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REGENERATIVE FUEL CELL SYSTEM FOR LUNAR NIGHT SURVIVAL

Abstract

Before 2030 the moon should see a return of humans on its soil. This time the aim will be to stay on our closest satellite and prepare humans for longer missions towards Mars. Thus, the moon will become an exciting playground for testing technologies and assessing permanent human life in space. Many agencies endorsed this ambition and are willing to contribute to this challenging and motivating objective. However, a lot of technological gaps are present and need to be addressed before thinking of a sustainable activity on the moon. This is especially the case for space transportation (reliable lunar landers and rovers), habitat and human health (to provide efficient shelters for preserving human health) or ISRU (capability to use resources present on the moon). A common point of all these different fields is the energy challenge. Indeed, the moon environment is known to be harsh with long periods of darkness and cold (two weeks or permanently). During these lunar nights, the sun cannot provide power anymore and thus energy must be stored. Most common energy storage systems rely on batteries. Even though this technology is highly matured (present in all satellites) it has some limits when the lunar night is too long. This is due to the presently low energy density of batteries (around 150 Wh/Kg). Thus, a higher energy density system must be developed which is the case of RFCS (Regenerative Fuel Cell Systems). The principle is very simple. It consists of splitting the water molecule into H2 and O2 when energy from the sun is available and storing them. Then using the H2 and O2 in a Fuel Cell to produce electrical power when solar energy is no longer available. Unlike batteries, in an RFCS the power output and stored energy are decoupled from each other. Thus, this system can be built having an energy density in a wide range, from 200-300 up to 1000 Wh/kg (low power, very high energy stored), which can reduce the total mass of the energy storage system compared to batteries. Additional mass savings are possible due to potential synergies of RFCS hardware (mainly water electrolyser and gas storage) with other systems required on the Lunar surface such as In-Situ Resource Utilisation and life support systems.

To validate the RFCS technology performance, ESA released a contract in 2019 to design, manufacture and test a TRL 5 Regenerative Fuel Cell System that could provide enough power for a smaller robotic mission to survive on the Lunar surface for three consecutive 18 days-long Lunar nights. Prototech with Airbus Defense Space and Air Liquide as subcontractors were granted this contract with the aim of having a breadboard tested at the end of 2021. Prototech stands for design, production and testing of the breadboard; Airbus provides input and requirements for the system, while Air Liquide develops the modeling software tool, helps assess the way forward and provides its commercial PEM fuel cell stack for the breadboard test. This consortium will present the specification, design and preliminary results of this breadboard.