

# SUSTAINABLE ENERGY GENERATION FROM WASTE MATERIALS

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## ABSTRACT

*This project mainly focuses on: Using heat and light energy, waste materials are converted into power using TEGs and solar energy systems. A large amount of energy is lost when industrial byproducts and municipal garbage are thrown without being properly utilized. By the suggested technology effectively captures thermal and radiation energy from these materials turns garbage to usable electricity.*

*The design features waste-burning heating panels, thermoelectric modules for waste heat-to-electricity conversion, and solar panels for harnessing sunlight energy. The system has integrated with Arduino UNO for real-time monitoring and optimization. A pollution control filter is also used to prevent harmful emissions from waste combustion. This technology promotes sustainable energy, lowers pollution, and recovers energy from discarded materials, harmonizing with global aims.*

**Keywords:** Waste-to-energy (WTE), Thermoelectric generator (TEG), Solar panel system, renewable energy, energy recovery, Arduino UNO

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## 1. Introduction

Globally, increased urbanization and industrialization have greatly boosted economic growth, but they have also created major environmental problems like energy scarcity, global warming, and an increasing amount of garbage. A large portion of this waste, whether it be industrial leftovers or municipal solid waste, includes untapped heat and electrical power that is typically lost when the trash is disposed of. In addition to wasting potential energy, the traditional methods of disposing of waste such as landfilling and open burning also seriously contaminate the environment by producing greenhouse gases and hazardous emissions. Investigating alternative and sustainable approaches for waste management and energy generation has become essential due to increasing pressure on natural energy resources and the urgent need to reduce environmental pollution [8].

Waste-to-energy technology is a promising and innovative technique. Waste-to-energy (WTE) is the conversion of waste materials into useable energy, typically electricity and heat. This strategy saves waste and recovers energy that would otherwise go unutilized. Thermoelectric generators (TEGs) and solar-based systems are attractive WTE technologies because to their efficiency, simplicity, and minimal environmental impact. TEGs use the Seebeck effect, a thermodynamic mechanism that converts temperature differences between thermoelectric materials into electric voltages[8].

In a similar way, solar energy can be captured through photovoltaic panels placed in sunlight-exposed regions or from the light released during garbage combustion. A hybrid solution that optimizes energy recovery from both heat and light produced during waste processing can be created by combining solar and thermoelectric devices. In small-scale, localized settings like homes, rural areas, and small businesses, these systems can be employed to supply a clean, alternative energy source. Concerns regarding air quality and environmental protection are also addressed by the integration of a pollution control filter, which lowers the hazardous emissions brought on by waste combustion. Waste management and the lack of energy are two key worldwide issues that are concurrently addressed by this integrated approach. In addition to reducing the burden on landfills, the technique adds renewable energy to the conventional power source by turning garbage into a valuable energy resource [8].

As the world moves toward greener and more sustainable technology, waste-to-energy devices like this one can play a significant role in shaping how energy generation and environmental preservation are shaped in the future [8].

## 1.1 LITERATURE REVIEW

Prashantha.K ,Sonam Wango , Smart Power Generation From Waste Heat By Thermo Electric Generator, International Journal of Mechanical and Production Engineering (IJMPE), 2016: This study described thermoelectric generators (TEGs) as an environmentally friendly technology due to the absence of moving components and emissions during operation. These systems convert waste heat directly into electrical energy, making them suitable for sustainable energy applications. Compared to conventional methods, TEGs can operate with relatively low heat sources and can be used for small-scale applications such as charging mobile devices.[1].

Miftah Y Fauzan, S. M. Muyeen, Syed Islam, Experimental modelling of grid-tied thermoelectric generator from incinerator waste heat, International Journal of Smart Grid and Clean Energy, 2020: It conducted an experimental study on grid-connected thermoelectric generators utilizing waste heat from an incinerator. The system produced low power output (below 1 kW), which was expected due to the moderate temperature of the heat source. In laboratory conditions, an electrically controlled heat source was used for testing. A prototype system of approximately 0.02 kW was developed using 24 bismuth telluride TEG modules connected in series. Additionally, a cooling and temperature regulation system was integrated to evaluate system performance.[2].

## 1.2 PROBLEM STATEMENT

We observed that the generation of solid trash has increased significantly as a result of the fast population growth and urbanization, posing major problems for waste management and environmental sustainability. Hazardous gases like carbon monoxide and carbon dioxide are released by traditional trash disposal methods like open dumping and incineration, which contributes to air pollution and climate change.

Energy crises and environmental degradation have worsened concurrently with an increase in the world's electrical consumption and an excessive reliance on fossil fuels. An affordable, environmentally friendly system that can deal with garbage accumulation and energy shortages is desperately needed. The waste-to-energy systems in use today are either expensive, complicated, or inappropriate for decentralized use in rural or impoverished areas. This invention recognizes the issue of underutilized waste and suggests a system that not only efficiently manages waste but also uses solar and thermoelectric technologies to recover energy from it, minimizing environmental impact and offering a sustainable source of electricity from common garbage.

**1.3 OBJECTIVE**

1. To reduce energy loss by creating a system that effectively captures and converts waste heat and light energy from various waste items into usable electrical energy.
2. To maximize energy production efficiency by maximizing the thermoelectric generator’s ability to transform heat energy from waste materials into electricity.
3. To maximize solar energy conversion into power.
4. By extracting energy from waste materials, offer a substitute power source for a variety of uses.

**2. COMPONENTS REQUIRED**

Sr.No.	Name of components	Specifications	Quantity
1)	Step down transformer	Input voltage-230V, Output voltage-12V	01
2)	Bridge rectifier	-	01
3)	Filter/ capacitor	1000µF, 25V	01
4)	Thermoelectric Generator	Model No. TECI-12706	01
5)	Solar panel	6V, 2.5W	01
6)	DC Boost converter	-	01
7)	Metal fire box	-	01
8)	Dry cell battery	12V, 1.3Ah	01
9)	Modified Sine-wave inverter	-	01
10)	Arduino UNO	-	01
11)	LCD Display	16×2 LCD Display	01
12)	CFL Lamp	230V, 12W	01



**Fig-1.** Thermoelectric Generator



**Fig-2.** Step down Transformer



**Fig-3.** Battery



Fig-4. Solar panel



Fig-5. Rectifier



Fig-6. CFL Lamp



Fig-7. Arduino UNO



Fig-8. LCD Display



Fig-9. Capacitor



Fig-10. DC boost Converter



Fig-11. Modified Sine-wave Inverter

### 3. BLOCK DIAGRAM

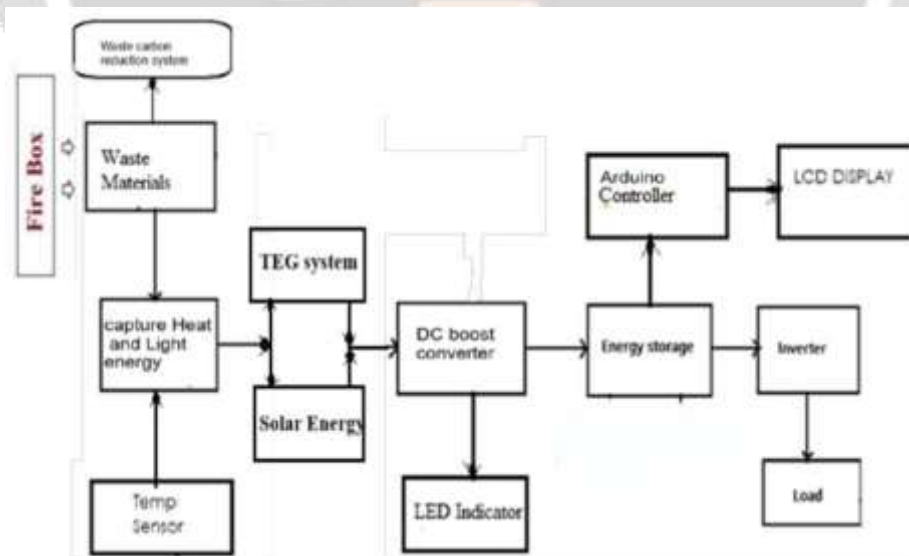


Fig-12. Block Diagram of proposed System

#### 3.1 WORKING PRINCIPLE

In proposed system, first the waste materials such as paper, dry leaves, plastic scraps, or biomass will be placed in the fire box. When the waste burns, it produces heat energy. This heat becomes the primary energy source for the thermoelectric generator system.

When waste materials (paper, plastics, biomass) burnt, releases CO<sub>2</sub> and other toxic gases which is dangerous for our environment and life's health to address this a system is added called carbon reduction system which captures or reduces these emissions to lower the carbon footprint of electricity generation. The techniques include carbon capture, scrubbing, or enhanced combustion control.

The generated heat is then sent to the thermoelectric generator (TEGs) system that Converts heat energy directly into electrical energy. TEG works on the Seebeck Effect. TEG has two side i.e. hot and cold side, one side is heated called hot side other side is kept cooler called cold side. The temperature difference produces DC voltage.

In this system we also added solar panel system, it provides additional renewable power. The solar panel capture sunlight for conversion of electricity in the form of DC output. This energy supports the system when waste heat is low. It makes the system a hybrid energy system.

The output voltage generated by both system i.e. thermoelectric generator (TEGs) and solar panel system is small (0.5-3V), so that here we are using DC boost converter which Increases the output voltage generated by (5-12V) the TEG and solar panel system. Energy is then from the TEG and solar panel is stored in the battery. The stored energy can be used later when required, which maintain continuity of supply.

To Controls and monitors the system the Arduino Controller is used. Arduino collects data from sensors. It monitors voltage, current, and system status. It also controls the display and system operation. LCD Display is also used in order to displays system parameters. It Shows real-time information such as: Voltage, Current, Power status System condition. Further the generated energy is fed to the modified Sine-wave Inverter which Converts DC power into AC power. The battery stores DC power but many appliances need AC power. This inverter converts DC to 230V AC and finally it will be supplied to the load.



**Fig-13.** Working model of proposed System

### 3.2 FUTURE SCOPE

1. Contribution to climate goals: Helps reduce greenhouse gas emissions and supports a cleaner environment.
2. Role of AI automation and digitalization research opportunities.
3. Renewable Energy Source: Waste can become a reliable alternative energy source for homes and industries.
4. High growth potential in developing nations.
5. Job Creation: Development of waste-to-energy systems will create employment in recycling and energy sectors.
6. Waste Management Systems: Integration with smart cities for efficient waste collection and energy production.

### 4. RESULTS AND DISCUSSION

The proposed system successfully demonstrate the desired output, indicate that the combined system improves overall energy efficiency compared to standalone systems. The TEG provided stable energy output even in the absence of

sunlight, ensuring continuity, whereas the solar panel enhanced total energy generation during peak solar radiation periods. The system maintains the battery level, allowing for extended field operation without external power sources.

## 5. CONCLUSIONS

This study demonstrates that sustainable energy generation from waste materials using a hybrid thermoelectric generator (TEG) and solar photovoltaic system is both feasible and effective. The integration of waste heat recovery with solar energy enhances overall system performance, ensuring continuous, reliable power generation and waste management.

Overall, the study demonstrates that hybrid energy generation using waste materials is a practical and sustainable approach for small-scale power generation, particularly in remote and off-grid regions.

## 6. REFERENCES

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