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'Solar Roadways': A Significant Infrastructural Reform

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Abstract - *Solar roadways are basically structurally engineered solar panels, which can easily and effectively pose as conventional roads, the only difference being smartness and intelligence. These solar roads are very much intelligent by themselves, and perfectly suited for the current era's development; and hence, these have been appropriately termed as 'Smart Roads'. The main motive is to fairly minimize the use of conventional asphalt and concrete roads, parking lots and driveways, and to supplant a majority of them by solar road panels which will be responsible for the generation of clean renewable energy, which in turn will be used for powering a specific or all the area of a fairly developed city. An intelligent highway infrastructure and a self-healing decentralized power grid will effectively help in reducing the use of fossil fuels, and hence, will limit the emission of greenhouse gases considerably. This will result in a 50% decrease in the air pollution of that particular area, where this technology is used. All these goals can be achieved by paying just a little extra. This is a smart system which pays for itself. So, it is time to upgrade our infrastructure for the betterment of the not-so-distant future.*

Key Words: *Electric Vehicles, Fossil Fuels, Intelligent Roads, Smart Grids, Solar Panels, Solar Roadways.*

1. INTRODUCTION

The concerns about increasing global warming as a result of pollution and the overuse of fossil fuels led to the birth of solar roadways. This innovation took place in the early 2009 and hence its development began. Eventually, a company by the name of 'Solar Roadways' was established in the U.S. which was awarded a contract by the federal government.

The technology of solar roadways is aimed at achieving long- term benefits instead of short-term profits. The solar roadways system, at present, costs about 3 times more than the conventional asphalt road, but it is more durable, more technically sound, more easily replaced in modular fashion and is able to pay for itself by generating more electricity than our economy can consume. At just 15% efficiency, which is far below what is expected, a '100% solar roadways' enabled driving infrastructure can produce 3 times the total electricity demand.

Here, we speak not only about surplus electricity generation, but also about other benefits. This road system can be termed as smart and intelligent, and hence works for the convenience of those using it. Especially during emergencies, such as during an accident, an obstacle on the road, or during a natural calamity, the road itself alerts the drivers about what lies ahead.

Asphalting and concreting, the conventional methods, work in many ways, and are also easy to lay-down as compared to other methods. These are the base of our transportation industry which have also resulted in gradual, but steady development of our automotive infrastructure, and have brought us this far. But there are hidden costs that are making it increasingly difficult to continue preferring these conventional road systems as the predominant road-paving model for the entire nation. Therefore, we are in need of a major reform in the road systems for the betterment of the transportation industry, which is currently being provided by solar roadways.

The solar roadways technology results in the automotive infrastructure being more efficient and also reduces the electricity costs to consumers and businesses. They make the newly emerging electric vehicle technology more affordable and easier to manage. They can help us eliminate the expenditure of hundreds of billions of dollars over fossil fuels. They also lead to the production of clean and green energy, which can conveniently satisfy the needs of the current various development programs.

If this technology is used to upgrade the current road system, more jobs can be created, more revenues can be generated, spurring private investment on a massive scale, with relatively less extra cost.

2. SOLAR ROADWAYS

The solar roadways consist of structurally engineered solar panels, the size of each being 1sq. ft. (approximately). In addition to electric power, data signals also travel through the solar roadways which act as a conduit for the data cables. This eliminates the unpleasant sight of utility poles, power lines and relay stations all over the countryside. It also eliminates power cut-offs and failures caused by fallen or broken electric lines or poles.

Each solar road panel uses some of the electricity it produces to light up embedded LEDs, which illuminate the road lines from beneath the surface. This feature also makes it possible for word messages to be lit up on the

road surface, and to create markings and signs to let the driver know about diversions and lanes. At night, the roads will be fairly illuminated, hence, contributing to the safety of the driver.

In regions of heavy snowfall, the roads can be designed in such a way so as to contain heater units, and hence, when there is snowfall, the road itself gets heated up and melts all the snow, eradicating the need to manually clear the roads and also eradicating the blockages caused by snow.

The solar roadways will also make the electric vehicle technology more practical. Recharging stations can be built in parking lots and rest stations, and also alongside the roads at equal intervals of length. It will also make travelling and transportation cheaper due to the continuously increasing prices of petroleum products and due to the fact that electric vehicles are cheaper to use than combustion engine vehicles.

3. SOLAR PANELS AND PAVEMENT LAYERS

The solar panels, after they are interlinked, form the basic infrastructure of the solar roads. These solar panels consist of the following parts:

i. Road Surface Layer

ii. Electronics Layer

iii. Base Plate Layer

3.1. Road Surface Layer

This is the uppermost layer of the road assembly. This is the layer covering the solar cells (photovoltaic cells) embedded in solar panels. This layer should be translucent for sunlight to pass through, and at the same time, it should be rough enough to provide sufficient traction to avoid skidding of vehicles. It is made to be very tough and strong so as to handle huge traffic loads and also it is made waterproof so that it can protect all the electronic elements beneath it.

3.2. Electronics Layer

This is the layer situated below the road surface layer. It contains microprocessor boards, fitted at every 12 feet, which can sense loads on the surface. The LEDs and road lights will light up only when it senses a car travelling on it so that the lights will remain off when there is no load on it, saving energy. It also contains a heating element which melts the snow on the roads, a feature which is specifically necessary in snowy areas. The lights light up when a car is in a specific distance range, say, 500 m or 250 m from the light. This facility has helped to reduce night accidents in England by about 70%. It can also display words, markings, and signs on the road surface with the help of LEDs to inform the driver about any obstructions, detours, etc. All this makes this road assembly an "Intelligent Highway System".

3.3. Base Plate Layer

This is the layer situated below the electronics layer. It distributes all the power generated from the energy collected by the electronic layer, down-line to all the houses, offices, industries, etc. connected to the solar roadway. This layer is also made water proof to protect the electronics layer from ground water.

Below are some figures which briefly describe the structure of solar road panels.

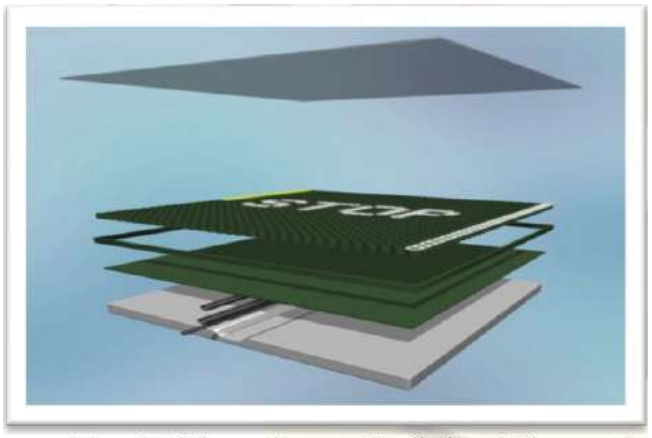
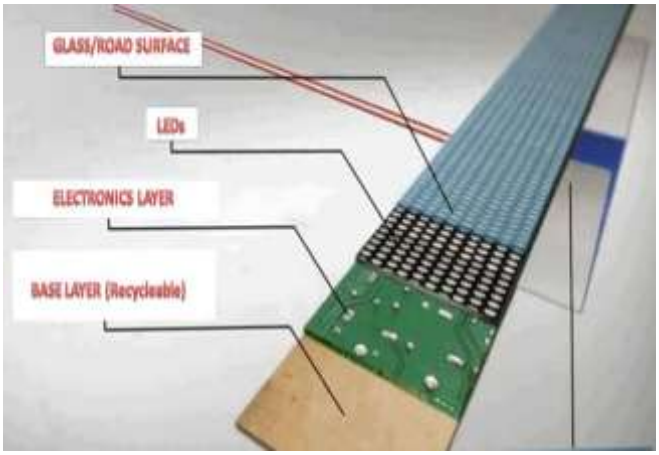
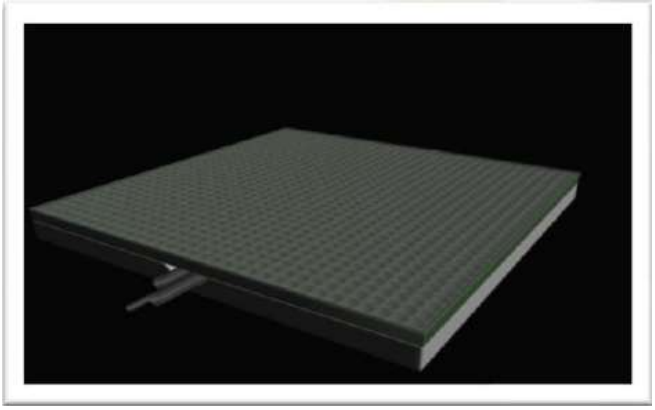


Fig: 1 Different layers of a distinct Solar panel





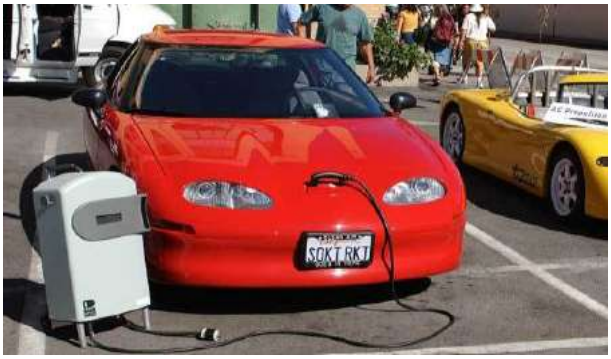
4. OIL DEPENDENCY

In 2010 alone, thousands of lives have been lost in coal mine and oil rig disasters and gas line explosions. Our oil dependency is such that even loss of life would not make us think for a second option. Well, it is not possible to completely eradicate the use of petroleum products and other fossil fuels, but at least we can try to figure out about a better replacement for these. What (more) is it going to take to drive us to wean ourselves off of our dependency of fossil fuels?

In order to continue at today's pace, we will have to increase our world supply from 80 million barrels a day to 120 million barrels a day by 2030. If this continues, the world consumption would rise by a factor of almost 10.

So, what will happen if the world runs out of oil? Well, we according to calculations, we have about another 50 years before this happens, but this fact is still debateable. No one can predict what may happen after, say, 10 years. Hence, instead of waiting until the eleventh hour, it is beneficial to commence works on some substitutes, preferably, solar energy.

It is going to be of immense relief, if a fully operational, real time substitute, like solar energy, can be used to fuel even 70% to 80% of our day to day needs and works. The invention of electric cars is considered to be of utmost importance for the current given situation. The proper implementation of solar roads and electric vehicles can help reduce oil dependency by a great fraction. And moreover, clean and green energy, must be always preferred.



Electric vehicles are expected to be a major turning point in the automotive as well as the transportation industry. The proper implementation of these very useful technologies is going to be a humongous contribution to the betterment of the future generations.

5. SMART GRIDS

The power grids presently in use are based and dependent on centralized power stations. The transmission lines (overhead or underground) handle the distribution of power, with the assistance of relay stations and transformers. When a line goes down (due to snowfall, heavy rainfall, lightening, tress, utility pole hit by car, etc.), the entire area on the wrong side on the line faces absolute loss of power until the line is repaired. And moreover, if a power station goes down, an entire section of a country goes dark.

The solar roadways, on the other hand, have the ability to replace all the presently centralized power stations, including thermal, nuclear and hydroelectric power stations. Power is generated everywhere; every road, parking lot, driveway contributes to the electricity production. No more power outages, voltage errors, etc. need to be face. Also, it totally eliminates the risk of death or a serious injury due to direct contact with live wire. Hence, the solar roadways have been precisely termed as 'Smart Grids'.

6. APPLICATION IN INDIA

The main reason of doing research on solar roadways and making a paper out of it was to help make India an advanced country in all aspects. One of the ways this can be done is through reducing pollution and, creating smart highways and providing 24/7 electricity to the nation.

Now, we did an estimate on how much electricity would be generated if the pavement of one of the major national highways was replaced with solar roadways. Moreover, it might also help to create a smart-highways network. For this purpose, we considered replacing the pavement of National Highway 4 (NH-4), i.e., the Mumbai-Pune Expressway with solar roadways.

According to the estimate, the total length of the highway is 96 km. And taking the width as 6 (number of lanes) multiplied by 3.5 m (width of one lane), the total area covered by NH-4 is 2016000 m^2. Now, considering a 1ft*1ft section of a solar panel rated 15 W, its area is 1 ft^2 or 0.093 m^2. Hence, total electricity produced by NH-4 if replaced by solar roadways will be around 32500 MW. But, the state of Maharashtra has a daily requirement of 20340 MW only. Hence, with this replacement, we can fulfil the daily needs of an entire state and also have a surplus of around 12000 MW generated. So, this is a solution by means of which smart roads, sufficient electricity and pollution-free generation of electricity can be achieved.

Moreover, the total power generation capacity of Maharashtra is 13602 MW and 10842 MW of this power, i.e., nearly 80%, is being generated from thermal and gas turbine power plants. This is one of the major reasons of

increasing pollution in our country. Hence, with this technology of solar roadways, we can totally discard thermal and gas turbine power plants from our generation system, live in a pollution-free environment and still be able to meet all our electricity needs and have surplus of power stored with us.

7. ADVANTAGES

7.1. Renewability

The primary advantage of solar roads is that they produce energy from a renewable source, unlike other methods and technologies, which use conventional and non-renewable sources for power generation. It also helps in reducing our dependency on coal, oil and other fossil fuels by a great fraction.

7.2. Life-Span

There is a big difference in the average life-span of solar roads and the average life-span of conventional asphalt and concrete roads. The average life-span of solar roads is 30 to 40 years, whereas that of the conventional roads is 7 to 12 years. This makes the maintenance of the solar roads less frequent and hassle-free than that of the conventional roads.

7.3. Maintenance time

The solar roadways are made to be tough, strong and technically sound, but still, if it gets damaged in any way, the repair is very convenient, easy and quick, unlike the conventional roads. The damaged part is straightaway replaced or repaired (depending upon its state) within very less time as compared to the conventional roads.

8. DISADVANTAGES

There is only one major disadvantage that has a drastic effect on the use of this technology. The initial installation and maintenance costs of solar panels are very high. Therefore, it cannot be constructed into under-developed, poor and economically weak countries. But, however, advances in this technology may hopefully cause these prices to fall.

9. CONCLUSION

Solar roadways use tempered glass and photovoltaic cells to create a completely smart and intelligent road system. The technology is still in its primitive stage, but with proper funding, small scale prototypes have been constructed and successfully tested upon. China has already started replacing its main roads with solar road system, in real time. Although the initial investment is high for this technology, it is an excellent replacement for fossil fuels, cutting later costs and also reducing environmental pollution.

REFERENCES

[1] IJERA, Solar Roadways, vol. 3, issue 3, by Alark A. Kulkarni.

[2] The Promise of Solar Roadways, at TEDx Talks, by Scott Brusaw.

[3] Report on Solar Roadways by Asst. Prof. Ankit Singh.

[4] Solar Roadways Report by Mr. Swapnil Vilas Patwari, Swami Ramanand Teerth Marathwada University.

[5] Seminar Report on Solar Roadways by Mr. Jeevan Kumar Naik, Visvesvaraya Technological University.

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