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A MODEL-BASED APPROACH FOR SPACE-BASED SOLAR POWER: TECHNICAL FEASIBILITY, EFFICIENCY AND MISSION COST

Abstract

The paper deals with the study of a future photovoltaic power station in Earth orbit, whose task would be to collect solar energy in space, convert it and transmit it wirelessly to the Earth's surface. This very challenging study is referred to as Space-Based Solar Power (SBSP) funded by the European Space Agency (ESA). It is in line with the broader objectives of the ESA SOLARIS initiative, which aims to pave the way for a cleaner and more secure energy future for European citizens. The ultimate goal of this work is to facilitate a comprehensive quantitative understanding of the entire SBSP system, using a model-based approach that encompasses a number of system aspects, ranging from performance simulations to cost and energy investment evaluations. An ad-hoc optimization model that considers the entire Space-Based Solar Power (SBSP) efficiency chain was used to perform in-depth architectural trade-offs. This model allows the identification of the optimal combination of the system main areas, consisting of: solar panel area, on-board antenna area, and ground power station area. In addition, a fully parametric cost and energy model for SBSP was developed using the appropriate methodologies. This model is used to assess the overall mission costs, required energy investments, and associated greenhouse gas emissions for a selected architecture. In addition, a high-level architecture of the SBSP system, covering both space and ground components, has been developed following a Model-Based System Engineering (MBSE) approach. Each architectural block includes Simulink models to evaluate and simulate different end-to-end power transfer scenarios. The final architecture has been integrated into the MathWorks System Composer toolkit. Finally, a dedicated parametric model has been further developed to represent a potential SBSP demonstrator mission.