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A REVIEW ARTICLE OF SOLARPOWER SATELLITES

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ABSTRACT

Solar power is a reality. Today, increasing numbers of photovoltaic and other solar-powered installations are in service around the world and in space. These uses range from primary electric power sources for satellites, remote site scientific experiments and villages in developing countries to supplementing the commercial electric grid and providing partial power for individual businesses and homeowners in developed countries. In space, electricity generated by photovoltaic conversion of solar energy is the mainstay of power for low Earth and geostationary satellite constellations. Still, for all its acceptance as a benign and environmentally friendly energy source, terrestrial solar power has yet to be seriously considered a viable technology for providing base electrical generating capacity. The obvious reason is sunshine on earth is too unreliable. In addition to the diurnal and seasonal cycles, inclement weather reduces the average daily period and intensity of insolation. However, the sun shines constantly in space. The challenge is to harvest and transmit the energy from space to earth

1. INTRODUCTION

In the coming future due to extensive use of energy with limited amount of resources and the pollution in environment from present resources e.g. (wood, coal, fossil fuel etc.), alternative sources for production of energy and new ways to generate poawer which are eco-friendly, efficient, cost effective and produce less amount of losses are of great concern. Wireless Power Transmission (WPT) has become an major point as research point of view and these days it lies in top 10 future hot trending technologies that are under research work.

1.1 History:

The history of wireless power transmission at microwave frequencies is reviewed with emphasis upon the time period starting with the post-World War II efforts to use the new microwave technology developed during the war. A nationally televised demonstration of a microwave powered helicopter at the Spencer Laboratory of the Raytheon Co., in 1964 was the result of these early efforts and broadly introduced the concept of wireless power transmission to scientific and engineering communities and to the public. Subsequent development efforts centered on improving the efficiency of the inter conversion of D.C. and microwave power at the ends of the system to reach a demonstrated overall D.C. to D.C. system efficiency of 54% in 1974. The response to the requirements of applications such as the Solar Power Satellite and high altitude microwave powered aircraft have changed the direction of technology development and greatly expanded the technology base. Recent and current efforts are centered on examining the use of higher frequencies than the baseline 2.45 GHz, and in reducing the system costs at 2.45 GHz.

1.2 Transmission of power:

The Transfer of power i.e. electricity, involves physical connection (wired connection) between source and receiver. One of the main issue in wired power system is the losses occurs due to internal wire resistance during the transmission and distribution of electricity. The loss of power during transmission and distribution of electricity is approximate about 26%. The major reason for power loss in Transmission and distribution is the internal resistance of wires used for grid. Power Transmission through microwave is one of the promising technologies and may be the good alternative for effective power transmission. Wireless transmission is useful

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to power electrical devices in case where interconnecting wires are inconvenient, hazardous, or place where it is not possible. For example the life of WSN is its node which consists of several device controllers, memory, sensors, actuators, transceivers and battery.
The transceiver can operate in four states,
1) Transmit
2) Receive
3) Idle and
4) Sleep.

The main energy problem of a transmitter of a node is its receiving in idle state, as in this state it is always being ready to receive, consuming great amount of power. However, the battery has a very short lifetime and moreover in some developments owing to both practically and economically infeasible or may involve significant resists to human life. That is why energy harvesting for WSN in replacement of battery is the only and unique solution. In wireless power transfer, a transmitter device source, such as the mains power line, transmits power by electromagnetic fields across an Intervening space to one or more receiver devices, where it is converted back to electric power and utilized. In Communication the goal is the transmission of information, so the amount of power reaching the receiver is unimportant as long as it is enough that signal to noise ratio is high enough that the information can be received intelligibly. In wireless communication technologies, generally, only tiny amounts of power reach the receiver. By contrast, in wireless power, the amount of power received is the important thing, so the efficiency (fraction of transmitted power that is received) is the more significant parameter.

2. CHALLENGES AND BARRIERS

SPS as it was proposed in the 1970s was an extremely large-scale, never-before-attempted space project that promised great risks as well as great rewards. Yet SPS was neither put into production in the 1970s nor given a firm commitment to enter into the 20 year development period that would have ended with the launch of the first solar power satellite around year 2000.23 This section looks into the challenges and barriers of the time in an attempt to answer the following question: "Why did SPS never come to be in the 1970s?" For the reminder of this section, the term barrier shall be associated with obstacles that could not be overcome; in other words, barriers were the showstoppers that prevented SPS from proceeding. Challenges, on the other hand, shall be associated with difficulties that could hinder or further complicate SPS development but were alone insufficient to stop the program.

Technical challenges to the SPS system came in all shapes, sizes, and compositions, which is hardly surprising considering that the proposal called for the development, over fifty years, of a fleet of 60 satellites each spanning 55 km2 . Just sending the components to space required the design of an entire fleet of vehicles including, among others, a HLLV capable of lifting 200-500 tons of payload into LEO. Then there was the sheer number of launches: 400- 750 per year—numbers that seem unimaginable in 2007. However, although the heavy lift capability and high launch frequencies seem difficult, there are obviously no physical limits that hinder development in this area. Therefore, although challenging, none of the aforementioned concerns constituted a barrier for SPS development. The remainder of this section contains some of the other challenges considered in SPS design. The list is far from comprehensive, but provides a sample of the variety of problems that were taken into account. Like the HLLV, none of these challenges alone prevented the progression of the SPS. Unfortunately, in most cases, the SPS development never progressed far enough to either prove or disprove their potential solutions.

Advantages Of Space Solar Power

1) Unlike oil, gas, ethanol, and coal plants, space solar power does not emit greenhouse gases.
2) Unlike bio-ethanol or bio-diesel, space solar power does not compete for increasingly valuable farm land or depend on natural-gas-derived fertilizer. Food can continue to be a major export instead of a fuel provider.
3) Unlike nuclear power plants, space solar power will not produce hazardous waste, which needs to be stored and guarded for hundreds of years.
4) Unlike terrestrial solar and wind power plants, space solar power is available 24 hours a day, 7 days a week, in huge quantities. It works regardless of cloud cover, daylight, or wind speed.
5) Unlike nuclear power plants, space solar power does not provide easy targets for terrorists.
6) Unlike coal and nuclear fuels, space solar power does not require environmentally problematic mining operations.

7) Space solar power will provide true energy independence for the nations that develop it, eliminating a major source of national competition for limited Earth-based energy resources.

Disadvantages Of Space Solar Power

1) Maintenance of SPS is expensive and challenging.
2) Geosynchronous orbit is already in heavy use; could be endangered by space debris coming from such a large project.
3) The size of construction for the rectenna is massive.
4) Transportation of all the materials from earth to space and installation is highly challenging.

3. ISUES OF OLD ARTICLE

C. COUGNET: The Solar Power Satellite (SPS) system is a candidate solution to deliver power to space vehicles or to elements on planetary surfaces. It relies on RF or laser power transmitting systems, depending on the type of application and relevant constraints. The SPS system is characterized by the frequency of the power beam, its overall efficiency and mass. It is driven by user needs and SPS location relative to the user. Several wavelengths can be considered for laser transmission systems. The visible and near infrared spectrum, allowing the use of photovoltaic cells as receiver surface, has been retained. Different frequencies can be used for the RF transmission system. The 35 GHz frequency has been considered as a good compromise between transmission efficiency and available component performances. The utilization of the SPS to deliver power to small rovers or human outpost on Mars, and to an infrastructure on the Moon allows to assess different drivers in terms of user needs, receiver surface, distance between SPS and target, and to perform a preliminary sizing, based on current or reasonably achievable technologies, with respect to different sets of constraints. The SPS system appears as an attractive solution for these applications. The use of advanced or new technologies would drastically lower mass and increase the performances of the SPS system.

DANIEL EDWARD RAIBLE: This paper describes work supporting the development of a high intensity laser power beaming (HILPB) system for the purpose of wireless power transmission. The main contribution of this research is utilizing high intensity lasers to illuminate vertical multi-junction (VMJ) solar cells developed by NASA-GRC. Several HILPB receivers are designed, constructed and evaluated with various lasers to assess the performance of the VMJ cells and the receiver under a variety of conditions. Several matters such as parallel cell back-feeding, optimal receiver geometry, laser wavelength, non-uniform illumination and thermal effects at high intensities are investigated. Substantial power densities are achieved, and suggestions are made to improve the performance of the system in future iterations. Thus far, the highest amount of energy obtained from a receiver during these tests was 23.7778 watts. In addition, one VMJ cell was able to achieve a power density of 13.6 watts per cm2, at a conversion efficiency of 24 %. These experiments confirm that the VMJ technology can withstand and utilize the high intensity laser energy without damage and/or significant reduction in the conversion efficiency.

NEELIMA KRISHNA MURTHY ADDANKI: Space Based Solar Power satellites use solar arrays to generate clean, green, and renewable electricity in space and transmit it to earth via microwave, radiowave or laser beams to corresponding receivers (ground stations). These traditionally are large structures orbiting around earth at the geo-synchronous altitude. This thesis introduces a new architecture for a Space Based Solar Power satellite constellation. The proposed concept reduces the high cost involved in the construction of the space satellite and in the multiple launches to the geo-synchronous altitude. The proposed concept is a constellation of Low Earth Orbit satellites that are smaller in size than the conventional system. For this application a Repeated Sun-Synchronous Track Circular Orbit is considered (RSSTO). In these orbits, the spacecraft re-visits the same locations on earth periodically every given desired number of days with the line of nodes of the spacecraft's orbit fixed relative to the Sun. A wide range of solutions are studied, and, in this thesis, a two-orbit constellation design is chosen and simulated. The number of satellites is chosen based on the electric power demands in a given set of global cities.

The orbits of the satellites are designed such that their ground tracks visit a maximum number of ground stations during the revisit period. In the simulation, the locations of the ground stations are chosen close to big cities, in USA and worldwide, so that the space power constellation beams down power directly to locations of high electric power demands. The j2 perturbations are included in the mathematical model used in orbit design.

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The Coverage time of each spacecraft over a ground site and the gap time between two consecutive spacecraft's visiting a ground site are simulated in order to evaluate the coverage continuity of the proposed solar power constellation. It has been observed from simulations that there always periods in which s spacecraft does not communicate with any ground station. For this reason, it is suggested that each satellite in the constellation be equipped with power storage components so that it can store power for later transmission.

FRANK E. LITTLE: Solar power is a reality. Today, increasing numbers of photovoltaic and other solar-powered installations are in service around the world and in space. The Solar Power Satellite has been hailed by proponents as the answer to future global energy security and dismissed by detractors as impractical and uneconomic. This paper reviews recent design and feasibility studies, advances made in enabling technologies (particularly wireless power transmission) and the development of supporting infrastructure. It identifies current progress towards practical demonstrations of space solar power technology that could lead to an economically viable Solar Power Satellite system.

THORAT ASHWINI ANIL, PROF.KATARIYA S. S.: 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. In the United States, the SPS concept was examined extensively during the late 1970s by the U.S. Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA). More recently, the subject of space solar power (SSP) was re-examined by NASA from 1995-1997 in the "Fresh Look Study" and during 1998 in an SSP "Concept Definition Study." As a result of these efforts, in 1999-2000, NASA undertook the SSP Exploratory Research and Technology (SERT) program, which pursued preliminary strategic technology research and development to enable large, multimegawatt SSP systems and wireless power transmission (WPT) for government missions and commercial markets (in space and terrestrial). During 2001-2002, NASA has been pursuing an SSP Concept and Technology Maturation (SCTM) [1] program follow-up to the SERT, with special emphasis on identifying new, high-leverage technologies that might advance the feasibility of future SSP systems.

MS. S.G. SATAVEKAR: Solar Power Satellites (SPS) converts solar energy in to micro waves and sends that microwaves in to a beam to a receiving antenna on the Earth for conversion to ordinary Electricity. SPS is a clean, large-scale, stable electric power source. For SPS Wireless power transmission is essential. WPT contains microwave beam, which can be directed to any desired location on Earth surface. This beam collects Solar Energy and converts it into Electrical Energy. This concept is more advantageous than conventional methods. The SPS will be a central attraction of space and energy technology in coming decades. It is not a pollutant but more aptly, a man made extension of the naturally generated electromagnetic spectrum that provides heat and light for our sustenance. The new millennium has introduced increased pressure for finding new renewable energy sources. The exponential increase in population has led to the global crisis such as global warming, environmental pollution and change and rapid decrease of fossil reservoirs. Also the demand of electric power increases at a much higher pace than other energy demands as the world is industrialized and computerized. Under these circumstances, research has been carried out to look in to the possibility of building a power station in space to transmit electricity to Earth by way of radio waves-the Solar Power Satellites.

JOSEPH R. LARACY, DAMIEN BADOR, DANIELLE ADAMS, ANNALISA WEIGEL: Since the late 1960s, there has been interest in the United States, and later in other nations, to capture solar energy in space and efficiently transmit it back to Earth. Starting with his seminal paper in 1968, Dr. Peter Glaser began architecting a prototype system that was further explored by the US Department of Energy in the Concept Development and Evaluation Program. This initial study showed that the project was very ambitious and fraught with technical, social, and economic uncertainties. Energy economics and the lack of a reliable, high frequency space launch capability brought most research to a halt in the 1990s. This paper proposes a rational technical strategy to refocus Solar Power Satellite (SPS) research. It suggests a 30 year timeline for program milestones and analyzes potential technical performance. Real options analysis is used to manage uncertainty and permits the exploration of possible futures that are dependent on launch costs and electricity market prices. We propose that the U.S. can make progress toward implementing a small scale SPS system within several decades if work is begun now on technology development and on addressing societal concerns.

Architecture of the 1970s

Dr. Peter Glaser, in 1968, was the first to propose a means of taking advantage of the benefits of space solar power. The concept was seriously studied by the United States between 1978 and 1980 when the Department of Energy led an in-depth feasibility study called the Concept Development and Evaluation Program (CDEP). Since that time, numerous papers have been written and studies conducted to explore the technical feasibility, lifecycle costs, environmental impacts, and policy issues associated with a space-based solar power system. The SPS system discussed in this section is based on the U.S. Department of Energy and NASA system definition studies9 conducted by the Boeing Aerospace Company under contract from the Johnson Space Center (1977) and conducted by Rockwell International under contract from the Marshall Space Flight Center (1978). The SPS Reference System was sized for a 5 GW power output into a conventional power grid. The operational date for the SPS Reference System was the year 2000 with two 5 GW systems deployed per year for 30 years, yielding a total power output of 300 GW. This is about 100 times the peak power needed to run New York City in the summer of 2000.10 The satellite was designed for an overall efficiency of approximately 7%, meaning that approximately 70 GW of solar energy would need to be intercepted. The satellite design had one end-mounted microwave antenna to transmit energy to a rectifying antenna (rectenna) on the ground. The rectenna served to convert microwave energy into electricity. The key subsystems of the satellite included solar arrays, a power distribution system, and a microwave power transmitter.

4. DRIVERS FOR SOLAR POWER SATELLITES

In 1973, the Organization of Petroleum Exporting Countries (OPEC) announced that it would no longer export petroleum to countries that had supported Israel during the Yom Kippur war. On the international front, oil prices skyrocketed as a result of the decreased supply and triggered inflation, unemployment, and recession in Europe. U.S. daily imports were reduced by over 90% and “prices at the pump” nearly doubled, resulting in the creation of a national effort to ration fuel and to seek alternate sources of energy. Six years later, energy crisis lightning struck again during the Iranian revolution, renewing U.S. interest in developing alternate fuel sources and alleviating dependence upon foreign sources.2 The Western Energy crisis of 2001 illustrated that concerns over energy supply are not limited to international providers. In the early 1970s, the state of California elected not to develop nuclear energy as a means of keeping pace with commercial and residential energy requirements. Rather, the state decided to procure energy from hydroelectric producers in the Pacific Northwest and from natural gas. In 2000, higher gas prices and a drought in the Northwest created a recipe for two years of rolling blackouts throughout California. Higher energy prices extended throughout the West Coast and led to a state-of-emergency declaration from Governor Gray Davis.3 The crisis showed the effects of not investing appropriate capital to keep pace with forecasted energy demand. All three of these crises highlight reasons that support the development of alternate energy sources such as SPS. One reason is that domestic and world demand for energy is growing. Significant capital investment is required to alleviate projected capacity gaps. Also, the creation of more environmentally friendly energy sources is an obligation that all economies (emerging, transitional, and mature) share equally. A detailed discussion of each of these drivers follows next.

5. CONCLUSION AND FUTURE SCOPE

The SPS will be a central attraction of space and energy technology in coming decades. However, large scale retro directive power transmission has not yet been proven and needs further development. Another important area of technological development will be the reduction of the size and weight of individual elements in the space section of SPS. Large-scale transportation and robotics for the construction of large-scale structures in space include the other major fields of technologies requiring further developments. The electromagnetic energy is a tool to improve the quality of life for mankind. It is not a pollutant but more aptly, a man made extension of the naturally generated electromagnetic spectrum that provides heat and light for our sustenance. From this view point, the SPS is merely a down frequency converter from the visible spectrum to microwaves.

REFERENCES

[1]. Criswell, D. R. and Waldron, R. D., “Results of analysis of a lunar-based power system to supply Earth with 20,000 GW of electric power”, SPS 91 Power from Space Paris/Gif-sur-Yvette 27 to 30 August 1991, pp. 186-193

[2]. US Department of Energy Energy Information Administration, “International Energy Outlook 2002” Report No. DOE/EIA 0484 (2001) March 2002

[3]. Glaser, P.E. 1968 “Power from the Sun: Its future”, Science, 162, 857 (1968)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

[4]. DOE 1978 "Satellite power system (SPS) concept development and evaluation program (CDEP) Reference System Report", DOE/ER-0023, October 1978
[5]. Electric Power from Orbit: A Critique of a Satellite Power System, National Research Council, National Academy Press, Washington, D.C., 1981
[6]. M. Nagatomo, S. Sasaki, Y. Naruo and V.A. Vanke, "Solar Power Systems (SPS)— investigations at the Institute of Space and Astronautical Science of Japan" Physics – Uspekhi 37 (6) 589-599 (1994) Translated by V.L. Savvin, revised by S.P. Harrop from UspekhiFizicheskikhNauk 164 (6) 631-641 (1994), http://ufn.ioc.ac.ru/ufn94/ufn94_6/ufn46d.pdf
[7]. M. Nagatomo, Space Power 6 299 (1986) cited in [6]
[8]. R. Akiba and H. Yukota in Proceedings of the Pacific ISY Conference— A planning Meeting for the Internatkional Space Year, (Kona, Hawaii, 1987) cited in [6]
[9]. David R. Criswell "Overview of the Proposed Lunar-Solar power System", in WPT-93: First Annual Wireless Power Transmission Conference, Center for Space Power, Texas A&M University, College Station, Texas PP. 223-231 (1993)
[10]. Harvey Feingold, et al, "Space Solar Power— A fresh Look at the Feasibility of Generating Solar Power in Space for Use on Earth": Science Applications International Corporation Report SAIC-97/1005, Science Applications International Corporation, Schaumberg, Illinois, 1997
[11]. Harvey Feingold, et al, (1999) "SPACE SOLAR POWER 1998 CONCEPT DEFINITION STUDY", Report Number SAIC-99/1016 Science Applications International Corporation, Schaumburg, Illinois, 1999
[12]. Nobuyuki Kaya, "A New Concept of SPS With a Power Generator/Transmitter of a Sandwich Structure and a Large Solar Collector", Space Energy and Transportation, Vol. 1, No. 3, 1996, pp. 205-213
[13]. Laying the Foundation for Space Solar Power: An Assessment of NASA's Space Solar Power Investment Strategy (2001), National Research Council, National Academy Press, Washington, D.C., 2001 http://books.nap.edu/books/0309075971/html
[14]. Matthew H. Smith, Richard L. Fork and Spencer T. Cole "Safe delivery of optical power from space" Optics Express, 8 (10) 537-546 (2001).

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