International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 10 | Oct - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Generating Electricity from Human Footsteps

Mr J Sathishkumar[1], M Anas Mohammed[2], G Gowtham[3], V Saravanavel[4]

[1] *Assistant Professor/Information,Technology,Kongunadu College of Engineering and Technology*

[2]*Information Technology,Kongunadu College of Engineering and Technology*

[3]*Information Technology,Kongunadu College of Engineering and Technology*

[4]*Information Technology,Kongunadu College of Engineering and Technology*

---***---

Abstract - The Footstep Energy Generator is a renewable energy solution designed to harvest electricity from human footsteps using piezoelectric sensors. As dependency on fossil fuels persists and the need for sustainable energy sources grows, this project addresses the challenge of capturing ambient mechanical energy that is otherwise wasted. The system operates on the piezoelectric effect, where mechanical stress from footsteps is converted into an alternating current (AC) voltage. This AC output is then rectified into direct current (DC), stored in capacitors or rechargeable batteries, and used to power low-power devices such as LEDs and mobile chargers. An ESP32 microcontroller is integrated into the system to monitor the generated energy, process sensor data, and enable IoT connectivity for real-time tracking and reporting of energy production. The system is designed to be eco-friendly, cost-effective, and is particularly useful in high-footfall areas like shopping malls, railway stations, schools, and smart city pathways. This project demonstrates how everyday human activity can be transformed into a supplementary source of green energy, promoting smart infrastructure, sustainability, and intelligent energy management through IoT technology

Key Words: *Footstep Energy Generator, Piezoelectric Sensors, Renewable Energy, Energy Harvesting, Sustainable Infrastructure, Smart Cities, Eco-friendly Power*

1.INTRODUCTION

The global demand for energy continues to rise, necessitating the exploration of alternative and renewable energy sources. A significant amount of ambient energy, particularly in urban environments, is generated by human activity but is often wasted. The Footstep Energy Generator project was developed to address this gap by creating a system that converts the kinetic energy from human footsteps into usable electrical power. Traditional energy sources contribute to pollution and are finite, making sustainable solutions critical for future development.

This system offers a simple, low-cost, and eco-friendly method for generating electricity, making it ideal for deployment in crowded public spaces. While the power generated from a single footstep is small, the cumulative effect in high-traffic areas can become a significant supplementary power source for localized needs like lighting, mobile charging, and powering small sensors.

objectives:

1. To design and implement a system that generates electricity from human footsteps using the piezoelectric effect.
2. To efficiently convert the generated AC voltage to DC and store it in capacitors or rechargeable batteries for later use.
3. To demonstrate a low-cost and eco-friendly renewable energy system suitable for public infrastructure.
4. To apply this system in public places like railway stations, shopping malls, schools, and smart city pathways.
5. To contribute toward sustainable energy and reduce dependency on conventional energy sources.

2.RELATED WORK

The concept of harvesting energy from human motion is well-established in academic research. Numerous studies have explored piezoelectric materials for their ability to convert mechanical stress into electrical energy. However, challenges related to low power output, durability, and high installation costs remain significant hurdles.

Our review of existing literature reveals a consistent trend toward improving the efficiency and practicality of piezoelectric systems. While early models focused on proof-of-concept, recent work has shifted toward optimizing materials, circuit design, and large-scale implementation in smart infrastructure. Studies have confirmed that piezoelectric tiles can generate quantifiable energy in public spaces like metro stations and have explored hybrid mechanisms to increase power output, though often at the cost of increased complexity. The primary limitation identified across multiple studies is that the energy output remains suitable only for low-power applications. Our proposed system builds upon these findings by focusing on a simple, scalable, and cost-effective design that can be practically deployed, acknowledging its role as a supplementary, rather than primary, power source

2.1 LITERATURE REVIEW:

Research highlights the growing need for sustainable and renewable energy sources that can harness untapped mechanical energy from everyday human activities. Studies show that piezoelectric-based systems offer a promising solution for converting mechanical pressure into usable electrical energy. A review of existing literature indicates that while large-scale renewable systems like solar and wind are well established, localized micro-energy harvesting systems remain underexplored. Kumar, R. (2021) observed that piezoelectric materials can efficiently generate power from repetitive mechanical stress, such as footsteps, making them ideal for smart flooring applications. Sharma, P., & Gupta, N. (2022) emphasized that integrating energy storage and efficient rectification circuits significantly improves system output. By enabling real-time energy harvesting from human motion, such systems can reduce energy wastage and contribute to the development of sustainable smart infrastructures.

S.NO	Title and Authors	Technology Used	Key Findings	Limitations
1	Energy generation in public buildings using piezoelectric flooring tiles ***Firoozyar et al*** (2021)	Piezoelectric flooring tiles	A case study quantified the energy generation potential in a metro station.	Economic viability remains challenging
2	Review of piezoelectric energy harvesting tiles: designs & applications ***van den Ende et al.*** (2022)	Piezoelectric energy harvesting tiles	Provided a consolidated review of various floor tile designs and applications.	Highlighted existing reliability and cost gaps in the technology.
3	New framework of piezoelectric floor tiles (hybrid mechanisms) ***Ren et al.*** (2023)	Hybrid piezoelectric tiles (PZT & TENG)	Achieved higher energy output by combining PZT and TENG mechanisms	The hybrid approach increased complexity and manufacturing costs.
4	Piezoelectric sensors integrated into footsteps for energy harvesting ***Bayram et al.*** (2024)	Integrated piezoelectric sensors	A full-sized tile (455x405mm) with integrated sensors was successfully tested.	The energy output is still only suitable for low-power applications.
5	Low-cost compact piezoelectric energy harvesting floor tile (battery-free wireless) ***Guo et al.*** (2024)	Compact piezoelectric tiles, Battery-free wireless systems	Presented an attractive battery-free concept with a working prototype.	The study involved limited long-term testing of the prototype

Table -1: Literature Review

<u>Summary of Literature Review:</u>

The Footstep Energy Generator is a renewable energy system that uses piezoelectric sensors to capture electricity from human footsteps. When a person steps on the platform, the mechanical pressure is converted into an AC voltage, which is then changed to DC and stored in capacitors or rechargeable batteries. This stored power can be used for low-power applications like lighting LEDs or charging mobile devices. The system is designed to be cost-effective, eco-friendly, and is most effective in crowded areas like malls, schools, and railway stations.

2.2 EXISTING SYSTEM AND DISADVANTAGES.

In the existing system, piezoelectric tiles are used to generate electricity from human footsteps by converting the applied pressure into electrical energy.The power produced is very small, so it can only be used for low-power devices like LEDs or mobile chargers.These systems also face durability issues due to continuous mechanical stress on the sensors and are effective mainly in crowded areas with heavy foot traffic such as malls, schools, and railway stations.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 10 | Oct - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

DISADVANTAGES:

1. Low Power Output:

Generates only a small amount of electricity per step suitable only for low-power devices.

2. Durability Concerns:

Piezoelectric sensors may degrade under continuous mechanical stress.

3. Requires High Foot Traffic:

Effective only in crowded areas where many people walk frequently.

4. Initial Setup Cost in Large Scale:

While individual modules are cheap, large-scale deployment can be expensive.

5. Limited Energy Storage:

Energy stored is minimal and cannot support heavy loads or long-term storage without upgrades.

3. PROPOSED SYSTEM ARCHITECTURE AND METHODOLOGY

The proposed system is a user-centric, modular energy harvesting unit designed to be easily replicable and scalable. The architecture ensures a seamless and efficient flow from mechanical energy input to usable electrical output, addressing the core challenge of capturing and storing small bursts of energy.

System Architecture:

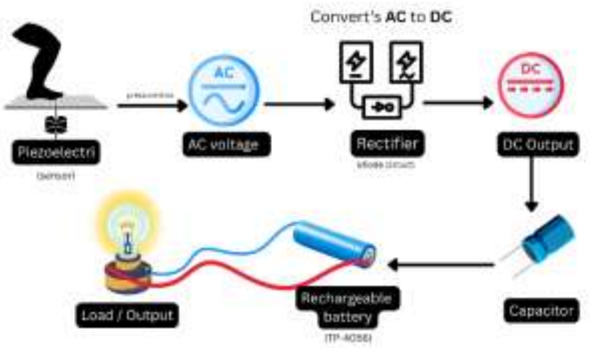


Fig -1: Architecture Diagram

The system architecture is composed of five interconnected modules that handle the entire energy conversion process:

- **Footstep Platform Module:** This is the mechanical interface of the system, consisting of a base tile made of wood or acrylic. It is designed to house the piezoelectric sensors and efficiently transfer the pressure from footsteps directly onto them.
- **Piezoelectric Sensor Module:** At the heart of the system, these sensors convert the applied mechanical pressure into an AC electrical signal using the piezoelectric effect. Each step is expected to produce a small voltage of about 3–5 V.
- **Rectifier Circuit Module:** This module transforms the raw AC voltage from the sensors into a usable DC voltage. It employs a simple and low-cost bridge rectifier circuit made from diodes.
- **Energy Storage Module:** To provide a stable power supply, this module stores the converted DC energy. It uses capacitors for immediate storage and a rechargeable battery managed by a TP4056 charging module for long-term power retention and safety.
- **ESP32 Monitoring & IoT Module:** The ESP32 microcontroller monitors the energy generated by the piezoelectric sensors, measures voltage and current levels, and manages data processing. It enables real-time tracking, wireless transmission of energy statistics, and integration with IoT platforms for smart energy management.
- **Load/Output Module:** The final stage delivers the stored energy to power low-power devices like LEDs or mobile charging ports, demonstrating the practical application of the harvested energy.

ADVANTAGES:

1. Renewable and Eco-friendly:

Uses human footsteps as a renewable energy source, reducing dependence on fossil fuels

2. Waste Energy Utilization:

Converts otherwise wasted mechanical energy into usable electrical power.

3. Low Cost and Simple Design:

The system is built using affordable components (piezo sensors, rectifier, battery, etc.), making it cost-effective.

4. Scalable and Portable:

Can be implemented in various high-footfall public areas such as malls, schools, and railway stations.

5. Promotes Sustainability:

Supports smart infrastructure and green energy initiatives.

6. No Pollution or Noise:

Operates silently without producing any emissions.

7. Useful for Low-power Applications:

Can power LEDs, sensors, and small charging devices efficiently.

4. IMPLEMENTATION DETAILS

4.1 Technology and Components

The prototype is implemented using readily available and cost-effective components to ensure the design is simple and replicable.

- **Hardware Requirements:**
  - Piezoelectric Sensors: The core transducers for energy conversion.
  - Diodes (1N4007): Used to build the bridge rectifier circuit.
  - Capacitor (1000µF or higher): For filtering and temporarily storing the rectified DC voltage.
  - Rechargeable Battery: For long-term energy storage.
  - TP4056 Charging Module: To safely manage the charging of the battery.
  - Platform Materials: A wooden or acrylic tile, foam padding, and wires provide the mechanical structure.
  - ESP32 Microcontroller: Monitors voltage and current from the piezoelectric sensors, processes the data, and enables IoT connectivity for real-time energy tracking and smart management.

4.2 Working Principle and Algorithm

The operational logic of the system follows a direct energy conversion and storage process:

1. Energy Conversion: When a person steps on the platform, the piezoelectric sensors are compressed. Based on the piezoelectric effect, this mechanical stress generates a small, transient AC voltage.
2. Rectification: The generated AC voltage is immediately fed into a full-wave bridge rectifier. This circuit converts the bidirectional AC flow into a single-direction, pulsating DC voltage.
3. Storage: The DC voltage is then stored in two stages: first in a capacitor to smooth the pulsations and handle quick energy bursts, and then routed to a rechargeable battery via the TP4056 module for stable, long-term storage.
4. Monitoring & IoT (ESP32)**:** The ESP32 microcontroller continuously monitors the voltage, current, and energy generated by the sensors. It processes the data and can wirelessly transmit energy statistics to IoT platforms, enabling real-time tracking and smart energy management.
5. Output: The stored energy can then be drawn by a connected load, such as an LED light bulb or a USB charging port

5. RESULT& DISCUSSION

The implemented system successfully demonstrates the feasibility of generating usable electricity from footsteps. The prototype was tested to evaluate its power output and validate the design.

Implemented Prototype The image above shows the physical setup of the project. The platform houses the piezoelectric sensors underneath, converting footsteps into energy. The circuitry, laid out on the blue board, includes the rectifier, capacitor, and connections for the battery and the output load. The prototype successfully illuminates an LED bulb, providing a clear visual confirmation that the system is converting mechanical pressure into sufficient electrical power for a low-power application.

5.2 Performance Analysis

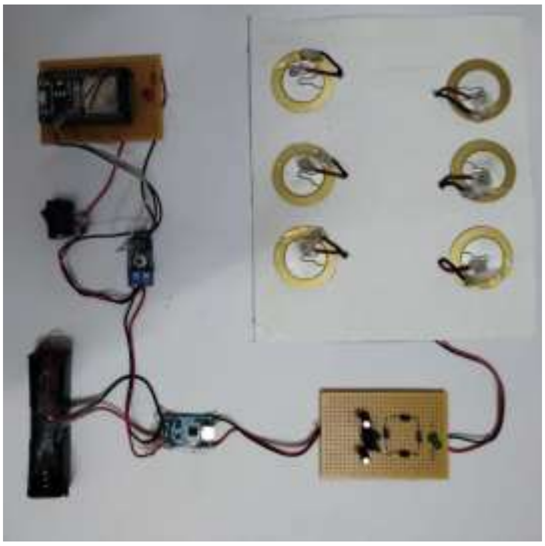
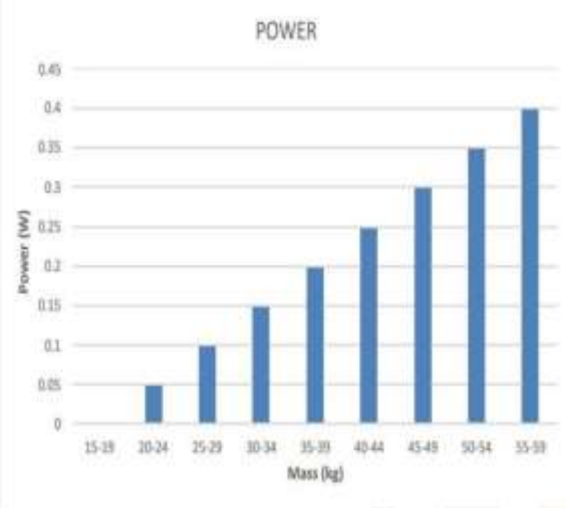


Fig -2: Figure

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 10 | Oct - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Power Output vs. Mass This bar chart illustrates the direct relationship between the mass of the person stepping on the platform and the power generated. As observed, the power output (in Watts) increases linearly with the applied mass (in kg). For instance, a mass in the 20-24 kg range produces approximately 0.05 W, while a mass in the 55-59 kg range produces 0.4 W. This data empirically confirms that greater pressure on the piezoelectric sensors results in higher energy generation. This provides a crucial baseline for estimating the potential power output in real-world scenarios, which would depend on foot traffic density and the average weight of pedestrians.

CHART:



Performance Analysis: Power Generation vs. Applied Mass

The bar chart, titled **"POWER,"** illustrates the relationship between the mass applied to the footstep platform and the resulting electrical power generated. The x-axis represents different mass ranges in kilograms (kg), while the y-axis measures the power output in Watts (W).

The data clearly demonstrates a strong positive correlation between mass and power generation. As the applied mass increases, the power output rises consistently.

Key data points from the chart include:

- A mass in the 20-24 kg range generates approximately 0.05 W of power.
- The power output steadily increases, with the 40-44 kg range producing 0.25 W.
- The highest tested mass range of 55-59 kg yielded the maximum power output of 0.4 W.

This result confirms that greater pressure and force exerted on the piezoelectric sensors lead to a higher energy yield. The findings are significant as they provide a quantitative baseline for the system's performance, indicating that its efficiency in a real-world setting would be directly proportional to the foot traffic and the weight of the pedestrians.

6. CONCLUSIONS

The Footstep Energy Generator project successfully demonstrates an effective and eco-friendly method for harvesting renewable energy from human footsteps. By using piezoelectric sensors, the system efficiently converts mechanical energy into storable electrical energy capable of powering small devices like LEDs. The project proves its viability as a cost-effective, portable, and scalable solution suitable for smart energy systems in high-traffic public areas such as schools, malls, and railway stations. It effectively shows that even small, everyday actions like walking can contribute to sustainable energy generation and the development of smart infrastructure, promoting awareness of innovative green technologies.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to their guide, Mr. J. Sathishkumar, AP/IT, for his invaluable support, guidance, and expertise throughout the development of this project.

REFERENCES

1. K. K. Selim, et al., "Piezoelectric Sensors Pressed by Human Footsteps for Energy Harvesting," *Energies*, vol. 17, no. 10, p. 2297, 2024[1].
2. H. Bamoumen, et al., "Piezoelectric Footstep Power Generator for Smart University Campus," *ResearchGate*, 2024[2].
3. N. Sezer, "Review on Piezoelectric Energy Harvesting: Materials and Applications," *ScienceDirect*, 2021[3].
4. A. Ali, "Advances in Piezoelectric Wearable Energy Harvesting," *ScienceDirect*, 2024[4].
5. Q. He, "Piezoelectric Energy Harvester Technologies: Synthesis and Applications," *ACS Applied Materials & Interfaces*, 2024[5].
6. L. Sun, et al., "Recent Developments in Wearable Piezoelectric Energy Harvesters," *Review of Scientific Instruments, 2024*[6].
7. B. Zhao, et al., "A Review of Piezoelectric Footwear Energy Harvesters: Principles, Methods, and Applications," *Sensors*, vol. 23, no. 13, p. 5841, 2023[7].
8. N. A. P. N. Ashari, et al., "A Piezoelectric Energy Harvesting System from Human Footsteps for Low Power Applications," in *2018 IEEE Conference on Systems, Process and Control (ICSPC)*, 2018.
9. J. Shwetha, V. Vijay, H. P. Sushma, and S. Prathibha, "Foot Step Power Generation Using Piezoelectric Sensor," *International Journal of Engineering Research & Technology (IJERT)*, vol. 10, no. 11, 2022[8].

10. G. Jing, et al., "Piezoelectric Energy Harvesters for Railways: Recent Trends and Future Opportunities," *Multiscale and Multidisciplinary Modeling, Experiments and Design*, vol. 8, p. 325, 2025[9].

BIOGRAPHIES

Sathishkumar J is working as an Assistant Professor at Kongunadu College of Engineering and Technology, with Seventeen years of teaching experience. He pursued his Bachelor of Engineering – Computer Science and Engineering at M.Kumarasamy College of Engineering in 2006. Subsequently, he pursued his Master of Technology with a Specialization in Information Technology at Sasurie College of Engineering in 2013. He is currently pursuing his Ph.D. with a focus on Deep Learning.

Anas Mohammed M is a dedicated student in the Department of Information Technology. As a key contributor to the 'Footstep Energy Generator' project, his interests lie in sustainable energy solutions, embedded systems, and practical hardware implementation. His work on this project focused on the core principles of piezoelectric generation and efficient power conditioning to create a viable renewable energy solution.

Gowtham G is a passionate student in the Department of Information Technology. As a member of the "Footstep Energy Generator" project team, his focus was on the practical hardware setup, sensor integration, and testing of the system. He has a strong interest in renewable energy applications, circuit design, and embedded systems. His contribution ensured that the piezoelectric modules and conditioning circuits were properly implemented for real-time performance and reliability.

Saravanavel V is an enthusiastic student in the Department of Information Technology. In the "Footstep Energy Generator" project, he contributed to system design, circuit optimization, and performance analysis. His interests include embedded systems, renewable energy technologies, and sustainable engineering solutions. Through his efforts, the project achieved improved energy harvesting efficiency and demonstrated the potential of piezoelectric systems in real-world smart infrastructure applications.