

Research Article

# Economic feasibility of an inverter and conventional air conditioners 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 from 1800 BTU inverter and non-inverter type split 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 15 hours per day has shortest PP of only (3 year), and the net present value (NPV=+900,221.05 IQD) and internal rate of return (IRR=55%).*

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

## 1. 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 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

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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) highlighted that air-conditioning contributes highest energy demand for typical commercial buildings about 50-60%. The same situation also occurs in transportation sector where the air-conditioning system consumes the largest of energy among accessories equipped 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. It was found that for all considered cases, 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) studied the economic feasibility for integrating a solar liquid desiccant dehumidification system with a conventional vapour compression air-conditioning system for the weather condition of Hong Kong. They found annual operation energy savings for the hybrid system was 6760 kWh and the payback period was around 7 years. The study showed that the solar assisted air-conditioning system is a viable technology for utilizations in subtropical areas. (Sanaye *et al*, 2010) conducted an economic analysis of using gas engine heat pumps (in comparison 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 an annual 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. Gas engine heat pump was more economical than the electrical heat pump in residential section and various climate regions. In commercial section and all four climate regions, the electrical heat pumps in all capacities were more economical than gas engine heat pumps. The selection of gas engine heat pump instead of an electrical heat pump showed that the payback period decreases with increment of system capacity. (Subiantoro and Kim 2013) performed an economic analysis of the installation of expanders on to existing vapour compression cooling systems, particularly medium scale air conditioners with various refrigerants.

They found that with a 50% of expander efficiency, the payback periods of most conventional systems were below 3 years in high temperature countries with high electricity tariffs, and were above 5 years in other countries. Expanders were attractive for the transcritical CO<sub>2</sub> and the R404A systems. The payback periods were shorter for systems with highly efficient expanders, high cooling loads, high ambient temperatures and for low refrigerating temperature applications. (Allouhi *et al*, 2015) investigated the potential 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<sub>2</sub> emissions and increase energy savings. The high installation cost was a main obstacle facing their implementation. (Almutairi *et al*, 2015) evaluated the relationship of economics to environmental effects, life cycle cost and payback period. They found in the economic point of view, an energy efficient air conditioner was not attractive in the locations where the cooling energy consumption was the lowest. It is marginally attractive for buildings in regions requiring the greatest consumption of cooling power. From the government's perspective, the use of more efficient air conditioners was always beneficial from an economic perspective, as well as improving environmental quality.

Emerging non-fossil sources of electricity may have the greatest positive impacts on the environment and require some policy decisions. (Chaiyat, 2015) performed an economic analysis of air conditioner using phase change material (PCM) under Thailand climate. found that The electrical consumption of the air-conditioner with PCM could be decreased around 3.09 kWh per day. The saving cost from the PCM bed could be 9.10% with payback period of around 4.15 years. (Al-Ugla *et al*, 2016) develop viable recommendations in mitigating the electrical peak power demand in Saudi Arabia by utilizing solar cooling technology in commercial buildings as well as to establish the tangible economic benefits from applying such technology. The results showed that a solar absorption system was more economically feasible than a solar PV-vapor-compression system. Moreover, the feasibility of both solar-powered systems improved as the size of the commercial building and the electricity rate increased. (Cai *et al*, 2016) conducted green retrofit survey and analysis for HVAC system in public institutions in Shenyang, China. They found the energy saving effects were obvious, especially coal saving effect. The coal saving rate was as high as 64.1%, and electricity saving rate was between 21.1 to 29.2%. (Kharseh and AlKhawaja, 2016)

To study the effect of different retrofitting measures for reducing cooling load of buildings in hot climate, the results showed that Replacing single glazed window with double glazed reduced the cooling load by 4.5%. Adding 2 cm of polyurethane to the external walls reduced the cooling load by 28%. 53% reduction in the cooling load can be obtained by implementing all measures. The payback period of considered retrofitting measures varies between 0.5 and 4 years. (Yu *et al*, 2017) analysed 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.

## 2. Economic analysis and mathematical model

Because a high-cost air conditioner consumer should choose the right kind and economic. 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

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

$$EC_{\text{non-inverter}} = Q_{\text{non-inverter}} \times OT \times EC \quad (3)$$

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

**Table.1.** 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

## 3. 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 -2 presents the air conditioner information selected in this research.

**Table .2** 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 Supply	220-240V, 50/60HZ	220-240V, 50/60HZ
Cooling Capacity [BTU]	18,000	18,000
EER (W / W)	3.64	3
Compressor	Dual Inverter Compressor	Inverter Compressor
Refrigerant Type	R410A	R410A
Energy Saving (%)	up to 53% Energy Saving	-
price of air conditioner\$	600 \$	300 \$

## 4. 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.

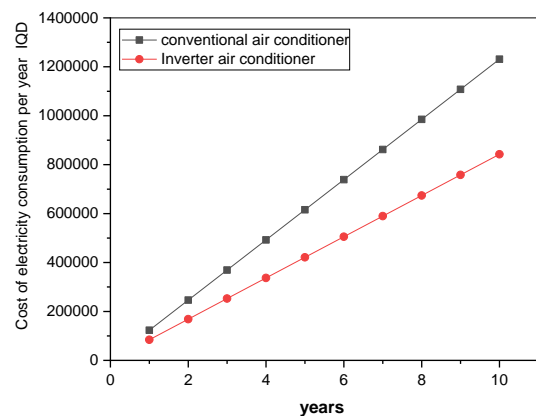
$$NPV = PV - C \quad (5)$$

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

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 where, B<sub>t</sub> 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 = 10 IQD. The economic analysis was conducted during the summer season, in particular from April to October.

## 6. Results and discussion

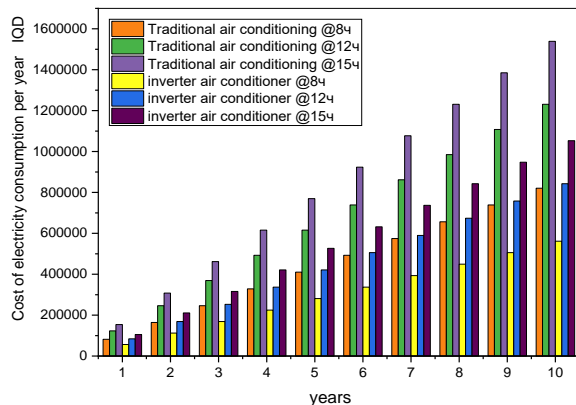
In this study, energy conservation and air conditioner operating hours were chosen because of their impact on the daily life of the consumer. It is also important to investigate how these parameters influence on consumer's decision to choose a high-efficiency air conditioner. Figure 1 shows the efficiency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



**Fig.1** cost of electricity consumption for an inverter and traditional air conditioner

Figure 2 shows the effect of daily operating hours for conventional and inverter air conditioner and its role

the energy saving or (reduce the cost of electrical bill per year)



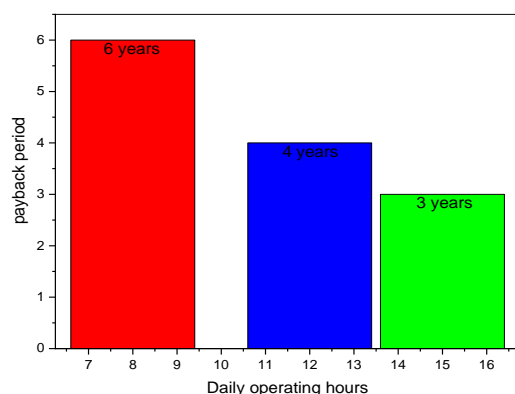
**Fig. 2** shows the effect of daily operating hours for conventional and inverter air conditioner

### 6.1 Net present value and internal rate of return

As is known, the NPV method and IRR are used to examine and evaluate the economic viability of projects. Table 3 shows the net present value and IRR of the inverter air conditioner.

**Table .3** shows the net present value and internal rate of Return of the air conditioner supported by the inverter technology.

-600000 IQD	Cost of investment
5%	Interest rate
Annual savings (IQD)	Years
38880	1
38880	2
38880	3
38880	4
38880	5
38880	6
38880	7
38880	8
38880	9
38880	10
+900,221.05 IQD	NPV
55%	IRR



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

## Conclusions

From above it can be 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
OP	operation time
NPV	Net present value
IRR	internal rate of return
t	years
C	Cost of investment
PV	Present value

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