Volume-6, Issue-1, January - 2017 • ISSN No 2277 - 8160 IF : 3.62 | IC Value 80.26

Original Research Paper Engineering

A STUDY ON SOLAR POWER APPLICATIONS: SOLAR POWER SATELLITE

Rajeev Ranjan Assistant Professor, Deptt Of Electrical Engg Womens Institute Of Technology.L.N.Mithila University, Darbhanga

ABSTRACT *The energy problem is one of the main problems in the world. Solar energy now is the important energy source for human, and it can help human to get out of energy problems.*
Solar power is a reality. Today, increasing numbers of photovoltaic and other solar-powered installations are in service around the world and in space. The Solar Power Satellite has been hailed by proponents as the answer to future global energy security and dismissed by detractors as impractical and uneconomic. This paper reviews recent design and feasibility studies, advances made in enabling technologies and the development of supporting infrastructure. It identifies current progress towards practical demonstrations of space solar power technology that could lead to an economically viable Solar Power Satellite system. The information of the project was collected by using network and books.By using the solar power one can reduce the harmful effect on environment and provide economical, efficient and environment friendly sustainable energy.

KEYWORDS : solar power, solar power satellite, SPS technology, rectenna, space based solar power satellite

INTRODUCTION

The Sun is responsible for all of the earth energy. In outer space there is an uninterrupted availability of huge amount of solar energy in the form of light and heat. So the use of satellites primarily aimed at collecting the solar energy and beams it back to the earth. In geosynchronous orbit, i.e. 36,000 km, a Solar Power Satellite (SPS) would be able to face the sun over 99% of the time. No need for costly storage devices for when the sun is not in view. Only a few days at spring and fall equinox would the satellite be in shadow. Unused heat is radiated back into the space. Power can be beamed to the location where it is needed, need not have to invest in as large as a grid. On the one hand, the major loss of power occurs during transmission, from

generating stations to the end users. The resistance of the wire in the electrical grid distribution system causes a loss of 26% to 30% of the energy generated. Therefore, the loss implies that our present system of electrical transmission is 70% efficient. On the other hand, the generation is done primarily based on fossil fuels, which will not last long (say by 2050). In 1968, Dr. Peter Glaser introduced the concept of a large solar power satellite system of square miles of solar collectors in geosynchronous orbit, for collection and conversion of sun's energy into an electromagnetic microwave beam to transmit usable energy to large receiving antennas (rectennas) on earth for distribution on the national electric power grid.

SOLAR POWER SATELLITE SYSTEM

The concept of the Solar Power Satellite (SPS) is very simple. It is a gigantic satellite designed as an electric power plant orbiting the earth which uses wireless power transmission of space based solar power. Space-based solar power essentially consists of three functional units:

A. Solar energy collector to convert the solar energy into DC (Direct current) electricity.

B. DC to Microwave converter.

C. Large antenna array to beam the Microwave power to the ground.

D. A means of receiving power on earth, for example via microwave antennas (Rectenna).

The space-based portion will be in freefall, vacuum environment and will not need to support itself against gravity other than weak tidal stresses stresses.

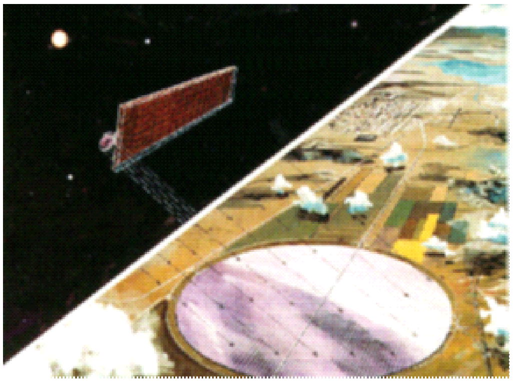

Fig 1: solar power satellite

Two basic methods of converting sunlight to electricity have been studied: photovoltaic (PV) conversion, and solar dynamic (SD) conversion. Photovoltaic conversion (commonly known as "solar cells") uses semiconductor cells (e.g., silicon or gallium arsenide) to directly convert photons into electrical power via a quantum mechanical mechanism. Photovoltaic cells are not perfect in practice, as material purity and processing issues during production affect performance. In an SPS implementation, photovoltaic cells will likely be rather different from the glass-pane protected solar cell panels familiar to many from current terrestrial use, since they will be optimized for weight, and will be designed to be tolerant to the space radiation environment (it turns out fortuitously, that thin film silicon solar panels are highly insensitive to ionizing radiation), but will not need to be encapsulated against corrosion by the elements. They do not require the structural support required for terrestrial use, where the considerable gravity and wind loading imposes structural requirements on terrestrial implementations.

A. Converting DC to Microwave Power

To convert the DC power to microwave for the transmission through antenna towards the earth's receiving antenna, microwave oscillators like Klystrons, Magnetrons can be used. In transmission, an alternating current is created in the elements by applying a voltage at the antenna terminals, causing the elements to radiate an electromagnetic field. The DC power must be converted to microwave power at the transmitting end of the system by using microwave oven magnetron. The heat of microwave oven is the high voltage system. The nucleus of high voltage system is the magnetron tube. The magnetron is diode type electron tube, which uses the interaction of magnetic and electric field in the complex cavity to produce oscillation of very high peak power. It employs

Volume-6, Issue-1, January - 2017 • ISSN No 2277 - 8160

radial electric field, axial magnetic field, anode structure and a cylindrical cathode. Due to the interaction of rotating space charge wheel with the configuration of the surface of anode, an alternating current of very high frequency is produced in the resonant cavities of the anode. The output is taken from one of these cavities through waveguide. The low cost and readily available magnetron is used in ground. The same principle would be used but a special magnetron would be developed for space use. Because of the pulsed operation of these magnetrons they generate much spurious noise. A solar power satellite operating with 10 GW of radiated power would radiate a total power of one microwatt in a 400 Hz channel width.

C. Transmitting Antennae Power Transmission via radio waves can be made more directional, allowing longer distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in the microwave range. Power beaming using microwaves has been proposed for the transmission of energy from orbiting solar power satellites to Earth and the beaming of power to spacecraft leaving orbit has been considered.The size of the components may be dictated by the distance from transmitter to receiver distance, the wavelength and the Rayliegh Criterion or diffraction limit, used in standard radio frequency antenna design, which also applies to lasers. In addition to the Rayleigh criterion Airy's diffraction limit is also frequently used to determine an approximate spot size at an arbitrary distance from the aperture.

Microwave power beaming can be more efficient than lasers, and is less prone to atmospheric attenuation caused by dust or water vapor losing atmosphere to vaporize the water in contact.

WIRELESS POWER TRANSMISSION

As the electro-magnetic induction and electro-magnetic radiation has disadvantages we are going for implementation of electrical conduction and resonant frequency methods. Of this, the resonant induction method is the most implement able. In the distant future this method could allow for elimination of many existing high tension power transmission lines and facilitate the inter connection of electric generation plants in a global scale. The microwave source consists of microwave oven magnetron with electronics to control the output power. The output microwave power ranges from 50W to 200W at 2.45GHz. A coaxial cable connects the output of the microwave source to a coax-to-wave adaptor. This adapter is connected to a tuning waveguide ferrite circulator is connected to a tuning waveguide section to match the wave guide impedance to the antenna input impedance. The slotted wave guide antenna consists of 8 waveguide sections with 8 slots on each section. These 64 slots radiate the power uniformly through free space to the rectifying antenna called rectenna. The slotted waveguide antenna is ideal for power transmission because of its high aperture efficiency (>95%) and high power handling capability. Microwaves are situated on the electromagnetic spectrum with frequencies ranging from 0.3 to 300 Ghz.

The energy transmitted by a microwave is very diffusive in nature, such that the receiving antenna area must be very large when compared to the transmitter. Although the use of microwaves to transmit energy from space down to earth is attractive, most part of the microwaves receives significant interference due to atmosphere. Still thereare certain frequency windows in which these interactions are minimized. The frequency windows in which there is a minimum of atmospheric signal attenuation are in the range of 2.45-5.8GHz, and also 35-38GHz; specifically we might expect losses of 2-6%, and 8-11% respectively for these two microwave signal ranges. As the microwave power is beamed towards a particular point (Point to point) using parabolic antennas (Drum antennas) the free space path loss (FSPL) is not in a considerable amount. Wireless Power Transmission (using microwaves) is well proven. Experiments in the tens of kilowatts have been performed at Goldstone in California in 1975 and more recently (1997) at Grand Bassin on Reunion Island. These methods achieve distances on the order of a kilometer.

RECEPTION OF POWER FROM SPS

The SPS system will require a large receiving area with a Rectenna array and the power network connected to the existing power grids on the ground. Although each rectenna element supplies only a few watts, the total received power is in the Gigawatts (GW). A Rectenna may be used to convert the microwave energy back into electricity. Rectenna conversion efficiencies exceeding 95% have been realized. The word„Rectenna is formed from„rectifying circuit and „antenna. A rectifying antenna called rectenna receives the transmitted power and converts the microwave power to direct current (DC) power. The rectenna is a passive element with a rectifying diode, and is operated without any extra power source. The rectenna has a low-pass filter between the antenna and the rectifying diode to suppress re-radiation of higher harmonics.

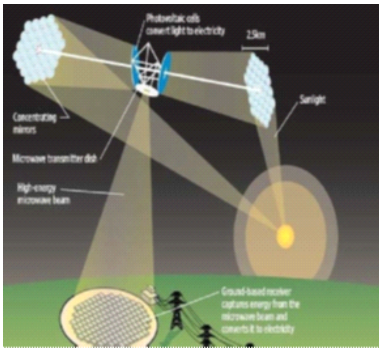

Fig 2: schematic diagram of SPS

It also has an output smoothing filter. This demonstration rectenna consists of 6 rows of dipole antennas, where 8 dipoles belong to each row. Each row is connected to a rectifying circuit which consists of low pass filters and a rectifier. The rectifier is a GA-As Schottky barrier diode, that is impedance matched to the dipoles by allow pass filter. The 6 rectifying diodes are connected to the light bulbs for indicating that the power is received. The light bulbs also dissipate the received power. The Earth-based receiver antenna (or rectenna) is a critical part of the original SPS concept. It would consist of many short dipole antennas, connected via diodes. Microwaves broadcast from the SPS will be received in the dipoles with about 85% efficiency. With a conventional microwave antenna, the reception efficiency is still better, but the cost and complexity is also considerably greater, almost certainly prohibitively so, Rectenna would be multiple kilometers across. Crops and farm animals may be raised underneath a rectenna, as the thin wires used for support and for the dipoles will only slightly reduce sunlight. so such a rectenna would not be as expensive in terms of land use as might be supposed. This rectenna has a 25% collection and conversion efficiency, But rectennas have been tested with greater than 90%.

ADVANTAGES

1) Unlike oil, gas, ethanol, and coal plants, space solar power does not emit greenhouse gases.

2) Unlike bio-ethanol or bio-diesel, space solar power does not compete for increasingly valuable farm land or depend on natural-gas-derived fertilizer. Food can continue to be a major export instead of a fuel provider.

3) Unlike nuclear power plants, space solar power will not produce hazardous waste, which needs to be stored and guarded for hundreds of years.

4) Unlike terrestrial solar and wind power plants, space solar power is available 24 hours a day, 7 days a week, in huge quantities. It works regardless of cloud cover, daylight, or wind speed.

5) Unlike nuclear power plants, space solar power does not provide

easy targets for terrorists.

6) Unlike coal and nuclear fuels, space solar power does not require environmentally problematic mining operations.

7) Space solar power will provide true energy independence for the nations that develop it, eliminating a major source of national competition for limited Earth-based energy resources.

DISADVANTAGES

1) Maintenance of SPS is expensive and challenging.

2) Geosynchronous orbit is already in heavy use; could be endangered by space debris coming from such a large project.

3) The size of construction for the rectenna is massive.

4) Transportation of all the materials from earth to space and installation is highly challenging.

CONCLUSIONS

The concept of placing enormous solar power satellite (SPS) systems in space represents one of a handful of new technological options that might provide large-scale, environmentally clean base load power into terrestrial markets. In the United States, the SPS concept was examined extensively during the late 1970s by the U.S. Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). More recently, the subject

of space solar power (SSP) was re-examined by NASA from 1995-1997 in the "Fresh Look Study" and during 1998 in an SSP "Concept Definition Study." As a result of these efforts, in 1999-2000, NASA undertook the SSP Exploratory Research and Technology (SERT) program, which pursued preliminary strategic technology research and development to enable large, multimegawatt SSP systems and wireless power transmission (WPT) for government missions and commercial markets (in space and terrestrial). During 2001-2002, NASA has been pursuing an SSP Concept and Technology Maturation (SCTM) program follow-up to the SERT, with special emphasis on identifying new, high-leverage technologies that might advance the feasibility of future SPS systems.

REFERENCES:

1. J. O. Mcspadden and J. C. Mankins, "Space solar power programs and microwave wireless power transmission technology," IEEE Microwave Mag., pp. 46–57, Dec. 2002.
2. W. C. Brown and E. E. Eves, "Beamed microwave power transmission and its application to space," IEEE Transactions on Microwave Theory and Techniques, vol. 40, no. 6, June 1992.
3. Brown., W. C. (September 1984). "The History of Power Transmission by Radio Waves." Microwave Theory and Techniques, IEEE Transactions on (Volume: 32, Issue: 9 on page(s): 1230- 1242 + ISSN: 0018-9480).
4. Glaser, P.E. 1968 "Power from the Sun: Its future", Science, 162, 857 (1968)
5. DOE 1978 "Satellite power system (SPS) concept development and evaluation program (CDEP) Reference System Report", DOE/ER-0023, October 1978
6. Electric Power from Orbit: A Critique of a Satellite Power System, National Research Council, National Academy Press, Washington, D.C., 1981