Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 6 Issue 2, February - 2019

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

Mohammed Ali Sami
Tambov State Technical University
Department of Thermal Power Engineering
Russia – Tambov
Mr.mohammedali1993@gmail.com

***Abstract* — The use of air conditioners in the Republic of Iraq is necessary because of the very hot weather of Iraq to help citizens withstand the high temperatures during the summer. This led to increases the load on the Iraqi Ministry of Electricity to meet the energy requirement and increase the annual electricity bill. The aim of this paper is to investigate the economic feasibility of an inverter air conditioner and its role in increase energy efficiency and energy saving for residential building. The article presents economic analysis to check out the payback period and net present value between the conventional air conditioner and an inverter air conditioner. The selected air conditioners in this investigation are 1.5 Ton inverter and conventional air conditioner. The mathematical model of economic analysis is developed based on proposed model developed by previous researches. The results of economic investigation showed that the increasing in the daily operating hours reduces the payback period in the case of using inverter air conditioner. It was found that the inverter type air conditioner with the highest operating time of 24 hours per day, has the shortest payback period of only (2.27 years) with annual benefit / saving (308,352 IQD), and the net present value (NPV = + 1,194,690 IQD) at 10 % interest rate.**

Keywords* — *economic feasibility, payback period, inverter air conditioner, conventional air conditioner, net present value.

1 INTRODUCTION

Given the interlinking factors between extreme weather conditions and increase in population, in addition to the expansion in the construction sector, the air conditioners market in Iraq is expected to witness an annual growth of 8% in the next five years, according to forecasts of the air conditioners market in Iraq. This growth has increased the demand for refrigeration equipment and encouraged companies to research and find solutions for air-conditioners that are highly efficient in terms of energy conservation in addition to the economic benefit. 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. The air conditioning systems consumes about 70% of total electricity consumption in buildings, equivalent to more than two-thirds of the electricity consumed. All these indicators call for a study on the selection of high-efficiency air conditioning equipment that reduce electricity consumption in residential buildings. The importance of the study lies in the fact that it deals with an important issue due to the large impact of the economic aspects of citizens in reducing the monthly and annual electricity bill. There are many types of air conditioners available in the markets for the consumers to choose and buy. For split type air conditioner, there are two types in the markets the first is the traditional air conditioner and the other is the inverter air conditioner. What is the Inverter technology in air conditioners? The Inverter technology (DC) is the latest evolution of technology concerning the electromotors 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 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. In contrast, non-inverter air conditioners have a fixed cooling / heating capacity and can only control the indoor temperature by starting or stopping their compressors. Non-inverter air-conditioners stops and starts repeatedly. The power consumption and current goes down when the operation stops, but it goes up sharply at the time of restart and thus it has high average power consumption and temperature variations. As a result, inverter air conditioners are more energy saving and comfortable than non-inverter air-conditioners.

Figure 1 shows how the capacity change for air conditioners.

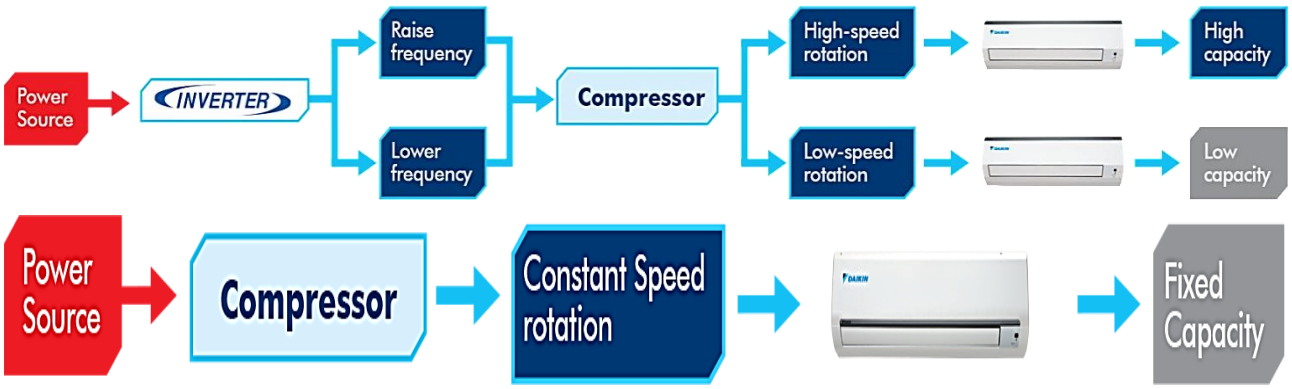

Fig 1. Shows how the capacity change in case of inverter air conditioners.

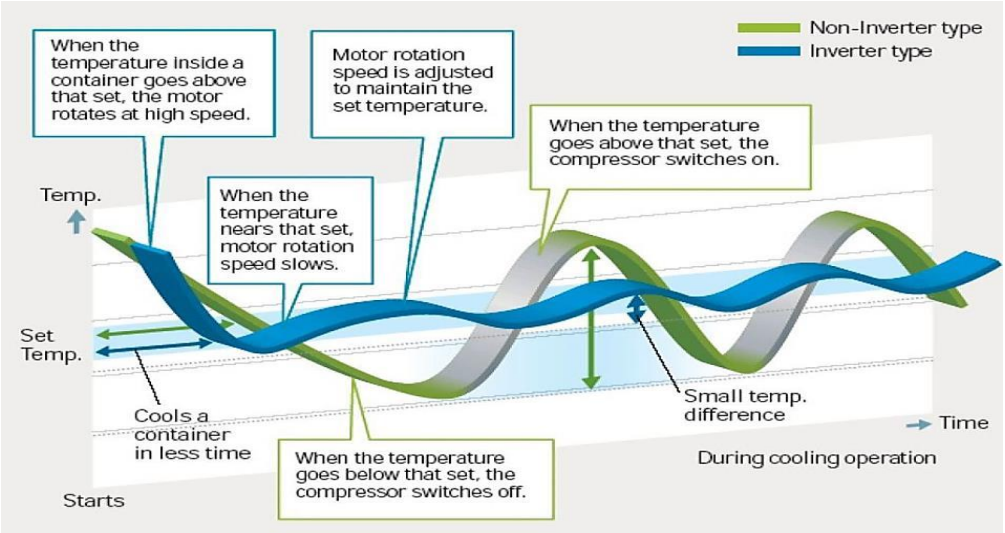

Fig 2. Shows the difference between working principle of inverter air conditioner and non inverter air conditioner.

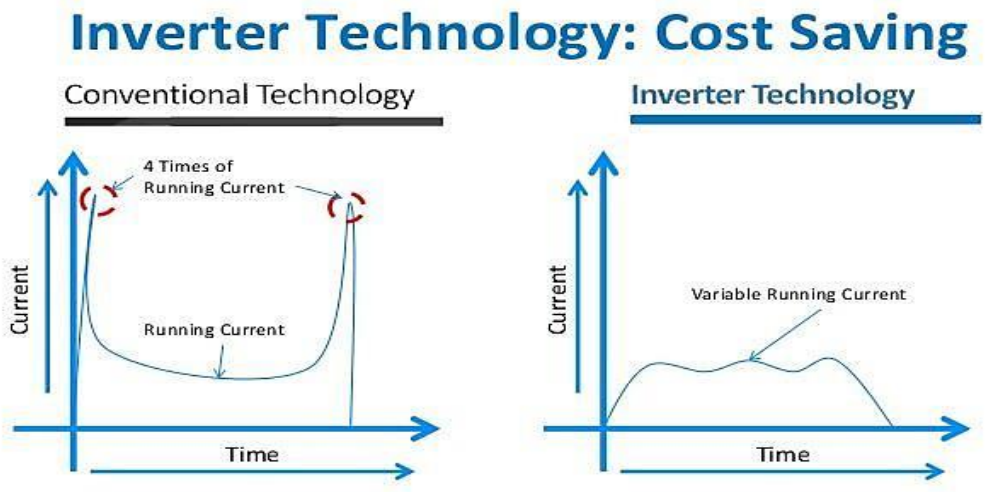

Fig 3. Shows the consumption of electricity for inverter and conventional air conditioner.

Inverter air-conditioners are able to vary their operating capacity. Non-inverter air-conditioners can only operate at a fixed capacity. The inverter AC units might be more expensive than the constant speed air conditioners, but this is balanced by lower energy bills. In the past few years, many researchers have conducted economic analysis of different types of air conditioning systems. Sukri et al. [2], mentioned that air-conditioning consume the highest energy for typical residential buildings about 50 – 60. That is also taken place in transportation sector where the air conditioning system consumes the highest energy compare with others accessories in typical land vehicles. Aktacir et al.[3], 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. [4], 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 that 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. [5], 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. The selection of gas engine heat pump instead of an electrical heat pump showed that the payback period decreases with increment of system capacity. Allouhi et al. [6], 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 CO_2 emissions and increase energy savings. The high installation cost was a main obstacle facing their implementation. Al-Ugla et al. [7], created 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. [8], analyzed the economic benefits of an air-cooled chiller retrofitted with advanced heat rejection features. The results pointed out that 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.

2 Economic analysis and mathematical model

As is known, there are several methods for feasibility study or projects evaluation. In this paper, the payback period (PP) and net present value (NPV) are used to evaluate the feasibility of using inverter air conditioner. A simple economic analysis can be performed to forecast the payback period of the proposed air conditioners, and depending on the PP, the consumer can choose the best economic types of air conditioners. The payback period is the number of years required to recover the capital invested. Assuming no additional maintenance cost and depreciation cost and no cost of interest on the initial capital cost. The simple PP can be calculated by the following equation,

$$\text{SPP} = \frac{\text{Cost of energy efficient product}}{\text{Annual electricity savings}} \quad (1)$$

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

$$\text{AES} = \text{ECC}_{\text{conventional AC}} - \text{ECC}_{\text{inverter AC}} \quad (2)$$

$$\text{ECC}_{\text{conventional AC}} = \text{P} \times \text{OT} \times \text{PK} \quad (3)$$

$$\text{ECC}_{\text{inverter AC}} = \text{P} \times \text{OT} \times \text{PK} \quad (4)$$

Where, AES: Annual energy saving. ECC: Cost of energy consumption for each air conditioner. P: The electrical power consumed for each air conditioner. PK: Price of kilowatt hour in Iraq (IQD/ KWh). OT: Operating time for each air conditioner.

The NPV takes into account more systematically the time of cash flows, cost of money including interest on the capital cost investment, lifetime 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 NPV can be calculated from the following equation:

$$\text{NPV} = \text{PV} - \text{C} \quad (5)$$

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

Where, PV: The present value of the total energy saving in N years as expressed in Eq.(6). C: The total installation cost of inverter air conditioner. i : The interest rate which is taken as 10 %. Bt : is the value

of annual energy saving at t year. The NPV is calculated for n = 10 years, according to lifetime of air conditioner. The cost of electricity consumption in this economic investigation was based on the tariff of the Iraqi Ministry of electricity, where 1KWh = 80 IQD (Iraqi dinar). The economic analysis was conducted during summer season, in particular from April to October.

TABLE 1. Price of kilowatt hour in Iraq
(Source: Iraqi Ministry of Electricity)

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

2.1 Types of the air conditioners

There are many types of air conditioners available on the market for the consumer to choose it. The air conditioners available on the market can be window type air conditioners or split type air conditioners, with different features and capacities, and from different manufacturers such as LG, Samsung, Panasonic and other companies. In this research paper, two models were taken from the same manufacturer to investigate the economic feasibility. Table 2 presents the air conditioners specifications selected in this paper.

TABLE 2. Specifications of selected air conditioners.

Specifications	*Conventional air conditioner*	*Inverter air conditioner*
Manufacturer company	LG	LG
Power Input (KW)	2.200	1.320 (Running)
Cooling capacity (Ton)	1.5	1.5
Refrigerant type	R 22	R410A
Energy saving (%)	-	up to 53% energy saving
Cost of air conditioner IQD	400000	700000
Warranty (years)	10	10

3 Results and Discussion

In this economic investigation, the hour of daily operations is determined because it has a significant impact and is closely related to the daily life of the consumer. The daily operation hours of air conditioners is directly proportional to the cost of electrical energy consumed. The longer the daily operating hours of air conditioners, the higher the cost of consuming electrical energy. Therefore, the use of the energy saving inverter air conditioner will be of great benefit in terms of energy conservation and in addition to the economic aspects that are important for the consumer. Figure 4 shows the energy consumed of air conditioners, as shown, the amount of electrical energy consumed by conventional air conditioner is high compared to energy-saving air conditioner (inverter air conditioners), which means lower cost of electricity bill in case of using inverter air conditioner.

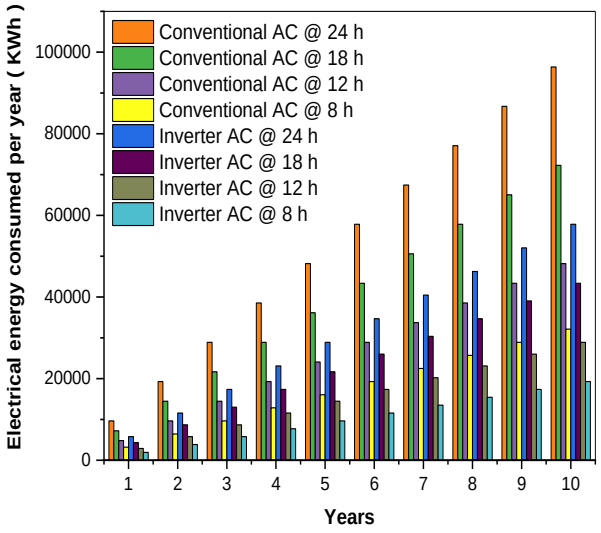

Fig 4. Shows electrical energy consumed for an inverter and conventional air conditioner.

Figure 5 shows the cost of electrical energy consumed by conventional and inverter air conditioner. As shown, the cost of energy consumed by an inverter air conditioner is low compared to conventional air conditioner, and the figure also explain the role of an inverter air conditioner in the energy saving and reduce the cost of electrical bill per year.

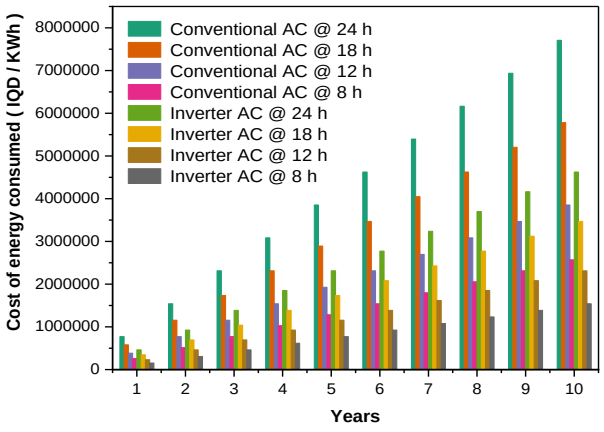

Fig 5. Shows cost of electrical energy consumed for an inverter and conventional air conditioner.

The payback period is shown in figure 6. The results of investigation showed that the PP is 2.27 years when the air conditioners operate 24 hours per day, 3 years at 18 hours, 4.5 years at 12 hours and 6.8 years at 8 hours according to equation 1. As shown in the figure 6, the PP decreases with increasing the daily operating hours of an inverter air conditioner.

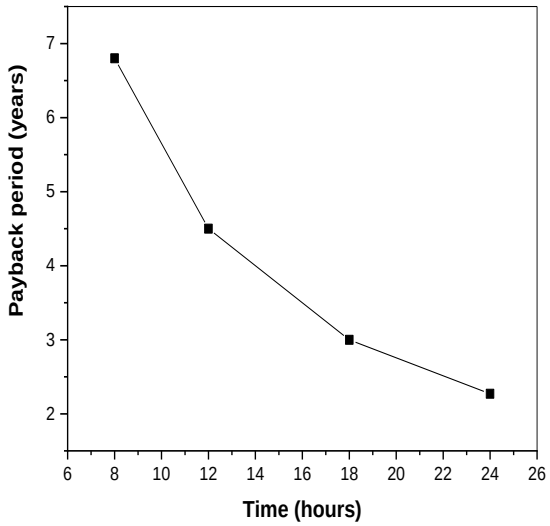

Fig 6. Shows the the payback period vs daily operating hours.

For a more accurate economic investigation, the net present value is calculated. Table 3 shows the net present value during the lifetime of an inverter air conditioner.

TABLE .3. Shows the net present value.

Cost of investment (inverter air conditioner)	700000 IQD
Interest rate	10 %
Annual saving (IQD)	Years
308352	1
308352	2
308352	3
308352	4
308352	5
308352	6
308352	7
308352	8
308352	9
308352	10
PV	**1894690 IQD**
NPV	**1194690 IQD**

Figure 7 illustrates the values of net present value at different interest rate, as shown the net present value decreases with increasing of interest rate.

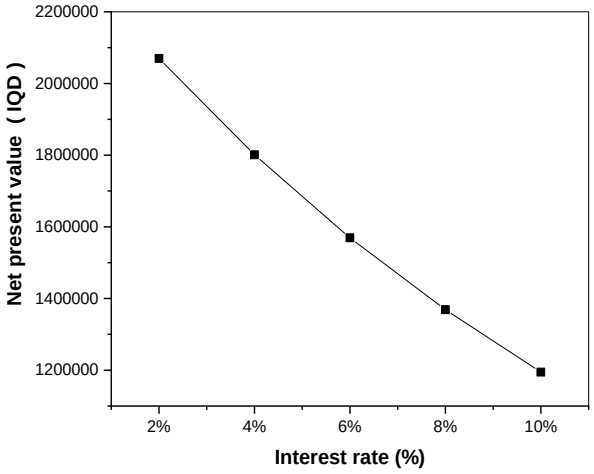

Fig 7. Shows the net present value vs interest rate.

4 CONCLUSIONS

From the results of the economic investigation, it can be concluded that:

1. In this economic investigation, the increment of daily operation hours reduce the payback period in case of using inverter air conditioners compared to non-inverter type.
2. The use of inverter air conditioners increases energy conservation and thus reduces the monthly or annual electricity bill. The rationalization of the use of electric energy has significant economic benefits in the country, and this reflects positively on improving services in the country, such as education, infrastructure, and other important aspects.
3. An inverter air conditioners with addition of other latest advanced technologies such as dual human activity sensor, sunlight sensor and temperature wave, the energy saving can be increased of up to 65%.
4. It is recommended to use an inverter air conditioner because it is suitable for the conditions in Iraq and plays an important role in energy conservation.

REFERENCES

[1] Sukri, M. F., et al. "An analytical investigation of overall thermal transfer value on commercial building in Malaysia." International Review of Mechanical Engineering 6.5 (2012): 1050-1056.

[2] Sukri, M. F., et al. "Experimental Investigation of an Automobile Air-Conditioning System using Integrated Brushless Direct Current Motor Rotary Compressor." MATEC Web of Conferences. Vol. 74. EDP Sciences, 2016.

[3] Aktacir, Mehmet Azmi, Orhan Büyükalaca, and Tuncay Yılmaz. "Life-cycle cost analysis for constant-air-volume and variable-air-volume air-conditioning systems." Applied energy 83.6 (2006): 606-627.

[4] Li, Yutong, Lin Lu, and Hongxing Yang. "Energy and economic performance analysis of an open cycle solar desiccant dehumidification air-conditioning system for application in Hong Kong." Solar Energy 84.12 (2010): 2085-2095.

[5] Sanaye, Sepehr, Mehdi Aghaei Meybodi, and Mahmood Chahartaghi. "Modeling and economic analysis of gas engine heat pumps for residential and commercial buildings in various climate regions of Iran." Energy and Buildings 42.7 (2010): 1129-1138.

[6] Allouhi, Amine, et al. "Economic and environmental assessment of solar air-conditioning systems in Morocco." Renewable and Sustainable Energy Reviews 50 (2015): 770-781.

[7] Al-Ugla, A. A., et al. "Techno-economic analysis of solar-assisted air-conditioning systems for commercial buildings in Saudi Arabia." Renewable and Sustainable Energy Reviews 54 (2016): 1301-1310.

[8] Yu, F. W., et al. "Economic analysis of air-cooled chiller with advanced heat rejection." International Journal of Refrigeration 73 (2017): 54-64.