An innovative Thermo-energy Harvesting Module for asphalt roadway pavement

Developing a method for reusing thermal energy in pavement into low power for lighting and signal warnings

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20PUTSA42

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Total Project Cost:

$138,001

With roadways expanding, the number of vehicles is sharply increasing. This causes more congestion and higher crash rates. One of the great challenges in Texas is the road fatalities. Texas has over 675,000 miles of road, far more than any other state. Texas speed limits are also among the highest in the country. Therefore, risk of death is more likely on Texas roadways. Evidently, year 2016 has record fatalities of 3700 with more than 55% of them occurring on rural roads and intersections, 2.4 times greater than fatality rates in urban areas. The lack of street lighting, active signage and sustainable power in rural areas is a major cause of crashes and fatalities (US Census 2015). The significance of this project is in the need to enable safer, viable transportation networks by integrating an innovative and sustainable pavement cooling technique and low-watt traffic signals and LED lighting. The proposed prototype will absorb pavement heat and convert it into electric power, thus reducing pavement temperature. The self-produced power will be used to provide a source of power for low-watt traffic signals and LED lighting. Unlike conventional solar panels which require maintenance and are at risk of breakage and/or theft, the proposed embedded modules do not require maintenance which make them readily applicable.

Problem Statement

The concepts of energy conservation and developing alternative energy resources have become pressing due to the environmental impact of fossil fuel use. The generation of greenhouse gases is disturbing the climate balance and nonrenewable conventional energy resources are being depleted. Moreover, seeking current, green energy resources becomes increasingly necessary. Energy harvesting (scavenging) is a process that captures unused ambient energy that would otherwise be lost in the form of heat, vibration, stress, or deformation. With growing population and traffic volumes, the demand for safe, sustainable roadways is increasing. Roadways are exposed to several sources of strain energy by vehicle traffic loading, and thermal energy gradients by solar heat. These resources can possibly be converted and stored as usable electric power. Using innovative technologies to harvest this green energy may lead to a sustainable transportation network, particularly in remote areas with no power grids.

Objectives

This research addresses a major challenge in rising traffic fatalities in the rural transportation systems by integrating novel concepts of energy harvesting from asphalt roadway pavements. The concepts are aimed at converting waste thermal energy in pavement into low power for lighting and signal warnings. The aim of the study is to draft and implement a novel robust self-powered Pavement Energy Conversion Module (PECM) to cooling pavement surface and power LED lighting with limited utility power network. The module will absorb pavement heat and turn it into electrical power using Thermoelectric Generator (TEG) devices to cool the pavement where these modules are. The harvested power can be used in lighting and sensing applications. The specific objectives include:

- Design a thermal-collector module for power conversion and storage to transform the thermal gradient in pavement into useable electric power.
- Perform lab testing to assess the module functionality and durability under simulated Texas roadways environment and traffic conditions.
- Install the module at roadway pavement sections for on-site readings.
- Conduct economic feasibility and environmental assessment on the impact of the PECM versus other green energy resources (e.g., solar)

Figure 1: Asphalt Solar Collector System (De Bondt 2003)

Intended Implementation of Research

Workforce Development: The results of this research project will be incorporated into graduate-level courses at University of Texas at San Antonio (UTSA). This will give graduate students the opportunity to learn about the data.

Education: The proposed research project will fund one Ph.D student at the UTSA. The research activities provide the researchers with firsthand experience in laboratory and in the field in designing and testing sensors, energy converters, and storage systems.

Outreach: The PI's for this project will

1) Recruit and prepare students from underrepresented groups including Hispanic, Native American, and women (50% of the undergraduate population in UTSA are Hispanic and other minorities).

2) Conduct seminars explaining the concept and project results will be shown to DOTs, cities, and the industry.

Anticipated Impacts/Benefits of Implementation

The final product upon completion of this task will fulfill analytical criteria and give a complete review for selecting most efficient energy harvesting systems in terms of cost, environmental benefits, and long-term sustainability. The main deliverables from this study are: 1) a final report containing the problem statement, procedures, data, and recommendations, 2) journal publications and presentations to be given at Tran-SET conferences

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.