Interest of MELiSSA space developments for circular economy: relevance, feasibility, challenges and recommendations

Key Words:
Biorefinery, industrial ecology, industrial metabolism, Life support, circular economy.

Abstract:
Circular systems are essential in space regenerative life support systems and becoming important for high human density location on Earth (e.g. cities, schools, hospitals,..) as well as in remote and harsh locations. They have to be functional and efficient to allow the continuous recovery of various products, such as food or water, from diverse waste resources. These recovery functions are also needed in the concept of bio-refineries, aiming to produce chemicals, materials and energy, in addition to food and feed. This concept is currently intensively developed to substitute fossil sourced products by renewable ones. In this sense, the circular system expertise acquired in the MELiSSA project can be extremely useful when considering terrestrial applications. The quasi-cyclic feature of MELiSSA is particularly interesting for enhancing the economic and environmental potential of the bio-refineries approach.
The goal of this activity is 1) to assess the integration of processes developed for the life support systems with high potential for being applied in terrestrial applications, following the principles of industrial ecology, 2) to design analogues (but not necessarily similar) of process assembly for terrestrial bio-refineries, 3) to quantify and optimize the mass (in terms of carbon, water and nutrients) and energy balance of metabolic pathways. Configurations maximizing the incorporation of carbon in final products should be preferred.

During this PhD, MEliSSA system tools will be used (e.g. ALISSE, EnRum, Simulink,..) as reference tools. Concrete terrestrial will be considered as study case.

MELiSSA partners: UNILausanne (CH), UCLermont Auvergne (F), VITO (B), IPStar (NL), Sherpa (F)

Impact on MELiSSA:

This study will precisely quantify the energy and material balances of the current processes of the MELiSSA loop, analyse and simulate them, then optimize the system as integrated configuration and possibly identify and issue recommendations.

References:

Sonnenberg, Anton, Johan Baars, and Patrick Hendrickx. 2007. « IEA Bioenergy Task 42 Biorefinery ».

Menon, Vishnu, and Mala Rao. 2012. «Trends in bioconversion of lignocellulose: Biofuels, platform chemicals & biorefinery concept». Progress in Energy and Combustion Science 38 (4): 522-50.

Polyakov, Yuriy S., Ibrahim Musaev, and Sergey V. Polyakov. 2010. « Closed bioregenerative life support systems: Applicability to hot deserts ». Life Sciences in Space 46 (6): 775-86.

Desired knowledge:

Candidates should possess a degree in biology, chemistry, biochemistry, bioengineering, or related. Experience in establishing material flow analysis (MFA) or life cycle assessment (LCA) as well as good knowledge of biomass conversion technologies are considered as a plus.