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Waste monitoring system for sustainable electricity generation

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Abstract -*The current emphasis on cleanliness in India, spurred by both individual and governmental efforts, acknowledges the inadequacy of traditional waste management practices in tackling the challenges posed by urbanization and industrialization. The escalating volume of non-biodegradable waste contributes to environmental pollution and health issues, necessitating innovative solutions. One such proposal involves generating electricity from solid waste, aiming to mitigate pollution and address the power crisis by utilizing abundant waste resources. This Waste to Energy concept holds promise for sustainable energy production and environmental preservation in India.*

Key Words: **Waste monitoring system, Raspberry Pi, Electricity Generation**

1. INTRODUCTION

Addressing the critical challenge of waste management in the context of rapid urbanization and industrialization, our project proposes an innovative solution: using waste materials to generate electricity. This approach not only contributes to waste reduction but also aligns with the goals of sustainable energy generation and circular economy practices. Our holistic approach involves three key stages: Monitoring, Sorting, and Generation. Through Raspberry Pi technology, we monitor dry waste in real time, enabling data-driven decision-making. We automate sorting with Arduino technology, enhancing efficiency and material quality. Finally, we harness the energy potential of sorted waste materials to generate electricity sustainably, thereby revolutionizing waste management and promoting eco-friendly energy production.

1.1 PROBLEM STATEMENT

The management of municipal solid waste is a significant challenge in urban areas, leading to pollution, resource depletion, and health risks. Traditional fossil fuel reliance on electricity worsens climate change. Innovative solutions are needed to improve waste management and utilize waste for renewable energy. Existing systems lack efficient monitoring and sorting, hindering resource recovery. This project proposes a solution using Raspberry Pi and Arduino to monitor, sort, and generate electricity from dry waste, aiming to optimize waste-to-energy conversion and promote sustainable electricity generation.

2. OBJECTIVES

The project comprises three main components: a waste monitoring system utilizing Raspberry Pi technology for real-time data collection, an automated sorting mechanism driven by Arduino technology to efficiently segregate dry waste materials, and a waste-to-energy conversion process for electricity generation. Through controlled combustion of materials like paper and dry leaves, heat energy will be harnessed and converted into electricity. The system's performance and feasibility will be rigorously evaluated to ensure scalability and suitability for urban waste management, promoting sustainable practices at a broader scale.

3. METHODOLOGY

A. WASTE MONITORING SYSTEM

• Waste collection: Waste materials are collected and monitored from various sources, such as households, businesses, and industries, and transported to a waste- to-energy plant.
• Waste handling and Monitoring: The system detects parameters like distance with the help of two ultrasonic sensors. Some predefined values of these sensors are stored in Raspberry Pi.
• Management of filled container: When the contact value is reached the LED begins to glow, if the garbage bin is completely filled then both the LED glows otherwise, only one LED glows. This results in the ringing of the buzzer.

B. METAL SORTING SYSTEM

This typically includes a conveyor belt to move waste.
• Setup and Calibration: Set up the metal detector module and the sound sensor in the waste processingline.
• Metal detection: when metal is passed over a metal detector module, the sound is produced by the module, which is taken as an input for the sound sensor.
• Metal sorting: the sound detected will activate the servo motor to divert waste when metal is detected or when a certain sound threshold is exceeded, indicating the presence of metal.

C. ELECTRICITY GENERATION

- Incineration: The sorted dry waste is sent to the burning process through a conveyor belt and burned in a combustion chamber at high temperatures, producing heat and gases.
- Generation: The solar panels will detect the light and the thermoelectric generator will detect heat which results in the generation of electricity.
- Conversion: the 12v DC power is to converted 230V AC by using Inverter.
- Energy recovery: the heat generated from burning dry waste is used to produce sustainable Electricity.

3.1 BLOCK DIAGRAM

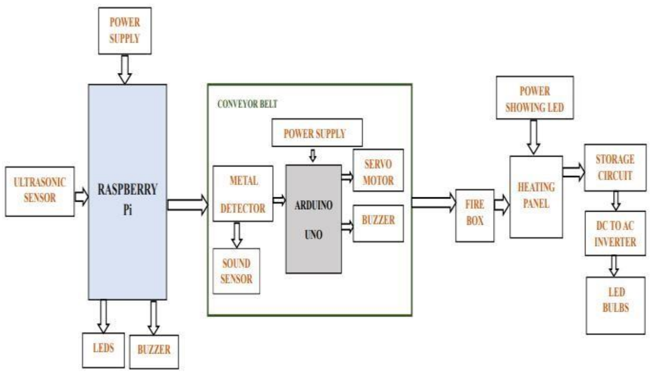

Fig -3.1: Block diagram for electricity generation

3.2 CIRCUIT DIAGRAM

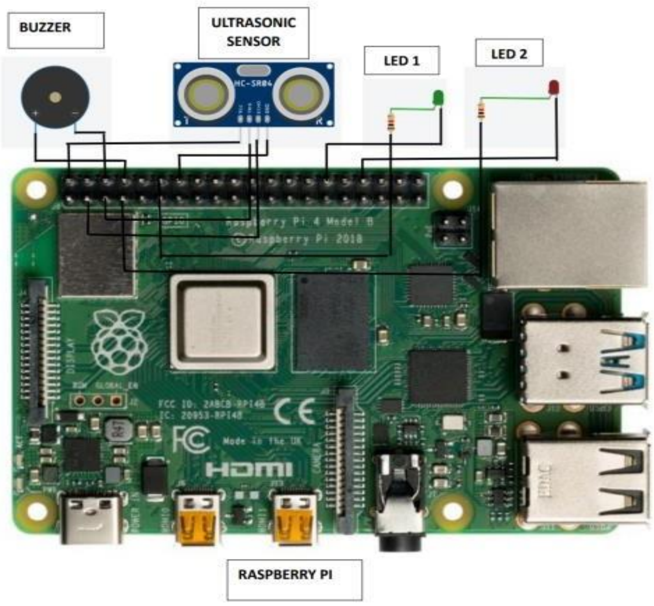

Fig-3.2 :(a) Waste Monitoring System

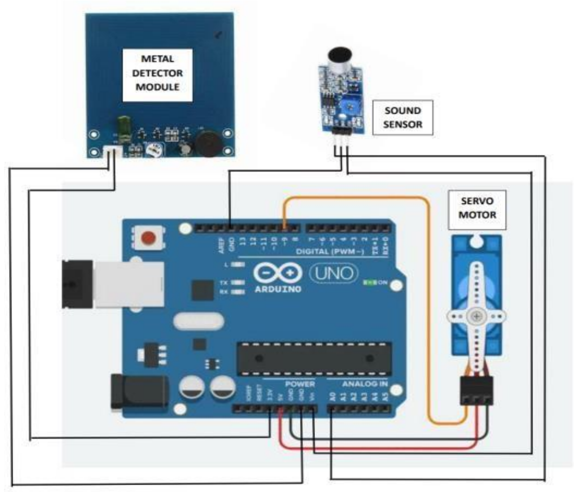

Fig 3.3: (b) Metal Sorting System

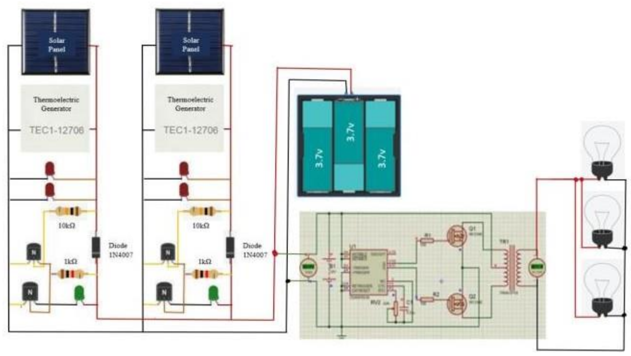

Fig 3.4: (c) Electricity Generation

4. RESULTS

The implemented waste management system has been assessed across various critical aspects. The Raspberry Pi-based monitoring system has demonstrated commendable accuracy as shown in table 4.1.In tracking key parameters of dry waste, aligning closely with ground truth measurements obtained through manual inspection.

Table 4.1 Waste monitoring result

LENGTH (cm)	LED 1	LED 2	BUZZER
23 cm	OFF	OFF	OFF
20 cm	ON	OFF	OFF
18 cm	OFF	OFF	OFF
17 cm	OFF	ON	ON
15 cm	OFF	ON	ON

The Arduino-based sorting mechanism has exhibited high efficiency in segregating dry waste materials, boasting impressive sorting accuracy, throughput, and reliability based on real-world testing observations. The waste sorting results in Table 4.2 show that out of the listed objects, only ferrous metal was detected as metal, indicated by a status of '1'. Other objects, including dry leaves, paper, stainless steel, non-ferrous metal, and wood, were not detected as metal, all marked with a status of '0'.

Table 4.2 Waste Sorting Result

WASTE OBJECTS	METAL DETECTION STATUS
Dry Leaves	0
Paper	0
Ferrous Metal	1
Stainless Steel	0
Non-Ferrous Metal	0
Wood	0

Moreover, the waste-to-energy conversion process has proven successful, with quantifiable energy output generated from the combustion of sorted dry waste materials, showcasing the system's ability to convert waste into renewable energy effectively. Performance metrics, including waste processing throughput and energy generation capacity, have met or exceeded predefined benchmarks, emphasizing the system's efficiency and effectiveness. Table 4.3 illustrates the output load characteristics for different material weights. As the material weight increases, both the maximum electricity generation and the duration of electricity generation rise, with 250 grams producing 10V for 1-2 days and 2000 grams producing 30V for 10 days. The timing of burning also increases with the material weight and the same trends are illustrated in the fig 4.1,fig 4.2 and fig 4.3

. Table 4.3 Output Load

MATERIALS	TIMINGOF BURNING	MAXIMUM ELECTRICITY GENERATION (V)	ELECTRICI TY GENERATI NG TIME (DAYS)
250 gram	4-5 min	10V	1-2 days
500 gram	5-8 min	18V	3 days
1000 gram	15-17 min	20V	7 days
2000 gram	20-22 min	30V	10 days

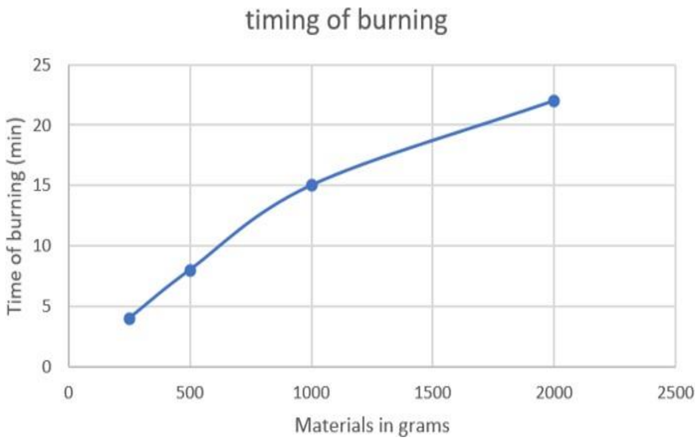

Fig 4.1 Time taken for burning

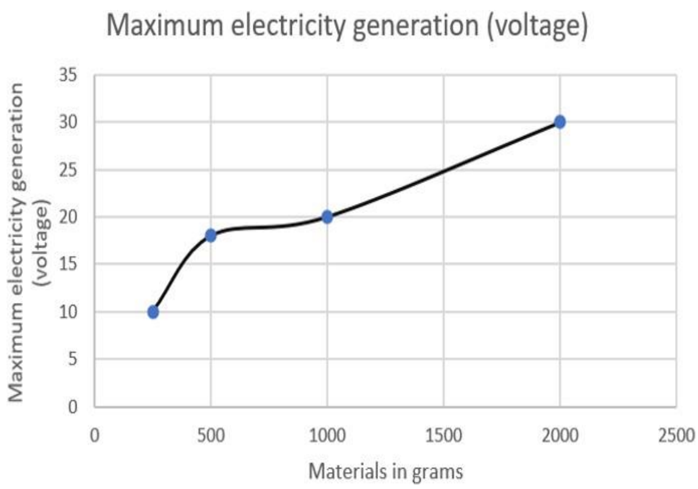

Fig 4.2 Maximum electricity generation

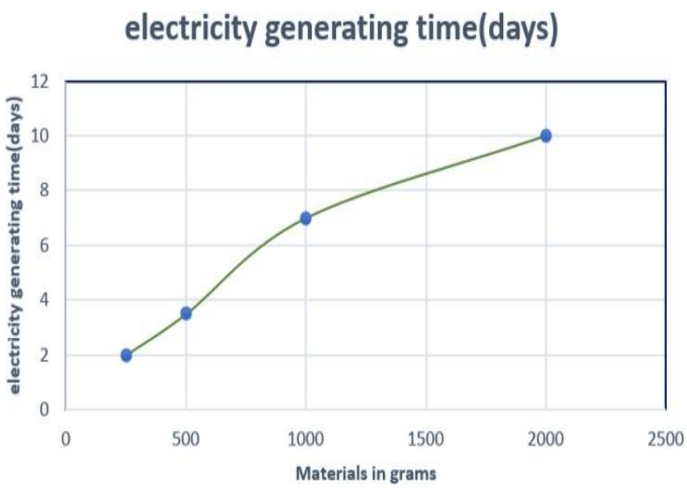

Fig 4.3 Electricity generating time

Table 4.4 Power Generation

AMP-HOURS	VOLTAGE	KILO-WATT HOUR
5	3.7V	0.0185
10	7.4V	0.0370
20	14.8V	0.0740

Table 4.4 shows power generation details, where increasing amp hours and voltage result in higher kilo- watt hours. Specifically, 5 amp hours at 3.7V produce 0.0185 kWh, 10 amp hours at 7.4V generate 0.0370 kWh, and 20 amp hours at 14.8V yield 0.0740 kWh and the same trends are illustrated in graph 4.2.

Fig 4.4 Power generation

TO CALCULATE THE ELECTRICAL ENERGY GENERATED FROM BURNING PAPER WASTE AND THE CONVERSION EFFICIENCY:

1. Measure the mass of paper waste and determine its calorific value.
2. Calculate the thermal energy input also called total energy.
3. Directly measure the electrical energy output.
4. Convert the measured electrical energy to MJ if needed.
5. Calculate the conversion efficiency using the measured electrical energy output and the calculated thermal energy input.

a) Determine the Mass of Paper Waste (m):

For example, let's say we have 6 paper sheets used for burning which weigh up to 36 grams.

Mass of the paper(m): 0.036 kg

b) Find the Calorific Value of Paper (CV):

The typical calorific value of paper is around 10 MJ/kg.

c)Calculate the Total Thermal Energy Input (total energy):

Thermal Energy Input= m× CV

For 0.036 kg of paper,

Thermal Energy Input= 0.036 kg× 10 MJ/kg

= 0.36 MJ

d) Measure the Electrical Energy Output:

The electrical energy output is typically measured using instruments such as power meters or multi-meters. To calculate the power, the formula is

P=V×I

where: P is the power in watts (W),

V is the voltage in volts (V),

I is the current in amps (A).

Given: Voltage (V) = 14.8v, Current (I)= 5amps

Substituting the values into the formula: P=14.8v×5amps

P=74 watt

Therefore, the power is 74 watts = 0.074 kWh.

If the electrical energy is measured in kWh, it is converted to MJ using the conversion factor 1kWh= 3.6MJ

Hence, 0.074 kWh= 0.266MJ.

e) Calculate the Conversion Efficiency (%):

Conversion Efficiency = (Electrical Energy Output (MJ)/ Thermal Energy Input (MJ)) x 100

= (0.266 MJ/ 0.36MJ) ×100

= 73.89%

Lastly, the feasibility and scalability of the implemented solution for urban waste management systems have been evaluated, considering factors such as cost-effectiveness, ease of deployment, and adaptability to different environmental conditions. Based on real-world implementation and feedback, the system demonstrates promise for broader adoption and replication in diverse contexts, contributing to sustainable waste management practices.

Fig -4.5: sustainable electricity generation

Fig -4.6: Model for sustainable electricity generation

5. CONCLUSIONS

The combination of Raspberry Pi technology for waste monitoring and Arduino-based automation for sorting signifies a remarkable leap in waste management practices. Real-time monitoring and analysis of dry waste parameters empower informed decision-making, boosting resource allocation efficiency and operational effectiveness. Automated sorting mechanisms not only enhance the quality of sorted waste materials but also streamline downstream processing, maximizing resource recovery. Moreover, the establishment of a waste-to-energy conversion process underscores the system's commitment to sustainable energy generation, minimizing environmental impact while promoting renewable energy production.

This holistic approach to waste management reflects the principles of circular economy and sustainable development, emphasizing resource efficiency and environmental stewardship. Rigorous performance evaluation and feasibility assessments confirm the system's efficacy and scalability for urban waste management systems, paving the way for broader adoption and replication across diverse contexts. Overall, the implemented waste monitoring, sorting, and electricity generation system represents a significant stride toward addressing pressing waste management challenges and fostering a cleaner, greener future.

REFERENCES

[1]. Prakash, Prabhu, "IoT based management system for smart cities", International Journal of Innovative Research in Science, Engineering and Technology, vol 4, Issue 2, February 2021.

[2]. Shoaib Banday, Adil Bashir, and Ab Rouf Khan," DESIGN AND IMPLEMENTATION OF AUTOMATIC WASTE MANAGEMENT",IEEE, September 2020.

[3]. Kanchan Mahajan, Prof J. S. Chitode, "Waste Bin Monitoring System Using Integrated Technologies", International Journal of Innovative Research in Science, Engineering andTechnology (An ISO 3297:2007 Certified Organization) Vol 3,Issue 7, July 2014.

[4]. Electricity generation by waste materials", International Journal of Advanced in Science, Communication and Technology (IJARSCT) Volume2, Issue 3, May 2022 by Mr. Ashish R. Chandane, Mr. Sagar D. Hedau, MR. Lucky S. Sarode.

[5]. "Generation of electricity using solid waste" Project reference No: 45S-BE-1864 By Dr. Nalini E Rebello, Mr. Anvith V B adikana, Mr. MuhammadShunaif, Ms. Sahana J.