Al-Rafidain Engineering Journal (AREJ) Vol.27, No.1, March 2022, pp.56-63

# The Use of Solar Water Heaters in Iraq: An Economic Study

**Wael H. Hamdon*** waelhashem_67@uomosul.edu.iq
**Mahmoud U. Jasim**** mahmood14@uomosul.edu.iq
**Majid S. M. Al-Hafidh*** alhafidms@uomosul.edu.iq

Electrical Engineering Department, Collage of Engineering, University of Mosul*
Mechatronics Engineering Department, Collage of Engineering, University of Mosul**

Received: 18/8/2021 Accepted: 21/10/2021

***ABSTRACT***

*The Iraqi electrical system suffers from an increased electrical load for the available generation, which leads to the separation of a large number of consumers, especially during the peak load period. The water heating load represents a great value, so reducing water heating consumption can reduce the cut-off times. Solar water heaters possess many benefits. Therefore, they are used in many countries in the world today. The climate of Iraq is mostly hot and sunny. This makes using a solar water heater is convenient for consumers, especially in urban areas. For studying the use of solar water heaters in the residential sector, three consumers were selected in Mosul city in northern Iraq. Each consumer differs from the others by the value of their consumption of electrical energy (high, medium, and low). Electricity tariffs for the residential sector in Iraq vary, depending on consumption. The information for the three consumers was obtained from a previous questionnaire. In addition to obtaining their needs for hot water, the results of using solar water heaters on the roofs of the three houses of consumers showed a decrease in electricity consumption and a noticeable saving in the electricity bill. The payback period of the solar water heater system was calculated for each consumer. Reducing consumption reduces the gap between generation and load, resulting in reduced programmed shedding times for consumers. For these benefits and environmental features, it is necessary to generalize the use of solar water heaters in the residential sector in Iraq.*

***Keywords:***
*Solar Water Heaters, Iraqi Residential Sector, Electricity Energy Saving, Payback Period.*


=============================================================================

## 1. INTRODUCTION

Due to the high cost of conventional fuels (fossil fuels), the serious environmental problems associated with them, also the growing need to rationalize consumption, and use-demand renewable resources, solar energy usage is increasing in both developing and developed countries [1].

The problem of energy consumption of household appliances has increased in recent years due to the increased load density in the residential sector. Increasing efficiency, rationalizing energy consumption, and using renewable energies are the main key to manage energy in the houses [2].

Due to its share in total consumption, water heating in residential units is one of the major concerns in energy consumption for buildings. Energy demand for hot water is being met in several ways such as the use of electricity or fossil fuels. However, heating water with these resources is expensive [3].

Residential loads represent the largest consumer of electrical energy in Iraq. 32.29% of this value is used for heating water [4]. A large portion of this demand can be met by using renewable energy (solar water heater) [5].

Hot water is used in houses, hotels, hospitals, and factories. The most common way to use a solar heater is to use solar water heaters to get hot water. Solar water heating systems (SWHS) are used in millions of buildings around the world and they contribute significantly to sustainable earth development [1]. The main countries that have benefited from the advantages of SWHS are (China [6], Turkey [7], India [8], Brazil [9], and Germany).

To promote the use of solar heating in a residential building, financial support, tax exemptions, and mandatory policies are policies adopted by countries such as China, New Zealand, and many European countries [10].

The use of SWHS is a long-term investment. It brings many benefits like reducing energy demand, saving money spent on heating water. In addition to, reducing emissions of gases that cause environmental problems. The availability of hot water for these systems is safe from power outages [11].

The current research shows the use of solar heaters in providing hot water to residential units, reducing electrical consumption, and reducing the electricity bill. The results showed that these benefits were achieved, in addition to minimizing programmed cutting.

## 2. Research Methodology

The Iraqi electrical power system suffers from many problems. One of these problems is the lack of sufficient capacity to supply the loads. This shortage of generation causes the source to be cut for long periods (programmed cut). Despite the relentless pursuit to increase generation capacity, the growth of loads leads to the continuation of programmed cuts. Therefore, the appropriate solution is to rationalize loads. The residential load represents the largest load in the Iraqi electricity system. Some components of a residential load can be compensated by using renewable energies. The use of renewable energies in rationalizing residential loads, reduces programmed cutting times, reduces the electricity bill, and reduces pollution . . . etc.

In cooperation with the Nineveh Electricity Distribution - State Company of the Electricity Distribution for North – Ministry of Electricity, the electrical load for the residential sector was studied. Studies began to find the Diversity Factor of the distribution system [12]. Then to study the peak load of residential units [13]. Previous studies led to the conclusion that rationalizing consumption and using appropriate alternatives, especially renewable energies, is the solution. To take appropriate rationalization steps, you must first know the electric load components.

The components of the residential load in the Iraqi system were studied. The residential load was classified into five components. Lighting, home appliances, heating, cooling, and water heating. The amount of each component was determined over months of the year. These components were drawn with months for a whole year [14]. In another apervious study, the possibility of reducing the Lighting component was studied [15].

In another study, the possibility of reducing the water heating component using solar water heaters was studied. Solar water heaters were added to a number of houses in the city of Mosul. A SWHS reduces, but does not eliminate, the need for electric or fossil fuel heating water. The performance of a SWHS can be defined by a solar fraction. The effective solar fraction of a SWHS depends on the intensity of a solar radiation, the technical characteristics of the individual system and the load characteristics [4, 16].

A small electric heater (1 kW) was added to the solar heater to provide complementary heating. The readings recorded the energy consumed in heating water with and without the solar water heater for a full year. The results showed that using a solar water heater reduced consumption from 32.29% to 13.1% (19.19%) [4].

Complementary aspects of previous research were studied in this research. The current research aims to study the effect of using solar heaters on electricity consumption and electricity bill. Also, study the investment payback period. The study was applied to three consumers of varying electricity consumption, low, medium, and high consumption. The results showed a significant reduction in electricity consumption, significant savings in the electricity bill, as well as an adequate payback period. In addition to the above, reducing consumption contributes to shortening programmed cutting times.

## 3. Weather effect on residential load

Residential electrical load in Iraq is affected by weather, especially temperature. The electric load increases in winter due to the use of heating equipment and water heating. On the other hand, the electrical load during summer is high due to the use of cooling and refrigeration types of equipment. For spring and autumn seasons, when the temperature is moderate, the electrical load is relatively lower compared to summer and winter seasons.

Figure 1 shows the daily minimum (blue) and maximum (black) temperature changes for a full year in Iraq [14]. Readings begin on April 1st and end on March 31st. Due to the significant change in temperature, the need to heat water in the seasons varies. The need to heat water can be divided into four categories:

1. No need to heat water: There is no need to heat water when the temperature exceeds 40° C. This condition occurs in summer and lasts between 90 - 100 days.

2. No need for supplemental heating: The solar water heater provides hot water that is sufficient for the need, without the need for complementary heating. This condition occurs at temperatures between 30-40° C. This condition lasts between 90-100 days and occurs in spring and autumn.

3. The need for low complementary heating: The solar water heater does not provide enough hot water at appropriate temperatures for the entire household needs. Therefore, the need for supplementary electric heating at a small value is necessary. This condition occurs at temperatures between 20-30° C. This condition lasts between 85-95 days in a spring and fall procedure.
4. The need for high complementary heating: At low temperatures, below 20° C, the need for complementary heating is high. This condition lasts between 70-80 days in winter.

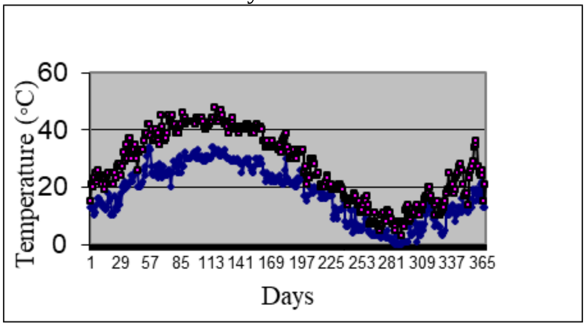



Figure 1 Daily minimum and maximum temperatures in Iraq.

## 4. Solar water heating system SWHS

Iraq receives the highest solar energy in June & July with a values of (5.8 - 7.6) kWh/m2/day, while the lowest solar energy in December is (2.5-2.8) kWh/m2/day, [17]. The long term average global horizontal irradiation is between (5.0-5.8) kWh/m²/day [17, 18], which encourages the use of the SWHS in Iraq.

A solar water heating system has to be installed on the rooftop of the houses under this study to eliminate, or reduce, the electricity consumption spent on heating the needed hot water for residential usages and evaluate the real application of the SWHS.

SWHS requires some auxiliary or complementary heating during days of low or not enough solar radiation. The auxiliary energy source with installed SWHS is a small capacity of about 1 kW electric heater.

The SWHS types are mainly divided into two main groups, the active systems and the passive system [19-22].

### 4-1 The active system

It contains a pump to circulate the heat transfer fluid throughout the system elements. It requires an electric supply (DC or AC) to run so. It does not work when no electric current. It should be supplied with the control system and it may require the use of freeze-resistant heat transfer fluid, which made this system not available in the Iraqi market [19, 20].

### 4-2 The passive system

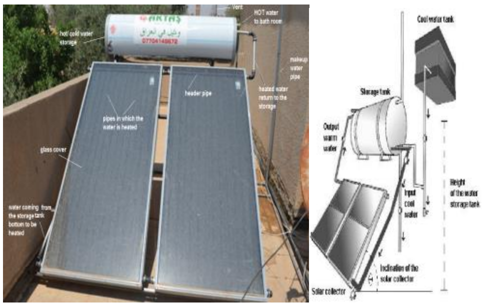
It does not contain a water pump to circulate the working fluid. Its heat transfer fluid circulates in the system by bouncy effect, i.e. naturally without the need for electric power to circulate, as required in the case of the active system. Also, the control units are not needed and the heat transfer fluid is normal water available in the house and no antifreeze addition is required. Therefore, these systems are simpler and cheaper than the active systems and they are available in the Iraqi market. The passive SWHSs found in the Iraq market is divided into two types [19-21]:

#### 4-2-1 Water-in-glass type passive SWH collectors

These systems consist of several evacuated solar Pyrex tubes, directly connected to a metallic heat-insulated hot/cold water tank, and horizontally mounted to a metallic frame that mounts the solar collector's parts. These systems were not chosen for this study as they require more careful operating conditions, for example, if some water leak from the sealant has happened, some troubles may result related to water spread and if one of the solar evacuated tubes is broken, the whole system completely stops working until it would be fixed or replaced [21, 22].

#### 4-2-2 Flat plate solar collectors

The flat plate solar collector is consisted of an absorber plate (black coated) to absorb the energy of the solar radiation and conduct the absorbed heat energy to several metallic pipes attached or welded to this absorber plate, which through them the heated water is passed, see figure 2-a. The absorber plate is weather proofed by enclosing it in a heat insulated metallic box of glass cover from the top side to allow the solar radiation to reach the absorber plate. The cold water comes from the bottom of a storage tank through a pipe to the footer distributing pipe at the bottom of the collector then rises up through the pipes mentioned above as its density becomes less when heated. The heated water is collected by the header pipe then it continues the flow to the top of the hot/cold water storage tank through a connecting pipe. The heated water is pushed out of the storage tank, to the bathroom, under the pressure of the makeup water tank installed about 1.5 m higher than the storage tank, as shown in figure 2-b, [22].



(a) (b)

Figure 2 Solar Water Heater used in the research.

The selected SWHS by the authors is a similar type to those discussed in 4-2-2 mentioned above. It consists of two flat plate collectors connected in parallel and the assembly is connected to a single thermal insulated hot/cold water storage tank. The capacity of the selected system can be increased, if needed, by adding a third or more collector unit to the system.

## 5. Case Study- Iraqi system

The current research aims to study the savings in residential electric bills. The electrical energy tariff for the residential sector in Iraq is based on the amount of consumption as in Table 1 [15].

Table 1 The electrical energy tariff for the residential sector in Iraq.

| level of consumption | the amount of consumption kWh | The price of kWh (ID) | The price of kWh ($) |
|---|---|---|---|
| low | 0-1500 | 10 | Lessthan1C. |
| medium | 1501-3000 | 35 | About 3 C. |
| high | 3001-4000 | 80 | About 6.5 C. |
| Very high | >4000 | 120 | About 10 C. |

The study was applied at different levels of consumers (three consumers). The first consumer is at a low consumption level. The second consumer is at a medium consumption level. The third consumer is at a high consumption level. In the next section, an explanation, clarification and discussion for the application details and results [14].

## 6 Results and Discussion

A questionnaire form was prepared and distributed to a large number of participants of the housing units. Appendix A shows the used questionnaire form. According to the questionnaire form, the registration of household loads is distributed on the components mentioned above. The recorded information was used in a number of studies on residential loads in Iraq [4,12-14]. The obtained results in the questionnaire were used in this study for three consumers, which are high, medium, and low consumption consumers.

### 6.1 Total energy consumption

The annual electrical energy consumption of the three consumers (high, medium, and low consumption) with and without solar water heaters was studied. Figure 3 shows the monthly load of the three consumers. The total annual consumption of the three consumers (without solar water heater) is 40441, 24755, and 14695 kWh respectively. When adding a solar water heater, the consumption is reduced to 32,040, 19659, and 11,610 kWh respectively. The saving is the difference between consumption without and with a solar water heater. The ratio between savings and consumption without a solar water heater represents the percentage of savings. Table 2 summarizes the annual consumption with or without a solar heater, the amount, and the savings percentage. The annual electrical energy consumption savings range between 20.6-21%.

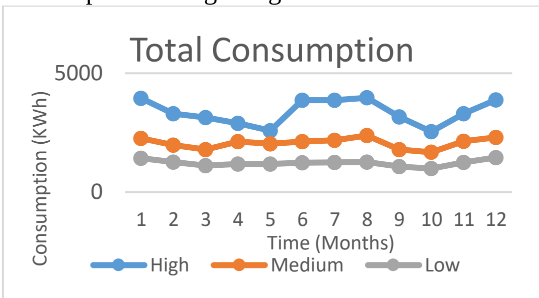



Figure 3 Monthly consumption of the three consumers without SWHS.

Table 2 Annual consumption and saving of the three consumers.

| | High | Medium | Low |
|---|---|---|---|
| Annual consumption Without SWH (kWh) | 40441 | 24755 | 14695 |
| Annual consumption With SWH (kWh) | 32040 | 19659 | 11610 |
| Savings (kWh) | 8401 | 5096 | 3085 |
| Savings % | 20.8 | 20.6 | 21 |

### 6.2 Energy consumed in water heating

Figure 4 shows the monthly value of the water heating component for the three consumers without a solar water heater. When adding the depreciation value of this component, the result is 12721, 7765, and 4728 kWh respectively. The consumption decreases when the solar water heater is added to reach the annual consumption of 4320, 2669, and 1643 kWh, respectively. The difference between consumption without and with a solar water heater represents the amount of savings. The ratio between savings and consumption without a solar water heater is the annual coverage percentage. Table 3 summarizes the annual values of water heating components with and without a solar heater, the savings, and their annual coverage ratio. The annual coverage ratio ranges between 65.3 - 67.2.

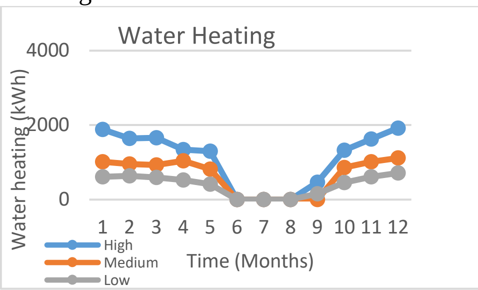



Figure 4 Monthly value of water heating consumption for the three consumers without SWHS.

Table 3 Annual values of water heating consumption with and without a solar heater, savings and its annual coverage percentage of the three consumer.

| | High | Medium | Low |
|---|---|---|---|
| Annual water heating component without SWH (kWh) | 12721 | 7765 | 4728 |
| Annual water heating component with SWH (kWh) | 4320 | 2669 | 1643 |
| Savings (kWh) | 8401 | 5096 | 3085 |
| Coverage (%) | 67.2 | 65.6 | 65.2 |

### 6.3 Electricity bill and savings

The electricity bill, for the residential sector in Iraq, is calculated based on the value of consumption. Table 1 represents the electricity tariff for the residential sector. Figure 5 shows the monthly electricity bill for the three consumers without the solar water heater. The total annual electricity bill for the three consumers is 1,209,740, 416,425, and 146950 Iraqi dinars, respectively. The list of electricity decreases when adding a solar water heater to 797875, 274415, and 116100 Iraqi dinars, respectively. The difference between the two values (the bill of electricity with and without a solar water heater) represents the value of the savings in Iraqi dinars. The savings percentage is the value of savings to the electricity bill without a solar water heater. Table No. 4 summarizes the annual electricity bill with or without a solar heater with the savings percentage and the recovery period. The percentage of savings in the electricity bill ranges between 20.9 - 34.1%.

The purchase and installation of a solar water heater cost up to nine hundred thousand Iraqi dinars (about $ 750, Depending on local prices). According to the annual savings, the payback period is about 2.185 years for the highly consuming consumer. Whereas, for the medium consumption consumer, it is about 6.337 years. For the low consumption consumer, it is about 29.173 years. The significant difference in the payback period is due to the method of calculating the electricity bill, which is ascending depending on consumption.

Using a solar heater in houses in Iraq achieves many benefits, including reducing the electricity bill, reducing pollution, increasing the use of environmentally friendly energies (Solar energy), and reducing the use of fossil fuel. In addition, reducing electricity consumption brings important benefits to the electricity system, which suffers from many problems most notably generation shortage and the failure to cover all loads in the system.

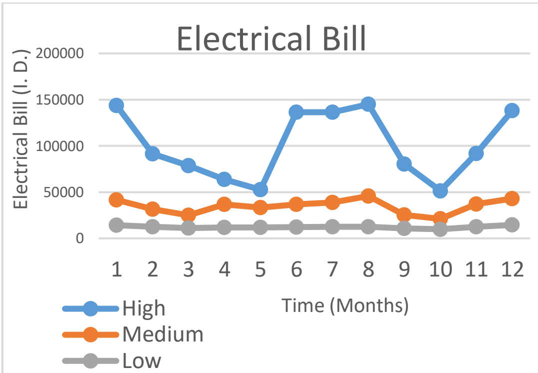



Figure 5 Monthly electricity bill for the three consumers without SWHS.

Table 4 Annual bill of electricity with and without a solar water heater, saving, saving percentage, and the payback period.

| | High | Medium | Low |
|---|---|---|---|
| Annual bill without solar water heater (I. D.) | 1209740 | 416425 | 146950 |
| Annual bill with solar water heater (I. D.) | 797875 | 274415 | 116100 |
| Saving (I. D.) | 411865 | 142010 | 30850 |
| Saving percentage (%) | 34 | 34.1 | 20.9 |
| payback period (years) | 2.185 | 6.337 | 29.173 |

## 7. Conclusions

The possibility of using solar water heaters to provide hot water in the residential sector in Mosul city - northern Iraq was studied. The use of solar water heaters achieves many benefits. It reduces the consumption of electrical energy, reduces the electricity bill, and covers a high percentage of domestic needs for hot water. The savings value differs, because the tariff depends on the consumption value. The payback period is also reasonable.

The electricity system in Iraq suffers from several problems. The most notably problem is electricity generation shortage. Reducing the electrical energy consumption in the Iraqi electrical system is important to reduce the gap between generation and consumption. Therefore, government incentives must be put to encourage the use of SWHSs in the residential and other sectors.

### Acknowledgments

The authors gratefully acknowledge the General Director for State Company of the Electricity Distribution for North and its affiliates, especially the Director and Associates of the Nineveh Electricity Distribution Directorate for their cooperation and assistance in collecting information and providing support for the completion of this research.

## 8. References

[1] P. Asantewaa Owusu and S. Asumadu-Sarkodie "A review of renewable energy sources, sustainability issues and climate change mitigation" Cogent Engineering Vol. 3, Issue 1, 2016.

[2] X. Cao, X. Dai and J. Liu "Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade" Energy and Buildings, Vol. 128, 15 Sept. 2016, PP 198-213.

[3] I. Halil Yelmaz "Residential use of solar water heating in Turkey: A novel thermos economic optimization for energy savings, cost benefit and ecology" Journal of Cleaner Production, Vol. 204, Dec. 2018, PP 511-524.

[4] S. Majid Al-Hafidh, Mudhafar A. Al-Nama and Azher S. Al-Fahadi "Utilization of Solar Water Heaters to Reduce Residential Electrical Load" UHD Journal of Science and Technology, Apr. 2017, Vol 1, Issue 1, PP 23-26.

[5] A. Gautam, Sunil Chamoli, Alok Kumar, Satyendra Singh "A review on technical improvements, economic feasibility and world scenario of solar water heating system" Renewable and Sustainable Energy Reviews, Vol. 68, 2017, PP541–562.

[6] J. Huang, Zhiyong Tian and Jianhuo Fan "A Comprehensive Analysis on Development and Transition of the Solar Thermal Market in China with more than 70 % market share worldwide" Energy, Vol. 174, May 2019, PP 611-624.

[7] H. Benli "Potential application of solar water heaters for hot water production in Turkey" Renewable and Sustainable Energy Reviews, Vol. 54, Feb. 2016, PP 99-109.

[8] G. Srivastava and A. Saxena "Potential and Economics of Solar Water Heating" MIT International Journal of Mechanical Engineering Vol. 2, No. 2, Aug. 2012, PP 97-104.

[9] L. Altoé, D. Oliveira Filho, J. Correna Carlo, P. Marcos de Barros Monteiro and I. Theresa de Almeida Martins "An analysis of the economic viability and greenhouse gas emissions reductions resulting from the use of solar water heaters in a typical Brazilian dwelling" Latin American Journal of Energy Research – Lajer, Vol. 4, No. 2, 2017, PP 1–10.

[10] T. Rasku and J. Kiviluoma "A Comparison of Widespread Flexible Residential Electric Heating and Energy Efficiency in a Future Nordic Power System" Energies, Vol. 12, Issue 1, 2019.

[11] R. Kishore Singh, I. J. Lazarus and M. Souliotis "Recent developments in integrated collector storage (ICS) solar water heaters: A review" Renewable and Sustainable Energy Reviews, Vol. 54, Feb. 2016, PP 270-298.

[12] M. A. Al-Nama, M. S. Al-Hafid, and Azher S. Al-Fahadi, 'Estimation of the Diversity Factor for the Iraqi Distribution System Using intelligent Methods', Al-

rafidain Engineering Journal , vol. 17, no. 1, pp. 14–21, 2009.

[13] M. A. Al-Nama, M. S. Al-Hafidh and A. S. Al-Fahadi "Estimation of the Consumer Peak Load for the Iraqi Distribution System Using intelligent Methods" Iraqi Journal Electrical and Electronic Engineering, Vol.7 No.2, 2011, PP180-184.

[14] M. S. Al-Hafidh, M. A. Al-Nama and A. S. Al-Fahadi "Determination of Residential Electrical Load Components in Iraqi North Region" Iraqi Journal of Electrical and Electronic Engineering, Vol. 13, No.2, 2017, PP 161-165.

[15] Y. M.Y Ameen, O. Sh. Al-Yozbaky and M. S. M. Al-Hafidh "Energy Efficiency Enhancement for Residential Sector: Case Study of Lighting in Iraq", Al-Rafidain Engineering Journal (AREJ) Vol.26, No. 1, 2021, PP 53-62.

[16] M. U. Jasim "Performance evaluation of solar water heating for residential application in Iraq" SET2011, 10th International Conference on Sustainable Energy Technologies, Istanbul, Turkey, 4-7 Sep. 2011.

[17] A. A Akrawi, Hikmat y. Najar "Calculation and mapping of the distribution of global and diffuse solar radiation in Iraq" J. Solar Energy Res. Vol.5 No.1, PP 1-25.

[18] https://globalsolaratlas.info/downloa/ Iraq.

[19] Vishal G. Shelke, Chinmay V. Patil and Kishor R. Sontakke "Solar Water Heating Systems: A Review" International Journal of Scientific Engineering and Research (IJSER), Volume 3 Issue 4, April 2015, PP 13-17.

[20] R. Shukla, K.Sumathy, Phillip Erickson and Jiawei Gong "Recent advances in the solar water heating systems: A review" Renewable and Sustainable Energy Reviews, Vol. 19, March 2013, PP 173-190.

[21] S. Alhassan, Badamasi Haruna, Dauda Garba, Mustapha Usman, Adamu Baba Wada and Sagir Lawan Waziri "Solar Water Heating Systems Potential in Nigeria- A Review" International Journal of Advances in Scientific Research and Engineering (ijasre), Vol. 5, Issue 8, Aug. 2019, PP 6-15.

[22] N.V. Ogueke, E. E. Anyanwu and O. V. Ekechukwu "A review of solar water heating systems" Journal of Renewable and Sustainable Energy, Vol. 1, Issue 4, June 2009.

**Appendix A**

| Device current | Rated power | No. | Information/ device name | Class | Item | |
|---|---|---|---|---|---|---|
| | | | house land area | | | 1 |
| | | | Number of rooms (bedroom, sitting, reception, bathroom, etc.) | | | 2 |
| | | | Number of individuals | | | 3 |
| | | | Electrical supply (single-phase, three-phase) | | | 4 |
| | | | Tungsten lamps | Lighting | A | 5 |
| | | | fluorescent lamps | | B | |
| | | | Other | | C | |
| | | | Audiovisual devices (recorder, radio, TV, etc.) | household appliance | A | 6 |
| | | | Kitchen appliances (washing machine, dishwasher, vacuum cleaner, water pump ... etc.) | | B | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Food preservation devices (refrigerator, freezer, water cooler ... etc.) | | C | |
| | | | Fan (roof, vertical ... etc.) | Cooling devices | A | 7 |
| | | | Air cooler | | B | |
| | | | Air conditioner /cooling | | C | |
| | | | Electric heater | Heating devices | A | 8 |
| | | | cooking Heater, oven . . . etc. | | B | |
| | | | Air conditioner /heating | | C | |
| | | | Electric bath geyser | Water heating | | 9 |

# استخدام سخانات المياه بالطاقة الشمسية في العراق: دراسة اقتصادية

**وائل هاشم حمدون*** **محمود اسامة جاسم**** **ماجد صالح الحافظ***
waelhashem_67@uomosul.edu.iq mahmood14@uomosul.edu.iq alhafidms@uomosul.edu.iq

*جامعة الموصل - كلية الهندسة - قسم الهندسة الكهربائية
**جامعة الموصل - كلية الهندسة – قسم الهندسة الميكانيكية

***الملخص***

*يعاني النظام الكهربائي العراقي من زيادة الحمل الكهربائي على التوليد المتوفر مما يؤدي إلى فصل عدد كبير من المستهلكين خاصة خلال فترة ذروة الحمل. يمثل حمل تسخين المياه قيمة كبيرة ، لذا فإن تقليل استهلاك تسخين المياه يمكن أن يقلل من أوقات القطع المبرمج.*
*تمتلك مسخنات المياه بالطاقة الشمسية العديد من الفوائد. لذلك ، يتم استخدامها في العديد من دول العالم اليوم. مناخ العراق حار ومشمس في الغالب. يجعل هذا استخدام مسخنات المياه الشمسية مناسبًا للمستهلكين ، خاصة في المناطق الحضرية.*
*تختلف تعرفة الكهرباء للقطاع السكني في العراق حسب الاستهلاك. لدراسة استخدام مسخنات المياه بالطاقة الشمسية في القطاع السكني ، تم اختيار ثلاثة مستهلكين في مدينة الموصل شمال العراق. يختلف كل مستهلك عن غيره من حيث قيمة استهلاكه للطاقة الكهربائية (عالية ، ومتوسطة ، ومنخفضة). تم الحصول على المعلومات الخاصة بالمستهلكين الثلاثة من استبيان سابق. بالإضافة إلى حصولهم على احتياجاتهم من الماء الساخن . أظهرت نتائج استخدام مسخنات المياه بالطاقة الشمسية على أسطح منازل المستهلكين الثلاثة انخفاضًا في استهلاك الكهرباء وتوفيرًا ملحوظًا في فاتورة الكهرباء. تم حساب فترة الاسترداد لنظام مسخنة المياه الشمسية لكل مستهلك.*
*يقلل تقليل الاستهلاك من الفجوة بين التوليد والحمل ، مما يؤدي إلى تقليل أوقات القطع المبرمج للمستهلكين. لهذه الفوائد والمميزات البيئية ، من الضروري تعميم استخدام سخانات المياه بالطاقة الشمسية في القطاع السكني في العراق.*

***الكلمات الداله :***
*مسخنات المياه بالطاقة الشمسية ، القطاع السكني العراقي ، توفير الطاقة الكهربائية ، فترة الاسترداد.*