A STUDY ON SPACE-BASED SOLAR POWER

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Abstract- The study presents *Space Based Solar Power (SBSP)*, an emerging technology which is under a heavy research phase. Here geosynchronous satellites are used for collecting sunlight, harnessing it to produce solar power and transmitting the generated power back to Earth using *Wireless power transmission (WPT)*, safely and reliably. The advantage of placing solar cells in space is the 24 hour availability of sunlight. Also the urgency of finding an alternative energy source due to the depleting energy resources on earth calls for SBSP. Here we study the concept of *Solar Power Satellites (SPS)*, investigate the feasibility of implementation, the overall architecture & the underlying components. The results highlight the effectiveness of this system as an environment friendly, low-loss and large-scale method of energy transfer

Keywords: *Space Based Solar Power, Wireless power transmission, Alternative energy (solar)*

I. INTRODUCTION

The search for "inexhaustible" energy resources to satisfy long-term needs is a high priority undertaking which has been recognized by the government and the public alike. Also in a recent survey conducted on consumption of the existing Oil reserves on earth revealed shocking facts that if we keep consuming oil at the current rate, the oil wells might dry up within the next 65 years. This situation certainly demands for an alternative energy source for future generations.

The solution to these difficulties in producing solar power. Solar industry is a 40 billion dollar a year market, producing gigawatts of power which is unfortunately less than 1/10th of 1% of the energy we currently use and demand. The solution to this demand is the help of a Solar Power Satellites (SPS) .The solar power satellites are an integral part of Space Based Solar Power (SBSP) .The SPS are illuminated by the Sun for 99% of the time in a year except for a short duration during equinox.

II. POTENTIALS

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

•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 as it is always solar noon in space and full sun, 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 earth surface solar panels currently collect power for an average of 29% of the 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 base load or peak load power needs. Typical contracts would be for base load, continuous power, since peaking power is ephemeral.

•With very large scale implementations, especially at lower altitudes, it potentially can reduce incoming solar radiation reaching earth's surface. This would be desirable for counteracting the effects of global warming.

Compared to natural gas, oil, coal plants and ethanol, space based solar power does not result into by-products like greenhouse gases. Also like nuclear power plants, space solar power will not produce hazardous waste, which needs to be stored and guarded for hundreds of years. The following figure also shows that in future the cost of producing electricity using coal will go on increasing. Whereas, that using Solar Satellites, if implemented, will keep reducing over the years.

III. LITERATURE REVIEW

Two basic methods of conversion have been studied. Most analyses of SBSP have focused on photovoltaic conversion using solar cells that directly convert sunlight into electricity. Solar dynamic uses mirrors to concentrate light on a boiler.If photovoltaic, it can use planar arrays or concentrating collectors. The cells can be made of silicon, gallium arsenide, klystron, magnetron, TWT etc. And can vary in size, thickness, mass, construction, and performance.

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.

a) Microwave power transmission:

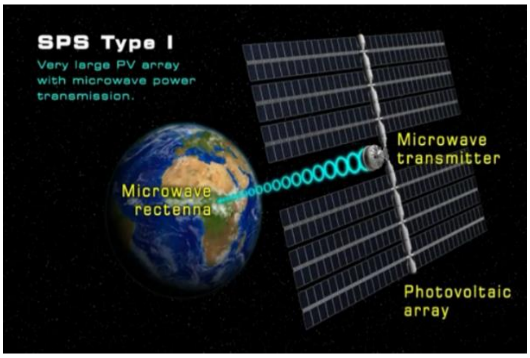

Fig 1: Microwave concept satellite.

Power transmission via radio waves can be made more directional, allowing longer-distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in the may be used to convert the microwave energy back into electricity. Rectenna conversion efficiencies exceeding 95% have been realized. Power beaming using microwaves has been proposed for the transmission of energy from orbiting to Earth and the leaving orbit has been considered.

b) Laser power beaming:

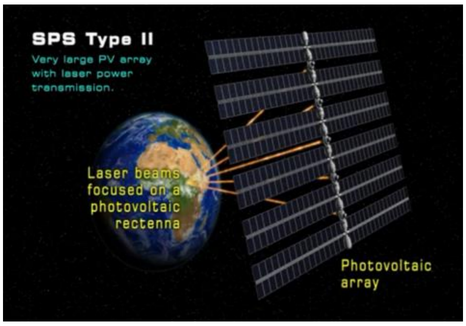

Fig 2: basic transmission working.

In the case of electromagnetic radiation closer to the visible region of the spectrum (tens of micrometres to tens of nanometres), power can be transmitted by converting electricity into a laser beam that is then pointed at a photovoltaic cell.

This mechanism is generally known as 'power beaming' because the power is beamed at a receiver that can convert it to electrical energy. At the receiver, special photovoltaic laser power converters which are optimized for monochromatic light conversion are applied.

c) Orbital location:

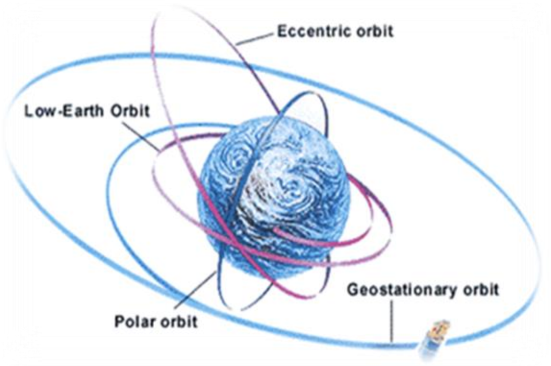

Fig 3: Orbits.

The main advantage of locating a space power station in geostationary orbit is that the antenna geometry stays constant, and so keeping the antennas lined up is simpler. Another advantage is that nearly continuous power transmission is immediately available as soon as the first space power station is placed in orbit; other space-based power stations have much longer start-up times before they are producing nearly continuous power. A collection of LEO space power stations has been proposed as a precursor to GEO space-based solar power. The idea of the Solar Power Satellite energy system is placing giant satellites, with wide arrays of solar cells embedded on them, 35,780km above the Earth's surface in the geosynchronous orbit.

d) Earth-Based Receiver:

Microwave broadcasts from the satellite would be received in the dipoles with about 85% efficiency. With a conventional microwave antenna, the reception efficiency is better, but its cost and complexity are also considerably greater. Rectennas would likely be several kilometers across.

IV. SAFETY

Having currently a 50 year history of being able to send Satellites into space powered by solar panel that generate that electricity converted a radio wave and beam it back to earth (it's called communication satellite industries) and as result of that form the last 50 years is that the physics of wireless power transmission is very well understood, their well-documented especially.

Impacts on Environment and Biodiversity: Wireless power transmission through SPS has no major impacts on Environment or life on Earth. Studies reveal that the microwave radiations used are not higher than that experienced while opening a kitchen microwave oven. The microwave radiations are well within the prescribed safety guidelines. Thus SPS might provide a large scale, clean, green and efficient source of power.

V. THE REAL PROMISE OF SPACE-BASED-SOLAR-POWER

Technology that has the ability to transfer energy on demand anywhere on earth in real time as its needed 24 hours a day, which no other energy source can promise. Also the World Govts, NGOs, all understand that one of the fastest ways to take people out of poverty in this developing world is to give them access to electricity, this is why The World Bank have made it one of their mandates to make rural electrification one of the high priorities. The challenges is that most of these areas that are affected the most cannot get on the grid, here SBSP could actually enable rural electrification like no other form of electricity.

If focused on current water crisis the implications of that are that with receding glaciers and falling water tables we know that fresh waters are going to be a big issue as we face it in the coming years ahead now, here SBSP can help as most of the govts that have access on costal lines like India are embarking on desalination programmes, such desalination plants need huge amounts of energy that can be fulfilled.

VI. ECONOMIC BENEFITS

Creation of about a quarter of a million jobs that are likely to be generated in India alone at a time where unemployment is the highest for nearly a quarter of a century now.

VII. DRAWBACKS

The SBSP concept also has a number of problems:

•The large cost of building a satellite and sending into space and the large size and corresponding cost of the receiving station on the ground.

•Inaccessibility: Maintenance of an earth-based solar panel is relatively simple, but construction and maintenance on a solar panel in space would typically be done tele-robotically. In addition to cost, astronauts working in GEO are exposed to unacceptably high radiation dangers and risk and cost about one thousand times more than the same task done tele-robotically.

•The space environment is hostile; panels suffer about 8 times the degradation they would on Earth (except at orbits that are protected by the magnetosphere).

•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.

VIII. PERSONAL SUGGESTIONS

- To solve the problem of large size, we can try implementing Nanotechnology concept into the solar panel to reduce the size by a great fraction and hence if size reduces the cost of launching also reduces. Reduction of size reduces the maintenance cost.
- For the astronauts that would be at GEO, radiation proof suits can be made by suitable materials or nanomaterial that can be programed to absorb or deflect the radiation.
- The panels, rest of the satellite parts much be made by a long lasting material that would reduce the degradation time.
- To protect the satellite form space debris (or) space junk, we can implement the protective shield like structure around the delicate parts it prevent contact/damage.

IX. CONCLUSION

From the above considerations it can be inferred that SBSP can prove to be a promising alternative to fossil fuels .We also came across the fact that the losses in Wireless power transfer are much less compared to the transmission lines. Microwave Power Transmission (MPT) also has no harmful effect on the biodiversity and the environment on the Earth. But the major hurdle in the implementation of Solar Power Satellites is not technology but economic factors. A large scale research is ongoing to overcome the high cost of fabrication and launching of these satellites.

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