International SBSP Space Race?

China is planning a Space Based Solar Power (SBSP) Plant producing 1 Billion Watts.

At an expert forum during the China Space Conference in east China's Hefei on April 24, 2023, Li Ming of the Chinese Society for Astronautics said that China's planned space solar power plant is expected to have a capacity of *one billion watts*. However, there are still many more challenges to be overcome before Project 2040 can be implemented.

Explaining the difference in size over time, Li Ming, director of the Commission on Solar Energy in Space at the Chinese Society for Astronautics, told a technical forum: "The first Chinese satellite, Dongfanghong, weighed only 173 kilograms, China's space station, which was completed in 2022, weighs 100 tons. Our spacecraft power capabilities have grown from a few watts to more than 100 watts and now surpass the 10,000 watt mark with the China Space Station. For the future we are planning the construction of a space solar power plant, which according to the current plans should have an output of one billion watts - i.e. one gigawatt. And the mega-project will be ready for commercial exploitation."

According to Li Ming, the future space power plant will likely weigh more than 10,000 tons. To achieve this goal, China needs to master wireless power transmission technology, which is both a must and the biggest challenge in the whole process.

So, although such a space solar power plant seems to belong in the realm of science fiction, it describes the technology of generating electricity from solar energy and transmitting it wirelessly to another destination in space or to users on the surface of the Earth. This technology is gaining increasing attention around the world as it could make an important contribution to new great human endeavors for example to power space systems, to tackle climate change, to promote new energy options and to develop the space economy.

Wang Li, another member of the commission, said that feasibility studies to develop and evaluate space power plants are gaining importance in countries and space agencies such as the United States, the United Kingdom, the European Space Agency (ESA), Japan and South Korea. Many have already renewed their development strategies and increased their budgets to research this area.

Wang predicted that in-orbit experiments and verification of key technologies for space-based solar power plants could become a focus of space exploration in the next five to 10 years. By 2040, the world could see the first gigawatt solar power plant in space.

China has also made tremendous innovations and breakthroughs in key technologies in this field, Wang said, stressing that "the country has caught up with the world's scientific key developments mainly in areas such as modular design of space power plants, high-efficiency power transmission and control, and highly flexible thin solar cells with high efficiency. However, Wang said there will still be some challenges in this process, such as wireless power transmission over long distances.

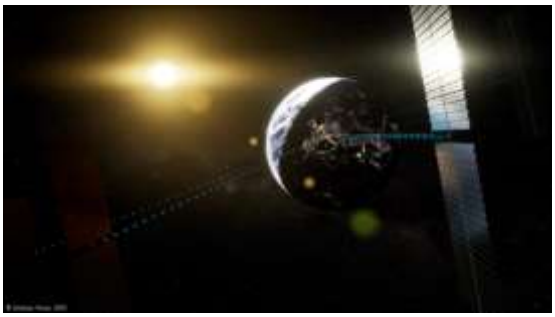
The space infrastructure, including the space power plant, will be an important path for future space exploitation, helping to meet China's dual carbon reduction targets and make the country a major "space-power", Wang said. [1]

Current SBSP plans outside China

With the climate change crisis, reducing CO_2 production and abandoning fossil energy production the idea of using Space Based Solar Power (SBSP) became popular again for many spacefaring nations.

Europe

ESA has signed contracts for two parallel concept studies for commercial-scale Space Based Solar Power plants, representing a crucial step in the Agency's new SOLARIS initiative – maturing the feasibility of gathering solar energy from space for terrestrial clean energy needs.



Due to be completed before the end of 2023, the parallel contracts are being led by Arthur D. Little and Thales Alenia Space Italy, respectively. These concepts will serve as an up-to-date reference for the overall SOLARIS effort, guiding the scope of specific R&D activities that will follow.
Results from SOLARIS should allow Europe to make an informed decision by the end of 2025, on proceeding with a full development program for commercial-scale Space Based Solar Power, beginning with a subscale in-orbit demonstrator to beam power from space to Earth. [2]

United States
In May 2020, the US Naval Research Laboratory conducted its first test of solar power generation in a satellite. Also the USAF has its Space Solar Power Incremental Demonstrations and Research Project (SSPIDR) planning to launch the ARACHNE test satellite. Arachne is due to launch in 2024.
In August 2021, the California Institute of Technology (Caltech) announced that it planned to launch a SBSP test array by 2023, and at the same time revealed that Donald Bren and his wife Brigitte, both Caltech trustees, had been funding the institute's Space-based Solar Power Project, donating over $100 million since 2013.
Wireless power transfer was demonstrated on March 3, 2023 by MAPLE, one of three key technologies being tested by the Space Solar Power Demonstrator (SSPD-1), the first space-borne prototype from Caltech's Space Solar Power Project (SSPP). SSPP aims to harvest solar power in space and transmit it to the Earth's surface. [3]

Russia
As of February 2, 2022 the Russian Space Systems holding (part of the Roscosmos State Corporation) has developed a project for a promising solar space power plant (SCES). It is designed to supply power to hard-to-reach – islands, mountainous and northern - regions of the Earth, as well as for scheduled and emergency recharging of spacecraft.
According to the project, the SCES consists of two segments. The first, transmitting module is an unmanned spacecraft with an area of 70 m^2 which accumulates the energy of the Sun and transmits it to the Earth. The second receiving module is a system of ground-based rectennas (mobile antennas) with batteries that receive solar energy from the spacecraft via a laser channel, convert it into electricity and distribute it to consumers. The advantages of laser energy transfer are fast translation (from a nanosecond) and extremely low beam divergence. The transmitting module can also serve as an orbital charging station – to transfer the accumulated energy to space satellites for operational recharging. This was the status in 2022, however with the Ukraine conflict and the resulting global consequences the current status of this project could not be determined. [4]

Japan
In 2008, Japan passed its Basic Space Law which established space solar power as a national goal.
JAXA, the Japanese space agency established a roadmap to commercial SBSP.
JAXA announced on 12 March 2015 that they wirelessly beamed 1.8 kilowatts 50 meters to a small receiver by converting electricity to microwaves and then back to electricity
In 2019 Aditya Baraskar and Prof Toshiya Hanada from Space System Dynamic Laboratory, Kyushu University proposed Energy Orbit (E-Orbit), a small Space Solar Power Satellite constellation for power beaming between satellites in low earth orbit. A total of 1600 satellites to transmit 10 kilowatts of electricity in a 500 km radius at an altitude of 900 km was proposed. [5]

India
After President Obama's maiden flight to India, in a press conference at Washington D.C., on 4 November 2010 details of the 'Kalam-NSS (National Space Society) Indian-American Energy Initiative' – a joint US-Indian endeavor intended to build clean space-based solar power satellites – was announced: "By 2025, even if we will use every available source of energy, whether clean or dirty we will fall short of the energy we need." Kalam said in 2010. [6]

The initiative took a giant step forward with its participation in the 4th China Energy and Environment Summit (CEES) on August 28, 2011 at the International University of Business and Economics (IUBE) in Beijing, China, organized by IUBE Vice President Dr. Lin Zhiqin. This high-level meeting focused on China's future energy requirements and their impact on China's environment, and included some of China's leading academicians, technologists, and government officials.

The National Space Society pursued this agenda with a meeting later in India with Dr. Kalam and members of the Indian Space Research Organization (ISRO), also led by Mark Hopkins, and including Canadian collaborators from Space Canada, George Dietrich and Howard Bloom. The International Astronautical Academy report on space-based solar power development under the direction of John Mankins was be released later. The NSS delegation also met with Dr. M. Nair, the former ISRO director and chair of the International Academy of Astronautics while they were in India. They discussed how to develop international interest and momentum for space-based solar power. Of the G-20 nations, Japan's government than made a strategic commitment to develop space-based solar power. The NSS-Kalam initiative also involved additional countries towards a strategic commitment to space-based solar research and development, including Canada, China, India, and the United States. NSS is still finalizing a more formal global collaborative structure. [7]

United Kingdom (UK)
The UK Space Energy Initiative, founded in 2021 is headed by Martin Soltau who cited the initiative's core parameters in an interview on Sept. 15, 2022: A weight of 2,000 tons, a diameter of 1.7km and geosynchronous orbit at a height of 35,786km above the Earth generating a little above 3GW of power. That would enable a high-frequency microwave beam somewhere within the 'atmospheric window' of 1-10GHz to be directed with extreme precision down to a ground station guided by a pilot beam emitted from the ground. [8]
A UK government-commissioned an independent study in 2021 found that space-based solar power could generate up to 10GW of electricity a year by 2050, a quarter of the UK's current electricity demand. UK universities and tech companies are to receive £4.3m in government funding to develop space-based solar power. (Status: 13 June 2023) [9]

Canada
SPACE Canada is dedicated to promoting, supporting and encouraging international dialogue on space-based solar power through research, education and commercialization.
Canada's motto is "We will accomplish our mission by serving as a facilitator, enabling individuals, organizations and governments to engage in a dialogue that will transform our world view from one of isolated energy solutions to a comprehensive global system."
Consequently Canadian students are participating in the 2023 International Space Solar Power Student Competition at NSS ISDC and the IAC, [10]

South Korea
On January 19, 2022, the Hanwha Group announced its plan to develop diverse space business models and proudly announced "[…] *including space PV power generation (SBSP), space resource discovery and a space shuttle. Please pay close attention to the moves of Hanwha Group to become one of the*

strongest players in the aerospace and Space Based Solar Power industries."
Established in 1977, Hanwha Aerospace is the only aircraft engine producer in South Korea. Trusted in the global market for original application technologies, they contribute to the nation's aerospace industry by providing gas turbine engines, engine components, aircraft components and launch vehicle engines. [11]

Oberth's Dream
In his book "The Rocket into Planetary Space" the German rocket pioneer Hermann Oberth proposed using space based solar energy on Earth already in 1923 using adjustable mirrors – photovoltaic cells were not invented at the time:

"This station [an earth-orbiting vehicle which could also carry humans] would have some practical use, but the following would be even greater: One could spread out a circular, wire net (Fig. 57) by rotation about its center. In the gaps between the individual wires (shown here exaggerated in size), movable mirrors of light sheet metal could be mounted so that one can move them to any position with respect to the plane of the wire net by electric currents from the station. The entire mirror would

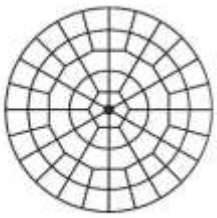


Fig. 57.

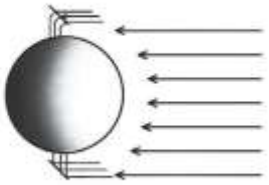


Fig. 58.

gravitate around Earth in a plane perpendicular to the plane of Earth's orbit and the net would be inclined to the rays of the Sun by 45°. Now by proper positioning of the individual facets, one could concentrate, as needed, all the solar energy reflected by the mirror to single points on Earth, or spread over large stretches of land, or, when one has no more use for it, let it radiate back into space (see Oberth's original Fig. 57 and 58).
If, for example, the mirror is 1000 km wide, then the solar image projected by each facet would be 10 km in diameter; if they were all congruent, then the energy would be concentrated on an area of 78km^2. Because the reflecting surface could be as large as desired, colossal effects could be achieved. For example, through such concentrated sunrays it could keep the route to Spitzbergen or to the northern Siberian ports free of ice. If, for example, the mirror only had a diameter of 100 km, it could make broad stretches of land in the north habitable by using diffused light to heat, and in our latitudes it could prevent the feared spring freezes in addition to night frosts in the spring and autumn, thereby saving the fruit and vegetable harvests of entire countries. It is especially significant that the mirror is not fixed over a single point on Earth and could therefore perform all these tasks simultaneously
A mirror 100 km in diameter in this way would come to be about 3 billion Marks, and its construction would require about 15 years […] it cannot even be ruled out that one of the civilized nations might begin the implementation of this invention in the foreseeable future, especially because even in peacetime a large part of the invested capital should bear interest." [12]

We just had to wait for a 100 years that all major space faring nations picked up in earnest on Hermann Oberth's simple, but clairvoyant idea: To bring the energy of the Sun to places where it is needed!

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