Development of monitoring system with IoT technology for harvested energy from burning process

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ABSTRACT

In this paper, it is being proposed on the development of the product that consists of thermoelectric generator (TEG) with integrating IoT system. The product is mainly concerned to harvest the heat energy using biomass sources to generate electricity, DC and AC electricity for community need. Besides that, analytical graphs have been produced based on the data collected and these data can be viewed into a different dimension such as gadget based or web view based as the data will be called-off from each time the burning process happens.

Keywords: *Thermoelectric Generator (TEG); IoT; Biomass; Heat Energy; Electricity.*

Introduction

Energy has constantly been the most basic thing for the headway of economic and social improvement in country [1]. It is never again observed as

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extravagance as it used to be. Anyway, it has transformed into a drive-in our standard everyday exercise. The world is talented with sustainable power sources, for instance as hydro, wind, solar based, geothermal and tsunami however the majority of these sustainable power source assets are not fully utilized. As Gima and Yoshitake [25] concluded in their study on energy security, the diversification of power generation and innovation regarding clean energy are important key factors for energy security. Therefore, the availability of local capability in energy power plant should be an immediate goal of the development. More noteworthy improvement of these benefits will be required centering alternate points of view and tremendous test. Solar based is a standout amongst the most useful strategy that can be seen actualizing the greater part of the spot on the planet [2].

Solar Energy has been the most utilized sustainable power source since its simple execution and the method for use. Most of the organizations have utilized sunlight based Energy as their elective source other than the average power that as of now they have. Be that as it may, at a point, solar energy cost high when it's gone to the upkeep and the measure of sunlight based tile utilized and the extent of the tile is huge and expend a ton of room for the execution [22]-[23]. TEG module is one more elective approach to collect the heat energy and is converted to power [3]. In this paper, a prototype has been established utilizing the TEG module, to change over the heat energy to electrical and channel it into AC and DC sources. TEG is utilized in this undertaking primarily because of the cost sparing and simple upkeep. The size of the TEG module is small and does not need much space whenever contrasted with a solar tile [3].

As of late, numerous analysts worried about Energy gathering, which is the procedure of extraction of Energy from the outside encompassing. Bagheri [4] asserted a response for little scale off matrix implemented by abusing the temperature tendency that exists in the typical condition. The results were distributed in the paper that the proposed gadget can work both in winter time just as mid-year. In 2016, [5] proposed a consolidating low voltage interior start-up circuit and DC-DC Boost Converter for low voltage thermoelectric generator (TEG). Detailed outcomes demonstrate inductor base Boost converter most extreme power yield voltage is 40 μW [5]. In extra, Bozalakov [6] present a sustainable power source which uses waste heat to produce electrical energy. As per their outcomes, the choose Seebeck unit can deliver enough energy to charge any sort of cell phone.

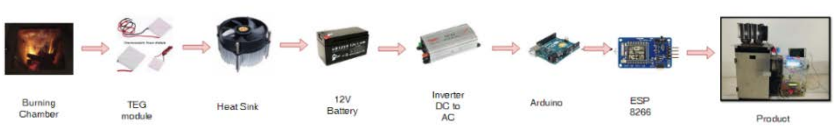

Figure 1: Block diagram of the project

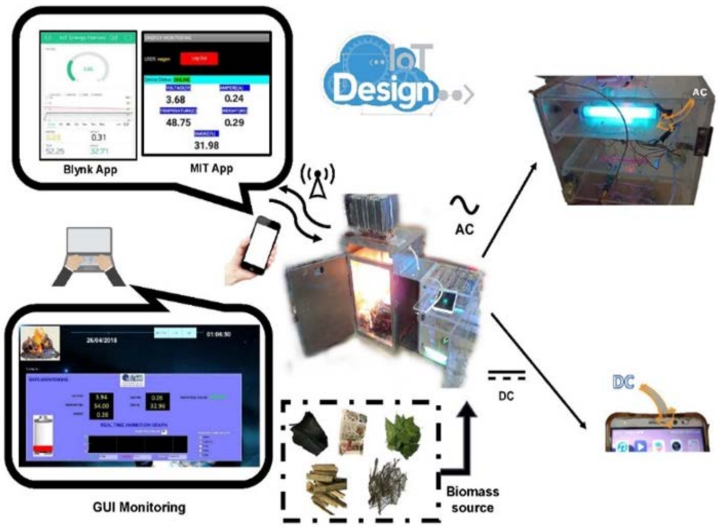

Figure 2: Illustration diagram of the project

In view of past examinations and research, for the improvement, energy from the TEG is stored in a battery and consistently energize when the consuming procedure happens [7]. Other than that, an observing structure incorporated with IoT based for the reason to gather an assortment of information regarding emissivity of material voltage that produces by TEG subject to the material for a scope of time and smoke parameter that was directed. Starting late, gadget such as handphone has been a champion among the most useful contraptions in human life. Regardless, the handphones have been important and the most used gadget in human life. On outdoor activities, a mobile phone is carried out to contact people at the outside if there ought to emerge an event of an emergency. In any case, if the handphone battery is empty after a period of utilization, the handphone can't be used again until the point that the battery is battery-powered. Besides that, there are various emergency situations where this product is beneficial for the community, for instance, flood, and power surge. In such an emergency condition, people must find selective ways to deal with this emergency situation. This prototype is an advantage fitting for outside activities and these sorts of emergency conditions. In this manner, individuals need to know how to produce power from the source and this product is convenient and useful to use during such a crisis happens. As such, people need to make sense of how to deliver power from the source and this item is helpful and valuable to use amid such emergency occurs. This project has the novelty where by using the biomass sources, the heat energy that produced based on that can channel into two different sources of energy which is AC and DC. Hence, the product could be beneficial for the community especially during flood or power surge happens where by using this product the power could be generated for a temporary time of period. Furthermore, this product can also be beneficial for indigenous people in rural areas where electricity is a major problem for them. These rural villages are rich in biomass sources and there is often no electricity, hence this product can benefit them to provide electricity by utilizing biomass sources around them. In comparison with the conventional product that sells in the market, those two source features are not available where it only has a DC source of energy.

Methodology

TEG module is the vital component use to change overheat energy into electrical energy and the result is that from conversion from the TEG, the electrical sources that produce will be kept and stored into a battery and it will keep continuing to energize while the item in progress or in use [8]. The reason TEG module utilize in this project because the cost of the module is very cheap and no maintenance required compared to solar panels is very expensive and it requires maintenance. Hence, due to the cost factor TEG module were used so that electrical energy is able to produce.

Figure 1 demonstrates the block diagram and explain the flow of the product whereas figure 2 shows the illustration diagram of the project including the hardware and software that were used in this product structure. Biomass source was utilized for testing the item and the output was subsequently broke down and analyzed the material heat emissivity to comprehend the power gain delivered by every material. The five basic segments to execute this task are starts from TEG module, Arduino, sensors, ESP Wi-Fi 8266 module and it is considered to be successful whenever the data are pumped and stored in the server and can be retrieved for analyzing the graphs. The TEG module will be dynamic when there's an energy harvesting process going on [9]. The information store in cloud server can be recovered whenever relying upon the structure or data that required amid the specific minute dependent on the prerequisites [11]. Sensors like weight, voltage, current, temperature and smoke. Temperature sensor utilized in this project is thermocouple which can quantify the temperature running from 0 to 1024 deg. C (32 deg. F to 1875 F). Next, weight sensor HX711 load cell speaker can measure up with respect to 5kg. MQ-7 module Carbon monoxide gas sensor utilized to distinguish the smoke and the conspicuous centre is10-1000ppmCO. 5A Range Current Sensor Module ACS712 was utilized and voltage acknowledgment module voltage sensor for Arduino voltage with ID extent of DC 0.02445V-25V was used to record voltage perusing [12].

System fabrication

This project consists of integration between hardware and software. For the hardware part, the focus on the development of the innovation from the design of the whole structure till the placement of TEG as in figure 3 and most importantly how the heat sink and the TEG should be designed at final. Next would be the connection between the Arduino Uno and sensors shown in figure 4, such as voltage, current, weight, temperature modules by using wires were mainly focused for the development of IoT integrated platform by using the ESP Wi-Fi module to interconnected synchronize the data over the Android App neither GUI. The development of software was another part of these project compromises because a monitoring system was needed to monitor the output result when burning process happened. In this project, as mentioned earlier, the ESP8266 Wi-Fi module was used to connect with the app using the Blynk server by configuring the Wi-Fi module [13]. The Blynk app activated via phone and merge the auth token are added with the coding as in figure 5, and the Blynk server will be used to retrieve data from the ESP8266 Wi-Fi module to the IoT interface through the Android app at the phone. All the interfaces that used in this project such as GUI and MIT app will share the same consequence with synchronization simultaneously at a time. Blynk server and Google administration are utilized to store every one of the information that will be created through the Blynk application.

Figure 3: Heat Sink with TEG Arrangement

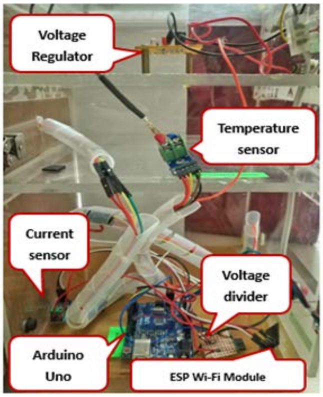

Figure 4: The connection between Arduino and sensors

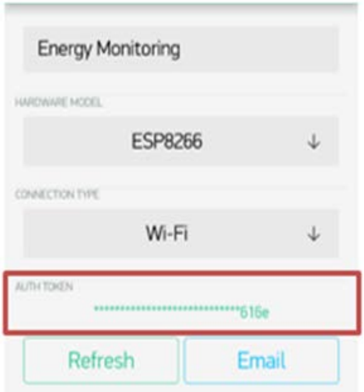

Figure 5: Authorization token from Blynk app

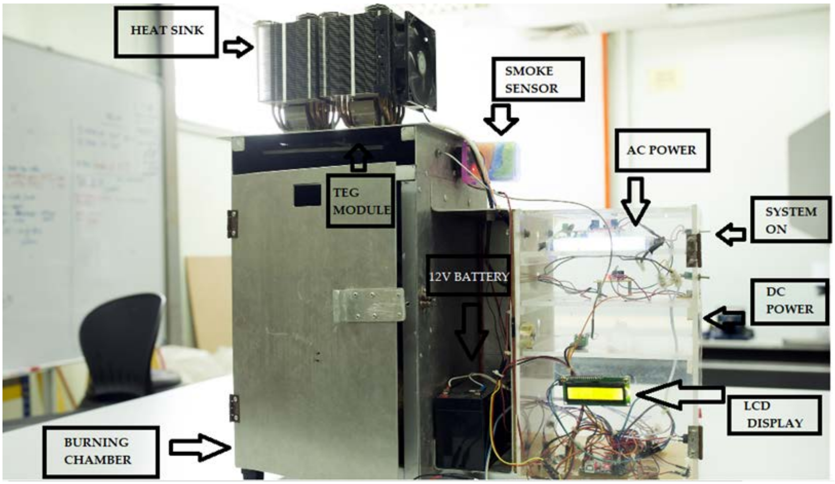

Figure 6: Prototype setup of the product

Analysis

In this work, exploratory information has been gathered dependent on the prerequisites for figuring the internal resistance, output power estimation of efficiency. The data parameters such as voltage, temperatures, power, weight, and current have been taken into account.

TEG Internal Resistance

The voltage and power generated would be affected by internal resistance (Rin) [24]. Therefore after VOC and VL are measured, the Rin can be calculated as [14]:

$$Rin = \frac{(Voc - VL) \times \text{RL}}{VL} \qquad (1)$$

Output Power (PL)

The output power (PL) can be obtained by taking into account Rin, RL and VOC [15]:

$$PL = \frac{V^2 oc}{(Rin + RL)^2} \times RL \qquad (2)$$

At that point, the power density (PD) can be determined as the output power (PL) separated by the area (A) of the TEG.

Biomass Gasification

The distinction contrasted with burning is that the measure of oxidant, for example, oxygen in air or unadulterated oxygen or then again steam, isn't sufficiently high to power total oxidation, for example, ignition**.**

Biomass has an erratic issue extent, favoring frames that grow pyrolysis and breaking, conveying increase in CH4/H2, appealing for use in the most nearly business control gadgets. The responses occurring amid the various strides of gasification are [16]:

$$C(s) + H_2O \rightarrow CO + H_2 \qquad (3)$$

$$\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2 \qquad (4)$$

$$\text{C(s)} + 2\,\text{H}_2 \rightarrow \text{CH}_4 \qquad (5)$$

$$\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2 \qquad (6)$$

Experimental Investigation

There are 5 kinds of factors contemplated which are voltage, current, temperature, weight and smoke watched. These are recorded and broke down dependent on various sorts of material consumed, for example, leaves, twigs, wood, paper, and charcoal.

Regression data analysis

This examination was carried out to discover the connection between the factors and kinds of materials utilized, for example, charcoal, twigs, leaves, wood, and charcoal. Next, this investigation is vital on the grounds that by playing out this a linear regression line between the kind of material and power discharge is obtained. The following are the information acquired for power and voltage is determined to utilize scientific condition which P=VI.

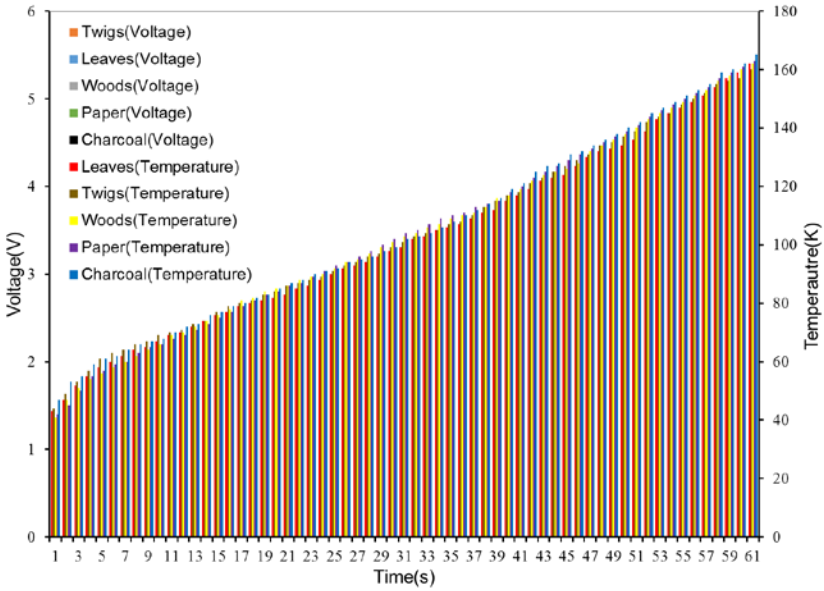

Figure 7: Voltage and Temperature vs Time

Experimental results

Data of voltage and temperature data were compared against time and presented in the form of a bar graph as showed in figure 7. It tends to be seen that as the voltage increase the temperature also increase. Hence, this is tallied with the thermoelectric generator hot and cold side characteristics whereby the temperature of TEG increases when the voltage increase [17]-[18]. Therefore, the experimental data obtained is proved theoretically by taking into consideration the properties of the TEG module.

Next, data of power were presented in terms of the chart as showed in figure 8. It shows charcoal produced the highest energy compared to the other materials. Twigs harvest the least amount of energy due to its low emissivity value [19]. Wood position after charcoal for heat emissivity since the fixed carbon made by wood lower appears differently in relation to charcoal. Power increments continuously and the material can support a satisfactory measure of voltage for delivering power [19]. All the materials tabulated according to their rank of delivering energy as shown in table 1. Hence, it can be seen the power increase from twigs to leaves is 2% whereby there is a drastic increase in energy approximately 15% from leaves to paper followed by a small increase from paper to wood and 5% of the increase from wood to charcoal.

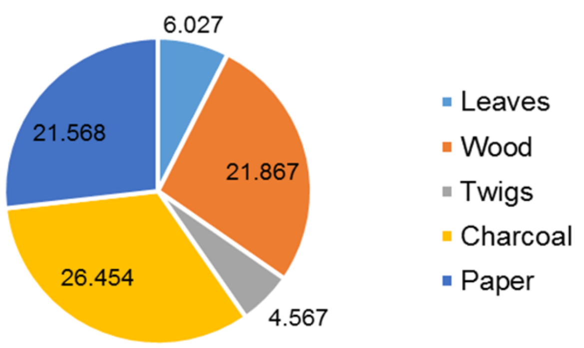

Figure 8: Power for five different materials

Table 1: Comparison of power in different materials

Type of Materials	Power (W)
Charcoal	26.454
Wood	21.867
Paper	21.568
Leaves	6.027
Twigs	4.567

Table 2: Summary Output

	Coeff.	Standard Error	t Stat	P value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-8.51	1.58	-5.38	9.81	-11.75	-5.27	-11.75	-5.27
Charcoal	7.34	0.69	10.57	2.78	5.92	8.76	5.92	8.76

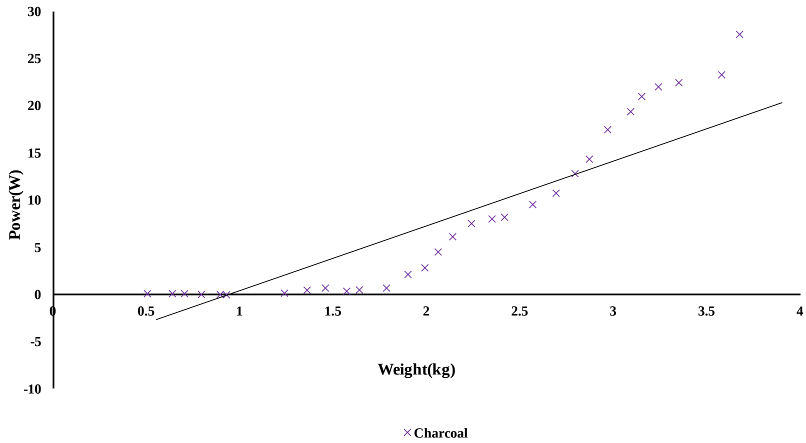

Figure 9: Best line fit diagram

Efficiency mathematical calculation

Mathematical calculation was done in order to find out the TEG internal resistance and output power. TEG Internal Resistance: VOC and VL of charcoal are 5.8V and 4.9V respectively. The RL is 1**Ω** is utilized. Hence the Rin is:

$$Rin = \frac{(Voc - VL) \times \mathrm{RL}}{VL} \tag{8}$$

Output Power (PL): To measure the PL, utilized the value of VOC, Rin, and RL.

$$PL = \frac{V^2 oc}{(Rin + RL)^2} \times RL \tag{9}$$

$$PL = \frac{5.8^2}{(5.8+1)^2} \times 1 = 0.728W \tag{10}$$

Linear Regression Analysis

Subsequent investigating, charcoal was settled as the suitable material for power release. This was proved by drawing a straight regression examination and regression was conveyed as showed up in figure 9. In light of examination, multiple R-value acquired was 0.89 as in Table 3, which implies that the esteem recorded is near to 1. Hypothetically, if the R-value for dependably lies between - 1 and +1 implies there is a connection between the two factors [20]. Thus, this is known as a strong positive linear correlation. Hence creating higher power, more weight of the material should set fire. In this way, expanding the heaviness of the material will result in an increment of intensity created [21].

Table 3: Regression statistics

Regression Statistics	
Multiple R	0.89
R Square	0.79
Adjusted R Square	0.79
Standard Error	3.52
Observations	30

Regression equation

Linear regression line equation can be written as where x is an informative variable and is the dependent variable. The line slope a1 and b1 is the interception (the value of y when x = 0) [21]. According to table 2 mathematical model that determined the value of charcoal is:

$$\hat{y} = -8.51 + 7.34x \qquad (11)$$

This numerical condition is profitable when making future forecast or indications of past lead. For example, the 8kg weight of charcoal to be added, therefore by applying the mathematical model obtained an expected value of charcoal can be produced:

$$\hat{y} = -8.51 + 7.34(8) = 50.24W \qquad (12)$$

Therefore, the power of 8 kg is 50.23575W. Hence, this mathematical model is useful for future forecasting of power value.

Future recommendation

Further research is coordinated to minimize the mass and adding channels to diminish the smoke so as to empower cleaner air. In addition, examining the information gathered so as to improve the nature of the product in order to market the prototype.

Conclusion

This paper gives an overview of the technique of recreating the energy harvesting using the biomass sources. Various existing biomass sources are used as a source to harvest the energy from the most real heat was discussed. This paper additionally addresses current energy harvesting applications and monitoring system, with applications to harvesting energy using the burning process. This paper also addresses the importance of TEG module as a vital component to convert the heat energy into electrical energy compared to utilizing another method to produce electrical energy such as solar panels where the installation cost is expensive and cost of maintenance is high. This paper finishes up by characterizing some future research headings and conceivable innovation exhibitions improvement that are gone for rising above the idea of consuming procedure for energy.

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Nomenclature

TEG	Thermoelectric Generator	V_{OC}	Open-circuit voltage
H_2O	Hydrogen oxide	V_L	Loading voltage
H_2	Hydrogen	R_{in}	Internal resistance
K	thermal conductivity, W cm^{-1} K^{-1}	R_L	Loading resistance
S	Seebeck coefficient, V K^{-1}	P_L	Output power
T	Temperature, K	CH_4	Methane
C	Carbon		

Greek symbols

σ	electrical conductivity,Ω^{-1} cm^{-1}

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