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REVIEW ARTICLE

A REVIEW ON FUTURE HIGHWAY (THE NEW ERA OF SMART ROADWAYS)

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ABSTRACT

The today's world is heading towards better environmental conditions through reduction of degrading factors of it. One of such initiative for cleaner environment is more acceptances of renewable resources rather than the traditional ways of using exhaustible resources. The Solar Roadway is a great innovation leading towards clean energy and cleaner environment. Solar energy has been the subject of great development in the past years, which led to the concept of Solar Roads. The Solar Roadway is a series of solar panels which is used to drive upon. The purpose of presenting this paper is to take a survey of solar roads which uses the solar panels to absorb the solar energy for working of solar road. This new technology road consists of solar panels, photovoltaic effect, LEDs and microprocessor chips. Basically, the idea of using solar road is to replace all current petroleum based road, parking lots, etc with latest technological road i.e. Solar Roadway made of solar panels. These solar panels collect energy from sun which can be used in our homes as well as businesses. By using solar energy the requirement of fossil fuel can be reduced which is being used for the generation of electricity as well as it will reduce the use of oil/diesel for driving the vehicle. Reduction in use of fossil fuel as well as oil/diesel will reduce the greenhouse effect nearly to half. Solar power generation has emerged as one of the most rapidly growing renewable sources of electricity solar power generation has other advantages over another form of electricity generation. A solar roadway is an intelligent highway infrastructure which is capable of self-healing decentralized power grid which eliminates the need for fossil fuels in future. It also features wildlife preservation, the elimination of impervious surfaces, law enforcement, DUI detection, counter-terrorism, etc. Therefore, it's time to update our infrastructure (especially roads & power grids) with the latest technology roads utilizing the solar energy i.e. "Solar Roadways". Solar power production generates electricity with a limited impact on the environment as compared to other forms of electricity. The solar roadways are eco-friendly, feasible & reduce the 70%accident.

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INTRODUCTION

As we all know that solar energy is an important source of renewable energy which is being used in solar roadway for the proper functioning. Solar roadways consist of structurally designed solar panels. Each solar road panel interlinks with neighboring panel to form solar roadways system. The present petroleum-based highways are replaced by the new solar roadway i.e. with an intelligent road that works on solar energy and pays itself through the generation of electricity using solar energy. The solar roadways are made up of structurally associated solar panels, each made of 12 ft x 12 ft (3.658 m x 3.658 m) size, interlinked onto each other. The solar panels are made up of photovoltaic cells which have the function of converting the solar energy into electrical energy.

The solar photovoltaic has the advantage of direct conversion of sunlight to electricity and also well suitable for most of the regions therefore it is highly preferred when compared to other renewable energy sources. Global energy crises and environmental concerns from conventional fossil fuels have attracted more and more renewable energy developments in the worldwide. The cells consists of a semiconductor materials showcasing the photo voltaic effects of absorbing the electromagnetic radiation acting on the surface and ultimately extracting of electrons solely used as the source comportment of current flow. The Solar Roadways system at present, cost about three times to that required for the installation of an asphalt road. Solar Roadways can pay dividends for the public budget, making our spending on infrastructure more efficient and significantly reducing electricity costs to consumers and businesses. The roadways can also communicate with drivers,

by sending him signal in the form of visual messages of the presence of pedestrians in a crosswalk. It is one method to capitalize the new trend of roads and expand the new technology, and also shows that how quickly we can make the shift to an economy rooted in abundant, domestic, clean energy resources.

Construction of Solar Roadways

Solar roadways are basically made up of solar panels. The solar panels used here are made of glass, but not ordinary glasses. It was sent for traction testing and showed that it can withstand a load of 250,000pounds, i.e. more than three times the weight of a fully loaded semi-truck. Each of the solar roadway hexagonal panels covers an area of about 4.39square feet.

Solar Roadway consists of three layers:

- Road/Glass Surface Layer.
- Electronics Layer.
- Base Plate Layer.

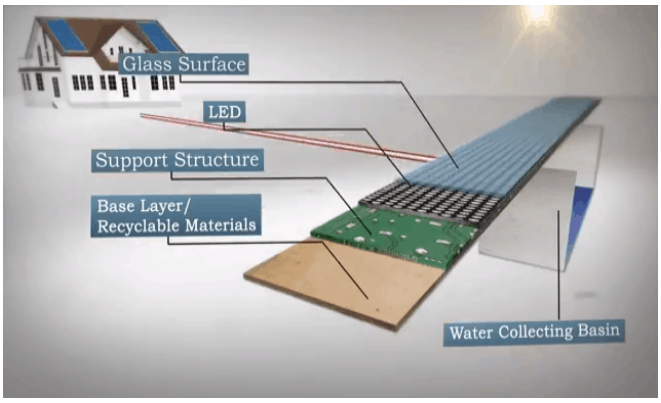

Figure. Working of Solar Roadway

Road surface layer

This is the top most layers of the assembly and also from this layer the solar rays will reach up to the photovoltaic cells. It should be translucent and should have high-strength. It is made in such a manner that it provides enough traction to avoid the skidding of vehicles. Since the material of this layer is made rough but the material used is translucent, therefore it still passes sunlight through it to the solar collector photovoltaic cells embedded within it, along with LEDs and a heating element. Also it is tough enough for handling today's heaviest loads under the worst conditions and it is made water-proof so that it can prevent electronics layer beneath it.

Electronics Layer

It is the second most layer of the solar road which contains photovoltaic cells which absorb solar energy and converts it into electricity. It also consists of a microprocessor board with support circuitry for sensing loads on the surface and controlling a heating element. This board contains a heating element which help in melting of snow/ice and also sensors are used which sense the load which results in no more school/business closings due to inclement weather in the snow falling regions will take place. Electrical components are placed on a circuit board which is placed between two pieces of glass and hermetically sealed to protect the sensitive electronics. Each panel can sense road conditions and can communicate it to drivers. The on-board microprocessor controls lighting, communications, monitoring, etc. which shows that the Solar Roadways is an "Intelligent Highway System".

Base Plate Layer

It is the bottom layer of the solar road which is placed after electronic layer. The energy collected from sun where as the base plate collect the power and data signals (phone, TV, internet, etc.) from electronic layer and distributes it to all homes as well as businesses connected to the Solar Roadway via electronic layer. The base layer is made weatherproof so that it can provide the electronic layer above it.

Block Diagram

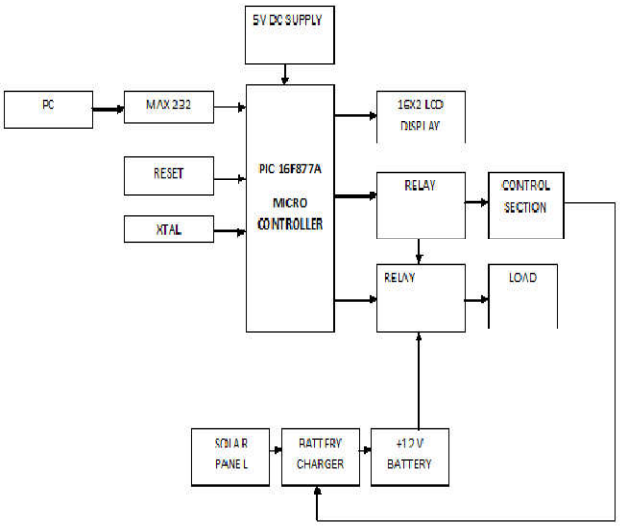

Figure Block Diagram

Solar Panel

A solar panel consists of a collection of solar cells which absorb energy from sun and utilize it for working of solar roadway. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. In order to get enough sufficient power, solar panels must be pointed directly towards the Sun. These solar panels are connected in series in such a manner that they all together collect energy from sun and store it in photovoltaic cell.

Micro Controller

The solar panels are the fundamental components for the conversion of solar-energy which are fixed at a certain angle and are not able to track the sunlight direction with diurnal and seasonal changes. This limits the area of exposure of sunlight on solar panels and efficiency of the solar tracking system involving solar panels. In order to improve the power efficiency of the solar panels a solar tracking system using a combination of micro-controller, stepper motor and light dependent resistors (LDR's) have been developed. The main component of this tracker is AT89S52 micro-controller which is programmed to detect the sunlight with the help of LDRs and then actuate the stepper motor to position the solar panel in

such a way that it gets the maximum sunlight for generating enough current. Thus this system can achieve maximum illumination and can reduce the cost of electricity generation by requiring minimum number of solar panels with proper orientation with the sunlight.

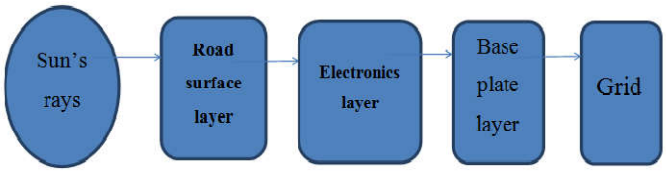

Figure Block diagram representing solar roadway functioning

Relay: A relay is an electrically operated switch. Current through the coil of the relay flows and creates a magnetic field which in turn attracts a lever of the relay and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

Significances

a)Environmental significance: The solar roadways have been great origination if an environment perspective is to be ascertained. The traditional way of constructing the road with use of asphalt and bitumen has been degrading the environmental system intermittently causing impairment to sensitive ecosystem, demographic changes, natural disasters, degradation of climatic condition of earth, starter of various deadly diseases affecting environmental health, etc. During the construction of bituminous roads, the greenhouse gases substantially released directly or indirectly during process popularly named as carbon footprint. The solar roadway on the other hand, has no influence to environmental ecology due to reduction in use of fossil fuels which would ultimately minimize the emission of carbon footprint. The solar roadways help in maintaining the hydrological system reducing the impact on infiltration rate, runoff in comparison to paved ones. In cold regions where snowfall is frequent, the de-icing of roads is to be done so that the vehicle can smoothly run without any traffic hindrance. Thus, in case of solar roadways, the de-icing of roads is not required due to heat transfer behavior by the photovoltaic cells in the road structure.

Economic significance: The certain economic advantages which are initiated through use of solar roadways are given as under:

- The solar roadways render a profitable scenario for the formulation of tactics and strategies for the government by paying out the dividends of public budget through spending more effective infrastructural development. This scenario can be made possible as the solar roadways render the huge amount of electrical energy which can be utilized by the nearby buildings, street lights, etc. thus, reducing the consumption through other energy sources.
- The construction of solar roadways doesn't require the usage of bitumen. Thus, it will eliminate in wastage of hundreds of billions of dollars per year due to lessening in use of fossil fuels.
- The solar roadway turn out to be an intelligent, self-healing, and secure power grid replacing the parking lots, driveways, and street areas. The areas connected to these roads are aided through power generation.

Other Significance

- In case of military emergency and rescue operations, solar roadways act as a key aspect for power generation as the energy source is renewable and doesn't get halted under shortage of exhaustible resources.
- The lighting up of roads can be undertaken by adding up LEDs underneath the glass panels for night travel, imparting messages to warn commuters of accidents, detours and preferably also for aesthetic look.
- The traffic management is the most important feature in roadways which need to be followed efficiently. The solar roadways helps in managing the traffic through use of microprocessor in electronic layer which makes vehicles maintain proper speed, the traffic congestions in particular area and detours around it, pedestrians walk arrangement, etc.
- The national security can be ascertained through tracking of suspicious vehicles onto the road surface through microprocessor embedded in it.
- The solar roadways save the energy consumption as the subsequent power required for running the traffic signs, street lights, and traffic crossings can be easily restored through it.

Shortcomings

The solar roadways, an innovative concept, have followed up with many shortcomings considerably making the use of idea onto the reality, a hectic touch. The shortcomings yielded by the solar roadways are illuminated imparting the variation onto the feasibility of the project:

- In hot climate, the temperature of solar cell gets stuck in a close environment which is bad for both the efficiency and for the lifetime of the cell. Thus, solar roadways hinder the efficiency of solar cells present beneath the road surface layer during hot weather conditions.
- Occurrence of subsidence is the major problem due to solid nature of solar roadways initiating destruction of panels in the structure. The degradation of panels will not supply any electricity triggering the failure of the structure. However in case of traditional bituminous roads, they are able to flex whenever subsidence occurs.
- Solar roadways is not effective to all scenarios of traffic conditions such as the areas with frequent traffic jams which mean, the roads will remained shadow by the vehicles not rendering the electrical energy efficiently, the areas with more heavy loaded traffic as the roads are prone to more damage, the areas where 24x7 running of vehicles is expected causing the repair work uneasy in case of malfunction of roads.
- The characteristics of solar roadways melting the snow is dubious claim as the asphalt, itself being good thermal solar collector, is not able to melt snow present in it, then claiming the melting of snow in glass textured layer is impractical.
- The geometrical design is the concern area for efficacious highway operation. Bitumen roads can be curved naturally and smoothly in valley, summit or horizontal curves. But, in case solar roadways being a

rigid structure, doesn't allow getting effective natural curve for the road.

- The rolling of additional traffic density or public density in these roadways is not accepted as these roadways are designed for particular set of geometrical protocols such as maximum traffic density, weight of vehicular loads acting onto it, pedestrian's density, etc. Thus, durability is kindly reduced in case of solar roadways.
- The seasonal variation causes the change in effectiveness of solar roadways. Thus, the additional energy source may be required for operating the infrastructural works during off season duration such as winter, monsoon, etc. Thus, the effectiveness is reduced and the increase in monetary factor is ascertained.
- The solar roadways made up of precious semiconductor materials flops when the circumstances like spilling of water onto the circuitry during heavy rains, extraneous material entering the circuitry due to dirt present in the surface, etc. are entertained. Fatal destruction of public as well as infrastructure may be instigated in case of outbreak of fire or accident, causing damage of surface layer.
- The solar roadways with its rigid and unbent structure cause the accumulation of rubber, salt, soil and other stuffs that block sunlight and must be removed for operation of solar panels. Thus, the durability certainly decreases, and further increasing maintenance costs.

FEATURES

Illuminated roads: The Solar Roadways have LEDs that illuminates the lanes. During night many people face the problem of seeing the road lines during driving. By implementation of these illuminated roads accidents at night time can be reduced and henceforth the night-time driving will be safer for all. The LEDs are used to paint roads with instructions like SLOW DOWN, GO, SPEED LIMIT, STOP, etc. It gives warning to drivers if an animal arrives on the road or in case of a detour ahead or an accident or construction work.

Electric Vehicles: A Solar Roadway can recharge electric vehicles (EVs) anywhere. EV owners will be able to charge EVs with clean renewable energy at solar parking lots, at restaurants. EVs will then be charged by the road while driving. This means that there is no need for carrying large batteries, which will lighten their load and require less power to go the same distance.

Oil independence: Solar roadways reduce the dependency on oils. Demand of oil is also increasing with number of vehicles. And so the sources of fossil fuel are not sufficient to supply such a huge demand. By replacing oil driven vehicles by electric vehicles, dependency on oil can be reduced.

Smart Grid: The energy produced from solar roadways can be transferred to the grid**.** With sufficient installed infrastructure; solar roadways can replace all current centralized power stations and become the smart grid for each nation. The Cable Corridor can replace the poles needed to run the overhead lines. Power lines, telephone lines, etc. can be placed within the Cable Corridor and can significantly reduce outages (a period when a power supply or other service is not available) from storm events. Much of the power is utilized near the power source.

Advantages and disadvantages: Following are the advantages and disadvantages of solar roadways:

a)Advantages

1) Utilizes a renewable source of energy to produce electricity.
2) Reduces dependency on conventional energy sources such as coal, petroleum and other fossil fuels.
3) It provides electrical power to all business and homes.
4) It can replace our current centralized power stations and become the smart grid for each nation.
5) It is environment friendly and causes no pollution, produces no greenhouse gases.
6) Has greater life span, for around 20-30 years while the life span of an asphalt road is 7 to 8 years.
7) Solar Roadway is modular, so repair will be much quicker and easier. In case of defect, the panel could be swapped out and reprogrammed in a few minutes and then can be inserted back.

b)Disadvantages

1) Following are the disadvantages of solar roadways:
2) It has very high initial and maintenance cost.
3) The average efficiency of the solar panels is currently 20%.
4) Due to high initial cost, it cannot be constructed in the poorest developing nations.
5) Due to fewer amounts of sun rays, it becomes less efficient in winter season.

FUTURESCOPE

The normal roads can be replaced by solar roads in the near future. As it requires huge initial investment, it would be difficult to install solar roadways in developing countries. In developed countries like United States, if the entire US were surfaced with solar panels, it would produce more than three times the amount of electricity currently used nationwide which is almost enough to power the entire world. Solar roadways will also solve the problems of usage of fossil fuels and energy consumption.

Conclusion

The solar roadways are a new technology highway that can be a decentralized power grid that pays for itself. The idea of solar roadway is to replace the asphalt roads with solar roadways on our streets, highways parking lots and sidewalks that collect solar energy to be used by our homes and businesses. Our dependency on oil has long been a matter of national security and we don't want to wait until it's gone to decide what to do next. We have the technology to solve this problem in a relatively short period of time, which may be all we have left.
In developing counties the major part of the geographical area is to be explored in terms of road connectivity. So instead of implementing the higher targets roads to be developed per day such countries can reduce the target and develop solar road so they could improve economy with infrastructure.

Generally the Solar Roadways will:-

- Create an intelligent, secure highway infrastructure that pays for itself.
- Create an intelligent, secure, decentralized, self-healing power grid.
- Eliminate the need for coal-fired or nuclear power plants.
- Dependency on oil and other fossil fuels (oil, coal and natural gas) is no more.
- Cut our nation's greenhouse gas emissions by over 50%.
- Provide safer driving conditions.
- Snow & ice management
- Traffic management
- Wild life protection
- National security
- Usage of recycled material

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