Impact of Solar Power Satellite on the Radio Astronomy Service

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We review and update the information in existing studies (1,2,3) carried out in the US between 1976 and 1980.

Reference System: The DOE/NASA reference system consists of 60 solar power satellites spaced 1 degree apart in geosynchronous orbit above the US. Each satellite generates 6.7 GW of power at 2.45 GHz, 5 GW of which is collected at the ground and delivered to the utility power network. Each satellite consists of a 10.4 km by 5.2 km array of solar cells and a circular transmitting array of diameter 1 km. The microwave power is generated by 50 to 70 kW klystrons; crossed field tubes, such as magnetrons, and solid state devices were also considered. The array is phase locked to pilot tones transmitted from the reception area on the ground. The power collection systems consist of rectennas typically 10 km by 13 km, consisting of arrays of dipoles, each with a rectifying and filtering circuit. The power flux at the center of the array is 230 W m-2 at the center of the array, falling to 10 W m-2 at the edge. The mean spacing between rectenna sites within the US is about 350 km.

Effects on Radio Astronomy: Receivers for radio astronomy are extremely sensitive. A failure that places less than a thousandth of the radiation of one of the 6 million klystrons in orbit inside a radio astronomy band would be more than a thousand times above the detrimental limit, essentially destroying the use of that band for radio astronomy. The engineering requirements on reliability and limiting unwanted emissions are therefore truly formidable. The reference system of solar power satellites permanently block a strip of sky, corresponding to the geostationary arc. This severely limits future radar or other observations of solar system objects, as this strip includes much of the ecliptic plane. Several of the reference system radiation mechanisms include broad band components at levels above the detrimental interference levels given in ITU-R RA.769 in bands allocated to radio astronomy. In addition, the power signal overloads sensitive radio astronomy receivers, requiring development and installation of cryogenic, preferably superconducting, stopband filters. This reduces system sensitivity and becomes particularly problematic for modern array designs with very large numbers of antennas and receivers. It is estimated that about 2on the rectennas at 2.45 GHz is reflected and reradiated. This stray emission along with radiation of noise and harmonics from the rectennas will place restrictions on choice of sites for the receiving antennas relative to existing observatories, and on possible new observatory sites.

The following references summarize earlier studies:

1) "Solar Power Satellites", 1981, Report of the Office of Technology Assessment, US Govt. Printing Office, Library of Congress Catalog Card Number 81-600129.

2) "Electric Power from Orbit: A Critique of a Solar Power Satellite System", 1981, National Academy Press, Washington, D.C.

3) A. R. Thompson, 1981, "Effects of a Satellite Power System on Ground-Based Radio and Radar Astronomy", Radio Science, vol. 16, pp 35-45.