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Economic Feasibility of an inverter Air Conditioner for Residential Buildings in Iraq

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***Abstract*— The use of air conditioners has become a necessity recently in the Republic of Iraq due to the very hot weather of Iraq and the inability of citizens to withstand high temperatures in the summer. This led to an increase in the annual electricity bill, hence the aim of this study is to study the economic feasibility of air conditioners supported by the technology of the inverter and its importance in energy saving. This research presents economic analysis to investigate the Payback period (PP) and net present value (NPV) between a conventional air conditioner and inverter type air conditioner. The selected air conditioners used in this study are 1800 BTU inverter and non-inverter type spilt unit, residential air conditioner. The mathematical model of economic analysis is developed based on proposed model developed by previous researches. The economic analysis showed that the increase in the percentage of energy saving and the daily operating hours reduces the Payback period in the case of the use of air conditioner supported by an Inverter technology compared to a traditional air conditioner. It is found that an inverter type air conditioner with highest operating time of 24 hours per day has shortest PP of only (5 year), and the net present value(NPV=+ 300,589 IQD)**

Keywords*— Economic feasibility, payback period, inverter air conditioner, conventional air conditioner, net present value (NPV).

I. INTRODUCTION

Given the inter-related factors between extreme climatic conditions and growing population growth as well as the expansion of the construction sector, the air conditioner market in Iraq is expected to witness an annualized growth of 8.7% over the next five years, according to expectations of the air conditioner market in Iraq for 2017.Growth the expansion of infrastructure and industry, as well as the expansion of the housing sector dictated by the growing nature of Iraq's population. This growth has helped to increase sales and solutions of air conditioning systems. The emphasis on compliance with energy efficiency and air conditioning systems has played a major role in the search for solutions that are more compatible with Iraq's climate. Air conditioning consumes about 70% of total electricity consumption in buildings, equivalent to more than two-thirds of the electricity consumed in Iraq. All these indicators call for a study on the selection of high-efficiency cooling devices that reduce electricity consumption in residential buildings. The importance of the study is that it deals with an important issue because of the significant impact of economic aspects of the citizens in reducing the monthly electricity bill. There are many types of air conditioners available in the market for the consumer to choose. For split type air conditioner, there are two types in the markets first is the traditional air conditioner and the other is the inverter air conditioner inverter. The Inverter technology (DC) is the latest evolution of technology concerning the electro motors of the compressors. An Inverter is used to control the speed of the compressor motor, so as to continuously regulate the temperature. The DC Inverter units have a variable-frequency drive that comprises an adjustable electrical inverter to control the speed of the electromotor, which means the compressor and the cooling / heating output. The drive converts the incoming AC current to DC and then through a modulation in an electrical inverter produces current of desired frequency. A microcontroller can sample each ambient air temperature and adjust accordingly the speed of the compressor. The inverter air conditioning units have increased efficiency in contraction to traditional air conditioners, extended life of their parts and the sharp fluctuations in the load are eliminated. This makes the inverter AC units quieter, with lower operating cost and with less broke downs. The inverter AC units might be more expensive than the constant speed air conditioners, but this is balanced by lower energy bills. In the last few years there has been little economic analysis on the air conditioning system. Sukri et al. (2012) explained that air-conditioning consume highest energy for typical household buildings about 50- 60%. that is also take place in transportation sector where the air conditioning system consumes highest energy compare with others accessories in typical land vehicles Sukri et al, (2016). (Aktacir et al, 2006) evaluated the economic feasibilities of constant air volume (CAV) and variable-air-volume (VAV) air-conditioning systems .they found that, although initial cost of the VAV system was higher

than that of the CAV system, the present worth cost of the VAV system was lower than that of the CAV system at the end of the lifetime due to lower fan-operating costs.(Li et al, 2010) examined the economic feasibility for integrating a solar liquid desiccant dehumidification system with a conventional vapour compression air-conditioning system for the climate state of Hong Kong. They discovered yearly operation energy savings for the hybrid system was 6760 kWh and the payback period was around 7 years. The examination demonstrated that the solar assisted air-conditioning system is a viable technology for utilizations in subtropical areas.(Sanaye et al, 2010) led a financial investigation of utilizing gas engine heat pumps (in correlation with the electrical heat pumps) at various climate regions of Iran, for both residential and commercial buildings, and for both cooling and heating modes. They found a yearly operating cost for electrical heat pumps was higher than that for the gas engine heat pumps in both residential and commercial sections and all studied climate regions.(Allouhi et al, 2015) examined the capability of solar closed cycle over conventional cycle air-conditioning systems in Morocco based on economic indicator. They found that the solar air-conditioning systems in hot climates must be an attractive alternative to mitigate CO2 emissions and increase energy savings. The high installation cost was a main obstacle facing their implementation.(Al-Ugla et al, 2016) create suitable suggestions in relieving the electrical peak power demand in Saudi Arabia by using solar cooling technology in commercial buildings as well as to establish the tangible economic benefits from applying such technology. The outcomes demonstrated that a solar absorption system was more economically feasible than a solar PV-vapor-compression system. In addition, the feasibility of both solar-powered systems improved as the size of the commercial building and the electricity rate increased. (Yu et al, 2017) analyzed the economic benefits of an air-cooled chiller retrofitted with advanced heat rejection features. Found For a chiller system serving an office building, the mode of variable speed control for condenser fans with an adjustable condensing temperature gave the highest economic benefit with a simple payback of 10.83 years and an internal rate of return of 4.38% over a 15 years lifetime.

II. ECONOMIC ANALYSIS AND MATHEMATICAL MODEL

As is known, there are several methods of feasibility study or project evaluation. In this study, the Payback period and net present value were used to evaluate this air conditioning system. An economic analysis can be made to calculate the payback period (PP) for two types of air conditioners, and depending on (PP) the consumer can choose the best and economic type of air conditioner.

$$\text{Payback} = \frac{\text{Cost of Energy Efficient Product}}{\text{Annual Electricity Savings}} \quad (1)$$

Annual Cost Savings The quickest way to calculate savings is to insert the wattage difference between the two products, as follows

$$\text{Annual Electricity Savings} = EC_{conventional} - EC_{inverter} \quad (2)$$

$$EC_{conventional} = Q_{conventional} \times OT \times EC \quad (3)$$

$$EC_{inverter} = Q_{inverter} \times OT \times EC \quad (4)$$

TABLE I. Energy cost for residential buildings in Iraq from ministry of electric.

Tariff category	EC (IQD/ KWh)
From (1-1500) KWh	10
From (1501-3000) KWh	35
From (3001-4000) KWh	80
From (4001-5000) KWh	120

III. MODEL OF THE AIR CONDITIONERS

In the market there are different types of air conditioners with different features. In this study, two models were taken from the same manufacturer to study the benefit and economic feasibility. Table -II presents the air conditioner information selected in this research.

TABLE II shows features, of selected split air conditioners

Specifications	NS182C2 Dual Inverter Smart, Cool Only, Split Air Conditioner, Warranty (10 years) LG	B1824C Smart Eco Cool Only, Split Air Conditioner Non Inverter Warranty (10 years) LG
Power Input (KW)	1.3 KW 220-240V, 50/60HZ	1.9 KW 220-240V, 50/60HZ
Cooling Capacity [BTU]	18,000	18,000
EER (W / W)	3.64	3
Compressor	Dual Inverter Compressor	Compressor
Refrigerant Type	R410A	R410A
Energy Saving (%)	up to 53% Energy Saving	-
Cost of air conditioner IQD	500000	350000

A. Net Present Value (NPV)

The NPV takes into account more systematically the time of cash flows, cost of money including interest on the capital cost investment, life time of equipment/installation, etc., which can better reflect the effectiveness of the investment. This method gives a present value to future earnings, which are expected

to be derived from an investment .The net present value method was used in this study, where net present value can be calculated from the following equation.

$$NPV = PV - C \quad (5)$$

$$PV = \sum_{t=1}^{n} \frac{B_t}{(1+i)^t} \quad (6)$$

Where PV is the present value of the total energy saving in N years as expressed in Eq. (6), C is the total installation cost and, i is the interest rate which is taken as 5 % and, Bt is the value of annual energy saving at t year. The NPV is calculated for n = 10 years. The cost of electricity in this economic analysis was based on the tariff of the Iraqi Ministry of electricity, where 1 KWh = 40 IQD. The economic analysis was conducted during the summer season, in particular from April to October.

IV. RESULTS AND DISCUSSION

In this study, energy conservation and air conditioner operating hours were chosen because of their impact on the daily life of the consumer. It is also important to investigate how these parameters influence on consumer's decision to choose a high-efficiency air conditioner. Fig. 1 shows the efficiency of air conditioners supported by the inverter technology in energy saving as it consumes a small amount of electrical energy, which means lower cost of electricity bill.

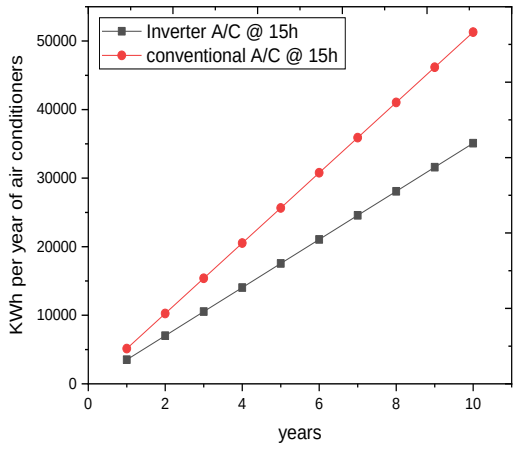

Fig.1 Shows electrical energy consumption for an inverter and conventional air conditioner

Fig.2 shows the effect of daily operating hours for conventional and inverter air conditioner and its role in the energy saving or (reduce the cost of electrical bill per year)

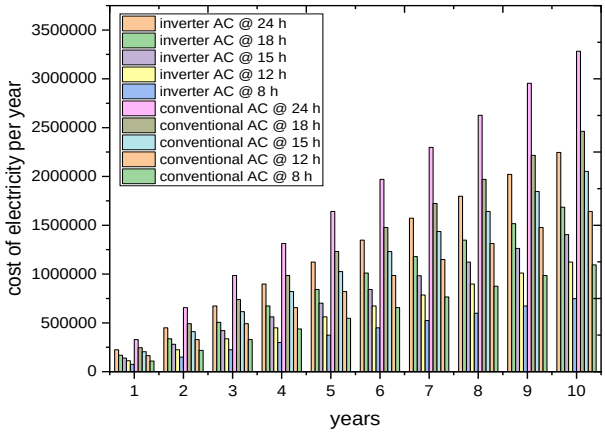

Fig.2 shows the effect of daily operating hours for conventional and inverter air conditioner on the energy saving

To make sure more of the economic feasibility of the inverter technology, net present value has been used. Table 3 shows the net present value of the inverter air conditioner.

TABLE .III shows the net present value of air conditioner supported by the inverter technology.

-500000 IQD	**Cost of investment**
5%	**Interest rate**
Annual savings (IQD)	**Years**
103680	1
103680	2
103680	3
103680	4
103680	5
103680	6
103680	7
103680	8
103680	9
103680	10
+ 300,589.48 IQD	**NPV**

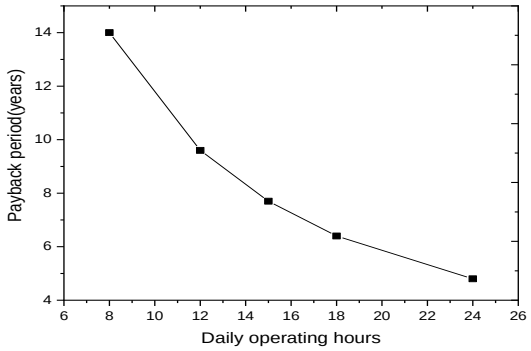

Fig .4 shows the effect of daily operating hours on the payback period

V. CONCLUSIONS

From above it can conclude that:'

1) In this analysis, the increment of percentage on energy saving, hours of daily operation reduce the PP of inverter split type air conditioner compared to non-inverter type.

2) It is visibly shown that there is significant In short, the percentage of energy saving has dominant effect on PP followed by the effect of operating hours per day.

3) In the end, it is clear that air conditioners supported by the inverter technology have a big role in conserving energy and reducing the electricity bill.

Nomenclature

PP	Payback period
EC	energy cost
OT	operation time
NPV	Net present value
t	years
C	Cost of investment
PV	Present value

References

[1] Aktacir M.A., Bu¨yu¨kalaca O. and Yılmaz T, (2006). Lifecycle cost analysis for constant-air-volume and variableair-volume air-conditioning systems, Applied Energy,83,606-627.

[2] Allouhi A., Kousksou T., Jamil A., Rhafiki T.E., Mourad Y.and Zeraouli Y,(2015).Economic and environmental assessment of solar air-conditioning systems in Morocco.Renewable and Sustainable Energy Reviews. 50, 770-781.

[3] Almutairi K.,Thoma G.,Burek J.Salem Algarni S.and Nutter D,(2015).Life cycle assessment and economic analysis of residential air conditioning in Saudi Arabia. Energy and Buildings.102,370-379.

[4] Cai X., Li H., Feng G., Yu S. and Zhao Y, (2016). HVAC system green retrofit survey and analysis of public institutions building in cold region. Procedia Engineering.146,218-223.

[5] Chaiyat N,(2015).Energy and economic analysis of a building air-conditioner with a phase change material (PCM).Energy Conversion and Management, 94,150 - 158.

[6] Li Y., Lu L. and Yang H,(2010).Energy and economic performance analysis of an open cycle solar desiccant dehumidification air-conditioning system for application in Hong Kong. Solar Energy, 84, 2085-2095.

[7] Kharseh M. and Al-Khawaja M, (2016).Retrofitting measures for reducing buildings cooling requirements in cooling-dominated environment: Residential house.Applied Thermal Engineering. 98, 352-356.

[8] Pérez-Lombard L., Ortiz L. and Pout C,(2008).A review on buildings energy consumption information.Energy and Buildings. 40(3), 394-398.

[9] Sanaye S., Meybodi M.A. and Chahartaghi M ,(2010). Modeling and economic analysis of gas engine heat pumps for residential and commercial buildings in various climate regions of Iran. Energy and Buildings.42, 1129-1138.

[10] Subiantoro A. and Ooi K.T,(2013).Economic analysis of the application of expanders in medium scale airconditioners with conventional refrigerants,R1234yf and CO2, International Journal of Refrigeration. 36, 1472 - 1482.

[11] Sukri M.F., Salim M.A., Mohd Rosli M.A., Azraai S.B. and Mat Dan, R,(2012).Analytical Investigation of Overall Thermal Transfer Value on Commercial Building in Malaysia. International Review of Mechanical Engineering .6(5),1050 1056.