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A Study on Space-based Solar Power System

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Abstract: *With the increase in rate of global warming, environmental planning and management has become an indispensable concern. Environmental planning is the process of facilitating decision making to carry out development with the consideration given to the natural environmental, social, political, economic and governance factors and provides a holistic frame work to achieve sustainable outcomes. The present paper deals with the alternative method of acquiring electricity as the environmental impact of electricity generation is significant because modern society uses large amounts of electrical power. This power is normally generated at power plants that convert some other kind of energy into electrical power. Each system has advantages and disadvantages, but many of them pose environmental concerns. Energy conservation is the foundation of energy independence. Considering this, the idea of generating solar power from space has been gathering momentum for quite some time. The paper reviews the current challenges of launching and building very large space systems. A building block approach is proposed in order to achieve near-term solar power satellite risk reduction while promoting the necessary long-term technology advances.*

Key Concepts: *Rectenna,Solar Power Satellite, Orbiting Satellite, Wireless Power Transmission,*

I. INTRODUCTION

Space-based solar power (SBSP) is the concept of collecting solar power in space (using an "SPS", that is, a "solar-power satellite") for use on Earth. It has been in research since the early 1970s. SBSP would differ from current solar collection methods in that the means used to collect energy would reside on an orbiting satellite instead of on Earth's surface. Some projected benefits of such a system are a higher collection rate and a longer collection period due to the lack of a diffusing atmosphere and night time in space.

Part of the solar energy (55-60%) is lost on its way through the atmosphere by the effects of reflection and absorption. Space-based solar power systems convert sunlight to microwaves outside the atmosphere, avoiding these losses, and the downtime due to the Earth's rotation.

II. REVIEW OF LITERATURE

Glaser, Peter E. (1973) was granted U.S. patent number 3,781,647 for his method of transmitting power over long distances (e.g. from an SPS to Earth's surface) using microwaves from a very large antenna (up to one square kilometer) on the satellite to a much larger one, now known as a rectenna, on the ground. **Glaser** then was a vice president at **Arthur D. Little**; **Inc. NASA** signed a contract with **ADL** to lead four other companies in a broader study in **1974**. They found that, while the concept had several major problems – chiefly the expense of putting the required materials in orbit and the lack of experience on projects of this scale in space – it showed enough promise to merit further investigation and research.

In **1997, NASA** conducted its "Fresh Look" study to examine the modern state of SBSP feasibility. NASA asserted that: US National Space Policy now calls for NASA to make significant investments in technology to drive the costs of ETO [Earth to Orbit] transportation down dramatically. This is, of course, an absolute requirement of space solar power.

On **Nov 2, 2012**, **China** proposed space collaboration with **India** that mentioned SBSP, Space-based Solar Power initiative so that both India and China can work for long term association with proper funding along with other willing space faring nations to bring space solar power to earth.

In **1999, NASA's Space Solar Power Exploratory Research and Technology program (SERT)** was initiated. SERT went about developing a solar power satellite (SPS) concept for a future Gigawatt space power system, to provide electrical power by converting the Sun's energy and beaming it to Earth's surface, and provided a conceptual development path that would utilize current technologies.

Japan Aerospace Exploration Agency (JAXA), has "been the subject of many previous studies and the stuff of sci-fi for decades, but space-based solar power could at last become a reality—and within 25 years, according to a proposal from researchers" there which is noted in the **May 2014 IEEE Spectrum magazine** has a lengthy article "It's Always Sunny in Space" by **Dr. Susumu Sasaki**. JAXA announced on **12 March 2015** that they wirelessly beamed 1.8 kilowatts 50 meters to a small receiver by converting electricity to microwaves and then back to electricity. This is the standard plan for this type of power. On **12 March 2015 Mitsubishi Heavy Industries** demonstrated transmission of 10 kilowatts (kW) of power to a receiver unit located at a distance of 500 meters away.

III. METHODOLOGY

Researchers are aspiring to design and develop a Space-based solar farm that would generate 1GW of power and allow it to transfer back to the earth through microwaves or lasers. This will require an area of 4 sq. kilometer consisting of rows of solar panels. This space solar farm will be housed 36,000 km above the earth surface.

SBSP designs generally include the use of some manner of wireless power transmission. The collecting satellite would convert solar energy into electrical energy on board, powering a microwave transmitter or laser emitter, and focus its beam toward a collector (rectenna) on Earth's surface.

IV. DESIGN

Space-based solar power essentially consists of three elements:

- a means of collecting solar power in space, for example via solar concentrators, solar cells or a heat engine.
- a means of transmitting power to earth, for example via microwave or laser.
- a means of receiving power on earth, for example via a microwave antenna (rectenna).

The space-based portion will not need to support itself against gravity. It needs no protection from terrestrial wind or weather, but will have to cope with space hazards such as micro meteors and solar flares.

Two basic methods of conversion have been studied: photovoltaic (PV) and solar dynamic (SD). Photovoltaic conversion uses semiconductor cells to directly convert photons into electrical power. Solar dynamic uses mirrors to concentrate light on a boiler. The use of solar dynamic could reduce mass per watt. Most analyses of SBSP have focused on photovoltaic conversion (commonly known as “solar cells”).

Wireless power transmission was proposed early on as a means to transfer energy from collection to the Earth's surface, using either microwave or laser radiation at a variety of frequencies.

V. PROGRESS STATUS

There are many technological challenges to solve before SSPS can be implemented. However, in principle, researchers are getting close to the stage where it is feasible, and they have just moved from the study phase to the technology demonstration phase. Researchers have started preparation for the world’s first demonstration of 1 kW-class wireless power transmission technology, and are aiming for practical use in the 2030s.

VI. ADVANTAGES

The SBSP concept is attractive because space has several major advantages over the Earth's surface for the collection of solar power.

- There is no air in space, so collecting surfaces could receive much more intense sunlight.
- Space solar power can be exported to virtually any place in the world, and its energy can be converted for local needs.
- Collecting surfaces could receive much more intense sunlight, owing to the lack of obstructions such as atmospheric gasses, clouds, dust and other weather events. Consequently, the intensity in orbit is approximately 144% of the maximum attainable intensity on Earth's surface.
- A satellite could be illuminated over 99% of the time, and be in Earth's shadow a maximum of only 72 minutes per night at the spring and fall equinoxes at local midnight. Orbiting satellites can be exposed to a consistently high degree of solar radiation, generally for 24 hours per day, whereas the average earth surface solar panels currently collect power for an average of 29% per day.
- Power could be relatively quickly redirected directly to areas that need it most. A collecting satellite could possibly direct power on demand to different surface locations based on geographical baseload or peak

load power needs. Typical contracts would be for baseload, continuous power, since peaking power is ephemeral.

VII. CHALLENGES

- The large cost of launching a satellite into space.
- Space debris is a major hazard to large objects in space, and all large structures such as SBSP systems have been mentioned as potential sources of orbital debris.
- The energy required for producing and putting solar panels into space versus the amount of energy generate. One of the solutions can be that we can utilize the concept of space elevators.
- Space solar power development costs will be very large but its cost always needs to be compared to the cost of not developing space solar power.

EFFECTIVE SUGGESTIONS

- Researchers should work on some sort of wireless technique to transmit the trapped solar energy stored in satellite, back to the earth.
- The whole working and processing of the system must be cost effective.

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