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MULTIOBJECTIVE OPTIMISATION OF INTEGRATED SPACE-BASED AND TERRESTRIAL SOLAR ENERGY SYSTEMS

Abstract

Concepts for solar power from space have received renewed attention over the past few years. High costs for fossil fuel during most of 2007 and 2008 have contributed to increasing the interest in advanced green energy options usually considered to be at the fringes of current technological capabilities. Solar Power Satellite is among these advanced options. Within the next 15-20 years a significant portion of the world power plants will need to be replaced and the discussion on which energy production system will be the most appropriate for the 21st century is still open and vibrant. Following the maturation of wind power plants into commercial competitiveness, solar power plants are expected to reach this level soon at good locations. Thus far, the small percentage generated by solar power plants does not require delivery guarantees. The emergence of progressively more commercial solar thermal power plants in some south-European countries, and the recent plans to build large installations in North Africa and the Middle East to supply Europe are an important step forward in this direction. In addition to the plants, high efficiency energy storage and distribution still require further research. Concepts for space-based solar power plants will benefit from these terrestrial developments, and their integration into terrestrial solar power infrastructures has the potential of a win-win opportunity, especially if considered early in the building up of such a new renewable energy infrastructure.

The paper will present a multi-objective optimisation of a combined space and terrestrial-based solar power infrastructure. A simplified model of one and several space-based and terrestrial solar power plant is used to optimise the key parameters of the ground and space segments of the combined system. The goals are to minimise the cost of the overall system and to maximise the provision-reliability of electric power for an entire day based on extrapolations of current measured electricity demand profiles over two selected areas of the world, which are expected to have the highest demands of electric power in the next twenty years. Given the current launch cost per kg of mass, particular attention is dedicated to the optimisation of the space segment in order to propose a realistic design. The attempt is to optimise the complex interaction between orbital parameters, architecture of the spacecraft, size of the terrestrial plant, size of the terrestrial storage system and coverage in order to provide a constant delivery and low cost per kW.