Performance and Cost Analysis of Various Appliances for Cooling in this Era of Global Warming

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***Abstract*— In this work, to combat the problem faced by people in the era of global warming- methods available for cooling are looked at first. It includes the latest trends of urbanization and its associated difficulties in high population density living. Such a living with affordability in mind – solutions are investigated with India as an example. Based on these investigations – the final answer is arrived at. The demand for higher energy is also discussed when the joint family system has changed to nuclear family system.**

***Index Terms*— Appliances for cooling, Power consumption of appliances, Refrigeration of water, Global warming.**

I. INTRODUCTION

The world is facing high energy prices these days due to supply line disruptions and consequently the inflation rate is very high globally. At the same time the world is experiencing high temperatures globally which causes the rise in energy and power demands. There are power shortages even in industrially advanced countries. The peak power demands due to the heat requires operation of air conditioners which consume high electrical energy which, in large number of cases cannot be met by electrical power generation companies. The result is that there are load shedding or power rationing in large number of countries.

Secondly, in countries like India, there has been mass migrations of people from the rural areas to urban areas. People are living under cramped conditions including in the high rise buildings where they live in apartments. The population density per square kilometer of land is very high. In addition, the joint families have broken down into nuclear families which also causes increase in power demand.

Traditionally, to avoid hot nights, people were sleeping in open spaces such as outdoors or on terraces of houses but they cannot do so now because such possibilities do not exist in the cities when they are living in the apartments. So, all require some kind of appliances for cooling due to the increased heat in this era of global warming.

Thirdly, most countries have experienced high crime rates as a result they cannot sleep in open spaces due to safety reasons.

The net result is that people can no longer live under natural conditions and have to use some electronic appliances. Then the question arises: Which appliances to choose considering the rising temperature conditions and power shortages due to increased peak power demand?

The objective of this paper is to analyse the above issues and suggest solution or solutions.

The rising temperature trend in India is discussed in [1].This rising temperatures are also being experienced globally [2-4]. India is a big country with diverse climatic conditions. The heat in India is felt the most in the north-west regions which are affected by wind blowing from the Arabian countries. References [5-11] show the maximum temperatures of various places in the north or North West India.

II. ANALYSIS OF VARIOUS COOLING APPLIANCES

Fig. 1 shows an air cooler where water is stored at the bottom of a tank. In this appliance, the water is pumped using a Tulu pump which requires small amount of energy. Another component is a fan which also consumes small amount of energy. Here, water is used as a cooling medium which exchanges (cools) the air in contact. Naturally, the higher the water temperature or air temperature, greater is the need of thermal cooling rate. Once the air temperature becomes too high then this poses problem in cooling the air to a comfortable temperature range of the room.

Fig. 2 shows an air conditioner which has higher rating or the cooling capacity. In this appliance, heat is extracted (cooled) when the phase of the refrigerant is changed when the refrigerant pressure is reduced or it goes through expansion. It is a closed cycle process where the air flows over a cooled surface by the refrigerant which has gone through an expansion process.

This figure shows that this unit consumes high amount of energy 7.033 kW. The compressor which is the main energy consuming component - is a higher in mass which can also cause a lot of noise and vibration. This equipment is designed such that it has two sub-component – the cold air is vented (Fig. 2a) in the room but the compressor and other components are contained in a separate unit (Fig. 2b). To avoid noise and vibration- many times it is located outside the building on ground. The air is passed through lines connecting the two components.

The drawback of such units is that it poses problems in apartments in high-rise buildings. Due to high vibration and noise, it would not be desirable to locate it within an

apartment. The vibration and noise impose severe constraint on high power use of such types of air conditioners in apartments.

Fig. 3 shows another air conditioner which has lower energy consumption (5.274 kW) - therefore low power compressor. Naturally, its cooling capacity will be much lower. But it will have less noise and vibration problem.

What should be done when the air temperature gets too high as it is happening these days due to the global warming and high density urbanized living? In this case, none of the two air conditioners, or the air cooler may prove to be adequate to attain comfortable room temperature.

The answer comes from the use of ice in air cooler shown in Fig. 1. The presence of ice in the tank lowers the water temperature hence it provides increased cooling capacity. As long as the ice is present in well stirred tank, the water temperature is less likely higher. IN this case the problem boils down to the supply of ice which can be had if we also keep freezers in the apartments. Making ice in the apartment using freezers of sufficient capacity will solve the problem even in the case of global warming. Fig. 4 shows a 2.2 kW freezer.

III. CALCULATION OF ENERGY COSTS

1. The total energy consumption per hour of the appliances shown in Figs 1 and 4 are equal to 2.2 + 0.3 =2.5 kWhr which is 2.5 units of electricity. In India, if an unit costs Rs 8 then per hour it would cost Rs 20.0. However, it would be Rs 56 in the case of the unit shown in Fig 2 or Rs 42 in the case of Fig. 3.
2. Secondly, if the air temperature keeps on going higher then these two appliances shown Figs 2 and 3 may not have adequate cooling capacity whereas the appliance in Fig. 1 can still be used as long as we can get sufficient ice from the freezer supplemented, if needed, from the market.

IV. EXPERIMENTAL EVALUATION

An experiment was performed at Khadiya whose location is shown in Fig. 5. This place gets very hot in summer months and it is located in the coal mining area. This place undergoes high temperatures all through the summer months.

On the day of the experiment, 2 kilos of ice were used in the air cooler - to obtain a comfortable temperature for an hour in the room when the outside temperature was 44 ^{o}C. An experiment was conducted to obtain ice in the freezer shown in Fig. 4. For calculation purposes, the cost of ice was determined based on the volume fraction occupied by the ice container in the freeze. This fraction was o.2 or it occupied 20% of the volume space. Since the freezer in Fig. 4 consumes 2.2 units of electricity and it took 3 hours to freeze water – the cost of 2 kilos of ice would equal to 2.2 x 3 x 8 x 0.20. This comes to Rest 9.64.

The Table 1 shows costs of various options discussed above

It is obvious from this table that Option 4 is the best from cost point of view. In addition, this option provides tremendous possibility if there is drastic increase in the air temperature due to the global warming, one merely needs increased ice supply where the same appliance can be used – the other appliances may prove to be inadequate.

Here, the depreciation of appliance cost or any other cost is neglected because on per hour basis – this will be so.

V. CONCLUSION

In this work, a review was made of the change in the pattern of living where there has been mass migration of people from the rural to the urban areas. This high urban population area density caused the construction of high rise buildings containing apartments where nuclear families have started living. Such type of living has caused increased power demands.

This work also included cost analysis of various appliances which were shown in the Table 1. From the cost analysis it is determined that the combination of an air cooler and a freezer is the best option for cooling to a comfortable temperature.

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TABLE 1: COST COMPARISON OF VARIOUS OPTIONS

OPTION NUMBER	APPLIANCES IN VARIOUS FIGURES	POWER CONSUMPTION (kWhr)	COST OF OPERATION PER HOUR (Rs)	CCOST FRACTION RELATIVE TO FIG 2
1	FIG. 1	0.3	2.40	0.04
2	FIG 2	7.033	56.26	1.00
3	FIG 3	5.274	42.19	0.75
4	FIG 1 + FIG 4	0.3+(2.2*0.2)=2.5	Rs 20	0.36

FIG 1 AIR COOLER 300 Watts

FIG. 2A

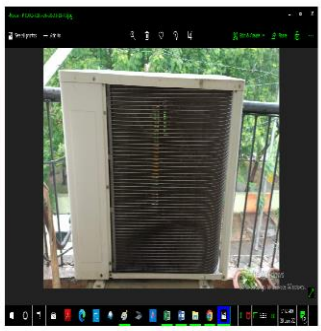
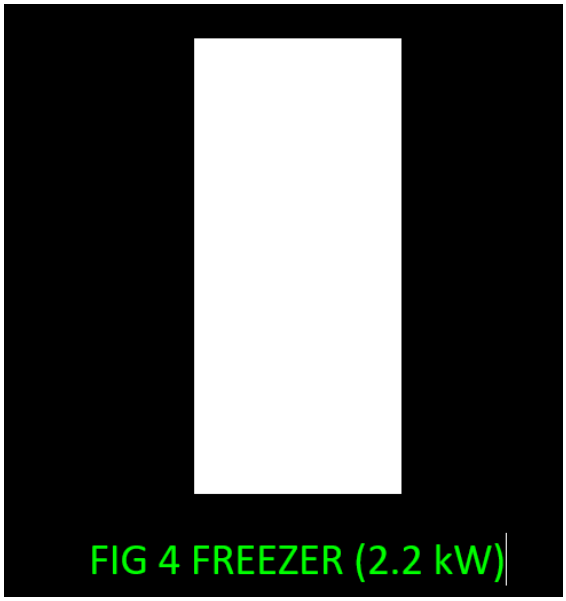


FIG 2B

SPLIT AIR CONDITIONER2 TONS (7.033 KWhr)

FIG 3 AIR CONDITIONER 1.5 TONS (5.274 KWhr)



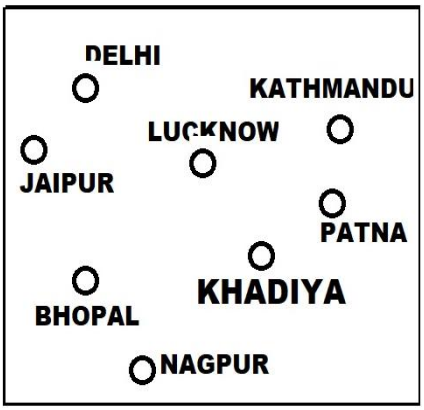


FIG 5 LOCATION OF KHADIYA IN UTTAR PRADESH INDIA