Solar Power Satellite

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Abstract- Solar Power Satellite (SPS) is an energy system which collects solar energy in space and transmits it to the ground. It has been believed as a promising infrastructure to resolve global environmental and energy problems for human beings. One of the most important technologies for the SPS is the wireless power transmission from the geostationary orbit to the ground. 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.

Key Words- Solar Power Satellite, Solar Dynamics, Photovoltaic, Space Based Solar Power

I. Introduction

The increased demand for power faces many constraints, in particular the sizing of the power generation system, driven by eclipse periods and the solar intensity at the operational spot. The global problem in the closed earth system will be effectively solved by a paradigm shift to the open earth-space system. There is unlimited constant solar energy supply in space free from the whether conditions, quite different from that on the earth. Electrical power accounts for much of the energy consumed. 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% to 74% efficient. On the other hand, the generation is done primarily based on fossil fuels, which will not last long (say by 2050).

II. Basic of Solar Power Satellite

Solar Energy Conversion - Solar Photons to DC Two basic methods of converting sunlight to electricity have been studied: photovoltaic (PV) conversion, and solar dynamic (SD) conversion. Most analyses of solar power satellites have focused on photovoltaic conversion (commonly known as "solar cells"). Photovoltaic conversion uses semiconductor cells (e.g.silicon or gallium arsenide) to directly convert photons

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into electrical power via a quantum mechanical mechanism. 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.

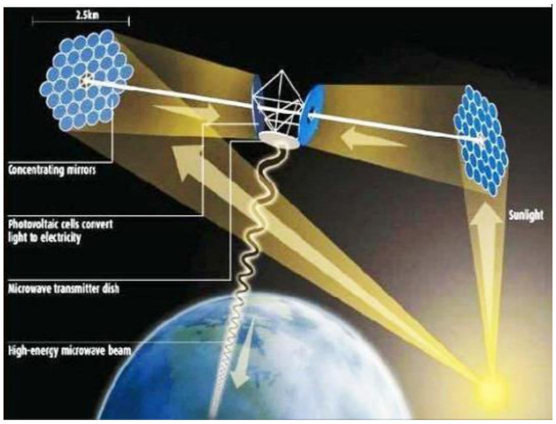

Fig.1. Solar Power Satellite (SPS)

The solar power satellite was proposed (by Glaser) to solve future problems caused by activities of human beings on the global scale. The research areas of SPS are concerned with not only technology and engineering, but also big problems such as "large scale project", "global energy production" and "exploitation of extraterrestrial resources", as well as economic problems such as "large scale and long-term investment' and "risk analysis". The earth environment, which will be related to SPS, is already a societal issue of global scale.

III. Wireless Power Transmission

In the 1960s the increasing interest in solar energy conversion methods and solar energy applications and the limitations for producing cost-effective base load power caused by adverse weather conditions and diurnal changes led to the solar power satellite concept in 1968 as a means to convert solar energy with solar cell arrays into electricity and feed it to a microwave power generator forming planar, phased-array antenna.

The antenna would direct a microwave beam of very low power density precisely to one or more receiving antennas at particular locations on Earth, in geosynchronous orbit. At a receiving side antenna, the microwave energy would be very efficiently reconverted into electricity and then transmitted to users. The purpose is to demonstrate a functioning solar power satellite system including the wireless transmission link and develop the ground infrastructure in several locations to provide the basis for a space solar power market.

Fig.2.Wireless Power Transmission

IV. Microwave Power Transmission in SPS

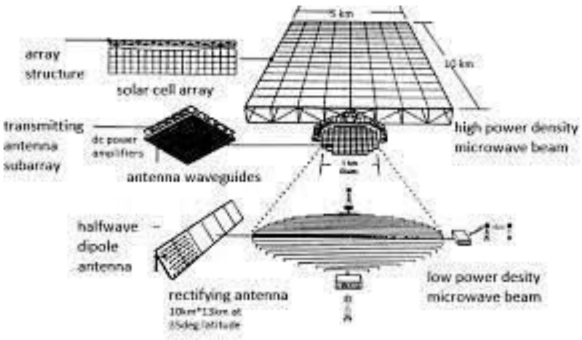

Fig.3. Microwave Power Transmission

The key microwave components in a WPT system are the transmitter, beam control and the receiver called rectenna. At the transmitter, magnetrons and klystrons which are called as microwave power tubes are used as RF power sources. Rectenna is a component unique to WPT systems. More recently, microwave power transmission has been demonstrated, in conjunction with solar energy capture, between a mountain top in Maui and the island of Hawaii (92 miles away), by a team under John C. Mankins. Technological challenges in terms of array layout, single radiation element design, and overall efficiency, as well as the associated theoretical limits are presently a subject of research, as it was demonstrated by the Special Session on "Analysis of Electromagnetic Wireless Systems for Solar Power Transmission".

V. Transmitter

The key requirement of a transmitter is its ability to convert dc power to RF power efficiently and radiate the power to a controlled manner with low power loss. The transmitter's efficiency defines the end to-end efficiency as well as thermal management system.

VI. Rectenna

Brown was the pioneer in developing the first 2.45GHz rectenna. Rectenna is the microwave to dc converting device and is mainly composed of a receiving antenna and a rectifying circuit Fig.2. shows the schematic of retina circuit. It consists of an input low pass filter, a receiving antenna, a rectifying circuit and an output smoothing filter. The input low pass filter is needed to suppress radiation of high harmonics that are generated by the nonlinear characteristics of rectifying circuit.

Fig.4. Rectenna

Microwave broadcasts from the satellite would be received in the dipoles with about 85% efficiency. With a conventional microwave antenna, the reception efficiency is better, but its cost and complexity are also considerably greater. Rectennas would likely be several kilometers across.

VII. Advantages

1. No fuel cost
2. Not harmful for environment
3. No Water pollution & wastages
4. Simple concept
5. Unlimited energy source
6. No air pollution
7. Reduces fossil fuel consumption in other plants

VIII. Disadvantages

1. The large cost of launching a satellite into space
2. The large size and corresponding cost of the receiving station on the ground
3. Takes more year to built
4. Installation & Maintenance cost is very high
5. Create problems for communication with satellite

IX. Conclusion

The increasing global energy demand is likely to continue for many decades. New power plants of all sizes will be built. Fossils fuels will run off in another 3-4 decades. However energy independence is something only Space based solar power can deliver. Space based solar power (SBSP) concept is attractive because it is much more advantageous than ground based solar power. One of the most critical technologies for the SPS is microwave power transmission from the geosynchronous orbit to the ground. Evolutionary microwave technologies are required for high power conversion efficiency more than 80 % from to DC and an extremely high-precise beam control with 10 μrad accuracy.

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