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Eco Power: Smart Waste to Electricity System with Sensor Integration and GSM Control

Mr. Pundareeka B L[1], Abhishek S K[2], Manoj V[3], Mohammad Mohseen[4], Sathish Kumar K[5]

Assistant Professor, Department of ECE, East West Institute of Technology, Bangalore, India[1]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[2]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[3]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[4]

Student, Department of ECE, East West Institute of Technology, Bangalore, India[5]

Abstract: The Eco-Smart Waste-to-Electricity System is an innovative sustainable-energy solution that integrates waste management, renewable electricity generation, sensor-based automation, and GSM-enabled remote monitoring. The core objective of the project is to convert different types of waste—such as plastics, paper, and organic materials—into usable electrical energy while ensuring operational safety and real-time supervision.
In this system, waste materials are collected and fed into a Zaar Box (Heating/Burning Chamber). When the waste begins to burn, the heat generated is transferred to a heating panel, which converts the thermal energy into electrical energy. This generated electricity is stored in a 12V, 1.2Ah lead-acid battery. The stored energy is later used to power various loads such as LED bulbs or small DC devices. A heating sensor/temperature sensor plays a crucial role—during the electricity generation and charging phase, the output supply remains OFF for safety. Once charging reaches the required level and the temperature stabilizes, the sensor triggers the system to turn ON the output power supply, allowing the bulb to glow and demonstrating live energy generation from waste.

Keywords: Arduino uno, GSM (Globel System for Mobile Communication), Heating panel, Temperature Sensor, Voltage Sensor.

I. INTRODUCTION

The proposed Eco-Smart Waste-to-Electricity System with Sensor Integration and GSM Control addresses these challenges by introducing automation, remote monitoring, and sensor-based safety mechanisms. In this system, everyday waste materials—including plastics, dry waste, and organic matter—are introduced into a controlled burning or heatgenerating chamber known as the Zaar Box. The heat produced from burning the waste is captured by a heating panel capable of converting thermal energy into electrical energy. This electricity is stored in a rechargeable 12V battery, which can later be used to operate small electrical loads such as LED bulbs, fans, or sensors. This concept demonstrates a live, practical, small-scale implementation of generating electricity from waste.
To ensure safety and automation, the system integrates an Arduino Uno microcontroller along with multiple sensors and modules. A voltage sensor monitors the generated energy, while a DHT11 sensor measures the temperature and humidity of the heating chamber. A heating sensor ensures that during the electricity storage process, the output remains OFF to avoid overload or risk. Once the system confirms stable temperature and adequate stored energy, it automatically activates the output load. This ensures that the process remains safe, efficient, and operator-free.
The introduction of a GSM SIM800 module adds significant value to the system. Through GSM communication, the Arduino can send alerts regarding system performance, temperature conditions, or emergency warnings directly to a mobile device. Such remote monitoring features make the system intelligent, user-friendly, and suitable for deployment in rural areas, municipal facilities, or low-supervision zones. The inclusion of relay modules enables control over connected loads such as fans or lights.

II. LITERATURE SURVEY

A review of existing literature on smart waste management systems shows rapid growth in technologies that integrate sensors, IoT, and communication modules to improve urban waste collection efficiency. Many studies highlight the challenges posed by increasing waste generation and emphasize the importance of automation and real-time monitoring. Ultrasonic, gas, moisture, and weight sensors are commonly used in smart bins to detect fill-levels, odors, and waste conditions, enabling timely alerts to authorities. Several works incorporate GSM or GPRS modules to send SMS

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notifications when bins are full or when hazardous gases are detected, demonstrating the reliability of cellular communication for remote waste monitoring. Advanced IoT architectures also link sensor nodes to dashboards or cloud platforms, allowing data analytics and decision-making, while solar-powered smart bins reduce maintenance and make systems more sustainable. However, although significant progress has been made in sensing and communication, the literature reveals a major gap: very few studies integrate these monitoring systems with actual waste-to-energy (WTE) conversion processes. Most smart bin research focuses only on detection and reporting rather than transforming collected waste into usable electricity. Some works explore AI-based waste classification using deep learning, which can improve sorting efficiency prior to energy conversion, but fully automated systems combining sensing, GSM control, and onsite energy generation remain limited. This gap presents an opportunity for systems like "Eco Power," which propose linking real-time sensor data with biogas or thermal conversion units to create a self-regulating waste-to-electricity mechanism. Studies also emphasize challenges such as power consumption of sensors and GSM modules, the need for durable hardware in harsh environments, scalability in dense urban areas, and the importance of secure, reliable data transmission. Emerging research suggests the potential of hybrid communication systems, predictive analytics for waste generation patterns, and self-powered electronics for long-term autonomous operation. Overall, the literature indicates that while IoT-based smart waste monitoring is well developed, integrating these technologies with sustainable energy recovery remains an underexplored but promising direction—one that the Eco Power concept aims to address through sensor integration, GSM-based control, and efficient waste-to-electricity conversion.

III. METHODOLOGY

The methodology of the proposed s The development of the Eco Power system follows a structured methodology that integrates sensing, communication, and energy conversion to create a smart waste-to-electricity solution. The process begins with the design of an intelligent waste bin equipped with ultrasonic sensors to measure waste fill-level, gas sensors to detect decomposition gases, and moisture or weight sensors to assess waste type and suitability for energy conversion. These sensors are interfaced with a microcontroller—typically Arduino or ESP-based—which collects, filters, and processes real-time data. The microcontroller continuously monitors threshold values; when the bin reaches a preset level or when gas accumulation indicates readiness for conversion, it activates the system's control logic. A GSM module is integrated to send SMS alerts to authorized personnel or a central monitoring unit, ensuring remote supervision and enabling immediate action if abnormalities occur. In parallel, the system channels the collected biodegradable waste into a small-scale waste-to-energy unit, such as a biogas digester or thermal conversion chamber, where organic matter is broken down and converted into usable electricity through a generator or micro-turbine setup. The generated electricity is measured, stored using a battery unit, and can be used to power sensors, the GSM module, or external low-power devices, thus making the system partially self-sustaining. Data from the sensors, conversion unit, and power output are logged and, if needed, transmitted for analysis to evaluate system performance. The methodology concludes with iterative testing, calibration of sensors, tuning of GSM communication reliability, and evaluation of energy output under various waste compositions to optimize efficiency, durability, and real-world applicability.

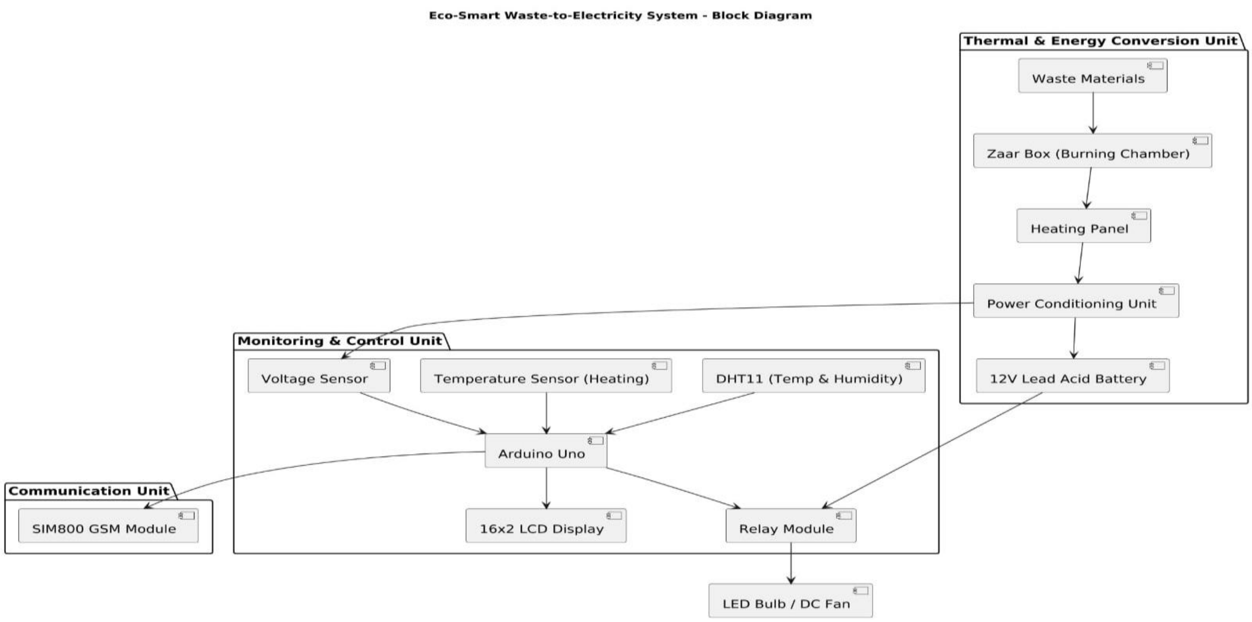

Figure 1: Block Diagram of Proposed System

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IV. IMPLEMENTATION

The flowchart gives a clear picture of how the proposed Eco-Smart Waste-to-Electricity System operates from start to finish. The sequence begins the moment the device is powered on.

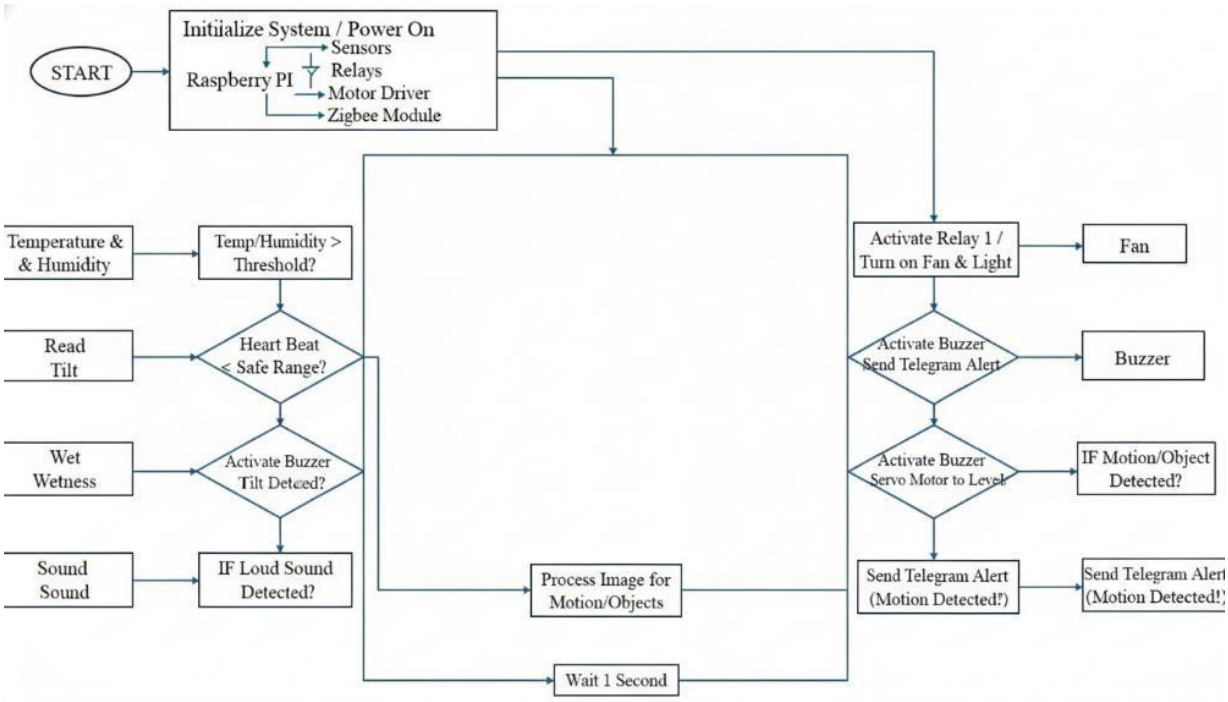

Figure 2: Flow Chart of Proposed System

The System Flow Architecture illustrates how waste is transformed into usable electrical energy and how the system is controlled, monitored, and supervised remotely.

1. **Waste Input & Burning Unit:** The process begins when waste materials such as plastic, paper, and dry organic waste are placed in the Zaar Box (Burning Chamber). This controlled chamber burns the waste, generating heat.
The flow moves from: Waste Materials → Burning Chamber → Heat Generation
2. **Thermal-to-Electric Conversion Unit: The** heat produced in the Zaar Box is transferred to a Heating Panel, which converts thermal energy into electrical energy. Since raw output is unstable, it is passed through the Power Conditioning Unit, which stabilizes voltage, applies filtering, and makes the electricity suitable for storage.
Burning Chamber → Heating Panel → Power Conditioning Unit
3. **Energy Storage & Output Unit: The** conditioned power is stored in a 12V Lead Acid Battery.
The stored energy is used to drive relay-controlled loads such as: LED bulb, DC fan, Additional small loads The relay ensures safe switching between charging mode and output mode.
Power Conditioning → Battery → Relay → Output Loads
4. **Monitoring & Control Unit (Arduino-Based):** The Arduino Uno acts as the brain of the system.
It receives inputs from: Voltage Sensor (battery & panel output), Temperature Sensor (combustion chamber heat), DHT11 sensor (temperature & humidity)
Sensors → Arduino → Relay Control → Load
5. **Communication System (SIM800 GSM Module):** The Arduino communicates with the SIM800 GSM Module via AT commands.
It sends SMS alerts for: Over-temperature warnings, System ON/OFF, Battery full/low, Fault notifications Arduino → GSM Module → User's Mobile

V. RESULTS

The proposed Eco-Smart Waste-to-Electricity System with Sensor Integration and GSM Control addresses these challenges by introducing automation, remote monitoring, and sensor-based safety mechanisms. In this system, everyday waste materials—including plastics, dry waste, and organic matter—are introduced into a controlled burning or heat generating chamber known as the Zaar Box. The heat produced from burning the waste is captured by a heating panel

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capable of converting thermal energy into electrical energy. This electricity is stored in a rechargeable 12V battery, which can later be used to operate small electrical loads such as LED bulbs, fans, or sensors. This concept demonstrates a live, practical, small-scale implementation of generating electricity from waste.

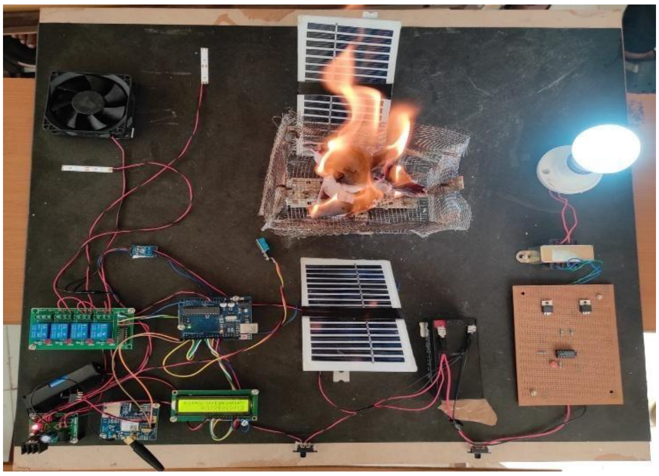

Fig 5.1: Prototype of Proposed System

This prototype of the proposed Eco Power system is developed as a compact, functional model that integrates sensing technology, wireless communication, and waste-to-electricity conversion within a single unit. The prototype consists of a customized waste bin fitted with an ultrasonic sensor mounted at the top to measure fill-level, a gas sensor positioned inside the chamber to detect methane or other decomposition gases, and a weight or moisture sensor installed at the base to determine waste type and readiness for processing.

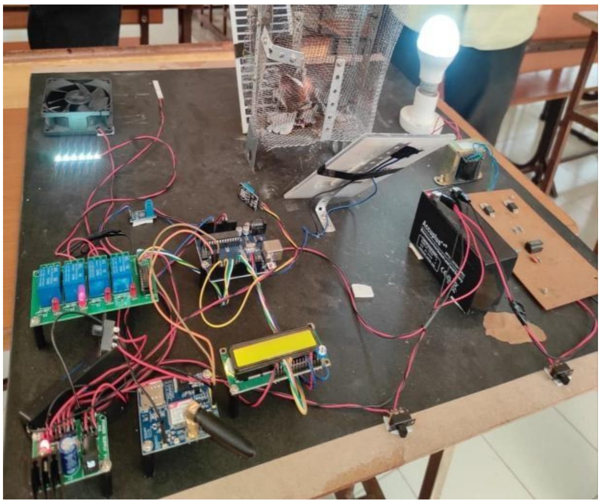

Fig 5.2: Working of project

The Eco Power system operates by continuously monitoring the waste deposited in the smart bin and automatically converting suitable waste into usable electrical energy. When waste is added to the bin, the ultrasonic sensor measures the fill-level to determine how much space remains, while the gas sensor detects methane or other gases produced during decomposition, and a weight or moisture sensor evaluates whether the waste is biodegradable and ready for processing.

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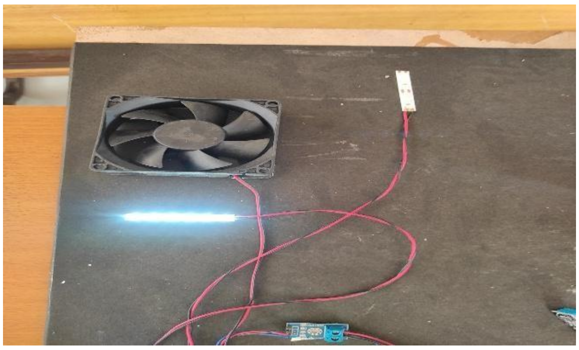

Fig 5.3: Working Fan and Light

In the Eco Power system, the fan and light are powered directly by the electricity generated from the waste-to-energy unit, demonstrating the practical utilization of the converted energy. Once the biodegradable waste inside the digester produces biogas and the micro-generator begins generating electrical power, this energy is stored in a rechargeable battery

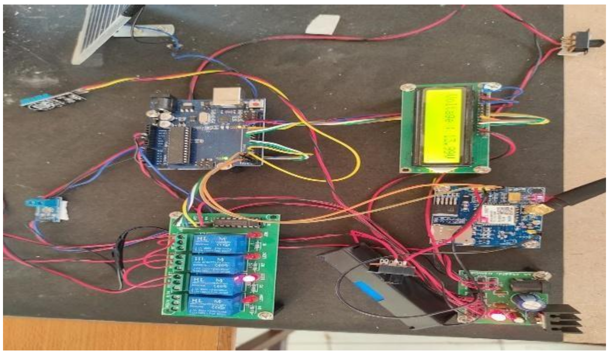

Fig 5.4: Working heat and voltage detection

In the Eco Power system, heat and voltage detection play an essential role in monitoring the performance and safety of the waste-to-electricity conversion process. During the conversion stage—especially in systems using biogas combustion or small thermal units—the temperature inside the energy generation chamber can rise significantly. A heat sensor such as an LM35 or DHT11 is installed near the conversion unit to continuously measure this temperature.

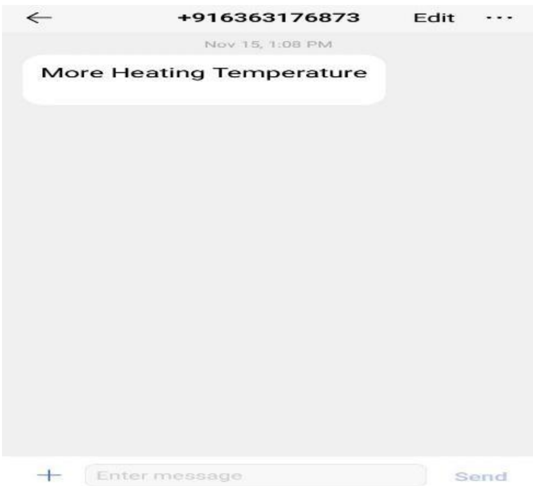

Fig 5.5: Addressing Message

In the Eco Power system, the addressing message refers to the automated SMS notifications generated by the GSM module to inform the user about the system's real-time status. Whenever the sensors detect critical conditions—such as the waste bin reaching its maximum fill-level, a rise in gas concentration indicating active decomposition, excessive heat in the conversion chamber, or sufficient voltage generation—the microcontroller formats this information into a predefined message and sends it to the registered mobile number.

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VI. CONCLUSION AND FUTURE SCOPE

The Eco-Smart Waste-to-Electricity System successfully demonstrates that household and municipal waste can be converted into usable electrical energy using a controlled burning chamber and heat-to-electricity conversion panel.
The integration of sensors ensures operational safety, accuracy, and smart automation. The Arduino Uno microcontroller serves as the central control unit that monitors all parameters and performs intelligent decision-making in real time. Through the SIM800 GSM module, the system provides remote alerts, making it an IoT-enabled waste-to-energy prototype.

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