Centre for Air Power Studies (CAPS)
Forum for National Security Studies (FNSS)

WIRELESS POWER TRANSMISSION FROM SPACE

Gp Capt PA Patil
Research Fellow, CAPS

China is considering the concept of placing solar panels spanning an area equivalent to a small town aboard the largest-ever spacecraft in the geosynchronous orbit to meet its energy demands on ground. The concept aims towards continued accumulation of solar energy, converting it into microwaves and then beaming it towards the earth where this energy is collected and reconverted to electrical energy for use. The Chinese Academy of Sciences (CAS) and Chinese Academy of Engineering (CAE) have proposed that that China should build an experimental space solar power station by year 2030, and construct a commercially viable space power station by year 2050.

The idea of wireless power transmission was floated more than a century ago by Nikola Tesla in the 1890's when he published his research titled "The transmission of electrical energy without wires".[1] This was followed up by NASA scientist Peter Glaser who in the late 1960s proposed the concept of a solar power satellite as a means of harnessing solar energy for transmission to earth and published his ideas in the journal *Science* in November 1968.[2] In the last few years, many scientists and research institutes across the globe are contemplating the feasibility of such a proposal and mulling over the recent technological developments to make this concept a reality.

Basic Principle

The basic principle of a space based solar system perceived for wireless transmission of electricity is depicted in figure 1. Wireless transmission of power from space would need a solar panel spanning an area of few square kilometres. The solar panel would convert the

heat energy to Direct Current (DC). This current would drive a microwave device to generate a microwave beam which would be beamed towards earth using an antenna. This beam would be collected by a terrestrial based rectifying antenna (also called rectenna) which directly converts the microwave energy to DC. Rectennas are highly efficient at converting microwave energy to electricity and efficiencies of over 85% have been observed in laboratory conditions.[3] If the technological advances would permit such efficiency in field conditions as well, there is a strong possibility to access 90% of the energy harvested by the satellite on the ground.[4]

Figure 1: Basic Principle for wireless power transmission from space[5]

Present state of Research and Development

In addition to the Chinese proposal, space based solar power has already attracted the R&D community of US, Japan, India and Russia amongst others. United States 'NASA' and Japan Aerospace Exploration Agency (JAXA) have carried out a number of studies on the concept of a space based solar power station. JAXA is targeting to establish a 1 GW system, equivalent to a medium-sized atomic power plant that would produce electricity at eight yen (nine cents) per kilowatt-hour, six times cheaper than its current cost in Japan.[6] Japan is presently working towards placing and evaluating a few kilowatt level microwave power station in LEO. This would be followed with a launch of large flexible photovoltaic structure with 10 megawatt power capacity, and thereafter, it plans a 250 megawatt prototype.[7] From here, it has proposed the requirement of an international consortium involving experts from around the globe to construct a 1 GW commercial SPS throughout the 2030s.

Benefits of wireless power transmission from space

Today the world is aware that fossil fuel stocks are limited and would not sustain for ever to meet the escalating global energy demands. Also, use of fossil fuels has been a cause of concern due to the pollution it creates and contributes to the phenomenon cause of global warming. While energy from alternate sources of sun, wind and sea are being tried out, the capacity and efficiency of such systems is limited. Nuclear energy being another preferred choice of generating electricity would depend on the availability of nuclear fuel and involves safety issues. While any new sources of electricity are welcome, if solar power could be exploited in an efficient manner to generate electricity, it would become the most important source of clean energy in the 21st Century. As and when such a system is conceived, it would provide for an everlasting source for electricity and help solve the energy crisis of world. Further, basing solar panels in space would be many time more efficient as the solar panels would capture the sun rays round the clock and would not be

affected by weather conditions. As per the statement of Wang Xiji, an academician of the Chinese Academy of Sciences (CAS) and a member of the International Academy of Astronautics, *"Construction of a space solar power station will be a milestone for human utilization of space resources. And it will promote technological progress in the fields of energy, electricity, materials and aerospace"*.[8]

Challenges

Generation and wireless transmission from space based system has its own technological limitations. While the developmental cost is high, the efficacy of such a proposal can be worked out in incremental stages and thus is a long drawn process over the next century. The enormous infrastructural requirement in space would demand higher payload capability of launch vehicles. The solar panels would require thin and ultra light solar panels that would unfold themselves post launch. Another cause of concern is that as and when such a system is established, it would be highly vulnerable to attacks by space weapons and can be compromised by cyber means as well. One more challenge would be to safeguard the power station from space debris and orbital collisions.

Solar Power and India

India presently has a power generation capacity in the range of 259 GW. As per a survey report, India would need an additional power 455 GW of power by the year 2034.[9] Going by the present trends of power growth at 20 MW annually, the supply and demand ratios are bound to increase and lead to energy crisis. The approximate breakdown of power sources includes fossil fuel 70%, hydro 12%, Nuclear 2% and renewable energy at 16%.[10] In renewable energy, of the 31GW, solar energy accounts for only 2.6 GW of total power generating capacity, and the plan was to take it up to 20 GW by year 2022 under the Jawaharlal Nehru National Solar Mission.[11] However, recently the government has proposed fivefold multiplication in the set target and is considering new schemes for

installing solar power plants with 100 GW capacities in the country by 2022.[12] A 100 GW of solar power capacity over five years is the equivalent of about 30 GW of coal-thermal capacity, as solar power generation is only possible during day time and their also the efficiency being affected by prevailing weather conditions.[13]

The R&D community in India and Indian Space Research Organisation have already carried out preliminary concept studies on Space based Solar Power systems. India and the US-based National Space Society (NSS) have already announced the launch of a space-based solar power initiative that plans to forge an international organisation to develop space solar power. During an NSS Press Conference, former President and an eminent scientist of India, Dr. A.P.J. Kalam, stated that in the year 2050, even after utilising all available energy resources, the world would be short of energy by 66%, and the only solution visualised for both developed and developing countries would be to harness solar power from space. [14]

As the entire countries world over would face acute power crisis, it is now important that all leading nations join hand together and contribute towards generation of renewable energy devoting the necessary technological and financial resources. Today, as the individual nations are looking at a timeline of 30 to 40 years for establishing a solar power station in space, this timeline could be reduced by another 10 to 15 years if these nations congregate their resources for harvesting energy from space.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

[1] Nikola Tesla, "The transmission of electrical energy without wires", *Electrical World and Engineer*, March 5, 1904
[2] "Resource for Energy Research: The Peter E. Glaser Papers, 1944-2000", *MIT Institute Archives & Special Collections*, accessed at https://libraries.mit.edu/archives/exhibits/glaser/ on April 27, 2015
[3] "Space Based Solar Power, solar power satellite (SPS) concept", accessed at http://www.altenergy.org/new_energy/space-solar-power.html on April 27, 2015
[4] ibid
[5] Image accessed at http://billionyearplan.blogspot.in/2010/08/how-far-weve-come-space-based-solar.html
[6] Karyn Poupee, "Japan eyes solar station in space as new energy source", accessed at http://phys.org/news176879161.html on April 27, 2015
[7] ibid
[8] "Chinese scientists mull power station in space", accessed at http://www.spacedaily.com/reports/Chinese_scientists_mull_power_station_in_space_999.html on April 24, 2015
[9] "India needs additional 455 GW capacity needed to meet power demand by 2034", accessed at http://www.dnaindia.com/money/report-india-needs-additional-455-gw-capacity-needed-to-meet-power-demand-by-2034-2056036 on April 28, 2015
[10] http://www.cea.nic.in/reports/monthly/inst_capacity/jan15.pdf
[11] JNNSM, accessed at http://www.seci.gov.in/content/innerinitiative/jnnsm.php on April 28, 2015
[12] "Schemes for Installing Large Solar Power Plants", Ministry of New and Renewable Energy, accessed at http://pib.nic.in/newsite/pmreleases.aspx?mincode=28 on April 28, 2015
[13] "Achieving 100 GW power by 2019 is a big challenge for Modi" , accessed at http://www.rediff.com/money/column/column-why-modis-ambitious-100-gw-power-capacity-is-unachievable/20141103.htm on April 28, 2015
[14] "NSS Press Conference Announcement on Kalam-NSS Energy Initiative", November 2, 2010, accessed at https://www.facebook.com/notes/national-space-society/the-kalam-nss-international-preliminary-feasibility-study-on-space-based-solar-p/165924656777804 on April 28, 2010
