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# SMART MULTI-APPLICATION ENERGY HARVESTER USING ARDUINO

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## ABSTRACT

This paper presents a Smart Multi-App Harvester Energy Using Arduino for energy harvesting. The system consists of a few mechanical parts such as solar, thermal plate and dynamo (for kinetic) to harvest the energy. The objectives of the project are to harvest the wasted energy from the mechanical parts and used it as a backup and also as an alternative energy source to provide a small power supply. An Arduino is used as a controller to limit the power stored from the input. A boost converter will be used to covert a direct current to an alternating current. The harvested energy will be stored in a storage circuit, which consists of lithium ion battery. By using a voltage regulator, the input voltage is regulated to 5V and then amplified to 220V or remained at 5V for the output. The power stored from the harvested energy can for other device applications.

**Keywords:** harvest energy; Arduino; multi-application; natural energy.

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## 1. INTRODUCTION

Energy harvesting can be defined as power harvesting or energy scavenging which is a process that captures small amounts of energy that would otherwise be lost as heat, light, sound, vibration or movement. It uses the captured energy to improve efficiency, enable new technology, etc. which provide significant economical and environmental impact. Energy harvesting utilizes naturally occurring sources of energy and converts them into forms that can be utilized in the normal ways. Traditionally, energy has been taken from coal, gas, fossil fuels etc. which are finite and environmentally costly. However, to ensure that greenhouse gasses and other forms of pollution are not created, energy harvesting techniques can be used to overcome the climate change and global warming. Although large wind [8] generators could be termed energy harvesting, this technology typically looks more at the forms of energy harvesting that provide small amounts of power for powering low-energy electronics.

**1.1. Energy Harvesting Sources**

There are a number of sources of energy that can be used for energy harvesting namely solar [12] power, thermal [11] energy, wind [15] energy, tide energy, kinetic [13] energy, etc. There is plenty of energy available within the environment. The challenge is to harvest or capture the energy and convert it into a usable format. Different types of waste [9] energy can be captured using different energy harvesting techniques. The most promising microscale energy harvesting technologies [1] in development including vibration, movement and sound can be captured and transformed into electrical power using piezoelectric [19] materials, heat can be captured and transformed into electrical power using thermoelectric and pyroelectric materials.

**1.2. Energy Harvesting Basics**

Energy harvesting technology aims to convert ambient energy into electrical energy that can be used for a variety of purposes. It has attracted a considerable degree of interest in wide application. Some systems convert motion such as ocean waves into electricity to be used by oceanographic monitoring [26] sensors [4] for autonomous [16] operation. Future applications may include high power output devices (or arrays of such devices) deployed at remote locations to serve as reliable power stations for large systems. Another application is in wearable [6-7] electronics where energy harvesting devices can power or recharge cellphones, mobile computers, radio communication equipment [18], etc. All of these devices must be

sufficiently robust to endure long-term exposure to hostile environments and have a broad range of dynamic sensitivity to exploit the entire spectrum of wave motions.

### 1.3. Energy Harvesting Techniques

There are many energy harvesting techniques that are available. The actual techniques to be employed will obviously vary according to the source and the form of energy to be harvested and also the load [10] to be supplied-some will be very small (e.g. remote wireless sensors [2], etc.) others will be much larger (e.g. to provide energy for motors, etc.). There are many technologies that can be used for energy harvesting such as RF energy harvesting, piezoelectric energy harvesting, thermo-electric energy harvesting, wind generators, solar cells, etc.

### 1.4. Harvested Power Storage

Often harvested power sources may not produce an even supply of power. Solar energy [3] or wind energy are two good examples of this. Unfortunately many loads need a constant supply of electricity otherwise they may cease to function when they are needed.

In order to overcome this, power needs to be stored. There are a number of alternatives that may be used for power storage dependent upon the application / power requirement namely capacitor, super capacitor, rechargeable batteries, etc.

This project proposes a green technology called Smart Multi-Application Energy Harvester using Arduino. It is a combination of several types of energy harvester circuits to recycle several types of natural energy. The circuit combination can be done using Arduino microcontroller. The project will store the harvested energy by using mechanical [5] part like solar panel, thermal plate and dynamo (for kinetic energy) as the input. This is an automatic technology where it harvests the energy during rainy or sunny weather. Energy will be harvested in both situations where solar panel and thermal plate are used in hot condition, while water turbine and wind turbine are used in rain [14] condition.

The harvested energy is a DC power because it is directly from natural energy and need to be converted into AC using inverter. The harvested energy will be stored in the storage circuit which consists of lithium ion battery. The energy will be ready to be used after the harvesting process. It is usable by small type of electrical appliances, which need a little amount of

energy such as for charging. The project also can be as a backup source when there is a power outage or disruption. So, the project aims to reuse, reduce and recycle the wasted energy that commonly happens nowadays. It also helps the public to use it when needed as an alternative.

## 2. METHODOLOGY

### 2.1. System Overview

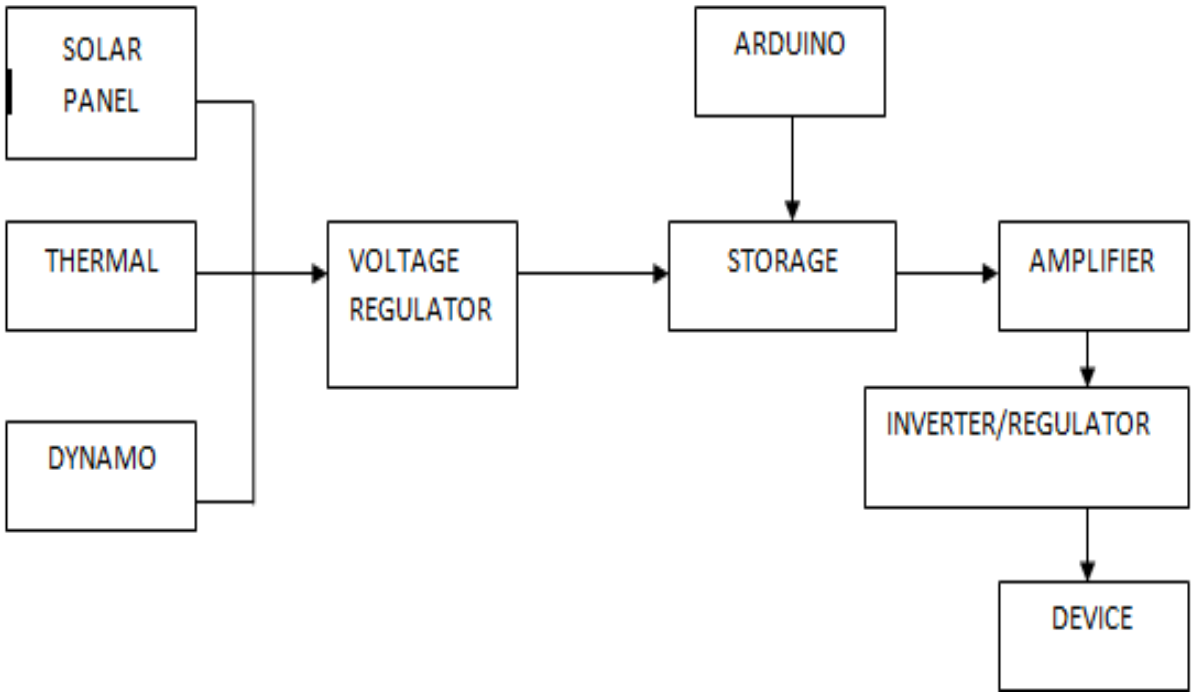


**Fig.1.** Block diagram of proposed design

Fig. 1 shows the block diagram of Smart Multi-Application Energy Harvester using Arduino. The mechanical part like solar panel, thermal and dynamo are used to harvest energy from natural energy. Then, it will be stored in the storage. Boost converter is used to convert the harvested energy from direct current source to alternating current source. The Arduino is used as a switch to control the capacity of harvest power in storage. The power from storage will amplify the power to 220V and 5V. The output for the project is to store the energy in a device or as a charger.

### 2.2. Flow Chart

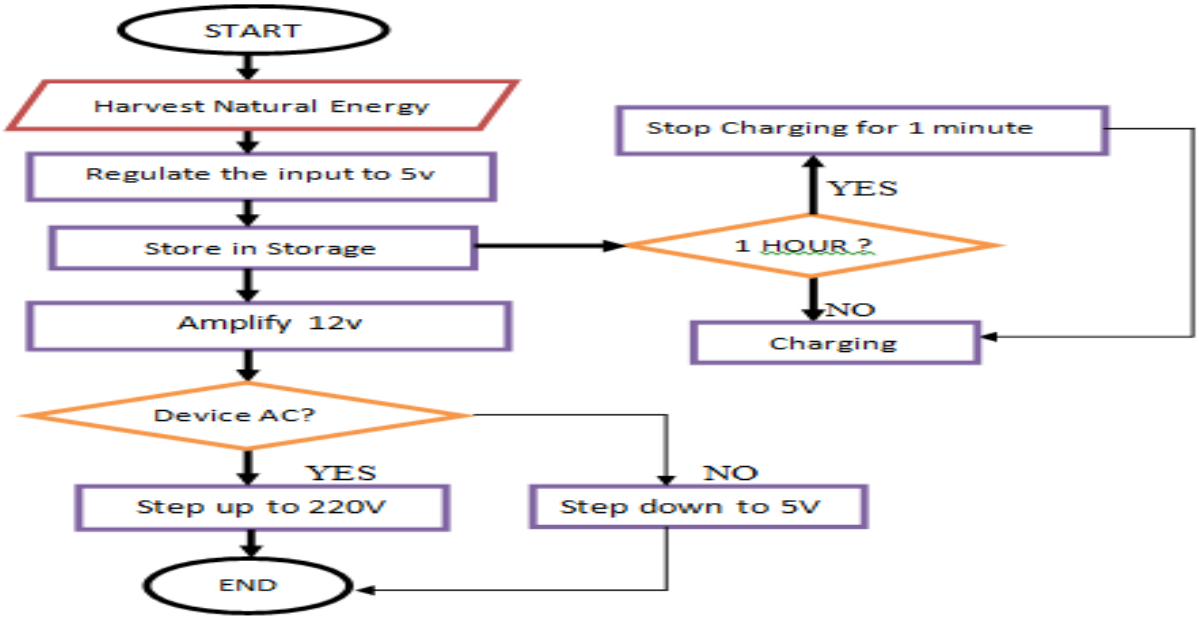


**Fig.2.** Flow chart of proposed design

Fig. 2 shows the flowchart for the Smart Multi-Application Energy Harvester using Arduino. The project starts when the natural energy is harvested by solar panel, thermal, dynamo for kinetic energy and stored the power in lithium ion battery. The value of input is varied and the power need to be regulated to 5V storage. The period to charging the storage is limited to one hour, then will stop charging for one minute to avoid overheat. The function of Arduino is to control the capacity harvest power from mechanical part to store in storage. The output circuit needs to amplify the power from storage to 12V. The users are able to use the stored power through device or as a charger. The output of the project can be used neither in DC nor AC.

### 2.3. Input Circuit

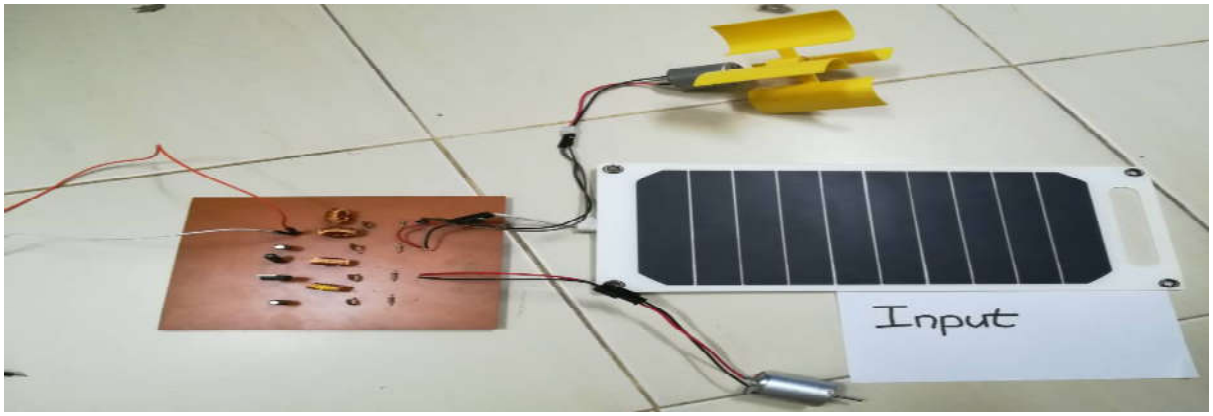


**Fig.3.** Input circuit

Fig. 3 is a combination of mechanical part as the input which are from solar panel, wind turbine, water turbine and also thermal generator.

### 2.4. Solar Panel Circuit


**Fig.4.** Solar panel circuit

The solar panels convert the sunlight into a usable amount of DC electricity. The DC electricity is fed to the storage via a voltage regulator.

### 2.5. Wind and Water Turbine Circuit

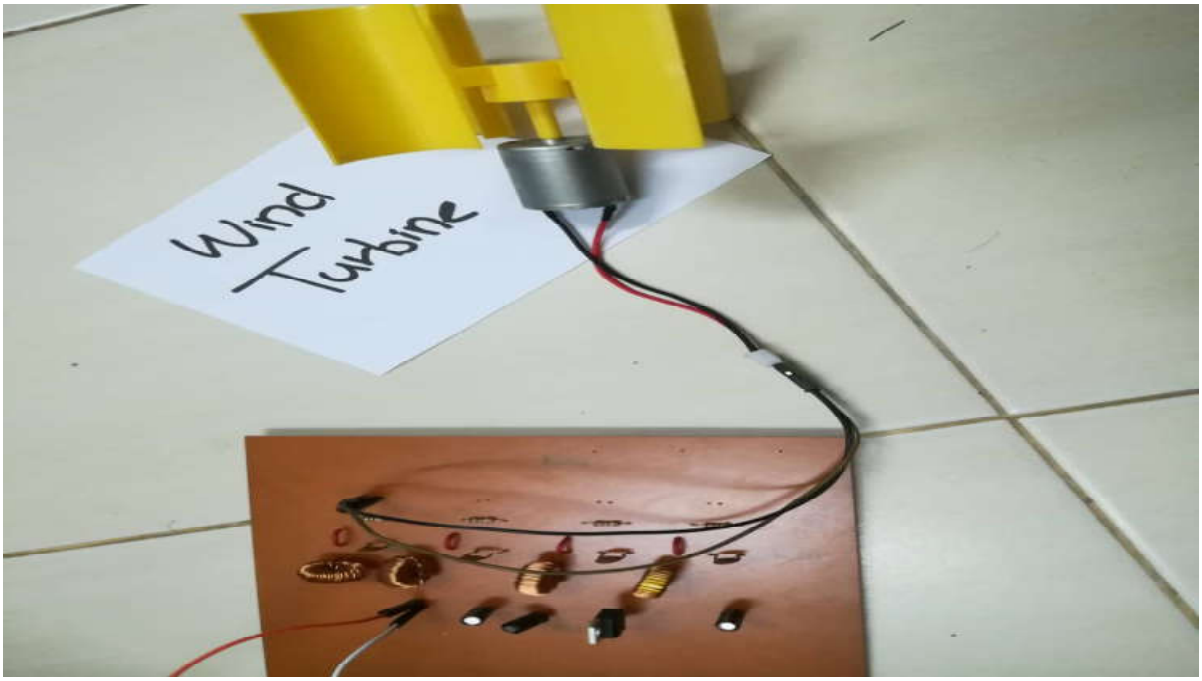


**Fig.5.** Wind turbine circuit

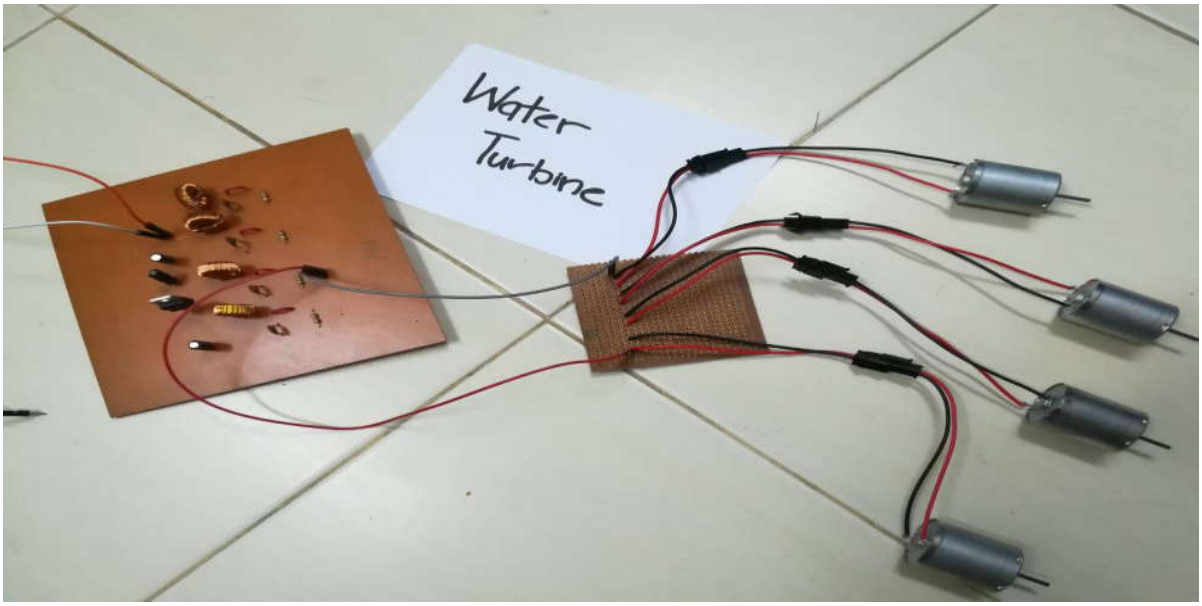


**Fig.6.** Water turbine circuit

Both water and water turbines use dynamo. The turbine converts the kinetic energy into mechanical, then electrical energy. The harvested energy is fed to storage using voltage regulator.

**2.6. Thermoelectric Power Generator**

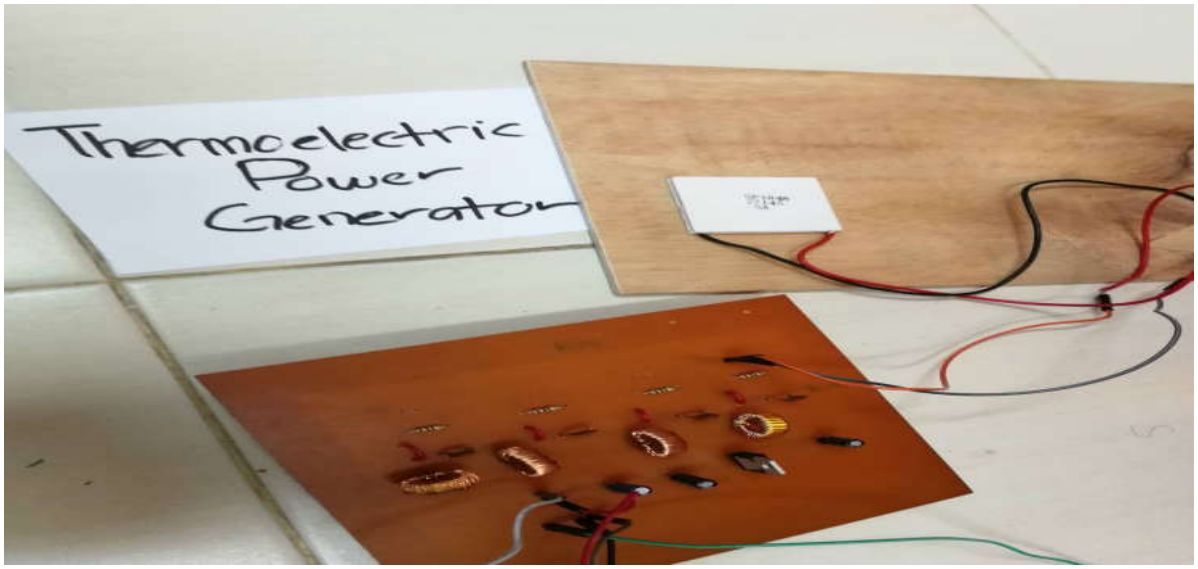


**Fig.7.** Thermoelectric power generator

Thermoelectric generator will convert heat into energy, which applies Seeback effect. The Seeback effect produces an electric current when dissimilar metals are exposed to a variance in temperature. The voltage produced by thermoelectric generator or Seeback generator is proportional to the temperature [17] distance across between the two metal junctions.

### 2.7. Voltage Regulator and Storage Circuit

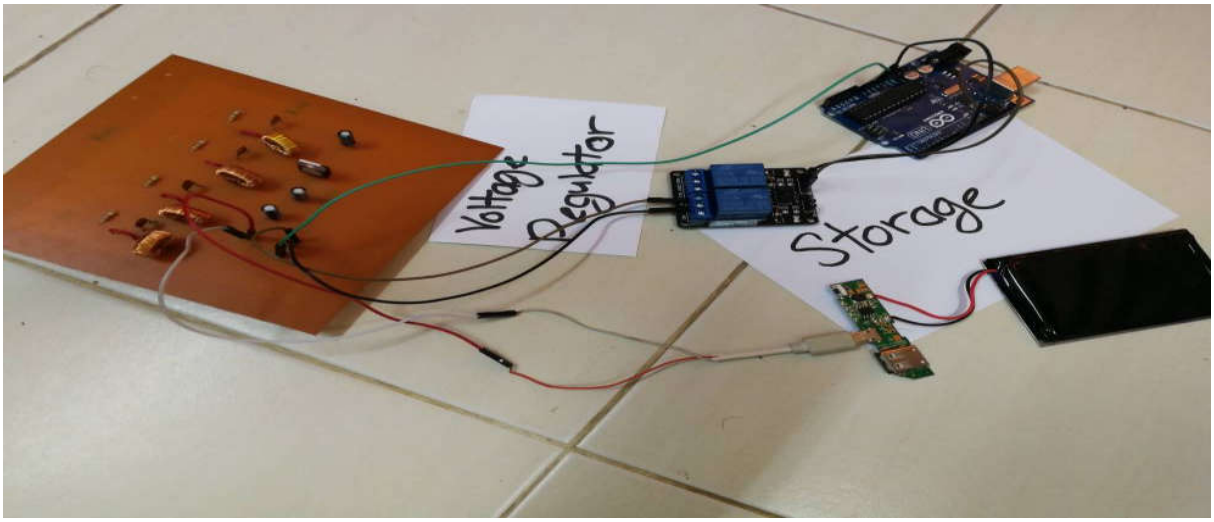


**Fig.8.** Voltage regulator and storage circuit

Harvested power is not same from various of inputs. The power at the storage circuit need to be regulated to 5V using voltage regulator.

### 2.8. Boost Converter and Output Circuit

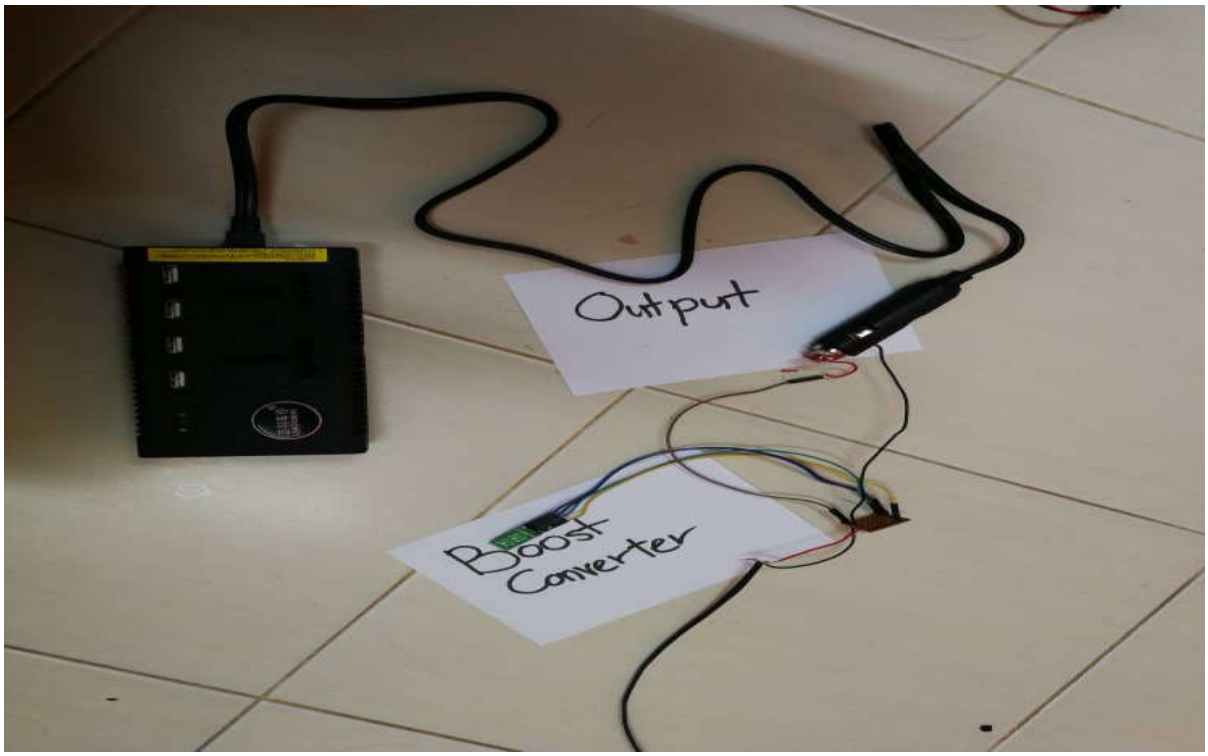


**Fig.9.** Boost converter and output circuit

The boost converter converts an input voltage to a higher output voltage. It is also called as a step up converter. The output of the boost converter circuit can be used for both types of currents, either DC or AC.

## 3. RESULTS AND DISCUSSION

### 3.1. Results

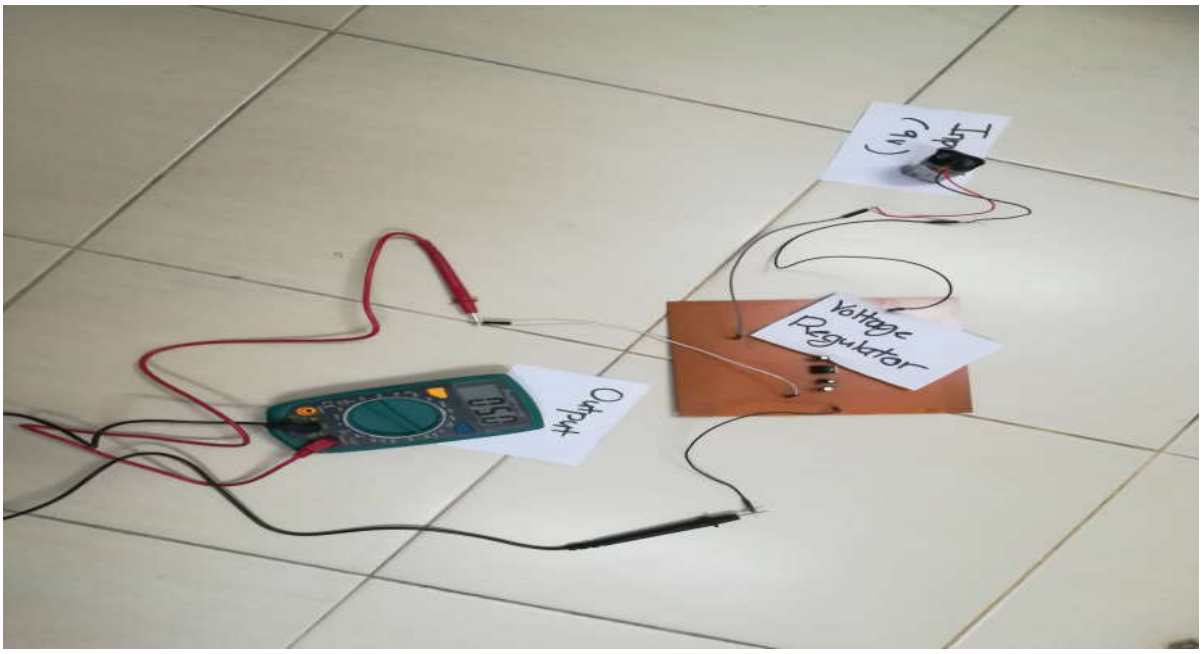


**Fig.10.** Measurement of voltage regulator

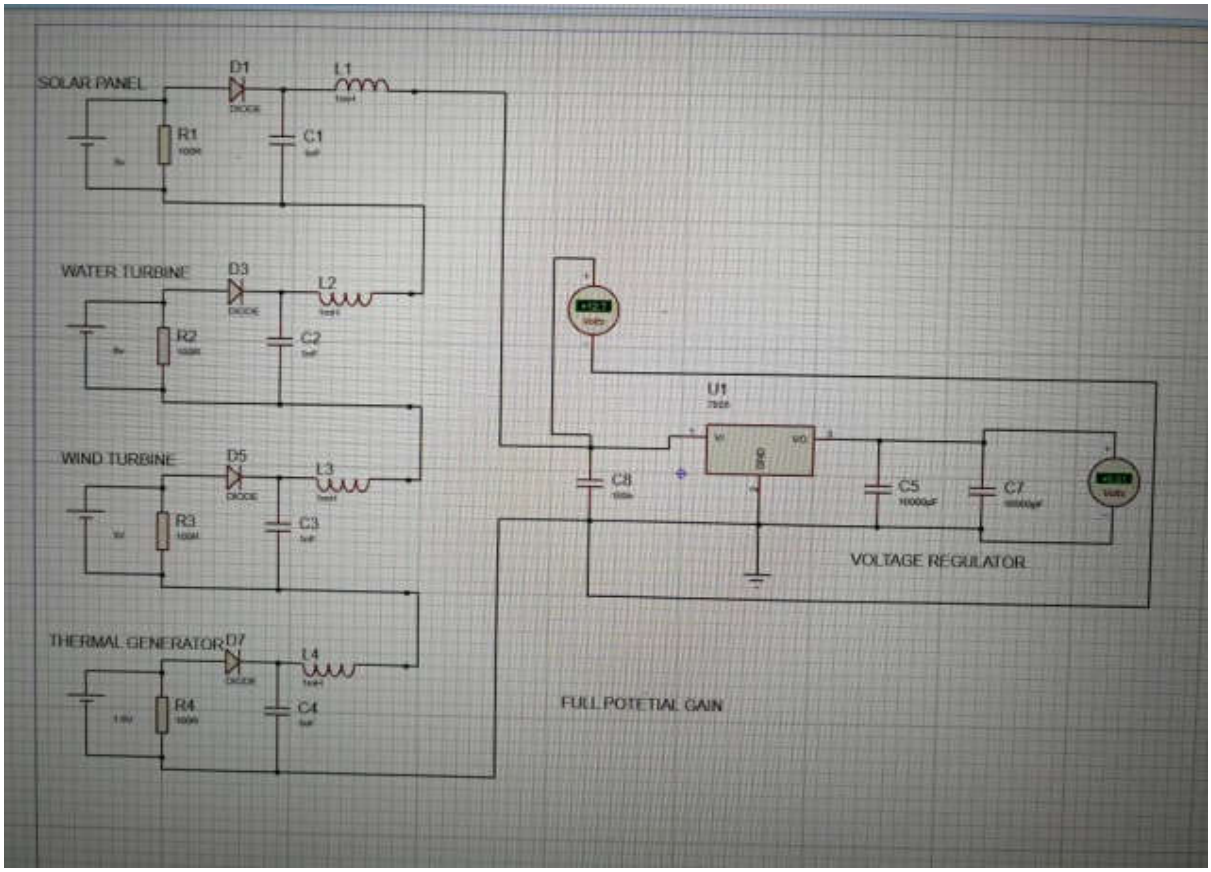


**Fig.11.** Simulation result

This circuit consists of various inputs. The value of each input is different. The value of input

power is amplified to 12V. The harvested energy will be stored in storage circuit. The maximum value of the storage circuit only 5V of power. Therefore, by using voltage regulator, the voltage is regulated to 5V.

### 3.2. PCB Board Layout


**Fig.12.** Complete circuit

Fig. 12 shows a full circuit of Smart Multi-Application Energy Harvester using Arduino. The circuit consists of panel solar, wind turbine, water turbine and thermal generator. The harvested energy will be stored in storage circuit. Voltage regulator is used to regulate the power of input. Arduino in this circuit is used as a controller or a switch to the storage circuit. The period of charging the storage circuit is limited to one hour, then the charging process will stop for one minute to avoid overheating. This charging process will controlled by Arduino. Boost converter can supply large over voltage, they will always include some regulation to control [24-25, 28] the output voltage. However, it is important to remember that as. If the output voltage is increased, the available output current will decrease. The output can be in two types either DC or AC. So, user can used both.

**Fig.13.** Center view of prototype

**Table 1.** Time taken to charge 1% of the storage circuit

| Current (A) | Time (min) | Rate of Charging | |
|---|---|---|---|
| 1 | 30 | 200 mAh | 1% |
| 0.5 | 57 | 200 mAh | 1% |
| 0.3 | 95 | 200 mAh | 1% |
| 0.1 | 285 | 200 mAh | 1% |
| 0.05 | 570 | 200 mAh | 1% |

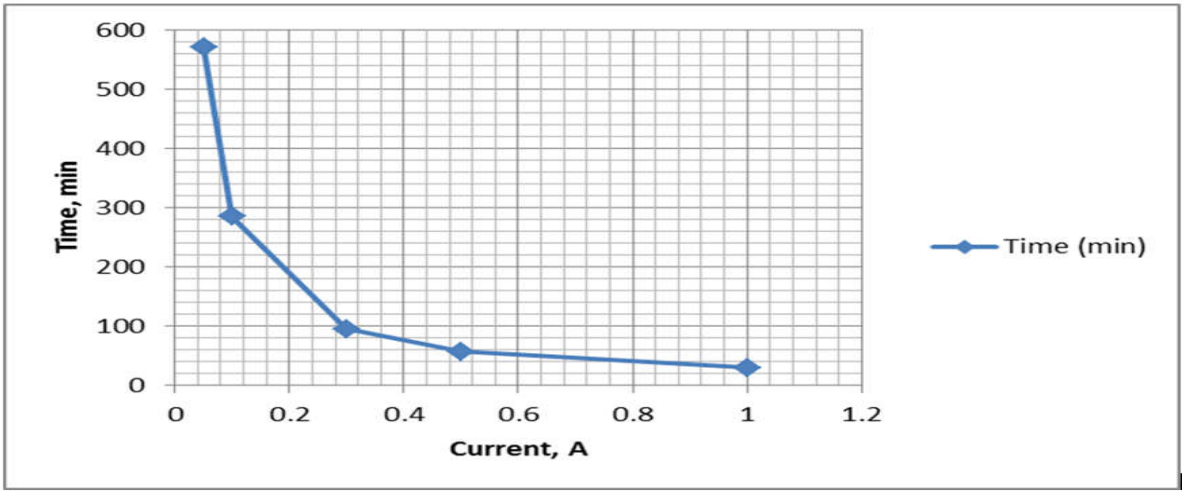


**Fig.14.** Time (min) versus current (A)

**Table 2.** Percent of output discharge (%)

| Output Discharge | |
|---|---|
| DC (min) | AC (min) |
| 1% | 3% |

This circuit consist of varies input with different value, but is combine and amplified to 12V max at full potential. The harvest power will be stored in storage circuit (20000mAh) which can only feed 5V, so the voltage is regulated to 5V. The Arduino worked as controller [27] or switch to the storage circuit. When specific amount of time passed, Arduino will stop the storage circuit from charging. For the output circuit, voltage regulator is used to step down the voltage to 5V while inverter used to step up and covert it to AC which can supply 220V. As the result, the project called Smart Multi-Application Energy Harvester using Arduino successfully is demonstrated. Smart Multi-Application Energy Harvester using Arduino [20-21] is an automatic [22-23] technology, where either the weather neither hot nor rain. It will automatically harvest the energy. By using mechanical part like solar panel, thermal plate and dynamo (for kinetic energy) as the input, it will detect the daily weather and harvest the energy into electrical energy. The variation of weather condition affected the current generation at the input circuit. The input current affects the rate of charging. If the input current is high, the rate of charging will become faster. Low current flow will cause the shortage of power to operate AC devices properly. The output will be discharged in alternating current (AC) and direct current (DC). The storage will discharge 600 mAh (3%) from the storage circuit every 1 minute for AC output, while 200 mAh (1%) every minute for DC output. Lastly, the power can be used by user as a charger for any device.

## 4. CONCLUSION

In conclusion, the concept of reducing, reusing and recycling is correctly applied in this project. The aim to design this unique circuit is accomplished. The prototype works accordingly to the proposed idea. However, the operation varies as the components used for energy harvesting are low powered devices. There are several changes have been applied from the previous prototype to increase its performance. For the future research, some

improvements can be made by focusing on other types of energy harvesting source and devices which use different harvesting method.

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