04/2301 Biomass-based Fuel Cells for Manned Space Exploration

Type of activity: Medium Study (4 months, 25 KEUR)

The increasing quantity of greenhouse gases in the atmosphere and the decrease in fossil fuels availability are driving the investigation of alternative energy sources for Earth applications. Among others, different processes for the conversion of biomass into useful fuels are under development or have been implemented in various Countries. The transfer of this technology to space represents a promising approach in the frame of in-situ resources utilisation projects, in view of the ambitious plans for future manned exploration of Mars and the Moon.

ESA has been extensively investigating the recycling of human waste for the production of consumables (e.g. breathable air, water) for closed space systems (e.g. ISS and future manned missions to the Moon and Mars) in the frame of the Melissa Project.

Besides the regeneration of consumables human faeces represent a potential source of methane and hence hydrogen, which can be used as fuel in a fuel cell, or in propellant gas mixtures. Such a process would at the same time provide fuel from available resources, reducing fuel transportation from Earth, and contribute to waste disposal.

Anaerobic digestion processes are able to convert about 40 % to 60 % of organic matter to biogas, composed of 65% methane and 35% carbon dioxide. Parallel to anaerobic digestion other biological routes like fermentation and photobiological decomposition, and different technologies like thermochemical, photochemical and photocatalytic decomposition of biomass need to be explored in order to individuate possible complementary and alternative processes.

Study Objectives

The object of this study is the exploration of different routes for the production of fuels for a fuel cell from organic waste, and in particular from human excrements, during manned exploration of the Moon and Mars. A trade-off between the processes will be performed and discussed.

The investigation shall provide:

- An overview of the technologies available for the conversion of biomass to fuels, and in particular to methane and hydrogen. Biomass will mainly consist of human waste a small portion might consist of plants/vegetables residues.

- An estimation of the kind of fuels that can be obtained from human waste and with which purity grade.

- Assessment of the possibility to set and control the reactors' operating conditions in order to selectively produce methane (as far as possible) or in any case to maximise methane and hydrogen production.

- The definition of selected process steps operating conditions and requirements.
- An estimation of the energy balance of the overall process.

References:

[1] Melissa Final Report for 1999, Activity Memorandum of Understanding ECT/FG/MMM/97.012 ESA/EWP-2092.

[2] T.A. Milne et al, Hydrogen from Biomass, State of the Art and Research Challenges, IEA/H2/TR-02/001.

[3] P. Lusk, Methane Recovery from Animal Manures: The Current Opportunities Casebook. NREL/SR-580-25145.