

## METHOD OF SPACE BASED SOLAR POWER EXTRACTION USING MICROWAVES

Aniruddha Chowdhury<sup>1</sup>, [orcid](#), K. Vijayaraja<sup>1</sup>

<sup>1</sup>K.C.G. College of Technology (Autonomous), Anna University, Chennai

**Keywords:** Space-based solar power extraction, solar power, microwave transmission.

### Abstract

Space-based solar power (SBSP) presents a promising solution to meet the increasing global demand for clean and sustainable energy. This abstract outline a novel method for extracting solar power from space through the utilization of microwaves. By leveraging advances in wireless power transmission and space-based infrastructure, this method aims to overcome the limitations of terrestrial solar power generation, such as intermittent sunlight and land constraints. The proposed method involves the deployment of a network of solar power satellites (SPS) in geostationary orbit, equipped with highly efficient solar panels to capture sunlight. The collected solar energy is then converted into microwave radiation using specialized rectifying antennas and microwave transmitters aboard the SPS. These microwaves are beamed towards a receiving station on Earth, which consists of a large rectifying antenna array. At the receiving station, the microwave energy is converted back into electrical energy using high-efficiency rectifiers. The electricity can then be integrated into the existing power grid for immediate distribution and consumption. The use of microwaves allows for long-range wireless power transmission, overcoming the limitations of traditional power transmission methods.

This proposed method offers several advantages. Firstly, by capturing solar energy in space, it eliminates many of the limitations faced by ground-based solar power, such as weather conditions and daylight fluctuations. Moreover, the large surface area available on solar power satellites allows for efficient energy collection. Additionally, the wireless transmission of power minimizes energy losses during distribution, making it a highly efficient and environmentally friendly solution. The feasibility of this method requires advancements in several key areas, including the development of lightweight and cost-effective solar panels, efficient rectifying antennas, and high-power microwave transmitters. Furthermore, extensive research is necessary to ensure the safety and minimal environmental impact of the microwave energy beam during transmission.

### Introduction

The world is facing a growing energy demand, and renewable energy is becoming an increasingly important solution to meeting this demand while reducing carbon emissions. One potential solution to meet the growing energy demand is space-based solar power (SBSP) using microwaves. SBSP involves capturing solar energy in space and transmitting it to Earth using microwaves. This paper will explore the method of space-based solar power using microwaves, its advantages and challenges, its potential as a sustainable and reliable alternative energy source, and its economic and political implications. Fig. 1.

explains the basic working of the space based solar power extraction using microwaves.

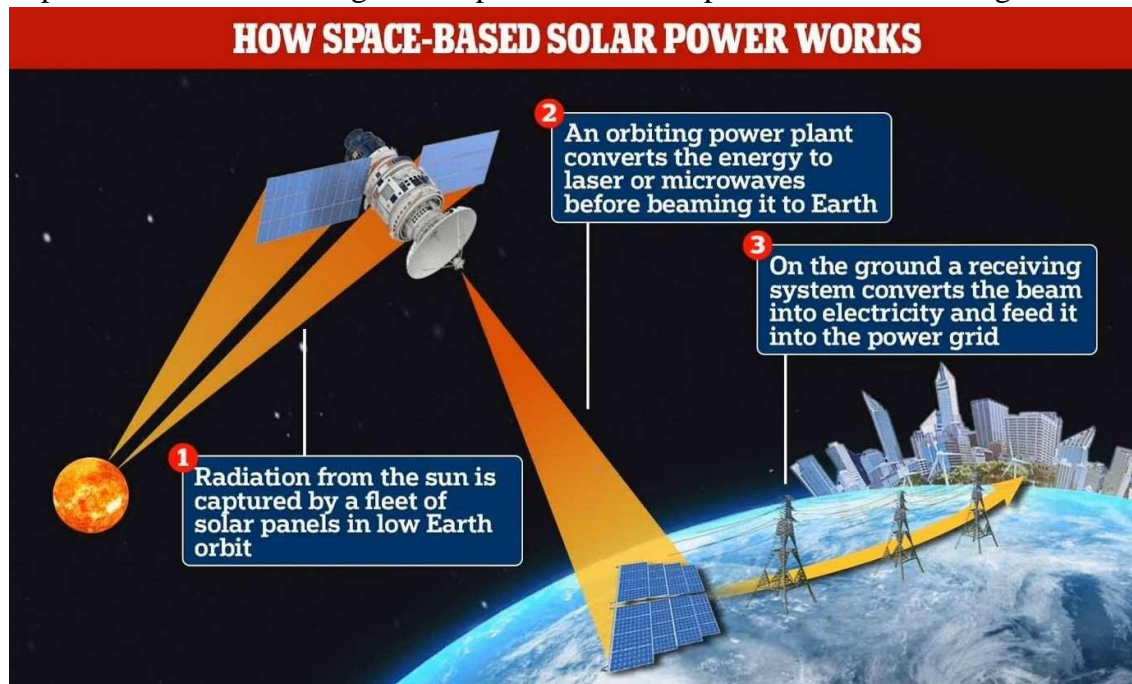


Fig. 1.

### Working of Space based Solar Power

#### Method for Space-Based Solar Power Using Microwaves

##### 1. Capturing Solar Energy in Space

The first step in SBSP is capturing solar energy in space. This can be achieved through the use of solar panels and mirrors. Solar panels convert solar energy into electrical energy, while mirrors concentrate the solar energy onto the solar panels to increase their efficiency.

##### 2. Transmitting Energy from Space to Earth

Once the solar energy has been captured in space, it needs to be transmitted to Earth. This is accomplished using microwaves, which are electromagnetic waves with wavelengths between one millimeter and one meter. As shown in Fig. 2, the sunlight reflects off the large mirrors into the centre of the satellite. Then the sunlight is transformed into uninterrupted microwave energy and directed towards the microwave transmitter. Microwave transmitter in space sends a microwave beam to a receiver on Earth, which then converts the microwave energy into electrical energy.

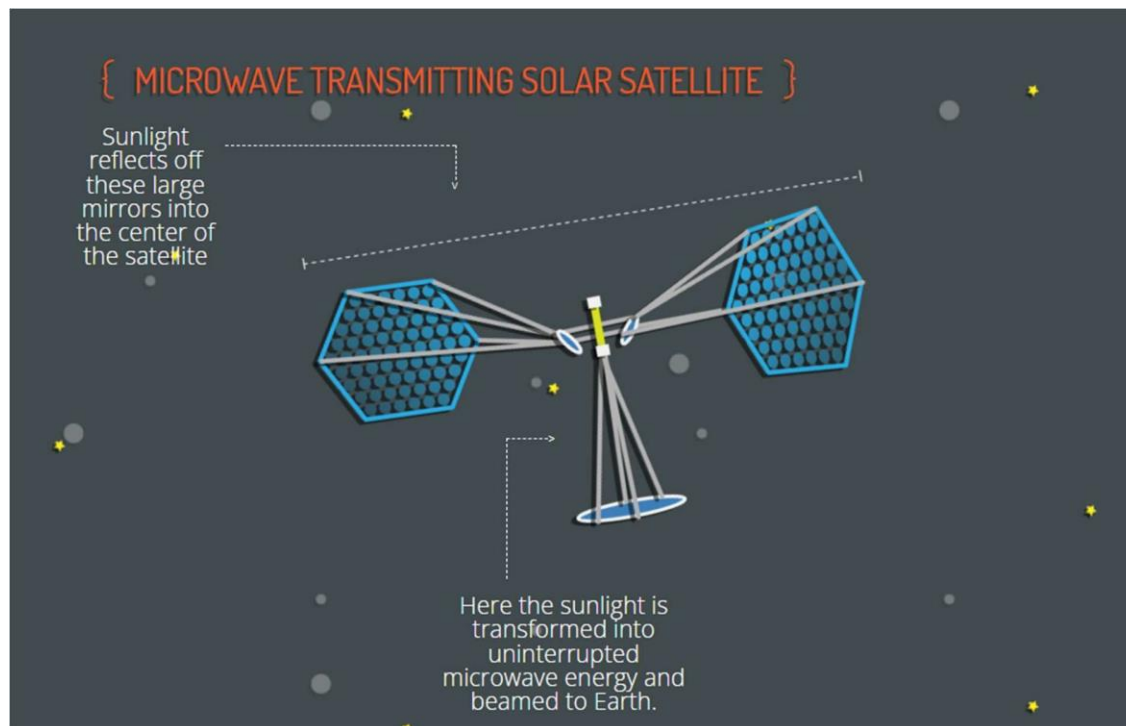


Fig. 2.

### Transmission of microwave energy using solar satellite

#### Working

As shown in Fig. 3., at first the solar radiation is made incident to the surface of the mirrors and solar panels of the satellite. In orbit the intensity of sunlight is much higher than the intensity at Earth's surface. This is taken as an overall advantage to get maximum supply of this solar radiation or solar energy. The very next step is capturing this radiation and energy and regulate it in an efficient manner. Sunlight is converted into a current, then prepared for radio frequency beaming to Earth. Proceeding to this is power beaming of the current that has been converted. Energy is sent down to Earth using phased arrays, laser emitters and/or microwave transmission. Here microwave transmission is taken into account and used for the transmission of energy. The energy beam is made sure to be accurate, reliable and should have the capability to retain as much of its power as possible as it travels through Earth's atmosphere. Now this transmitted beam energy i.e., the transmitted microwave is captured by the ground stations. The energy beam or microwave is captured with photo voltaic cells or with an antenna. This captured electromagnetic energy or microwave is converted by the antenna to electricity. The satellite is able to transmit or beam energy down to a single site or to several locations around the entire Earth surface. Next the role of power transmission is activated. Systems that captured the space-based solar power on Earth is safely and sustainably integrated into existing power grids. Power distribution is done as per the need. Energy utilization plays a vital role even though it is a reliable and renewable source of energy. Space-based solar power technologies could provide the flexibility and reliability required for science and exploration missions where other power sources are limited.

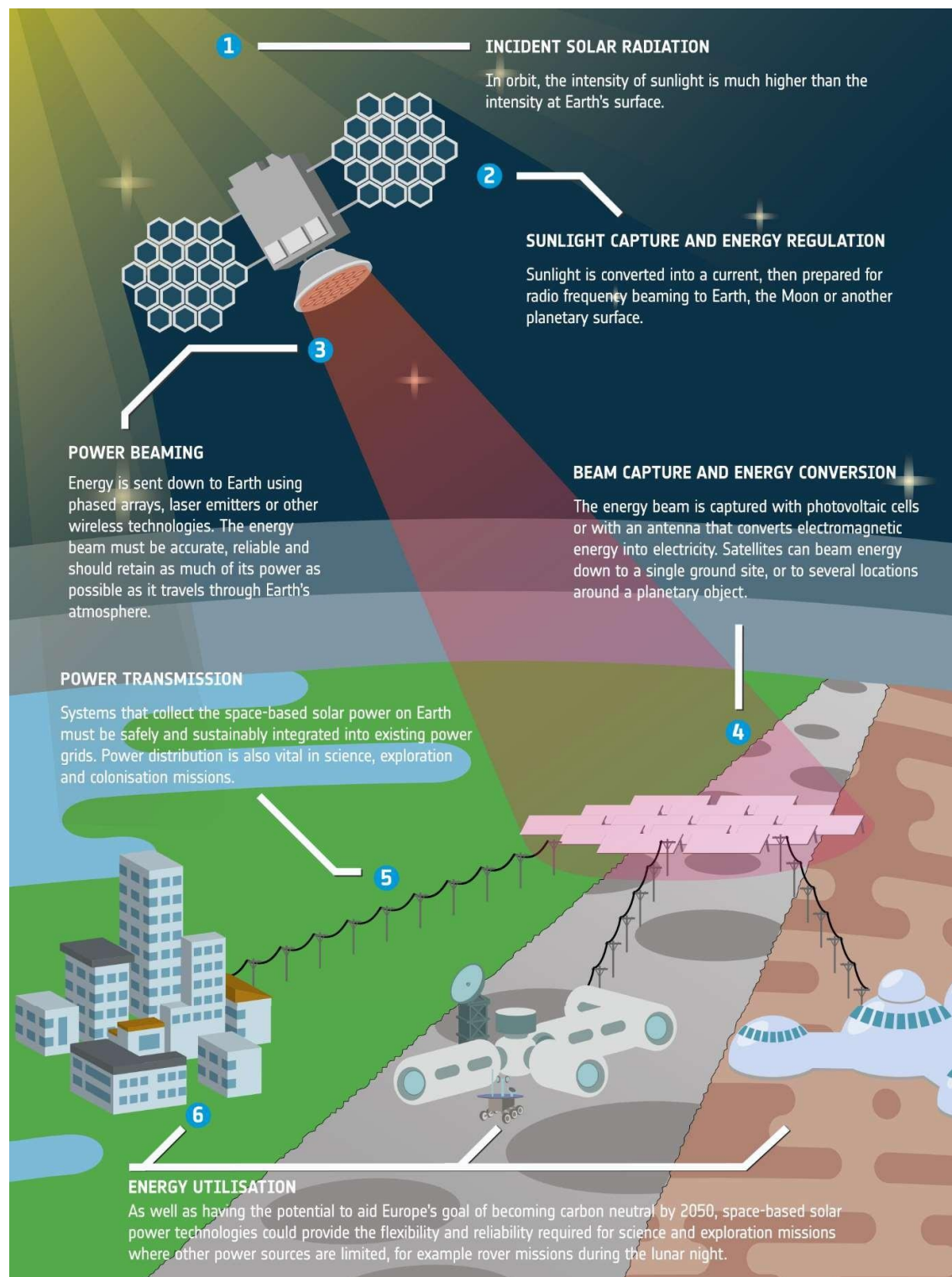


Fig. 3.

Working of the Solar based Solar Power Extraction, Transmission and Utilization.



## **Advantages of Space-Based Solar Power Using Microwaves**

### **1. Continuous Source of Energy**

SBSP using microwaves has the potential to provide a continuous source of energy, unlike terrestrial solar panels, which are affected by weather conditions and the day-night cycle. This makes SBSP a reliable and consistent source of energy.

### **2. Environmentally Friendly**

SBSP using microwaves is also environmentally friendly. The process of capturing solar energy in space does not produce any greenhouse gas emissions, and the transmission of energy using microwaves is much more efficient than other forms of energy transmission, such as high-voltage direct current transmission.

### **3. High Energy Output Potential**

SBSP using microwaves has a high energy output potential. The solar energy available in space is approximately six times greater than the solar energy available on Earth's surface, which means that SBSP has the potential to provide much more energy than other renewable energy sources.

## **Challenges of Space-Based Solar Power Using Microwaves**

### **1. High Launch Costs**

One of the main challenges of SBSP using microwaves is the high cost of launching the necessary equipment into space. This includes the solar panels, mirrors, and microwave transmitter.

### **2. Efficient Microwave Transmitters and Receivers**

The microwave transmitter and receiver must be highly efficient to minimize energy loss during transmission. This requires advanced technology, which can be expensive and difficult to develop.

### **3. Potential Environmental Impact**

SBSP using microwaves has the potential to affect wildlife and the environment. The microwave beam can be harmful to birds and other animals, and there is a risk of the transmission interfering with other electromagnetic signals.

## **Potential of Space-Based Solar Power Using Microwaves**

### **1. Research and Development Progress**

Research and development in SBSP using microwaves has been ongoing since the 1960s. The technology has improved significantly in recent years, with advancements in materials science and engineering.

### **2. Advancements in Materials Science and Engineering**

Advancements in materials science and engineering have made it possible to develop more efficient solar panels and mirrors, as well as more reliable and efficient microwave transmitters and receivers.

### 3. Potential as a Sustainable and Reliable Alternative Energy Source

SBSP using microwaves has the potential to become a sustainable and reliable alternative energy source, with the ability to provide a constant source of energy to meet growing demand. It has the potential to reduce carbon emissions and help mitigate the effects of climate change.

## Case Studies and Examples of Space-Based Solar Power Using Microwave

Several case studies and examples of space-based solar power using microwaves exist. In the 1970s, NASA conducted a feasibility study on the technology and found it to be viable. In recent years, several countries, including Japan and China, have conducted experiments and research on space-based solar power using microwaves. In 2020, China launched the first experimental microwave power transmission station into space.

## Comparison to Other Forms of Renewable Energy

Space-based solar power using microwaves offers several advantages over other forms of renewable energy. For example, it provides a continuous source of energy, unlike terrestrial solar panels that are affected by weather conditions and time of day. Additionally, it has a higher energy output potential than other forms of renewable energy. However, the high launch costs associated with the technology make it less economically viable than other forms of renewable energy, such as wind or solar.

## Economic and Political Implications of Space-Based Solar Power Using Microwaves

The economic and political implications of space-based solar power using microwaves are significant. The technology offers the potential for energy independence and the ability to meet the world's energy needs. However, the high launch costs associated with the technology make it less economically viable than other forms of renewable energy, which may limit its adoption. Additionally, the technology has the potential to disrupt global energy markets and may require international cooperation and collaboration to implement. SBSP using microwaves requires significant initial investment, but the potential long-term benefits in terms of a reliable and sustainable source of energy.

## Conclusion:

In conclusion, the proposed method of space-based solar power extraction using microwaves offers a promising avenue for sustainable energy generation. By harnessing the vast potential of solar energy in space and employing wireless power transmission, this method has the potential to revolutionize global energy production, providing a reliable and clean energy source for a rapidly growing world population. Further research and technological advancements are vital to realizing the full potential of this innovative approach.

**References:**

1. <https://www.bbc.com/news/science-environment-62982113>
2. <https://eponline.com/articles/2022/12/09/solar-panels-and-their-effect.aspx>
3. <https://www.hindawi.com/journals/amse>
4. <https://www.peda.gov.in/how-solar-energy-is-converted-into-electricity-converted>
5. <https://space.nss.org/wp-content/uploads/NSS-Position-Paper-Space-Solar-Power.pdf>
6. <http://large.stanford.edu/courses/2017/ph240/long2>
7. <https://ieeexplore.ieee.org/document/8721134>
8. <https://www.energy.gov/space-based-solar-power>
9. [https://www.esa.int/ESA\\_Multimedia/Images/2020/08/Space-based\\_solar\\_power#.ZF8r8d\\_ZPzI.link](https://www.esa.int/ESA_Multimedia/Images/2020/08/Space-based_solar_power#.ZF8r8d_ZPzI.link)