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Space based Solar Power Fulfilling COP26: One Sun, One World

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Abstract - Space Based Solar Power is currently under intense research. Geosynchronous satellites collect sunlight, harness it to generate solar power, and transmit that power to Earth safely and reliably using Wireless power transmission (WPT). The advantage of installing solar cells in space is that sunlight is available 24 hours a day. Additionally, the depletion of energy resources on earth prompts the need for a space-based alternative energy source. In this study, we examine the concept of Solar Power Satellites (SPS), the feasibility of implementation, the overall architecture and the components involved. The results show that this system is an environment-friendly, low-loss, and large-scale method of energy transfer.

Key Words: Space Technology, Solar Energy, Alternate Power, SPS, SBSP

1. INTRODUCTION

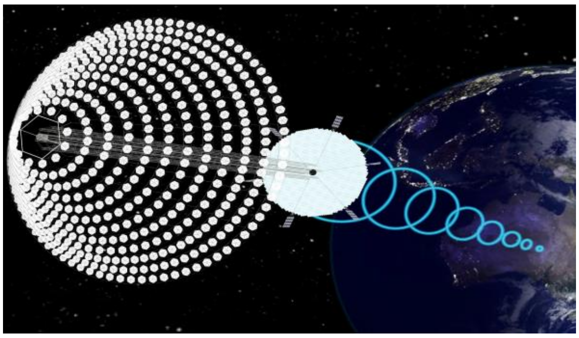
With a rise within the number of climatic hazards and catastrophic degradation in earth health, there's an instantaneous got to switch conventional methods of subsistence to avoid upcoming calamity. Conventional methods relied upon the utilization of fossils fuels that not only are disappearing at alarming rates but also pose a threat to environment when consumed by releasing harmful gases. The advent of solar cells led to the harnessing of solar energy as a renewable resource. However, solar cells on earth suffer from the lack of sunlight in the dark. Solar panels on earth are also adversely affected by clouds, which block the sun's rays. Using solar energy satellites (SPS) is one way to overcome the difficulty of producing solar energy on Earth. Space solar energy satellites (SSPS) collect solar energy from space and convert it into electric power, then they transmit that electricity wirelessly to the Earth. During a year, the SPS are illuminated by the Sun 99% of the time, apart from a brief interval during equinox. In addition, microwave power is unobstructed by clouds or other barriers, which makes it an ideal source of power. solar energy station, on the other hand, should be lightweight and portable, which necessitates use of light weight photovoltaic cells and high voltage power generation, in addition to meeting the following requirements: high efficiency, a large phased array, and economical rockets.

2. WIRELESS POWER TRANSMISSION

Microwave Wireless Power Transmission is a vital technology for the long-term feasibility of SPS. William C. Brook, a pioneer of wireless power transmission technology, demonstrated by designing, developing, and demonstrating a device how power was often transferred by microwaves through free space. Early wireless power transmission proposals used microwave and laser radiation at a variety of frequencies to transfer energy from collection to the surface.

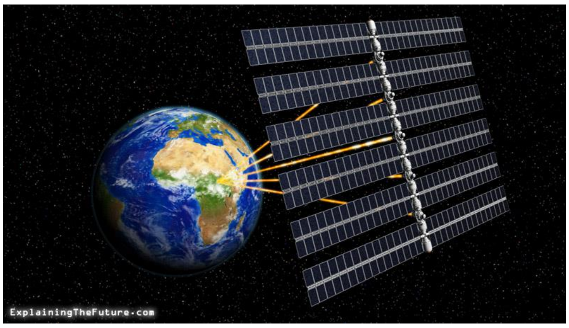
2.1 MICROWAVE POWER TRANSMISSION

A radio wave transmits power in a more directional manner, enabling the transmission of power over a long distance using shorter wavelengths of electromagnetic waves. The microwave energy can also be used to generate electricity. Rectennas can produce nearly 95% efficiency. Microwave power beaming has been proposed for transmitting power from orbit to Earth.



2.2 LASER POWER BEAMING

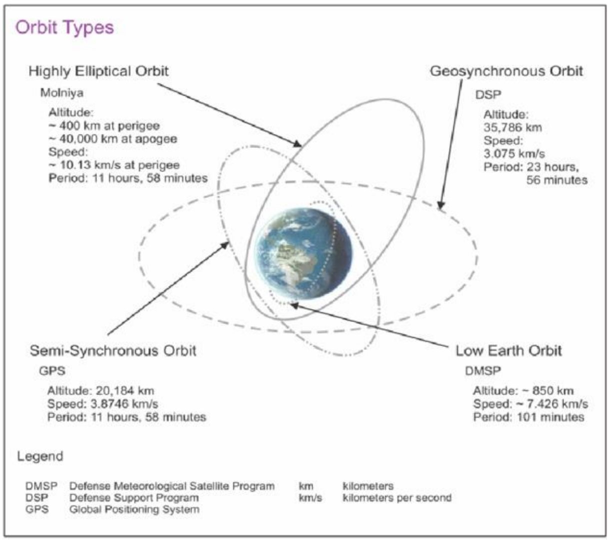
A solar cell receives power from converting electricity into a beam and directing it toward an electromagnetic wave closer to the visible region of the spectrum (tens of micrometers to tens of nanometers). An electric charge is then produced by converting the facility's energy to a beam. In the receiver, monochromatic laser power converters are used which are specially designed for monochromatic light conversion. Power beaming is sometimes called monochromatic laser power conversion.



2.3 ORBITAL LOCATION

Installing a power plant in geosynchronous orbit has the main advantage of keeping the antenna geometry constant, making it easier to align the antennas. Because of the first space power plant being placed in orbit, almost continuous power can be transmitted almost immediately; other space-based power stations need lengthy start-up times before they're producing nearly continuous power.

As a precursor to space-based solar energy in GEO, LEO power stations have been proposed. The idea behind the solar satellite energy system is to place giant satellites 35,780km above the surface with a large array of solar cells embedded on them.



2.4 EARTH BASED RECIEVER

85% efficiency would be achieved by satellite broadcasts of microwaves. Microwave antennas are best for receiving microwave signals, but are expensive and complex. Rectennas would probably have a range of several kilometres.

3. OVERALL STRUCTURE

3.1 MICROWAVE GENERATOR

Solar cells produce DC power, which the Microwave generator converts to radiated frequency output. A DCRF converter consists of an oscillator with low power, along with a gain stage and an influence amplifier. A Phase and Amplitude Controlled Magnetron device is typically preferred over microwave tubes (e.g., magnetrons). The most common microwave transmission frequencies are 2.45GHz or 5.8GHz of the ISM band.

3.2 TRANSMITTING ANTENNA

In order for a transmitter to function efficiently, it must convert dc power to RF power and radiate it in a controlled manner with low losses. The transmitter's efficiency drives the end-to-end efficiency also as thermal management. The foremost components of a transmitter include dc-to-RF converter and transmitting antenna. Power distribution at the transmitting antenna= $(1-r^2)$, where r is the radius of the antenna. Magnetrons, klystrons and solid-state amplifiers are the three types of dc-to-RF power converters.

3.3 RECTENNA

A word rectenna is made by merging rectifiers and antennas. These modules are used as receivers at receiving ground stations to reap wireless power transmitted through microwave frequency (RF) and convert respective energy into DC (DC). Each unit has a receiving antenna, an input low pass filter, a rectification circuit, and a smoothing circuit. The input filter is required to suppress radiation of high harmonics that are generated by the non-linear characteristics of the rectifying circuit. In order to realize effective rectification, the diode stop frequency should be approximately ten times the operating frequency. Breakdown voltage is directly related to series resistance and junction capacitance through inherent properties of the diode junction and material.

4. DESIGN

Wireless power transmission is generally used in SBSP designs. Solar energy collected by the satellite would be converted to electrical energy on board, powering a microwave transmitter or ray emitter, which would direct its ray to a collector (rectenna) positioned on Earth's surface.

Space- grounded solar power basically consists of three rudiments:

- A means of collecting solar power in space, for illustration via solar concentrators, solar cells or a heat machine.
- A means of transmitting power to earth, for illustration via microwave or ray.
- A means of entering power on earth, for illustration via a microwave antenna (rectenna).

The space- based portion won't need to support itself against graveness. No protection from wind or rainfall is required, but it will need to adapt to space hazards, such as micro meteors and solar flares. There have been two types of introductory conversion studied so far: photovoltaic (PV) and solar dynamic (SD). Photovoltaic conversion converts photons directly into electrical energy by using semiconductor cells. Solar dynamic uses glasses to concentrate light on a boiler. The use of solar dynamics could reduce mass per watt. Most analyses of SBSP have concentrated on photovoltaic conversion. Wireless power transmission was proposed beforehand as a means to transfer energy from collection to the Earth's face, using either microwave or laser radiation at a variety of frequencies.

5. ADVANTAGES

Energy harvesting would be clean and neat with a zero percent of fossil fuel emission in the environment all 24 hours. Also, like atomic power plants, space solar energy won't produce hazardous waste, which must be stored and guarded for many years

Collecting surfaces could receive far more intense sunlight, due to the shortage of obstructions like atmospheric gasses, clouds, dust and other weather events. Consequently, the intensity in orbit is approximately 144% of the utmost attainable intensity on the surface.

99% of the time, a satellite will be illuminated, and will only be in Earth's shadow for 72 minutes per night at the spring and fall equinoxes at midnight local time. Unlike earth surface solar panels, satellites are typically exposed to constant and high levels of radiation, generally for 24 hours a day, whereas solar panels on the earth's surface currently generate electricity for 29% of the time each day.

Power might be relatively quickly redirected to areas that require it most. It is possible to direct power from a collecting satellite to different surface locations depending on the demand. Since peaking power is ephemeral, typical contracts would be for baseload, continuous power.

6. DISADVANTAGES:

There is a high investment cost to build a satellite and send it into space as well as a high investment cost to build a receiving station on the ground.

Large objects in space are subject to a significant risk of space debris, and large structures like SBSP systems are considered potential sources of orbital debris.

The energy required for producing and putting solar panels into space versus the amount of energy generated. We can use the concept of space elevators as one solution.

Solar panels on Earth are simple to maintain, but solar panels in space would need to be telerobotic fully maintained. There is a high risk to astronauts working in GEO by radiation.

3. CONCLUSIONS

Based on the above considerations, SBSP can be regarded as a promising alternative to fossil fuels. Wireless power transfer has much lower losses than transmission lines. Microwave Power Transmission (MPT) also poses no threat to the environment or biodiversity on Earth. But the major hurdle in the implementation of Solar Power Satellites is not technology but economic factors. To overcome the high cost of fabricating and launching satellites, a large-scale research effort is underway.

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