ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Special Issue

INSIGHT'17 - Advanced Transportation Systems And Infrastructure Development in Developing India

Emerging Trends of Harnessing Solar Energy from Road Pavement: A Green Road Concept

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Abstract :- **Renewable resources are an integral part of nature which can be harvested with no limitation. Harnessing energy has become a necessity in present conditions of global crisis and innovative ideas need to be implemented to prevent the depletion of natural resources.**

The upcoming technologies and demands globally have made the road network facilities as a basic backbone for communication services. As per the emerging trends, the maintenance and the operation of the roads require the illumination facilities, GIS, GPS and various sensors where the demand for the electricity consumption has increased.

The present research paper puts forth some promising techniques to utilise solar energy from road infrastructure. It is a new research territory that encompasses technologies to capture the wasted energy in pavements, accumulate and store it to satisfy some of the daily needs. Implementation of such methodology can prove viability and prominence of the same.

Keywords: **- renewable, roads, solar energy, sensors, electricity, global crisis.**

I. INTRODUCTION

The energy received from the sun which is approx 174000 TW which exceeds the current energy demands around the world (18 TW). This is the very reason why using solar energy becomes a concrete, reliable, renewable, environment friendly alternative for overcoming the current energy crisis.

In India a major problem seen on road transport is the lack of electrical facilities such as street lights, neon billboards and hotels on the highways. Even though the electrical street lamps are being substituted by solar lamps, the electricity thus generated is utilized only for lighting of lamps and not the other elements in the vicinity of it.

Lack of functioning of lamps on highways and especially hilly regions have been causing tremendous amount of accidents. Methods need to be adopted so as to reduce the inefficiency of lamps and focus on providing electricity using renewable sources. One of the methods that can be implemented is use of photovoltaic cells along the lining of the road. Photovoltaic cells are those semiconductors which convert visible sunlight into direct current. Such cells can be lined along the length of the highways or roads. The photovoltaic cells could also be embedded in the roadway between the Jersey barrier and the adjacent rumble strip. The electricity thus generated could be utilized to power the street lamps neon flash boards as well as direction and danger signs especially in the hilly ghat regions

Another practical approach that can be adopted is to install water filled pipes below the asphalt pavement and let the solar energy heat the water. The hot water can be thus channelled to nearby hotels or restaurants on the highways to fulfil their hot water needs.

Use of thermo-electric effect to generate electricity can also be adopted to harness the energy coming from the sun. Two semiconductors where one is placed in the shady areas on the side of roads and another inside the pavement, the theory says that the temperature difference might be enough to create current flow. Though the electricity generate might be very small but it can be usable.

Above methods suggest few of the alternative ways to harness the solar energy from the road and convert it into useful amount of energy.

It is necessary that these methods be adopted because there have been cases in India where the drivers have to rely on their driving skills to get past the section of road owing to the lack of electrical supply or no availability of street lamps

II. LITERATURE SURVEY

"We have mile after mile of asphalt pavement around the country, and in the summer it absorbs a great deal of heat, warming the roads up to 140 degrees

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Fahrenheit or more," said K. Wayne Lee, a professor of civil and environmental engineering at the University of Rhode Island (URI) and the leader of the joint project. "If we can harvest that heat, we can use it for our daily use, save on fossil fuels, and reduce global warming."

France has been the first country in the world to develop a solar powered road and is testing whether more of these roads are worth pursuing. The road is 1km long and made of 2,880 solar panels. It is estimated that there will be enough energy produced from the road to provide street lighting for the small village of Tourouvre-au-Perche. If this project is successful, France will continue to roll out 1000km more of these roads.

Regarding photovoltaic cell Lee comments that, "Since the new generation of solar cells is so flexible, they can be installed so that regardless of the angle of the sun, it will be shining on the cells and generating electricity."

Andrew Correia, a Graduate student has built a prototype system demonstrating the working of water filled pipes under the asphalt pavement he says that "One property of asphalt is that it retains heat really well," he said, "so even after the sun goes down the asphalt and the water in the pipes stays warm. My tests showed that during some circumstances, the water even gets hotter than the asphalt."

URI chemistry professor Size Yang believes that thermo-electric materials could be embedded in the roadway at different depths or some could be in sunny areas and others in shade and the difference in temperature between the materials would generate an electric current.

III. METHODOLOGY

The following methods to harness the solar energy from pavements are discussed in details herewith.

A. Method 1: Solar cell-lined highways or photovoltaic applications in pavements

Solar voltaic power generation is the direct conversion of solar energy into electricity. Sunlight comes in many colours, combining low-energy (1.1eV) infrared photons with high-energy (3.5eV) ultraviolet photons and all the rainbow of visible-light photons in between. Solar cells, also called photovoltaic or PV cells, are semiconductor devices designed to capture these photons and convert their energy directly into electrical energy.

The basic principle on which the PV cells work on can be summed up as: When a photon with sufficient energy impinges upon a semiconductor it can transfer enough energy to a electron to free it from the bonds of the semiconductor's valence band so that it is free to move and thus carry an electric current. The junction in a semiconductor diode provides the necessary electric field to cause the current to flow in an external circuit. The typical output voltage of a PV cell is between 0.5 and 0.6 Volts and the energy conversion efficiency ranges from less than 10% to over 20%. A DC-to-AC converter is required to convert the energy into electrical output.

The amount of power produced depends entirely upon the amount of sunshine available. The location, the degree of shading, season/time of the year, time of day, and other local climatic factors are the variables on which the output of these solar panels installed will depend. A situation with a long roadway and smaller needs will have a much better chance of energy independence

One of the simplest ideas to harness the heat out of asphaltic or concrete pavements is to wrap flexible photovoltaic, or solar cells around the top of barriers or dividers, dividing highways to produce enough electricity for streetlights and light up road signs. The photovoltaic cells could also be embedded in the roadway between the adjacent rumble strips.

The rural areas or the ghat regions in India, where sufficient lighting is not available can be illuminated by the energy generated by this process by putting up the solar panels on dividers or borders of the road surface, without interrupting the heavy road traffic. These panels can sufficiently light up the streetlights and illumination boards in the same area without much loss of energy.

The method of placing photovoltaic cells could be successfully implemented on Pune-Bangalore Highway (NH 4) where the dividers can satisfy the criteria which are needed for the implementation of above methodology. Also the above method could be used in the hilly ghat regions of Konkan area where there is deficiency of proper electrical network.

If the storage of energy is required, a virtual grid system can be used with a specialized meter. These meters spin backward when extra energy is produced.

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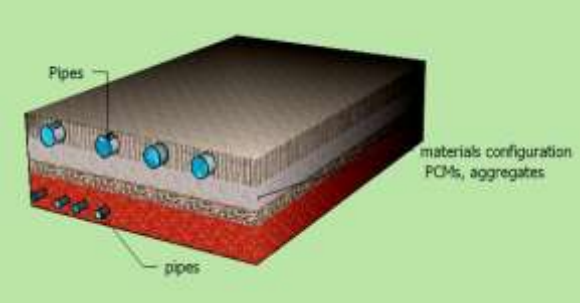
In turn, energy can be pulled back from the grid and it can be used to power the lights and heating elements in storm conditions when the panels may not produce sufficient energy due to lack of enough sunshine

B. Method 2: Subterranean pipes

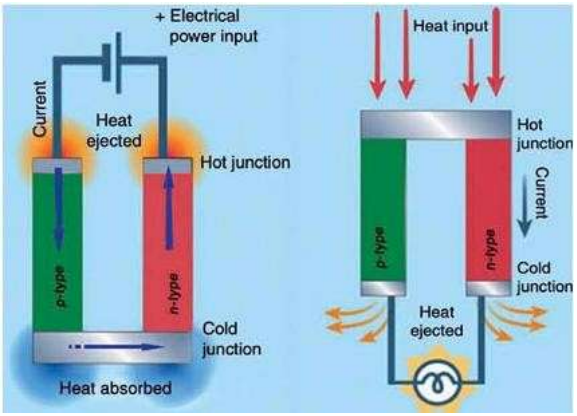


Another practical approach to harvest solar energy from pavements is to embed water-filled pipes beneath the asphaltic segment of the road and allow the sun to warm the water.

The method proposes embedding pipes and pumps in particular arrangements to harvest the extracted solar energy and convert it to thermal or electric energy. The arrangement used for this purpose is called asphalt solar collector (ASC) and it circulates water through a series of pipes below the pavement surface. The principle is that the radiation from the sun and atmosphere is absorbed in the pavement through an increase in warmth which is captured by water piping system and stored in the ground or other storage reservoirs.

The heated water could then be piped beneath the road surface and channelled into to nearby hotels or restaurants adjacent to the highways to satisfy heating or hot water needs, similar to geothermal heat pumps. It could even be converted to steam to turn a turbine in a small, traditional power plant.

C. Method 3: Generation of Energy using Thermo-electric effect



A third alternative uses thermo-electric effect to generate a small but usable amount of electricity using the thermal gradient of the pavement infrastructure which can satisfy the lighting needs on the road.

The thermo- electric effect is described when two types of semiconductors are connected to form a circuit linking a hot and a cold spot, there is a small amount of electricity generated in the circuit.

The semi-conductor devices exploit the temperature difference between the pavement sub-grade and the pavement surface that provides a potential source for electricity generation using the thermo-electrical principles.

The alternative technique that could be used is to embed the thermo-electric materials in sunny areas and others in shade along the road, and the difference in temperature between the materials would generate an electric current.

With many of these systems installed in parallel, enough electricity could be generated to light the streetlights and neon flashboards or for other purposes.

Instead of the traditional semiconductors, he proposes to use a family of organic polymeric semiconductors developed at his laboratory that can be fabricated inexpensively as plastic sheets or painted on a flexible plastic sheet.

IV. CONCLUSION:

The first method i.e the method of lining the highways with photovoltaic cells has an advantage of being cost efficient as well as generating maximum amount of energy thus utilising its purpose to its fullest The third method of using the thermo-electric effect generates a small but usable amount of energy compared to the first method. However research is still being conducted in this field of utilising the solar energy using the thermo-electric effect.

The implementation of subterranean pipes in the road network along with photovoltaic cells can be an efficient way to form an ideal green road. Whereas, the subterranean pipes can also be combined with thermo-electric generates but it would not yield the equally satisfactory results as the photovoltaic cells

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