Sourcing energy from space

Jaymin Gajjar & Saptak Ghosh, March 7, 2017,

Renewable energy sources have been championed as the future of energy in the past decade owing to serious threats posed to the planet's sustenance by climate change and contributing factors such as fossil fuels. In efforts to make the transition from conventional fossil fuels to renewable energy, innovative applications such as tandem solar cells, two-bladed wind turbines, hydrogen-based fuel cells etc are being developed. Space-based solar power (SBSP) is another such application that has been gaining traction now.

SBSP uses solar panels deployed in space to collect energy from sunlight, which is then transmitted wirelessly to Earth. This technology has the potential to solve our energy and greenhouse gas emission problems. The reason is the quantum of solar energy available in space is billion times more than that received on Earth.

Earth-based solar panels convert sunlight into energy during daytime. However, they cannot do so at night or under overcast conditions. Also, much of the Sun's radiation is reflected back into space by Earth's atmosphere. If the same solar panels are stationed in space, they will receive suitable solar radiation everyday.

Estimates show that one GW of Photovoltaics (PV) panels that generate 1,700 million units of electricity annually on Earth can generate more than five times when deployed in space. This is because light-to-energy conversion efficiency increases due to more wavelengths being captured, which also increases the Capacity Utilisation Factor (CUF) by about five times. For deployment in space, the PV panels can be installed on geosynchronous satellites and the power generated can be transmitted back to Earth in a safe, efficient and reliable manner using Wireless Power Transmission (WPT) technology. WPT consists of:

DC to microwave converter: To convert the DC power to microwave beams for transmission through antennas towards Earth-bound receiving station. Typically, DC to microwave conversion efficiency is 85-86%.

Transmitting antenna array to beam the microwave to Earth: The conversion efficiency of this process is

95%.

A mean to receive power on Earth: SBSP requires a receiving facility with a rectenna array and suitable power networks connected to the existing ground-based power grids. A rectenna converts the microwaves into electricity with conversion efficiencies of more than 95%.

Presently, China and Japan have aggressive R&D programmes to make SBSP viable. Members of the Chinese Academy of Sciences and Chinese Academy of Engineering, for instance, wrote a report in 2010, suggesting that China should build an experimental space solar power station by 2030, and construct a commercially viable space power station by 2050. In 2008, Japan passed its Basic Space Law which established Space Solar Power as a national goal and Japan Aerospace Exploration Agency (JAXA) is also actively conducting research for deploying massive solar panels in space in the near future and also has a roadmap to commercialise SBSP. As of now, the researchers at JAXA are the first to successfully deliver a power output of 1.8 kW using microwave beams to a receiver 55 m away with 'pin-point accuracy'.

Challenges ahead

In spite of the panoply of motivations to execute SBSP, there are some major challenges. At first, the launching cost with the Heavy Lift Launch Vehicle (HLLV) and the building cost of the SBSP system are exorbitantly high. JAXA has predicted total costs to be around one trillion Chinese Yuan. Furthermore, space is a hostile environment which causes approximately eight times more degradation of solar panels than on Earth. In addition, the receiving station on Earth will require several hectares of land. NASA estimates that a transmitting antenna of one km diameter and a receiving rectenna of 10 km diameter on ground for microwave beams at 2.45 GHz are required.

For a successful implementation, the space programmes of various leading countries need to collaborate and share resources. This, as a result, can bring down the costs immensely. In the meantime, the research community needs to delve deeper into the physics of SBSP to make such systems a reality for sustainable communities. Achievements like the recent deployment of 104 satellites by ISRO show India's space prowess and potential to contribute to SBSP programmes in the near future.

(The authors are with Center for Study of Science, Technology and Policy, Bengaluru)

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