Asia-Pacific Journal of Science and Technology: Volume: 21. Issue: 04. Article ID.: APST-21-04-09. Research Article

APST

Asia-Pacific Journal of Science and Technology

https://www.tci-thaijo.org/index.php/APST/index

Published by the Faculty of Engineering, Khon Kaen University, Thailand

Economic analysis of water heating technology in Thailand

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Abstract

The instantaneous water heaters (IWH) in Thailand are widely used to generate hot water in household, resort and hotel sectors. However, alternative water heating options such as solar hot water heaters (SWH) and heat pumps have potential to save energy consumption. This study aims to analyse the economic of changing water heating technology in Thailand. The household, resort and hotel sectors were calculated with formulations using Payback Period (PP), Net Present Value (NPV) and Internal Rate of Return (IRR) in six scenarios. The result showed that a heat pump has the payback period shorter than SWH technology in all sectors. While NPV of the heat pump was higher than SWH. IRR of SWH in household, resort and hotel sector were 19, 138 and 44%, respectively. These results suggest that the heat pump has higher potential than SWH in term of economic. Especially the hotel sector should be encouraged due to its short PP, high NPV and high IRR.

Keywords: economic analysis, instantaneous water heaters, water heating, energy management

1. Introduction

A large number of households, resorts and hotels in Thailand use instantaneous water heaters (IWH) to generate hot water for daily use. With electric power of about 3.5 to 4.5 kilowatt (kW) [1], IWH increases significant share of power consumption, and emits high amounts of greenhouse gas emissions [2].

Alternative water heating options such as solar hot water heaters (SWH) and heat pumps have potential to reduce energy consumption by 2.4 to 4 times [3]. SWH provides an efficient method of using solar energy to heat water [4] and are widely used in Australia, Japan, Austria and China etc. [5].

The unit of SWH consists of a solar collector (vacuum thermal energy storage transferring heat to water), a water pump (to increase the pressure and flow rate of water in the systems), and a hot water tank. In Thailand, the most popular type of solar collector is a flat plate single glazed solar collector for heating the water to 40 – 70 °C [6]. The electric power of such an SWH, with a solar collector size of 20 square meters is only 20 Watt. In the case of adding the water pump, the electric power consumption increase depends on the water pump size [3].

Heat pump is a kind of vapour compression machine which is composed of four components i.e. evaporator, compressor, condenser and expansion valve [7]. Depending on the type of refrigerant, generally the range temperatures around 50 – 60 °C can be reached [8] & [9]. The electric power of heat pumps is usually around 0.78 – 1.28 kW for 300 litres of water capacity [3]. In terms of heating efficiency, a heat pump is three times as efficient as comparable IWH, and at least 66% energy savings can be achieved [8].

From the technological and environmental perspective, heat pumps and solar water heaters definitely are attractive to alternate to IWH. However, potential adopters know little about the economic feasibility of these alternatives [10] The IWH is mainly used in the households, resorts and hotels sector.

2. Material and Method

The research was conducted for three sectors in Thailand, household, resort and hotel sector.

2.1. Criteria for household sector

The census on 2013 found that Thailand has about 20.17 million households [11]. Approximately 14.4% of them or 2.9 million households are equipped with IWH [11]. They are popular mainly in Bangkok and perimeter (25.4%) while only 5.2% of households are in the south. The survey result from Nation Statistical Office found that each household has average IWH 1.1 unit or 3.2 million units as the whole country in 2013 [11].

The average number of people per households is 3.2 [12]. The average water usage is 40 L per capita per day [13]. Therefore, itis assumed that daily water consumption is 128 L per household. On average, the IWH with 4 kW of electric power was used 12 minutes per time per capita or calculated as 38.4 hours per month per household. This results in energy consumption of 153.6 kWh or electricity costs of THB 597 per month (Ft = 0.5809 THB per unit; Ftisthefeechargeper unit depending on the varies cost of the Electricity Generation of the Electricity Generating Authority of Thailand) based on the Protech Electrical version 1.5.0.0. – a software for calculation electric cost.

2.2. Criteria for resort sector

In 2014, Thailand whole resorts have 5,557 hotels or 167,017 rooms [14] which reflect the IWH 167,017 units or 30 units per resort.

The calculation for the resort sector was calculated with the following assumption: One 4 kW of IWH per room, two persons per room, average water usage 260 L per day per room [13]. The period for taking a shower/ a bath was 20 minutes per time per capita or 40 hours for a month per room. This results in an energy consumption of 160 kWh or electric costs of THB 626 per month (Ft = 0.5809 THB per unit) based on the Protech Electrical version 1.5.0.0.

2.3. Criteria for hotel sector

The total hotels in 2014 as classified according to Thai Industry Standards as type I subtype 55 Accommodation which provides short-term accommodation including activity 55,101 hotels (excluding resorts, bungalows, motels and apartments) [15]. Totally Thailand has 3,989 hotels or 316,439 rooms, which are 80 rooms per hotel on average [14]. Generally 90% of the rooms had been equippedwith air-conditioner and IWH [15]. It can be concluded that 72 rooms per hotel are equipped with an instantaneous water heater.

We assume the same water consumption as hotel for the resort sector, which is 260 L per day per room, and 18,720 L per day per hotel. The energy consumed amounts is 11,520 kWh per month or electric costs of THB 55,480 (Ft = 0.5809 THB per unit) based on the Protech Electrical version 1.5.0.0.

2.4. Economic analysis

For the economic analysis, we applied three methods:

2.4.1. Payback Period method (PP)

PP is the simplest financial metric. It calculates after how many years the investment cost is equal to the total of income/savings. Itwould be simply calculated without considering interest and discount rates follow by equation (1).

$$Payback\ Period = \frac{Investment\ (THB)}{income\ or\ saving\ (THB\ per\ year)} \quad (1)$$

2.4.2. The Net Present Value Method (NPV)

This method is more complex than PP but provides better information. NPV shows the actual value of completing a project. It is the total of all cash flows, discounting future cash flows for the time value of money [16]. We assume a discount of 2%, following the bank of Thailand on Feb 2015 [17]. The NPV can be calculated as follows equation (2).

$$NPV = \left(\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}\right) - I \quad (2)$$

Where

t	=	the time of the cash flow
n	=	the total time of the project
r	=	the discount rate
C_t	=	the net cash flow at time t
I	=	the investment at the first time

2.4.3. The Internal Rate of Return Method (IRR)

IRR is the discount rate that makes the NPV to zero. It is commonly used as a method for making a decision on investments or projects. When comparing a number of investment alternatives, the one with the highest IRR should be chosen. The IRR is calculated as follows equation (3).

$$0 = \left(\sum_{t=1}^{n} \frac{C_t}{(1+IRR)^t}\right) - I \quad (3)$$

Where

t	=	the time of the cash flow
n	=	the total time of the project
C_t	=	the net cash flow at time t
I	=	the investment at the first time

We present six scenarios (Table 1.), in which all three investment appraisal methods are used to calculate the economic feasibility.

3. Result

Under Renewable Energy Development Division of EGAT [18], the model of SWH for the household sector should be S-160 or 160 L of the water capacity. The lifetime of SWH is 15 years. It requires space for installation of 1.20x2.50 square meters. The cost is around 49,000-59,000 THB for SWH and around 6,000-8,000 THB for installation. Moreover, the other components are also necessary i.e. hot water pipes, cold water pipes and wires. The total price of SWH for a household sector (calculated) is 65,500 THB.

The resort sector uses 260 L of water per day. S-320 (320 L of the water capacity) is suitable for 1 room of the resort. The space for setting is 2.50x2.50 square meters. The price is 90,000-102,500 THB for SWH and 8,000-10,000 THB for installation which higher than a household sector. When combined with other accessories, it cost 105,400 THB approximately.

On average the hotel sector determined 72 rooms with 18,720 L of used water per day. The appropriate SWH is S-600 or 600 L of the water capacity. The lifetime of SWH is 20 years. For this sector, it needs at least 31 sets of SWH. The area for installation is 5.00x3.00 square meters. The SWH price is 137,000-180,000 THB and 15,000 THB for installation. The total price after calculated with other material components is 4,860,000 THB for a hotel sector.

Further, pump is essential for this system. There are many models of pump. The selection of pump depends on its usage. The suitable pump for household, resort and hotel sector [19] is described in Table 2.

The total investments of SWH (Table 3) are 67,350 THB, 107,250 THB and 4,874,000 THB in household, resort and hotel sector, respectively. After the technology changing to SWH, the electricity price saved 98.3%, 98.2%, and 99.6% respectively

Table 1 Scenario 1-6 for calculation

Scenario #	Description
Scenario 1	Household Sector with SWH
Scenario 2	Resort Sector with SWH
Scenario 3	Hotel Sector with SWH
Scenario 4	Household Sector with heat pump
Scenario 5	Resort Sector with heat pump
Scenario 6	Hotel Sector with heat pump

Table 2 Pump for household, resort and hotel sector

	Unit	Sector		
		Household	Resort	Hotel
Number of usage		1	1	5
Electric Power	HP	0.5	0.5	1.5
	kW	0.373	0.373	1.12
Water volume	L/min	50	50	160
Price	THB	1,850	1,850	2,800
Usage	min/month	90	150	600
Electric cost	THB/year	122.4	134.4	2400

Hint: The calculation of percent saving was calculated as:

$$\%\ saving = \frac{100 \times (Current\ electricity\ cost - New\ technology\ electricity\ cost)}{Current\ Electricity\ cost} \quad (4)$$

For example, the percent saving of technology changing in household sector is 98.3% which calculated from

$$\frac{100 \times (7164 - 122.4)}{7164}. \quad (5)$$

Table 3 The total investments of SWH for household, resort and hotel sector (Unit: THB)

	Sector		
	Household	Resort	Hotel
SWH	65,500	105,400	4,860,000
Pump	1,850	1,850	14,000
Total	67,350	107,250	4,874,000

Table 4 Heat Pump model for household, resort and hotel sector

	Unit	Sector		
		Household	Resort	Hotel
Number of usage		1	1	4
Electric Power	kW	1.25	1.75	2.80
Water Flow	L/hour	100 – 150	150 – 160	2,000 – 3,000
Price	THB	43,650	43,650	121,600
Electric cost	THB/year	183.6	215.040	868.92

Table 5 Economic Analysis

Scenario #	PP	NPV	IRR
Scenario 1	9.56*	23,130*	6.24*
Scenario 2	14.56	-12,450	0.79
Scenario 3	7.12	5,972,890	24.53
Scenario 4	6.25	19,050	9.59
Scenario 5	5.98	21,900	10.63
Scenario 6	0.73	8,056,960	136.7

*Example Calculate: PP $= \frac{67350}{7041.6} = 9.56$, NPV $= \left(\sum_{t=1}^{15} \frac{7041.6}{(1+0.02)^{15}}\right) - 67350$, $0 = \left(\sum_{t=1}^{15} \frac{7041.6}{(1+IRR)^{15}}\right) - 67350$

The heat pump price is cheaper than SWH. The model of household sector should be 100 – 115 L/hour of water flow rate, while the water flow rate 150 – 160 L/hour which appropriate for resort sector. The lifetime of both heat pumps is 10 years. Electric power, heat pump price and electric cost were shown in Table 4.

The water flow rate of heat pump for hotel sector is around 2,000 – 3,000 L/hour. On average, its lifetime is 15 years. Each hotel should install four heat pumps. Each heat pump price is approximately 121,600 THB or

486,400 THB for each hotel. The electric power is 2.80 kW. The calculated electricity price is just only 72.41 THB per month or 868.92 THB per year.

The economic analysis metrics showed in Table 5. The heat pump payback period is shorter than SWH. The hotel sector has the shortest payback period in each technology. The changing technology to SWH of resort sector has to use long period to breakeven point which is 14.56 years which 15 years of lifetime. The NPV is positive except in scenario 2. IRR or returns of the technology changing were calculated. The hotel sector gives the highest for SWH and heat pump as 24.53% and 136.7%, respectively). The changing to SWH in resort sector is just only 0.79%.

4. Discussion

Six scenarios show the possibility of the changing of water heating technology in Thailand. Household sector, resort sector and hotel sector has breakeven period for SWH as 63.7%, 97.1% and 35.6% respectively when compared with the SWH's lifetime. On the other hand, the breakeven period for heat pump technology in household sector, resort sector and hotel sector are 62.5%, 59.8% and 4.9% respectively. Every sector has short time for payback in heat pump technology. In scenario 2, SWH for resort sector, NPV is negative. The negative NPV can be interpreted that it is not worthy to change the water heating technology to SWH for resort sector. The returns of each sector between SWH and heat pump were compared and found that the return of heat pump technology is higher than SWH 19% and 44% for household sector and hotel sector, respectively. The household sector has all lifetime profit at 0.3 and 0.4 times in SWH and heat pump technology, respectively. While resort sector has all lifetime profit as 0.5 times for heat pump. Hotel sector has the highest profit at 1.2 and 16.6 times in SWH and heat pump technology, respectively. IRR shows the compensation which as high value as more profit. Hence, the changing of water heating technology is possible for Thailand. Heat pump is worth to investment than SWH due to its return. The hotel sector should be encouraged because of low payback period and its worth returns. Not only the money back but the environmental and energy saving are reasonable for investment.

5. Conclusion

The IWH is widely used in the household, resort, and hotel sector. Under economic analysis metrics by 3 methods; PP, NPV and IRR in 6 scenarios, this research used the model of SWH and heat pumps which is suitable for each sector. The number for calculation make up from many reliable database in Thailand. Household sector refers to 3.2 persons which used 128 L of water daily. They paid THB 7,164 per years for IWH. Resort sector means 1 rooms of the resort with 2 persons that daily consumed 260 L of water represent in THB 7,512 for electric cost. Hotel sector calculates 72 rooms per hotel. It spent 18,720 L of water, THB 55,480 for electric cost.

Household sector is possible for technology changing to S-160 SWH and an AR-105 pump which investment cost THB 67,350. They need 9.56 years for payback. The NPV under 15 years is 23,130 and IRR are 6.24%. The heat pump model KYS-200LFT is suitable for this sector cost THB 43,650. The PP is 6.25 years which 10 years of all lifetime. The NPV and IRR are THB 19,050 and 9.59%, respectively.

The changing of technology to SWH of resort sector uses S-320 SH and AR-105 pump by THB 107,250 investment. PP is 14.56 years while its lifetime is 15 years. Nevertheless, the NPV is negative. The IRR is only 0.79% that lowers than r (the discount rate = 2%). We can conclude that this project should be cancelled. However, it is possible for changing to heat pump with investment THB 43,650 for KYS-500LFT. Its lifetime is 10 years. The PP is about 6 years with NPV THB 21,900. The IRR is about 10%.

Hotel sector uses S-600 SWHs 31 units and 10 units of AR-115 pumps cost THB 4,874,000. It is suitable to change due to 7.12 years of PP which 20 years of all lifetime. The NPV is nearly THB 6M. The IRR is high about 25%. While 4 of JK03R heat pumps are worth for investment with THB 486,400. The heat pump should be encouraged for this sector. It is only 0.73 years or 8 months for the payback period. The NPV is THB 8M with approximately 140% of IRR under 15 years of all lifetime.

6. Acknowledgements

The author would like to thank the Oesterreichische Austauschdienst GmbH (OeAD) for the ASEA-UNINET Staff Exchange and also the host – Prof. Dr. Ropert Baugartner, Dr. Ralf Aschemann and Dr. Thomas Brudermann, Karl Franzens Universitat Graz and Prof. Dr. Franz Wirl,University of Vienna. The financial support for this research is from Research and Researcher for Industry RRi (Ph.D. Level), The Thailand Research Fund (TRF) together with Advance Thermo Solution Co., Ltd.

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