

A Novel Route for Construction of Smart Highways by Using Photovoltaic Solar Panels

Abhishek Rajendra Patil^{a*}, Vaibhav Yashwant Khairnar^a, Dr. Anil V. Kokate^a and Dr. Rajendra S. Narkhede^a

^a MET's, Institute Of Technology- Polytechnic, Bhujbal Knowledge City, Adgaon, Nashik

Abstract

The solar smart highways involves photovoltaic effect. The solar radiations are directly converted into electricity by using single crystalline silicon or cadmium telluride based solar cells. The transparent concrete is used for paving the surface of solar roads which can bear 10 times more pressure than regular concrete. Fine concrete and optical fibre are used for preparation of structure of smart highway. The LEDs are embedded in the smart structure with transparent panel and solar road gets illuminated for safe travelling at night and gives aesthetic look. A microprocessor based technology is used for controlling the fitting element. The cost for construction of such smart highways is taken in the account.

Keywords- Smart Highways, Photovoltaic Panels, Crystalline Silicon, Transparent Concrete, Optical Fibre, Microprocessor LEDs.

*Author for Correspondence- abhishekpatilce@gmail.com

1.1 Introduction-

As the sky grows dark, the smart highways begin to glow by the assistance of photovoltaic solar panel road. The solar road consists of numbers of panel when it interlinks with each other. This intelligent road pays for itself through the generation of electricity replacing petroleum based asphalt highway and thus enhancing the highway infrastructure.

In India, approximately an area of 8.5 billion square metre is covered with roadways in which approximately 30% is under ill-lighting. The vehicles running on such asphalt roads consuming fossil fuel outsend a large amount of carbon monoxide and other green house gases which increase large amount of carbon footprints.

Today, we are indeed aware that the fossil fuels such as coal, oil and natural gas as well as automatic energy are finite resources. Excessive worldwide usage has also introduce conflict and modern concept such as global warming, smog alerts, acid rain, etc. presently, as much as 80% of energy consumed come from chemical energy stored in fossil reserves. Any major changes in energy consumption are not foreseen in the near future. Instead, the global energy demand is

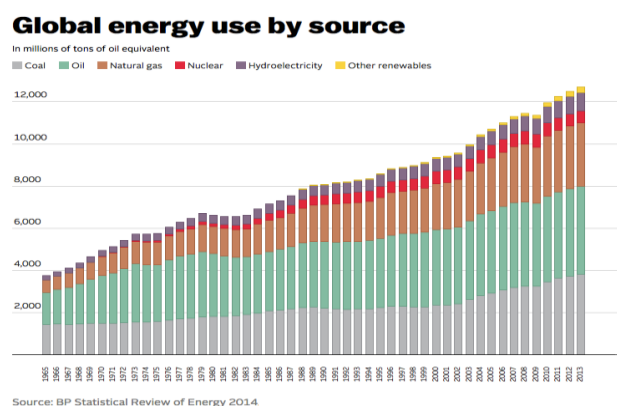


Fig1. Global statistical utilization review of energy.

expected to increase by upto 60% and CO₂emission by 70% by 2020 which, put pressure on an already stressed energy system. Therefore it is of great importance to develop new alternative sources, which are not based on fossil fuels.

Many island countries like FIJI island, PAPUA NEW GUINEA, NIGERIA etc. depend on fossil fuel for generation of electricity (almost 85%). This fossil fuel may runout in next 53 years. To replace this fossil fuel. The solar photovoltaic (PV), a proven technology for energy generation is a clean and renewable source of energy. The solar photovoltaic panel will provide electricity to illuminate the LED's through highways at night. The same LED's could be used to display messages that warn drivers of weather condition, road obstruction and accidents.

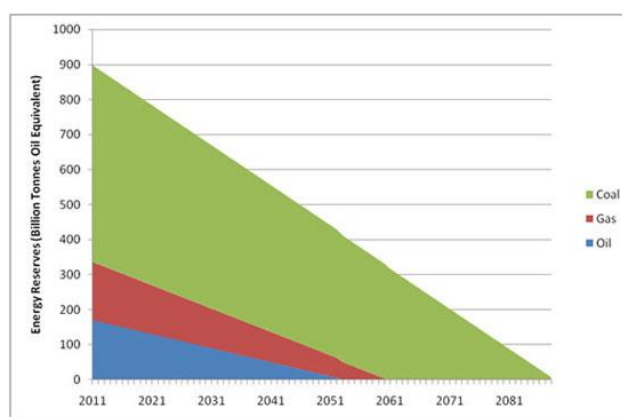


Fig.2 Estimated rate fall of fossil fuels

Solar energy being a renewable energy source represents a real solution to the problems of conventional energy supply taking into account that the amount of energy reaching our planet in a year is about 10000 times more abundant in comparison with the annual consumption in the whole world, if we are able to manage to harvest even a moderate fraction of this gigantic source, we would be able to satisfy more than our need.

Solar photovoltaic (PV) is a renewable technology which has ability to shape a clean, reliable, scalable and affordable electricity system for the future. In regard of this fact governments of most countries are encouraging the development and deployment of solar photovoltaic (PV) technology. This technology can make the emerging electric vehicles far more affordable and easily manageable. It can help in eliminating a huge expenditure on burning fossil fuels. Solar roadways at just 15% efficiency which is far below than what is expected would produce thrice total electricity demand.

1.2 Case study-

Fig.3 shows the construction of solar roads 1km long in JINAN, the capitol of SHANGDONG in CHINA. This 1km stretch comprise of 2 lane solar road which covers an area about 5875 square metre and can generate upto 1million kilo watt hours of power annually according to Xinhua net this generated power is enough to be used for 800 Chinese homes. Fig.4 shows final typical view of smart road with PV panels.



Fig.3 construction of highway with PV panels.



Fig.4 Typical view of smart highway with photovoltaic panels.

1.3 Preparation of transparent concrete-

The transparent concrete is used for paving the surface of solar roads which can bear ten times more pressure than regular concrete. The working of this concrete is based on Nano-optics. There are two basic material used for preparation of translucent concrete namely

1. Fine concrete
2. Optical fibre

1. Fine concrete-

Fine concrete consists of cement and fine aggregate such as sand. The cement used is 53 grade ordinary Portland cement. The sand passing through 4.75mm IS sieve is used. All properties of sand are tested under the guidance of IS specification.

2. Optical fibre-

Optical fibre consist of three layers which are-

1. Core – It is the innermost layer of fibre with a thin glass centre allowing the light to travel through it.
2. Cladding- It is the layer surrounding the core which has less refractive index as compare to core so as to confine reflection in the core
3. Buffer coating- It is the outermost layer of fibre protecting it from damage and moisture.

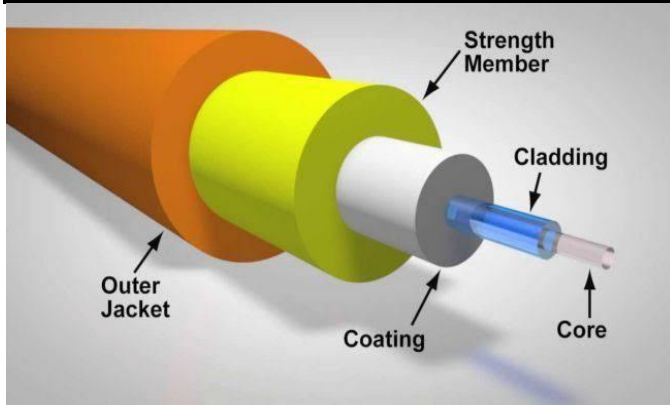


Fig.5 Structure of optical fibre

1.4 Material performance-

1. Concrete retains its strength
2. High density top layer concrete
3. Infused with optical fibres
4. Frost and de-icing salt resistance
5. Fire protection
6. Highest UV resistance

This technology of translucent concrete has few manufacturers which includes LITRACON, LUCON and LUCEM LICHBETON. The cost of Translucent concrete rated by LITRACON is around \$1000.

1.5 Photovoltaic effect-

Solar roadways involve photovoltaic effect. It is the method of generating power by connecting solar radiations into direct current electricity by using semi-conductors that exhibit the photovoltaic effect. PV power generation hires solar panels composed of a number of solar cells containing a photovoltaic materials. The photovoltaic materials mainly includes monocrystalline silicon or polycrystalline silicon or cadmium telluride or cadmiumsulphide etc. `

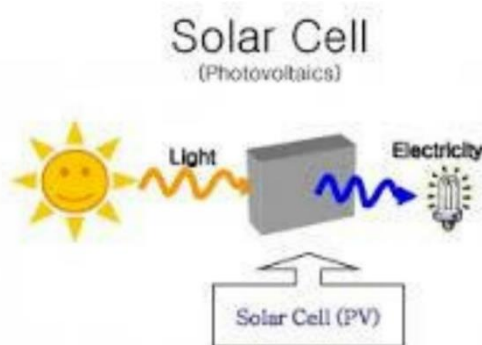


Fig.6Working of photovoltaic cell.

When the sunlight falls on the solar panel, the solar energy is converted into electrical energy thus generating electricity. The excess energy stored at the same time is transferred to near by houses and power stations. LED's controlled by microprocessor display information on the surface of the road. The de-icing layer clears the road and also senses changes in weight. This makes driving at night much safer. Unlike the dark roads the solar road ways will paint the lanes with LED's which can be instantly customised as needed. Thus the solar roadways with clean renewable energy make the highway more smart and intelligent.

1.6 structure formation of smarhighways

Road surface layer-

The road surface layer is a semi transparent topmost layer of the assembly. This layer allows the solar rays to reach upto the photovoltaic cell where solar energy is collected. The material is made rough enough to provide great traction thus avoiding skidding of vehicle. It is tough enough for handling today's heaviest load under worst conditions and is made waterproof thus preventing electronic layer beneath it.



Fig.7 A typical view of Road surface layer

Electronics layer-

The electronic layer contains solar photovoltaic cells which absorb solar energy. It also contains a microprocessor board with support circuitry for sensing loads on the surface and controlling the heating elements. This technology eliminates the snow/ice removal and school or business closings due to unrelenting weather in the snow-falling regions. The lighting, communications, monitoring, etc. are controlled by on-board microprocessors which are installed at every 12 feet distance.

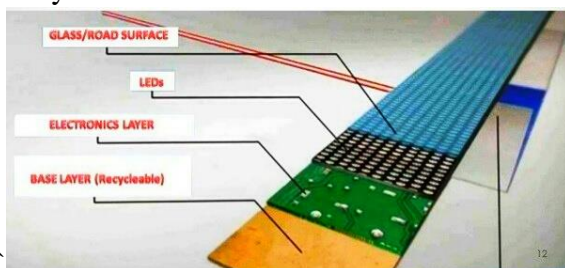


Fig.8 Layers of solar panel highway

Base plate layer-

The solar energy collected by the electronics layer is distributed using the base plate layer. The power and data signals are distributed "down-line" to all homes and businesses connected to the solar road ways. This layer needs to be weather-proof to protect the electronic layer above it.

1.7 Advantages-

The leading advantage of the smart highway concept is that it utilizes a clean and renewable source of energy. The life span of a solar panel is around 20 years, which is greater than a normal asphalt road which only lasts up to 7-12 years. The solar road way does not require the development of unused and potentially environmentally sensitive lands. It does not require an external connection to an artificial power source as the solar power is renewable. By embedding LEDs beneath the transparent panel, the solar road will get illuminated for safe travelling at night and give an aesthetic look.



Fig. 9 Typical aesthetic look of PV panel based highway

1.8 Conclusions-

The solar roadways can be implemented with little extra cost than the current system. This technology can help in reducing nation's greenhouse gas emission by 50%. It creates an intelligent, secure, decentralised, self-healing power grid. It also helps in prevention of accidents caused by snow and ice.

1.9 Future scope-

The solar roadways are one of the smartest ways to expand our market and multiply the job requirements. Now a day tracking of the vehicles i.e. high risk vehicles is difficult but by assistance of solar road ways we can track high risk vehicles that we want to track by installing radio frequency tags on these vehicles. In this solar road all electric cars can be recharged while in motion on top of these roads by assistance of embedded induction plates.

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