Jurnal Ilmiah Multidisiplin Indonesia (JIM-ID)
Volume 1, Number 01, Januari 2022
doi.org/10.58471/esaprom
E.SSN 2828-9463 (Online)

# Utilization Of Exhaust Air Conditioning In Apartments For Hot Water Supply: Overview Of Economic Aspects

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**ABSTRACT**

The economic crisis that has hit almost all parts of the world has forced everyone to rethink their own economic arrangements. One thing to consider is the use of hot water. Not by eliminating it, but by looking for other alternatives to produce hot water. The heat-generating system that is widely used by the community is the electric water heater. On the one hand, this system works effectively because it can produce hot water with a maximum temperature of 750C. But on the other hand this system is not economical, because the electricity costs are very large. An alternative that can be given is the use of Air Conditioning Water Heater. Compared to the use of other types of water heaters, hot water produced by ACWH can be said to be "free hot water" because it is produced by utilizing the exhaust heat of the air conditioner and does not require additional electricity costs. The purpose of this research is to determine the most economical type of water heater. The research includes variations in the price of water heaters on the market and the electricity costs paid. From the results of the research, it was found that the most economical type of water heater is ACWH PK with an accumulated electricity cost of Rp. 5.010.300,- in the first year to Rp. 15.003.008,- in the 10th year. The results of this study are expected to be a solution to the economic crisis that hit almost the whole world. In addition, the ACWH system is also environmentally friendly and can reduce global warming because it does not consume energy and utilizes waste heat as its energy source.

**Keywords:**
Economic Crisis, ACWH, Economical, Water Heater, Electricity Cost



## INTRODUCTION

Lately there are 2 big issues circulating, namely the economic crisis and global warming. The impact of the economic crisis was also felt by Indonesia. The economic crisis in Indonesia began in 1998 and is increasingly felt to this day[1]. This economic crisis requires people to be more frugal, for example in terms of electricity consumption[2]. Indirectly, excessive electricity consumption also has an impact on global warming. Government policies that prioritize the use of fossil energy to meet the needs of the community have given rise to dependence on fossil fuels so that many life activities are felt to be unable to run without the presence of fossil energy.[3]. In Indonesia itself, the need for fossil fuels is still high. From the list of power plants in Indonesia, it shows that PLN's power plants use the most fuel (36%) and are followed by generators that use gas (25%), coal (23%), hydropower (15%) and geothermal (2%). ). It can be concluded that electricity is generated from power plants which mostly use non-renewable fossil fuels as fuel. This not only triggers energy conservation problems, but also has a major impact on global warming.

The human need for energy is increasing along with the success of the development carried out. This also means that the demand for electrical power is also increasing[4]. This can be seen from the increasing number of houses and apartments that use air conditioning as well as electric water heaters and solar water heaters[5]. However, the heat generated in the cooling system is simply dumped into the environment. Whereas the heat energy that is wasted from the cooling system can be used to heat water[6].

One application of energy conservation in residential areas is the Air Conditioner Water Heater (ACWH).[7]. ACWH is not a new system, this system has been developed more than 50 years before. ACWH works by utilizing exhaust heat from the AC system to heat water[8]. This method can be carried out with a heat exchanger that does not require additional electricity[9]. With this system, we get two advantages at once, the cooling effect of the room and the energy-saving effect of heating water. The type of water heater that people use today is an electric water heater. Although effective, this type requires a large amount of electrical power which results in the higher electricity costs that must be paid[10]. Public knowledge of the system and the comparison of ACWH cost calculations with other types of water heaters is still very small, so the use of ACWH in the community is still very minimal.

## METHOD

The methodology used in this paper include:

a. Study of literature. Literature study is the process of learning materials related to discussion material from books, scientific journals, and internet sites.
b. ACWH testing. The performance of the tool is carried out by a thermocouple calibration process, taking temperature and pressure data on the test equipment
c. Calculations, Analysis, and Conclusions Tests. The data obtained from the test is then processed to obtain ACWH test graphs. From the graph, an analysis will be carried out that describes the performance characteristics of the ACWH system. Analysis is also carried out for the consumption of electricity costs and the costs required. From the analysis, conclusions can be drawn from the process of testing and research on electricity costs and provide suggestions for the further development of the ACWH system.

## RESULTS AND DISCUSSION

In the ACWH system, heat transfer occurs from the refrigerant with a high temperature after it leaves the compressor with water that has a low temperature in the water storage. With this heat transfer, it is expected that the refrigerant temperature will decrease and vice versa there will be an increase in the temperature of the water in the water storage.

### Testing Equipment Installation

The test equipment consists of an AC system with refrigerant flow connected to a coil type heat exchanger located in water storage. The compressor outlet pipe and the condenser inlet pipe are cut and then connected to a heat exchanger. Thus, the refrigerant with a high temperature coming out of the compressor will flow first through the heat exchanger and then into the condenser. In water storage there will be heat exchange between the refrigerant and water due to the temperature difference between the two.

Thermocouples are installed at the entry and exit points of the working fluids. The refrigerant pressure was measured using a bourdon tube type pressure gauge at several points, compressor discharge pressure (HE inlet), HE outlet pressure, capillary tube outlet pressure, and compressor suction pressure. With the temperature and pressure data obtained, the cycle can be entered in a Ph. diagram. The electric current entering the compressor is measured using a clamp meter. Details for the design and installation of a heat exchanger testing device on an Air Conditioner Water Heater can be seen in the schematic of the test equipment.

### Testing Tool Components

The Air Conditioner (AC) used in this test is a split type with a power of 1 PK and PK. The

indoor unit, which consists of the evaporator, and the outdoor unit, which consists of the compressor, condenser, and capillary tube. All existing refrigerant piping lines are isolated to prevent thermal leakage which can degrade the performance of the air conditioner. The heat exchanger is a inch coil pipe. The material from copper pipe was chosen because it has a large conductivity and is similar to AC pipes in general, making it easy to do welding. Water storage will be used for bathing purposes, so it is desirable that the water remains colorless and smells good. Water storage materials must also be resistant to corrosion and high temperatures. Then the material chosen is stainless steel with a thickness of 1.5 mm.

The data acquisition (DAQ) used for reading the output voltage of this type K thermocouple is NI cDAQ 9174 with 4 ports. In the application, only 2 ports are used. This DAQ is a data acquisition that can accept digital input. In use, the DAQ is connected to a computer via a USB port and uses a 12V DC power supply. There are 2 software used, namely Lab View version 8.5 and NI-DAQmx. In the Lab View software used, a display (user interface) of the thermocouple used has been created. The results of the temperature reading will be read on the computer screen.

A thermocouple is a device that works based on the Seebeck effect which states that if two different conductor materials are connected and form a junction, it will produce a voltage difference (electromotive force / emf) if there is a temperature difference between the two junctions. The magnitude of the voltage-temperature gradient is different for each thermocouple, depending on the material that makes up the thermocouple. The thermocouple used in this study is a type K thermocouple with the constituent materials of chromel and alumel. This type is the most common type and is easy to use, with a temperature range between -200C to +1200C.

**Procedure for Data Collection and Processing**

The steps carried out in data collection on ACWH with a heat exchanger in the form of a coil in water storage are:

a. Fill the water storage with water that has a normal temperature until it is full
b. Powering on and connecting the DAQ with a computer via a USB cable
c. Run the DAQ program to determine the initial temperature at each data collection point (Evaporator in & out, HE in & out, Water in & out). This checking process is important so that each data collection of all components are at the initial temperature
d. Turn on the AC and set the temperature setting of the AC evaporator at 160C
e. Lights up as a cooling load (2600, 2400, 2200, 2000, and 1800 Watts)
f. Starts saving data every second on the DAQ program automatically after first pressing the write to file button on the computer
g. Manually record the pressure on the evaporator and HE which can be seen on the pressure gauge every minute
h. Manually record the current price required by the compressor by looking at the clamp meter every minute
i. Circulate water (mix) in water storage with the help of a water pump at 45, 90, and 120 minutes
j. Turning off the air conditioner after 2 hours of trial and waiting 1-2 hours for the next trial (cooling load variation) for the air conditioner to return to its initial state

Data processing is carried out with several assumptions:

a. The heat exchanger works in steady condition
b. No heat loss to the environment
c. The temperature of each fluid is uniform at every intersection of the heat exchanger
d. The fluid flow velocity is evenly distributed on each side

The Coefficient of Performance (COP) states the ratio between the benefits achieved and the work/effort done to obtain these benefits. The benefits obtained from ACWH are the cooling effect on the indoor unit and hot water heating. While the work done is the compressor work that rotates the refrigerant. No additional effort is made because the water used has already gone through the pump before. This illustrates the simulation of the ACWH application where ACWH will be installed in apartment units that already have pump and water piping installations.

## Discussion

Cost analysis was carried out on 3 types of water heaters, namely Plate Water Heater 1 PK, ACWH 1PK and ACWH PK. Cost analysis was carried out to find the most economical and efficient type of water heater. The data is processed and presented in graphical form. The purchase price for each water heater is based on market prices, but the price for water storage at ACWH is determined based on the design and selection of materials and production processes. The following is the design process for ACWH water storage.

The following is a flowchart in the manufacturing process for water storage

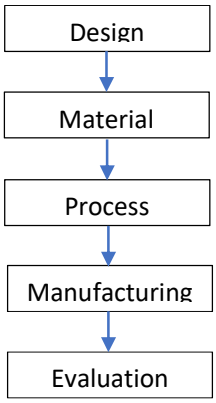


**Figure 1** Flowchart of water storage design

Water storage will be used as a place to store water which will be heated by the helical coil. For that the tank must have the following characteristics:

a. It has a water storage capacity of 50 L because this tank is used to store hot water for bathing
b. There are no leaks that can reduce the volume of the tank. There should be no heat loss in the hot water in the tank
c. Inside the tank there are 3 channels, namely the water inlet, the water outlet, and a channel to remove trapped air when the tank is filled from an empty state.

Water storage consists of 2 parts, the inner tube and the outer tube. The inner tube consists of 3 parts, namely the right cover, the tube cover and the left cover which will be insulated by polyurethane. The outer tube consists of 3 parts, namely the right cover, outer cover and left cover.

This process applies to both the inner and outer tubes. For the outer blanket and inner blanket, the process is carried out by roll forming. For the right cover and left cover, the process is done by bending and forming. After that the left and right covers are welded. After that, the polyurethane is injected into the finished water storage. After going through the above process, the estimated price for 1 water storage is IDR 1,200,000.-.

Based on information that shows that the life cycle of each type of water heater is approximately 10 years and with the following assumptions:

**Table 1.** Power and time of water heater usage per day

| Model | Power (W) | Usage Time per Day (hours) |
|---|---|---|
| PHE | 924 | 8 |
| ACWH 1 PK | 901 | 8 |
| ACWH 3/4 PK | 679 | 8 |

then the accumulated electricity costs for the air conditioner and each type of water heater are:

**Table 2.** Accumulated water heater electricity costs for 10 years

| Year | ACWH 3/4 PK | ACWH 1 PK | ACWH PHE |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 1 | 5,010,300.8 | 5,473,315.2 | 6,810,924.8 |
| 2 | 6,120,601.6 | 6,946.630.4 | 8,321,849.6 |
| 3 | 7,230,902.4 | 8,419,945.6 | 9,832,774,4 |
| 4 | 8,341,203.2 | 9,893,260.8 | 11,343,699.2 |
| 5 | 9,451,504 | 11,366,576 | 12,854,624 |
| 6 | 10,561,804.8 | 12,839,891.2 | 14,365,548.8 |
| 7 | 11,672,105.6 | 14,313,206.4 | 15,876.473,6 |
| 8 | 12,782,406.4 | 15,786.521.6 | 17,387,398.4 |
| 9 | 13,892,707,2 | 17,259,836.8 | 18,898,323.2 |
| 10 | 15.003.008 | 18,733.152 | 20,409,248 |

Based on the cost of electricity accumulation until the 10th year, the most economical use of water heaters is ACWH PK, which is Rp. 5,010,300 in the first year to Rp. 15,003.008, - in the 10th year. Meanwhile, the largest cost of electricity accumulation is the use of ACWH PHE, which is Rp. 6,856,038.4 to Rp. 20,409,248,-. This happens because the smallest power consumption is ACWH PK, which is 1,664.4 kW per year and the largest power consumption is ACWH PHE, which is 2698.08 kW per year.

## CONCLUSION

Based on the analysis obtained during the test, it can be concluded that the most economical use of a water heater and meets the average temperature used for bathing is ACWH PK. For further testing, several improvements can be made, such as: for more optimal test results, it must be carried out at the same ambient temperature conditions. Because the difference in ambient temperature affects the refrigerant temperature and for application to apartments, it is necessary to test with a real cooling room and load.

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