# New Strategic Race to develop on demand Space-Based Solar power anywhere in the world

The increasing energy demands to support continued (and sustainable) global economic growth, thrust for renewable power because of environmental/climate concerns, has inspired researchers to look for fundamentally new energy technologies. Space-based solar power (SBSP) – in which Miles-long satellites covered with solar panels capture the Sun's radiation, convert it to electricity and then transmit it back to Earth in the form of either microwaves or lasers could form basis of unlimited, renewable electricity.

That power could also used in space to meet the energy demands of future space mining and resource extraction operations. NASA is examining how space solar power could support robotic mining operations on the moon or asteroids—a stepping stone toward enabling long-term human space exploration and possible colonization of the solar system beyond Earth.

There is race between countries like US, Japan, China and Russia who have all made huge investment in this area, and the space departments of India, South Korea, and Europe are also conducting related research.

Li Ming, research fellow of China Academy of Space Technology (CAST) has claimed that China now holds a leading position in the research of space-based solar power after decades of research which has narrowed the gap between itself and leading countries. Space-based solar power will ease environmental and energy pressure in China, and also spur the country's innovation and emerging industries, Wang added.

The US Military has also become interested in this concept as

it would save their billions in fuel costs as well as provide ultimate flexibility in their expeditionary missions as solar power could be redirected anywhere on the planet. The SPS would also be useful for disaster missions, a thin, portable rectenna can be unfolded and deployed to receive microwaves from space, which can be converted into electrical energy.

Ralph Nansen from the US-based advocacy group Solar High, urges the US to act on this because he believes that whoever develops SBSP first, will have a monopoly position in the world economy, just like England did during the industrial revolution because of coal.

## Space Based Solar power (SBSP)

Even as early as 1960s, Dr. Peter Glaser of Arthur D. Little invented Solar Power Satellite (SPS) concept: a large platform, positioned in geostationary orbit in space continuously collects sunlight, converts it into microwaves or laser beams, and transmits these to the ground; and a power receiving facility on the ground, converts it into electricity and hydrogen for practical use.

In space there is ten times more available solar energy than on Earth, there are no efficiency reductions due to the day-night cycle, seasonal variation, or weather conditions. Paul Jaffe, spacecraft engineer at the U.S. Naval Research Laboratory, declared that if there are solar panels in space, they are going to be illuminated 24 hours a day, seven days a week, 99% of the year. Due to the fact that Earth’s axis of rotation is tilted, the solar satellite could pick up sunlight almost all the time. Jaffe continues by explaining that individual space-based solar arrays would be able to produce 250 megawatts, and go up to 5 gigawatts of energy.  As an example, Jaffe has given New York City, which needs around 20 gigawatts of power. By his calculations, the system required would consist of four arrays, each providing 5 gigawatts, thus

being able to power the entire city.

However, the construction has long been a challenge for scientists, because its weight and size are way beyond the current carrying-capacity of spacecraft.  Many studies and experiments in the past have found the concept to be too costly  in terms of space transportation, billions of dollars to send a rig that could be several kilometers across and weigh several thousand tons;  and too complex to assemble a structure in space which is ten times the size of the International Space Station that itself is about the size of a football field.

Researchers estimate that lightweight designs of space solar panels could produce 1 kW per kilogram, thus requiring 4,000 metric tons of solar panels to produce 4 gigawatts of power. Energy captured in space-based solar panels would be transmitted back to Earth based antennas wirelessly.

“It’s a lot of money to put one of these things up in space,” said Ian Lange, assistant professor of economics and business and director of the Mineral and Energy Economics Program, “You need more than a model that says nuclear power is 15 cents per kilowatt hour and this is 14.”

In addition a broad range of technical challenges must be addressed in order to establish the economic feasibility of SPS like synchronizing the phases of microwaves produced by more than billion antennas, that would be installed on a single SPS, to produce a single precisely focused beam; the efficiency degradation of wireless power transmission (WPT) due to diffraction of energy through the water vapor absorption, the need of very light materials for the mirror structures to allow for the formation flight. Power generation, and power management, including extremely high-voltage power transmission cables that could channel the power from the solar panels to the transmission unit with minimal resistive losses.

However, falling costs of space launches – Musk's company plans to slash the cost of launching into space to $1,100/kg ($500/lb) from currently $20,000/kg ($10,000/lb) through reusable launch vehicles, improvement of the efficiency of solar cells from 10 to 40% over the last four decades, advancements in space robotics, development of new lightweight materials – including graphene and advanced polymers have brought back the interest in the concept of SPS once again. The International Academy of Astronautics recently stated that space-based solar power would be viable within 30 years.

## Japan

Japan, where the disastrous Fukushima meltdown heightened the search for safe, sustainable alternative energy, is also looking at space based space power. Japan Aerospace Exploration Agency (JAXA), which leads the world in research on space-based solar power systems, now has a technology road map that suggests a series of ground and orbital demonstrations leading to the development in the 2030s of a 1-gigawatt commercial system—about the same output as a typical nuclear power plant.

JAXA has already demonstrated wireless microwave transmission of solar power in space by beaming 1.8 kilowatts of electricity via microwave transmission 55 meters to a pinpoint target on a receiver. The microwave was successfully converted into direct electrical current at the receiving end. The experiment was conducted in March 2015.

If implemented, microwave-transmitting solar satellites would be set up approximately 35,000 kilometers from Earth. Jaxa says that a receiver set up on Earth with an approximately 3-kilometer, or 1.9-mile, radius could create up to one gigawatt of electricity, which is about the same as one nuclear reactor.

It will be many years before that happens, if it ever does. Researchers “are aiming for practical use in the 2030s,” Yasuyuki Fukumuro, a researcher at Jaxa, said on its website.

While the energy is transmitted in the same microwaves used in microwave ovens, it doesn’t fry a bird or an airplane traveling on its path because of its low-energy density, according to the Jaxa spokesman

## China

Taking space-based solar power as a key research program since 2008, China has made a number of major breakthroughs in wireless energy transmission and proposed various energy-collecting solutions.

“China will build a space station in around 2020, which will open an opportunity to develop space solar power technology,” Li Ming, vice president of the China Academy of Space Technology, was quoted as saying to the Xinhuan news agency. China Association for Science and Technology (CAST) revealed more details of a 100kW SBSP demonstration, which it plans to put in low earth orbit is expected by 2025, followed by a fully-operational SBSP system in geostationary orbit by 2050.
The project, which is still in the conceptual stage, would involve a satellite that weighs more than 10,000 lbs., dwarfing anything previously placed into orbit, including the International Space Station, according to the China-based Xinhuanet, part of the Xinhua News Agency.

The world has recognized the need to replace fossil fuels with clean energies. However, the ground-based solar, wind, water and other renewable energy sources are too limited in volume and unstable. “The world will panic when the fossil fuels can no longer sustain human development. We must acquire space

solar power technology before then," Wang, an academician of the Chinese Academy of Sciences (CAS) and a member of the International Academy of Astronautics, says.
"Whoever obtains the technology first could occupy the future energy market. So it's of great strategic significance," Wang says.

"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," says Wang.

"We need a cheap heavy-lift launch vehicle," says Wang, who designed China's first carrier rocket more than 40 years ago.
"We also need to make very thin and light solar panels. The weight of the panel must be less than 200 grams per square meter."

He also points out that the space solar power station could become economically viable only when the efficiency of wireless power transmission, using microwave or laser radiation, reaches around 50 percent.

## Russia

A division of the Russian Federal Space Agency (Roscosmos) revealed that it has a working prototype of a 100kW SBSP system in development; although no launch date was announced.

## US Military

The U.S. Naval Research Laboratory (NRL) is building a "sandwich" module; the top side is a photovoltaic panel that absorbs the Sun's rays. An electronics system in the middle converts the energy to a radio frequency, and the bottom is an

antenna that transfers the power to a target on the ground. Ultimately, the idea is to assemble many of these modules in space by robots – something the NRL's Space Robotics Groups is already working on – to form a one kilometer, very powerful satellite.

## 3D printing in space

3D printing has been developed at a fast pace in recent years, It is thought that by sending up special 3D printers into space to manufacturer the solar panels in orbit, the installation costs can be drastically reduced, compared to sending up pre-made solar panels. In 2014 an astronaut on the International Space Station used a 3D printer to make a socket wrench in space, hinting at a future when digital code will replace the need to launch specialized tools into orbit.

## NASA / LaRC "SpiderFab" for automated on-orbit construction

Company called Tethers Unlimited (TUI) is currently developing architecture and a suite of technologies called "SpiderFab" for automated on-orbit construction of very large structures and multifunctional space system components, such as kilometer-scale antenna reflectors.

This process will enable space systems to be launched in a compact and durable 'embryonic' state. Once on orbit, these systems will use techniques evolved from emerging additive manufacturing and automated assembly technologies to fabricate and integrate components such as antennas, shrouds, booms, concentrators, and optics.

Under a NASA/LaRC Phase I SBIR contract, TUI is currently

implementing the first step in the SpiderFab architecture: a machine that uses 3D printing techniques and robotic assembly to fabricate long, high-performance truss structures. This “Trusselator” device will enable construction of large support structures for systems such as multi-hundred-kilowat solar arrays, large solar sails, and football-field sized antennas.

The development of economically viable SPS now depends more on the availability of adequate budgets; finally the vision of a ring of satellites in orbit to provide nearly unlimited energy for the earth’s needs may become reality.

## References and Resources also include


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