EFFICIENT USAGE OF WASTE HEAT FROM AIR CONDITIONER

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ABSTRACT

As the energy demand in our day to day life escalates significantly, there are plenty of energies are shuffled in the universe. Energies are put in an order of low grade and high grade energies. The regeneration of low grade energy into some beneficial work is a fantastic job. One such low grade energy is heat energy. So it is imperative that a significant and concrete effort should be taken for using heat energy through waste heat recovery. This paper concentrates on the theoretical analysis of production of hot water and reduction of LPG gas using air conditioner waste heat. Now a day, Air Conditioner is a banal device which occupies most of our condominium for our comforts. An attempt has been taken to recover waste heat rejected by the 1 TR air conditioning systems. For this water cooled condenser is exerted and the water is promulgated by the pump until our desired temperature is acquired. Then the hot water is accumulated in insulated tank for our use. The result of the paper shows that the temperature of hot water, time required for attaining that temperature for the necessary volume of water and the reduction of LPG gas by using hot water is also confabulated. Factors like supply and demand, condenser coil design are pondered and theoretically calculated and the corresponding graphs are drawn. Finally this could be the surrogate for water heater and it fulfils all the applications of Hot water. Similarly, it could tackle the demand of LPG gas.

KEYWORDS: *Waste heat, Hot water, 1 TR air conditioning system, Water cooled condenser, Saves LPG.*

I. INTRODUCTION

Energy saving is one of the key issues not only from the view of energy conservation but also for the aegis of global environment. Waste heat is the heat generated all along most of the operations of system and then it is dumped into the surroundings even though it could be still utilized for some other beneficial and remunerative purposes. Waste heat is usually correlated with waste streams of air or water and it put into the environment. Recovery of waste heat is a hefty research area among majority of scientists. The temperature of the unthriftiness heat plays a hefty role in recovery of waste heat. Waste heat which is repudiated from a process at a temperature higher than atmospheric temperature can be dexterously and efficaciously procured and bestowed for some other profitable work. The technique of culling the waste heat relies upon the temperature of waste heat and the purpose for which the heat is extracted. Due to scorching summer in India people suffer a lot and most of the people would aggrandize Air conditioning system for their comfort. Air conditioner consumes lavish amount of electricity and so it rejects voluminous amount of heat in the condenser. There are millions and billions of Air conditioning system in the universe. So the heat rejected from the air conditioners would be the root cause for global warming. On concentrating in this issue, we came across the effective and expedient solution. The solution is that usage of waste heat which is repudiated from the condenser of the air conditioning unit. This solution uses the heat efficaciously for some other beneficial work and also bulwark the environment. For this water cooled condenser is employed in the air conditioning system.

This paper focuses on production of hot water for various applications using waste heat repudiated by the air conditioning system. We designed a system for effective apprehending of waste heat which goes to the surroundings. Circulating chamber is erected and the tube is fitted between circulating chamber and water cooled condenser. Insulated tank is implemented for cumulating of the hot water for later use. The insulated pipes are fitted which connects the circulating chamber and insulating tank. Researchers are going on in the field of waste heat recovery. Our confabulation is about waste heat recovery in 1 TR air conditioning system by heat pipe heat exchanger. The considerable amount of heat is repudiated from the condenser unit and it is utilized for the generation of hot water and it is supplied where the demand of hot water exists. Results of the production of hot water and production time and temperature are briefly deliberated and explained. As a whole if it is erected, energy demand is easily tackled and the huge amount of LPG gas gets rescued. The demand of LPG is tackled. These are the key points on this paper.

The concept development and evaluation of "*Hot Water Production System"* using Air Conditioner Waste heat is organised into eight sub-sections. The preliminary section describes the theories and research works which was pursued by Researchers related to our systems, and is followed by the second section which discusses the *Construction* of Hot Water System integrated with Air Conditioning Unit with figure. The Third Section illuminates the *Working* principles and driving concepts of our system with flow chart. The Fourth Section includes the methodology of exhibiting the experiments for investigation of percentage loss in the amount of LPG gas. The *detailed Mathematical calculation* about our system, Calculations of LPG gas savings and cost calculations of our system with tabulation including payback period is illuminated in the Fifth Section. The Sixth Section consists of *Results and Discussion* which throws light on the inferences from mathematical calculations and the appropriate graphs are plotted. The Seventh section discussed about *Future scope* and benefits of our system. The Eighth Section is the *Conclusion* which elucidates the Practicality of the concept and the LPG gas savings per year.

II. EXISTING SYSTEMS

In the past years*, E.F. Gorzelnik* [9] indulged in the recovery of energy in the heat of compression from air conditioning, refrigeration, or heat-pump equipment in 1977 itself. *Kaushik and Singh* [1] confabulated about 40 percent of heat is recovered using Canopus heat exchanger in 1995. *Hung et al* [5] discussed in a review of Organic Rankine Cycle for the feasibility of recovery of low grade industrial waste heat in 2000. *M.Bojic* [14] studied and explained the heat rise in environment due to heat rejected from Air Conditioners in 2001. *T.T. Chow* [10] explained about the heat dissipation of split type Air Conditioning system in 2002. *Soylemez* [4] studied on the thermo economical optimization of Heat Pipe Heat Exchanger for waste heat Recovery system in 2003. *M.M. Rahman* [18] studied and confabulated about heat utilization from Split Air Conditioners in 2004. Then *Tugural ogulata* [2] discussed about utilization of heat in textile drying process in 2004. *Abu-Mulaweh* [3] had done a case study of a Thermo siphon heat recovery system which recovers heat rejected from an Air Conditioner in 2006. In *ASHRAE Handbook* [11] energy consumption of Air Conditioners and energy efficient buildings and plans are discussed in detail in 2008. *Y.Xiaowen* [12] undergone an experimental study on the performance of a domestic water-cooled Air conditioner (WAC) using tube-in-tube helical heat Exchanger for preheating of domestic hot water was carried out in 2009. *Sathiamurthi* et al [6 & 7] discussed in studies on Waste Heat Recovery from an Air Conditioning Unit that the energy can be recovered and utilized without sacrificing comfort level in 2011. *N.Balaji* [8] confabulated that he used intercooler which increases the efficiency of Air Conditioning system in 2012. Similarly lots of works are going on in waste heat recovery.

III. DESCRIPTION

In India, we are exposed to exorbitant slat of torrid summer and all of us are longing of comforts so we would aggrandize Air conditioning system. The main hitch of this system is that it dumped gob of heat to the surroundings. The drinking water which we procured from water board is perpetually contaminated and we are in need of expurgation of that water. So we are necessitated to heat the water to certain temperature and concede it to cool for drinking. On confabulating these key issues, an idea

has come to light that we have delineated the system which deals with the both issues and saves energy. The hot water system uses the unthriftiness heat repudiated from Air conditioning system and heats the water which saves the lot of LPG gas. The hot water is also supplied to the needy areas like hospitals, commercial buildings, residential areas for washing vegetables, cooking etc. The hot water system (Figure 1) consists of circulating chamber, insulating tank, pipe lines for promulgating and for delivering of hot water. The heat required for this process is carved out from the heat repudiated by the conventional Air conditioning system.

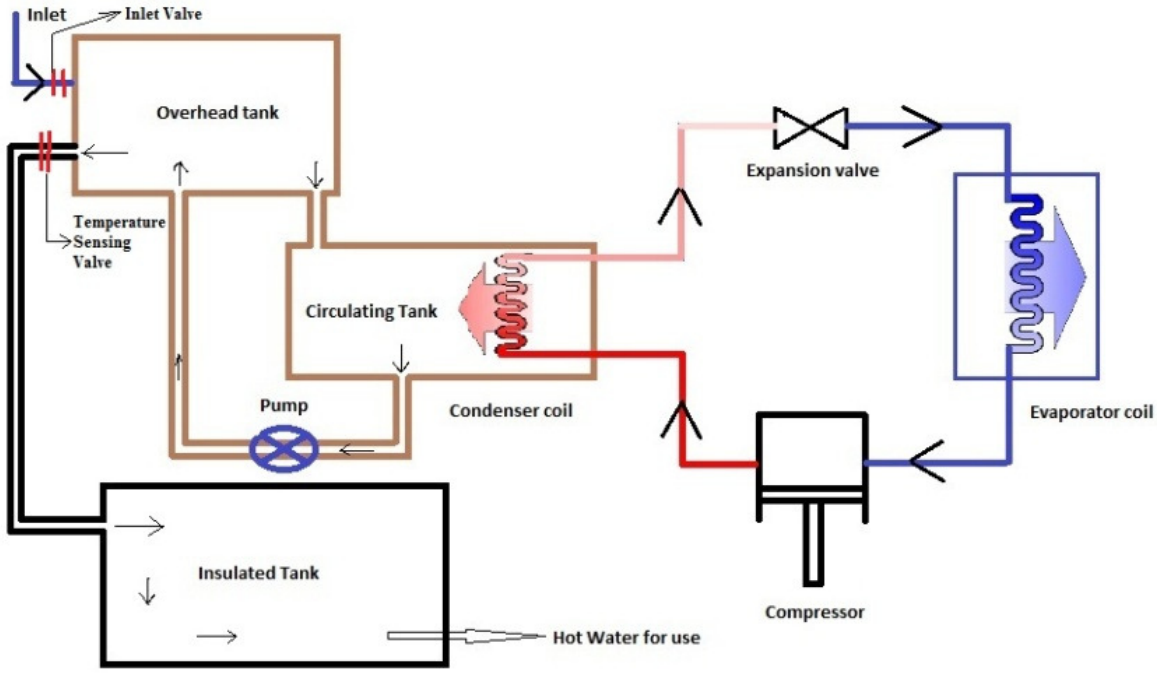


Figure 1: Sketch of production of hot water system integrated with Air Conditioning system

We have taken the 1 TR Air conditioning units and the heat rejected from the condenser unit. In normal AC system, there is an air cooled condenser and it have to be put in place by water cooled condenser. Circulating chamber is exerted for our required volume of hot water. It is nothing but a tank with one inlet and one outlet for water flow. A pump is needed for promulgating water from tank to the water cooled condenser and this process continues until our desired temperature is reached. If thermostat operating valve is provided, hot water with our required temperature is achieved. We have to erect an insulated tank for depository of the hot water and it has been used for cooking, bathing etc. These components are put together to form a hot water system. By installing this system, global warming is greatly reduced and the lavish amount of energy gets saved and lavish amount of LPG gas is also rescued. This system meets the demand of LPG gas also.

IV. WORKING

The whole system deals by utilizing the waste heat energy discharged by the condenser. This system consists of several processes to achieve the desired output. An Air Conditioner mainly consists of four parts as Condenser, Expansion valve, Evaporator and Compressor. In normal Air Conditioning the process proceeds by compressing the working substance where the input energy is fed to the Air Conditioner and this working substance then enters the condenser where the heat energy releases at a certain rate. Then it is subjected to expansion valve where isentropic process takes place and the temperature and pressure of the working substance is drastically reduced. This will absorb the heat energy in the leeway and which takes place in the cooling coil and the air in the leeway is also ventilated and which is then compensated by letting the fresh air in a desired mass flow rate.

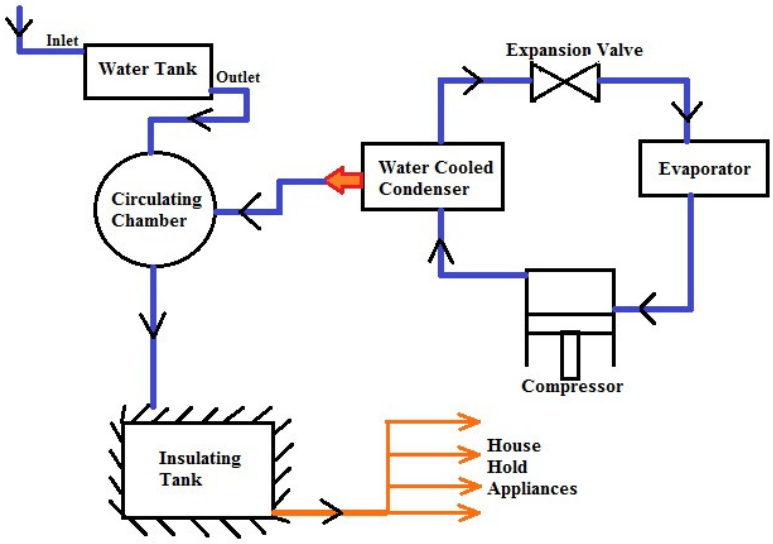


Figure 2: Flow chart for working of AC integrated Hot water system

In the process (Figure 2) stated above this paper mainly focuses on utilizing the waste heat discharged at the outlet. The waste heat is utilized by transferring the heat to the water and using it in many ways. In the first stage the calculated quantity of water is filled in the tank via inlet and the volume of the water remains fixed until it reaches the calculated temperature. The water from the tank is then circulated in a circulating chamber. Condenser coil is placed in the circulating chamber. Circulating water absorbs the heat rejected by the condenser and the heat is added by constant volume process. The temperature of the circulating water increases to the calculated temperature. When the desired temperature is reached in the circulating water it is then drained into the separate insulated storage tank. Suddenly fresh water will be filled into the tank as mentioned in the first stage and this process continues as whenever the Air Conditioner operates. Thus this large quantity of water is stored in the storage tank. Pipes can be connected from the tank to the household appliances. Thus the vegetables and raw materials for cooking can be washed cleanly in the hot water. This hot water is obtained by the waste heat rejected by the condenser. Thus is more economic process of obtaining the hot water. Water is the main course in each and every cooking. Hence utilizing hot water will save energy such as Liquefied Petroleum Gas, electrical energy in case of using an induction stove. This system can also applied in the hospitals for washing the patients clothes in hot water will save energy and also reduces the cost of washing. Further more if need for the temperature of the water is high then one should have a good refrigerant as a working substance otherwise the water to be drained in the insulated tank should be raised to a temperature of a desired level.

V. METHODOLOGY

It is always better that experiment are quite accurate when compared with ideal cases in real time applications. So we conducted experiments for some of our system to give accurate calculations which are as follows:

5.1 Experimental Analysis to calculate the saving of LPG gas:

An experimental set up consists of a gas stove with one LPG gas cylinder. Now we have to appraise the amount of LPG gas needed for elevating the temperature of water at 20 degree Celsius to attain 55 degree Celsius for 5 liters of water. A vessel is taken with 5 liters of water at 20 degree Celsius and places it in a gas stove. The temperature of water is periodically checked by using thermometer. Then we have to calculate the time of 5 liters of water to attain 55 degree Celsius. Mass flow rate of LPG gas is calculated and then appraise the amount of LPG gas needed to achieve our task. For a normal house, we have calculated the no of cylinders saved per year. This is calculated by simple experiments in our house. Finally this system meets the demand of LPG gas.

VI. CALCULATION

Assumptions:

- Usage of water per person is 50kg/day
- Loss of water in the pipeline is 5°C
- Minimum number of five cooking recipe is prepared per day
- COP of Air Conditioner is taken as 2
- Running hours of Air Conditioner is 8 hrs/day

Calculation for Air Conditioner

COP = QL/W

= QL/ (QH - QL)

QH = QL * (1+ 1/COP)

Where,

QH = Quantity of heat rejected by Air Conditioner

QL = Total Capacity of Air Conditioner (Input Power)

For 1 ton AC,

Capacity of Air Conditioner = 3.5 kW

Average COP for 1 ton of AC = 2

QH = 3.5 * (1+ ½)

QH = 5.25 kW

For ideal case,

Waste heat rejected over a day = 5.25 * 8 * 3600

= 151200 kJ /day

For 7 persons in a house,

Quantity of water needed = 350 L/day

In winter season the temperature of water at inlet = 20°C

Required temperature of water at insulated tank = 55°C

Quantity of heat required to raise the temperature

Q = m * Cp * dT

= 350 * 4.186 * 35

= 512785.4kJ/day

Heat rejection rate = 5.25 kJ/s

Time for 350L water to reach 55°C = 512785.4/5.25

T = 2.71 hrs

Calculation for LPG gas

By experiment, it was found that when cooking is done for 4 hours per day with 14.1 kg of LPG gas, it will be depleted in 40 days.

Mass flow rate $M = 2.4479 * 10^{-5}$ kg/s

By experiment,

Time to reach 55^{o}C for 5 L of water t_1 = 13 min (780 sec)

Mass of gas consumed for t_1 time = 19.09 g/ 5L of water boiling

For average of 5 cooking recipe is done per day then,

Mass of LPG gas saved = 95.45 g/day

For 40 days,

Amount of LPG gas saved = 3.818 kg

Number of days saved = 27 days/cycle

Number of LPG cylinders

it has saved per year = 4 per house

Cost Calculation of for producing 350 litre of water at 20 degree Celsius to attain 55 degree Celsius

Heat Required = 51728.5 KJ/Day.

To achieve this amount of heat 14 KWh of Electricity is needed.

So Cost for one day is Rs.100.

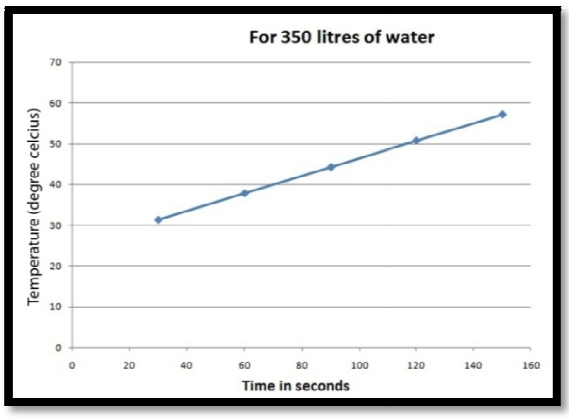
Table1. Cost calculation for installing our Hot Water System

S.NO	Components of our Hot Water system	Cost (in Rs.)
1.	1 TR Air Conditioning System	4000
2.	Piping and Valve Arrangements	2000
3.	500 litre capacity water tank	7000
4.	Tank Insulation	700
5.	Insulation of hot water pipe	500
6.	Motor (0.5 KW)	4000
	Total	18200

As a total, Payback period is **6 months**.

VII. RESULTS AND DISCUSSION

Results of our system are confabulated and explained with the help of corresponding graphs. For a normal house, 1 TR air conditioning system gives more comfort. So we have picked the one TR Air conditioner for our system. By assuming, Air conditioner is in operation of 8 hours per day we have estimated the amount of heat repudiated by the condenser per day. For ideal case we have calculated the time for increasing the temperature of water from 20 degree Celsius to 50 degree Celsius for the voluminous amount of water. By pondering the volume of 350 litres, a graph (Figure 3) is plotted between time and temperature. But according to our requirements volume of hot water needed is changing by time to time, so we ponder water to attain the temperature of 60 degree Celsius. With this consideration a graph (Figure 4) is plotted between volume of water and time to reach that temperature.



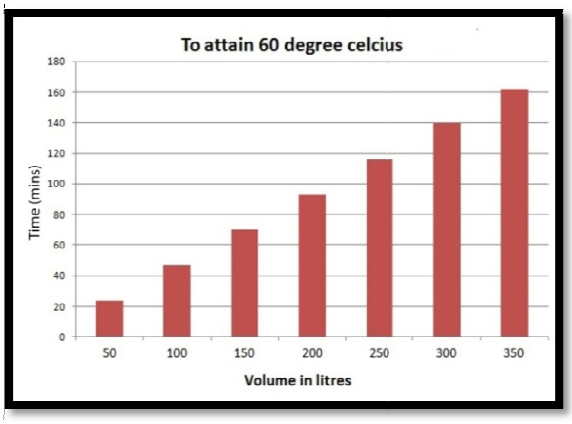


Figure 3: Variation of Temperature with Time

Figure 4: Variation of Time with Volume

But some people have raising a question that we are using certain volume of water for 30 minutes what is the temperature we attained. In order to answer that question we are plotting graph (Figure 5) between volume of water and temperature of water for 30 minutes of time.

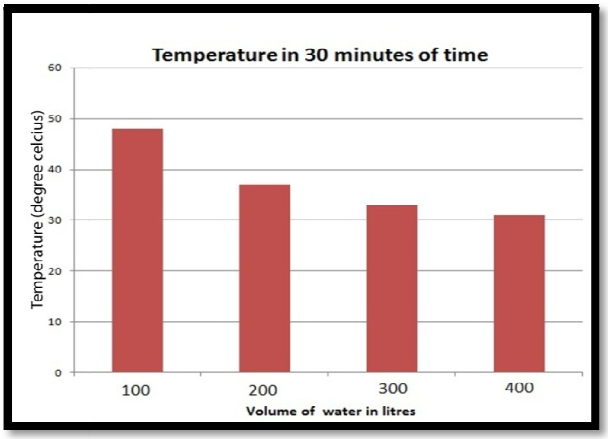


Figure 5: Variation of Temperature with Volume

Majority of houses in India uses either LPG gas or water heater for producing hot water. Water heater is the equipment which works in electricity. We have demand for both electricity and LPG gas. We have referred some websites and come to know that among majority of equipments water heater consumes huge amount of electricity compared to other appliances. So we have plotted the graph (Figure 6 &7) between equipments and power consumed per year.

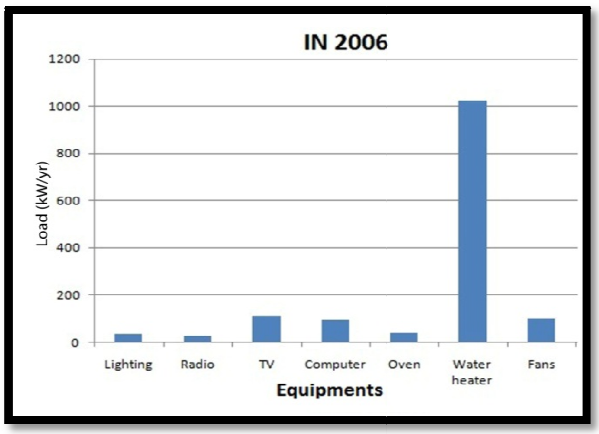


Figure 6: Variation of Load with Equipments in 2006

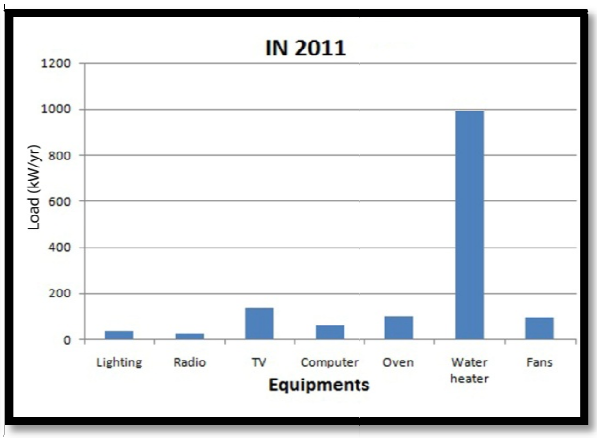


Figure 7: Variation of Load with Equipments in 2011

So our system saves large amount of electricity if it is erected in the house. For considering 350 litres of water, our system rescues 5040 units of electricity. We have drawn the graph (Figure 8) between month and consumption of electricity.

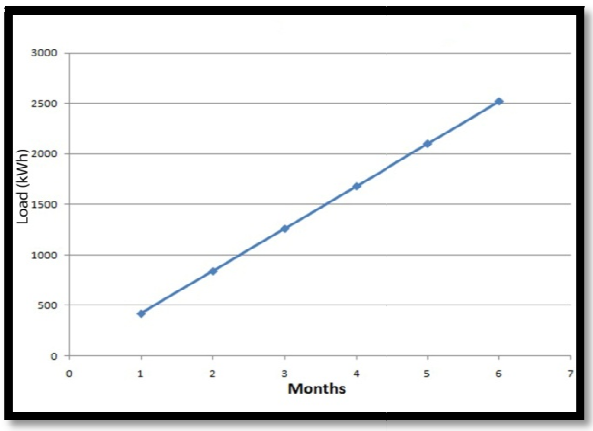


Figure 8: Variation of Load with Months

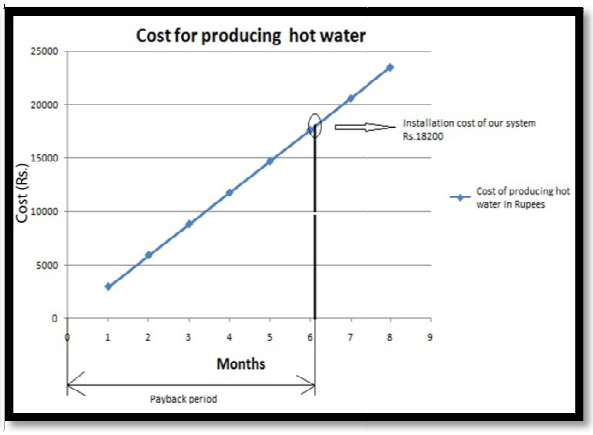


Figure 9: Comparison of Cost with Months

Now a day also in India, lot of houses are still using wood for producing hot water. If suppose hot water is produced by means of wood, lot of carbon emissions would have been emitted to the surroundings. If our system is erected, it protects our environment. If LPG gas is used, it gets wasted. If our system is installed, we would have saved *4 cylinders* per year per house. Somebody can altercate questions that how can you able to rescue this much of LPG gas. Our answer is for cooking or boiling of any dish, we are using boiling of water only. We are providing you the water at higher temperature, so we can save lot of LPG gas. Finally, all of us are thinking about cost of our system. We have tabulated (Table 1) the cost of our system and the corresponding graph (Figure 9) is drawn for cost of electricity and month and payback period is also noticed in the graph.

VIII. FUTURE SCOPE

As our global temperature is aggrandizing day by day, human life in earth is exhausted in the future. So it is our chore to control the alarming rise in temperature. Almost hefty of the people in India are using Air Conditioning System and it repudiates lavish amount of heat to environment. Our System efficaciously utilizes the heat repudiated by Air Conditioning System and uses it for producing Hot Water which was used for cooking and wherever Hot water is required. By installing our system in India, Global Temperature is easily controlled and the demand for LPG is also easily tackled by using

Hot water produced by our system. So our system lights double benefits. By improving our idea and confulating with researchers it is the best solution for reducing alarming global temperature rise and it is the Right time to do that.

IX. CONCLUSION

From the above experimental analysis, it has been perceived that by supplanting the normal Air Conditioner by this system will vanguards to rescue 4 numbers of LPG gas cylinders per year. This not only saves the cost but also it bulwarks the environment by truncating the global warming engendered because of LPG gas. By avulsing heat from the Air conditioning unit which are going to the environment, we are able to truncate Global warming considerably. We are confabulated the cost of our system and payback period and benefits of providing this system is Altercated. This system is further enrooted by research on this kind of systems. If this system is established all over India, lavish amount of LPG gas gets saved and global warming is controlled by certain extent and this could be a surrogate to water heater and it is the scope for the future.

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