Solar power satellite - the ultimate Radio Science application

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INTRODUCTION

Solar power satellites (SPSs) were first proposed in the 1960's and studied in more detail in the 1970's during and after the so-called oil crisis [1]. An SPS is a satellite with large solar panels whose purpose is to beam microwave power to a ground-based receiver (rectenna field). SPS is among those very few reneweable energy technologies which could be deployed in a global scale (terawatt level). In comparison to ordinary ground-based solar panels, SPS produces continuous power, thus eliminating the need for energy storage. SPS also makes more efficient use of the expensive solar panel material because the panels are permanently sunlit and because the use of concentrator-type panels fits naturally to the scheme. Presently the main hurdle of SPSs is the high per-kilogramme cost of launching material to Earth orbit of about 5000 eur/kg. However, it is conceivable that reusable launcher technology and larger launch volumes would eventually bring the launch costs down to a level (100-500 eur/kg) which would ultimate make SPS electricity economically competitive with present-day fission power cost level (0.06 eur/kWh) with reasonable usable lifetime of the satellites (30 years).

The purpose of the paper is to raise the Finnish radio science community's interest in the SPS field and tell about some recent developments which may contribute towards making the SPS a realistic mid-term goal. Although SPSs are large systems, there is no technical reason why the development work of their components such as solar panels and microwave transmitters could not start now at a smaller scale.

THE ELECTRIC SAIL

The electric solar wind sail (electric sail for short, Fig. 1) is a Finnish space propulsion invention from 2006 [2] whose detailed technical development is in full swing and progressing towards a test mission. The electric sail promises an economical way of transporting material around in the solar system. One potential application of this capability would be to mine water ice from asteroids and transport it with electric sails to Earth orbit. Water could be used as a propellant for orbital transfer vehicles using electrolysis propulsion [3] or heliothermal steam rocket propulsion. This would free us from having to lift the orbital transfer propellant from Earth, effectively bringing the access cost to geostationary Earth orbit (GEO) down to the level of low Earth orbit (LEO) access cost. This could reduce the net transportation costs of large SPS payloads to GEO or MEO (middle Earth orbit) by up to 50-60%.

NATIONAL INTERESTS AND FINLAND'S HIGH LATITUDE LOCATION

Due to its high latitude location, Finland is a country where ground-based solar energy, although available, is less favourable than elsewhere because of the larger capacity need

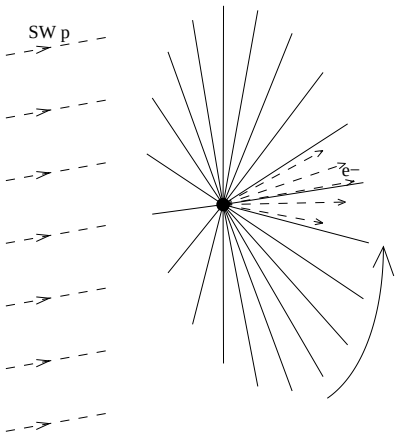

Figure 1: Principle of electric solar wind sail propulsion

to store the collected energy over the winter. Therefore SPSs should be interesting for Finland. However, most studies of SPSs hitherto made have considered SPSs on equatorial, geostationary orbits similar to telecommunication satellites. Were this orbits globally adopted for SPS use, it might create a problem for receiving the microwave beam in Finland because of the low elevation angle of the satellite as seen from the receiver array. For Finland and other high latitude countries, navigation satellite type middle Earth orbits might be more favourable. Therefore it should fall in our national interests to develop reasonable MEO SPS designs and at least study the relative feasibility of GEO versus MEO SPSs.

R&D OPPORTUNITIES

Microwave sources suitable for SPS use and telepresence robotics which is needed to assemble the SPSs in orbit are example areas where the expertise of the Finnish radio science community could help the emerging global SPS effort.

CONCLUSION

In our view, solar power satellites are a realistic possibility for solving Earth's future energy needs in an environmentally clean and safe way. The issues or SPSs are not fundamental or technical but mainly economical, and there is reason to believe that the economics will eventually work out favourably. Thus SPSs are a technology of potentially enormous usefulness while not appearing to require new breakthroughs before realisation.

References

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