World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 4.326

A NEW CONCEPT FOR UTILIZATION OF SOLAR ENERGY AS SOLAR ROADWAYS FOR A SMART CITY

[*1]Devendra Singh Chundawat, [1]Vishal Soni and [2]Anurika Mehta

[1]B. Tech. Students, Civil Engineering, Poornima Institute of Engg. and Tech., Jaipur.

[2]Associate Professor, Poornima Institute of Engg. and Tech., Jaipur.

Article Received on 05/06/2017 Article Revised on 26/06/2017 Article Accepted on 17/07/2017

***Corresponding Author**
Devendra Singh Chundawat
B. Tech. Students, Civil Engineering, Poornima Institute of Engg. and Tech., Jaipur.

ABSTRACT

The smallest cities initiative by the government of India presents an opportunity to transform the way in which we run our cities. Development of cities is depends on the energy sources i.e., coal, biomass & waste, petroleum & oath liquids, natural gas, nuclear, hydroelectric etc. in which mostly are fossil fuels. However fossil fuels are here to stay for few decades, no longer. Therefore it is important that a few technologies be considered for research, development and deployment through the transition phase from fossil fuels to renewable forms of energy i.e. wind energy and solar energy. These technologies made the city as "Smart City". Now-a-days solar energy in the form of solar roof is a popular energy resource. India has a potential of 750 GW of solar energy according to the National Institute of Solar Energy. This paper presents a review on a new concept of solar energy as solar roadways. In this new concept of solar roadways, roads of cities are constructed with the solar panel which is based on the photovoltaic system. Energy is generated by absorption of sun rays as well as frictional heat produced by the movement of vehicles on the road and energy is generated.

KEYWORDS: Smart city, Fossil fuels, Renewable energy sources, Solar roadways.

1.0 INTRODUCTION

The vision of modern India encapsulates the concept of smart cities to address the phenomenally rapid urbanization of our nation. The government has announced plans to

create a hundred smart cities to meet the challenge of the future. A Smart city must provide 21st century standard quality of life based on cutting edge information and communication technology so that the citizens are able to live in secure, peaceful, productive and organized environment with assured amenities. It is estimated that by 2030, India's energy requirement will increase by almost 200 percent (Shekhar 2015). We would primarily have to depend upon fossil fuel and gas based energy like coal, biomass, petroleum etc. while we focus on new and alternative sources for power. The alternative means comprise hydro, solar, wind, geothermal, solid biomass and energy created from waste. In a country like India where there is abundance of sun light, solar energy has the potential to meet a major part of our future energy needs (John 2015). Hence cities can become the developing centres to promote the application of solar energy on a large scale and sustainable scale in India. Solar applications such as solar street, solar water heaters, solar rooftop, solar roadways etc. will give go a long way in promoting the usage of renewable forms of energy and thus help the country fight the growing concerns of global warming and pollution.

Our idea is to increase awareness and to step on further work and further development of the concept of Solar Road Technologies developed by Solar Roadways. Solar roadways are developing solar powered road panels. Their technology combines a transparent driving surface with underlying solar cells, electronics and sensors to act as solar array with programmable capability. The proposed system would require the development of strong transparent and self cleaning glass and that has the important traction and impact resistance properties. The idea is not only to store solar energy but to also make smart roads for smart cities. Roads that illuminate themselves at night, heat themselves in winter and are easily programmable to directly (Gopinath 2016). But much more the potentials of the technology allow us to further contribute to some more green concepts as smart city, the connected things and smart grid applications, hybrid and electric cars and other. Therefore from the initial idea to put the normal solar panel to a better and much more practical use, there can be derived many new benefits.

This paper presents a review on solar roadways concept which is a bit new in utilization of renewable energy sources.

2.0 Status of Solar Energy

2.1 Solar Energy in World

Many developed countries have installed solar power into their electrical grids to provide an alternative to conventional energy sources while an increasing number of developing countries have turn to solar to reduce dependence on expensive imported fuels. Germany remains for one year the world's largest producer of solar power with an overall installed capacity of 32.8 GW. There are now 20 countries around the world with a cumulative PV capacity of more than 1 GW. The available solar PV capacity in Itlay, Germany and Greece is now sufficient to supply between 7-8% of their respective domestic electricity consumption (Gopinath 2016).

2.2 Solar Energy in India

Solar power industries are fast growing in India and as of 31 December 2016, the country's solar grid had a cumulative capacity of 9.01 GW. In January 2015, the Indian Government expanded its solar plans targeting US$ 100 billion of investment and 100GW of solar capacity.

2.3 Solar Energy in Rajasthan

Rajasthan is one of India's most solar developed states. The district of Jodhpur leads Rajasthan with 42 projects totalling 293 MW followed by Jaisalmer and Bikaner. A 4000 MW Ultra Mega Green Solar Power Project (UMPP) is being built near Sambhar Lake in Rajasthan.

The solar energy is using in Rajasthan as well as in India in following manner:

- Solar water heaters
- Rural electrification
- Solar lamps
- Agricultural support
- Solar rooftop

3.0 New concept in use of solar energy: Solar Roadways

A solar roadway is road surface that generates electricity by solar power photovoltaic cells. Solar roadway incorporated is a start-up company based in Sandpoint, Idaho, that is developing solar powered road panels. To create traffic warnings or crosswalks and excess electricity could be used to charge electric vehicles and power grid by using a layer of

embedded LEDs. Sun light is absorbs by sensors and these heat is converted into electricity which is used for various purpose. The electrical components will be embedded between layers of extremely durable and textured glass.

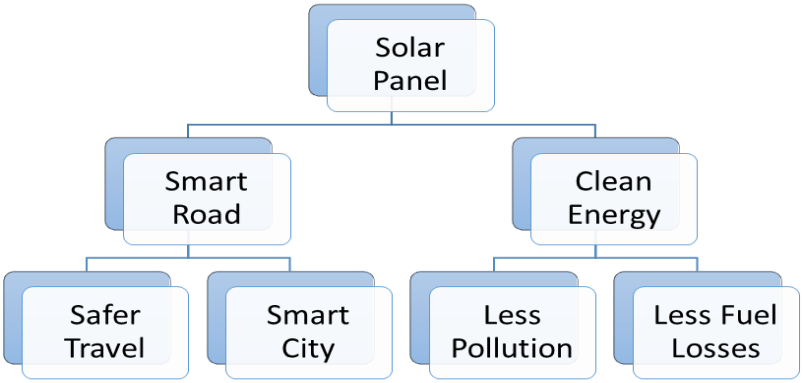

Figure 3.1: Use of Solar panel.

3.1 Construction

Solar panel consist of three layers

1. **Road surface layer:** Translucent and high strength, it is a rough enough to provide sufficient traction, yet still passes sunlight through to the solar collector cells embedded within, along with LEDs and heating element. This layer needs to be capable of handling today's loads under the worst of conditions.
2. **Electronics layer:** It contains photovoltaic cells which absorbs solar energy. It also contains microprocessor board with support circuitry for sensing load on the surface and controlling a heating element with a view to reducing snow. The microprocessor controls lighting communications, monitoring etc. with a communication device which make solar roadway can be an intelligent highway system.
3. **Base plate layer:** While the electronics layer collects energy from the sun, it is the base plate layer that distributes that power as well as data signals to the grid.

3.2 MPPT System

Tracking the maximum power point (MPP) of a photovoltaic (PV) array is usually an essential art of PV system. Maximum power point tracking technique is used to improve the efficiency of the solar panel. It tracks maximum power point from PV panel in order to generate PWM signal for DC-DC converter which is installed between source and load for efficient uses of power. As such many MPP tacking methods are available. The methods vary in complexity, sensors required, convergence speed, cost, range of effectiveness,

implementation, hardware, popularity and in other aspects. In fact so many methods available that it has become difficult to adequately determine which method newly proposed or existing is more appropriate for a given PV system (Gopinath 2016).

Due to non linear characteristics of PV panel, photovoltaic systems have three big problems:

- The efficiency of PV power generation is very low, specially under low radiation states.
- The amount of electric power generated by solar arrays is always changing with weather conditions i.e. temperature and irradiation.
- To match the PV source and load impedance properly for any weather condition to get maximum power generation by achieving high efficiency in PV power generation is the important problem of consideration.

According to maximum power transfer theorem the power output of a circuit is maximum when the Thevenin impedance of the circuit matches with load impedance. Hence our problem of tracking the maximum power point reduces to an impedance matching problem. It is composed to the PV module to convert solar energy into the electrical energy and DC-DC convertor for step up and step down depends upon load requirements. In the PV module, a voltage and current are measured and the power is calculated and the MPPT control is performed about the solar radiation change. By using reference voltage outputted from the MPPT control, the DC-DC convertor is controlled through PWM.

3.3 DC Power Output of Solar Road

Together with information on the hourly computed operating efficiency and the incident radiation, the dc power output can be estimated.

Integrating over the year, the total estimated energy yield is 410 KWh/year per half section of the solar road. With an area of 4.674 m^2 and the solar radiation of 4730 KWh/ year per half section, the overall annual efficiency is 8.7%.

The area of entire solar road element is 9.45 m^2 giving an overall annual efficiency of 8.6% and total energy yield of 821 KWh/ year. With inverter efficiency of the inverter at 97%, the solar road is able to inject 84 KWh/m^2/year into the grid. In this estimation, the impact of shading, road surface fouling and cloud cover has not been included (Gopinath 2016).

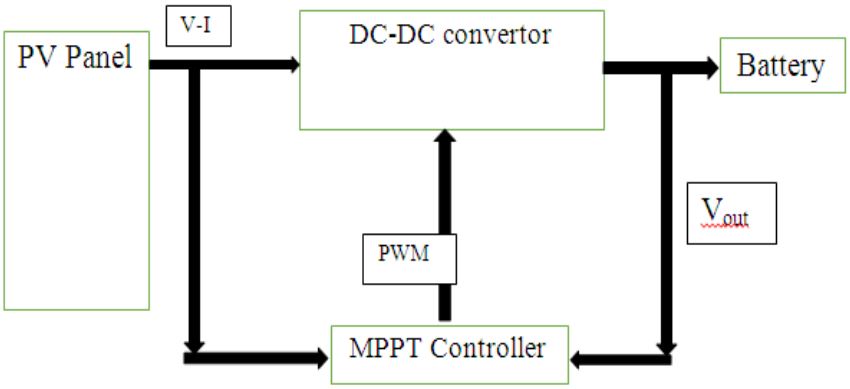

Figure 3.1: Maximum Power Point Tracking Controller.

4.0 Advantages and Disadvantages

4.1 Advantages

1. **Renewable energy source:** The sun is a natural source of energy for life time so it has the potential to reduce dependence on conventional sources of energy such as coal, petroleum and other fossil fuels.
2. **Military and Rescue Assistance:** In the environment of disaster or military emergency, solar roadways provide power when it is need most. It does not require extra effort to produce the power.
3. **Non-pollutant:** Construction of solar road is eco-friendly and it does not causes harmful effects on human life as well as wild animals.

4.2 Disadvantages

1. **Seasonal Efficiency:** In India the solar road will work efficiently in summer while it will give comparatively less efficiency in other season due to lack of sun radiations.
2. **Cost:** The arrangement or construction of solar panel is costly and it require more maintenance cost of road but it has more beneficial to all of us.

5.0 Applications

1. Traffic control or signal

In a modern busy metropolis, traffic congestion is a major hurdle in our journey to create a smart city. A traffic management plan must take into consideration all relevant factors like ever exploding vehicle population on the road, geometry of the city roads, travel needs of citizens and needs of various administering authorities having jurisdiction in parts or whole of the city. In India, traffic congestion is controlled by signals which is operated by electricity and it consume more power and also take effort to transport the power from grid. Solar road

resolve these problem, the solar panel work as a signal which indicates to the drivers and power is also saved which is our main motive.

2. Street Lights

Currently more than 27 million street lights light up the nights in India. Most of there are CFL, metal halides or sodium vapour lights. Various sources place the demand of electricity for these street lights as anywhere between 20-40% of the energy produced in India. Therefore the government is looking to adopt LED technology to reduce the energy demand. Further in this direction, the electricity produced by solar roads is a good scope of uses. These electricity reduce the effort and also beneficial to the environment.

3. Safety

Cities and urban centres are hothouses for economic growth, innovation and cultural development. Unfortunately their very success attracts wrongdoers from petty crime to lethal terrorist's attacks. Safe and smart city projects include deploying all types of sensors in designated area, installing a communications network, CCTV cameras and setting up regional and central intelligent command and control centres. These all projects required energy to implement them then solar energy produced by solar road in particular region is good source of energy which reduces dependency on fossil fuel.

4. Charging station

Nowadays, it is increasingly necessary and even vital to be able to use our mobile phone at any time during the day. We nervously keep an eye on our battery bar, dreading that fateful moment when our phone will run out of juice and we will lose our link with the rest of the world. Running out of battery power is more common that one would think, but it is a problem that now has a solution renewable energy powered mobile device charging station. This system marketed as the smart city charging station provides a focus point for increasing citizen awareness about the need for efficient uses of resources. The power generated by solar roads is best convenient source for charging stations.

6.0 CONCLUSIONS

According to this drastic review it is concluded that solar energy is a vast and abundantly used renewable energy resource all over the world. It is used in different traditional sources of energy such as solar heater, solar cooker etc. but now the time is utilizing some more

advance technologies for making a city as Smart City and this paper shown a very significant part of the solar energy use as solar roadways.

REFERENCES

1. Developments in Renewable Energy – "Current Trends & Future Prospects, Power Market in India", Way Forward IIT Kanpur 2nd March, 2016.
2. Shekhar A., Klerks S., Bauer P. and Prasanth V., "Solar Road Operating Efficiency and Energy Yield – An Integrated Approach Towards Inductive Power Transfer", 2015.
3. John Byrne A., Jobtaminiau A. N., Ladokurdgelashvili A. and Kyungnamkim, "A Review of the Solar City Concept and Methods to Assess Rooftop Solar Electric Potential, with an Illustrative Application to the City of Seoul", Renewable and sustainable energy reviews, 2015; 41: 830–844.
4. Gopinath K., D. Seshachalam D., "Modelling and Simulation of Photovoltaic System for Installation of Solar Highways across India", International Journal of Electrical Electronics & Computer Science Engineering Special Issue - NEWS, 2016; 59-71.