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Review Article

Performance, Cost, and Environmental Comparison of an Inexpensive Plastic Solar Water Heater - A Case Study

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Abstract

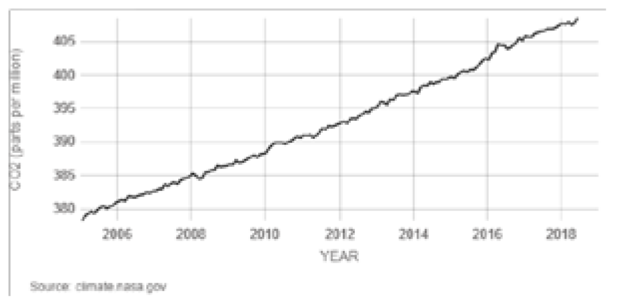
A novel solar water heater was designed using plastic as an inexpensive alternative to the conventional solar water heaters that are commonly found on the market. The unique design feature of this plastic solar water heater is the use of a black plastic sheet as the thermal energy absorber/insulator instead of a metal plate. The performance of this plastic solar water heater was compared to a conventional one, with respect to the volume of flow and increase in temperature. The test results showed that the plastic solar water heater can generate 43°C water at 21 L/hour. This performance is comparable with the conventional solar water heater. The two heaters were then compared with respect to the cost and the impact on the environment. The estimated manufacturing cost of the plastic solar water heater was 25% of the cost of the traditional solar water heater of comparable size. In nearly every category, except natural resource depletion, the plastic solar water heater was less detrimental to the environment. Hence the plastic solar water heater provides comparable performance to that of a metal solar water heater while proving superior performance with respect to the cost and environmental impact.

Keywords: Plastic solar water heater; Black plastic; Performance; Cost analysis; Sustainability analysis

Introduction

Despite recent efforts to avert the dangers of global climate change, temperatures have continued to rise as fossil fuels continue to be used as the primary energy source of the world. While fossil fuels have remained a cheap source of energy, the consequences of such heavy dependence have become truly visible. In 2017, the rising emissions were attributed to intensive natural disasters such as wildfires, hurricanes, and destroying natural habitats [1]. Such disasters have contributed to higher emissions thus creating a vicious cycle where climate change is exacerbated year by year creating an increasingly dire situation. As shown in Figure 1, carbon dioxide level stands at 408 ppm as of June 2018 [2]. As a result, the impetus on the fossil fuel industry to make the transition to renewable energy sources has increased tremendously in recent years. According to the [3], the expected global energy consumption will rise to 766 exajoules by the year of 2040. Thus, the continued usage of fossil fuels at high rate is evidently unfeasible. As a limited resource, fossil fuels will eventually be unable to match such rapidly increasing energy consumption. And yet, due to such a heavy reliance on non-renewable energy sources, the transition into renewable energy will leave a void that needs to be filled. Solar energy is poised to do so as it provides nearly boundless potential with approximately four million exajoules of energy reaching the Earth from the Sun each year. With ever-improving technology, solar energy has the potential to not only provide the much-needed energy, but also as a clean source. Although the capturing of solar power does contribute to greenhouse gas emissions due to the fabricated devices, it does so in the range of 0.03 – 0.09 kilowatt hours as opposed to natural gas which is in the range of 0.27-0.91 kilowatt hours, and to those coal which is in the range of 0.64-1.63 kilowatt hours [4]. Solar energy has risen in viability among renewable energies due to rapidly advancing technology and its versatility at all scales (Figure 1).

Figure 1: Global Average Carbon Dioxide levels over the past 12 years [2].



As the population increases and nations become developed, the need for hot water will continue to increase dramatically. It is particularly vital in areas such as hospitals and homes, where hot water is needed 24 hours of the day, seven days a week. Since it is necessary to continuously heat water to satisfy such a large usage, solar water heaters are useful as they can be used to produce and store the hot water. Therefore, they could prove to be a viable alternative to the fossil fuel counterparts as solar heaters utilize clean, limitless energy that has been shown to avoid consumption of non-renewable energy [5]. Solar water heaters have steadily grown in popularity as cost-effective methods to generate hot water for homes. There are two types of solar water heaters that are commonly used: passive and active. The active solar water heaters utilize circulating pumps and control the water flow through the system, whereas passive heaters rely on changes in temperature and thus density in order to circulate water. Thus, while active systems are typically more efficient, the focus of this manuscript will be on passive water heaters as they are more reliable, durable, and rarely require any maintenance. Also, passive solar water heaters utilize simple mechanisms to function and are therefore more versatile and practical in developing nations. Passive solar water heaters are composed of a collector and storage tank. Through the properties of a thermo-syphon, hot water flows up the collector, into the outlet pipe, and into the storage tank. Generally, solar water heaters can heat water to 45°C-50°C which is usable for most sanitation purposes [6]. Flat plate solar water heaters, which consist of four main parts: the absorber, the casing, the insulation, and the cover sheet, are the most commonly used devices in practice. While pricing and sizing are based upon a variety of factors including climate and amount of water needed, solar waters are costlier to install than electric systems but will pay back in the long term. For example, models such as the AET Morning Star Series solar collector and the Stiebel Eltron SOL25 Plus solar collector cost $18.86 and $12.93 per square foot respectively. As such, while these solar water heaters do offer clear advantages as opposed to their fossil fuel counterparts, they still have limitations that are yet unresolved. These include a lengthy and costly installation phase and the unreliable nature of the sun itself. To effectively utilize solar power to heat water, there must be a voluminous storage unit as well as backup methods as the sun is often unavailable on cloudy days, at night, and in the winter. As such, it is vital to maximize efficiency where possible and this begins with cost. With the aim of reducing the manufacturing cost, a novel solar water heater was designed and fabricated [7]. having the primary composition as plastic. The plastic has the additional advantages as the use of plastic can reduce the risk of theft and difficulty of manufacturing. Typically, conventional solar heaters as found on the market utilize a mixture of metals, plastics, and sometimes glass. Their defining feature is the use of a copper plate as an energy absorber and a frame made almost entirely of metal. In this research, viability of this novel solar water heater is compared with a conventional metal solar water heater in terms of performance efficiency, cost and environmental impact.

Design Details of the Plastic Solar Water Heater

The primary components of the heater are two plastic sheets; one black in color and other transparent, these sheets act as the energy absorber and cover sheet respectively. The bottom one is selected as black to best absorb sunlight and retain heat. Conversely, the transparent plastic sheet allows the sunlight into the heater. As shown in Figure 2, the clear plastic sheet has the dimensions of 1/8" by 22" by 44". The black plastic sheet shares the length and width as the clear sheet but differs in its thickness of ¼". Two circles ½" in diameter are drilled into the top and bottom of the black sheet as for the inlet and outlet pipes. These sheets are separated by Polyvinyl Chloride (PVC) spacers. These spacers are placed between the frames to keep the plates equidistant to each other at all points. Due to the rectangular shape of the panel, two different sizes of spacers are needed. Two ¼" by 1" by 48" spacers run parallel to the flow of the water and two ¼" by 1" by 26" spacers run perpendicular to the flow of water. The solar water heater is encased in a framing that extends out of each side of the panel itself. The frame is also made of a plastic sheet. Two sheets of ½" by 2" by 24" and two sheets of ½" by 2" by 48" make up the frame which holds the solar water heater to increase its sturdiness and durability. The epoxy glue is used to hold the components i.e., plastic sheets, and frame intact. In total, approximately 0.16 gallons of epoxy is applied to each solar water heater. Furthermore, to compliment the glue, bolts and screws are drilled through the panel. 28 hex Zinc plated steel bolts, 9 on the long sides of the panel and 5 on the headers, were used. 6 additional bolts were also used throughout the Plexiglas sheet as central supports. And finally, the connections through which the inlet and outlet pipes are attached with brass nipples that are 1/8" in diameter and 1.5" in length. Due to the size of the farm as well as the surface area of the bolts, the total surface area through which the panel can absorb solar energy is 22" by 44" or 6.72 square feet. The composition of the plastic solar water heater is much simpler than that of its metal counterpart (Figure 2).

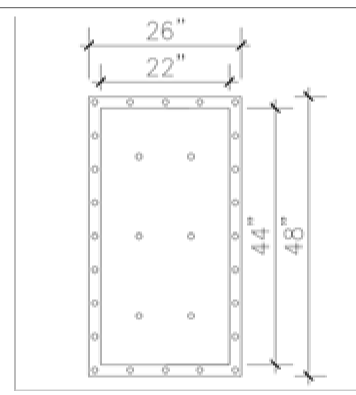


Figure 2: Plastic Solar Water Heater Diagram

Material Selection

The decision to use plastic was primarily based upon the cost of fabrication. The idea that inspired the creation of this design was that cheap, recyclable plastics are 8-15 times cheaper when compared to the copper used in market solar water heaters which lends itself to ease of access [7]. Furthermore, whereas solar water heaters rely on welding and thus skilled labor to assemble, it is relatively easy to build a plastic solar water heater. Therefore, in the developing countries where this design is most needed, there are minimal barriers to fabricating such a device. One of the primary concerns with the selection of plastic was its longevity. Whereas metal is known for its durability, plastic is susceptible to degradation in direct contact with the sun over long periods of time. UV radiation is particularly harmful to plastics, often causing crazing and brittleness in plastics in short periods of time. However, Plexiglas plastic which is used in this design is typically manufactured with Ultra-violet stabilizer protection that prevents yellowing of the sheet for at least 10 years. Furthermore, 1/8" thick Plexiglas is strong and hence the water heater should be safe from the wear and tear during transportation, installation or daily use. Another issue is, of course, thermal expansion. Plexiglas expands and contracts at a rate of 0.0000410 Inches/Inch/°F as opposed to the 0.0000129 Inches/Inch/°F of Aluminum [8]. As such, while this could eventually create an issue in the long term, this can be resolved by ensuring that the fit to connections is tight enough to be waterproof whilst leaving room for expansion.

Metal Solar Water Heater

The comparable metal solar water heater that was used for the comparison was the Heliatos EZ-37 solar water heater panel. The schematic diagram of this model is shown in Figure 3, it is 24" by 24" size overall with an effective size of 23" by 23", Once the frame was deducted. This heater is designed with lightweight materials in order to minimize or reduce the load placed on a roof as well as maximizing portability [9] (Figure 3).

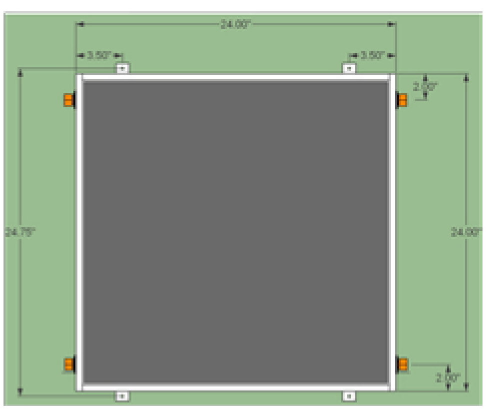


Figure 3. Heliatos EZ-37 [9].

The Heliatos model consists of 5 different components. The first of which is the glazing. The glazing is made of UV resistant twin wall polycarbonate. This material is typically used to create greenhouse conditions. The twin wall polycarbonate allows sunlight through to the system, insulates against heating, and absorbs up to 98% of UV rays reducing UV damage to the heater [8]. This sheet comes is 0.3937 millimeters by 23" by 23". The heater is encased on the sides by aluminum channel that is 1/8" by 2" by 1". The backing of the entire assembly is an aluminum sheet that is 0.08" by 23" by 23". Another aluminum sheet is placed behind the glazing sheet that is 0.25" by 23" by 23". This sheet is black in color is used for thermal absorption in conjunction with the copper tubes. The choice of aluminum was made with the purpose of a durable light-weight design. The signature part of this model is the water conduit which consists of copper tubing. Once water is introduced into the heater, it flows along the tubing which runs in a serpentine shape to maximize the duration that the water is contact with the copper tube and therefore the heating potential. These pipes are 0.03937" in thickness, 0.47244" in outside diameter and 192" in total length. With a thermal conductivity constant of approximately 401 W/ (m K), copper is the ideal choice as this value allowed the solar absorber to transfer as much heat as possible to the water. Behind the copper tubing, the insulation was placed. For the insulation foam, a sheet of rigid polyisocyanurate is used. This material is more commonly known as Polyiso foam and is 1" by 23" by 23". This layer ensures that minimal heat leaves the copper through the back so that the majority of the heat finds its way into the water. Finally, the last part is the fittings. There are four screws at each corner each of which is made of stainless steel and measure ½" in length. 2 inlets can be found on opposite sides of the panel that are made of brass nipples. These nipples are ½" by 1/8" by 1". The panel requires skilled labor to fabricate as it is held together with approximately 0.071 gallons of adhesive between the glazing sheet and aluminum sheet and welding to join the metal components.

Performance Comparison

With a thermal conductivity of 401 W/ (m K), the copper is at first the obvious choice for a solar water heater. In theory, copper would absorb the most thermal energy from the sun and as a result transfer the most heat into water. The issue, however, is that the high thermal conductivity of the copper allows thermal energy to transmit through the copper pipe to the surroundings, effectively wasting heat. The response in the Heliatos EZ-37 model is the use of a polyurethane sheet as an insulator. Polyurethane foam consists of blowing agent gas with an extremely low thermal conductivity that is interspersed within a closed structure. This results in an extremely efficient thermal insulator with a thermal conductivity of approximately 0.02 to 0.03 W/ (m K) [10]. While black plastic is unable to match copper in its thermal conductivity as it possess a constant of 0.2 W/ (m K), but it serves the dual purpose of an insulator as well as an absorber [11]. Thus, the plastic solar water heater should almost exclusively transfer heat to the water. This would allow, in theory, for the plastic solar water heater to compare with the metal solar water heater in efficiency as wasted heated is minimalized.

Experimental Setup

The plastic collector of 48" by 26" with 6.72 square feet of exposed surface area was placed flat on the ground in the sun. As shown in figure 4, it was connected to an inlet bucket with a clear pipe which was placed 24 centimeters above the highest point in the panel. The panel was connected to an exhaust pipe which transferred the water into an outlet bucket which was placed 10 centimeters above the ground. Thus, the water flowing into the outlet bucket was 14 centimeters above the bottom of the reservoir bucket. Water was introduced into the panel by filling up the inlet bucket to 75% of its total volume. Due to a combination of the water pressure and gravity, the water flowed into the pipe and then into the heater. Once the heater was filled and as the sun continuously transmitted thermal energy to the absorber, the water gradually began to move out of the panel into the exhaust pipe and outlet bucket. This occurred because of the difference in densities between the heated water and the colder water introduced in the panel. The experiment began at 1 PM to maximize the amount of sunlight. Every 10 minutes for an hour, the temperature of the water inside the inlet bucket as well as the temperature in the outlet bucket was taken. After 1 hour, at 2PM, the temperature of the water was observed to be stabilized at its peak with no further increase in temperature and the flow rate was measured using a graduated cylinder and a stopwatch. This experiment was repeated of three consecutive days to obtain the average. A similar test was performed with the metal heater of 24" by 24" and 3.36 square feet of exposed surface area but with the inlet and outlet bucket placed at different heights. The inlet bucket was again placed at 24 centimeters above the highest point of the panel, while the outlet bucket was placed at ground level. As shown in figure 5, the above procedure resulted in similar flow rates from both the plastic solar water heater as well as the metal solar water heater. Therefore, both can be compared despite the different dimensions and capacities of the two models. The temperature of the inlet water that was introduced to the plastic and metal solar water heaters were relatively the same at 24.3 and 23.8°C respectively. As shown in figure 5, the temperature of the inlet water for both heaters, while increasing slightly over time, remained extremely close. Once the water initially flowed through the outlet pipe, the temperature of the water from the plastic heater is already slightly higher, at 34.1°C. Over the time, it was observed that the outlet water temperatures began to increase with the water from the plastic solar water heater trending upwards at a faster rate than the water from the metal solar water heater. By the end of the experiment, the water from the plastic design was measured at 42.3°C while the water from the metal design was found to be 44.2°C. (Figure 4, Figure 5)

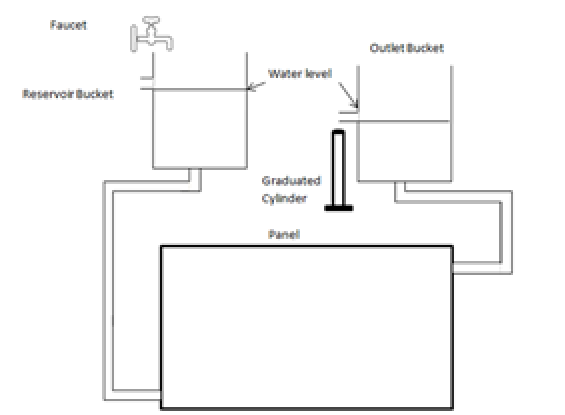


Figure 4: Sketch of experimental setup.

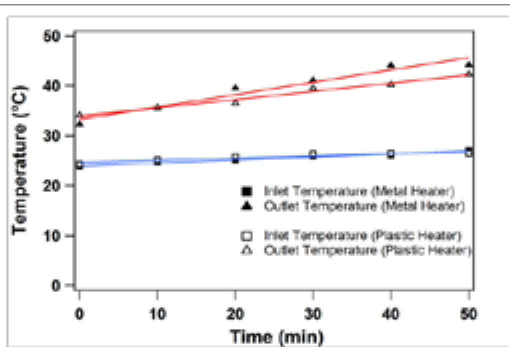


Figure 5: Inlet and outlet water temperatures.

Average total irradiation incident on the panel from 1 PM to 2 PM was estimated to be around 303 BTU/(hr-ft^2) on a sunny day [9]. To calculate the efficiency of the solar water heaters, the total energy change of the water that flowed through the solar water panels was divided by the total solar energy incident upon the panel. Using 303 BTU/(hr-ft^2) as the total solar water incident upon the area. This value was then multiplied by the exposed square footage of each panel and the length of the experiment conducted to find the total energy incident upon the panel. To find the total energy change of the water, the specific heat of water was multiplied by the total mass of the water that flowed through the system and the change in temperature of the water. From these calculations, the plastic solar water heater was determined to heat water at an efficiency of 56.47% compared to the 42.8% efficiency for the metal solar water heater.

Cost Comparison

Although flat plate solar water collectors are available around the world, their presence is most sorely needed in developing countries. Such countries, particularly those located near the equator, could make great use of a source of hot water with a quick payback period and little necessity for maintenance. But, the primary barrier to the success of these heaters is cost. While the Heliatos EZ-37 is relatively cheap at $148.99 (EZ-37, 2015), this price is not viable for those who live in poverty. However, to create a consistent comparison, the metal solar water heater was disassembled, and the cost of the materials and fabrication cost were estimated. To properly compare the cost of each solar water heater, the panels were compared for 1,000 square feet of exposed surface area. Due to the difference in size of the frames, this meant that the total cost of 255 Heliatos EZ-37 models was compared against 149 plastic solar water heaters.

Environmental Sustainability

Due to their utilization of a renewable resource as opposed to the typical usage of fossil fuels, primarily wood, in order to heat water, solar water heaters are generally environmentally preferred. With quickly rising concerns over the state of the environment, however, it is vital to minimize the carbon footprint wherever possible. As such, it is important that this design not only encourages the transition to renewable energy, but also ensures that the plastic solar water heater itself had less of a detrimental impact on the environment than its metal counterpart. Therefore, to compare the panels, the effect of 255 Heliatos solar water heaters and 149 plastic solar water heaters on the environment was simulated using the SimaPro. SimaPro is the world's leading life cycle assessment (LCA) software package. Using the program, a life cycle analysis was conducted comparing the two models and the results of SimaPro are shown in Figure 6. Material quantities were obtained from last columns of Tables 2 and 3.

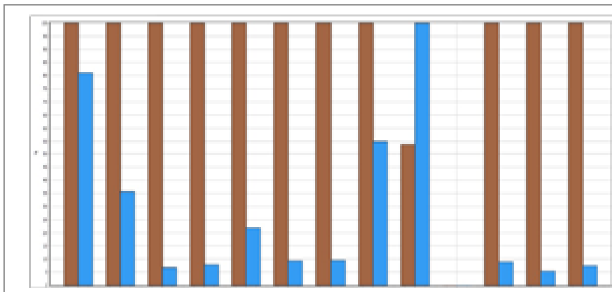


Figure 6: SimaPro Environmental Comparison.

Table 1: Flow rate of plastic and metal water heaters.

Attribute	Trial 1(mL/s)	Trial 2 (mL/s)	Trial 3 (mL/s)	Average (mL/s)
Plastic Solar Heater	5.895	5.865	5.867	5.875
Heliatos EZ-37	5.754	5.749	5.767	5.763

Table 2: Cost Estimation of the Heliatos EZ-37 Solar Water Heater

Item Number	Component	Size Required	Standard Size	Price(Unit)	Total Quantity	Density	Total Price	Total Quantity
1	Glazing sheet	10mm thick of 24”*48”	10 mm thick of 48”*96”	$68.64	32	0.0013kg/in^2 for 10 mm thickness	$2,193.28	191.7 kg
2	Polyiso Foam	1”*24”*24”	1”*48”*96”	$20.95	32	0.0007 kg/in^3	$670.40	103.2 kg
3	Alumium sheet(Behind glazing sheet)	1/4”*24”*24”	1/4”*24”*24”	$70.78	255	0.044kg/in^3	$18,048.90	1615.7kg
4	Alumium Sheet(Behind Frame)	0.08”*24”*24”	0.08”*24”*24”	$30.80	255	0.044kg/in^3	$7,854	517kg
5	Alumium sheet(Covering Tube)	0.08”*24”*24”	0.08”*24”*24”	$30.80	255	0.044kg/in^3	$7,854	517kg
6	Alumium Channel(Frame)	(A)2”*(B)1”*1/8”T hick	(A)2”*(B)1”*1/8”T hick	$7.53	1020	0256kg per channel	$7,680.60	261.2kg
7	Copper Tube(Primary tube)	2 pipe of 12 mm od*1mm wall*24”length	12mm od*1mm wall*96”length	$102.50	128	0.75kg per pipe	$$13120	96.5 kg
8	Copper Tube(Secondary Tube)	9 pipe of 6.35mm od*1mm wall of 16”*144” length	6.35mm od*1mm wall* 144” length	$28	255	0.463kg per pipe	$7,140	118kg
9	Epoxy	Area of epoxy to be applied 8 of 1”×24”+2”×20”	1 gallon can cower 50 sqft	3.5 gallon price is $50	18.13 gallon	7.62kg per gallon	$260	138.21kg
10	Screw	16 screws per frame	1000No	$50	4080no	0.14kg per 100 screw	$204	5.712kg
11	Labor	Crew of 4 labor, 1 welder and 1 Foreman	Pay of each labor as $35 per hour and $45 for welder and forman	$160	43 hour	-	$6,680	-
12	Welding	Two welds of 20 mm per frame	-	-	10200 mm	-	-	10200mm
13	Electricity	Glazing sheet-7680 in^2	200 inches and 1.6kw per minute	-	38.4 min	-	-	61.44kW-min
		Polyiso foam-7680 in^2	200 inches and 1.6kW per minute	-	38.4 min	-	-	61.44W min
	Total Electricity	-	-	-	76.8 min	-	-	2.05kWh
14	Connections(Fiting)	2 brass nipple of 1/8”*1-1/2”per frame	Brass Nipple of 1/8”*1”*1/2”	$1.18 each	510	2.7 pound per 100 piece	$601.80	6.2kg
Total							$72,306.98	

Table 3: Cost Estimation of the Plastic solar water heater.

	Component	Size Required	Standard Size	Price(Unit)	Total Quantity	Density	Total Price	Total Quantity
1	Transparent Plexiglass	1/8”*24”*24”	1/8”*48”*96”	$43.40	38	0.01933kg/in3	$1,649.20	414.75 kg
2	Black Plexiglas	1/4”*24”*24”	1/4”*48”*96”	$104.30	38	0.01933kg/in3	$3,963.40	829.49kg
3	Spacer	3 1/4”*1”*24”	1/4”*48”*96”	$75.32	5	0.0241kg/in3	$376.60	131.88kg
4	Frame(Header,Longer side)	4 1/2”*1”*24”	1/2”*48”*96”	$155.79	6.25	0.0241kg/in3	$973.69	347kg
5	Frame(Header, Shorter Side)	4 1/2”*1”*20”	1/2”*48”*96”	$155.79	6	0.0241kg/in3	$934.73	305.4kg
6	Connections(Fitting)	In each frame 2 brass nipple of 1/8”*1-1/2”	Brass Nipple of 1/8”*1”*1/2”	$1.18 each	596	2.7 pounds per 100 piece	$703.28	6.2 kg
7	Epoxy	Area of epoxy to be applied 8 of 1”×24”+2”×20” in each frame	1 gallon can cower 50sqft	3.5 gallon price is $50	21.2 gallon	7.62 kg per gallon	$302.86	161.55kg
8	Screw, Bolt and Washer	24 Bolt in each frame	1/4”-dia length 1-3/4” inch with min. thread length 3/4”	$0.245 for each pair(1 hex blot,1 screw and 2 washer)	7200	4.34 lb per 100 pair	$1,766.08	141.88 kg
9	Labor	Crew of labor manu-facturing 10 panel in hour	$35 per hour	$140	30	-	$4,200	-
10	Electricity	Transparent Plexi-glas-3576 in	200” and 1.6 KW per minute	-	17.88 min	-	-	28.48 KWM
11		Black Plexiglas-3576 in	200” and 1.6KW per minute	-	17.88 min	-	-	28.48 kWmin
		Frame(Longer Side)-45600 in	200” and 1.6 kW per minute	-	228 min	-	-	364.8kWmin
		Frame (Short Side)-57024 in	200” and 1.6 kW per minute	-	285.12 min	-	-	456.19 kWmin
		Spacer- 21432 in	200” and 1.6kW per minute	-	107.16 min	-	-	171.46 kWmin
	Total Electricity	-	-	-	656.04 min	-	-	17.5 kWh
						Total	$22,431.53	

Results and Discussion

In total 1000 square feet of effective area of the metal solar water heater is compared against the 1000 square feet of the plastic solar water heater. After examining the materials and fabrication for each design, it was estimated that the total cost of the Heliatos EZ-37 models was $75,856.98 (Table 2) and the plastic solar water heater was $23,566.92 (Table 3). In other terms of unit costs, they were $74.37 and $18.25 per square feet of the metal and plastic solar water respectively (Figure 6).

Although the cost of the metal solar water heater seems overly expensive as it is higher than the selling price, this is due to a variety of factors that may have increased the expected cost for both model of solar collector. Such factors include purchasing from American manufacturers and costs of labor that, while are typical in the United States, can be vastly different and less expensive around the world. As such, while the cost estimation is not entirely accurate to the Heliatos EZ-37 design it provides valuable insight into the cost comparison with the plastic solar water heater.

When fabricating the prototype for a solar water heater made almost entirely out of plastic, the biggest concern was the efficiency. While theoretically the use of a plastic in place of copper made sense due to its unique capabilities to both absorb heat and act as an insulator, it was uncertain if this would materialize in practice particularly as this is a novel design that has not yet been tested commercially. After observing both models, however, it is apparent that the plastic solar water heater performed at an efficiency that is comparable if not greater than that of the Heliatos EZ-37 solar water heater. Both the plastic and metal solar water heaters are capable of heating the water up to appropriate temperatures for use at 44.2°C and 42.3°C respectively. The life cycle analysis comparison for the metal and plastic solar water heaters shows that the plastic solar water heater is much more environmentally sustainable. In nearly every category, notably global warming and ozone depletion, the plastic solar water heater is less detrimental due to its composition. The primary environmental issue with the metal solar water heater was its reliance on the use of aluminum. While aluminum is a strong and lightweight material, which is suited for such a device, the energy intensive nature of its production makes it the costliest of alternatives to plastic in terms of its impact upon the environment. Aluminum makes up 6% of mass from alternative materials to plastic, yet 39% of environmental costs including greenhouse gas emissions, air pollution, land pollution and water depletion [12]. Further, during the production process of aluminum, large quantities of carbon tetrafluoride is released. A chlorofluorocarbon, carbon tetrafluoride is extremely detrimental to the ozone layer, as it can destroy potentially thousands of molecules of ozone once it reaches the upper atmosphere. The exception to the analysis is natural resource depletion, for which the Heliatos EZ-37 heavily outperformed the plastic solar water heater. This can be explained by the makeup of plastic which is derived from primarily natural gas as well as other natural materials such as coal, natural gas, and salt. As such, while this could be an issue due to the non-renewable nature of oil and other fossil fuels, this can be offset by utilizing recycled plastic which has the added benefit of minimizing the environmental cost (Table 3).

Summary and Conclusion

To determine the effectiveness and viability of a newly designed plastic solar water heater, it was compared with a popular solar water heater that can be found on the market. This model, known as the Heliatos EZ-37 model, is made out of primarily metal, notably copper tubing as an energy absorber. These two designs were compared in three different categories: efficiency, cost, and environmental impact. At 51.3% efficiency, the plastic solar water heater performed slightly better than the Heliatos model thus justifying the use of plastic as opposed to metal for thermal energy absorption. Furthermore, the plastic solar water heater, per thousand square feet of exposed area, costs over 3 times less than the metal solar water heater. And as shown by the SimaPro simulation, the carbon footprint of the plastic model was minimal, thus increasing its appeal as a renewable energy alternative. Water heating around the world, particularly developing nations, consumes large quantities of fossil fuels. This novel design seeks to increase the appeal of solar water heaters and benefit those who are need of a cheap method to heat hot water while reducing the environmental impact.

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