Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 1 (2026)

Design And Evaluation of a Solar Water Heater Advocacy for Carbon Footprint Reduction

Alexius D. Silorio, Ph.D
Zamboanga Peninsula Polytechnic State University
alexiussilorio021867@gmail.com

Publication Date: January 12, 2026 DOI: 10.5281/zenodo.18232710

Abstract

The growing demand for sustainable energy solutions worldwide necessitates practical and affordable methods to lower household carbon emissions. Household energy use and carbon emissions is significantly influenced by electric water heating techniques. The need for effective tools to promote the usage of renewable energy sources is the main emphasis of this study. The main purpose was to create, build, and analyze a solar water heater (SWH) meant to operate as a practical advocacy device for minimizing carbon footprints.

The goal of the project development research was to assess the project's acceptability, design, and functionality as well as user approval. Using easily accessible materials, a functional SWH gadget was constructed. A user-focused evaluation was part of the assessment, where people tested the gadget and gave feedback. The data analysis of the findings and outcomes are positive.

The average mean score for the Solar Water Heaters(SWH's) design was 4.36, indicating that consumers "Strongly Agree" with its quality. With a score of 4.66, functionality was rated as having excellent agreement regarding efficiency. Additionally, acceptability achieved a mean score of 4.66, indicating an exceptional user experience and qualifying it as "very acceptable." The outcomes attest to the device's efficacy and ease of use. Its effectiveness and value as a tool for demonstrating the benefits of solar technology are confirmed by its high ratings in each category.

Harnessing solar energy for heating water significantly reduces reliance on fossil fuels, which in turn helps to cut down greenhouse gas emissions and lower carbon footprints. Studies show that solar water heaters can reduce carbon dioxide emissions by 50% or even more when compared to traditional water heating methods, thus playing a crucial role in efforts to combat climate change. Promoting the adoption and use of these effective solar water heating systems encourages environmental sustainability and actively aids in decreasing carbon footprints by utilizing clean and renewable energy.

Keywords: *Solar water Heater (SWH), Sustainable Energy, Carbon footprint, Renewable Energy, Functionality, User-friendly Design, Usability, Household Emissions*

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 1 (2026)

INTRODUCTION

These devices operate by using an electric resistance element to heat water stored in a tank or by heating it on demand as it flows through the unit. Their relative ease of installation and safety, with no need for flammable fuels or venting, has contributed to their widespread adoption in households globally. (Merwe, 2015)

While specific data on the percentage of Filipino households that utilize water heaters is not easily accessible, it is believed that the adoption rate is on the rise, driven by urbanization and an increased demand for effective heating solutions. (Research and Markets, 2025). Water heaters offer a reliable and readily available source of hot water for different household requirements, including bathing and cleaning. The water heater market in the Philippines is experiencing significant expansion, indicating a rising trend in consumption. Hills & Valleys Cafe states that almost 90% of adult Filipinos drink coffee daily. Instant coffee holds a substantial share of the market, representing nearly 90% according to information from Hills & Valleys Café. The market for coffee machines in the Philippines is expected to grow, indicating an increase in coffee maker usage. The market offers a variety of coffee makers, including traditional drip machines and advanced espresso and bean-to-cup models. Coffee makers offer convenience and allow Filipinos to make different (Y Luat, 2021)

However, the convenience of electric water heaters involves an environmental trade-off, mainly reflected in a heightened carbon footprint. Even though the heaters themselves do not release pollutants, their impact on the environment is associated with the electricity source that powers them. In regions heavily reliant on fossil fuels for power, (Cabeza, 2014)The impacts on both the economy and the environment from this carbon footprint are substantial (Lamiaa Abdullah, 2013). This environmental effect directly stems from the substantial energy required to heat water. In truth, heating water often represents the second-largest energy expense in a home.

To promote the advocacy for the reduction of carbon footprints, a proposed study on the development of a solar water heater project was made and evaluated in accordance with its design, functionality, and acceptability.

METHODOLOGY

The device underwent four (4) phases of development as based on the following objectives:

1. Design
2. Construct
3. Test and Demonstrate
4. Evaluate
    a. Design
    b. Functionality
    c. Acceptability

1. Design

The solar water heater is a compact, energy-efficient appliance designed to heat small quantities of water for domestic or office use. Its portability and fast heating capability make it

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 1 (2026)

ideal for tea, coffee, or instant meals. The design capacity is to heat 4oz to 12oz of water. Powered by a 12DC volts and 50 watts solar panel with a built-in battery as storage energy. Most of the materials a cheap and readily available using automotive discarded diesel heater elements and scrap metal materials for the outer casing. This incorporates digital temperature controllers and power stability circuitry.

2. Construct

The solar heater is a small insulated metal fabricated material with built-in secured heating element mounted on the surface base on the top where the cup is placed. The heating element is connected to a multi-controller circuit triggered through a relay with a heat sensor for automatic temperature control. The system is then connected to the charge controller from the battery to the solar panel. All components are enclosed in a compact heat-resistant casing in one assembly.

3. Test and Demonstrate

The unit is assessed for precision in temperature regulation, insulation, and adherence to safety standards regarding its operation. The boiling temperature of water is 100°c, while the lower temperature for warming ranges from 90°c to 96°c. The solar charging of the battery requires an 8-hour initial charge for it to be fully charged

. 4. Evaluate

The process of selecting respondents is a critical component of any evaluation or research study, as it directly influences the credibility, reliability, and applicability of the findings. In this study, the respondents chosen to evaluate and test the solar water heater in terms of the design, Functionality, and Acceptability were teachers and students of the Bachelor of Science in Electronics (BSElectronics) program. This was a purposive selection method.

The evaluation of a solar water heater use a 5-point Likert scale in gathering the data using an test instrument. Respondents rate statements related to the Design, and Functionality on a scale from 1 to 5, where: 1 = Strongly Disagree, 2 = Disagree, 3 = moderately Agree, 4 = Agree, 5 = Strongly Agree. And for Acceptability also from 1 to 5, where: 1 = Unacceptable, 2 = Poorly Acceptable, 3 = Acceptable, 4 = Moderately Acceptable, and 5 = Highly Acceptable. The collected ratings are then analyzed to identify strengths and areas needing improvement, providing quantitative insight into user perceptions and the Solar water Heater's performance.

RESULTS AND DISCUSSION

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal
of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 1 (2026)

DESIGN

NO.	ITEMS	MEAN Students	MEAN Teachers
1.	The Innovated Solar Water Heater is portable.	4.1	4.6
2.	The overall design of Innovated Solar Water Heater on esthetics appearance.	3.74	3.9
3.	The Innovated Solar Water Heater has it's features such as temperature display, LED indicators, buzzer, buttons, and LCD display.	4.41	4.8
4.	The Innovated Solar Water Heater has a 12v DC power provision.	4.68	4.74
5.	The Innovated Solar Water Heater has a safety insulated enclosure.	4.32	4.44
		4.23	4.5
	Over-All Mean	4.36	

Range: 4.20-5.0 (Strongly Agree), 3.40-4.19 (Agree): 2.60-3.39 (Neutral): 1.80- 2.59 (Disagree): 1.00-1.79 (Strongly Disagree)

Table 1. Shows the tabulated over-all mean for the design of SWH

FUNCTIONALITY

NO.	ITEMS	MEAN Students	MEAN Teachers
	The Innovated Solar Water Heater easy to operate.	4.61	5
	The Innovated Solar Water Heater can compete to commercial products.	4.1	4.6
	The Innovated Solar Water Heater can reach the water boiling point to 100°C at 25 minutes per 230ml.	4.32	4.7
	The Innovated Solar Water Heater can be used in camping, outdoor activities, offices, household, dormitory, etc.	4.79	5
	The Innovated Solar Water Heater can operate at 12V DC, and can automatically trip-off when reach to 100 °C.	4.71	4.8
		4.5	4.82
	Over-All Mean	4.66	

Range: 4.20-5.0 (Strongly Agree), 3.40-4.19 (Agree): 2.60-3.39 (Neutral): 1.80- 2.59 (Disagree): 1.00-1.79 (Strongly Disagree)

Table 2. Shows the tabulated over-all mean for the Functionality of SWH

Online ISSN: 3082-5121
Aloysian Interdisciplinary Journal
of Social Sciences, Education, and Allied Fields
https://journals.aloysianpublications.com
Volume 2 Issue 1 (2026)

ACCEPTABILITY

NO.	ITEMS	MEAN Students	MEAN Teachers
1.	The performance and usability of the Innovated Solar Water Heater is efficiently.	4.5	4.5
2.	The Innovated Solar Water Heater is considered as a low-cost device.	4.7	4.6
3.	The Innovated Solar Water Heater gives important to the environmental impact (energy savings, use of renewable energy).	4.8	4.8
4.	The Innovated Solar Water Heater is patentable.	4.8	4.71
5.	The Innovated Water Solar Heater has an automatic trip OFF detection when reach to 100°C and trip ON when temperature decrease 50°C.	4.2	5
		4.6	4.72
	Over-All Mean	4.66	

Range: 4.20-5.0 (Highly Acceptable), 3.40-4.19 (Moderately Acceptable): 2.60-3.39 (Acceptable): 1.80- 2.59 (Poorly Acceptable): 1.00-1.79 (Unacceptable)

Table 3. Shows the tabulated over-all mean for the Acceptability of SWH

Survey Results and Interpretation

Table 1. Design Assessment (Score: 4.36 - Strongly Agree Category)

The design of the solar water heater achieved an average score of 4.36 on a Likert scale, placing it in the "strongly agree" category. This indicated that the majority of participants regarded the device's physical design as very satisfactory. The design is rated for visual attractiveness, size efficiency, simple setup, and careful incorporation of elements that meet user requirements. The favorable design feedback showed an effective implementation of conceptual and engineering principles into a physical product that fulfills users' demands for aesthetic quality and structural robustness.

Table 2. Functionality Assessment (Score: 4.66 - Strongly Agree Range)

A functionality rating of 4.66 reflects an even greater agreement among users that the solar water heater fulfills its intended function efficiently. This indicates that the device consistently warms water using solar energy within the anticipated time and temperature ranges. Functionality rating indicated that the technical design, solar collector, thermal insulation, and heat transfer processes were effectively optimized.

.

Table 3. Acceptability Assessment (Score: 4.66 - Very Acceptable Range)

Usability achieved the top score of 4.66, classified as "highly acceptable," reflecting outstanding user experience and satisfaction. This measure probably includes usability, interface clarity, maintenance needs, safety attributes, and general convenience. The elevated usability rating indicates that the solar water heater is user-friendly for individuals with different technical skills and that the system does not need regular or complex maintenance.

Conclusion and Recommendation

This evaluation shows that the solar water heater performs very well in terms of design, functionality, and user acceptance. With a design score of 4.36 (strongly agree), the device is viewed as attractive, compact, easy to assemble, and closely aligned with user preferences, showcasing the efficient conversion of conceptual and engineering ideas into a solid product. Functionality scores of 4.66 for both usability and functionality (within the strongly agree/very acceptable range) indicate dependable efficiency in heating water, supported by enhanced solar collection, insulation, and heat transfer, along with an accessible user experience for different technical skill levels. Together, these findings indicate a cohesive approach that achieves technical goals while providing an outstanding user experience; however, continuous enhancement and upgrading might improve long-term upkeep and flexibility across various settings.

Recommendation

As a result of the study, the respondents recommend improving the design, enhancing the heating capacity to accommodate a larger volume of water, and extending the study to explore possible commercial applications, intellectual property patents, and applications for an industrial model.

REFERENCES

Alayi R., (2021) Thermal and environmental analysis solar water heater system for residential buildings. https://www.hindawi.com/journals/ijp/2021/6838138/

Brian N. (2011) Solar Water Heaters: A Review of Systems Research and Design Innovation.https://www.degruyter.com/document/doi/10.1515/green.2011.016/html?lang=en

Dhakar P., (2019) A Review Study on Solar Water Heating Systems https://www.researchgate.net/publication/345002100_A_Review_Study_on_Solar_Water_Heating_Systems

Eiri, B., (2022) Solar Water Heating System https://www.un.org/en/climatechange/what-is-renewable-energy?gad_source=1&gclid=Cj0KCQjw3tCyBhDBARIsAEY0XNl3NhxD7OmXIN-Q0dGhoQ5H2UPUpcB1rIgRE_h32JqUCV0Strkh22EaAgDIEALw_wcB

Eugene Water & Electric Board. (n.d.) Annual Water Heating Costs & Carbon Footprint. https://www.eweb.org/documents/Customer%20Programs/energy-efficiency/compare-hot-water-heater-fuel-type.pdf

Frid, S., (2018) The annual number of days that solar heated water satisfies a specified demand temperature https://www.researchgate.net/publication/245169213_The_annual_number_of_days_that_solar_heated_water_satisfies_a_specified_demand_temperature

Northeast Solar & Hot Water. (n.d.). Reduced Carbon Footprint. Retrieved from https://www.neshw.com/residential/reduced-carbon-footprint/, citing the University of Wisconsin's Solar Energy Laboratory.

Ntodeni S., Edoun Emmanuel., et. al. (2017) Innovation through the effects of solar water heating (SWH) in Africa https://www.businessperspectives.org/index.php/journals/environmental-economics/issue-256/innovation-through-the-effects-of-solar-water-heating-swh-in-africa

Sylvia N., Emmanuel E., et, al. (2017)Innovation through the effects of solaRecent progress in solar water heaters and solar collectors: A comprehensive review. https://www.researchgate.net/publication/351957123_Recent_progress_in_solar_water_heaters_and_solar_collectors_A_comprehensive_review

Sylvia N., Emmanuel E., et, al. (2017) Innovation through the effects of solar water heating https://www.researchgate.net/publication/320807773_Innovation through_the_effects_of_solar_water_heating_SWH_in_Africa

Taheri Y., Alimardani K., Ziapour M., et, al. (2015) Study of thermal effects and optical properties of an innovative absorber in integrated collector storage solar water heater https://ui.adsabs.harvard.edu/abs/2015HMT....51.1403T/abstract

U.S. Department of Energy. (n.d.).Water Heating. https://www.energy.gov/energysaver/water-heating

Yari S., Safarzadeh H., Bahiraei M., et. al, (2023)Experimental study of storage system of a solar water heater equipped with an innovative absorber spherical double-walled tank immersed in a phase change material https://www.sciencedirect.com/science/article/abs/pii/S2352152X23001792