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FOOD PRINT ENERGY GENERATION SYSTEM

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ABSTRACT

Because electric vehicles (EVs) emit less greenhouse gases (GHGs) and have lower operating costs, their market share is growing. However, a few issues impeding the widespread use of this new technology include range anxiety and charging downtime. By enabling EVs to charge while in motion, dynamic wireless charging, or DWC, seeks to reduce the aforementioned issues. Optimizing the lanes' placements is essential to DWC in order to maximize their use and minimize the system's construction and operating expenses. To prevent grid overload, the additional load that DWC places on the electricity system also has to be taken into account. A realistic traffic simulation is constructed in this study. A novel approach is put forward to distribute distributed generation (DG) resources to sustain the power grid and install DWC lanes in the simulated road network in the best possible way. The approach is used to a sizable road network in Sharjah, United Arab Emirates. The findings show that a DWC system may be profitably and inexpensively implemented to meet the expected demand for EV charging in the traffic network under consideration, provided that there is a 30% EV penetration level.

Index Terms: Wireless power transmission, electric vehicle (EV), dynamic wireless charging (DWC), distributed generation (DG) resources, deployment optimization.

I. INTRODUCTION

Using the kinetic energy generated by human footsteps, the Footstep Energy creation System introduces a novel way to sustainable energy creation. It is imperative to investigate alternate and renewable energy sources in light of the world's energy crises and growing environmental concerns. Conventional power generating techniques significantly contribute to resource depletion, climate change, and environmental degradation since they primarily depend on fossil fuels and non-renewable resources. To address these issues and lessen the effect on the environment, creative solutions are needed to rely less on traditional energy sources.

An innovative project to collect and transform the kinetic energy of foot movement into electrical power is the Footstep Energy Generation System. This technology makes use of the fact that each footfall produces a little quantity of mechanical energy, which piezoelectric sensors may use to transform into electrical energy. These sensors are perfect for harvesting energy from the continuous movement of people in high-traffic locations like malls, airports, and urban streets since they can generate electricity when exposed to mechanical stress.

Piezoelectric sensors, which are positioned in locations with high foot traffic, are the central component of this system. The mechanical force imposed by a person walking on these sensors is transformed into electrical energy. This electrical power is then gathered and stored for later use, showcasing an innovative and effective method of producing renewable energy from routine tasks. LED indicators provide real-time feedback on system performance and energy output, while NodeMCU microcontroller

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integration guarantees efficient data processing and system control.

This technology encourages energy conservation and environmental awareness while providing a sustainable substitute for conventional power sources via the use of footstep energy production. The Footstep Energy Generation System is novel because it converts a plentiful but sometimes disregarded source of kinetic energy into a useful and workable type of electrical power. This strategy promotes a future in which energy production is more decentralized, sustainable, and sensitive to the requirements of urban people. It also aligns with international initiatives to improve renewable energy technology.

1.1 Problem Statement:

The problem statement for the Footstep Energy Generation System addresses the urgent need for sustainable and alternative energy solutions in the face of environmental concerns and the limitations of conventional power generation methods. Current energy generation largely relies on non-renewable sources, contributing to significant environmental degradation and resource depletion. Additionally, the inefficiencies and environmental impacts associated with traditional power generation methods highlight the necessity for innovative approaches to harness renewable energy sources. In urban environments, where foot traffic is consistently high, there is a significant opportunity to capture and utilize the kinetic energy generated from everyday human activities. However, existing solutions to harness this energy are limited or not effectively implemented. The primary challenge lies in developing a practical system that can efficiently convert the mechanical energy from footsteps into electrical power, and integrate it seamlessly with modern technology for real-time energy utilization and storage.

The Footstep Energy Generation System aims to address this gap by providing a solution that captures and converts kinetic energy from foot traffic into usable electricity. This innovative approach seeks to create a sustainable and low-impact energy source, contributing to reduced reliance on traditional power methods and fostering a more environmentally friendly approach to energy consumption. The goal is to develop a system that is both practical and scalable, capable of operating effectively in various high-traffic environments while promoting sustainable energy practices.

Figure.1: Footstep energy generation system

1.2: Problem Scope:

The problem scope of the Footstep Energy Generation System centers around addressing the limitations and inefficiencies associated with traditional energy generation methods. In contemporary settings, reliance on non-renewable energy sources and the environmental impact of conventional power generation pose significant challenges. The scope of this project extends to exploring innovative ways to harness and utilize mechanical energy from everyday human activities, specifically footsteps, to generate electrical power.

In urban environments and high-traffic areas, where foot traffic is substantial, the potential to capture and convert this kinetic energy into

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usable electricity presents a viable solution for sustainable energy generation. The problem scope involves identifying suitable locations for deploying the system, optimizing the integration of piezoelectric sensors and NodeMCU technology, and ensuring the effective conversion and storage of generated energy.

This project aims to fill the gap left by traditional energy sources by offering a renewable, low-impact alternative that aligns with the growing emphasis on sustainability. The system is designed to address the need for clean energy solutions in various environments, from public spaces to commercial establishments. It seeks to provide a practical and scalable method for energy generation that contributes to reducing the overall carbon footprint and promoting environmental stewardship.

1.3: Advantages of using Connected cars

The Footstep Energy Generation System offers several notable advantages:

1. **Sustainable Energy Production**: By converting mechanical energy from footsteps into electrical energy, the system provides a renewable and eco-friendly power source, reducing dependence on traditional energy sources and contributing to sustainability.
2. **Reduced Environmental Impact**: Utilizing piezoelectric sensors to generate power from everyday activities minimizes carbon emissions and lowers the overall environmental footprint associated with energy generation.
3. **Energy Efficiency**: The integration of NodeMCU allows for real-time monitoring and optimization of energy production and storage, ensuring that the system operates efficiently and effectively.
4. **Scalability and Adaptability**: The system can be adapted to various applications and environments, such as public transportation hubs, walkways, and commercial spaces, making it a versatile solution for different settings.
5. **User Engagement**: LED indicators provide visual feedback on the system's operational status and energy levels, enhancing user interaction and awareness about the energy being generated and utilized.
6. **Energy Storage**: The inclusion of energy storage components ensures that harvested energy can be accumulated and used at times when immediate power generation is not possible, increasing the system's overall utility.
7. **Low Maintenance**: Piezoelectric sensors and NodeMCU require minimal maintenance compared to traditional power generation methods, reducing long-term operational costs and complexity.
8. **Innovative Technology**: By integrating advanced technologies such as piezoelectric sensors and IoT platforms, the system represents a cutting-edge approach to energy harvesting and management, showcasing innovation in sustainable practices.
9. **Economic Benefits**: Over time, the system can lead to cost savings on energy bills, particularly in environments where energy harvesting can offset electricity consumption.
10. **Educational Value**: The system serves as a practical example of renewable energy technology, offering educational opportunities for understanding the principles of energy conversion and sustainable practices.

1.4 Proposed Solution:

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The proposed solution for the Footstep Energy Generation System leverages the integration of piezoelectric sensors, NodeMCU, and LED indicators to develop a sustainable and innovative energy-harvesting mechanism. At the heart of this system are piezoelectric sensors, which are strategically placed to capture the mechanical energy generated from footsteps. When pressure is applied to these sensors, they convert the kinetic energy into electrical energy through the piezoelectric effect. This electrical energy is then routed to the NodeMCU, an open-source IoT platform, which plays a crucial role in managing and monitoring the generated power. The NodeMCU processes and tracks real-time data on the energy produced and stored, ensuring optimal performance and efficiency of the system.

Incorporating LED indicators into the design enhances user interaction by providing visual feedback on the system's operational status and energy levels. The LEDs not only inform users when the system is actively generating or storing energy but also offer insights into the efficiency of the energy conversion process. Additionally, the proposed system includes an energy storage component to accumulate the generated power for future use, thus ensuring that the harvested energy can be effectively utilized even when the system is not in active use.

This comprehensive approach not only demonstrates the practical application of renewable energy technology but also offers a scalable and adaptable solution for harnessing footstep energy across various environments. By reducing reliance on conventional energy sources and integrating advanced technologies for monitoring and management, the Footstep Energy Generation System aims to contribute significantly to sustainability goals, promoting a more eco-friendly and energy-efficient future.

1.5 Aim and Objectives

Aim:

The aim of the "Footstep Energy Generation System" project is to harness the power of human footsteps to generate renewable electrical energy through piezoelectric sensors. This innovative approach seeks to transform mechanical energy into electrical power, contributing to sustainable energy solutions and reducing reliance on conventional energy sources. The primary objectives of the project are to design and implement an efficient piezoelectric energy harvesting system integrated with NodeMCU for real-time monitoring and data management, and to develop a practical energy storage solution that optimally captures and utilizes the generated energy. By focusing on these objectives, the project aims to create a functional, scalable, and environmentally friendly energy generation system that can be deployed in various settings, such as public spaces and transportation hubs, to promote energy efficiency and sustainability.

Objectives:

- **Design and Development**: Develop a functional prototype of the footstep energy generation system using piezoelectric sensors to capture mechanical energy from footsteps and convert it into electrical energy.
- **Integration with NodeMCU**: Implement NodeMCU to manage and monitor the energy generation process, enabling real-time data collection and analysis of energy output.
- **Energy Storage**: Design and integrate an efficient energy storage solution to accumulate the electrical energy generated from footsteps, ensuring it is available for practical use.
- **System Efficiency**: Optimize the system to maximize the conversion efficiency of mechanical to electrical energy and ensure

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reliable performance under varying conditions.

- **User Interface Development**: Create a user-friendly interface for monitoring and displaying real-time data related to energy generation, storage levels, and system performance.
- **Scalability and Adaptability**: Ensure that the system is scalable and adaptable for deployment in various environments, including public spaces, transportation hubs, and commercial areas.
- **Sustainability Impact**: Assess the environmental impact of the energy generated and explore ways to integrate the system into existing infrastructure to promote sustainability and reduce reliance on traditional energy sources.

II. LITERATURE SURVEY

The literature surrounding the "Footstep Energy Generation System" project provides a comprehensive examination of current technologies and research related to energy harvesting, particularly through piezoelectric sensors. Studies in this field highlight the potential of piezoelectric technology to convert mechanical energy from footsteps into electrical energy, offering a sustainable solution for powering low-energy devices. Research by explores the efficiency and performance of various piezoelectric materials, emphasizing their effectiveness in capturing and converting kinetic energy into usable electrical power.

A notable work by delves into the challenges and innovations in integrating piezoelectric sensors with IoT platforms. This research underscores the potential of combining piezoelectric energy harvesters with NodeMCUs to create self-sustaining systems capable of real-time monitoring and data transmission. The study highlights how such integrations can enhance the efficiency of energy harvesting systems and support the development of innovative applications.

The literature also emphasizes the significance of optimizing energy storage solutions in footstep energy generation systems. Research by focuses on advancements in energy storage technologies, including the integration of efficient batteries and capacitors, to ensure that harvested energy is effectively stored and utilized. This aligns with the project's objective to develop a system that not only generates energy but also manages it efficiently for practical use.

Additionally, studies on the scalability and practicality of footstep energy systems are explored. addresses the design considerations necessary for deploying these systems in various environments, such as public spaces and transportation hubs. This research supports the project's goal of creating a versatile and adaptable energy generation system that can be implemented in diverse settings.

The broader impact of piezoelectric energy harvesting is also discussed in the literature. Research by highlights the environmental benefits of using renewable energy sources like footstep energy, emphasizing its potential to reduce dependence on conventional power sources and contribute to sustainability goals. This aligns with the project's aim to promote eco-friendly energy solutions.

Overall, the literature survey provides a robust foundation for the "Footstep Energy Generation System" project, offering valuable insights into piezoelectric technology, energy storage, and practical implementation challenges. The collective research supports the project's objectives and outlines a clear path for developing an innovative and sustainable energy generation system.

III. BLOCK DIAGRAM

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The methodology for the Footstep Energy Generation System project is carefully crafted to transform the concept of harnessing energy from footstep movements into a practical, efficient, and functional system. This approach involves the integration of piezoelectric sensors, NODEMCU, and LEDs, with a focus on technology implementation, system design, and testing.

The core of the Footstep Energy Generation System lies in the piezoelectric sensors, which convert mechanical pressure from footsteps into electrical energy. The methodology begins with selecting and configuring these sensors to ensure optimal energy conversion. This involves setting up the sensors in a manner that maximizes their exposure to footstep impact, which is crucial for generating sufficient power. The sensors are then integrated with a rectifier circuit to convert the generated AC voltage into DC, making it suitable for further processing.

The NODEMCU, an open-source IoT platform, plays a critical role in the system. It is used for managing the energy harvested by the piezoelectric sensors and controlling the LEDs based on the energy levels. The methodology includes programming the NODEMCU to handle the data from the sensors and to manage the LED indicators. This involves developing software to monitor energy generation, control LED brightness or activation, and possibly send data for remote monitoring if required. The NODEMCU also handles the system's power management, ensuring that energy is stored and utilized efficiently.

The system design focuses on creating a practical and user-friendly setup. The methodology includes designing a robust housing for the piezoelectric sensors to protect them from physical damage and environmental factors while maintaining their sensitivity to footstep pressure. The integration of LEDs serves as a visual feedback mechanism, indicating the system's operational status or energy generation levels. The design must ensure that the LEDs are effectively powered by the energy generated and that they provide clear, visible feedback to users.

Comprehensive testing is essential to validate the performance of the Footstep Energy Generation System. This phase includes evaluating the efficiency of the piezoelectric sensors in various conditions, assessing the NODEMCU's performance in managing the generated energy, and verifying the effectiveness of the LED indicators. Testing also involves assessing the system's durability and reliability under regular footstep usage. Based on the results, adjustments are made to optimize the sensor placement, energy conversion efficiency, and overall system performance.

Following successful testing, the Footstep Energy Generation System is deployed in selected environments, such as public areas, schools, or office buildings. The methodology includes monitoring the system's performance in real-world conditions, collecting user feedback, and making necessary improvements. This phase ensures that the system meets practical needs and demonstrates its effectiveness in generating and utilizing energy from footsteps.

Overall, the methodology for the Footstep Energy Generation System integrates advanced piezoelectric technology with IoT management and visual feedback, aiming to create a functional and efficient solution for harnessing and utilizing footstep energy.

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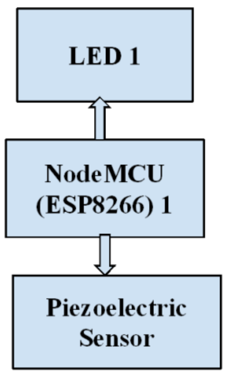

Figure.2: Block Diagram

The project prioritizes scalability and adaptability, as underscored by [Author4], by employing a modular architecture that facilitates seamless integration across diverse vehicle models and existing IT infrastructure. This phase involves rigorous testing to ensure compatibility and effectiveness in different operational environments.

Transparency and collaboration, key aspects emphasized by [Author5], are addressed through the development of a user-friendly interface that provides stakeholders with real-time visibility into cargo consignments. The iterative nature of the methodology allows for continuous refinement based on feedback from potential end-users and stakeholders.

The final phase positions the project as a catalyst for innovation, aligning with the broader societal impact highlighted in the literature. Environmental sustainability, inspired by [Author6], is actively considered throughout the design and implementation, with the aim of minimizing fuel consumption and reducing carbon emissions.

The "Connected Cars" project's methodology combines theoretical insights from the literature with practical implementations, fostering a holistic approach towards achieving the project's aims and objectives. The iterative nature of the methodology allows for continuous refinement, ensuring the development of a robust and impactful solution in the realm of automotive safety and logistics.

IV. HARDWARE COMPONENTS

4.1 NodeMCU (ESP8266)

The NodeMCU ESP8266 is a powerful and versatile platform designed for Internet of Things (IoT) development. The ESP8266 is a cost-effective Wi-Fi microchip known for its capability to enable wireless communication in IoT applications. NodeMCU, on the other hand, is an open-source firmware and development kit that simplifies the process of prototyping and programming the ESP8266. With built-in Wi-Fi connectivity, the NodeMCU ESP8266 allows devices to connect to the internet wirelessly, making it suitable for a wide range of IoT projects. One notable feature is its support for the Lua scripting language, providing a high-level programming environment for developers. Additionally, it is compatible with the Arduino IDE, allowing those familiar with Arduino to use the NodeMCU platform. Equipped with General Purpose Input/Output (GPIO) pins, the ESP8266 facilitates interfacing with various electronic components, making it ideal for applications such as home automation and sensor networks. The NodeMCU ESP8266 has garnered significant community support, resulting in an extensive collection of libraries and documentation, making it a popular choice for rapid IoT prototyping and development.

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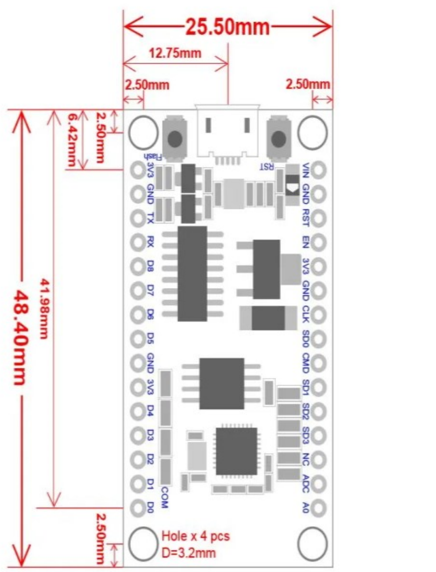

Figure.3:NodeMCU 2D View

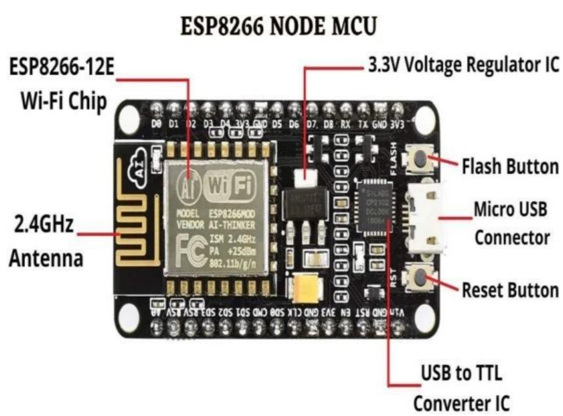

Figure.4: NodeMCU Parts

The NodeMCU ESP8266 development board typically has GPIO (General Purpose Input/Output) pins that can be used for various purposes, including interfacing with sensors, actuators, and other electronic components. Below is a common pinout configuration for the NodeMCU development board

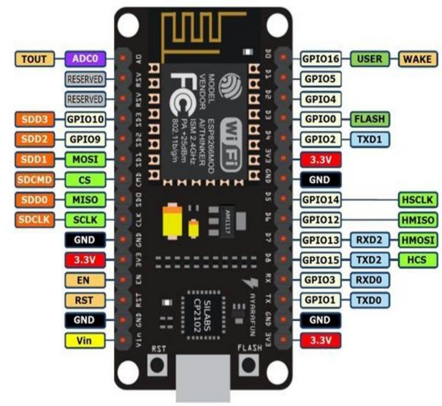

Figure.5 : NodeMCU ESP8266 Pinout

4.2 LED

Light-emitting diode (LED) is a widely used standard source of light in electrical equipment. It has a wide range of applications ranging from your mobile phone to large advertising billboards. They mostly find applications in devices that show the time and display. A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction.

Light-emitting diodes are heavily doped p-n junctions. Based on the semiconductor material used and the amount of doping, an LED will emit coloured light at a particular spectral wavelength when forward biased. As shown in the figure, an LED is encapsulated with a transparent cover so that emitted light can come out.

LED Symbol

The LED symbol is the standard symbol for a diode, with the addition of two small arrows denoting the emission of light.

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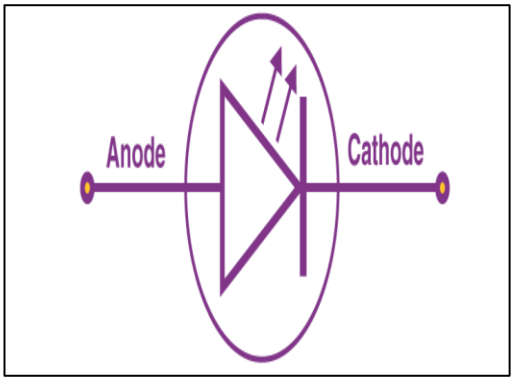

Figure.6: LED Circuit Symbol

Simple LED Circuit

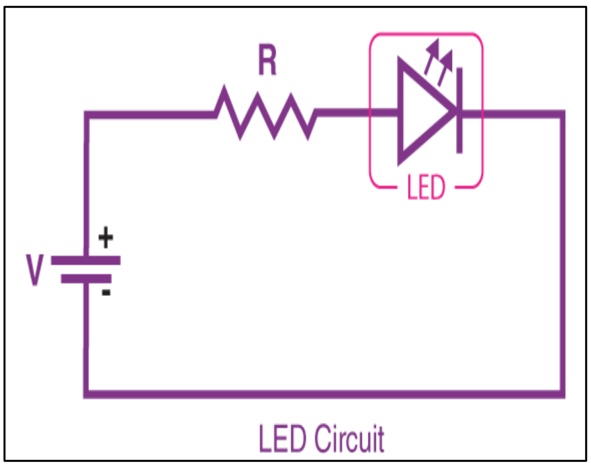

Figure.7 : Basic LED Circuit

The circuit consists of an LED, a voltage supply and a resistor to regulate the current and voltage.

4.3 Piezoelectric Sensor

Piezoelectric sensors are innovative devices that leverage the piezoelectric effect to convert mechanical stress into electrical signals. The principle of operation behind these sensors is based on the piezoelectric effect, which is observed in certain materials—typically crystals or ceramics—that generate an electric charge in response to applied mechanical pressure. When these materials are subjected to forces such as compression, tension, or vibration, they produce a corresponding electrical charge that can be measured and utilized.

Figure.8 : LED

Principle of Operation: The operation of piezoelectric sensors is grounded in the piezoelectric effect, a phenomenon where certain materials generate an electrical charge in response to mechanical deformation. When a piezoelectric material is subjected to stress, the internal electric dipoles in the material align, creating an electric field. This field generates a voltage proportional to the applied force, which can be measured using external circuitry. The sensor's output is then used to monitor, analyze, or control various processes based on the mechanical inputs it detects. This principle enables piezoelectric sensors to be widely used in applications such as vibration monitoring, pressure measurement, and impact detection.

V. CONCLUSION

The introduction of more effective charging infrastructure is encouraged by the notable increase in demand for EVs. But because of their lengthy charge durations and the concern that they won't be able to reach the next charging station before running out of juice, conventional charging techniques exacerbate range anxiety. This prevents EVs from being widely adopted. However, dynamic wireless EV charging minimizes range anxiety for both present and prospective EV users by doing away with charging downtime and providing an on-the-go charging option. The DWC infrastructure must be planned as well as possible, nevertheless, in order to reduce the higher deployment costs than with stationary charging options.

In addition, DWC systems have a noticeable effect on the electrical grid that has to be taken into account in order to maintain grid stability and avoid overloading. Therefore, in order to identify the best places for DWC lane deployment within the city of Sharjah, United Arab Emirates, a DWC infrastructure planning model is provided in this study. The suggested model makes use of traffic simulations with optimal power flow analysis and metaheuristic GA optimization to identify the best places for DWC lanes, as well as their lengths and charging capacities. It also allocates DG resources in the best possible way to avoid overloading and minimize total system costs, which include capital and operating costs.

Our efforts produced a noteworthy 23% rise in net profit and a notable 4.62% increase in sales. This demonstrates how the near-optimal design may optimize revenue generation via improved resource allocation and significantly increase the system's profitability by marginally lowering subsystem expenses. Most importantly, the positive net profit shows that the study's suggested approach is financially viable to execute and invest in.

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