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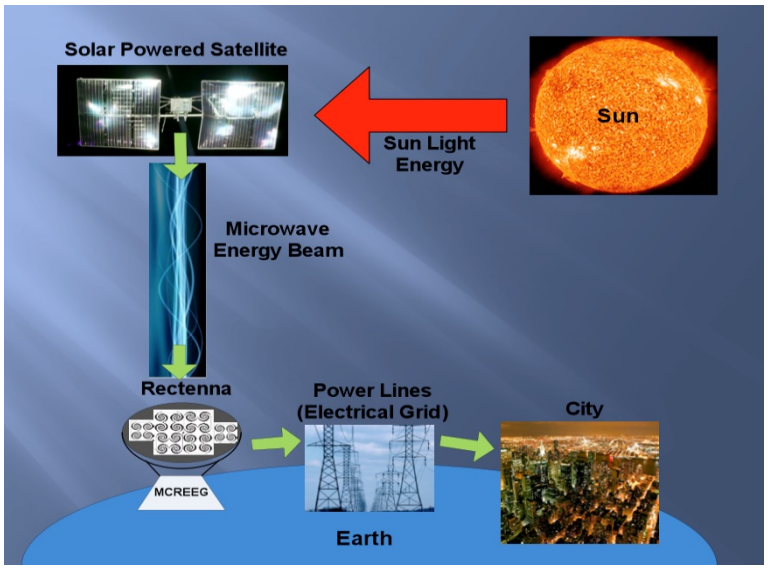

Space Solar Rectifying Antenna on Earth

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Abstract

The realization of solar power from space is becoming increasingly closer as a solution to solving the continued growth in energy demand. Space based solar power is also being perceived as an alternative solution for non-renewable energy resources. Future solar power satellites will be positioned in orbit around the Earth where they will collect solar radiation. That radiation will be transformed into a microwave energy beam that is targeted to a receiving rectifying antenna or “rectenna” located on Earth’s surface. The received microwave energy will be converted into direct current electricity.

This presentation focuses on the microwave patch antennas used with integrated rectifiers in ground receivers on Earth. Inset feed and quarter-wave microwave patch antennas and a microwave rectifier were engineered, manufactured, and tested in-house at the University of North Dakota. The results showed a resonant frequency close to the desired 2.45 GHz, but the rectifier demonstrated 21% power conversion efficiency from AC to DC at 15dBm. The antenna and rectifier were combined and analysis was performed for the parameters of distance of the receiving rectenna from the transmitter and power output upon rectification.

The innovation of this project is the “Multi-Combinational Renewable Energy Efficient Generator ” that allows such energy attachments as terrestrial solar and wind, geo-thermal

facilities, energy storage systems, and the rectenna itself to be integrated into the base structure. The future Global Electrical Grid will use solar power satellites as a space electrical node and, it is hoped, the MCREEG generator will serve as a ground electrical node. To view the technical paper on which this visualization is based, view the supplemental files to this article.

TECHNICAL BRIEF

The idea of Space Based Solar Power (SBSP) is to place solar powered satellites with large solar arrays into Earth's orbit for the purpose of gathering solar radiant energy. The collected energy is then converted into a microwave power beam that is transmitted to a rectifying antenna on Earth. The rectenna transforms the received microwave energy into a usable form. This brief describes a way to better link these ground antennas into the infrastructure of the terrestrial electrical grid.

The Electrical Grid

The World's electrical grid infrastructure is not yet prepared to accept additive base load power coming from SBSP. As early as 2003, the Department of Energy's Office of Electric Transmission and Distribution confirmed that; "America's electric system, the supreme engineering achievement of the 20th century, is aging, inefficient, and congested, and incapable of meeting the future energy needs of the Information Economy without operation changes and substantial capital investment over the next several decades." Thus, in order to adapt to such additional energy inputs as SBSP, the electrical grid system must be upgraded.

Rectenna

This creative visualization of SBSP examines the prospect for microwave "patch" rectennas as potential ground receivers for beamed energy from space. A rectenna consists of an antenna integrated with a rectifying circuit. Members of the University of North Dakota Electrical Engineering Department designed two antennas using computer aided design (CAD-FEKO), an inset feed and quarter wave patch antennas. Also, a microwave rectifying circuit was created using free online tools.

The antennas and rectifier were designed to support a resonant frequency of 2.45 GHz using Rodgers 4003 as a substrate. Fabrication was done by the UNDs Technology Department in two steps: 1) dry etching using a milling machine, and 2) chemical etching. Before the chemical etching preceded the design geometry of interest was laser etched in the substrate. Ports and components were added to the antennas and rectifier. Three laboratory tests were completed: 1) the resonant frequencies of both antennas were found to be about 2.45 GHz, 2) the rectifier was found to convert only about 9% alternating current into direct current, and 3) microwave power of 2.45 GHz was beamed at the antenna integrated with the rectifier (rectenna) from varying distances.

Multi-Combinational Renewable Energy Efficient Generator

The idea behind the MCREEG is to integrate energy-related components into a base structure to assure optimal energy output for a given location. The base structure is a truncated square

pyramid. Energy components are connected to the base structure may include a SBSP rectenna, terrestrial solar and wind facilities, geothermal or hydro outputs and energy storage systems.

For example, the MCREEG can serve as a massive energy storage for wind and/or solar farms so that new transmission lines do not have to be built for distribution. Keeping solar and wind energy production off the traditional electric grid will help to address the problem of intermittent generation.

Global Electrical Grid

When combining the output of solar power satellites with ground based sources, taking into consideration an “altitude grid expansion” with microwave beaming paths going from Earth to space, from space to space, or from space to Earth, the idea of a “Global Electrical Grid” takes on new reality and importance. Such a grid will allow energy to be transferred anywhere in the world by accessing the altitude grid expansion network. The Global Grid opens the prospect that humanity can be brought to a whole new level of ingenuity and creativity. New sources of clean energy will not only allow new businesses and new jobs to be created on Earth, space based solar power will be one of the evolutionary steps needed to bring humanity to the final frontier of space.

BUSINESS BRIEF

Value Proposition of MCREEG

The Multi-Combinational Renewable Energy Generator is designed to bring greater functionality and control to the flow of energy from the emerging altitude grid expansion networks into the existing electrical grid on the ground. This is so because it serves as an electrical node on Earth linking multiple sources. Losses from one node to the next will be known and understood, and therefore controlled. The new source of energy flowing through the global electrical grid will make electrical power available to a wider population base.

Business opportunities are many, both in-space and on the ground. Research and development related to the MCREEG will illustrate where those investments are most needed. One key component relates to those electrical nodes of the Earth rectenna that assure it is in sync with energy beaming from space and is providing an uninterrupted supply into the terrestrial electrical grid. The MCREEG serves as the point of interconnection where energy is received, transformed and re-transmitted on Earth.

The cost analysis for a project of this magnitude is not yet available but the time is getting nearer.

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