

International SSP Activities

by

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Review of Assessment Completed in September 2000: Non-U.S. Efforts of Interest

- (1) Japan's SPS-2000 (10 equatorial nations, led by Japan)**
 - 10-MW powersat into an 1100-km equatorial orbit
 - Demonstration experiments (rocket-boosted hardware and aerial platforms):
 - wireless power transmission
 - evaluation of space plasma interactions
 - advanced structural concepts
 - First major step toward an operational geostationary-

orbit demonstration by 2025

(2) Japanese studies: alternative SPS system concepts and technology variations:

- sandwich geometry
- power transmission
- retrodirective control techniques
- construction strategies
- high-voltage power management and distribution
- transmitting antenna designs
- advanced structures
- radiation damage and high-voltage arcing
- photovoltaic arrays

- scanning angles for low-orbit systems
- space transportation

(3) Canadian studies:

- SPS system concepts
- market analyses
- telerobotic assembly and construction methods
- electrical power distribution technologies
- adaptive optics
- interference effects
- dynamic beam-control methods
- demonstration experiments using airborne vehicles
- participation by industry (Hydro-Quebec)

(4) China, India, Indonesia, Egypt, the UK, Israel

- SSP concepts, economics, technologies, sociopolitics

(5) Former Soviet Union, Russian, and Ukrainian studies:

- alternative means for power generation (especially thermal dynamic and hybrid concepts)
- SSP satellite structural and deployment techniques
- modular space experiments to demonstrate various SSP subsystem elements and technologies
- wireless power transmission techniques
- components (e.g., klystrons and magnetrons)

- interference effects and demonstrations
- photovoltaic arrays and batteries
- radiation damage
- high-temperature superconductors for use in power management and distribution

(6) German studies:

- logistics and economic analyses
- new configuration concepts (e.g., the “bicycle wheel”)
- telerobotic assembly and logistic support
- space transportation options
- life-cycle energy analyses

(7) French studies (CNES and Electricite de France

- power beaming between spacecraft
- wireless power transmission from Earth to aircraft
- space power subsystem technologies
- SSP concept definition
- photovoltaic array and battery technologies
- alternative power generation scenarios
- operational wireless power transmission demonstration
(in Reunion)

(8) Global policy, economic, environmental, and legal activities (Unispace-2 recommendations):

- (1) Encourage studies on SSP technical and economic feasibility
- (2) Perform demonstrations to validate needed technology advances and engender global familiarization with SSP
- (3) Encourage countries to examine ways in which SSP might be uniquely suited to meeting a portion of their energy needs
- (4) Identify how SSP will improve the quality of life (e.g., clean air, clean water, communications, and standard of living)
- (5) Stimulate international collaboration, cooperation, and data-sharing
- (6) Engender standards and regulations re health, the environment, spectrum management, and orbit allocations
- (7) Organize and sponsor international conferences
- (8) Form a standing SSP committee under UN auspices

(9) Resolution of global SSP issues

- (1) Allocation of microwave frequencies for wireless power transmission
- (2) Allocation of acceptable orbits and locations within those orbits
- (3) Formulation of land-use policies for rectenna locations
- (4) Definition of the environmental and climate impact studies required
- (5) Definition of health and safety requirements
- (6) Identification and formulation of key demonstration projects
- (7) Definition and resolution of economic and market issues

Non-U.S. Activities Since September 2000

(1) Canada

- Spectrum 2001 (Saskatchewan): Demonstration of the SPS 2000 WPT working model

- Project plans:

- (1) Laser-powered roving vehicle for planetary or lunar exploration

- (2) Short-range terrestrial WPT to convey power across difficult terrain or water.

(2) Japan: Ministry of Economy, Trade and Industry (METI)

- Study concluded that SSP is economically and environmentally viable, but need public acceptance.

- High-efficiency low-cost solar cells. 2005 goals: > 30%; cost less than 100 yen/W
- NASDA Plan formulated for ground demonstrations by 2010; advanced R&D 2010 – 2020; commercial power by 2030.
- Mitsubishi Heavy Industries and Mitsubishi Electric teams now designing 10 kW – 1 MW demonstration satellite for launch in 2005 – 2007
- ISAS studies on on microwave transmission, rectenna elements, high-voltage solar power generation, effects of microwave irradiation, and social and commercial aspects of SPS.

(3) European Space Agency

- SSP is feasible; of interest to other missions (e.g., solar sails)

(4) France (CNES)

- Reunion Island ground-to-ground pilot plant
- Microwave-powered microgravity free flyer
- WPT '01 Conference (May, 2001, Reunion, France)
 - Demonstration of the Reunion Island power beaming pilot
 - International Rectenna Contest.
- Senate President Christian Poncelet cited promise of SSP and the importance of technology demonstrations.

(5) China

- SSP Workshop April 2001 (IAA/Chinese Society for Astronautics)

(6) World Energy Congress (October 2001; Buenos Aires)

(7) UNESCO's World Solar Energy Program

- Renewed interest in SSP, March 2001

(8) International Energy Agency

- Renewed interest in SSP, March 2001

(9) International Union of Radio Science (Asia-Pacific Radio Science Conference; Tokyo, August 2001)

- Special SSP/WPT session

(10) IAF (Toulouse, France, 2001)

- Space Power Symposium: 4 sessions; plus joint Round Table with IISL. Thirty-two papers, 70 authors, 9 countries, 45 organizations. Some selected papers:

- *A Survey of Space Solar Power Activities 2000-2001.* (France)

- *Summary of Studies on Space Solar Power Systems of the National Space Development Agency of Japan. (Japan)*
- *Functional Model for SPS of Sandwich Type. (Japan)*
- *SPS Interference and Its Mitigation for Leo Satellites (Japan)*
- *Recent Progress in Long-Duration Microwave Exposure. (Japan)*
- *Space Demonstration for Solar Power Satellite. (Japan)*
- *Energy Transfer for Technological Space Apparata with Microaccelerations Lower than 10^{-5} M/S^2 (Russia)*
- *A Case Study of the Market Context for a Point-to-Point WPT Application in Northern Canada. (Canada)*
- *The Case Study Results of the Application of the Space Solar Power System (SSPS) for Japanese Power Utilities. (Japan)*
- *A Case Study for SSP for Indonesia. (Japan and Indonesia)*
- *Prospects for Energy from Space in the Developing World: A Case Study for Mexico.*

- *Case Study in Reunion Island. (France)*
- *Studies on the Economic and Social Aspects for the Benefit of Space Solar Power Systems (Japan)*
- *Legal Constituencies and Economic Efficiencies of Space Solar Power: A Joint Japanese and American Perspective. (Japan, USA)*

(11) Japan - US Science, Technology and Space Applications Program (JUSTSAP)

- Past efforts: satellite communications, microgravity research, disaster monitoring and mitigation.
- New working group on SSP (November 2001):
 - Space power for applications in space
 - Space power for delivery to markets on the Earth

- Construction of space power systems on the Moon for the Earth's use
- Construction of power stations on the Moon for lunar nights
- International Student Projects
 - Three subcommittees:
- Space Power WG Program Committee (SPPC)
- Education / Student Activities Committee (ESAC)
- International Research and Demonstrations Coordination Committee (IRDC)

(12) Russia

- Technical papers on WPT:
 - Physical modeling experiments
 - Matrix method antenna synthesis

- Modeling of wave beams
- Discontinuous antennas
- Minimization of sidelobe diffraction patterns
- Diffraction reduction by modifying field distributions
- Design of scanning self-focusing antennas
- Phase synthesis numerical methods for antennas
- Antenna field distribution optimization

(13) IAF (World Space Congress, Houston, Texas, 2002)

Session R.1 – Power from Space - Prospects for the 21st Century

Session R.2 – Advanced Space Power Systems and Technologies

Session R.3 – Special Organized Session: Case Studies in Market
Analysis of SSP

Session R.4 – Joint Session with COSPAR on Energy-Rich
Approaches to Exploration