

Space-Based Solar Power

ECE 4803: Devices for Renewable Energy

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Introduction

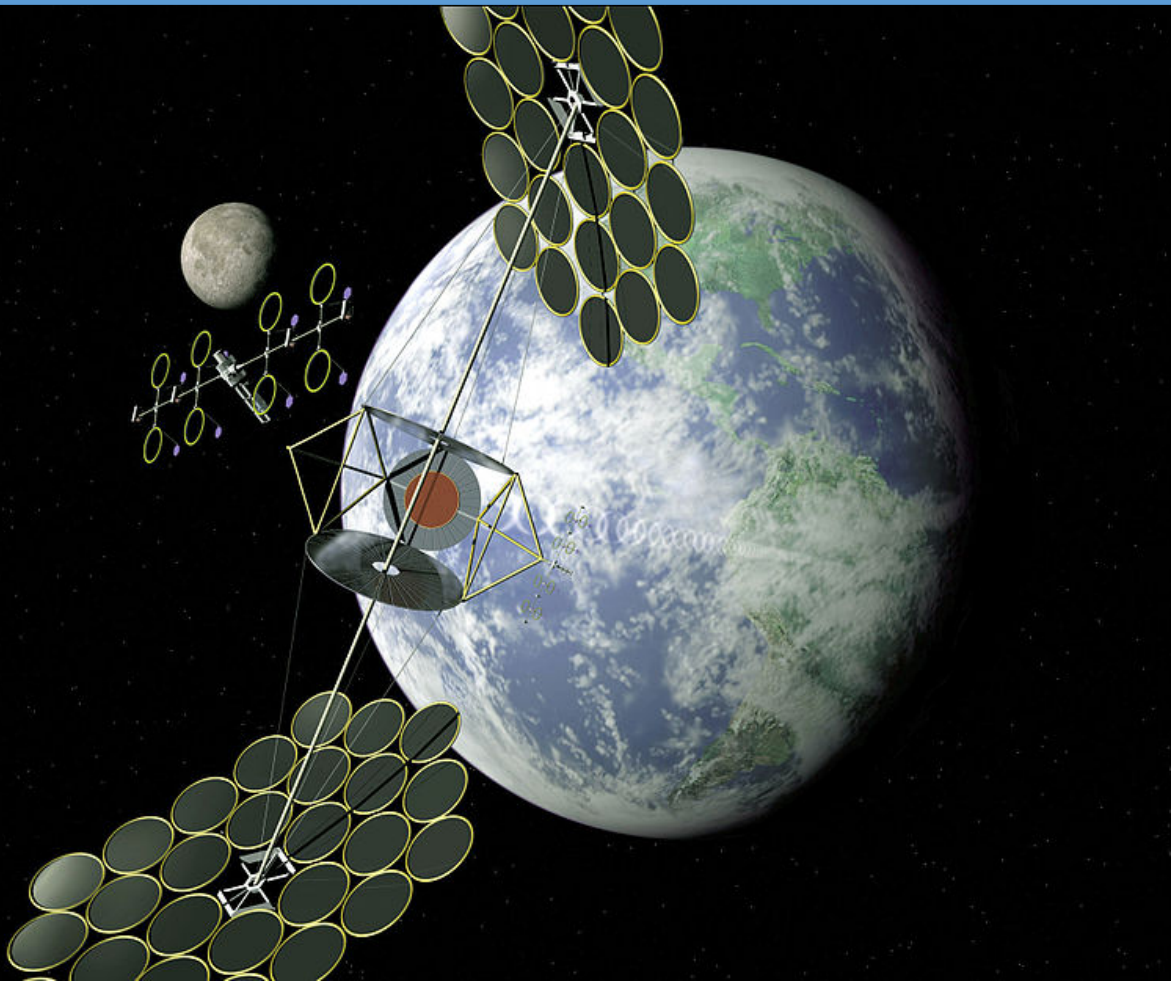
How do we Collect Power?

- Photovoltaic
- Solar Dynamic

How do we Transmit Power?

- Microwave Power Transmission
- Laser Power Transmission

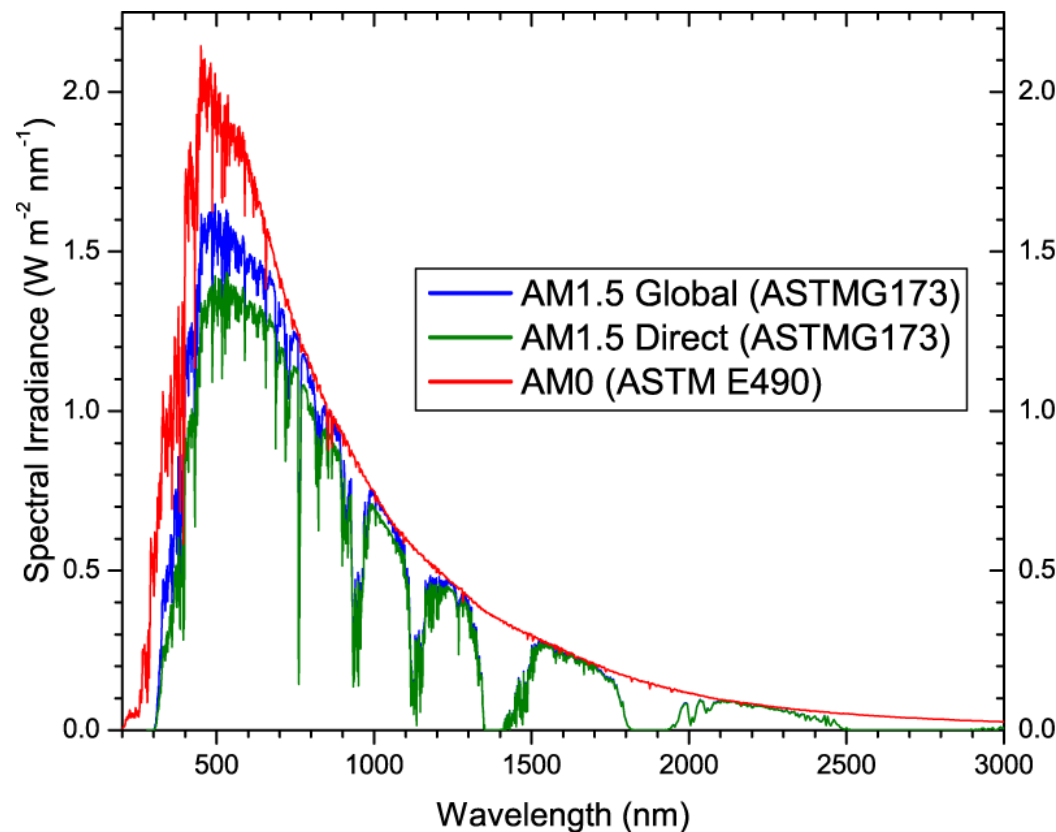
Concentrated Solar Cell



- Consists of solar concentrating mirrors focused on high efficiency photovoltaic cells
- Photovoltaic cells may be composed of multi-junction cells or single cells with larger area depending on weight.
- Concentrating mirrors may be made of thin films such as Mylar spanning ~3 km ^[3].

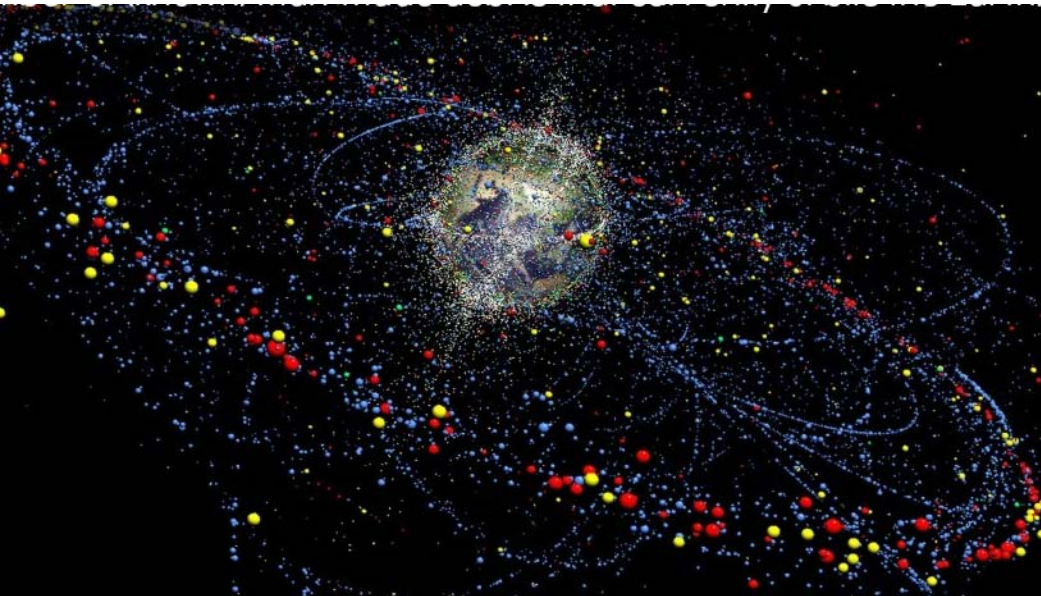
Concentrated Solar Cell - Advantages

- Traditional solar power density is $\sim 1000\text{W/m}^2$ versus 1366W/m^2
- Geosynchronous orbit provides near continuous power as opposed to earthbound PV
- Power transmitted nearly anywhere, allowing for local load balancing, unlike traditional renewable energy sources
- No hazardous waste and low operating costs



<http://www.pveducation.org/sites/default/files/PVCDROM/Appendices/Images/Spectra.png>

Concentrated Solar Cell - Disadvantages



- High cost per watt using current launch systems, ~\$40/watt^[4]
- Requires wireless power transmission
- High difficulty of installation and maintenance
- May experience orbital drag due to collision with small micro-meteorites
- If a large collision occurs, large amounts of debris can result in Kessler syndrome

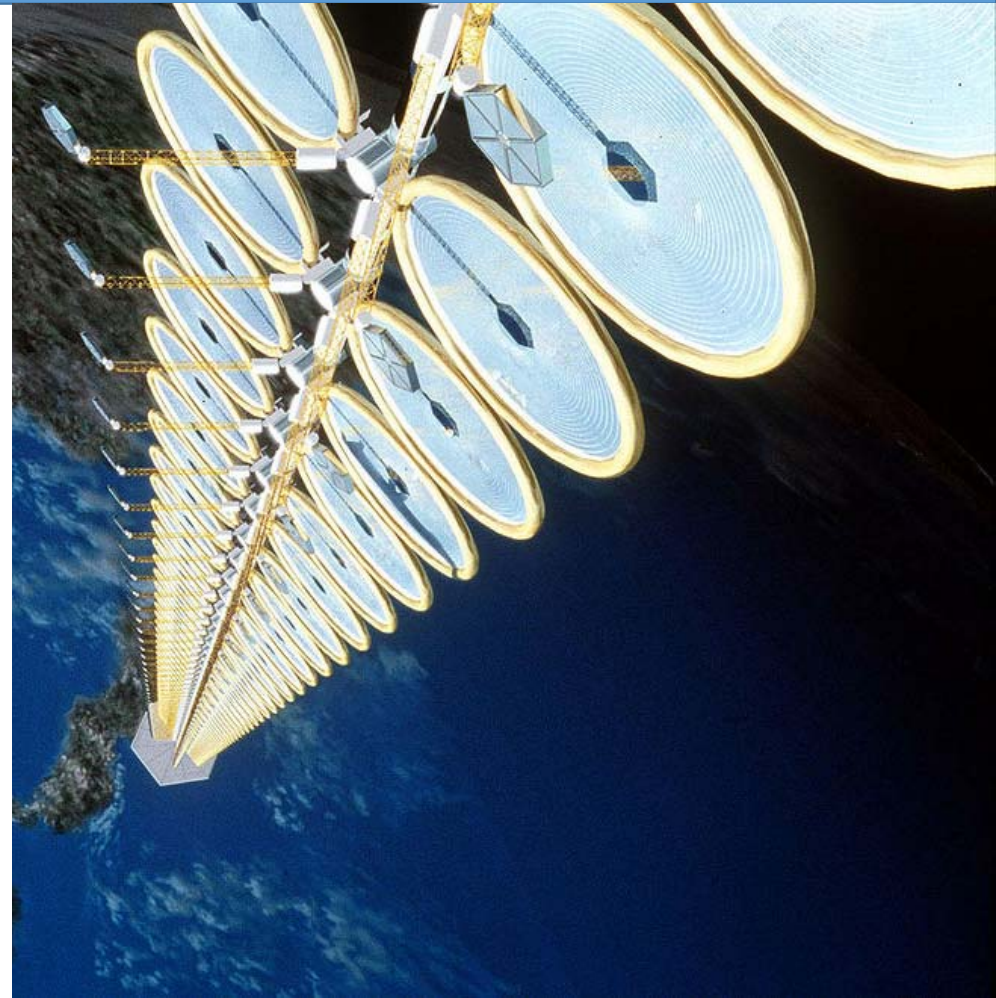
Solar Dynamic

Advantages

- Solar collectors would use mirrors to focus light to collect heat energy and transform into power through similar methods as ground based concentrated solar power (CSP)
- Area is less of a concern then ground based CSP and a larger power can be realized due to non conductive or convective loss
- Lower mass per watt than concentrated solar photovoltaic, which in turn means a lower launch cost as well as a lower cost per watt.

Disadvantages

- Similar disadvantages as concentrated solar photovoltaic



<http://www.nasa.gov/centers/marshall/home/news/news/photos/1999/photos99-096.htm>

Power Transmission - Microwave

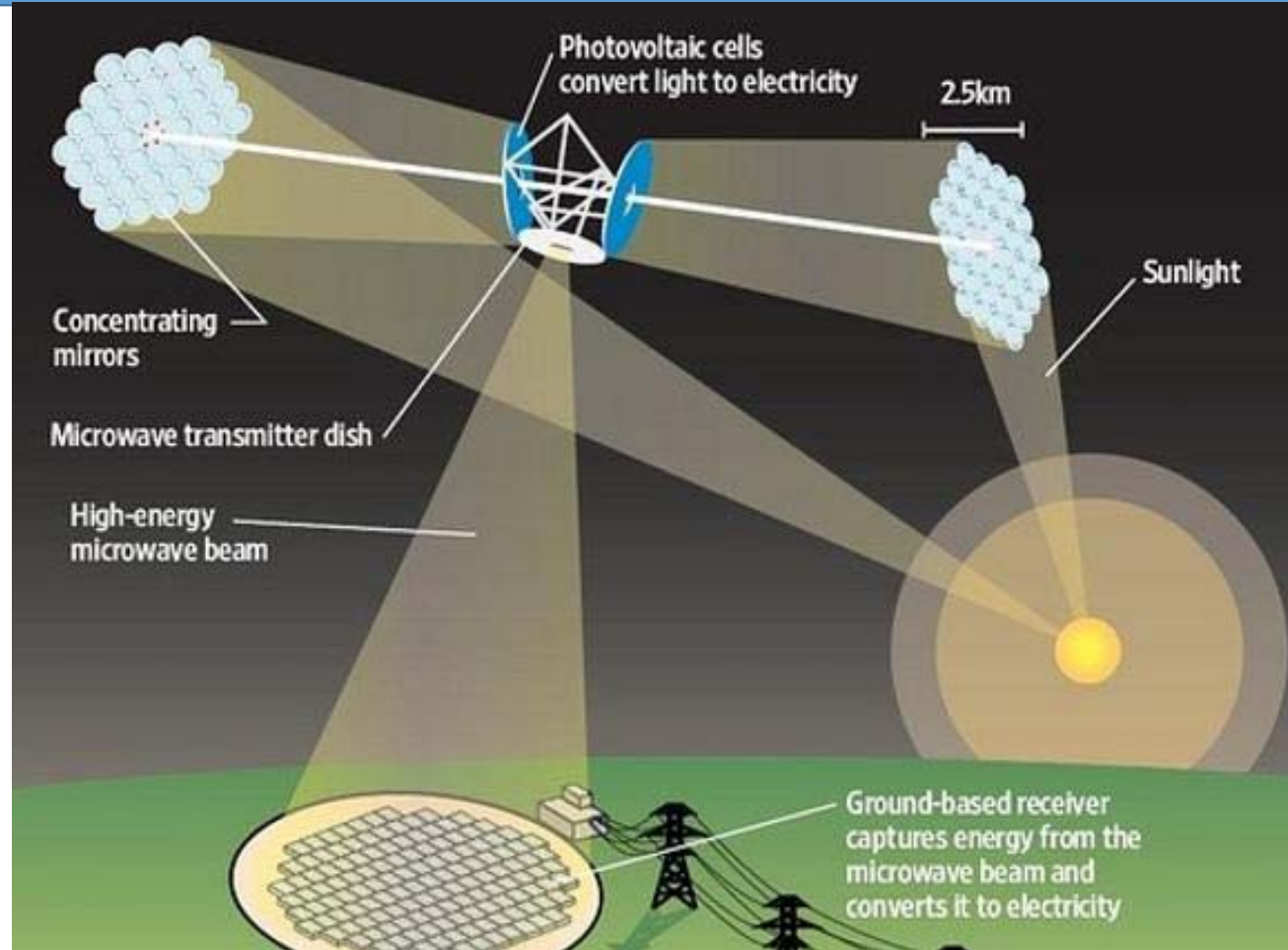
How Efficient?

~80% capture within a 4.6km diameter^[1]

Dangerous?

A power density of 1 mW/cm² distributed across a 10 km diameter area corresponds to 750 megawatts total power level^[2].

No longer term damage found in research animals as these exposure levels^[3].



<http://eandt.theiet.org/magazine/2014/10/space-based-solar-power.cfm>

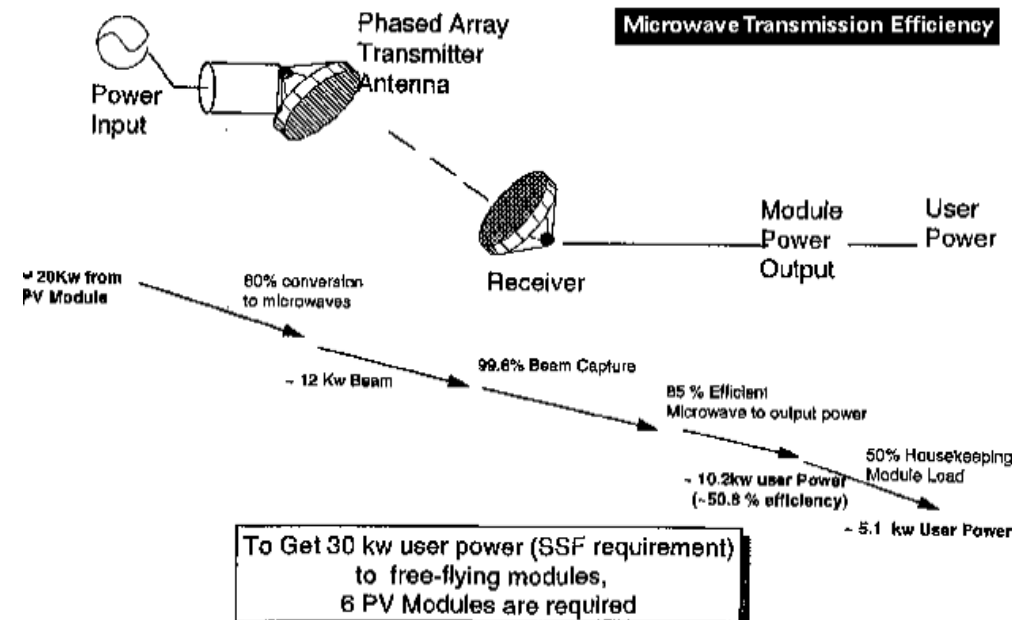
Power Transmission - Microwave (cont.)

Advantages

- High efficiency
- Continuous Power

Disadvantages

- Large and Heavy, 80,000 tons ^[3]
- Requires multiple launches per satellite



Power Transmission - Laser

How Efficient?

- ~50% capture using photovoltaic cells and diode pumped alkali lasers ^[4]

Advantages?

- Smaller Receiver and Transmitter due to larger beam density, with a beam size on the order of 2 meters ^[3].
- \$500 Million per 1-10 Megawatt

Disadvantages?

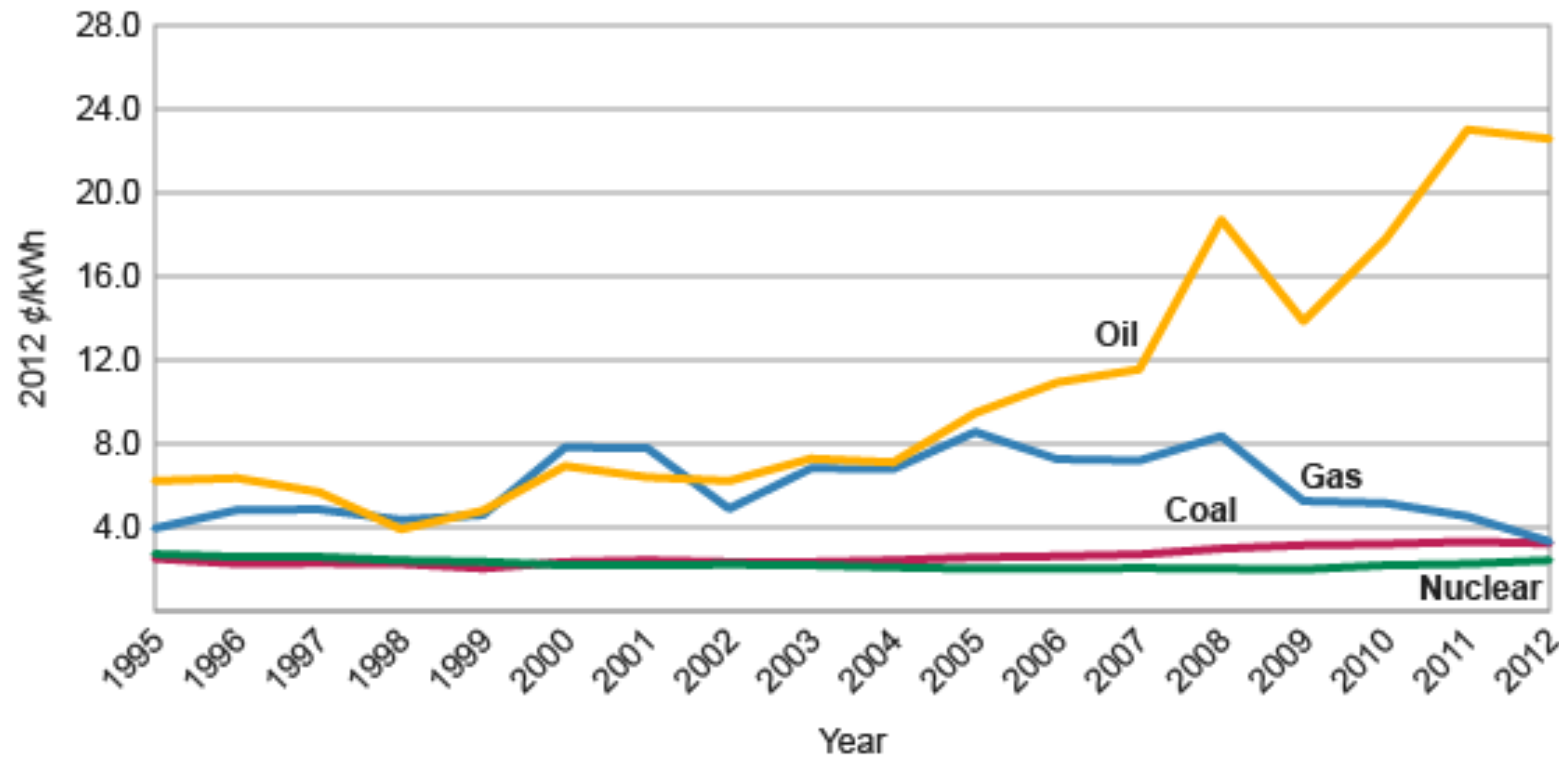
- Atmospheric beam energy loss due to clouds
- Militarization of space issues



[http:// www.popsci.com/technology/article/2011-06/satellites-could-gather-energy-sun-and-beam-it-down-earth](http://www.popsci.com/technology/article/2011-06/satellites-could-gather-energy-sun-and-beam-it-down-earth)

Conclusion/Questions

U.S. Electricity Production Costs, 1995-2012



Production costs = operation & maintenance + fuel. (excludes indirect costs and capital)

Source: Ventyx Velocity Suite / NEI, May 2013

http://www.world-nuclear.org/uploadedImages/org/info/Economic_Aspects/us-electricity-production-costs-95-12.png

References

- [1] Brown., W. C. (September 1984). ["The History of Power Transmission by Radio Waves"](#). [IEEE Transactions on Microwave Theory and Techniques](#) 32 (Volume: 32, Issue: 9 On page(s): 1230- 1242 + ISSN: 0018-9480): 1230. [Bibcode:1984ITMTT..32.1230B.doi:10.1109/TMTT.1984.1132833](#).

- [2] Hanley., G.M.. . ["Satellite Concept Power Systems \(SPS\) Definition Study"](#) (PDF).NASA CR 3317, Sept 1980.

- [3] Space-Based Solar Power. (n.d.). Retrieved April 10, 2015, from <http://energy.gov/articles/space-based-solar-power>

- [4] Do the Math. (n.d.). Retrieved April 10, 2015, from <http://physics.ucsd.edu/do-the-math/2012/03/space-based-solar-power>