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Prospects of Solar Power Satellite in Bangladesh

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Prospects of Solar Power Satellite in Bangladesh

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I. Introduction

Solar cell had been proved to be the best power source for space applications and extra-terrestrial missions (in 1950s) immediately after the successful development of solar cells at the Bell Telephone and RCA laboratories. After numerous research studies, during 1960-70s, more than 1000 satellites successfully integrated solar cells or panel to power them. It was found straightway that the solar energy available is space is billions of times greater than we use is Earth. But, a very little attention has been given till to date to utilize this enormous power to alleviate the increasing power crisis of Earth. Collecting energy from space might appear to be a distant and overly complex answer, but a careful look reveals surprising advantages and motivations. Responding these, a concept of Solar Power Satellites (SPS) has begun to implement very recently to capture the Sun's energy in space and to deliver it to Earth wirelessly as a non-polluting form of electrical power. It needs to employ some Microwave generators to convert sunlight to microwaves and to redirect the microwaves to Earth [1]. Also a rectena (rectifier and receiving antenna) is needed in the ground to convert it in the usable form of electricity. The drawbacks of this procedure are yet to be solved and the cost-effective versions are yet to be developed but we can take it immediately as we are in great threat of insufficient energy and we are seeking for permanent but renewable alternatives. SPS would serve us in both ways. The lifetime of the sun is an estimated 4-5 billion years, making space solar power a truly long-term energy solution. The radiation energy from Sun to Earth is around 1.77×10^{17} W which is fifty thousand fold of energy consumed by human beings. It seems properly oriented SPS can provide large quantities of energy to each and every person on Earth 24 hours in day and 7 days in week. Also it works regardless of cloud cover, daylight, or wind speed. Figure 1 depicts the idea of the utilization of space solar power.

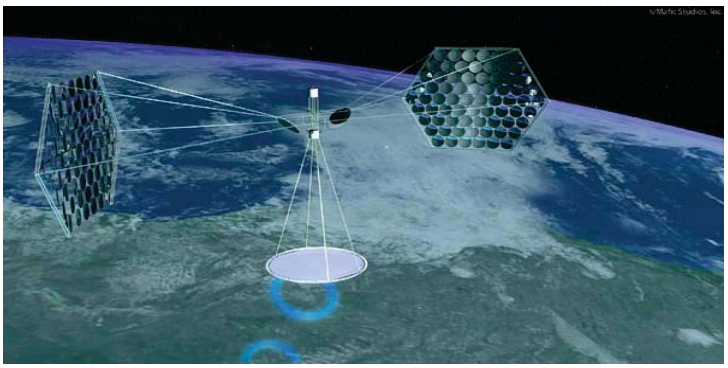

Figure 1 : An Example of the Solar Satellite Concept

Energy is the key to an industrialized economy, which calls for a doubling of electrical output every ten to twelve years [2]. Unfortunately Bangladesh is now facing worst power crisis due to declining production of oil and gas, environmental concerns with coal or nuclear and the insufficiencies of terrestrial wind and solar. To bring power to all the people everywhere in industry or private, only a space-based global power grid would do the job. The sooner we start and the harder we work to launch the SPS project, the shorter "long term" will be. But a poor developing country like Bangladesh must regard the concept as realistic, beneficial, and non-threatening as the challenges are not only the

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technology but also the economics and the legal issues. So, a deep research work and intelligent planning is mandatory to make a vision like SPS a reality.

II. Impacts of Space Solar Power

The Earth receives only one part in 2.3 billion of the Sun's output, as the maximum radiation is lost on its way through the atmosphere by the effects of reflection and absorption by the layers it intercept. As the SPS collects energy residing on an orbiting satellite instead of on Earth's surface, a higher collection rate and a longer collection period is obvious due to the lack of a diffusing atmosphere and the nighttime in space. Also it converts sunlight to microwaves outside the atmosphere, avoiding the losses and the downtime (and cosine losses for fixed flat-plate collectors) due to the Earth's rotation. Microwave beams are constant and can be beamed at densities substantially lower than that of sunlight. This delivers more energy per area than terrestrial solar energy. Even the peak density of the beam could be significantly less than noon sunlight. This low energy density and choice of the wavelength also means that biological effects (cancers or genetic damage) are less likely. The safety of the wild life wandering into the beam is not expected to be an issue. Also the size of the antenna makes microwave beaming unsuitable as a "secret" weapon. So, SPS would likely not face many liability issues resulting from microwave transmission or misuse [3].

The key to getting support for space solar power may be the growing awareness of the threat of rapid global environmental change. The world is now in huge pressure to find new sources of clean and renewable energy. Space solar power is poised to become the planet's most significant source of alternative energy. Unlike oil, gas, ethanol, and coal plants, it can solve our "energy and greenhouse gas emissions problems". Not just to help, not just to take a step in the right direction, but to solve. Also the impacts of wind circulations, ocean current, atmospheric vapor current that related to green-house gas could be controlled using SPS. Space solar power has a number of substantial advantages over other energy sources. Unlike coal and nuclear plants, it does not compete for or depend upon increasingly scarce fresh water resources. Unlike bio-ethanol or bio-diesel, it does not compete for increasingly valuable farm land or depend on natural-gas-derived fertilizer. Unlike nuclear power plants, it would not produce hazardous waste, which needs to be stored and guarded for hundreds of years. Unlike coal and nuclear fuels, it would not require environmentally problematic mining operations.

Although the cost of solar power is not at all compatible with the current prices of fossil fuels, there is a large initial cost of SPS prior to getting a return on the investment. The "Fresh Look at Space Solar Power" [4] study shows that the SPS implementation on an existing satellite may be feasible. The solar energy is routinely used on nearly all spacecraft today and the relevant technologies have reached its optimum level. It is likely to combine wireless power transmission to an established system and to supply the electrical needs of our planet. All it needs numerous research works which should be co-ordinated by both the Government and the private sectors.

III. The Origins of SPS and its Mechanics

Before analyzing the prospects of solar power satellites in a developing country like Bangladesh, it is necessary to understand how the technology works and the historic advents. In 1964, William C. Brown demonstrated the use of microwaves to wirelessly send power to a miniature helicopter and enabled it to fly for over ten hours [5]. His experiment showed the basic premise of wireless power transmission as a transfer of energy emitted by a cavity magnetron and captured by diode receiver [5]. However, the Communication Satellite had been introduced quite earlier than that. In 1968, SPS concept was first proposed by Dr. P.E. Glaser. In '70s SPS assessments were done by NASA and DOE and the reference system was designed. Later in 1991-93 SPS feasibility study was also sponsored by NEDO and MITI. NASA had done Fresh Look Study in 1995-96 and Concept Definition Study on 1997-98. In 1998 NASDA defined SSPS concepts and R&D scenario to develop an SSP experiment satellite. In1999-2000 SERT program was launched by NASA and also SPS2000 Research. In 2000, Ralph Nansen, the president of Solar Space Industries, testified this system before the Congress. Later a 2007 NSSO study concluded that space based solar power is a viable solution to the looming international energy crisis[6].

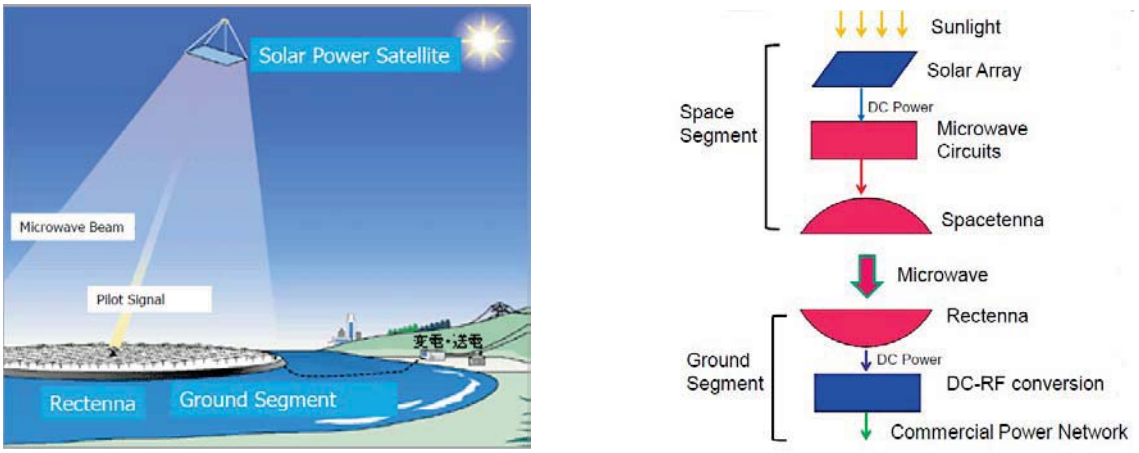
Burt Rutan developed an evaluation of the air launch to enable the the upper stages to launch well above of the sensible atmosphere. This reduces aerodynamic loads, but may be limited by a reasonable takeoff weight. Current assembly concepts have assumed construction in low earth orbit. After completion, the solar power satellite would be transferred to a higher orbit like GEO or else. Propulsion to accomplish this is a critical issue. One concept that has the specific impulse to make transfer practical is Variable Specific Impulse Magnetoplasma Rocket (VASIMR). A NASA spinoff firm, Ad Astra Rocket Company, has announced a key milestone in ground testing of its prototype plasma drive technology, The VASIMR "helicon first stage" - which generates the plasma for acceleration and the rest of the drive would achieve its full rated power of 30 kilowatts using Argon propellant, according to the company. The idea of the plasma drives is to use electric power to blast reaction

mass (in this case Argon) from its rocket nozzles at a much higher speed than regular chemical rockets can achieve [7].

There has been much advancement in subsystem technology that illustrates bright future of the SPS. These advances have included (a) improvements in photo-voltaic efficiency from about 10% (1970s) to more than 40% (2007); (b) increases in robotics capabilities from simple tele-operated manipulators in a few degrees of freedom (1970s) to fully autonomous robotics with insect-class intelligence and 30-100 degrees of freedom (2007); (c) increases in the efficiency of solid-state devices from around 20% (1970s) to as much as 70%-90% (2007); (d) improvements in materials for structures from simple aluminum (1970s) to advanced composites including nanotechnology composites (2007); (e) the application to large space structures; (f) high temperature super-conductors and many other technologies may be integrated into the design [7-8].

IV. Details of Solar Power Satellites (SPS)

To utilize the space as a power generation field, a highly efficient power transmission method is mandatory. Typical SPS system components can be classified as space segment and ground segment (schematics shown are in Figure2). Space segment constitutes solar array or panel to collect solar radiation, microwave circuits (like magnetron) to generate microwave, specetenna to transmit microwave to earth. The ground segment constitutes rectenna to receive microwaves and to rectify it in DC energy, DC-RF conversion section and commercial power network [2].



(a) (b)

Figure 2 : SPS illustrations (a) and the block diagram of the system (b)

Here a magnetron is a high power microwave oscillator in which the potential energy of an electron cloud near the cathode is converted into RF energy in a series of cavity resonators[]. The resonant frequency of a microwave cavity is thereby determined by the physical dimension of the resonator together with the reactive effect of any perturbations to the inductive or capacitive portion of the equivalent circuit. While the rectenna is a device designed to collect the energy associated to a free propagating EM wave and to transform it into Direct Current (DC) power, thus representing the key element for EM energy harvesting and wireless power transmission applications. Figure 3 shows the block diagram of the sub-sections of the rectenna.

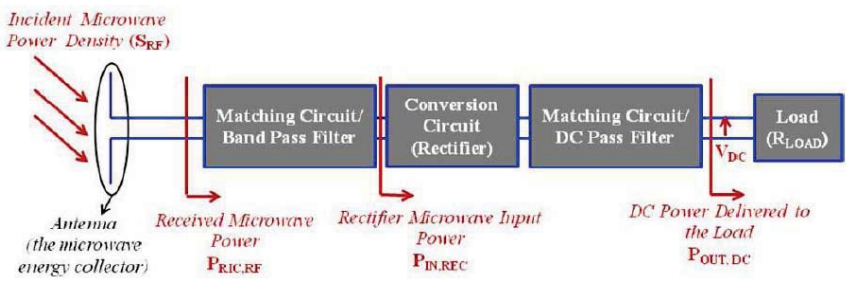


Figure 3 : Schematic representation of a rectenna

V. Drawbacks of SPS System

Lifting the satellites into orbit is extremely expensive, both financially and energetically. A series of launched could be necessary for optimized efficiency. Due to optical constraints, it is not feasible to scale down power satellites well, so 5 GW remains the smallest practical size possible which directly relates the cost of launching. Also, 50% of power generated by the time it is received on the ground would be lost due to conversion to microwaves, dispersion of energy during transmission and reconversion back from microwave. Outer space provides many potential hazards to the solar panels: space debris, space dust, asteroids, and extreme solar radiation. All of these could be very harmful to the integrity of the system. Nevertheless, a few practical experiments were conducted because even an experimental satellite power system would have cost billions of dollars to develop.

VI. Effectiveness of SPS in Bangladesh Perspective

People of Bangladesh now live in a society that has a growing demand for energy, while natural resources are being depleted. All current sources of energy here will sooner or later prove to be insufficient. So, the renewable and clean alternative sources are must. SPS would be an excellent solution in this regard. Also responding environmental threat, we need to move away from fossil fuels, diesels, oil from our transportation system. While electricity powers a few vehicles today in Bangladesh, hybrids will soon evolve into plug-in hybrids which would use electric energy from the grid. Due to rapid development of batteries, super-capacitors and fuel cells, the gasoline engine will gradually play a smaller and smaller role in transportation—but only if we can generate the enormous quantities of electrical energy. SPS can provide the needed clean power for any future electric transportation system. So, SPS would be really helpful for Bangladesh.

However, it involves placing satellites into space, outside the sovereign territory of any nation and to deliver energy to Earth via beams that pass through the atmosphere. Therefore, countries need to coordinate international agreements like available microwave transmission frequencies, satellite locations, and other necessary features of space operations in order to avoid international conflicts. The government of any developing country like Bangladesh would certainly have to play a critical role in international politics.

Although, SPS would be launched for the principal purpose of supplying power to earth, it would not only serve as the basis for the revitalization of the space industry which would be a luxurious thought for Bangladesh. We need to make sure of the maximum utilization of the SPS. It could be a key to the future economic strength and environmental health of our country. To justify the government investment in space solar power, the following factors would be important [8]:

- Space solar power would not require dependence on unstable or hostile foreign oil providers to meet energy needs, would enable us to expend resources in other ways.
- Space solar power could be exported to virtually any place in the world, and its energy could be converted for local needs — such as manufacture of methanol for use in rural places where there are no electric power grids. Space solar power can also be used for desalination of sea water.
- Space solar power would take advantage of our current and historic investment in aerospace expertise to expand employment opportunities in solving the difficult problems of energy security and climate change.
- Space solar power would provide a market large enough to develop the low-cost space transportation system that is required for its deployment. This, in turn, will also bring the resources of the solar system within economic reach.
- The Thunderstorm Solar Power Satellite (TSPS) is a concept for interacting with thunder-storms to prevent formation of tornadoes. TSPS benefits are saving lives and reducing property of the coastal areas which are in major weather threat.

a) Bangabandhu-1: The Probable Solution of SPS

Being a poor country, Bangladesh does not have the luxury of launching a series of test launch before the original SPS launch. Also it would remain a dream to launch a dedicated SPS besides communication Satellites. Even Bangladesh hasn't launched yet it's very first communication satellites. So, things aren't rosy here at all. But, the good news is Bangladesh is going to launch its first satellite into space in 2015, confirmed by Riajuddin Ahmed Raju, the current Posts and Telecommunications Minister of Bangladesh Government in a press conference on March 29, 2010. The project would cost 32,487 billion BDT and the satellite's life span would be around 25 years and the invests are supposed to be earned within first five years. The satellite would stay at 119.1°e East longitudes. An US firm *"Space Partnership International (SPI)"* is assigned by the country to design and to launch the satellite [9]. SPS would be the intelligent integration with Bangabandhu-1, the proposed name of the Satellite. As the whole project is in initial stage, it would not be much problematic to include SPS module with the original design. As this research is a costly one, and the Government fund may not be so huge, the commercial involvement is also required here.

The Earth stations of satellite Bangabandhu 1 will be set up at Betbunia in Chittagong and the BTCL Staff College in Gazipur while a maintenance office will be established at the BTRC building at Ramna in the capital. In our SPS proposal, the placement of rectnna is always a complex issue although a little side effect is forecasted by the research work. As Bangladesh is an over-populated land and a few places are as open as rectenna placement demands. Bangladesh has a 724 km long coast line and many small islands in the Bay of Bengal. This vast area can be used intelligently in this regard. A floating rectenna can work in the same manner described earlier. The regions near the sea sore are the main areas to empower primarily by the proposed rectenna, and the other cities & villages also.

If Bangladesh can successfully launch only the Bangabandhu-1 satellite, it will earn more than $50m by renting out to other countries, such as Nepal, Bhutan, and Myanmar, every year. If the SPS module could integrate with that, more economical benefits would be confirmed.

VII. Conclusion

Space solar power would provide true energy independence for the nations that develop it, eliminating a major source of national competition for limited Earth-based energy resources. Bangabandhu-1 could be the one for us that can make a vision like SPS a reality. Here the Bangladesh government would certainly have to play a supportive role to assure that the best co-ordination. Before SPS modification can be safely attempted, the combined structure of the satellite must be simulated and tested well.

References Références Referencias

1. Space Based Solar Power, Wikipedia. Available: http://en.wikipedia.org/wiki/Space-based_solar_power
2. Solar Power Satellites, *Don M. Flournoy,* Springer-International Space University Publication, 2012.
3. Monopole-Based Rectenna for Microwave Energy Harvesting Of UHF RFID Systems, *G. Monti, F. Congedo, D. De Donno, and L. Tarricone,* Progress in Electromagnetics Research C, Vol. 31, pp:109-121, 2012.
4. Solar Power Satellites: The Right to a Spot in the World's Highest Parking Lot, *Aleksey Shtivelman,* Available: www.bu.edu/law/central/jd/organizations/.../Shtivelman_web.pdf
5. Solar Power Satellite -Critical technologies towards SPSISAS, *JAXA, Department of Spacecraft Engineering*, Koji Tanaka, 2013.
6. Space Solar Power, *John C. Mankins*, International Academy of Astronautics. 2011 Available: iaaweb.org/iaa/Studies/sg311_finalreport_solarpower.pdf
7. Wireless Power Transmission for Solar Power Satellite- SPS, *N. Shinohara,* Available: www.sspi.gatech.edu/wptshinohara.pdf
8. Wireless Power Transmission: The Key to Solar Power Satellite- *Ralph H. Nansen.* Available: http://electricalandelectronics.org/wp-content/uploads/2008/10/00484148_2.pdf
9. Bangabandhu-1. Available: http://en.wikipedia.org/wiki/Bangabandhu-1

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