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Design and Development of a Sustainable Smart School Model Using Renewable and Recovered Energy Sources

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ABSTRACT

This paper proposes a comprehensive Smart School Model integrating renewable energy systems and innovative energy-harvesting technologies. The model incorporates piezoelectric flooring under playgrounds, energy-generating speed breakers, solar panels, motion-based power generation from play stations, rainwater harvesting, and biogas plants. Additional innovations include chalk duster-based frictional electricity generation and smart lighting systems with object sensors. The proposed system not only reduces operational costs but also promotes sustainability and acts as a living laboratory for students to learn real-world applications of physics and engineering.

Keywords: Smart School, Piezoelectric Energy, Renewable Energy, Biogas, Rainwater Harvesting, Sustainable Campus, Motion-based Energy.

Main text

The global energy crisis and environmental degradation have emphasized the importance of renewable and sustainable energy solutions [1], [2]. Educational institutions provide an ideal ecosystem for experimenting with green infrastructure due to their continuous energy demand and role in shaping future generations. This paper introduces a Smart School Model designed to harvest energy from multiple natural and artificial sources including: Piezoelectric flooring in playgrounds, Speed breakers generating energy from vehicular load, Solar panels for administrative and classroom energy requirements, Biogas plants for cooking fuel, Motion-powered playground equipment, Object-sensor-based lighting systems, and Friction-powered campus radio.

I. INTRODUCTION

The global energy crisis and environmental degradation have emphasized the importance of renewable and sustainable energy solutions [1], [2]. Educational institutions provide an ideal ecosystem for experimenting with green infrastructure due to their continuous energy demand and role in shaping future generations. This paper introduces a Smart School Model designed to harvest energy from multiple natural and artificial sources including: Piezoelectric flooring in playgrounds, Speed breakers generating energy from vehicular load, Solar panels for administrative and classroom energy requirements, Biogas plants for cooking fuel, Motion-powered playground equipment, Object-sensor-based lighting systems, and Friction-powered campus radio.

II. LITERATURE REVIEW

The concept of piezoelectric energy harvesting has been widely studied in physics and electronic engineering literature [3], [4]. Similarly, solar and biogas technologies are well-established [5]. Previous works mainly focus on isolated renewable systems, but integration of multisource energy harvesting within schools has received limited attention. This paper addresses the gap by presenting a unified Smart School model.

III. SYSTEM DESIGN

A. Piezoelectric Playground—Piezoelectric tiles beneath grass convert pressure from children’s movements into electrical energy. This energy is stored in batteries and used to power an automated irrigation system.

B. Speed Breaker Energy Generation—Specially designed breakers embedded with piezoelectric or hydraulic systems convert vehicular pressure into electricity. Heavy school buses and trucks generate sufficient force for significant energy output.

C. Solar Power—Roof-top solar panels installed on classrooms and office buildings provide clean energy during daytime.

D. Motion-Powered Play Stations—Seesaws, slides, and merry-go-rounds are connected to rotors and turbines. Kinetic energy from playing children is converted into electricity.

E. Smart Lighting Systems—Object-detection sensors installed in classrooms and corridors reduce wastage of electricity by controlling lights only when required.

F. Rainwater Harvesting and Biogas—Rainwater harvesting ensures water sustainability for irrigation and sanitation. The biogas plant, connected to the canteen, produces clean cooking fuel while reducing dependency on LPG.

G. Friction-Powered Campus Radio—Chalk dusters embedded with piezoelectric layers generate low-voltage electricity through friction. The generated energy powers a small community radio system for announcements.

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V. EDUCATIONAL VALUE

The Smart School infrastructure doubles as a learning laboratory. Students can directly observe and experiment with physics principles such as piezoelectricity, frictional energy, and motion-to-electricity conversion, thereby strengthening conceptual learning as prescribed in textbooks such as H.C. Verma [1] and Dubey [2].

VI. CONCLUSION

The proposed Smart School model integrates renewable energy harvesting, efficient water management, and smart automation. It reduces operational costs, promotes sustainability, and serves as a live demonstration platform for students. This model has the potential for large-scale implementation in educational institutions to create eco-friendly, self-sustaining campuses.

REFERENCES

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