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Space Solar Power: Star Player on the Bench

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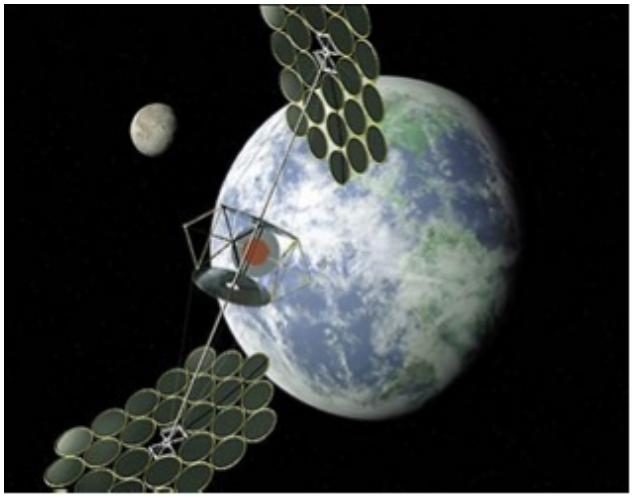
This is a guest post by Darel Preble, Chair of the Space Solar Power Workshop.

Our economy and wealth is constrained by the price of energy and our efficiency in using that energy to create value. Peaking fossil fuel production and climate change concerns have resulted in growing interest and subsidy for many forms of alternate energy. The EIA's Annual Energy Outlook notes that no alternate energy is expected to take up the slack expected as fossil fuel production swoons over the decades ahead - the U.S. is doing NOTHING on the massive energy scale required. Among the contenders, the cleanest, most promising, most poorly understood, most daunting and most ignored is Space Solar Power. Why?



Integrated Symmetric Concentrator (- a NASA design circa 2001)

SSP is a simple idea. As the picture shows, huge amounts of sunlight would be gathered in high, GeoSynchronous Orbit; reflected by mirrors to photovoltaic sheets; converted to electric power; then beamed from a large transmitter to even larger antennas (rectennas - rectifying antennas - is the proper term) on Earth. Each rectenna is actually part of the grid of a contracting electric utility which would buy, transmit and distribute the power to their customers. Numerous competing technologies, many quite mature, offer robustness to SSP designs. There are numerous advantages to putting these panels in space, beginning with the fact that panels would collect 9.6 times as much energy per day at GSO than on earth, on average.

Since PG&E contracted with Solaren last week for the First Space Solar Power Delivery in 2016, controversy about this unique capability has taken on new life. Half a dozen other companies are actively courting SSP contracts, such as Heliosat, Space Energy, Space Island Group, Powersat

and the Welsom Space Consortium. The reactions to Solaren's contract are frequently dubious. Clearly Solaren and other SSP hopefuls assume their designs will win the Billions in contracts necessary to turn SSP into a winner. The joker in this big poker game is that you don't know the depth of money that may be behind a given company. And this game has just begun.

Any company starting to build an SSP System (SSPS) will incur **significant** losses for years before turning a profit. Google did that as people wondered about their business plan for years - they have established quite a fine business. Still, there is nothing else quite on the scale of the SSP challenge and opportunity - capturing the energy of the sun. An SSPS with reasonable assumptions about shading, collection and beaming efficiency, etc., could collect 3000 Terawatts at GSO and inject 1500 Terawatts to contracting power grids owned by participating utilities, such as PG&E, virtually anywhere on Earth.

As I have participated in several volunteer SSP studies including the NSSO Business Case Analysis and the Space Solar Power Workshop, I encourage you to examine this energy option more closely. Modern SSPS designs have many advantages. Here are the top ten:

1. SSP is "**baseload**" power available 98% of the year from GeoSynchronous Orbit. Energy storage, the Achilles heel of wind power and ground solar is not really needed, since the outages occur at local midnight during the equinoxes - minimum power conditions. A photovoltaic (PV) panel at GSO would collect 9.6 times as much power per day as the same panel at an average U.S. ground location. (See this PDF). Considering storage and conversion losses, a ground PV or wind installation would need to collect another factor of about 9.6 to store power for just tomorrow – assuming we only need to cover one cloudy day – not two or more.


Terrestrial Solar Farm


Illustration of SBSP Rectenna

2. SPS requires no fuel – zero pollution – and has no operations personnel. It is an antenna with green farms or ranches beneath the rectenna. SSP is the cleanest source of virtually unlimited baseload energy. Ground solar takes 100 times as much land usage to provide the same power as baseload SSP, similar to baseload power plants. Eventually Sunsat Corp could even provide much of its own fuel, through electromagnetic launch which even now has been developed as a first stage.

3. SSP takes advantage of our historic investment in aerospace and other technical expertise to increase STEM jobs. SSP technology is near-term-available with multiple attractive approaches and would create millions of inspiring and important jobs. SSP would revitalize America by taking advantage of a multitude of space-development-related technologies that are vitally relevant to our current problems, including

space transportation
telerobotics
photovoltaics
control systems
communications
aerospace engineering

wireless power transfer
environmental science including “space weather” knowledge

4. Unlike oil, gas, ethanol, bio-fuel, and coal, SSP emits no CO_2 - it is a rectenna. Rising CO_2 drives climate change, compounding our massive environmental problems with slowly declining global nutrition, since most plants, such as rice and wheat, are critically dependent on CO_2 levels, and each plant, with its pests, responds differently. Weather changes from drought to hurricanes, we are still struggling to properly model.

5. Today's average coal-fired power plant withdraws 25,000 gallons of river water to provide an average household with 1,000 kilowatt-hours a month; 31,000 gallons if nuclear-fired. Waste heat is one of many problems with such baseload power plants. In drought conditions--a growing problem from California to the Carolinas--warming water from power plant exhaust has reduced power or shut down some power plants. Output water must be carefully monitored, especially in summer, to avoid fish kills from dangerously higher water temperatures. SSP cuts waste heat by about 80% and water use by 100%.

6. SSP would reduce competition for many other scarce resources besides water. Advanced thin-film space photovoltaic material now can generate 16.8 Kw/kg – using just one hundredth as much material as ground-type PV panels.

7. Unlike bio-ethanol or bio-diesel, SSP does not compete for increasingly valuable natural-gas-derived fertilizer. Corn can continue to be a major export instead of a fuel to burn, while raising the prices of foods from milk and eggs to cheese, hamburgers and Jack Daniels.

8. Liquid fuels can be made from SSP power, such as anhydrous ammonia which can be moved through the same pipelines as gasoline. It is 111 octane. We have been making liquid ammonia for 50 years for farming. It fueled the X-15 rocket plane! It can use existing piping, unlike ethanol. Synthetic fuels, electric hybrid vehicles and the electrification of our transportation system are all natural extensions of SSP’s beneficial impact.

9. Many other space businesses and jobs would be enabled by SSP’s low launch costs - from space mining to new telescopes which are now being considered for the Moon’s far side. Just as the railroad helped settle and open the western US, SSP can even provide a ready market for products made on the Moon or in space, enabling prospects such as lunar settlement, which this nation and others are committed to build and develop. Yet such settlements will not long endure if they cannot provide useful trade products, just more flags and footprints. SSP should have NO financial entanglements with these tangential developments, important as some may consider them, other than possibly being a customer on a level playing field with competing products from Earth. (It is twenty times more energy efficient to ship a product to GSO from the Moon than from Earth, for example.)

10. Asteroid protection is becoming more vital to not only protect Earth, but also a large assortment of critical space satellite resources. These are already subject to a growing panoply of threats from both hostile and natural objects. The advent of SSP increases the relevance and urgency of this issue, protecting us from a growing threat, as Russell Schweickart’s B612 Foundation have detailed.

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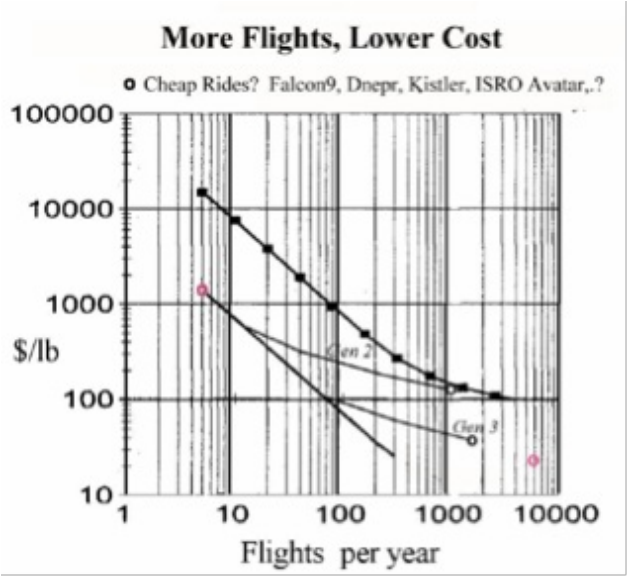
Closing the SSP business case depends on lowering the cost to orbit by an order of magnitude below the lowest costs currently available. The only market with the massive flight volume

necessary to create such a market is however, SSP. This chicken and egg situation could best be solved by chartering a Sunsat Corp with the deep pockets necessary to bridge this chasm. Do not be distracted by claims that SSP requires "unobtainium", such as space elevators, which are not on today's horizon of feasibility. Advanced Reusable Launch Vehicles are fully capable of achieving such lower launch cost with SSP's massive market. These could be obtained from many eager providers.

The time frame we have to address our energy and environment situation is rapidly dwindling. Historically, faced with such massive and immediate challenges in the past, the U.S. has chartered a public/private company to assume the job - from the Transcontinental Railroad and Telegraph (1862- Civil War) to Comsat (1962 - Cold War). There are simply too many engineering, financial, regulatory and managerial risks for existing companies to overcome, though many have tried since this new century began. Just as Comsat was chartered by Congress to build *communications* satellites, Congress should charter a company to build *power* satellites. The SSPW calls this new public/private company Sunsat Corp. Sample draft legislation, modeled after Comsat Corp, is on the SSPW website. You could buy stock in Sunsat. AT&T owned 29% of Comsat stock and assumed control. It would ultimately be a private company like any other international corporation, though regulated as a utility and also space law.

Some key principles in cutting the cost to build an SSP system are:

1. Cut the cost of launch to orbit. A major key to this is vehicle reusability - Spacex chief Elon Musk is aiming to build the first reusable launch vehicle, the Falcon 9, including a flyback stage. It would launch in under 60 minutes from the moment they leave their hangers. The path to lower costs is through higher volume – not bigger rockets:



2. Cut the weight of what you need to put in orbit, such as by using higher performance PV. As mentioned above, advanced thin-film space photovoltaic material now can generate 16.8 Kw/kg. That same film can be used on earth although it would be encased in a heavy protective panel to keep hail, sand, rain, pigeon "calling cards", etc., out

3. Another way cut weight is to use control moment gyroscopes (CMG)s as the ISS uses for station keeping and ultimately to fly these "solar sails" like Clipper ships in the solar wind. Astro Aerospace Corp. built a 58 foot long by 10 foot wide solar sail that was attached to the north side of NOAA's GOES-8 weather satellite, and used to stabilize it against solar radiation pressure,

saving station keeping fuel.

4.Don't use astronauts to bolt the SSP together – use telerobots –they are 1000 times cheaper than using people in space.

Rectennas would actually be owned by local utilities. They best serve and connect to the gigawatts of customer load envisioned. Microwave wireless power transfer (WPT) is dictated by the equations to be naturally large scale. The efficiency of power transfer is determined by the diameters of the transmitting antenna and the rectenna - bigger is better. A rectenna will therefore be kilometers across, built in consultation with Sunsat's marketing and a rectenna owner/operators group, SPARCO. Sunsat Corp would be a multinational super-utility, similar to existing multinationals in other industries, such as Intelsat. Incidentally, the safety of millions of microwave devices has been investigated by billions of people - as we use our cell phones against our ears, for example, and has been found to be quite safe. You could visit the giant Arecibo radio antenna in Puerto Rico and see a sample of what a rectenna might resemble. A lush jungle grows under Arecibo.

A typical draft ten year budget for this new public/private company Sunsat Corp, which the Space Solar Power Workshop has been constructing, illustrates how such a company could transition from the current dynamic market conditions to profitable SSPS business conditions, providing the energy keystone for a favorable future global energy, environment and economy.

Cheers, Darel Preble
Chair, Space Solar Power Workshop
Psalms 19:4-5