Journal of Engineering Technology Vol. 9(1): 36-44, 2021
ISSN 2231-8798© 2013 UniKLBMI

Development of Hybrid Cycle System to Generate Electrical Energy

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Abstract: Great majority of the energy comes from the traditional power plant run by fuel like oil, coal, gas, etc. The rate of energy consumption in the world is rapidly getting higher. Conversely, the huge amount of carbon emissions and the resulting disastrous greenhouse effect are damaging our world. By focusing on more renewable energy, hybrid energy generation is cleaner than the previous traditional power plant which can be cycled and regenerate the power production. More on that, this hybrid cycle system is using the Pelton wheel which is similar to mini-hydro but powered by a water pressure invention. The purpose of this project is to supply inland agriculture at the same time supplying electricity to the inland residents who did not get an electricity supply. Providing dirty energy for inland residents is not suitable for Mother Nature because it can cause a side damage effect to our green nature and air pollution. The DC motor-generator (turbine) and Solar Panel System are the main sources that produce electrical energy. In addition to the water pump, the water pump that shot with a high-speed ratio hit the turbine to spin. Both sources store energy into the battery bank and convert the energy from DC volt to AC volt. The charger controller will cycle charge the battery which supplies the water pump that powered the DC motor-generator (turbine). When the battery reached its' maximum capacity, it will automatically cut off the charging process. On the other side of controlling the charging process, if the battery capacity decreases below 20%, the DC motor-generator will automatically start operating.

Keywords: Cycle System, Hybrid Power, Inland Resident

1.0 INTRODUCTION

Moving forward to a better future, innovative technologies are the things to improve our daily lifestyle. In this new era, there are many brilliant ideas from the thinker that need to develop and apply to our living that lives in a modern world. But, the other side that all people did not see is that another living cannot feel the modernisms because of financial constraints, living in the inland area, and some people did not experience what electricity feels like. Regarding this matter, electricity is the main source which people needed the most to light up their future. Developing electrical energy can help others that need it such as the rural and poor areas to brighten up.

In the 21st century, plenty of the electricity comes from conventional fuel–operated power stations, such as gasoline coal, natural gas. The rate of energy consumption in the world gradually increasing significantly. Optionally, the enormous amount of carbon emission levels and the resulting disastrous greenhouse effect are negatively affecting the world [1].

2.0 LITERATURE REVIEW

As for the literature review, this part requires a study from the past journal that had been done by the professionals. The previous study had done some research throughout the project of hybrid energy.

In this literature review, all the articles are to compare to undergo an improvement towards the deficiency of the previous research. There is 3 literature review of a previous study. Based on the previous study, the results of every article need to compare to obtain an expected result as a reference to further observation.

2.1 A Review of Hybrid Renewable Energy Systems Based on Wind and Solar Energy: Modeling, Design, and Optimization.

This paper describes a new energy system that uses wind and solar energy methods. Its implementation is based on simulation, design, optimizing the output of electrical energy called PV-Wind. Energy trimmers, hybrid energy

storage, hybrid controllers for automation to achieve maximum power supply are proposed in this paper. Hybrid energy system components for power and power systems are developed. To achieve the goal of optimal power, the surface factor of solar panels is considered to replace the existing conventional energy sources.

By using a hybrid solar photovoltaic system with special materials used a polymer electrolyte membrane fuel cells, multilevel inverter, special battery storage can increase the maximum power electricity deliver for urban and rural areas.

With this system, the user can be widely used to help the rural population who do not have basic electricity facilities to carry out business activities, manufacturing, and entrepreneurship to improve the socio-economic community [2].

2.2 A Novel Off-Grid Hybrid Power System Comprised Of Solar Photovoltaic, Wind, And Hydro Energy Sources

Integrating a distributed energy system into a small-scale power improves reliability and performance of the power has become one of the techniques used to connect a hybrid photovoltaic system – wind system to renewables – dominant system by micro – connected grid. The findings have shown that these devices can be doped through the use of a combination charge controller and an appropriate electronic load controller [3].

2.3 *A Review on Hybrid Solar/Wind/Hydro Power Generation System*

Energy generated either by the combination of wind – hydro, solar – hydro, solar – the wind is far higher compared to a standalone system. Thus, when all the three parts are combined, the production is projected to be somewhat higher than the average two – stages hybrid systems [4].

2.4 Operation, Performance and Economic Analysis Of Low Head Micro-Hydropower Turbines For Rural And Remote Areas

Limited – head and micropower are the most convenient option to addressing the lack of electricity supply and economic difficulties in rural and poor areas. It is also vital to enhance research programs on this power scale [5].

2.5 Power Generation by Hybrid Approach Solar PV/battery Power/hydrogen Generation/fuel Cell

This paper discusses the development of hybrid systems that can use different renewable energies such as solar PV, wind energy, and biomass in combination with fuel cells, batteries, and hydrogen generators compared with a conventional method such as fossil fuels, biomass, etc. If many various choices of using renewable energy sources it will increase the electrical energy compared with a single source.

The direct current delivered by the solar module is used to charge the batteries. Meanwhile, the output inverter sine wave 230 V AC is connected to a hydrogen generator and 12 V DC to feed the electronic load-connected system. The hydrogen was generated is stored in the metal hydride canister to produce power when the solar PV in not function. This hybrid system approach is to improve and make the most of hydrogen production from a renewable source by storing the energy in batteries and utilizing this stored energy when power from solar is not available. The power will be delivered is 200W is quite complicated and high cost. [6].

2.6 A Substantial Modelling and Analysis of Solar Powered e-Rickshaw Drive System

This paper more explanation on the idea for modeling renewable energy with equipment and machinery to reduce polluted issues world. The methodology of e-rickshaw is based on the electric drive cycles with the solar charger, battery bank, electric motor, and e-rickshaw drive train. The electric rickshaw (e-Rickshaw) has a solar charging system with the provision of grid charging through a suitable DC power plug. The battery bank supplies the power to a dedicated electric motor to generate required mechanical torque and power to provide required speed to the e-Rickshaw through suitable converter compare old method using fossil fuel where it will produce high carbon emission and high noise.

This technique is suitable for short-distance between urban and rural areas. One of the main issues is energy storage, high cost for storage energy, charging battery time for a short period. However, this issue can be minimized using solar photovoltaic using maximum power point tracking (MPPT) technique shall be to improve the e-Rickshaw-drive range. The MPPT system will be operated to grasp the maximum solar energy and supply to the battery bank is monitored by the battery management system. Then, the electrical power from the battery bank is input to the electric motor through a DC-DC converter. The analysis for this system using Simulink Simulation shows that the speed e-Rickshaw from 12km/hr to 25km/hr for loaded 410kg – 750kg below 5 gradients and time taken to charge battery state of charge (SOC) are within 10% from low to high charge of the battery bank. It means that PV will absorb solar through MPPT faster 10% are compared from conventional such that can reduce air pollution and enhance the environment aspects [7].

2.7 Feasibility Study of Renewable Energy Using Levelized Cost Energy

The ideas from this paper are to provide the solution at Tioman Island using renewable energy using solar PV and hydro to supply electrical energy instead of diesel generator. Interm of calculation for the costing to reduce cost and sustainable energy for thought out of the year using LCOLE Excell. The total usage of electrical energy per night at Tioman Island is around 8.34kW to 4MW by a diesel generator. Therefore, the total cost of operating this typical diesel generator is very expensive. In the year 2015 TNB has incurred the cost RM14.4Milllion, the Year 2016 RM15.1Million, the Year 2017 RM15.8Million, the Year 2018 RM16.3Million. The cost increasing every year.

Due to that TNB take the initiative to propose a solar photovoltaic hybrid with Mini-Hydro compared to wind and diesel. Based on track of maintenance diesel needs to do maintenance frequently and they depend on the aging of generator sets, it will cause to replace with new gen-set. Also, gen-set delivers noise and high pollution. However, wind energy requires a windy area as wind not always blowing compare to water. In addition to that the renewable technologies are clean they do not need frequent maintenance as well as can reduce the workloads of workers. Therefore the installations of renewable energy can give more profits to TNB compared to the use of diesel generators which cause big losses to the company [8].

2.8 Renewable Tidal Power Generation Significance & Challenges

This paper describes a variety of renewable energy based on different sources such as solar, wind, hydro, ocean/tidal, geothermal, biomass, and geothermal. Hence, another energy potential from the underwater tidal turbine can be exploited for benefit of society. The availability of useful energy for power generation by tidal resource varies from 120 and 400 GW, dependent on the location and the prospective potential for conversion. Tidal energy is a form of green energy, it will not add significant carbon emissions required for generating electricity need for urban and rural. Therefore, adding an alternate energy source along with conventional energy sources like gas, fossil fuel, coal, nuclear, hydro, solar, and wind. Tidal energy possesses great potential for growing energy needs. It can also be utilized for energy consumption in coastal areas. The tidal energy potential can help overcome energy shortfall and enhance energy-related socio-economic activities in the coastal region. Following are the advantages and disadvantages of the tidal turbine.

Advantages:

- Tidal power is a green energy source in emitting zero greenhouse gases.
- Tidal energy required current water-flowing current and its energy-generating potential.
- The long-life tidal power plants are higher compared to the wind and solar plants. Their structure in developing tidal is concrete and built across river or ocean with proper safety.

Disadvantages:

- Need more studies on tidal turbines due to environmental degradation in the ocean will affect the force and pressure of waves.
- The tidal turbine needs more motor which rotates the blades, thus producing Electro-magnetic emissions into the ocean.
- Tidal power plants very expensive cost to built constructions

Tidal energy is a major source of sustainable green power. Therefore, from the above discussion, its advantages and disadvantages have been explained then it is proposed to include tidal as a green source for electricity source [9].

2.9 Pelton Turbine

This paper describes the alternative renewable energy from hydraulic systems for electrical generation. This method converts from hydraulic energy to mechanical lastly to electrical energy. Pelton turbine approached is implemented for large areas with specific parameters. Pelton turbines are requiring comparatively less quantity of water. Water is transported in penstocks from head race to the turbine in power generation house. Pelton turbine consists of a circular disc commonly called a runner on which several buckets are evenly spaced around its periphery. The impact of the water jet produces a force on the bucket causing the wheel to rotate. The jet of water splits equally by splitter and flows around the inner bucket surface and leaves at the outer edge of buckets. The advantage of using the Pelton turbine is that it works best at the high head and low flow conditions and produces higher power from a small turbine, and it is not necessary to be considered for specific flow conditions like other turbines. Also, the rate for each parameter of water such as jet velocity, flow, pressure, Pelton blade, and Pelton geometry are important criteria to generate electrical energy [10].

2.10 Review On Jet Of A Pelton Turbine

This paper more explained the performance of the Pelton turbine. The main factor will influence the performance Pelton turbine such as the shape of the water jet striking the Pelton bucket. Several variations of jet velocity, nozzle diameter, and nozzle angle are used to observed the performance and behavior of Pelton systems [11].

2.11 State of Art on Possibility & Optimization of Solar PV-Wind Hybrid System

The PV and wind systems, designing and improvement of the present scheme, as well as the various strategies for the management of the grid–linked and stand-alone systems were addressed. The main problem for the grid–bound network, along with the off-grid system is to satisfy energy demand by integrating two or more sources in parallel or changing the supply of multiple sources at various times of the day [12].

3.0 MATERIALS AND METHODS

Following are materials and methods for explanation in the development of this project.

3.1 Materials

a) Solar Panel

Solar Panels in Figure 1 are known as a radiant light trapper which easily absorbs the harnessed from the sun and converts it to electrical energy. A PV module is an assembly of photovoltaic cells that are mounted within an installation framework. Photovoltaic cells are sunlight as an energy source and generate electricity from the direct current. The effects of solar energy are recognized all over the world and that is why many nations' governments are involved in discovering the most effective ways to use it. Solar or photovoltaic cells form the basis for each solar panel system. It is necessary to understand how solar cell functions to understand the role of solar panels. Each solar cell has layers. One layer is positive, and another is a negative layer. That helps create an electric field. Photons from the sun also known as photons from the radiation join a cell where the electron is set free.

Figure 1: Solar Panel 12V

b) DC Motor Generator

A DC Motor Generator in Figure 2 is a small ratio of a motor-generator that produces a small number of voltages range from 3V – 24V. This DC Motor Generator produces different values based on the windings of the magnet inside the motor. The sum of torque on the generator determines motor-generator size and type. The most suitable winding of a given type of motor follows the current and voltage specifications produced.

Figure 2: DC Motor Generator

The collection data for the DC motor of generated voltage with the load is shown in Figure 3.

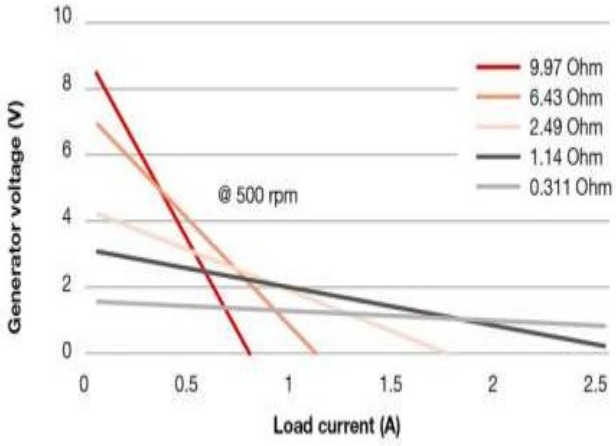

Figure 3: Data collected of a DC Motor rpm (V/A)

c) Charger Controller

The solar charger controller in Figure 4 is used to prevent overcharging the battery by regulating the current and voltage first from the solar module to the device. It is coded to the 15A / 200W unit and uses MPPT (Maximum Power Point Tracking) to accelerate the solar charging of the battery by up to 30% a day [13].

Figure 4: Solar Charger Controller

d). DC-DC Step-up Converter

DC-DC converter line–up encompasses a wide range of services. The Buck DC-DC converters do have high – performing configuration appropriate for input voltage plates. Quite a few attributes, along with current mode control, fixed ON time, and H3RegTM control, are provided to ensure interoperability with a diverse array of set needs. Figure 5 shows the DC-DC converter.

Figure 5: DC to DC Converter

e) 4 Channel Relay Module

The relay module in Figure 6 is a hardware interface unit used mostly for external system switching. This can manage equipment directly over the network. Platforms can be wirelessly powered on or off with directives coming from every software console to manage this relay switch. The relay is being used to detect external on or off circumstances and to control a diverse range of external devices. The correlation to the PC interface is made via serial ports.

Figure 6: 4 Channel Relay Module

f) DC – AC Converter

Figure 7 shows DC – AC converter is primarily utilized to convert a DC power supply to an AC power supply. DC power supply is relatively constant along with positive voltage source, while AC oscillates at a sinusoidal or square base level of approximately 0V. the transformer is an electrical system used to transform DC – AC. These devices are used by switching devices. DC – AC conversion can be made from 12, 24, 48 Volt to 110, 120, 220, 230, 240 Volt with 50/60 Hz frequency. Fast 12V DC – 240V AC transformer circuit intended to enhance DC – AC.

Figure 7: 12V to 240V Converter DC to AC

3.2 Methods

This section will describe the methodology to develop the project.

a) Block Diagram and Flow Chart

Based on Figure 8 is the block diagram for Solar Panel and DC Motor Generator are the sources to be charged into the battery. The current flowing need to pass through the charger controller which controls the battery intake supplies to recharge for standby mode operation. A 12V battery stores energy for the cycling process to be running continuously producing power for loads.

After the battery being charged by the two sources, DC voltage starts to flow to the relay gate which this relay is powered and programmed by the Arduino UNO to control the action of the voltage to pass through and goes to the converter. The Arduino UNO operating at 5VDC which controls the relay gate to allow the current-voltage to pass. From the relay gate, the DC voltage converts to AC voltage passing through the DC to AC converter and producing a 240V. For the overall project, observing the data output and input value from both sources which DC Motor Generator and Solar Panel produced.

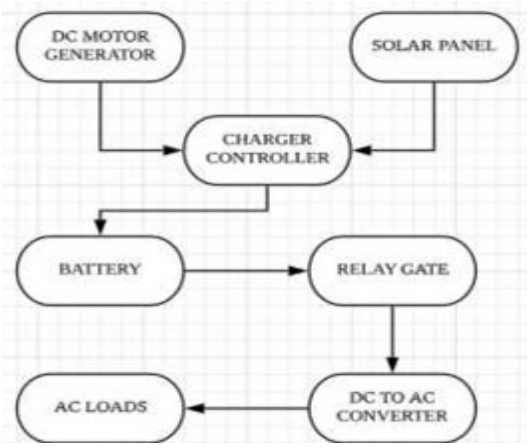

Figure 8: Block Diagram of the Project

The flowchart in Figure 9 is a diagram to illustrate the

sequence of movement which is involved in this project.

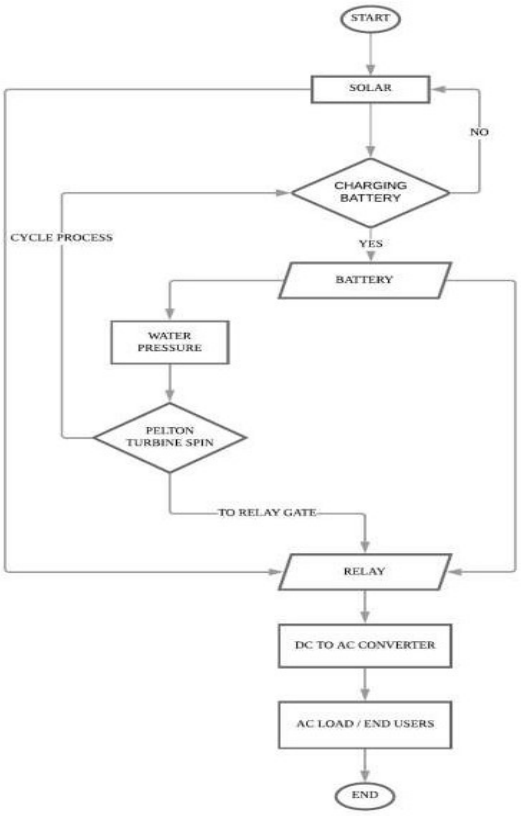

Figure 9: Flowchart of the Project

First and foremost, this hybrid cycle system requires two or three sources that will generate energy to produces electricity for better power. The first source is Solar which gains radiation energy from sunlight and converts it to electric energy. Then goes to the charging method that the solar power will charge a battery to store energy. The battery banks will power up a water pump to a direct current (DC) brushless motor that shoots water with very high pressure for the Pelton Turbine Wheel to spin.

As for the turbine wheel begin to spin, a second source from rotation mechanism energy is ready to converts and generate electric energy. This second source will start to generate electric energy which will directly produce DC power and also it will also do a cycle system that will recharge the battery that power up the water pump. The cycle system will occur in this part when the turbine wheel starts generating electric energy, the solar system will cut the connection from charging the battery banks and directly flow to the relay.

As for the final part, the relay stands as a gate for the DC supply to get through to flow into the DC to AC converter and supply to the end-users or any AC loads. The relay is a function to protect the circuit from damaging the converter. The relay is powered by the battery for a controller electronic device to turn on.

b) Charging Battery Process

Figure 10 shows the block diagram refer to the cycle process system where the charging process will always be charging with load output for DC load (DC water pump) to force the turbine fan to spin so that the DC motor generator maintains its power produce while solar panel gaining radiant light-absorbing energy to supply and send current flow to charger controller.

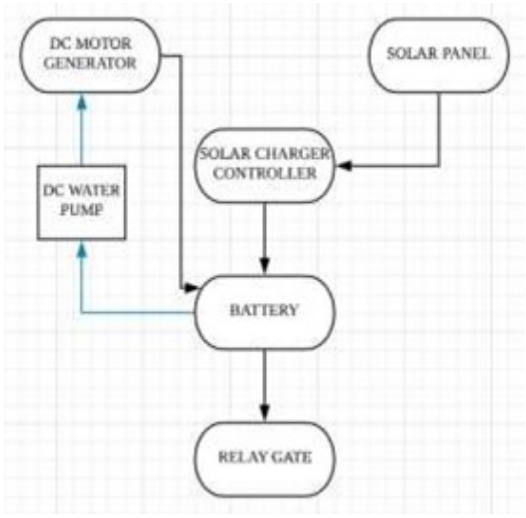

Figure 10: Process Charging Battery System

c) Schematic Diagram

Figure 11 shows the schematic diagram of installation and wiring for the whole system.

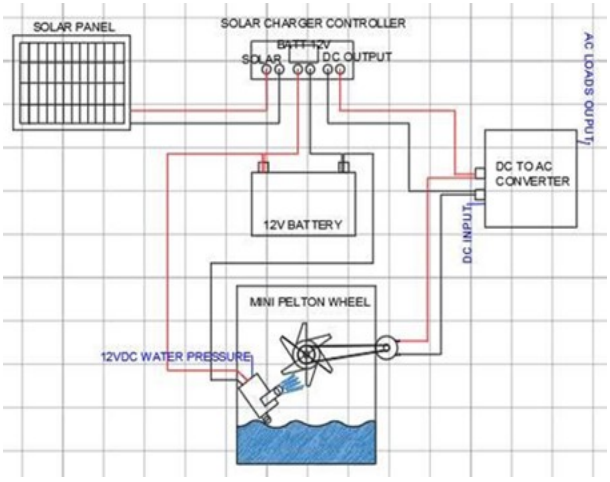

Figure 11: The Whole Schematic Diagram

4.0 RESULTS AND DISCUSSION

This section has described the results and discussion of development for this project.

4.1 Results

a) DC Motor Generator (Turbine)

Table 1 shows the results for the output DC Generator.

Table 1: Results for Output Voltage of DC Motor Generator

No.	Period (s)	Output Voltage DC (V)
1	10	12.83
2	40	12.76
3	70	12.30
4	120	11.39
5	150	12.15

b) DC Output Solar Panel PV

Table 2 shows the results for Output Voltage of solar panel PV.

Table 2: Results for the Output Voltage of Solar PV Panel

No.	Sunlight Radiation (%)	Vout (V)
1	80	24.0
2	70	22.0
3	60	21.4
4	50	20.7
5	30	16.68
6	20	12.43
7	8	9.11

Figure 12 shows the graph to present output voltage with the percentage of sunlight radiation.

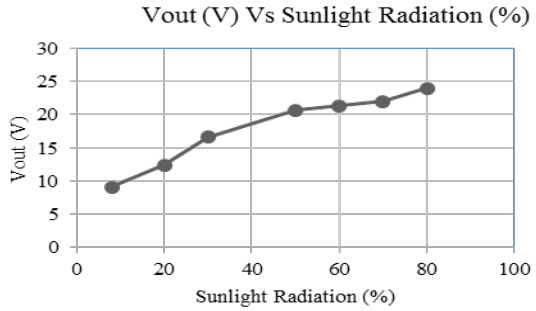

Figure 12: Graph for Output Voltage of Solar PV Panel versus Sunlight Radiation (%)

c) AC Output Voltage of Inverter

The output voltage of the DC-AC inverter is shown in Table 3.

Table 3: Results for DC-AC Inverter

No.	DC(V) (Input)	AC(V) (Output)	
1	21.4	238.3	
2	21.4	233.3	
3	20.7	228.3	

4.2 Discussion

Table 1 shows that the output voltage of a DC Motor Generator varies depending on the water pressure shot to the Pelton turbine blades, on average the output voltage is 12.29V. Table 1 also shows the minimum and maximum output voltage is 11.39-12.83V. It was found that the Pelton turbine had difficulty in rotating when the water in the water tank reached a level of 7-10 from the volume of the water tank because this water tank did not have water inlet and outlet holes. Therefore, water will stagnate in the water tank and prevent the Pelton turbine blades from moving strongly. The effect of this results in the voltage output of the DC Motor Generator being small.

Table 2 shows the output voltage produced by the PV depending on the percentage of sunlight radiation. It was found that, at 80% and 8% of the sunlight radiation, the PV panel would emit output voltages of 24V and 9.11V, respectively. In general, it shows that the PV output voltage will increase when sunlight radiation also increases. Thus, this behavior can be illustrated in Figure 12.

.

Table 3 shows the output inverter is AC in-between range 228.3 - 238.3V, 500W with load 125Ω. This AC output voltage will supply to the user who needs the electricity at a low cost for rural and urban use.

4.3 Prototype

Figure 13 shows the complete project prototype.

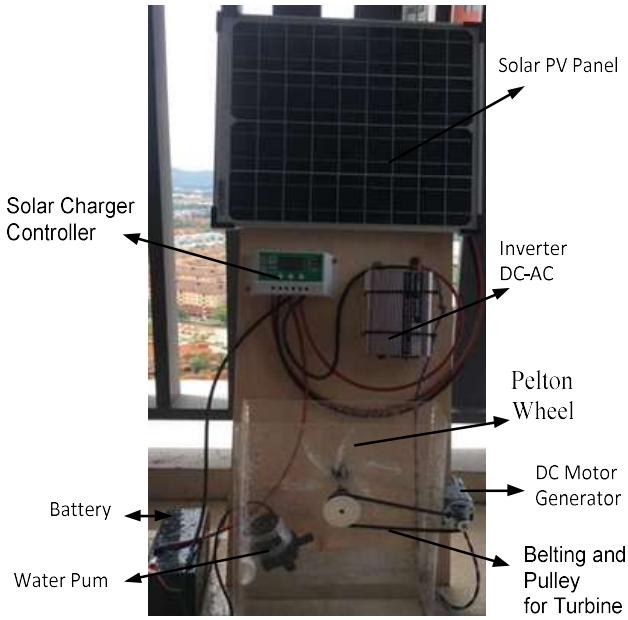

Figure 13: Prototype of Project

5.0 CONCLUSION

The development of a hybrid cycle system to generate electricity for the use of rural and urban areas especially residential areas has been successful. However, the output voltage produces by this system is AC 233.3V. It is shown that the error is 2.8%. It means that this error is quite low and acceptable.

6.0 RECOMMENDATION

There are several suggestions to improve the performance of this system.

1. Improvements in safety in protecting the circuit from becoming a short circuit to save all components that have been installed and also to avoid a long time for troubleshooting.

2. Improvements in designing Pelton turbines so that they are more practical and powerful. With the appropriate Pelton design, the Pelton turbine can rotate freely on the DC Motor bearing so that the DC Motor Generator can produce a large and consistent output voltage.

3. Improvements in the Pelton turbine casing so that no water leaks out of the casing.

4. Improvements to the water container by creating water holes in and out to prevent water from stagnating in the water container so that the Pelton turbine can rotate freely.

5. Replace the water pump with jet water so that the jet water can shoot with strong pressure to the Pelton turbine blades.

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