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Economics of Domestic Solar Hot Water Heating Systems in Malaysia

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Abstract

Malaysia has favorable climatic conditions for the development of solar energy due to the abundant sunshine and is considered good for harnessing energy from the sun. This is because solar hot water can represent the large energy consumer in Malaysian households but, because of the high initial cost of Solar Water Heating Systems (SWHSs) and easily to install and relatively inexpensive to purchase electric water heaters, many Malaysian families are still using Electric Water Heaters to hot their water needs. This paper is presented the comparing of techno-economic feasibility of some models of SWHS from Malaysian's market with the Electric Water Heaters (EWH) by study the annual cost of operation for both systems. The result shows that the annual cost of the electrical water heater becomes greater than the annual cost of the SWHS for all models in long-term run so it is advantageous for the family to use the solar water heater, at least after 4 years. In addition with installation SWHS the families can get long-term economical benefits,

environment friendly and also can doing its part to reduce this country's dependence on foreign oil that its price increase day after day.

Keywords: Solar energy, solar water heating system, techno-economic evaluation, Annual cost method.

1. Introduction

Using the sun's energy to heat water is not a new idea. More than one hundred years ago, black painted water tanks were used as simple solar water heaters in a number of countries. Solar water heating (SWH) technology has greatly improved during the past century. Today there are more than 30 million m of solar collectors installed around the globe.

One of economic reasons to install solar energy components is to available of amount site of sun radiation can be gets. Malaysia has a high solar energy potential; the monthly average daily solar radiation is 4000 - 5000 Whr/m^2, with the monthly average daily sunshine duration ranging from 4 hr to 8 hr (Sopian and Othman, 1992). So Malaysia has favorable climatic conditions for the development of solar energy and solar water heaters households used but, because of lack of public understanding and awareness of the working and potential benefits of Solar water heaters (SWH), the high initial cost of solar water heating systems (SWHSs) and easily to install and relatively inexpensive to purchase electric water heaters, many Malaysian families are still using Electric Water Heaters to hot their water needs.

This paper presents economic evaluation of some solar water heating systems models uses in Malaysia marketing with different purchase price such as Aztec, Solarmate, Solarpollo, Edwards, Summer, and Microsolar M80VTHE Indirect Vacum comparing with electric water heaters. The comparison between these systems is based on the direct monetary outlay of the user by calculate the annual cost method.

The objective of this paper is to study the annual cost of operating a SWHS and to compare it to the annual cost of the operation of an Electric Water Heating system. In addition, we want to find out which of each the systems is more economical than the other in operation time (N).

2. Techno-Economics Analysis

Solar system are generally characterized by high initial cost and low operational costs as compared with the relatively low initial costs and high operating costs of conventional (Electric Water Heater) systems. In additional heating water with the sun also means long-term benefits, such as being cushioned from future fuel shortages and price increases, and environmental benefits. The comparison between these systems is based on the direct monetary outlay of the end users. To study the economic feasibility of a system, different methods could be used to evaluate different figures of merit of the systems. In this study Annual Cost Method (AC) is used to comparing the relative costs of the SWHS with Electric Water Heater.

2.1. Annual Cost Method (AC)

It is intended in this study to let the operation time (N) of a system be variable because the wanted is to find the optimal operation life of both systems. ***The Annual Cost Method*** will be adapted in this study because it allows the comparison between the two systems that have different life times.

In general, taking the concept of time value of money in consideration, then the annual cost (AC) of a system can be expressed as the following equation:

$$AC = IC + AFC + AMC \quad (2.1)$$

Where:

- **IC,** initial cost of the system,[RM];
- **AFC,** annual fuel cost,[RM];
- **AMC,** annual maintenance cost,[RM / year].

2.1.1. Annual Fuel Cost (AFC)

The annual fuel cost for the Electric water heating systems are the electric bill cost over the year to provide hot water needs of an average family. The annual fuel cost for the SWHS is yearly electrical bill cost for the system which is built in coil electric heater used. Whoever; the SWHS without electric heater no has yearly electricity cost (RM 0.00 per year).

$$\mathrm{AFC}_{EH} = 365 * NOH * P_{el} \quad (2.2)$$

Where, *NOH* daily number of hour's electricity is used to provide hot water needs of a family [H]; P_{el} is a price of electricity [RM/KWh].

$$\mathrm{AFC}_{SWHS} = 12 * NOCD * NOH_s * P_{el} \quad (2.3)$$

Where, *NOCD* number of cloudy day per month, [day/month]; NOH_s number of hours switched thermostat [H]; P_{el} price of electricity [RM/KWh].

For SWHS without electric heater: The AFC_{SWHS} = RM 00.0, (no electricity cost).

2.1.2. Annual Maintenance Cost (AMC)

To simplify analysis, it will be assumed that the annual maintenance cost of the SWHS is directly proportional to its operation time so:

$$\mathrm{AMC}_{SWHS} = \alpha_{SWHS} * N \quad (2.4)$$

Where α_{SWHS} , proportionality constant, [RM/year].

2.2. Computer Implementation

The previous economic analysis of the two systems resulted in the following two final equations:

$$\mathrm{AC}_{SWHS} = IC_{SWHS} + 12 * NOCD * NOH_s * P_{el} + \alpha_{SWHS} * N \quad (2.5)$$

$$\mathrm{AC}_{EH} = IC_{EH} + 365 * NOH + P_{el} \quad (2.6)$$

To evaluate the annual cost for both systems the calculation prepared a spreadsheet on Excel that incorporated the above variables and parameters as Table 2.1. AC_{SWHS} and AC_{EH} are plotted against the variable *N*.

Table 2.1: Summery of the Values of the Parameters

SWHS	**EWH**
IC_{SWHS} = as the model use	IC_{EWH} = 450 ×2
NOH_s =5[H]	*NOH* = 2 hour/day for 4 px and 3 hour/day for 6 px
NOCD =8[day/month]	P_{el} = 3kw × 0.25 RM
P_{el} = 3kw × 0.25 RM *N* = 10 [year]	

3. Results And Discussion

Using simple formulations presented in the number (2.5) and 2.6), some exemplifying calculations have been done on Excel. The use of Excel was extremely powerful because any change in any

parameter was linked directly to a change in the graphs which was very useful for purposes of the sensitivity analysis of the parameters.

Firstly, for the electric water heater considered that the family installs 2 units and the rate of hot water needs for persons is 10 gallons per day. So as the Fig. 3.1 the AC_{EH} is different by different of family size.

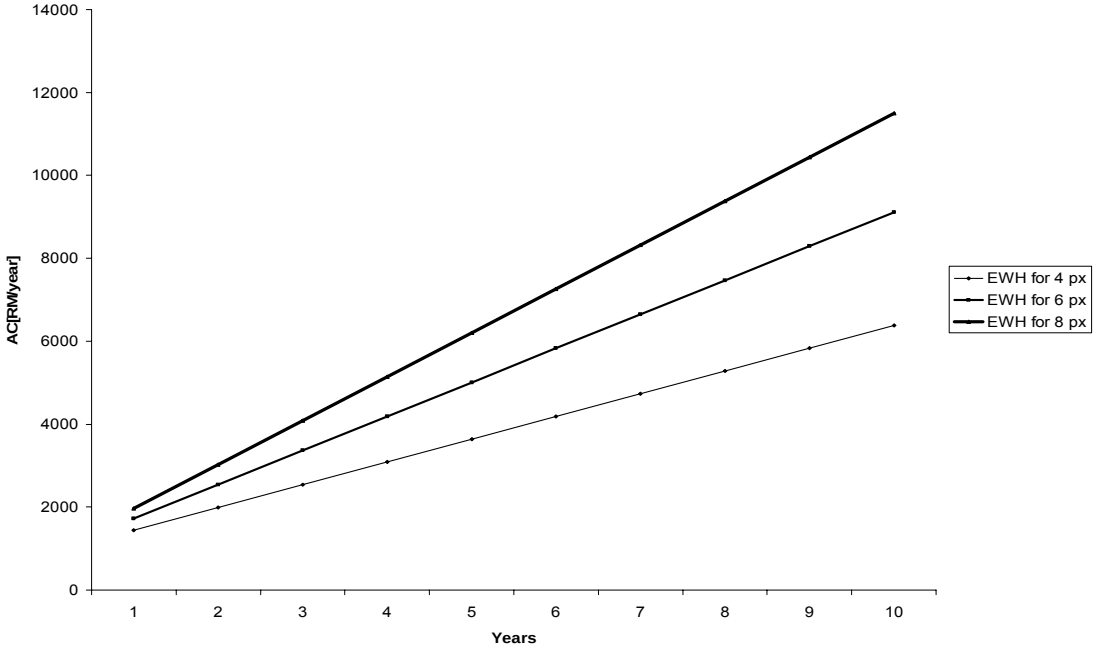
Secondly, for Solar water heating systems, Malaysia market expanded significantly from many years ago and as a result there are some popular models which are chosen to make this comparison of economic evaluation to find out which and when each of the systems is more economical than the other comparing with Electric water heater such as, Aztec, Solarmate, Solarpollo, Edwards, Microsolar M80VTHE Indirect Vacum, and Summer system.

3.1. Discussion

Close inspection of Eqs. (2.5), (2.6), and from the figures above reveals that:

- It would seem reasonable that energy consumption increases as the number of residents in the dwelling increases. This is clearly the case for the consumption of electricity by water heaters. With increasing family size, water heating appliance consumption increases more rapidly. This is because hot water is used on an individual basis as Fig. 3.1.
- The annual cost of the Electrical water heater EWH becomes greater than the annual cost of the SWHS. In the early years, it is advantageous to use the electrical water heater, but as time progresses, however, the cost of using the electrical water heater increases with increasing electricity bill. This narrows the difference between the electrical and solar water heaters, until it crosses the benefit point. Fig. 3.2, 3.3, 3.4, 3.5, 3.6 and 3.7.
- The benefit point is different from model to others, is depend on the capital costs of the models and the capacity of system's tank.
- The cost of a SWHS varies considerably with the quality of construction, but in general costs of solar water heating technologies are available depending on design, materials, system efficiency, expected life time, capacity of their tanks and total collector panel area.
- With more number of valves and larger glass area lead to faster reheat time (no need of backup electric heater) and higher overall temperature such as models Microsolar M80VTHE and they are more economical that others model as Fig. 3.6.
- The above result shows also that, in the long-run, it is advantageous for the family to use the solar water heater, at least after 5 years, when compared to the electrical water heater.

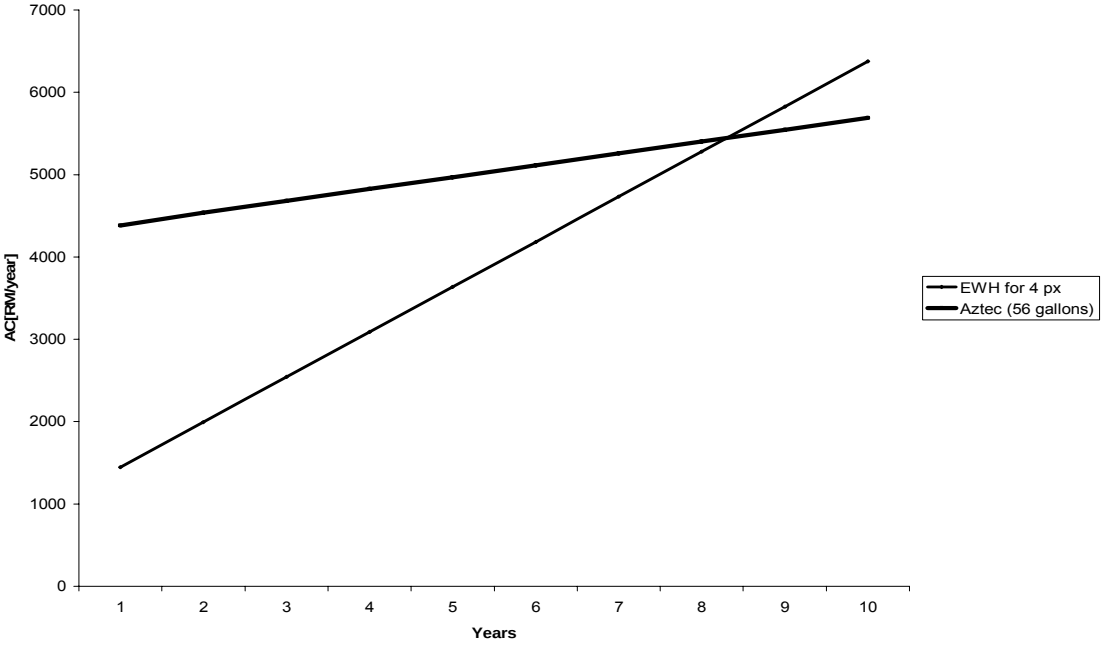
Figure 3.1: AC for Different Size of Families



1) Aztec **-** with:

- Price inclusive installation RM 4,250
- Total capacity is (56 gallons, 255 ltrs)

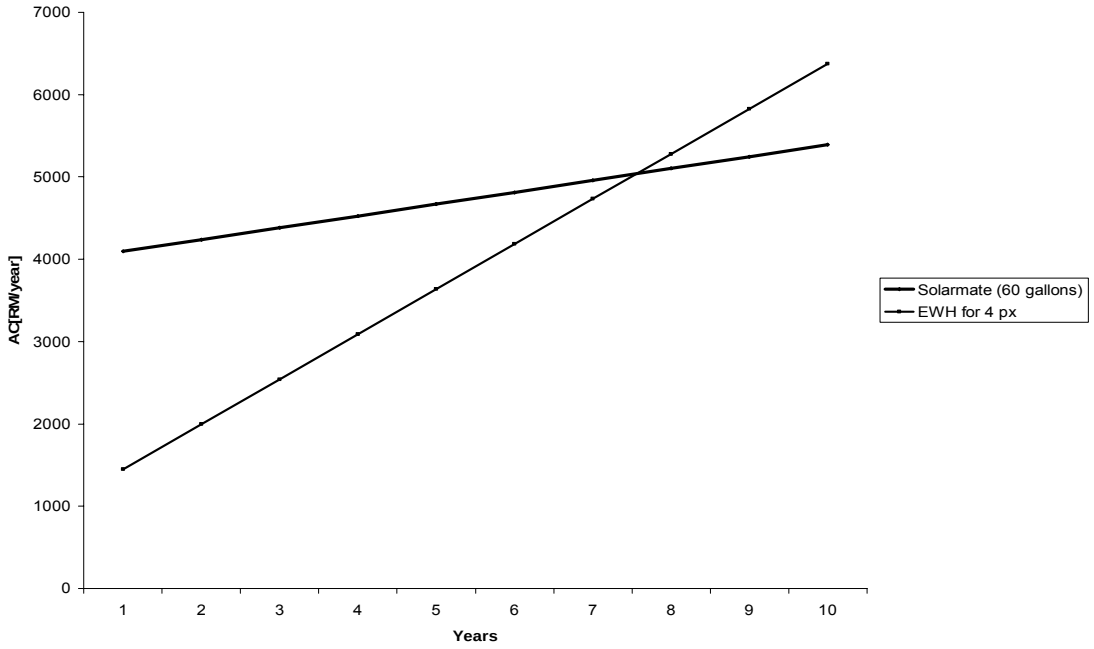
Figure 3.2: Comparison of Annual Cost of EWH of 4 Persons To Aztec System



2) Solarmate **-** with:

- Price inclusive installation RM 3,950
- Total capacity is (60 gallons, 270 ltrs)

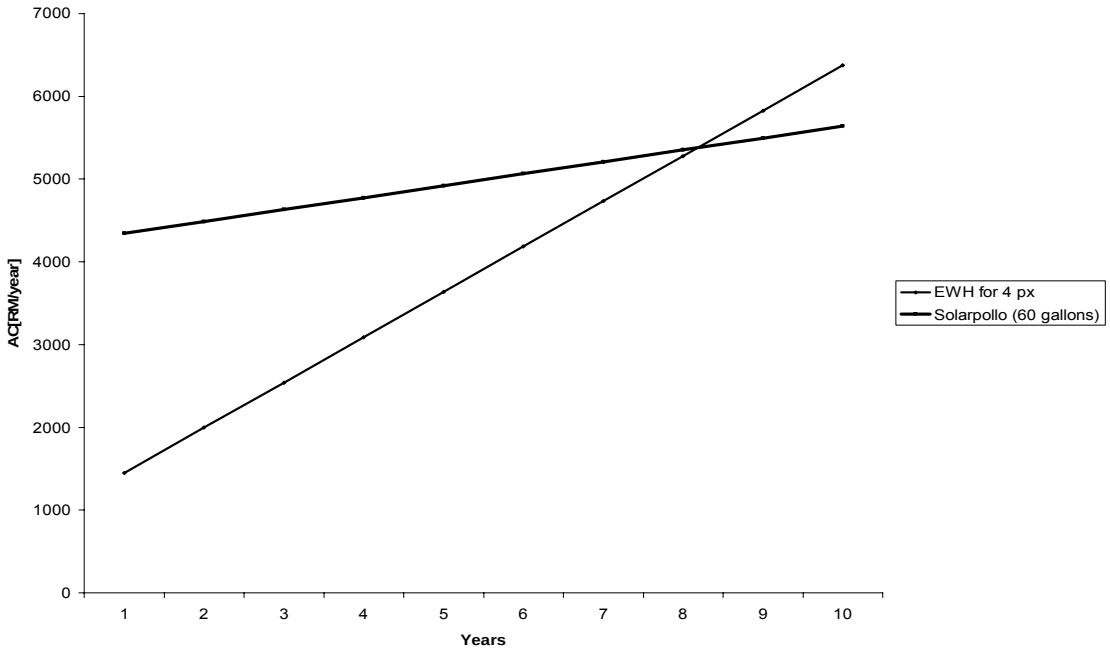
Figure 3.3: comparison of cost of EWH of 4 persons to Solarmate system



3) Solarpollo -- with:

- Price inclusive installation RM 4,200
- Total capacity is (60 gallons, 270 ltrs)

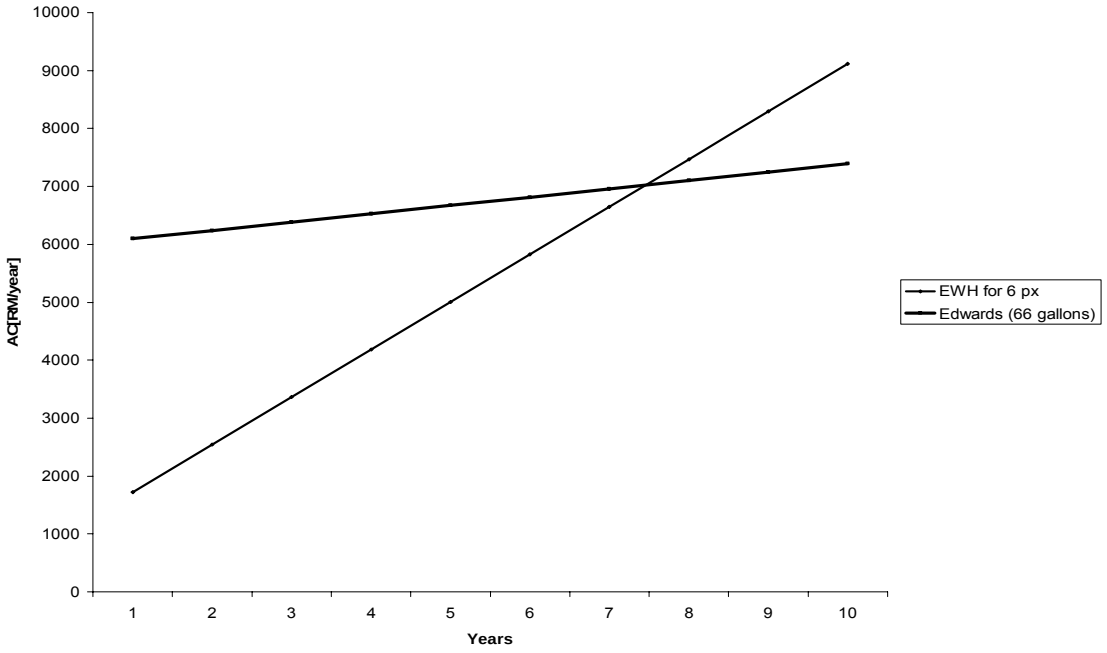
Figure 3.4: comparison of cost of EWH of 4 persons to Solarpollo system



4) Edwards - with:

- Price inclusive installation RM 5,950
- Total capacity is (66 gallons, 300 ltrs)

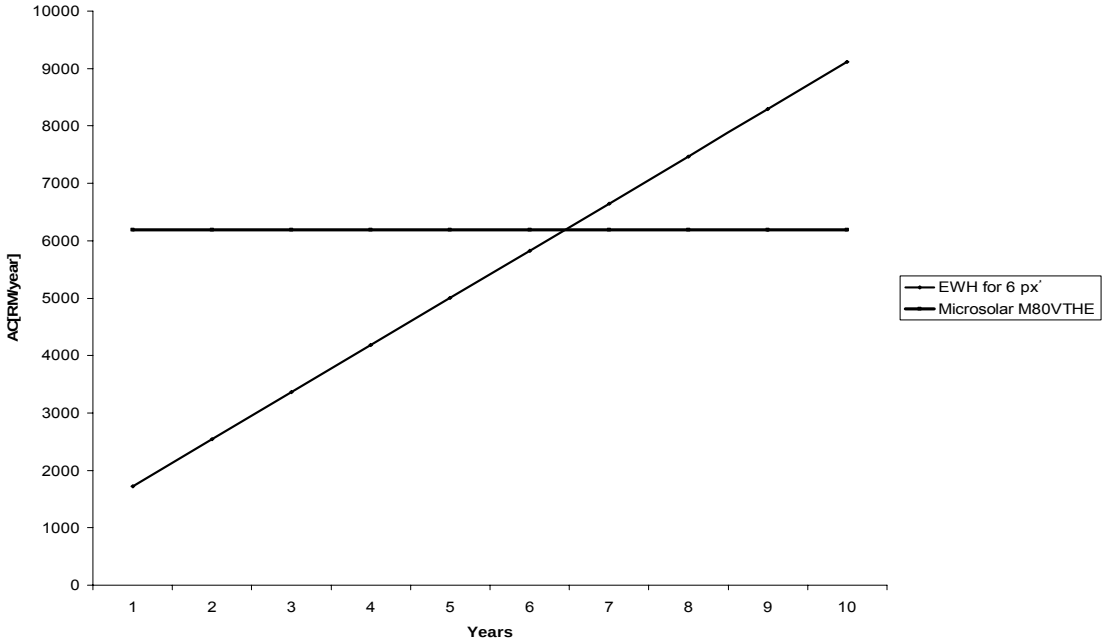
Figure 3.5: comparison of cost of EWH of 6 persons to Edwards system



5) Microsolar M80VTHE Indirect Vacuum **-** with:

- Price inclusive installation RM 6,190
- Total capacity is (78 gallons, 356 ltrs)

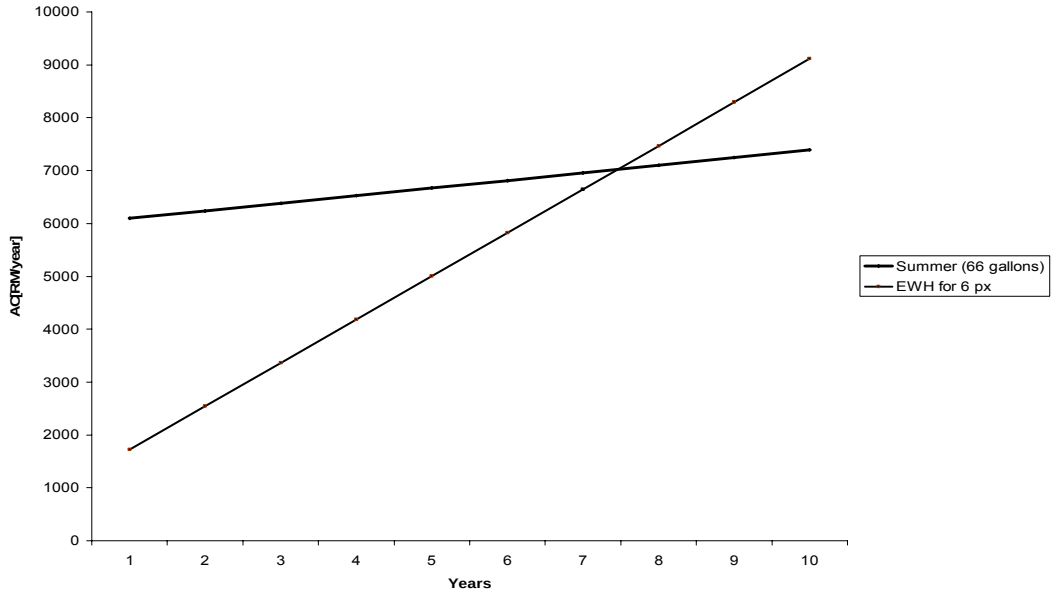
Figure 3.6: comparison of cost of EWH of 6 persons to Microsolar M80VTHE System



6) Summer **-** general descriptions:

- Price inclusive installation RM 5,950
- Total capacity is (66 gallons, 300 ltrs)

Figure 3.7: comparison of cost of EWH of 6 persons to Summer system



4. Conclusions

The argument for the family about using electric water heaters (EWH) or installing a solar water heating system (SWHS), leads to make comparisons of financial economic evaluation to decide which systems is more economical than the other.

By study the annual cost of operation of the some models of SWHS which are used in Malaysia and to compare it to the annual cost of the operation of a EWH the results show that the initial cost of a SWHS and the electricity price are the two most important parameters that determine the choice. As a rule of thumb, the cost of using the electrical water heater increases with increasing electricity bill and with increasing family size.

With using some calculations on Excel the result show that the SWHS is more economical and becomes more attractive than the EWH in long term- run, so it is advantageous for the family to use the solar water heater, at least after 4 years, when compared to the electrical water heater and for an option which has a renewable nature and environmental soundness, the SWHS seems to be a better proposition. Finally, more attention should be given to the families to install SWHS to get long-term economical benefits, environment friendly and also can doing its part to reduce this country's dependence on foreign oil that its price increase day after day.

Notations

SWHS	Solar Water Heating System
EWHS	Electric Water Heating System
RM	Malaysian Ringgit
AC	Annual cost of the system, [RM]
IC	Initial cost of the system, [RM]
AFC	Annual fuel cost of the system, [RM]
AMC	Annual maintenance cost of the system, [RM/year]
α	Proportionality constant, [RM/year]
N	operation time of the system, [year]
P_{el}	Price of electricity is used, [RM/kwh]
NOH	Number of hours electricity is used per day, [hour/day]
$NOCD$	Number of cloudy day per month, [day/month]
NOH_s	Number of hours switched thermostat, [hour/day]
AC_{EH}	Annual cost of electric water heater, [RM]
AC_{SWHS}	Annual cost of solar water heating system, [RM]

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