An Economical Approach for Using Solar Water Heaters in Mashhad, Iran

Seyed-Ali Hoseini and Ali Mostafaeipour
Industrial Engineering Department, Yazd University
Yazd, Iran
ali.hoseini2014@yahoo.com , mostafaei@yazd.ac.ir

Hamid Reza Arabnia
Computer Science Department
University of Georgia
Athens, Georgia, USA
hra@cs.uga.edu

Omid Alavi
Department of Electrical Engineering
K.N. Toosi University of Technology
Tehran, Iran
omidal1370@gmail.com

Saeed Shahmiri
Industrial Engineering Department
Iran University of Science and Technology
Tehran, Iran
Saeid-shahmiri@yahoo.com

Abstract

The fact of the fossil fuels ending, their effects on the environment, the transportation-oriented problems with fuels, their incapability of being reproduced, and the rising cost of the fossil fuels help us to realize the need for new sources of energy. In order to estimate the costs and set the economic logic of using solar water heaters, we have studied the properties of a residential apartment. Thus, the geographical and climatologically properties of the city of Mashhad are considered in this paper. This study is conducted using a descriptive-analytic method and a scaling procedure, categorized in progressive researches over the year of 2014. The results show that 16,431 cubic meters of gas will be saved over a one year period. The data analysis was performed using the RETSCREEN software. Based on the analyses, the financial outcomes show that the project is pro-economic. The volume of CO_2 will decrease 178 ton-CO_2 during the collectors' useful life, and it highlights their considerable influence in reducing the greenhouse gases. Generally, the results confirm that the required warm water will be provided by spending less money using solar water heaters in residencies considering the rising cost of gas and the subside management program.

Keywords
RETSCREEN Software, Economical Analysis, Solar Water Heaters, Solar Energy.

1. Introduction

Due to critical shortages of fossil fuels and other natural resources, concern related to these types of fuels have increased dramatically over the past several decades. Indiscriminate use of the fossil fuels resulted in environmental degradation effects such as global warming, acid rain, ozone depletion. On the other hand, different barriers for finding a suitable alternative as an energy source for industrialized countries is another influential factor in the fossil fuels reduction. This fact is leading the world to consider the new available energy sources (Mohammadi et al., 2016). Solar energy as a free, clean and safe energy has offered enormous advantages for years. The winds, seas, tide, fossil fuels, waterfalls, and some other energy are natural and have their roots from the sun (Azizi and Faryadi, 2009). The sun takes its energy from the interior interactions producing a temperature of 107 °K inside and 5,800 °K on its surface. The Earth only receives a small portion of the sun energy, an amount of 1300 W/m^2 and an average of 1 kW/m^2 (Azizi and Faryadi, 2009). Additionally, the Earth receives approximately 47% of the total energy produced by the sun (Sadeghi et al., 2011).
In recent decades, a greater number of societies are using the solar water heater systems for their economical (cutting of the costs, saving the fuels), environmental (cutting the fossil fuels usage and contaminators such as suspended ingredients, NO_x, CO_2, SO_x, and other contaminators), and social benefits (having cheaper, cleaner and safer hot water) (Haj Saghati, 2008). In addition, most of the industrialized countries intend to more investment in order to achieve beneficial plans and frameworks for using the solar energy. They also attempt to develop and complete the solar water heaters technology. It is all due to the high efficiency and public accessibility of this system. Generally, there are two kinds of technology in using the solar energy (Hashemi, 2012): First, the photovoltaic technology which transforms the sun light into electricity directly. Second, the thermal technology which transforms the sun light into thermal energy.
There are different researches and studies on the utilization of solar energy systems across the world. Mostafaeipour et al. (2016b) evaluated the installation of photovoltaic plants using a hybrid approach for Khuzestan province, Iran. Additionally, another study (Zarezade and Mostafaeipour, 2016) analyzed the influential factors on implementing the solar dryers for Yazd province, Iran. Khorasanizadeh et al. (2014) employed a diffuse solar radiation model for determining the optimum tilt angle of solar surfaces in Tabass, Iran. Shamshirband et al. (2015) assessed the suitability of extreme learning machine to predict horizontal global solar radiation. These studies confirm the importance of solar energy, particularly in Iran with a great solar potential.

1.1 Climatic Characteristics of Major Cities in Iran

Iran is located between the 25 to 40 °N latitudes. Consequently, it enjoys a very rich amount of solar energy comparing other countries. According to the pervious estimations, Iran receives 1,800 to 2,200 kWh/m^2 of solar energy every year (Khalili, 2013). The average of Iran's sunshine is 19.23 MJ/m^2, which reaches to more than 7.7 hours/day in its central parts. Reportedly, there are averagely 300 sunny days per year which is worth considering (Haj Saghati, 2008).

Table 1. The total solar energy in various stations of Iran

Station	Sun light extent calorie over cm^2 per day	Station	Sun light extent calorie over cm^2 per day
Shiraz	476.9	Orumiye	475.3
Tabas	481.8	Isfahan	461.6
Karaj	419.4	Bojnoord	397.2
Kerman	483.8	Booshehr	454.9
Kerman shah	422.8	Birjand	482.1
Mashhad	383.1	Tabriz	462.7
Hamadan	409	Tehran	422.8
Yazd	505.6	Ramasar	283
		Zanjan	423.3

1.2 An Introduction to Solar Water Heaters

Climax, the first solar water heater, was invented by Clarson Camp in 1981. It consists of four long cylindrical iron water supplies galvanized, colored in black and placed horizontally in an isolated glass box. The modern solar water

heater, which is similar to the thermo-siphon system, was registered in name of William J. Billy in 1909, California (Haj Saghati, 2008). Typically, there are two types of thermal collectors: convergent and divergent. The convergent collectors consist of refractors which stream the light into their focal point. By putting these refractors together and having a fluid passing over the focal points, the thermo-coruscation energy can be absorbed and be used to heat or produce electricity. The divergent collectors consist of flat collectors and vacuum pipe collectors (www.solarkar.ir).
Today, the market of these solar collectors has grown to an average of 20.8%. Although there is a minor decrease of 15% in 2007, the annual fixed capacity of the glazed collectors around the world has been nearly tripled from 2004 to 2009.
Table 2 presents a review of different applied collectors in several countries in terms of the total fixed solar heating capacity. Considering the vacuum-pipe collectors used to provide warm water, China ranks 1st in the total solar heating capacity. The United States (with the capacity of 4.14 GW) wins the second place in installing and launching a great number of non-galvanized collectors in order to warm up the pools. Germany with almost 9 GW takes the third place and then Turkey, Australia, Japan, and Brazil (Zhangyuan et al., 2015).
As listed in Table 2, China has occupied the first place in the annual fixed capacity which is considered as the largest solar heating market in the world with a constant growth rate of 22% (Weiss, 2011). By the end of 2009, the total capacity of the solar collectors was practically 172.4 GW across the world from which 9.58% (101 GW) belonged to China.

Table 2. Solar irradiation and solar heater capacity

	The average of annual sun light (kWh/m^2)	The capacity of the installed water heaters (GW)
China	1500	172
USA	1600	19
Germany	1000	12
Turkey	1400	11
Brazil	1900	5
Iran	2000	0.1

Figure 1 shows the extent of generating solar heating energy in which the red color stands for the generated and the blue color stands for the total capacity in practice. It is evident that all of the water-oriented solar heating systems (through which the water streams on) generated 142 TW over one hour in 2009 – which equals to 4.14 million tons of oil. It has been recommended that, under specified circumstance, the world will witness an hourly energy generation of 162 TW in 2012 from which 6.23 collectors have been recently launched. Comparing the other reproducible energy sources, the solar heating energy takes the second place after the wind power (Zhangyuan et al., 2015).

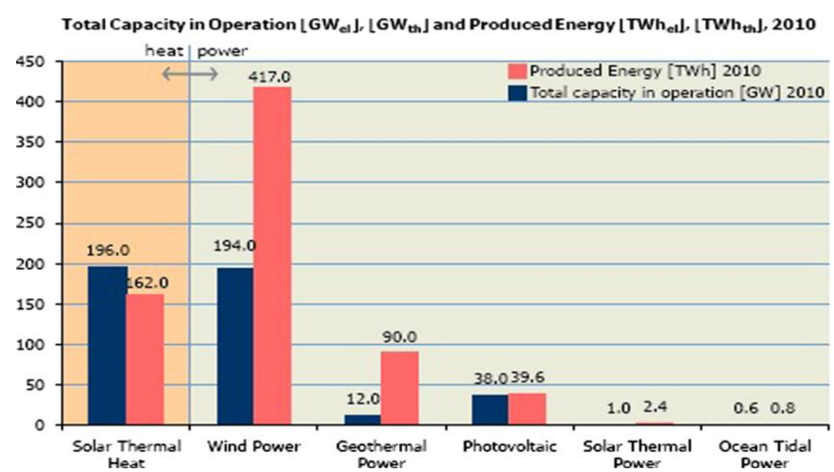

Figure 1. Solar heating energy generation

The prediction of solar heating systems market is in a lower place than the other countries. The predictor hypotheses indicate that the energy cost in 2014 would remain stable, and after a decrease in 2013, the economy of Czech Republic would grow from 1.4 to 2.2% in 2014.

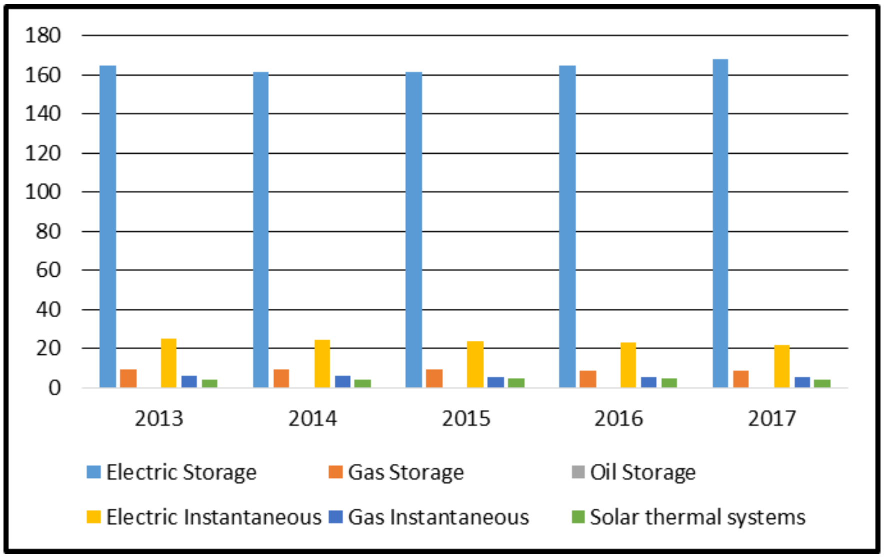

Figure 2. Prediction, warm water and solar heating systems

2. Research Background

Having a proper knowledge about solar energy and its benefits will enable us to use it more efficiently in order to provide warm water in houses, swimming pools, private and government offices, and industrial centers. There are several national and international researches with the aim of examining the economic, social, and environmental aspects properly. The following sections of this paper will describe this investigation. Eyvazi studied the status of the solar water heaters in the 22nd district of Tehran, the amount of produced contaminators, and the percentage of saved contaminators and pertained costs. According to his survey, 4.1 years will be needed to restore the primary investment.

Shadi Talab and Naye studied the effective factors on the willingness of the people living in Isfarayen's country side areas to use domestic water heaters. They believed that the project of installing solar water heaters and bathes in this area is one of the most important programs launched pertained using reproducible energy. As mentioned in this research, the salary raise and a proper knowledge about the benefits of solar water heaters have influences on the Iranian residents' willingness (Struckmann, 2008).

Hosseini and Sina compared the results of economic and technical examinations on the solar water heaters with the water heaters operating with gas, gasoline and electricity. Accordingly, by using the solar water heaters instead of the electric, gasoline and gas ones, the capital restoration was calculated 3.3, 6.3 and 16 years, respectively (Hassani, 2010).

Ying Wang and Huzo made different economic calculations concerning using the solar water heaters in Guan Zhu, China. They compared the preparation and storing costs related to the electric, gas and solar water heaters. In spite of high preparation costs, they introduced the solar collectors as the most pro-economic because of its long useful life (Ying, 2006). Han, Lung and Moo studied the economic, technical, environmental, and social performances of the solar water heaters in China. According to the obtained results, this type of solar heater is significantly popular among the Chinese people. This study suggested the policy of obligating the people to install the solar water heaters and also sending them to the country sides in order to extend the use of solar water heaters in this country (Han, 2010). Yasin et al. evaluated and analyzed the stability of solar water heaters in storing the energy in the coastal urban areas of Oman. The results revealed that 335,431 MW/h of energy and 48,590 tons of green gases (CO_2) could be saved over one year (Gastli, 2011).

In 2008, Egmond et al. conducted a study about the solar water heaters. They presumed a 50% injection of this product in the Zimbabwe's market and its extent from 2005 to 2030. Their findings showed that it is possible to save 104 pj of energy in the country (Ying, 2006). Authors investigated different renewable energy cases in Iran (Mostafaeipour & Abesi, 2010; Mohammadi et al., 2016; Shamshirband et al., 2016; Mostafaeipour et al., 2014;

Eratum to: Shamshirband et al., 2016; Mostafaeipour & Sadeghian, 2005; Sajjadi et al., 2016; Hosseini-Ezabadi et al., 2015; Mohammadi et al., 2014; Mostafaeipour, 2011; Mostafaeipour et al., 2016a).
Satkin (2001) presented an economic-social analysis regarding the solar water heater systems to provide the required warm water for 5-member families in Iran. To economically justify extensive investment, he determined the volume of pollution caused by using energy in old-fashion ways. According to the study, it takes 5.4 years to restore the primary investment in solar water heaters. Regarding the local (scenario 1) and global price (scenario 2) of electricity and natural gas. In scenario 2, the environmental damages caused by green gases decreased to $101 and the investment restore cycle decreased to 3.6 years. The results are economically justifiable concerning the global prices of natural gas and electricity (Gastli, 2011).

3. Methodology

This paper is a descriptive-analytic study with scaling method, and it is a progressive research. The case study is a four-floor residential apartment with eight unites, located in the north of Mashhad. The solar water heater was used to heat up water. Using the gas and electricity bills, the extent of usage in each residency was determined. The necessary information about the solar water heaters' costs was provided by Solarkar Company, which was responsible for preparing and installing them. The information about the gas and electricity prices was provided by the related agencies. The data were analyzed using the RETSCREEN software (www.retscreen.net).
Mashhad is suited in the center of Khorasan-e-Razavi province, and is located between the latitude of 36.3° and 42' and longitude of 59.6° and 19', 999 m above the sea level. According to the 2011 basic statistics, this city had a population of more than 2,766,258 people. The annual average of temperature was 14 °C and the annual average of rainfall was 241 mm. The climatic characteristics are presented in Table 3.

Table 3. Mashhad's climatic characteristics

Month	Temperature	Relative moisture	Sun light horizontally	Atmosphere pressure	Wind speed	The Earth temperature	Heat degree	Coldness degree
	°C	%	kWh/m2/day	kPa	m/s	°C	°C/day	°C/day
January	0.8	72.3	2.33	90.9	2.3	1.5	533	0
February	2.9	68.7	3.03	90.8	3.1	3.1	423	0
March	8.2	65.7	3.58	90.4	4.1	8.7	3.4	0
April	14.4	57.4	4.92	90.1	4.1	17.8	108	132
May	19.3	45.7	6.50	89.9	4.1	24.8	0	288
June	24.0	34.7	7.81	89.4	4.7	30.0	0	420
July	26.1	32.9	7.64	89.2	5.0	31.8	0	499
August	24.0	30.6	7.14	89.5	4.4	29.2	0	434
September	19.6	36.1	5.72	90.0	3.5	24.0	0	288
October	13.7	45.6	4.11	90.6	2.8	16.6	133	115
November	8.6	63.0	2.86	90.9	2.0	9.6	282	0
December	3.4	76.1	2.17	90.9	1.9	3.5	453	0
Average	13.8	51.9	4.83	90.2	3.5	16.8	2.236	2.176

4. Analysis using RETSCREEN software

RETSCREEN is an Excel-based analytic software designed for clean energy with a number of options for simulating the new energy projects. It has a very powerful database developed by the Canada government in some industrial centers. This software helps the decision makers to examine the practicality of the possibly reproducible energy projects, energy efficiency, and simultaneous production of electricity and heat in technical and financial aspects through a quick and low-price way (www.retscreen.net). To perform the desired analyses, we should take method-1 for the opportunity studies and method-2 for the possibility studies. In this study, we use both methods to analyze the data.
First, the apartment's properties should be entered into the software. The most appropriate temperature for domestic warm water is considered as 60–70 °C. Table 5 presents the apartment's properties. Regarding the changes in using fuel, especially the significant swings in using gas, the average of usage are used. Here, the angle between the solar collector and the horizon is considered as the inclination. In stable collectors, it is equal to the structure inclination

on which the collector is fixed. *Fr* coefficient in different collectors is almost in the range of 5.0–9.0. The least amount belongs to the under-vacuum collectors. *Fr-UL* coefficient is in the range of 0–7.0 (W/m^2/°C). The temperature coefficient is in the range of 0–1.0 (W/m^2/°C). Table 4 presents the technical properties of the collector used in this project.

Table 4. The collector's technical properties

Solar tracking	Fixd	Drops	3%
Collector inclination (d)	45	*Fr* coefficient	0.5
Pump power/solar collector area W/m^2	5	Supply and pile drops	4%
Solar plates area (m^2)	6.84	Temperature coefficient for *Fr UL* (°C/(W/m^2))	0
Focus surface of the solar collector (m^2)	5.6	*Fr UL* coefficient (°C/(W/m^2))	3
The number of used collectors	16	Collector lifetime (years)	20

In order to achieve the economical results, the financial data also should be entered into the software. Each cubic meter of natural gas costs 700 Rials and each kWh of electricity costs 480 Rials (www.amar.org.ir). One dollar equals 3,000 Toomans. The data related to the solar collectors are assessed by using the RETSCREEN software, and the results are listed in Table 5.

Table 5. The results of technical analysis

The minimum temperature of the water (°C)	9.3
The maximum temperature of the water (°C)	18.1
The annual sunlight – horizontal (MWh/m^2)	1.76
The annual sunlight – inclined (MWh/m^2)	1.87
Capacity (kW)	31.36
Pump electricity (MWh)	0.1
Produced heat (MWh)	10.2
The solar energy share in providing the power system	100%
The annual saving of fuel (m^3)	16,431
The cost of annual saving of fuel (Rial)	11,501,698

4.1 Data Analysis of Emissions

In this stage, the electricity leak related data are entered into the software so as to evaluate the extent to which the greenhouse gases generated by the solar collectors will decrease. The electricity leak in the Iran's transmission and distribution grid is approximately 6.17%, while the internationally accepted amount of its value is almost 10%.

Table 6. The results of data analysis of emissions

The leaking percentage	17.6%
The release coefficient of greenhouse gas (GHG) (MWh/tonCO_2)	0.537
The impure decrease of annual emission of GHG	13.9
The net decrease of annual emission of GHG	13.9

4.2 Financial Analysis through Method 1

After inserting the costs and information – such as 20% raise of fuel price, the inflation rate of 33% and the useful life for 20 years – the software will provide the financial analysis. The results are presented in Table 7. The diagram of pecuniary current in terms of year, regarding the useful life of collector is shown in Figure 3. The investment pay-back period is determined in the zero point of the x–axis.

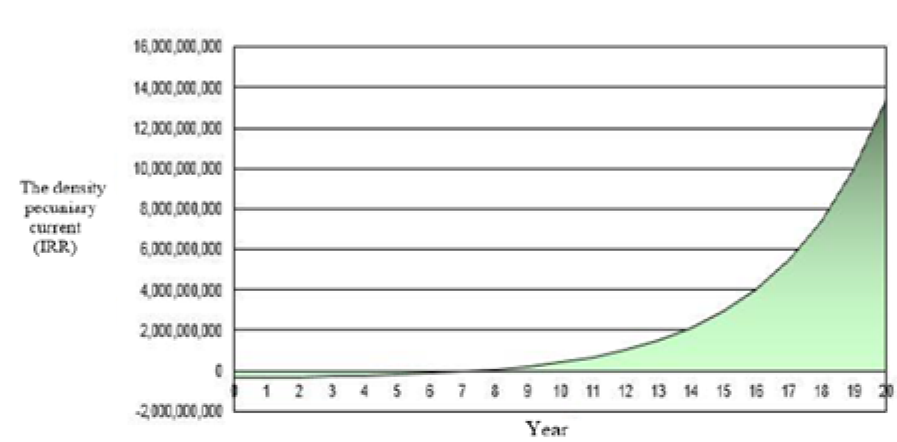

Figure 3. The diagram of the pecuniary current in terms of year

Table 7. The results of the technical analysis

The total costs of investment (Rial)	344,300,000
The total annual cost (Rial)	100,472
The total annual income and saving (Rial)	11,501,698
The annual benefit during the useful life (Rial/year)	305,945,166
The investment pay-back period (NPBP) (year)	7.5
The decrease in the green gases release in 20 years (ton-CO_2/year)	178
Decrease in the costs of environmental damages caused by greenhouse gases (ton-CO_2/Rial)	22,010,443

It is estimated that the sample apartment has saved 16,431 m^3 of natural gas in a year, which lead to a decrease in greenhouse gases emission due to the use of electricity and also saving the natural gas of 9.13 ton-CO_2/year.

4.3 Financial Analysis through Method 2

In this scenario, we consider the following prices in addition to the mentioned costs in the possibility examination studies. The engineering designing costs 16,000,000 Rials and the development costs 15,000,000 Rials. The possibility examination studies cost 250,000 Rials. The transportation costs 700,000 Rials. The worker's payment for installing each collector is 300,000 Rials. After inserting these data into the RETSCREEN software, the diagram of the pecuniary current over a year can be presented in Figure 4. The results of the financial analysis are calculated in accordance to Table 8.

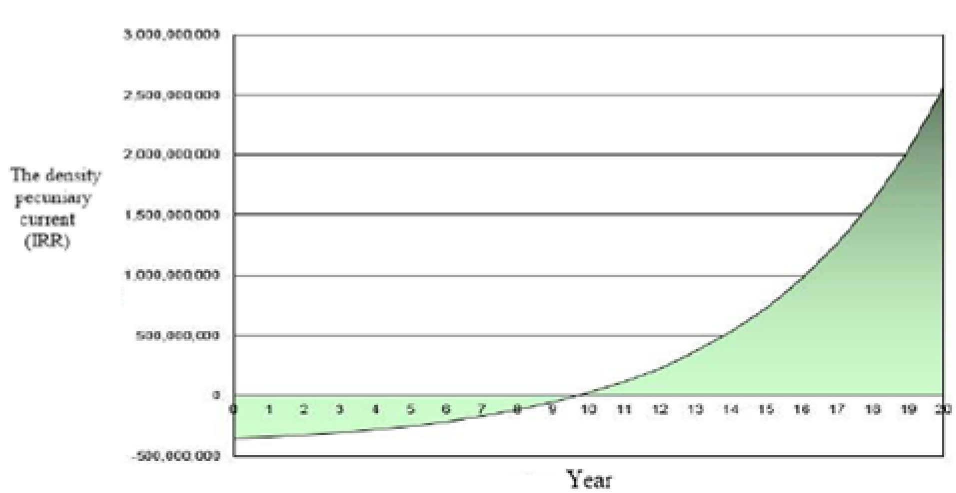

Figure 4. The diagram of the density pecuniary current over a year

Table 8. The results of the financial analysis

The total cost of investment (Rial)	351,950,000
The total annual cost (Rial)	100,472
The total annual income and saving (Rial)	12,076,783
The net present value (NPV) (Rial)	1,786,943,894
The annual benefit during the useful life of the system (Rial/year)	109,283,624
The investment pay-back period (NPBP) (year)	9.7
The internal revenue rate (IRR)	16.4%
Proportion (Cost/Benefit) or (C/B)	6.08
Decrease of the greenhouse gases in 20 years (ton-CO2/year)	178
Decrease in the costs of the environmental damages caused by the greenhouse gases (ton-CO2/Rial)	7,862,131

It is obvious that the NPBP and cost in method 2 increases in comparison to method 1. Considering the net value of the project time and the NPBP, this plan will be considered as pro-economic in case of using the two mentioned methods. Additionally, several benefit rates are used to calculate the financial and economic indexes of the plan. The present net value is calculated according to Table 8. With respect to Table 8, the present net value for each inflation rate is positive. It demonstrates that launching this project with any inflation rate will be pro-economic and commodious. The present net value is depicted in Figure 5.

Table 9. The net present value

Inflation rate	The present net value	Inflation rate	The present net value
5%	2,137,972,446	25%	2,019,783,961
10%	2,129,487,472	30%	1,902,623,692
15%	2,113,045,185	35%	1,681,743,069
20%	2,081,180,542	40%	1,270,921,539

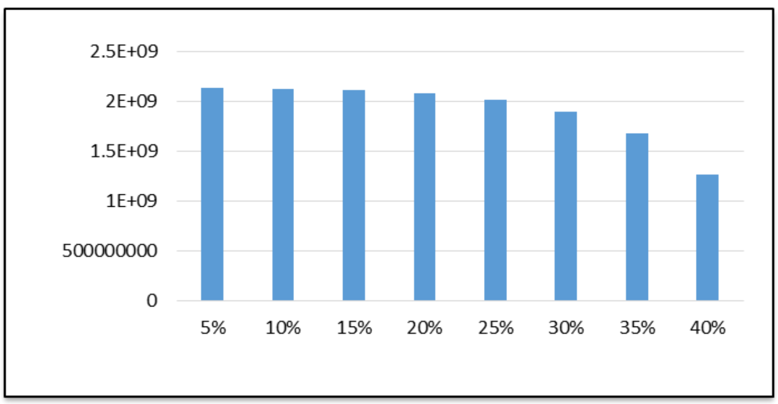

Figure 5. The net present value with different inflations

Figure 5 illustrates that the present net value of the project decreases when the inflation rate increases.

5. Conclusion

The sun blazes 1.1×10^{20} kWh of energy every second from which only 47% arrives to the Earth. As noted earlier, it can be concluded that three days of sun luminescence on the Earth equals to the total energy released from burning the whole of underground fossil fuels. If we are able to use the sun energy for 40 days, the overall energy of a century can be provided. Considering the gas cost for domestic use and also the second phase of the subside management program, 16,431 m^3 of gas can be saved over one year period in the case studies. Multiplying this number by the gas cost shows that almost 11,501,698 Rials will be saved over a year. By installing solar water heater in the case studies, 11,501.698 Rials can be saved and the pay-back period will be equal to 5.7 years. Considering this fact in addition to the averagely 20-year useful life, we can consume free and environmentally friendly energy for almost 50 years. It helps us to get benefits of a significant amount of energy gifted by the nature.

Generally, 20–30% of the total energy used in the buildings are used for water heating. Therefore, 60–75% of the energy from solar water heaters can be harvested. The greenhouse gases cost decreases approximately 22,010,443 Rials/ton-CO_2. It also confirmed that the project is great pro-economic. A decrease of 178 ton-CO_2 in greenhouse gases proved the crucial role of these collectors in decreasing greenhouse gases.

References

Azizi, A., and Faryadi, S., Analyzing of Socio-Economic and Environmental Benefits of Solar Water Heater in Shiraz City, *Iranian Journal of Energy,* vol. 15, no. 1, pp. 45-58, 2012.

Besarati, S. M., Padilla, R. V., Goswami, D. Y., and Stefanakos, E., The Potential of Harnessing Solar Radiation in Iran: Generating Solar Maps and Viability Study of PV Power Plants, *Renewable Energy*, vol. 53, pp. 193-199, 2013.

Erratum: Erratum to: Shamshirband, S., Mohammadi, K., Tong, C.W., Petcock, D. , Porcu, E., Mostafaeipour, A., Ch, S., Sedaghat, A., Application of extreme learning machine for estimation of wind speed distribution, *Climate Dynamics*, vol. 46, no., (5-6), pp. 1893-1907, 2016. DOI 10.1007/s00382-015-2682-2

Gastli, A., and Charabi, Y., Solar water heating initiative in Oman energy saving and carbon credits, *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 1851–1856, 2011.

Haj Saghati, A., *Principles and Applications of Solar Energy*, Second Edition, University Of. Science and Technology, 2001.

Han, J., Mol, A., and Lu, Y., Solar Water Heaters in China: A New Day Dawning, *Energy Policy*, vol. 38, no. 1, pp. 383-391, 2010.

Hashemi, M., and Keroni, A., *The sun, the clean energy*, Kian Rayane Sabz publication, 2012.

Hassani, A., and Sina, A., Decreasing the electricity usage through replacing the electric water heaters with solar water heaters, *Second conference of improving the model of using electricity*, Ahvaz, 2010.

Hosseini-Ezzabadi, J., Saryazdi, M.D., Mostafaeipour, A., Implementing Fuzzy Logic and AHP into the EFQM model for performance improvement: A case study, *Applied Soft Computing*, vol. 36, pp. 165-176, 2015.

Khalili, A., Study of the possibility of using new energies in Iran, A brief of the articles presented in the seminar of Energy in Tehran, 2013.

Khorasanizadeh, H., Mohammadi, K. and Mostafaeipour, A., Establishing a diffuse solar radiation model for determining the optimum tilt angle of solar surfaces in Tabass, Iran. *Energy Conversion and Management*, vol. 78, pp. 805-814, 2014.

Mohammadi, K., Alavi, O., Mostafaeipour, A., Goudarzi, N., and Jalilvand, M., Assessing different parameters estimation methods of Weibull distribution to compute wind power density. *Energy Conversion and Management*, vol. 108, pp.322-335, 2016.

Mostafaeipour, A., Sadeghian, A., Development of wind turbine in Iran, *World wind energy conference*, WWEC Press, Melbourne, Australia. 2005.

Mostafaeipour, A., Abesi, S., Wind turbine productivity and development in Iran, Biosciences (BIOSCIENCESWORLD), 2010 international conference on, 2010; 112-8.

Mostafaeipour, A., Productivity and development issues of global wind turbine industry, INTECH Open Access Publisher, 2011.

Mostafaeipour, A., Bardel, B., Mohammadi, K., Sedaghat, A., Dinpashoh, Y., Economic evaluation for cooling and ventilation of medicine storage warehouses utilizing wind catchers, *Renewable and sustainable energy reviews*, vol. 38, pp. 12-19, 2014.

Mostafaeipour, A., Khayyami, M., Sedaghat, A., Mohammadi, K., Shamshirband, S., Sehati, M.A., Gorakifard, E., Evaluating the wind energy potential for hydrogen production: A case study, *International Journal of Hydrogen Energy*, vol. 41, no., 15, pp. 6200-6210, 2016a.

Mostafaeipour, A., Qolipour, M. and Mohammadi, K., Evaluation of installing photovoltaic plants using a hybrid approach for Khuzestan province, Iran. *Renewable and Sustainable Energy Reviews*, vol. 60, pp. 60-74, 2016b.

Sadeghi, A., Larimian, T. and Molabashi, A., Evaluation of renewable energy sources for generating electricity in province of Yazd: a fuzzy MCDM approach. *Procedia-Social and Behavioral Sciences*, vol. 62, pp. 1095-1099, 2012.

Sajjadi, S., Shamshirband, S., Alizamir, M., Yee, L., Mansor, Z., Manaf, A.A., Altameen, T.A., Mostafaeipour, A., Extreme learning machine for prediction of heat load in district heating systems, *Energy and Buildings*, vol. 122, pp. 222-227, 2016.

Satkin, M., Techno-social analysis of using solar energy for heating water for small households in Iran, Third Energy Conference , Tehran, Iran, 2001.

Shamshirband, S., Mohammadi, K., Yee, L., Petković, D. and Mostafaeipour, A., A comparative evaluation for identifying the suitability of extreme learning machine to predict horizontal global solar radiation. *Renewable and Sustainable Energy Reviews*, vol. 52, pp.1031-1042, 2015.

Shamshirband, S., Mohammadi, K., Tong, C.W., Petcock, D ., Porcu, E., Mostafaeipour, A., Ch, S., Sedaghat, A., Application of extreme learning machine for estimation of wind speed distribution, *Climate Dynamics*, vol. 46, no., (5-6), pp. 1893-1907, 2016. DOI 10.1007/s00382-015-2682-2

Struckmann, F., Analysis of a flat-plate solar collector, 2008 MVK 160 Heatand Mass Transport, Project Report. Lund, Sweden; 8th May 2008.

Weiss, W., and Mauthner, F., *Solar heat worldwide: markets and contribution to the energy supply*, UK: IEA Solar Heating & Cooling Programme, 2011.

www.amar.org.ir

www.retscreen.net

www.solarkar.ir/index.php/products/water-cooler/2011-10-27-12-30-18.html

Zarezade, M. and Mostafaeipour, A., Identifying the effective factors on implementing the solar dryers for Yazd province, Iran. *Renewable and Sustainable Energy Reviews*, vol. 57, pp. 765-775, 2016.

Zhangyuan, W., Wansheng, Y., Feng, Q., Xiangmei, Z., and Xudong, Z., Solar water heating: From theory, application, marketing and research, *Renewable and Sustainable Energy Reviews*, vol. 41, pp. 68–84, 2015.

Zhao, L., and Ying, W., Economic Analysis of Solar Water Heaters in Guang Zhou, *Proceedings of the Sixth International Conference for Enhanced Building Operations,* Shenzhen, China, November 6 - 9, 2006.

Biography

Ali Mostafaeipour is an assistant professor of Industrial Engineering at Yazd University, Iran. He has been teaching at Yazd University since 1989. He studied at Winona State University (University of Minnesota) in state of Minnesota, USA; University of Wisconsin at Platteville, Wisconsin, USA; Alabama A&M, Alabama, USA; and Iran University of Science and Technology, Tehran, Iran. He has served as a committee member, guest speaker, and co-chairman of 145 international conferences. He has been reviewer of 17 international journals mainly Elsevier. He has presented 78 mostly International conferences throughout the world. He has undertaken and managed 18 research projects, and holds 3 patents. He has been editorial board of several professional journals. Finally, he has published 54 journal articles mostly at Elsevier (ISI), and he authored 4 books. He holds an award for excellence from Yazd University as the year 2013 distinguished researcher, also distinguished author of "Wind Energy" book (INTech publisher, 2012, Croatia) with more than 5000 downloads in six months. His research interest lies in renewable energies, wind energy, value engineering, economic evaluation, and feasibility study of project.

Seyed-Ali Hoseini is the M.S. graduate of Industrial engineering Department from Yazd University of Iran.

Hamid R. Arabnia is Hamid R. Arabnia received a Ph.D. degree in Computer Science from the University of Kent (Canterbury, England) in 1987. He is currently a Professor of Computer Science at University of Georgia (Georgia, USA), where he has been since October 1987. Prof. Arabnia is Editor-in-Chief of The Journal of Supercomputing (one of the oldest journals in Computer Science) published by Springer and has been Associate Editor of IEEE Transactions on Information Technology in Biomedicine (2008-2011). He is also on the editorial and advisory boards of 45 other journals. He is the book series editor-in-chief of "Transactions of Computational Science and Computational Intelligence" (Springer) and editor-in-chief of the book series entitled "Emerging Trends in Computer Science and Applied Computing" (Elsevier). Dr. Arabnia has received a number of awards; including: "Outstanding Achievement Award in Recognition of His Leadership and Outstanding Research Contributions to the Field of Supercomputing" 2007 (the award was presented to him at Harvard University Medical School. Prof. Arabnia has published extensively in journals and refereed conference proceedings. He has about 200 refereed publications as well as 360 edited research books in his areas of expertise.

Omid Alavi is the M.S. graduate of Electrical engineering from K.N. Toosi of Tehran, Iran. He has published few research works at different high rank journals.

Saeed Shahmiri is the M.S. graduate of Industrial engineering Department from Iran University of science and Technology, Tehran, Iran.