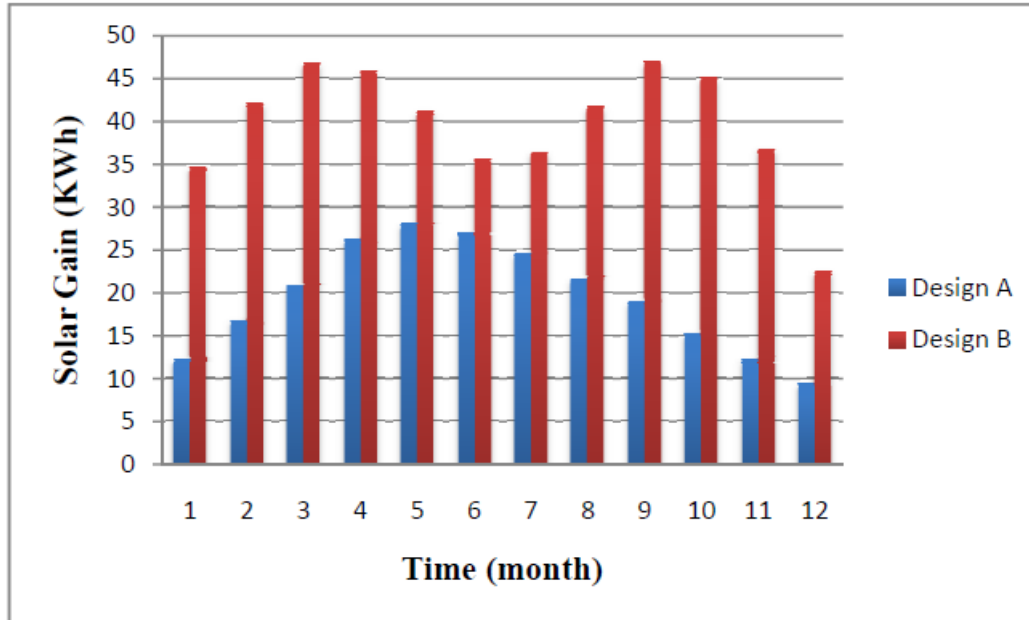


Fig.(14)Monthly Solar energy Gain Distribution – North Orientation

Figure (14) shows two peaks in fall and spring times from “Design B”, while “Design A” shows one peak in the beginning of summer time (May). The solar gain profile

“Design B” shows that in summer time “Design A”, and this return to more sun shine hours on both glazings of “Design B” (west and east) during sunrise and sunset times than in “Design A”. In winter time, most of solar gain mainly from diffuse radiation wave radiation exchange with surroundings. [15]

Figure (15) represents the case of South direction.

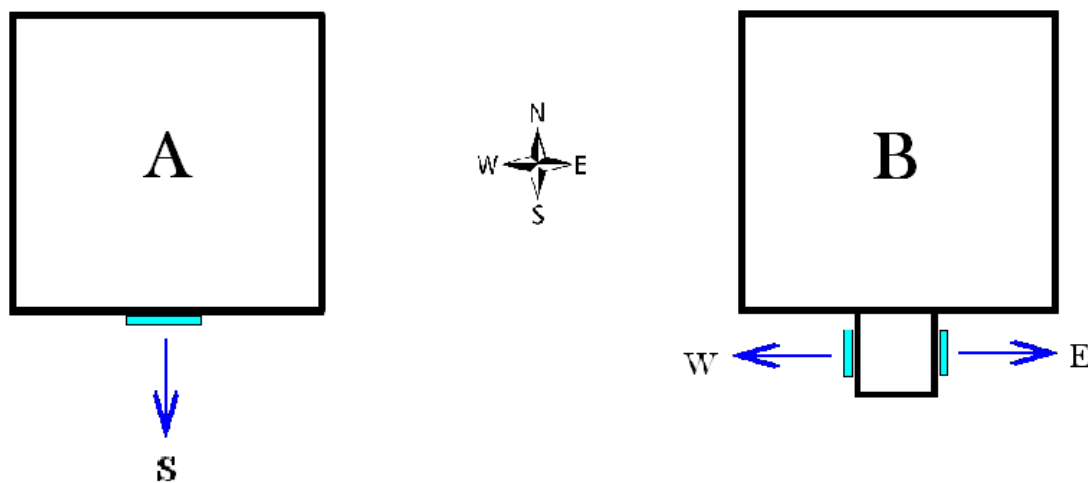


Figure (15). Design A (left) and Design B (right) – South Orientation

Figure (15) represents the case of South direction. Although the two glazings of “Design B” here oriented toward west and east - like in North case -, but the response with solar radiation was totally different, because the relative movement of the sun will keep the two designs always projected to the sun during the day and throughout the year. [16]

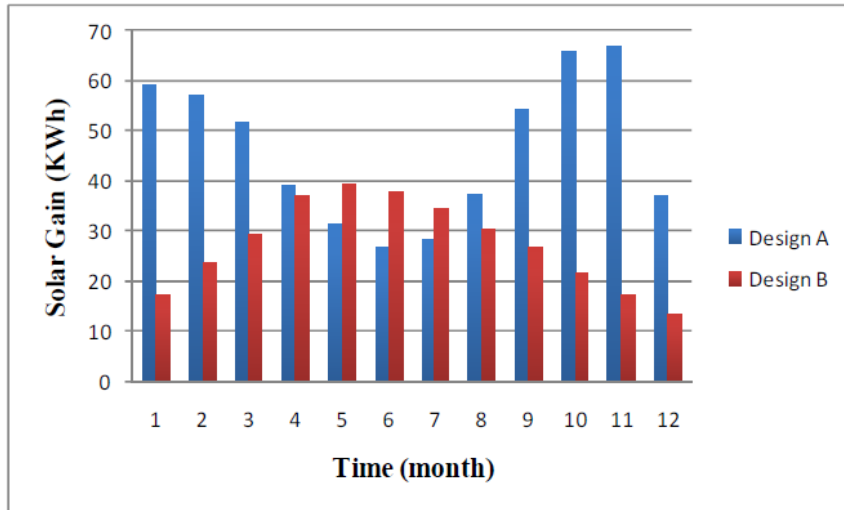


Figure (16). Monthly Solar energy Gain Distribution – South Orientation

Figure (16) proved that the continuous exposure to the solar radiation has reduced the energy gained in summer in “Design A” and increased it in “Design B”, while the situation in winter reversed markedly.

5. DISCUSSION OF THE PREVIOUS RESULTS:

Figure(17) shows a comparison of the gain profiles between “Design A” and “Design B” at three different orientations.

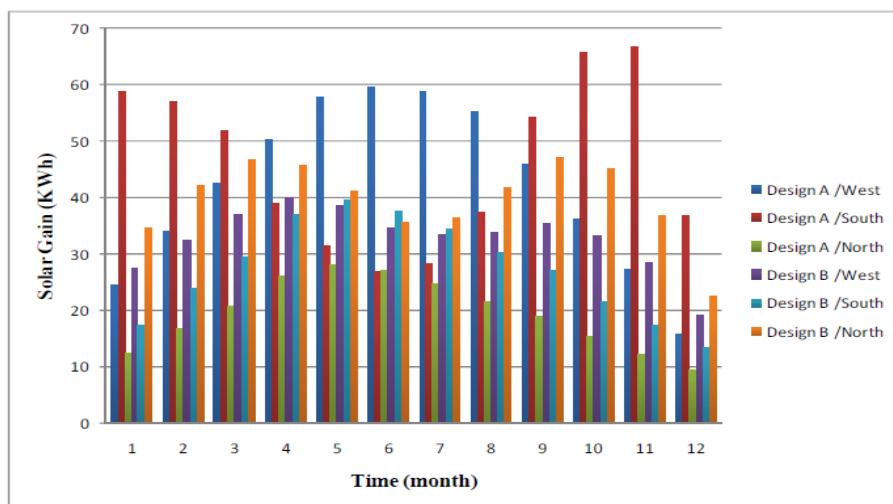


Figure (17). Comparison between Design A and Design B at Different Orientations

This comparison shows convergence in solar energy gained during summer in case of “Design B”, in contrast, it shows dissymmetry (spacing) when we talk about “Design A”.

5.1 Building Modeling results:

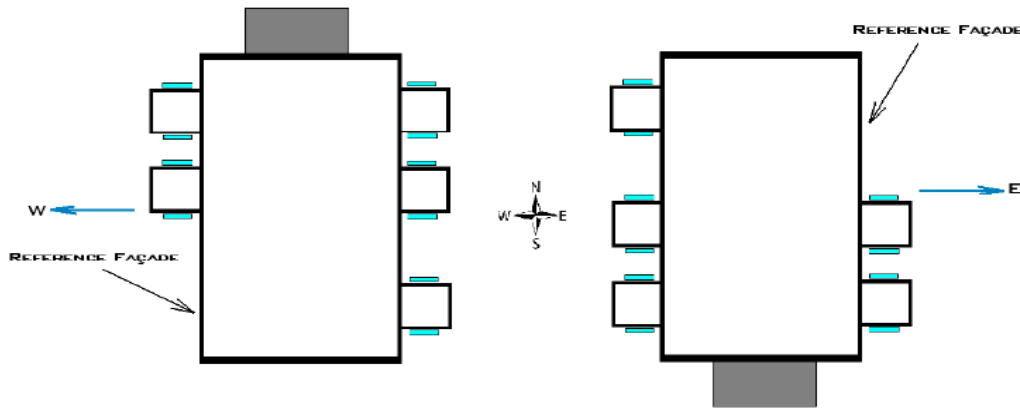


Figure (18). Building Position in case of West (left) and East (right) Orientation

Figure (18) above shows the position of the buildings in case of west(left) and east(right) orientation.

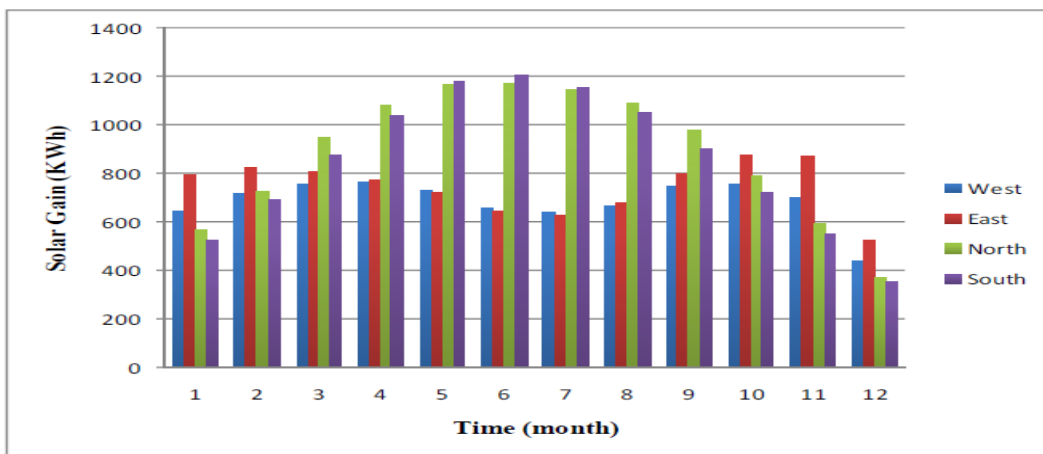


Figure (19). Monthly Solar Energy Gain Distribution (from left to right: West, East, Irbil)

Figure(19) above shows the monthly solar energy gain distribution (from left to right ,west east, Irbil).

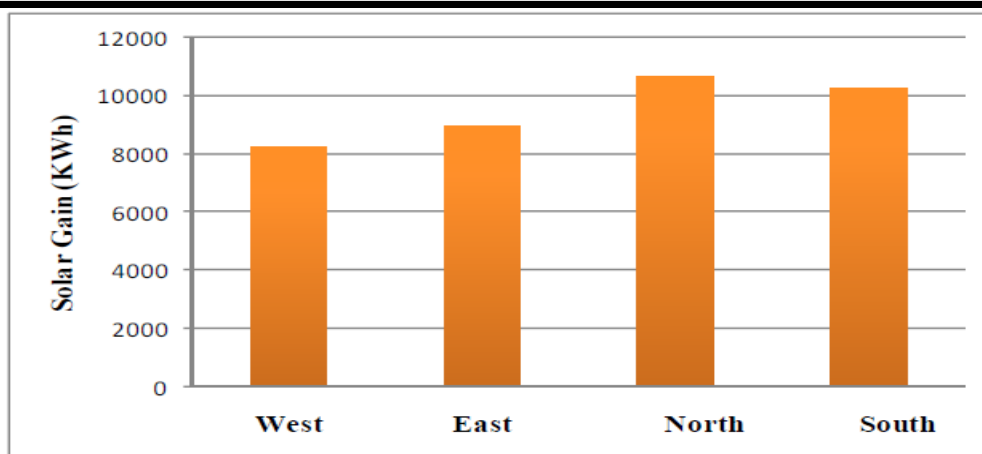


Figure (20). Annual Solar Energy Gain at Four Different Orientations / Irbil

All previous investigation about solar gain led to parallel conclusion of the energy demand for building. The solution proved that when there is much solar gain, the demand for heating will be less, while cooling will be higher.

Figure(21) presents cooling and heating demand of all four directions.

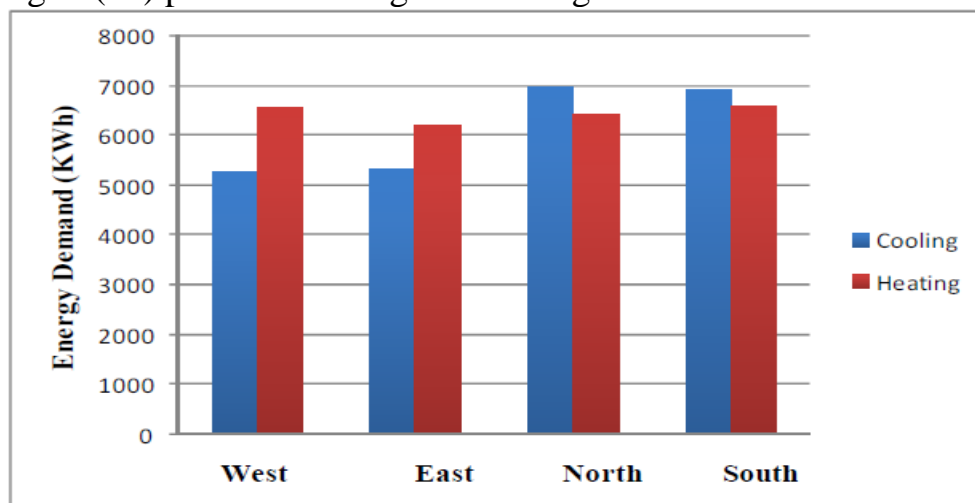


Figure (21). Annual Heating and Cooling Energy Demand at Four Different(Irbil)

From the Figure (21) it can note the followings:

- The highest cooling energy demand achieved when the reference façade oriented “South” with 6907 KWh/ annually. • The lowest cooling energy demand achieved when the reference façade oriented “West” with 5280 KWh/ annually.
- The highest heating energy demand achieved when the reference façade oriented “South” with 6597 KWh/ annually.
- The lowest heating demand achieved when the reference façade oriented “East” with 6200 KWh/annually.

5.2 Situation at Baghdad:

Figure(22) represents the sun-paths diagram of Baghdad.

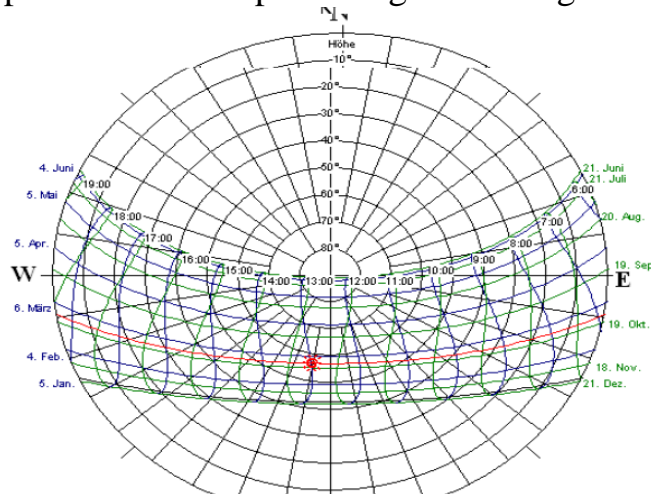


Fig.(22) Sun paths at Baghdad

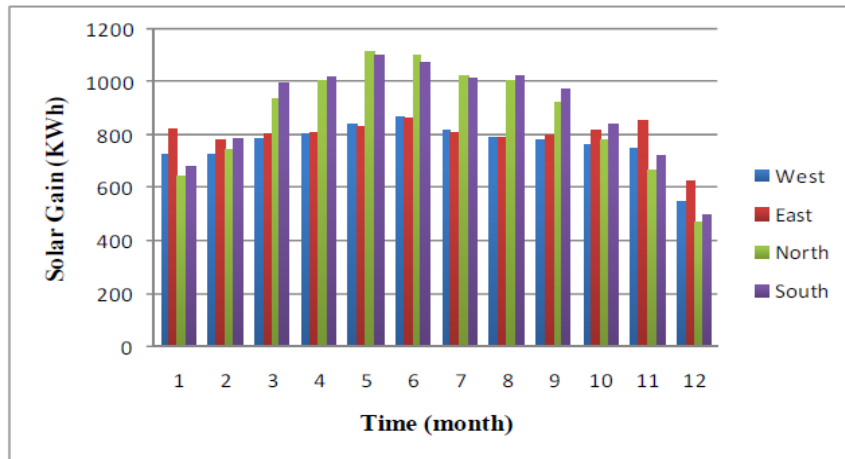


Figure (23). Monthly Solar Energy Gain Distribution (from left to right: West, East, North, South) / Baghdad

Figure(23) monthly solar energy gain distribution(from left to right, west east, north south at Baghdad).

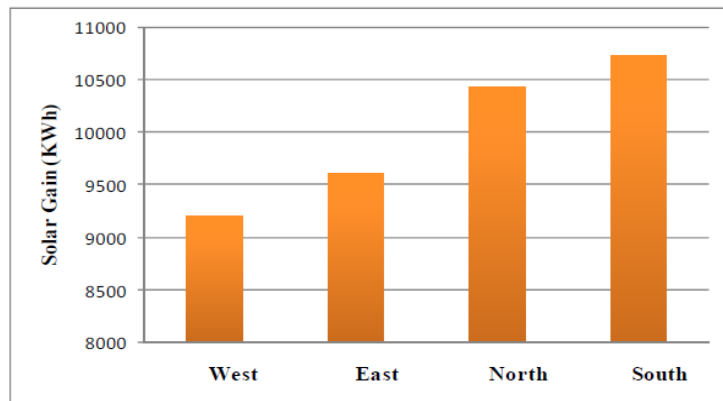


Fig.(24) Annual Solar Energy Gain at Four Different Orientations / Baghdad

Figure(24) the annual solar energy gain at four different orientations at Baghdad. Figure(25) below shows the demand at four orientations at Baghdad.

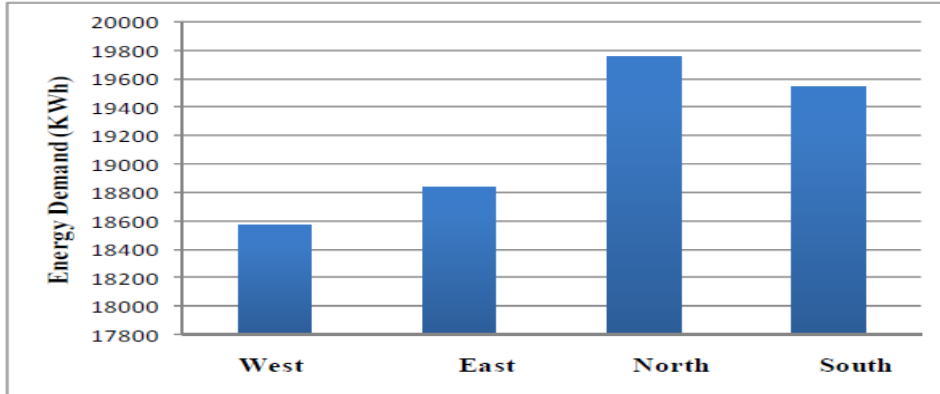


Fig.(25) Annual Cooling Energy Demand at Four Different Orientations / Baghdad

5.3 Absorption Chiller Modeling results:

The case study considered in this work corresponded to solar absorption refrigeration system serving a demand for air conditioning for building under the climate of city of Baghdad.

Fraction %

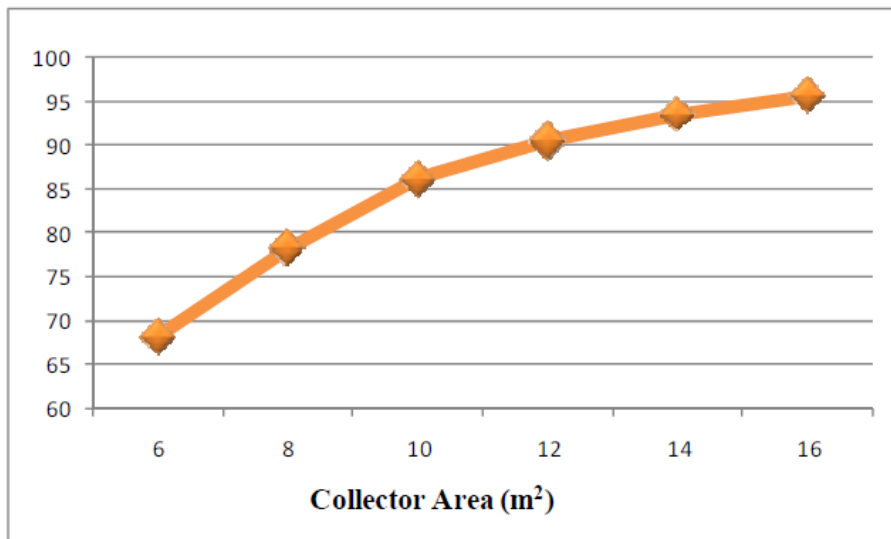


Fig.(26) Solar Fraction

The results of varying the collector area on the useful collector energy and the required auxiliary heating energy to drive the chiller can be seen in Fig.(26).

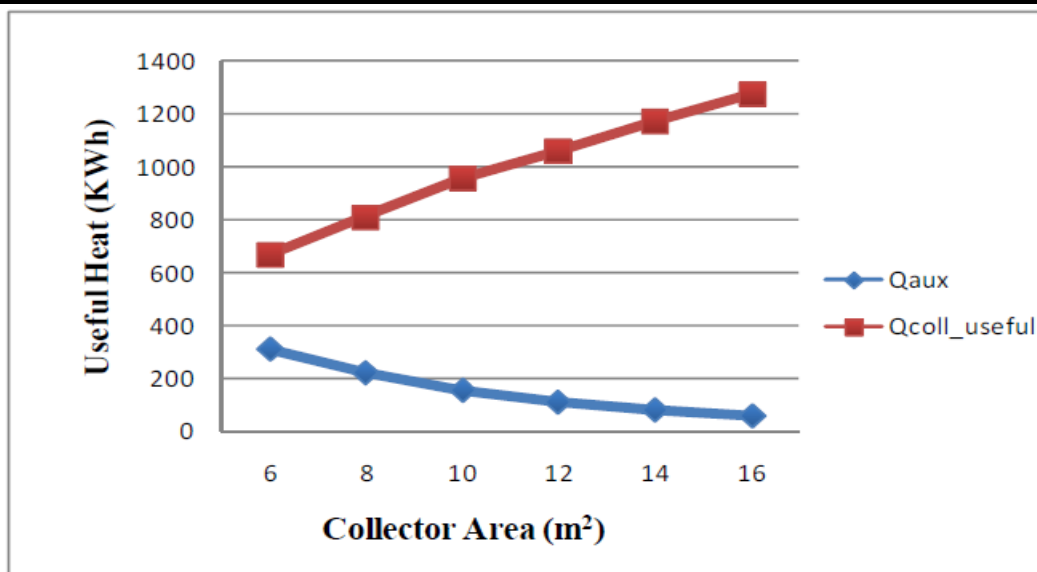


Fig.(27) Useful Collector Heat vs. Heat from Back-up

Figure(27) above shows the useful collector heat against the heat from back-up.

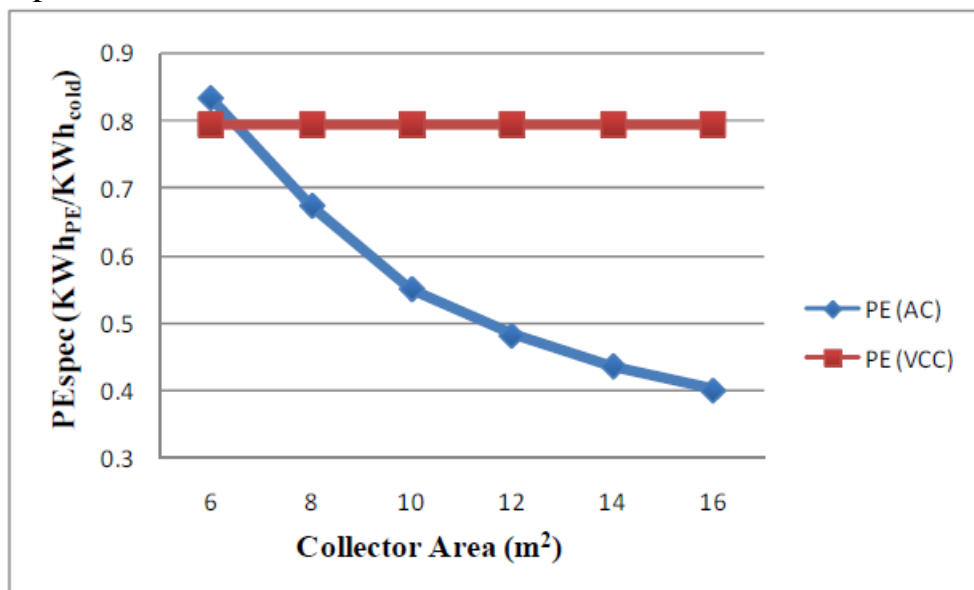


Fig.(28) Specific Primary Energy Consumption (Solar Absorption Chiller vs. Conventional Chiller).

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Figure(28) shows the specific primary energy consumption (solar absorption chiller against the conventional chiller). Figure (29) shows the CO₂ Emission (KgCO₂) against the collector area(m²) .

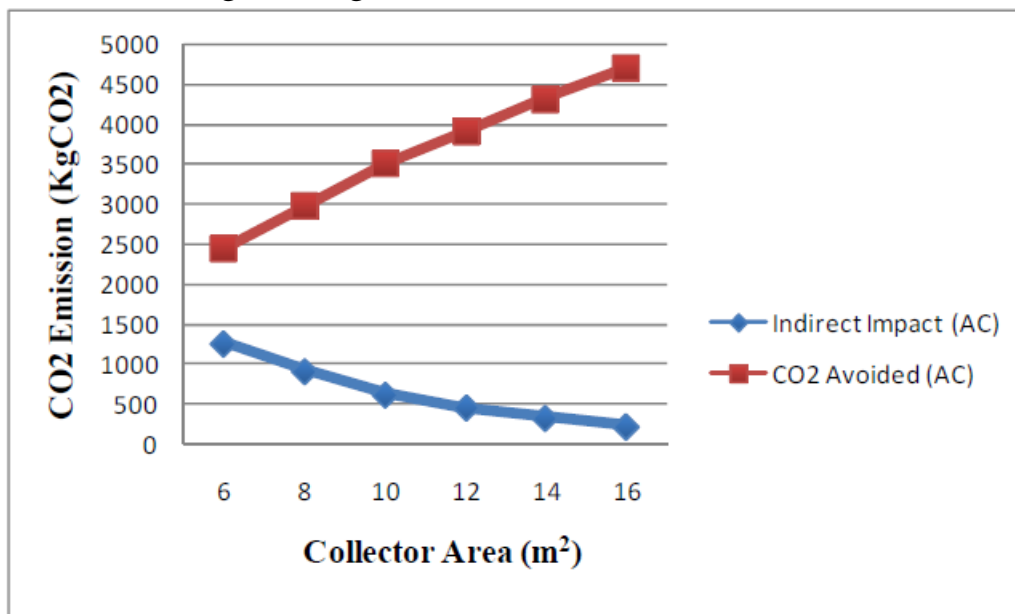


Fig.(29) Specific Primary Energy Consumption (Solar Absorption Chiller vs. Conventional Chiller)

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الخلاصة:

في الحقيقة أن معظم المباني السكنية في منطقة الشرق الأوسط ومنها العراق مصممة بعيدا لتكون على نحو فعال للتأثر بالطاقة الشمسية، كذلك فإن قدرا كبيرا من الطاقة المنتجة داخل هذه البلدان تستهلكها المباني والمنازل في هذه البلدان، وهذه الورقة البحثية محاولة لوضع معايير يمكن استخدامها في المستقبل على المباني السكنية لهذه المنطقة من وجهة نظر الطاقة، مع اقتراحات إضافية للآخرين للتدبير الأمثل للحصول على الكفاءة الكلية وتقليل التأثر من الطاقة الشمسية على المباني.

كما تهدف هذه الدراسة إلى التعرف على الطاقة الشمسية لتكوين نظام التبريد المناسب والحجم مع دراسة القيم المستهدفة في توفير الطاقة الأولية، والطاقة الشمسية الحرارية لاستغلال النظام والاقتصاد.

تقدم هذه الورقة التقنيات المختلفة لتصميم مبنى ذوكفاءة قادرة على الامتثال لشروط مناخية مختلفة في العراق.

كما تركز البحث على تقدير الطلب على الطاقة من مبنى اساسى باستخدام أدوات المحاكاة المتقدمة. اقترحت المحاكاة طريقة امتصاص الطاقة الشمسية الحرارية ، والتي يمكن استخدامها مع هذا النظام باستخدام تقنية (HVAC). تغطية أحمال التبريد خلال فترة الصيف