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ENHANCING TERRESTRIAL SOLAR POWER USING ORBITING SOLAR REFLECTORS

Abstract

One of the key challenges for the future is the delivery of truly global clean energy services. Amongst those energy services solar power offers scalability and has shown declining levelised costs in recent years. However, solar power is constrained by the day-night cycle and without energy storage can only deliver energy during daylight hours. This severely limits the utility of solar power for large-scale deployment and will ultimately limit its global market share.

This paper will provide a top-level analysis of the opportunities and challenges for the utilisation of orbiting solar reflectors to enhance the utility of terrestrial solar power. This is timely since there is a clear demand for global clean energy services, which overlaps with the prospect of falling launch costs and emerging technologies for in-orbit fabrication of large space structures.

First, a review of prior concepts will be provided. Since the 1970s orbiting solar reflectors have been proposed to illuminate terrestrial solar farms [Billmann et. al, NASA TM73-230, 1977]. A number of configurations were proposed from single large reflectors to multiple smaller ones. The earliest studies aimed at the ambitious goal of delivering solar energy as the primary energy source for the Earth. Later studies considered the more modest target of providing solar energy in critical dawn/dusk windows using reflectors in sun-synchronous orbits [Frass et al, 39th IEEE Photovoltaic Spec. Conf., 2013]. The trade-offs for various orbital configurations for such reflectors will be discussed.

Illuminating solar farms at critical hours of the day when output is low or zero will not only increase their total productive hours but also enhance the utility of their energy generation. For example, revenue increases will result from electricity provision during high demand, high price evening hours. The possibility of illuminating solar farms at different locations by a single set of orbiting reflectors also showcases their intrinsic value in providing clean energy on a global scale. The economic opportunities and challenges to scale the concept will be discussed.

Moreover, in order to reflect sunlight to a given solar power farm, the reflector must be continuously reoriented in its orbit. The selection of an adequate attitude control system is therefore key to maximising the power output at the solar farm. In particular, the actuators must provide the necessary torques to reorient the mirror and counteract external perturbations. Typical control torques for candidate orbits and different attitude control systems will be considered and discussed.