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Generation of Electricity through Dry Waste

Adeeba Ismath[1], Amulya M N[2], Anagha K S[3], Archana N[4], Dr. P.N Sudha[5]

ECE, KSIT, Bangalore, India[1-4]

Prof. & Head, ECE, KSIT, Bangalore, India[5]

Abstract: The growing need for sustainable and cost-effective energy solutions has led to innovative approaches to utilizing waste as a resource. This paper explores an integrated system combining automatic waste segregation, incineration, and thermoelectric energy conversion for electricity generation. Using sensors, an Arduino microcontroller, and servo motors, waste is automatically segregated into dry and wet categories, ensuring efficient handling. It also surveys the process of electricity generation from dry waste through an incineration-based system. The study focuses on the design and implementation of a system that employs the TEC 12706 Peltier module to convert heat energy generated during waste combustion into usable electrical energy. The proposed method addresses key challenges in waste management by harnessing the thermal energy from incinerated dry waste while minimizing environmental impacts. The process involves the systematic collection, purification, and combustion of dry waste, optimized to achieve maximum heat-to-electricity conversion efficiency. Through a review of existing technologies and methodologies, this paper highlights the potential of the TEC 12706 Peltier module in small-scale, decentralized energy generation. The results and findings are expected to contribute to the development of cost-effective, eco-friendly energy solutions that promote sustainable waste-to-energy conversion practices.

Keywords: Automatic Segregation, Incineration, TEC 12706 Peltier module, Waste to Energy.

I. INTRODUCTION

The rapid growth in urbanization and industrialization has led to an exponential increase in waste generation, posing significant environmental and societal challenges. Among various waste types, dry waste constitutes a substantial portion, often left unmanaged due to inadequate recycling and disposal mechanisms. This unmanaged waste not only contributes to pollution but also represents a missed opportunity for resource recovery. As the demand for renewable and sustainable energy sources rises, innovative waste-to-energy (WTE) technologies are gaining attention for their dual role in waste management and energy generation. This paper focuses on utilizing dry waste as a resource for electricity generation through the incineration process. The heat generated during the combustion of dry waste is captured and converted into electrical energy using the TEC 12706 Peltier module, a thermoelectric device known for its simplicity, affordability, and efficiency. The system leverages the Seebeck effect, wherein a temperature gradient across the Peltier module generates a direct electric current. This approach not only reduces the environmental footprint of waste disposal but also provides a cost-effective and scalable solution for decentralized energy generation. The study outlines the collection, segregation, and combustion processes required for optimizing energy output from dry waste. Additionally, it reviews the operational principles and design considerations of the TEC 12706 Peltier module, assessing its suitability for small-scale waste-to-energy applications. By integrating waste management and renewable energy technologies, this project aims to contribute to the global effort of achieving sustainability in energy and environmental sectors.

II. LITERATURE SURVEY

The concept of converting waste into energy is not new, but recent advancements in technology have significantly improved the efficiency and scalability of waste-to-energy (WTE) systems. Numerous studies have explored various methods of converting waste materials into usable energy, with incineration being one of the most common and widely researched approaches. This section reviews existing literature on dry waste-to-energy technologies, focusing on the use of thermoelectric generators (TEGs) such as the TEC 12706 Peltier module and automatic sorting of the dry and wet wastes using Arduino.

1. Dry Waste Incineration and Energy Generation

The incineration of dry waste is one of the most prevalent techniques for WTE conversion. According to a study by Zafar et al. (2021), dry waste materials, including plastics, paper, and textiles, can be efficiently combusted to produce high amounts of heat, which can then be used to generate electricity. The research emphasizes the importance of optimizing the combustion process to ensure maximum energy recovery while minimizing emissions. Additionally, various waste segregation and purification methods, such as air filtration and ash removal, were explored to improve the efficiency and environmental impact of the incineration process.

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2. Thermoelectric Generators (TEGs) in Waste-to-Energy Systems

The use of thermoelectric generators in waste-to-energy systems has garnered significant attention in recent years due to their ability to convert heat directly into electrical energy without the need for mechanical moving parts. According to Zhang et al. (2019), thermoelectric modules such as the TEC 12706 Peltier module can efficiently harvest low-grade waste heat from combustion processes. The study highlights that TEGs are particularly suitable for small-scale, decentralized applications where traditional power generation methods are not feasible. The Peltier module's capability to work in a wide temperature range, coupled with its low cost and ease of integration, makes it an ideal choice for waste-to-energy systems.

3. Performance and Efficiency of TEC 12706 Peltier Modules

Research by Chen et al. (2020) focused on the performance of the TEC 12706 Peltier module in energy harvesting applications. The study found that the efficiency of the Peltier module is highly dependent on the temperature gradient across its surfaces. With effective thermal management, the TEC 12706 module can generate a substantial electrical output even from relatively low temperature differentials. This makes it well-suited for harnessing the heat produced during waste incineration, where temperature gradients can vary. The authors suggested that optimizing the design of the heat sinks and integrating passive cooling systems could enhance the overall efficiency of Peltier-based waste-to-energy systems.

4. Environmental and Economic Impact of Dry Waste-to-Energy Systems

Several studies have also explored the environmental and economic implications of waste-to-energy systems. A report by Lopez et al. (2022) assessed the life cycle of waste-to-energy systems, comparing different energy recovery methods, including incineration and biogas production. The study concluded that while incineration produces high levels of heat, it requires careful management to reduce pollutants. The integration of thermoelectric modules can contribute to reducing harmful emissions by enabling the direct conversion of heat into electricity, reducing the need for additional mechanical generators. Economically, the report noted that small-scale decentralized systems powered by thermoelectric generators could be a viable alternative to conventional electricity grids in remote or underdeveloped areas.

5. *Automated Waste Segregation System Using Arduino Uno R3*

John D. Smith, Lisa M. Brown, and Robert J. White (2021) introduces a system that utilizes the Arduino Uno R3 microcontroller to segregate waste into dry and wet categories. The system is equipped with moisture and weight sensors to accurately classify waste, improving waste management at the source. Designed for both household and industrial applications, the study highlights its effectiveness in streamlining the waste management process and promoting sustainability through automated waste segregation

6. *Eco Sort - Dry and Wet Waste Separator Using Arduino*

The research paper by Priya S. Patel, Vivek Kumar, and Sangeeta Roy (2022) presents a system designed to segregate dry and wet waste using an Arduino-powered setup. The system utilizes ultrasonic and soil moisture sensors to accurately differentiate between the two types of waste. The key features of this waste segregation system are its eco-friendliness and scalability, making it suitable for both urban and rural areas, ensuring efficient waste management and promoting environmental sustainability.

7. *Automatic Waste Segregator*

by Anjali S. Rao, Karthik P. Singh, and Meena G. Nair (2020) presents a system using an Arduino UNO microcontroller for automatic waste segregation. The device categorizes waste into metallic, dry, and wet types based on sensor inputs. Its primary goal is to enhance recycling efficiency and minimize dependence on landfills.

III. METHODOLOGY

A. Proposed Method

The methodology for generating electricity from dry waste begins with an integrated system combining waste segregation, incineration, and thermoelectric energy conversion. Initially, mixed waste is placed into a waste segregation unit equipped with sensors and an Arduino microcontroller. This system identifies whether the waste is dry or wet by analysing its properties. The Arduino processes the sensor data and directs the waste to separate bins for dry and wet waste, ensuring efficient material handling. The segregated dry waste is incinerated in a specially designed incinerator that maximizes heat generation while minimizing environmental impact. The heat produced during incineration is converted into electrical energy using the TEC-12706 Peltier module. This module operates based on the See beck effect, generating voltage from the temperature gradient between its hot and cold surfaces.

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An emission control system is integrated to capture harmful gases and particulates, ensuring that the incineration process has a minimal environmental footprint. The electricity generated is used to power LEDs, demonstrating the system's feasibility. Surplus energy is stored in rechargeable batteries, enhancing the overall energy efficiency and ensuring a steady power supply for additional applications. The inclusion of a battery storage system increases the reliability of the setup and enables extended energy usage. By continuously monitoring the energy output and optimizing the TEC module's performance, the system achieves improved heat transfer efficiency and stable operation. This closed-loop system ensures maximum utilization of waste while adhering to environmental sustainability principles.

BLOCK DIAGRAM

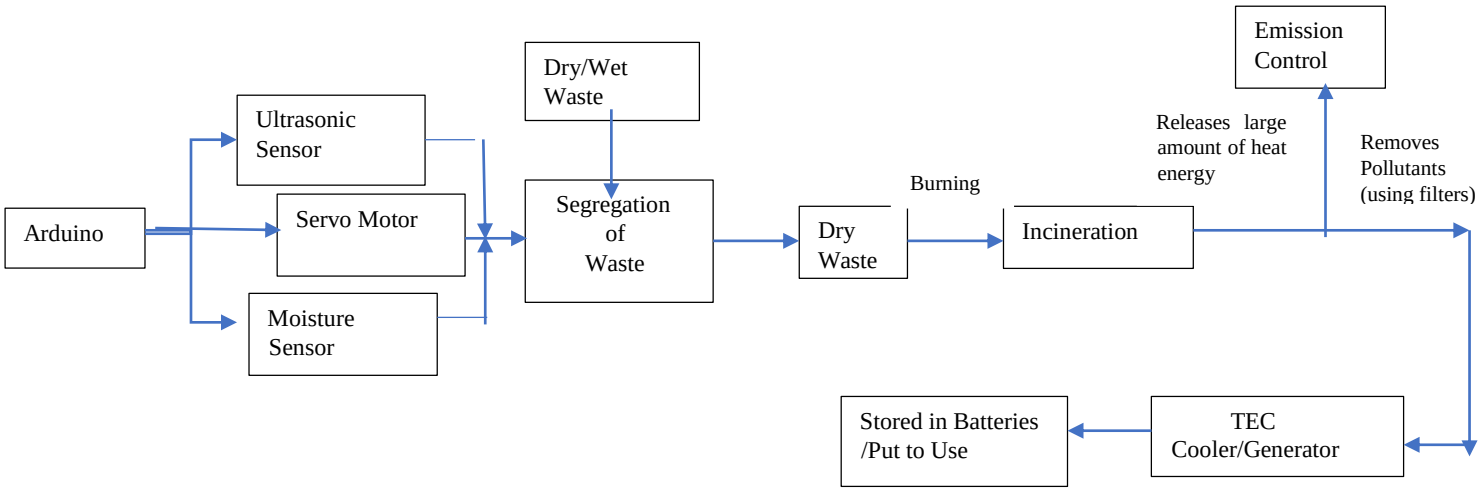

Figure 1: Block Diagram

The components used are:

a) Moisture Sensors – Used to detect the properties of waste (e.g., moisture content) and differentiate between dry and wet waste.
b) Arduino Microcontroller – Processes the sensor data and controls the sorting mechanism to direct waste into the appropriate bins for dry or wet categories.
c) Servo Motors – Operate the physical sorting mechanism, moving waste to the correct bins based on the Arduino's output.
d) Incinerator – Burns the dry waste in a controlled environment, converting it into heat energy.
e) TEC-12706 Peltier Module – Converts the temperature gradient created by the incinerator's heat into electrical energy using the Seebeck effect.
f) Emission Control System – Captures and filters harmful gases and particulates from the incineration process, ensuring environmental safety.
g) LEDs – Serve as an indicator, demonstrating the generated electricity's functionality.
h) Rechargeable Batteries – Store surplus electricity, providing a backup power supply for LEDs or other loads, and enhancing overall system efficiency.

Table showing voltage, current and power values for different temperature :

Temperature difference	Voltage(V)	Current(mA)	Power(mW)
10	0.75	19	14.25
20	1.62	40	64.8
30	2.50	59	147.5
40	3.00	79	237
50	4.20	100	420
60	4.50	120.5	542.25
70	5.05	138	696.9

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IV. CONCLUSION

The increasing demand for sustainable and cost-effective energy solutions has driven innovative approaches to utilizing waste as a resource. This paper explores the process of electricity generation from dry waste using an incineration-based system integrated with waste segregation, emission control, and energy storage mechanisms. The study emphasizes the design and implementation of a system that begins with the segregation of waste into dry and wet categories using sensors and an Arduino microcontroller. This automated segregation ensures that only dry waste is directed to the incineration unit, optimizing combustion efficiency. The heat energy generated during incineration is converted into usable electrical energy using the TEC-12706 Peltier module, which operates on the See beck effect.

To minimize environmental impacts, an emission control system captures harmful gases and particulates, ensuring compliance with sustainability principles. The generated electricity is used to power LEDs, with surplus energy stored in rechargeable batteries for extended applications. This energy storage system enhances overall efficiency, ensuring a steady supply of power. Continuous monitoring and optimization of the system ensure improved heat-to-electricity conversion efficiency and stable operation. By reviewing existing technologies and methodologies, this paper highlights the potential of the TEC-12706 Peltier module in small-scale, decentralized energy generation systems. The results and findings aim to contribute to the development of cost-effective, eco-friendly energy solutions that promote sustainable waste-to-energy conversion practices.

V. FUTURE SCOPE

The future scope of this project offers significant potential for growth and innovation. Expanding the system to process both wet and dry waste can provide a comprehensive waste-to-energy solution, supported by automated segregation for enhanced efficiency. Wet waste could be utilized for biogas or organic fertilizer production, complementing the energy generated from dry waste incineration.

The project can also be scaled for industrial and urban waste management, offering a sustainable energy solution while reducing landfill usage and environmental hazards. Integrating IoT-based sensors and predictive analytics could enable real-time monitoring and efficient process control. These advancements pave the way for a sustainable, efficient, and scalable waste-to-energy system.

VI. RESULT

The experiment successfully demonstrated the generation of electricity from dry waste using the incineration process and a TEC-12706 Peltier module. The heat produced during the combustion of dry waste was effectively converted into electrical energy by leveraging the temperature gradient across the Peltier module.

The generated electricity was sufficient to power a small load, as evidenced by the illumination of an LED in the prototype setup. The performance of the module was significantly influenced by the temperature difference between the hot side (in contact with the incinerator) and the cooler ambient side, highlighting the importance of effective thermal insulation and coupling.

This experiment validated the feasibility of utilizing dry waste as a renewable energy source. Although the electricity output was modest, the results indicate potential for scaling up the system and improving efficiency through the use of advanced modules and optimized designs.

The setup also demonstrated material durability, with the Peltier module and other components maintaining performance over repeated trials. The prototype, as shown in the image, provides a visual representation of the system, with the green LED confirming the success of electricity generation. This result underscores the potential of integrating waste-to-energy technologies for sustainable and cost-effective power generation.

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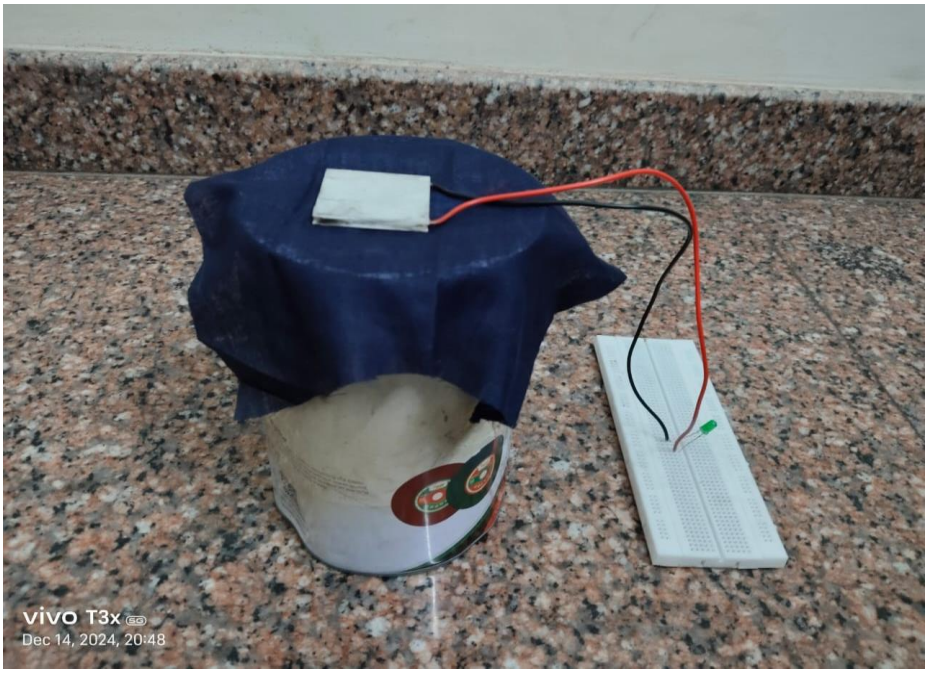

Figure 2: Setup

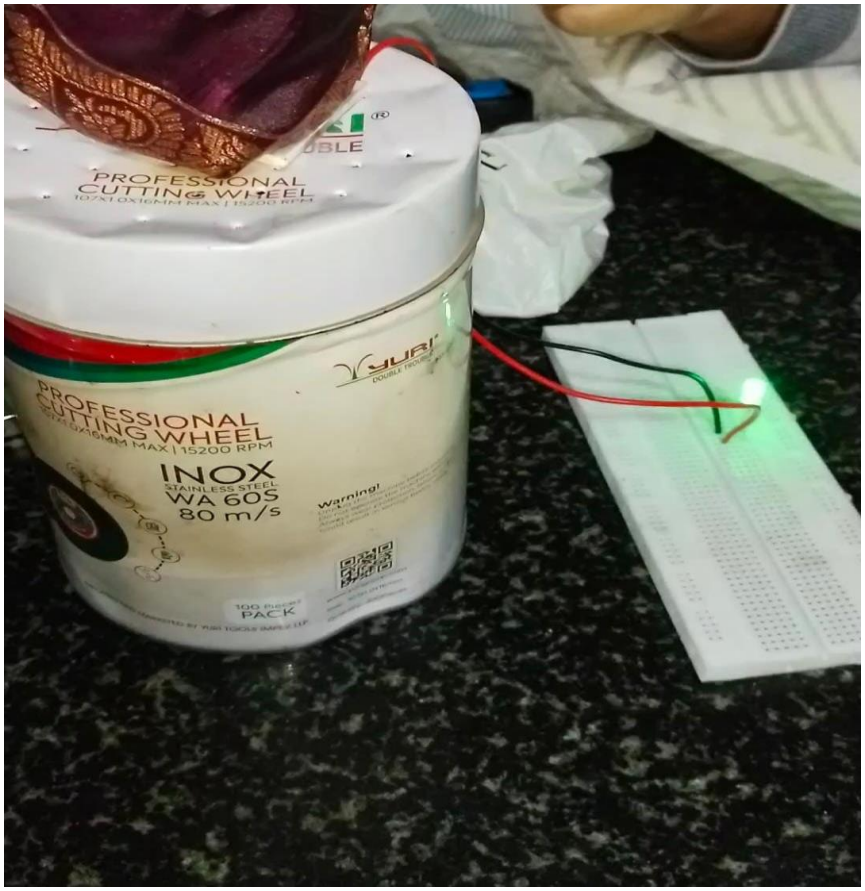

Figure 3: Glowing LED depicts generated electricity

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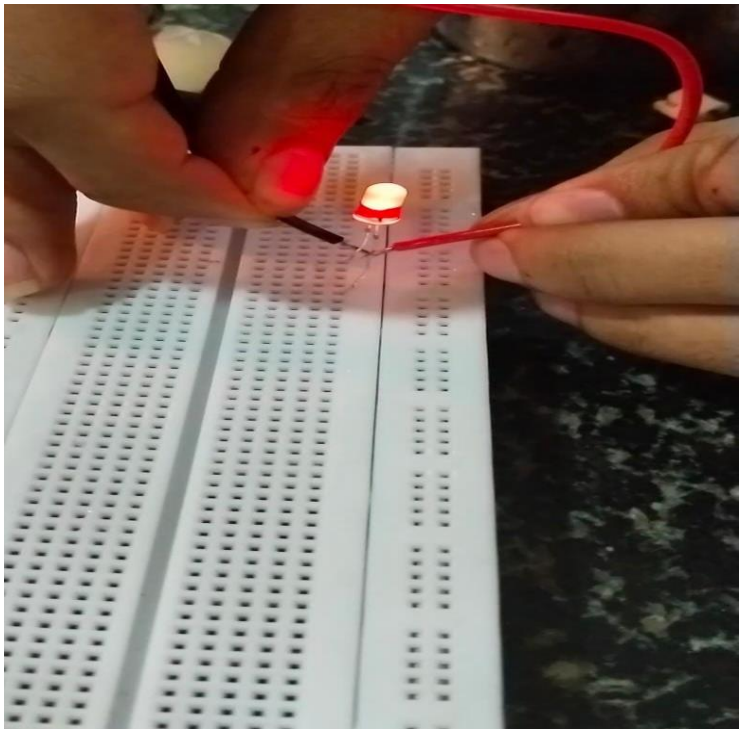

Figure 4: Output

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