IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

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RENEWABLE LIQUID PROPELLANTS: DECARBONIZING SPACE EXPLORATION

Abstract

Currently, the main liquid propellants used in space exploration include liquid hydrogen (L-H2), rocket-grade kerosene (e.g., RP-1) and liquid methane (L-CH4) (liquid oxygen is an oxidizer). Being fossil-based fuels, all of them (directly or indirectly) emit enormous amounts of CO2 and other greenhouse gas emissions during combustion adversely affecting Earth's climate. For example, SpaceX's Falcon Heavy rocket burns 400 metric tons of kerosene and emits 1320 tons of CO2 in a matter of few minutes. Recently, rocket emissions have been growing faster than global emissions from aviation and other traditional sources, and this growth is expected to accelerate in the near future. The objective of this paper is to demonstrate the technical and economic feasibility of the production of "green" liquid rocket propellants from renewable resources such as solar, biogas and biomass. Three technological pathways (scenarios) are analyzed in this paper. 1) Renewable (solar/photovoltaic, wind) electricity can now be made (in many locations) at relatively low costs, thus, it can be used to produce hydrogen and oxygen by water electrolysis at a cost less than reforming of natural gas and without CO2 emissions. Hydrogen and oxygen can then be liquefied (albeit, with high energy penalty of 33