Portable Hybrid Powered Water Filtration Device

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Abstract *– The existing water filtration device has features that can be developed to be more useful and functional during emergency situations. The project's development has been aided by following provisions in PEC, NEC, NEMA and Philippine National Standard for Safe Drinking Water provide standards for the construction of the project. These standards protect both the prototype and the user. These also served as guide for the maintenance of every component. The design of the portable hybrid powered water filtration device shows that the project has more advanced features such as portability and the power supply used such as photovoltaic module solar cells and manually operated generator. This also shows its effectiveness and reliability based on the results of discharging test, water quality test and water production test. Based on analysis of the overall financial aspects, the machine can be profitable and the amount of revenue and operating cost will increase as years pass. Using the proper machine/ tools and methods of fabrication helps in easy assembly of the project. The materials and components used are cost effective and efficient. The best time for charging the battery using solar panel is 9:00 am onwards while the hand crank generator is too slow because the generated current is little. The water filtration device is very efficient regarding the operating hours and water production. The machine may have a great effect to society and economy in generation of clean available water at less cost.*

Keywords: *filtration, hybrid, photovoltaic module, solar panel*

INTRODUCTION

It has been evident that the world is facing a big challenge: climate change. Today, man has experienced the negative effects of the destruction of the environment. Weather patterns have changed compared several years ago.

The Philippines have been through different calamities these past few years. Calamities such as typhoons, earthquakes, fires and volcanic eruptions affected the lives of many Filipinos. During these times, the primary concern aside from their safety is how they are going to survive the aftermath.

Although the government makes effort in order to help the survivors, their supply for basic necessity such as food, clothing, sanitary supplies and most especially drinking water is not enough and will not last for a long time.

With this, the researchers considered all these scenarios to develop a hybrid powered water filtration device. The design is meant to provide safe and clean drinking water to people in isolated areas and calamity victims. It is considered as a modern convenience because it is portable. It can be transported to areas affected by calamities. It is also environment-friendly because it utilizes renewable sources of energy which will contribute to the preservation and protection of the environment. With this project, people will be sure that the water they are drinking is free of chemicals and bacteria which can cause illnesses.

Sagara (2000) concluded in his study that three point-of-use filter systems that there should be a study on treatment performances, as well as costs, availability and social acceptability. It was observed from the filter experiments that in all three filter systems, the filtration process alone did not treat water to an acceptable level of drinking water quality set by WHO guidelines. Although manufacturers of the ceramic candle filters claimed that their products produced "pure" and "safe" water, they were found to be incapable of removing microbiological contaminants. This study is related to the project's output considered standards on drinking water presented by the Philippine National Standards on Drinking Water.

Tamisssetti's (2010) study on the use of cloth as filter revealed that all the cloths, with the exception of polyester, reduced the amount of turbidity in the water. Also, as the number of folds increased, the percent of the turbidity removed increased as well. However, in accordance with that, the rate of filtration decreased because it took longer for the water to filter through so many layers of cloth. The concepts were the same as the researchers' project except that instead of cloth, different kinds of filters were used.

Andal, et al (2011) designed and developed a solar water pump demonstrating apparatus. They cited that the efficient time for charging battery through solar panels was 11:00 am onwards depending on the weather condition.

The design of the portable hybrid powered water filtration device was made up of four components namely the water filter assembly, the solar panel, a water tank and the power source. The filter assemly was composed of 1 micron sediment filter, 0.9 micron antibacterial filter, 5 micron carbon filter and water softener, a pump and an ultraviolet light.

The power source is where all the switches and metering devices were located. A cart was provided for easy transportation of the device and a water storage tank was placed on the lower part of the cart beside the water filter assembly.

The computations of the components of the design were also presented including the sizing of solar panel, charge controller, fuse and battery. The total demand load of the device was 72 watts which was the sum of the individual load of the water pump, UV lamp and ballast. The researchers used three (3) 30 watts solar panel. The size of the charge controller was determined by computing the ampere rating which was 9.375 A and 10 A charge controller were used. The computed fuse rating was 6 A so the resarchers used 10 A in-line fuse. A 40 AH Deep Cycle battery was utilized because it is designed for solar applications and its rating fitted to the computed rating.

The design layout of every components was presented with dimensions and the internal views of the power supply and filtration device were also shown. The circuit diagram showed the connections of the solar panel, hand crank generator, battery and the loads. The total cost of the project would amount to thirty seven thousand five hundred six pesos (P37,506.00).

In line with this, the researchers gathered all the necessary information from recent and past studies which helped a lot in the development of the project.

OBJECTIVE OF THE STUDY

The main objective of this study was to design and develop a portable hybrid powered water filtration device. Specifically, it aimed to evaluate the existing water filters in terms of design, construction, operation and areas for improvement; determine the project's design requirements and considerations according to Philippine Electrical Code (PEC), National Electrical Code (NEC), National Electrical Manufacturer's Association (NEMA) and Philippine National Standards for Drinking Water; prepare the design plans in terms of General Description of the Project; Design Computation and Analysis; Design Layout; Circuit Diagram and Bill of Materials and Specification; to present the overall financial pictures in terms of operating cash requirements, profitability, and cash flow; determine the methods of fabrication and assembly in terms of Materials/Tools and Methods; test the performance of the portable hybrid powered water filtration device as to its sustainability, reliability, functionality and capability; and discuss the effects of the project in the society and the economy as a whole.

METHODS OF FABRICATION AND ASSEMBLY

The researchers accomplished various methods and assembled the working prototype. The following steps were undertaken in the fabrication of the prototype:

1. **Preparation of materials and equipment.** Materials and equipment to be used in the development and construction of the project were prepared beforehand. These were water filters, diaphragm pump, inlet and outlet hose, water, solar panel, charge controller, hand crank generator, multimeter, connecting wires and other miscellaneous components.
2. **Assembly of the project.** The design of the project was composed of the filters and the energy sources (the hand crank generator and solar panels).

2.1. Two housings made of aluminium were made first. The first housing would hold the diaphragm pump and the filters. This would ensure that the electrical components of the prototype would not get wet while filtering water. Components were tightened to the side of the compartment. Filters were connected to each other as well as to the water pump. The pressure gauge was connected in between the pump and the first filter. This is to monitor the pressure of the pump. The Ultraviolet light was connected at the bottom. This was the final stage of water filtration.

The second housing is where the generator and the batteries were located. These were connected to the charge controller in order to control the output voltage of the two sources. At the upmost portion of the housing is where solar charge controller and the voltmeter and ammeter were located. This is for monitoring the charging process. Also, voltmeter and ammeter were fixed at the front of the housing to monitor the discharging activity of the prototype.

2.2 The solar panel was separated and mounted to the desired height where maximum amount of sunlight could be drawn. The panel can be placed on a tripod where it can absorb enough sunlight needed for the operation of the prototype.

3. Testing of the prototype. This part is mostly composed of final procedures followed.

3.1 Partial testing of the project's operating capability.
3.2 Final testing and evaluation of the project operation
3.3 Testing of the output (filtered water).

RESULTS AND DISCUSSION

Table 1. Charging Test (Using Solar Panel)

Time	Trials	Current (A)	Voltage (V)	Power (W)	Battery Status
8:00am	1	2	12	24	Red
	2	2	12	24	Red
	3	2	12	24	Red
10:00am	1	5	12.5	62.5	Yellow
	2	4.5	13	58.5	Yellow
	3	4.5	12.5	56.25	Yellow
12:00am	1	3.5	16	56	Green
	2	3	17	51	Green
	3	3	14	42	Green
2:00pm	1	1	18	18	Green (Blink)
	2	1	18	18	Green (Blink)
	3	1	18	18	Green (Blink)
4:00pm					
	1	0	18	18	Green (Blink)
	2	0	18	18	Green (Blink)
	3	0	18	18	Green (Blink)

Legend: *Red – 0 – 30% Full ; Green – 71 – 99% Full; Yellow – 31 – 70% Full; Green(Blink) – 100% Full*

After the installation of the prototype, it underwent a series of tests to find its functionality. The tests evaluated different parameters necessary to assess the project. The tests included charging time, discharging time, water quality test and volume of water filtered.

The data collected served as the basis in determining the areas of improvement.

1. Charging Test. The prototype used a battery for energy storage. This test determined the amount of voltage stored in the battery within time duration. Battery status was determined by the light indicator.

The charging capability of the battery was tested in five different trials. Every period was tested three times. For every trial, the amount of voltage was recorded.

Table 2. Charging Test (Using Hand Crank Generator)

Time (minutes)	Trials	Current (mA)	Voltage (V)	Power (W)	Battery Status
15	**1**	100	12	1.2	Red
	2	100	12	1.2	Red
	3	100	12	1.2	Red
30	**1**	100	12	1.2	Red
	2	100	12	1.2	Red
	3	100	12	1.2	Red
45	**1**	75	12	0.9	Red
	2	75	12	0.9	Red
	3	75	12	0.9	Red
	1	75	12	0.9	Red
	2	75	12	0.9	Red
60	**3**	75	12	0.9	Red

Legend: *Red – 0 – 30% Full ; Green – 71 – 99% Full; Yellow – 31 – 70% Full; Green(Blink) – 100% Full*

Discharging Test. This test evaluated the period of time the battery could supply the load. The values of voltage and current for each trial were recorded

Table 3. Discharging Test

Trials (Hours)	Current (A)	Voltage (V)	Power (W)	Battery Status
1	1.2	12.5	15	Yellow
2	1.2	12.5	15	Yellow
3	1.2	12	14.4	Yellow
4	1.2	12	14.4	Yellow
5	1.2	12	14.4	Red
6	1.2	11	13.2	Red

Legend: *Red – 0 – 30% Full ; Green – 71 – 99% Full; Yellow – 31 – 70% Full; Green(Blink) – 100% Full*

3. Water Quality Test. This test examined the quality of the water being purified. It was the top priority of the researchers to ensure that the water would be safe for drinking.

This test was composed of two parts, the physical quality test (color, odor and taste) and the quality test (ph level, nitrates contents, lead content and bacterial content) of water samples after purification.

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4. Water Production Test. This test determined the volume of potable water that the device would be able to produce. This was done for four (6) hours

Table 4. Water Quality Test (Physical and Chemical Analyses)

Trials	ph	Color	Turbidity	Total Hardness	Remarks
1 (Calicanto)	7.88	<5 PCU	<0.05 NTU	265.58 mg CaCO3/L	Passed
2 (Cuta)	7.49	< 5PCU	<.05 NTU	245.97 mg CaCO3/L	Passed
3 (Capitolio)	7.71	<5 PCU	.11 NTU	247.98 mg CaCO3/L	Passed

Table 5. Water Quality Test (Physical and Chemical Analyses)

Trials	Nitrate	Iron	Lead Content	Acidity	Remarks
1 (Calicanto)	2.10 mg/L	<.03 mg/L	<.01 mg/L	14.50 mg/L	Passed
2 (Cuta)	.0651 mg/L	<0.03 mg/L	<0.01 mg/L	5.98 mg/L	Passed
3 (Capitolio)	12.54 mg/L	<0.03 mg/L	<0.01 mg/L	6.48 mg/L	Passed

Table 6. Water Quality Test (Microbiological Analyses)

Trials	Potability Test (Total Fecal Coliforms, MTFT)	Remarks
1 (Calicanto)	<1.1 MPN/100mL	Passed
2 (Cuta)	<1.1 MPN/100mL	Passed
3 (Capitolio)	<1.1 MPN/100mL	Passed

Table 7. Water Production Test (Flow Rate)

Trials	Volume of Water Produced (L)	Volume Flow Rate (L/min)
1	1.6965	1.6965 L/min
2	1.6965	1.6965 L/min
3	1.6965	1.6965 L/min

CONCLUSION AND RECOMMENDATION

The project study as a whole involves numerous operations to obtain the desired efficiency of the device to maintain its overall functionality and several considerations were taken in accomplishing the project. The following are the findings on how the construction was successfully complete.

The existing prototype is a type of filter known as "under sink reverse osmosis filter" made up five purifying stages with different filter cartridges. The filter assembly measures 38 cm x 21 cm x 46 cm and has a general weight of 15 kg. It consumes a total power of 30 watts and has 25 watts booster pump. The device uses an ac supply for its power source so it will not function when there is power interruption and limited for home use only.

The project design considered the provisions in the PEC, NEC, NEMA and Philippine National Standards for Drinking Water to ensure the quality and effectiveness of the design as well as the safety of the beneficiary of the device.

PEC provides the requirements for storage batteries and the overall guidelines for solar photovoltaic systems installation including circuit requirements and wiring methods. NEC provides standards for the over current protection of generators while NEMA tackled some provisions regarding the use of storage batteries. Philippine National Standards for drinking water stated standards concerning the physical and chemical quality of water as well as its microbiological aspects.

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After studying and interpreting the results of the project, it showed that the project has a low operating cost. With the projected volume of water sold, the total revenue of Php 25,200 may be acquired. The operating cost amounting to Php 7,406 compos the maintenance, depreciation and miscellaneous. Since the machine has a life expectancy of 10 years, it will have an annual depreciation of Php 3,750.60. It will take two years and seven months to recover the investment of the project.

The methods of fabrication were followed such as preparation of the materials and equipment. The project was assembled using different tools and machines. It became hard for the proponents to assemble the project because some of the components were not available in the market. Some components malfunctioned and the other needed replacement.

Four sets of test were conducted to check the functionality of the prototype according to the required output: (a) Charging test using solar panel and hand crank generator (b) discharging test (c) water quality test and (d) water production test.

Charging test using solar panel showed that the voltage and current increased from 8:00 to 11: 00 am and decreased from 12 : 00 to 4:00. The light indicator at 8:00 am was red indicating that the battery was 30% full while the yellow color was observed at 10:00 am. At 12:00 pm, the battery showed a green color indicating that the battery was fully charged. From 2:00 pm to 4:00 pm, light indicator keeps blinking meaning the battery was in float charging.

Charging test using hand crank generator showed the voltage and 30% full status of the battery remained constant throughout the testing time and the generated current ranged only from 75 mA and 100mA. The machine could run for six hours and current drawn during discharging test was constant. As the battery was discharged, the voltage dropped from 12.5v to 11V and status of the battery changed from 70%full to 30%full.

The water samples from the deep well of three different barangays namely Calicanto, Cuta and Capitolio were used. The results of the water quality test showed that the three samples used passed the standards in terms of physical, chemical and microbiological aspects. All water samples passed the standard limit for ph, color, turbidity, total hardness, nitrate, iron, lead content, acidity, total coliform count and fecal coliform count of water provided in Philippine National Standards for Drinking Water.

During the water production test, the volume flow rate of the machine was observed to be constant.

The portable hybrid powered water filtration can contribute to the society's growth and development since it can provide solution for unsafe drinking water problems and also helps to ensure the welfare of every human. By providing a machine that will be able to produce potable water which is cheaper as compared with commercially available drinking water, everyone will be able to save money.

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