# Energy Harvesting Tile Generator

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Abstract: Street lighting systems traditionally rely on conventional electricity sources, leading to rising energy costs and a larger carbon footprint. They often miss the opportunity to harness renewable energy, particularly from kinetic sources. This paper introduces an innovative system that uses piezoelectric plates installed beneath speed breakers to generate electricity from passing vehicles. As vehicles exert pressure on these plates, electrical energy is produced, which is then enhanced by a DC-DC boost converter and stored in a battery. This energy powers streetlights, effectively converting wasted kinetic energy into usable power. The system not only offers a sustainable and cost-effective alternative for street lighting but also reduces dependence on non-renewable energy, promoting greater energy efficiency in urban infrastructure. By addressing the high energy consumption associated with street lighting, this approach contributes to eco-friendly solutions and supports the development of smart, sustainable urban environments.

## 1 INTRODUCTION

The rapid expansion of urban infrastructure has significantly boosted energy demand, especially for public utilities like street lighting, which traditionally relies on non-renewable resources such as coal, oil, and natural gas. While essential for safety and urban life, these systems increase energy costs and contribute to climate change due to their high carbon emissions. This has created an urgent call for sustainable energy solutions. Although renewable sources like solar and wind have been integrated to some extent, many lighting systems remain inefficient. A promising yet underused solution is harnessing kinetic energy, such as that generated by vehicle movement, through piezoelectric technology, which can effectively convert mechanical energy into electricity.

Piezoelectric materials generate electricity when subjected to mechanical stress, offering a way to capture energy from the pressure exerted by vehicles passing over speed breakers. Embedding piezoelectric plates under speed breakers is a practical approach to collecting kinetic energy from vehicles, which is otherwise wasted. This concept forms the basis of the proposed system, which focuses on utilizing piezoelectric technology to create an energy-efficient and eco-friendly street lighting system.

The idea leverages the constant flow of traffic in urban areas to generate electricity without the need for additional infrastructure, making it a cost-effective solution for sustainable energy production.

The proposed system works by embedding piezoelectric plates under speed breakers. As vehicles drive over the speed breakers, the mechanical pressure on the piezoelectric plates generates electrical energy.

This energy is then routed to a DC-DC boost converter, which amplifies the voltage to make it suitable for practical use. The boosted energy is stored in a battery system, which powers streetlights, providing a continuous source of renewable energy. This method not only recycles otherwise wasted kinetic energy but also reduces the demand on conventional power grids, decreasing reliance on non-renewable energy sources.

This system offers several key advantages. It provides a sustainable alternative to traditional street

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lighting by utilizing a renewable, consistent energy source—kinetic energy from vehicular movement—which is less weather-dependent than solar or wind power. This approach helps reduce greenhouse gas emissions by decreasing reliance on fossil fuels, thus supporting climate change mitigation. Additionally, it offers a cost-effective option for municipalities aiming to reduce energy costs without sacrificing essential services. Aligned with global smart city initiatives, this system can integrate with other technologies to foster an interconnected, energy-efficient urban environment, a crucial step for sustainable development as cities expand and energy demand rises.

In conclusion, the proposed piezoelectric-based street lighting system offers a forward-thinking approach to addressing the challenges associated with high energy consumption and environmental degradation. By capturing wasted kinetic energy from vehicular traffic and converting it into electricity for street lighting, the system represents a viable and eco-friendly alternative to conventional energy sources. This approach not only improves energy efficiency in urban infrastructure but also contributes to reducing the overall carbon footprint, supporting the transition toward more sustainable cities.

# 2 METHODOLOGY

The methodology for this proposed system involves embedding piezoelectric plates beneath speed breakers to generate electricity from vehicular movement. When vehicles pass over these speed breakers, the pressure applied to the plates generates a low-voltage alternating current (AC) through the piezoelectric effect. This AC is then converted to direct current (DC) using a rectifier. Following rectification, the DC signal is boosted to a higher voltage level using a DC-DC boost converter, making it suitable for storage and later use. The amplified energy is stored in a battery, which supplies power to energy-efficient LED streetlights, ensuring a continuous energy source. A Power Management Unit (PMU) monitors the battery's charge level to prevent overcharging and deep discharge, optimizing battery lifespan and system efficiency. This setup offers a sustainable solution by converting otherwise wasted kinetic energy into usable power, reducing reliance on non-renewable energy sources, cutting energy costs, and minimizing environmental impact. Through this innovative use of kinetic energy, the system supports the development of smart, energy-efficient urban infrastructure.

# 3 PROBLEM STATEMENT

The problem addressed is the high energy demand and environmental impact of conventional street lighting systems, which heavily rely on non-renewable electricity sources, leading to increased costs and a growing carbon footprint. Current systems fail to capture renewable energy, particularly kinetic energy generated by urban traffic, which remains an untapped resource. There is a need for a sustainable solution that reduces dependence on fossil fuels while effectively utilizing available kinetic energy. This project proposes an innovative street lighting system that generates electricity through piezoelectric plates embedded in speed breakers, converting vehicular movement into a valuable power source, thus enhancing energy efficiency and supporting eco-friendly urban infrastructure.

# 4 EXISTING SYSTEM

This existing system focuses on the integration of Renewable Energy Sources (RESs) like wind and solar power into the power grid while managing the inherent variability in their energy output. Traditional power systems struggle to maintain stability due to these fluctuations, compounded by dynamic consumer demands. The system introduces a novel energy balancing method that accounts for worst-case fluctuations in power generation and consumption, establishing boundaries for stable operation under fluctuating conditions.

# 5 PROPOSED SYSYTEM

The proposed system captures kinetic energy from vehicular movement by embedding piezoelectric plates under speed breakers. When cars pass over these plates, the pressure generates a low-voltage AC signal through the piezoelectric effect. This AC signal is rectified to DC, then boosted via a DC-DC converter to suitable levels for street lighting. The generated energy is stored in a battery, regulated by a Power Management Unit (PMU) to prevent overcharging and deep discharge, enhancing battery efficiency and lifespan. The stored energy powers LED streetlights, which use less power than traditional lighting, and the system can also support traffic signals, roadside sensors, and other public lighting needs, offering a scalable, versatile solution for urban energy demands.

# 6 BLOCK DIAGRAM

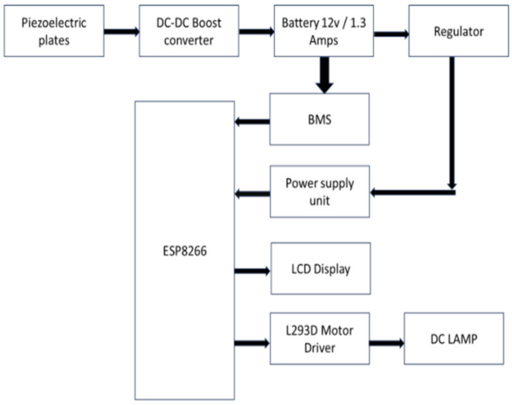


Figure 1: Block diagram.

# 7 COMPONENTS

## 7.1 Piezoelectric Plates

Figure 2: Piezoelectric plates.

Piezoelectric plates are materials that generate an electric charge in response to mechanical stress. In this project, they convert mechanical energy (from vibrations or pressure) into electrical energy, providing a renewable power source for other components in the system. Their efficiency and reliability make them ideal for applications in energy harvesting

## 7.2 DC-DC Boost Converter:

Figure 3: DC-DC boost converter.

A DC-DC boost converter is an electronic circuit that increases ("boosts") a lower input DC (direct current) voltage to a higher output DC voltage. It uses components like inductors, capacitors, diodes, and switches (typically transistors) to step up the voltage while maintaining efficient energy transfer. The converter works by rapidly switching the input voltage on and off, storing energy in the magnetic field of an inductor during the "on" phase, and then releasing it during the "off" phase. This process raises the output voltage above the input level. DC-DC boost converters are widely used in applications requiring a stable higher voltage from a lower voltage source, such as in battery-powered devices, solar power systems, electric vehicles, and LED lighting. They are essential for efficiently managing power in systems where energy must be conserved or where the available voltage is insufficient for the intended load**.**

## 7.3 L293D Motor Driver:

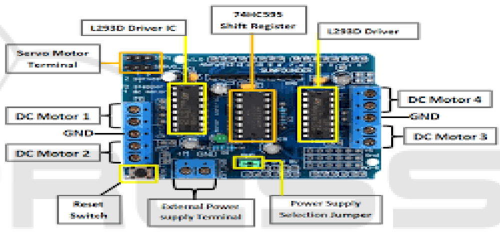


Figure 4: L293D Motor Driver.

**Function:** Controls two DC motors in both directions using an H-bridge configuration.
**Pin Configuratio:**
- 16 pins; requires high signals on enable pins (1 and 9) to operate.
- Four input pins control motor direction (clockwise/anticlockwise).

**Applications:** Common in robotics for controlling DC motors.

## 7.4 Regulator:

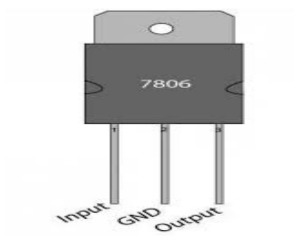


Figure 5: Regulator.

A regulator is an electronic device or circuit that maintains a constant output voltage or current regardless of variations in input voltage, load conditions, or temperature. Regulators are essential for ensuring that electronic components receive a stable power supply, protecting them from voltage fluctuations that could cause malfunction or damage.

### 7.5 BMS:

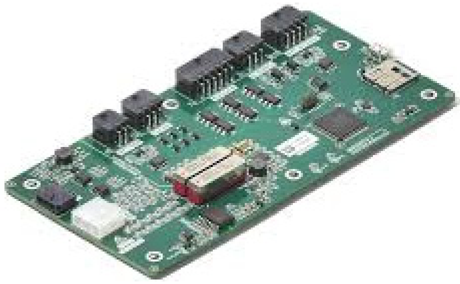

Figure 6: BMS.

A Battery Management System (BMS) is an electronic system designed to manage and monitor the performance of rechargeable batteries, ensuring their safe operation, longevity, and efficiency.

### 7.6 LCD Display

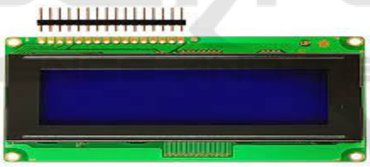

Figure 7: LCD Display.

A Liquid Crystal Display (LCD) is a type of flat-panel display technology commonly used in televisions, computer monitors, smartphones, and other electronic devices. LCDs work by manipulating light through the use of liquid crystals, which are substances that have properties between those of liquids and solid crystals.

### 7.7 DC Lamp

Figure 8: DC lamp.

A DC lamp is a type of lighting device designed to operate using direct current (DC) electricity. Unlike traditional incandescent or fluorescent lamps, which typically operate on alternating current (AC), DC lamps are specifically engineered to function with a constant, unidirectional flow of electrical current.

### 7.8 ESP8266 Controller


Figure 9: ESP8266 Controller.

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capabilities. Developed by Espressif Systems, it has become a popular choice for Internet of Things (IoT) applications due to its compact size, affordability, and ease of use.



## 8 SIMULATION RESULTS AND DISCUSSION

The simulation provides a comprehensive analysis of the system's performance under various conditions. Key metrics include:

Energy Conversion Efficiency: Measures the efficiency of converting kinetic energy into electrical energy.

Voltage and Current Stability: Assesses the stability of the power supply to the streetlights.

Battery Performance: Evaluates the charging and dischargig cycles to ensure the longevity and reliability of the energy storage system.

System Scalability: Determines the feasibility of scaling the system for larger applications.

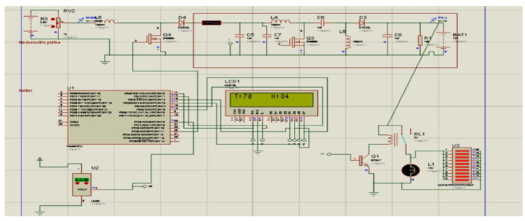

Figure 10: Circuit diagram.

The image shows an electronic circuit diagram including components like resistors, capacitors, diodes, transistors, an LCD, a microcontroller (labeled U1), a relay (labeled RL1), and other elements. It also depicts a piezoelectric plate, a filter, and a battery (BAT1). This diagram illustrates a specific application, potentially involving temperature and humidity measurement, as indicated by the LCD showing "T:70" and "H:84". This setup is relevant for understanding the design and functionality of the system.

# 9 CONCLUSION

This paper explores a cutting-edge approach to sustainable urban infrastructure through an energy-harvesting system for LED street lights, powered by piezoelectric technology. The system captures energy from everyday urban activity—like vehicular and pedestrian movement—using piezoelectric plates that convert mechanical stress into electricity. An integrated rectifier and boost converter ensure the power is suitable for storage and use, with a rechargeable battery and Battery Management System (BMS) supporting efficient, reliable energy distribution. LED lights further enhance energy efficiency, requiring less maintenance than traditional lighting.

A microcontroller, ESP8266, enables real-time monitoring via cloud-based platforms, allowing data on energy production, battery status, and system performance to inform timely maintenance and optimization. An LCD provides local feedback, engaging users and enhancing system accessibility.

Designed with safety and resilience in mind, the system's wiring and connectors are optimized for efficiency, aligning with sustainability goals by reducing carbon emissions and decreasing reliance on conventional energy sources. This solution highlights the potential of renewable energy in urban settings, contributing to smarter, eco-friendly city landscapes.

In summary, this project demonstrates how energy-harvesting technology can transform urban infrastructure. Its adaptability suggests potential applications in pedestrian pathways, transport hubs, and building designs, setting a precedent for sustainable urban development. By uniting city planners, engineers, and technology developers, such innovations foster collaborative solutions to pressing global challenges, steering cities towards a sustainable future.

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