International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 5, May - 2013

Solar Power Satellites

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Abstract

The Solar Power Satellite System is a concept to collect solar power in space, and then transport it to the surface of the Earth by microwave (or possibly laser) beam, where if is converted into electrical power for terrestrial use. The recent increase in energy costs,
predictions of the near-term exhaustion of oil, and prominence of possible climate change due to the "greenhouse effect" from burning of fossil fuels has again brought alternative energy sources to public attention, and the time is certainly appropriate to reexamine the economics of space based power. Several new concepts for Satellite Power System designs were evaluated to make the concept more economically feasible.Though solar power satellites is still a concept large strides are being taken by developed countries to turn this into reality by 2040.Japan has contributed a lot in achieving this by setting up large laboratories to conduct studies on Solar power satellites

1. Introduction

In 1968**,** Peter Glaser, then of Arthur D. Little, proposed the concept of a Space Solar Power Satellite as a means to solve the problem of providing energy for terrestrial use**.**Glaser's proposal was to place a large (-10 km2) solar array in geosynchronous orbit, and then to transmit power to the ground using a microwave beam**.**This is shown in schematic in fig1**.**. The beamed power is received on the ground by a rectifying antenna, or "rectenna," which converts the microwaves to DC electrical power at a DC-to-DC efficiency of roughly 80%. By locating the solar array in orbit, rather than on the ground, the array has the advantage of continuous full sunlight, without the day-night cycle, atmospheric attenuation, or douds to interrupt power. A space solar array produces roughly 10 times more power than the same array in a low-insolation location such as the Northeast, or about four times more power than the same array at a high-insolation location such as the southwest. Although significant technical barriers to implementing the concept existed, both then and now, the energy crisis of the late 1970s made the U.S. Department of Energy and NASA take the concept seriously enough that a feasibility study was done, and a conceptual "baseline" design for a Satellite Solar Power system was made**.**

This conceptual study was evaluated by the U.S. Office of Technology Assessment, who concluded that the concept was attractive, but could not be economically implemented with the technology of the time **.** The report suggested re-evaluating the concept in ten years time In 1995**,** a "Fresh Look" study of the concept was performed by NASA**.**The study assumed significant reductions in space launch cost, due to implementation of new technologies for reusable launch vehicles. This study examined a number of alternate concepts **,**and considered placing the solar power satellite at locations lower than geosynchronous orbit, drawing the conclusion that other orbits were not practical, since the advantage of geosynchronous orbit, with the power station always in view of the ground station, outweighed the disadvantage of the higher orbit. The study examined microwaves, high frequency microwaves, and laser transmission of energy. Figure2 shows one of the many alternate design concepts, the "Power Tower"**.**

The recent increase in energy costs, predictions of the near-term exhaustion of oil, and prominence of possible climate change due to the "greenhouse effect" from burning of fossil fuels has again brought alternative energy. sources to public attention, and the time appropriate to re examine the economics of space based power.

In 1990, the world demand for power exceeded 10 terrawatts (10X1012 Watts) thermal, with about 30% of the thermal energy being used to produce electricity. In 1990, the nations of the Organization for Economic Cooperation and Development (OECD) used more than two-thirds of the world’s total electrical power of >10.5 terrawatt-hours.However, beginning in 2015, the DOE has forecast that the non-OECD countries' share of electric power usage will
exceed fifty percent and will continue to rise. Energy demand is estimated to increase by more than 60% from the present 382 Quads (1999) to 612 Quads in 2020 and electricity, with an annual growth rate of 2.7% between 1999 and 2020 will outpace growth of other energy use, reaching more than 22.4 terrawatt-hours.

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. The idea for a Solar Power Satellite that would help meet the growing energy needs of developed and developing nations was conceived by Dr. Peter Glaser in 1968 [3]. Dr. Glaser's concept was orbiting satellites converting solar energy and transmitting the energy to earth via a radio frequency energy beam. Solar Power Satellites placed in geosynchronous equatorial orbit 35,800 kilometers above Earth's surface would be continuously illuminated for most of the year. As a result of the orbit location, the amount of sunlight shining on the satellite during the year is five times more than is available to any terrestrial location. At geosynchronous orbit, satellites have the same rotational period as the Earth and are therefore fixed over one location at all times, enabling the satellite to deliver almost uninterrupted power to a ground receiving site

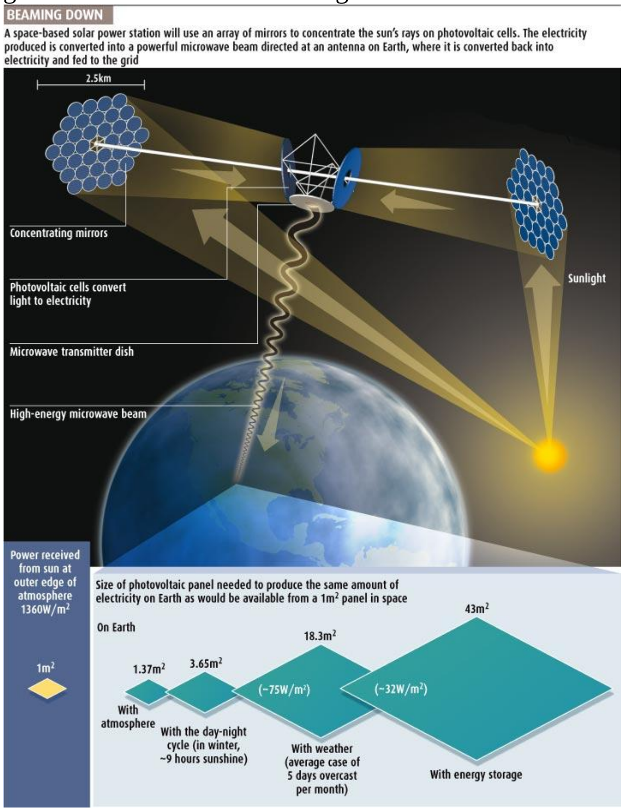


Fig2

Because the Earth's axis tilts 23° from the plane of the ecliptic, the satellites would pass either above or below the Earth's shadow except during the spring and fall equinox periods. During the 22 days prior to equinox, the satellite would experience a lengthening daily period of eclipse to a maximum of 72 minutes. The period of eclipse would then fall during the 22 days following equinox. The eclipse period occurs near local midnight when energy demand is at a minimum. The equinox eclipses will result in about a 1% decrease in the amount of solar radiation reaching the Solar Power Satellite and hence a 1% scheduled outage rate during the year.

2. Concept

A difficulty with the space solar power concept is that the concepts designed in the **1970s are** inherently large in scale (the 1979 baseline design produced 5 GW of power per satellite), and cannot be implemented at smaller sizes. The size limitation results from the size of the microwave transmission aperture needed, since the diffraction-limited spread of the microwave beam transmitting the energy is reduced for large transmitter aperture.

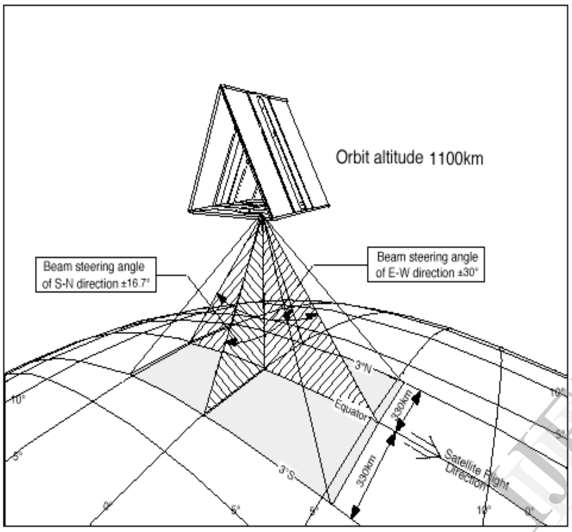
The fundamental formula for the diffraction-limited spot size is $D_{SPOT}=2.44d\lambda/D_{TRANS}$ where Dspt is the diameter of the beam reaching the ground (defined here as the first minimum in the Airy pattern, which contains 86% of the power), d is the distance transmitted, *h* is the wavelength, and is the diameter of the transmitting array. For microwaves at a frequency of 2.45 GHz, *h* is about 12 cm. A satellite in geosynchronous orbit is 36,000 km from the surface, and so the rectenna diameter Dmctenna needed on the ground is 10.5 kms. This does not include the size of the keep out buffer zone around the antenna. For .a receiving rectenna on the order of 10 km, a transmitter on the order of a kilometer in' diameter is required. At these large sizes, power levels of many GW are required to make the beam power density high enough for efficient conversion. The 1979 baseline design assumed a 1-km diameter transmitting antenna, fed by a 50-km2 solar array. Prices for baseline electlical power. The calculated cost was either immediately too expensive, or else yields a cost marginally competitive (but not significantly better) than terrestrial power technologies, with an internal rate of return too low for the initial multi-billion dollar investment to make money. Only if an "externality surcharge" is added to non-space power sources to account for the economic impact of fossil fuels did space solar power options make economic sense. While "externality" factors represent a true cost impact of fossil-fuel generation, it is unlikely that the world will impose such charges merely to make space solar power economically feasible.

2. Working

Solar power satellites, otherwise known as powersats, orbit the earth and are designed to capture solar energy and transmit that energy to receiving stations that are situated thousands of miles from each other on the surface of the earth. These satellites are made up of a number of modules outfitted with light weight photovoltaic solar panels.

What is so great about this technology? It is clean, it is green, and it is safe. Collecting solar power in space is also more efficient than collecting solar power on the surface of the earth for many reasons.

Several solar sat designs have been studied but the simplest consists of an enormous span of solar cells that convert sunlight into electricity, and an onboard core that converts that electricity into very weak, cell phone-like microwave beams that are transmitted down to equally large receiving antennas on Earth. The mesh-like antennas on the ground convert the beams back into DC electricity. If the antennas are on the rooftops of large industrial facilities like cement plants or aluminum smelters the DC electricity can be used directly by equipment in those plants. If not, equipment on the antennas can convert it into AC power and feed it into a standard electrical grid



In round numbers a solar satellite system able to provide 1,000 megawatts of output from the ground antenna will require a 1-square mile span of solar cells in orbit and a 1-square mile antenna on the ground. These ground receiving stations are safe enough to allow a wide variety of businesses to be conducted under them

3)Wireless Power Transmission for Solar Power Satellite (SPS)

It is known that electromagnetic energy also associated with the propagation of the electromagnetic waves. We can use theoretically all electromagnetic waves for a wireless power transmission (WPT). The difference between the WPT and communication systems is only efficiency. The Maxwell's Equations indicate that the electromagnetic field and its power diffuse to all directions. Although we transmit the energy in the communication system, the transmitted energy is diffused to all directions. Although the received power is enough for a transmission of information, the efficiency from the transmitter to receiver is quiet low. Therefore, we do not call it the WPT system. Typical WPT is a point-to-point power transmission. For the WPT, we had better concentrate power to receiver. It was proved that the power transmission efficiency can approach close to 100%. We can more concentrate the transmitted microwave power to the receiver aperture areas with taper method of the transmitting antenna power distribution. Famous power tapers of the transmitting antenna are Gaussian taper, Taylor distribution, and Chebychev distribution. These taper of the transmitting antenna is commonly used for suppression of sidelobes. It corresponds to increase the power transmission efficiency. Concerning the power transmission efficiency of the WPT, there are some good optical approaches in Russia

Future suitable and largest application of the WPT via microwave is a Space Solar Power Satellite (SPS). The SPS is a gigantic satellite designed as an electric power plant orbiting in the Geostationary Earth Orbit (GEO). It consists of mainly three segments; solar energy collector to convert the solar energy into DC (direct current) electricity, DC-to-microwave converter, and large antenna array to beam down the microwave power to the ground. The first solar collector can be either photovoltaic cells or solar thermal turbine. The second DC-to-microwave converter of the SPS can be either microwave tube system and/or semiconductor system. It may be their combination. The third segment is a gigantic antenna array. Table 1.1 shows some typical parameters of the transmitting antenna of the SPS. An amplitude taper on the transmitting antenna is adopted in order to increase the beam collection efficiency and to decrease sidelobe level in almost all SPS design. A typical amplitude taper is called 10 dB Gaussian in which the power density in the center of the transmitting antenna is ten times larger than that on the edge of the transmitting antenna

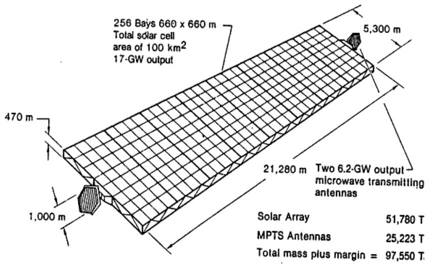
The SPS is expected to realize around 2030. Before the realization of the SPS, we can consider the other application of the WPT. In resent years, mobile devices advance quickly and require decreasing power consumption. It means that we can use the diffused weak microwave power as a power source of the mobile devices with low power consumption such as RF-ID.

Table 1.1 Typical parameters of the transmitting antenna of the SPS [7]

Model	Old JAXA model	JAXA1 model	JAXA2 Model	NASA/DOE model
Frequency	5.8 GHz	5.8 GHz	5.8 GHz	2.45 GHz
Diameter of transmitting antenna	2.6 kmϕ	1 kmϕ	1.93 kmϕ	1 kmϕ
Amplitude taper	10 dB Gaussian	10 dB Gaussian	10 dB Gaussian	10 dB Gaussian
Output power (beamed to earth)	1.3 GW	1.3 GW	1.3 GW	6.72 GW
Maximum power density at center	63 mW/ cm^2	420 mW/cm^2	114 mW/cm^2	2.2 W/ cm^2
Minimum power density at edge	6.3 mW/ cm^2	42 mW/ cm^2	11.4 mW/cm^2	0.22 W/ cm^2
Antenna spacing	0.75 λ	0.75 λ	0.75 λ	0.75 λ
Power per one antenna (Number of elements)	Max. 0.95 W (3.54 billion)	Max. 6.1W (540 million)	Max. 1.7 W (1,950 million)	Max. 185 W (97 million)
Rectenna Diameter	2.0 kmϕ	3.4 kmϕ	2.45 kmϕ	1 kmϕ
Maximum Power Density	180 mW/cm^2	26 mW/cm^2	100 mW/cm2	23 mW/cm^2
Collection Efficiency	96.5 %	86 %	87 %	89 %

JAXA : Japan Aerospace Exploration Agency, NASA : National Aeronautics and Space Administration, DOE : U.S. Department Of Energy

5)Power reception



The figure shows a SPS power reception solar panel

The power beam is received by a large antenna array on the ground. This array consists of widely-spaced poles with cables stretched between them, supporting small, inexpensive antenna modules. The land beneath the receiver remains suitable for range or agriculture. The received power is conditioned, and then placed on the existing grid, ready to service customers

4)Rectenna

Rectenna is defined as rectifying antenna. A rectenna is capable of receiving microwave energy from space and converting the received microwave power back to usable low frequency or DC power. A basic rcectenna consists of an antenna, a diode rectifier and a dc bypass filter. This work presents a rectenna designed at 2.4 GHz unlicensed band. The development starts with the design of microstrip patch antenna, followed by the design of a diode rectifier and a lowpass filter (LPF). The final output of the rectenna is dc power. Figure 1(a) shows the complete schematic diagram of a generic rectanna. Once the microwave power is received by the individual antenna, it passes through the high frequency rectifying diodes. A HSMS 8202 Schottky diode is used to convert high frequency power to DC voltage. The diode has a conversion gain of 0.45. After the successful design of ACMPA, the antenna is integrated with the rectifier diode followed by a lumped element LPF. The final output is a DC voltage collected by a DC Voltmeter

The high transmitted microwave power is captured by a large array antenna. The antenna element of the array is an aperture coupled microstrip patch antenna (ACMPA). The ACMPA is the most suitable candidate due to its low profile, light weight, better power handling capability in an array, each of integration with active devices, isolation between feedlines and antenna radiators.Both patch and feedline are designed on RT/duroid 5880 with 0.656 mm thickness and dielectric constant of 2.2. Figure 1b shows the photograph of the top of the rectenna and Figure 1c shows the bottom of the rectenna (feedline, the rectifying diode and the lumped element LPF). The ACMPA produces 5% bandwidth at 2.4 GHz, 60° 3-dB beamwidth and 6 dBi gain at 2.4 GHz.

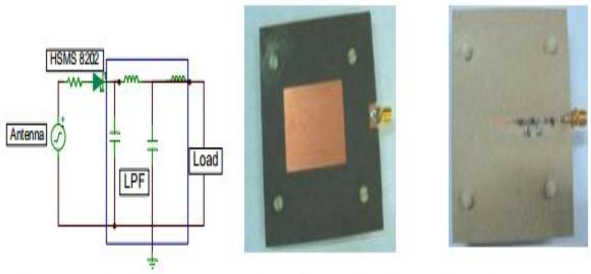


Figure 1 (a) Schematic of rectenna. Figure 1 (b) Top view of rectenna. Figure 1 (c) Bottom view of rectenna.

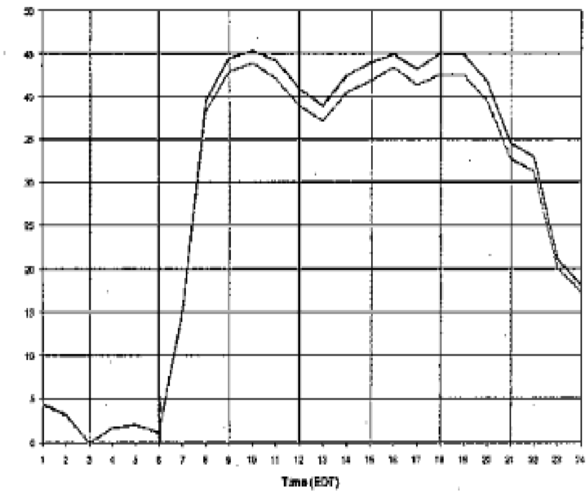
5)Power Profile

Past analyses have typically assumed an averaged (or "baseline") power pricing structure. In the real world, price varies with location, season; and time of day; and initial
markets for satellite solar electricity need to be selected to maximize revenue. The economic viability of space solar power is maximized if the power can be sold at peak
power rates, instead of baseline rate. New designs for a space sotar power system were analyzed to

provide electrical power to Earth for economically competitive
rates. The approach was to look. at innovative power architectures to more practical approaches to space solar power. A significant barrier is the initial investment
required before the first power is returned. . The market pn'ce of electricity to the distribution utility follows the demand. When the demand is low, then the lowest-cost generators are used. At high-demand periods, higher-cost "peak power" generation is required, with
spinning reserve needed to deal with instantaneous demand spikes. Figure 3 shows ,the cost of electrical power in New York City for a typical day in June 2000**.** The cost tracks demand: when demand is low, at night, only the low-cost baseline production is required, while when demand is high, higher-cost peaking-power supplies are brought on line to fill the demand. During the lowest demand period, from one to six AM, the price is under a quarter of a cent per kilowatt-hour.

6)Analysis

Since a solar power satellite beams power long distances, one possibility is to use a single power satellite to provide power to two different geographical markets that are substantially separated in longitude (and hence buy peak-rate power at different times). If the maximum allowable zenith angle at the receiver is 45 degrees, two locations served by the same geosynchronous orbit solar power satellite can be at most 87 degrees (5.3 hours) apart, as shown in figure 4. The maximum separation distance is lower if the sites are not
on the equator. This would be sufficient separation to extend the period over which the satellite is providing high-price power from roughly 12 hours per day to roughly 17 hours per day, assuming the ground infrastructure cost is not the major fraction of the power cost.
An alternate approach to providing power at the highest value is to simplify the solar power satellite by eliminating sun-tracking, and to fix the orientation to noon overfilling the peak demand.



7)Advantages and disadvantages

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

- There is no air_ in space, so the collecting surfaces could receive much more intense sunlight, unobstructed by weather. In space, transmission of solar energy is unaffected by the filtering effects of atmospheric gases. Consequently, collection in orbit is approximately 144% of the maximum attainable on Earth's surface.
- A satellite could be illuminated over 99% of the time, and be in Earth's shadow on only 75 minutes per night at the spring and fall equinoxes. Orbiting satellites can be exposed to a consistently high degree of solar radiation, generally for 24 hours per day, whereas surface panels can collect for 12 hours per day at most
- Relatively quick redirecting of power 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
- Elimination of weather concerns, since the collecting satellite would reside well outside of any atmospheric gasses, cloud cover, wind, and other weather events.
- Elimination of plant __and wild life interferences

Disadvantages

The SBSP concept also has a number of problems.

- The space environment is hostile; panels suffer about 10 times the degradation they would on Earth. System lifetimes on the order of a decade would be expected, which makes it difficult to produce enough power to be economical.
- Space debrisare a major hazard to large objects in space, and all large structures such as SBSP systems have been mentioned as a potential sources of orbital debris.
- The broadcast frequency of the microwave downlink (if used) would require isolating the SBSP systems away from other satellites. GEO space is already well used and it is considered unlikely the ITU would allow an SPS to be launched.

8)Is it Safe? Is there any concern about radiation from the beams? 9) Can you stand in the beam?

The powersat energy beam is incredibly safe and secure. Overall, the radio frequency radiation in the beam has less of an effect than an ordinary cell phone. The beams are directed only at the receiving stations and do not pass through the collectors. It is physically improbable that a human would be exposed to the path of the beam, as it would require being above the receiving stations, which are elevated 25 feet above the ground. Airplanes are able to safely cross the path of the beam without any kind of problem because the beam bounces off of the aluminum of the plane. Today, thousands of communication satellites, GPS and DirectTV transmit energy from space. Powersats utilize similiar technology

10) Launch cost

One problem for the SBSP concept is the cost of space launches and the amount of material that would need to be launched.Reusable launch systems are predicted to provide lower launch costs to low Earth orbit (LEO). Much of the material launched need not be delivered to its eventual orbit immediately, which raises the possibility that high efficiency (but slower) engines could move SPS material from LEO to GEO at an acceptable cost. Examples include ion thrusters or nuclear propulsion.

Power beaming from geostationary orbit by microwaves carries the difficulty that the required 'optical aperture' sizes are very large. For example, the 1978 NASA SPS study required a 1-km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz. These sizes can be somewhat decreased by using shorter wavelengths, although they have increased atmospheric absorption and even potential beam blockage by rain or water droplets. Because of the thinned array curse, it is not possible to make a narrower beam by combining the beams of several smaller satellites. The large size of the transmitting and receiving antennas means that the minimum practical power level for an SPS will necessarily be high; small SPS systems will be possible, but uneconomic

To give an idea of the scale of the problem, assuming a solar panel mass of 20 kg per kilowatt (without considering the mass of the supporting structure, antenna, or any significant mass reduction of any focusing mirrors) a 4 GW power station would weigh about 80,000 metric tons, all of which would, in current circumstances, be launched from the Earth. Very lightweight designs could likely achieve 1 kg/kW, meaning 4,000 metric tons for the solar panels for the same 4 GW capacity station. This would be the equivalent of between 40 and 150 heavy-lift launch vehicle(HLLV) launches to send the material to low earth orbit, where it would likely be converted into subassembly solar arrays, which then could use high-efficiency ion-engine style rockets to (slowly) reach GEO (Geostationary orbit). With an estimated serial launch cost for shuttle-based HLLVs of $500 million to $800 million, and launch costs for alternative HLLVs at $78 million, total launch costs would range between $11 billion (low cost HLLV, low weight panels) and $320 billion ('expensive' HLLV, heavier panels).For comparison, the direct cost of a new coal or nuclear power plant ranges from $3 billion to $6 billion dollars per GW (not including the full cost to the environment from CO2 emissions or storage of spent nuclear fuel, respectively); another example is the Apollo missions to the Moon cost a grand total of $24 billion (1970s' dollars), taking inflation into account, would cost $140 billion today, more expensive than the construction of the International Space Station.

Building from space

From lunar materials launched in orbit

Gerard O'Neill, noting the problem of high launch costs in the early 1970s, proposed building the SPS's in orbit with materials from the Moon Launch costs from the Moon are potentially much lower than from Earth, due to the lower gravity This 1970s proposal assumed the then-advertised future launch costing of NASA's space shuttle. This approach would require substantial up front capital investment to establish mass drivers on the Moon.

Nevertheless, on 30 April 1979, the Final Report ("Lunar Resources Utilization for Space Construction") by General Dynamics' Convair Division, under NASA contract NAS9-15560, concluded that use of lunar resources would be cheaper than Earth-based materials for a system of as few as thirty Solar Power Satellites of 10GW capacity each.

In 1980, when it became obvious NASA's launch cost estimates for the space shuttle were grossly optimistic, O'Neill et al. published another route to manufacturing using lunar materials with much lower startup costs. This 1980s SPS concept relied less on human presence in space and more on partially self-replicating systems on the lunar surface under remote control of workers stationed on Earth. The high net energy gain of this proposal derives from the Moon's much shallower gravitational well.

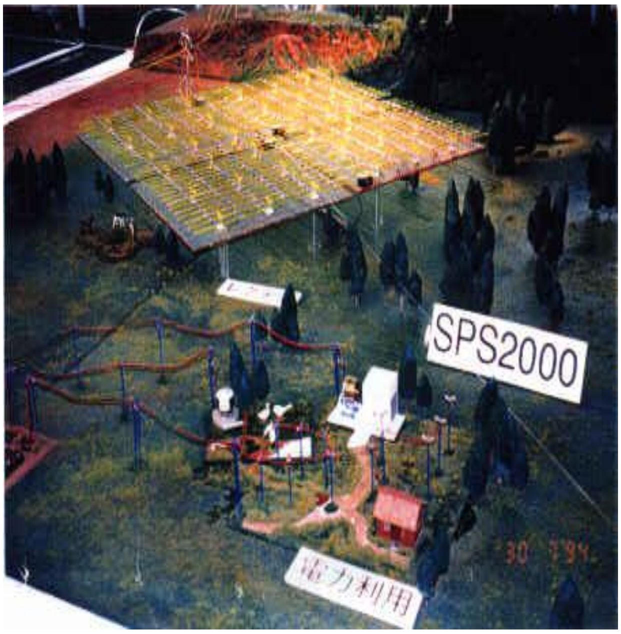
Having a relatively cheap per pound source of raw materials from space would lessen the concern for low mass designs and result in a different sort of SPS being built. The low cost per pound of lunar materials in O'Neill's vision would be supported by using lunar material to manufacture more facilities in orbit than just solar power satellites.

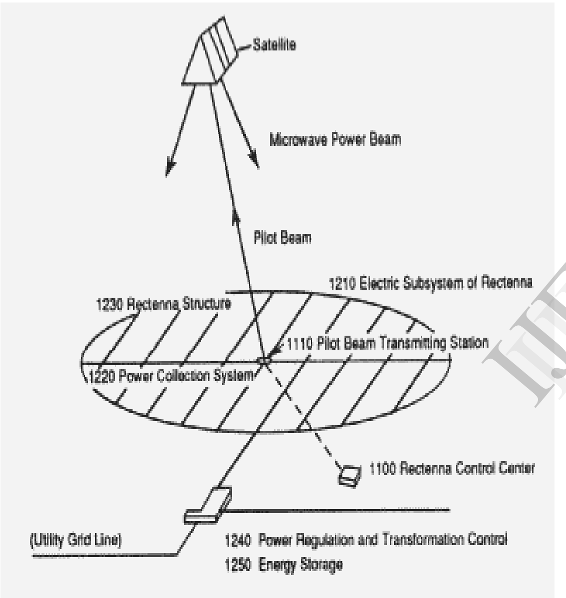
Advanced techniques for launching from the Moon may reduce the cost of building a solar power satellite from lunar materials. Some proposed techniques include the lunar mass driver and thelunar space elevator, first described by Jerome Pearson. It would require establishing silicon mining and solar cell manufacturing facilities on the Moon

DEMONSTRATION PROJECTS

SPS 2000

The prize for most ambitious wireless power transmission demonstration proposed since Tesla's Long Island tower experiment before World War I goes to the Japanese SPS 2000 project . The purpose is to demonstrate a functioning solar power satellite system including the wireless transmission link and develop the ground infrastructure in several locations to provide the basis for a space solar power market. The design calls for a gravity stabilized satellite capable of delivering 10 MW of electricity from a spherical 1100 km east-to-west equatorial orbit. The phased array antenna will be capable of steering ±30° along the orbital path (E-W) and ±16.7° perpendicular to the orbital path (N-S). This will limit the possible rectenna sites to close to the equator. In addition to being limited to an equatorial band, the receiving sites must be at least 1200 km apart to maximize the length of time for power transmission to each individual site. Because power can only be received intermittently at any ground site (about 4 minutes out of the 108 minute orbit for a beam scan angle of 30°) energy storage is an important component of any ground site. Further limitations are placed on the power available to any site by the diurnal rotation of the Earth, since the satellite is incapable of delivering energy while in eclipse over a site during the night. With an average daily coverage of less than 30 minutes per site, 4 to 4.5 MWh of energy could be available to a site from the SPS 2000 satellite.
The satellite is in the form of a long prism. The base of the satellite is always earth facing and mounts the transmitting array. The "roof" faces of the satellite are paneled with photovoltaic cells. The phased array transmitting array is based on a dense array of low energy solid state antenna elements (the design assumes an efficiency of 60%, which has not yet been achieved, the MILAX/METS antenna solid state elements achieved 42% efficiency.To assure target acquisition and tracking, a retrodirective beam at 245 MHz transmitted from each rectenna site is used. The satellite would be launched in sections and assembled on orbit. Initial designs studies have been completed and a scale model mock-up of the satellite has been made. Several potential receiving sites, from Pacific Islands to South American Andes locations have been visited by the SPS 2000 team, with a generally enthusiastic reception





A rectenna of the SPS 2000 system.

Functional model of SPS 2000 rectenna system

How long do they last?

The lifecycle of a powersat is approximately 30 years. Over that time period, the modules lose about 18-20% of their total generation capacity. However, because the powersat is made up of smaller modular solar panels, when certain modules begin to lose efficiency, it is easy to send new ones up to replace them, without a significant cost investment.

Is this technology feasible? What makes it ready for development today?

The advances in technology have made materials lighter and cheaper, making it economically viable to utilize powersats for baseload generation. A key enabling technology has been the development of thin-film solar cells which dramatically reduce the weight of the satellite. We also have a patented technology in the works to decrease launch cost. As well, the drive for carbon free renewable baseload power has now made powersats a viable economic alternative.

Is the powersat's transmission ability affected at all by Earth's shadow?

Because the PowerSat orbits much higher than Low Earth Orbital satellites, PowerSat is only affected by the earth's shadow for very brief periods during the fall and spring equinox.

11)CONCLUSION

The concept of a space solar .power system that provides power to terrestrial markets by microwave beamhas some advantages as an- approach to large-scale soelectrical power generation, but has many technical and political barriers before it can become economically
feasible. A new conceptual approach to the design of the satellite solar power station is outlined, with the advantages of a lower initiallcost and a better fit of the power generation profile **to** the user requirements.

Recent work at Off Earth WPT addressed system studies for ground-to-air wireless power supply systems, including a scaled airship demonstration. This demonstration would use a 12 meter phased array antenna, beaming at 300 meter altitude to a 3m diameter rectenna to provide adequate power to drive the airship at 30 mph. The airship would be some 30 m long and the system would be visible and useful for public relations. Estimated cost for the demonstration would be on the order of $5 million. A full-scale operational system at an altitude of 20 km would cost $40 - 50 million.

NASA has developed a series of flight demonstration model systems leading to development of a functioning solar power satellite. They progress in the level of satellite power from Model System Category (MSC) 1 at 100 kilowatts to MSC 4 at 1 gigawatt, which is essentially a full-scale system. Intermediate steps include MSC 1.5 at 1 megawatt and MSC 3 at 10 megawatts. MSC 2 is a lunar rover. Planning is currently underway to define appropriate technology demonstration experiments for MSC 1. It is currently scheduled to carry both laser and microwave power beaming experiments, space-to-space as well as space-to-ground.

NASDA

The National Space development Agency of Japan (NASDA) invited two teams of Japanese companies to submit proposals for a space solar power demonstration satellite [65]. The satellite would be capable of generating between 10 kilowatts and 1 megawatt of power. The program is aiming for a launch on the H-2A in 2005 to 2007. One of the teams developing design proposals consists of Mitsubishi Heavy Industries Ltd. and NEC Toshiba Space Systems Ltd.

12)REFERENCES

http://www.powersat.com/faq.html

http://esamultimedia.esa.int/docs/gsp/completed/EADS_Astrium-executive_summary.pdf

http://en.wikipedia.org/wiki/Space-based_solar_power

http://www.space.com/tech-robotstechnology/solar_power_sats_011017-1.html

http://www.thespacereview.com/article/214/1

http://www.spacefuture.com/archive/conceptual_study_of_a_solar_power_satellite_sps_2000.shtml

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"

P. E. Glaser, "Power from the Sun: Its Future,"

Bibliography

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