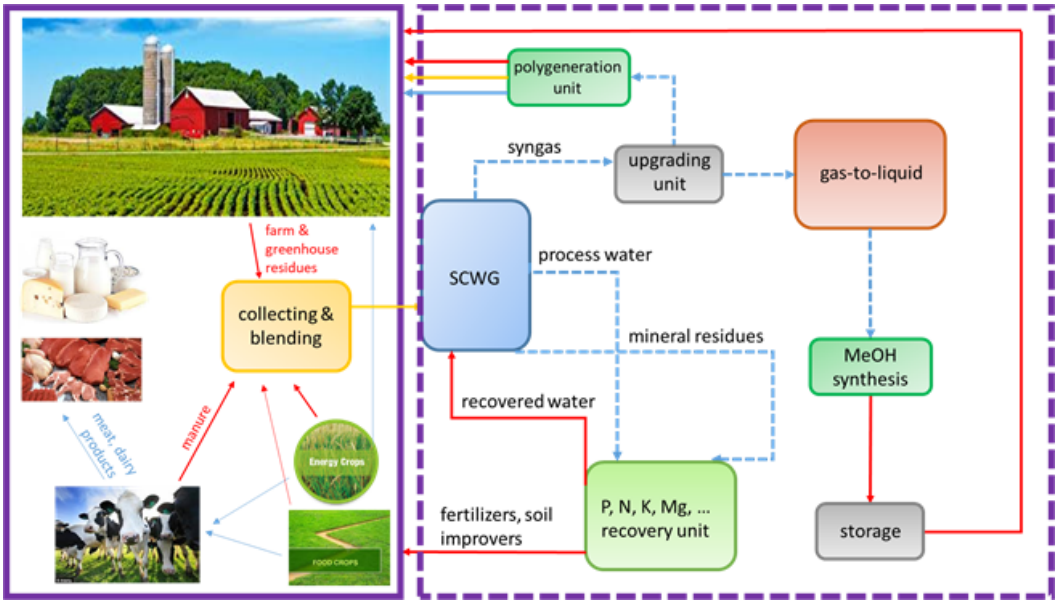
SUPERVALUE

SOLVING THE PROBLEM OF LOCALLY AVAILABLE WET RESIDUE STREAMS BY RECOVERING THE ENERGY CONTENT AND EXTRACTING THE VALUABLE ELEMENTS FROM THE INORGANIC PART USING A SMALL SCALE BIOREFINERY CONCEPT BASED ON THE SCWG PROCESS



2° Call:	2017
Project period:	07/2018 - 09/2020
Topic:	Biomass and Waste Valorisation, Agriculture
Keywords:	Supercritical Water Gasification, wet organic residues, biorefineries, energy recovery, syngas
Coordinator:	Dr. Marcin Siedlecki, Research and Innovation Center Pro-Akademia, Poland Email: marcin.siedlecki@proakademia.eu
Project partners:	Research and Innovation Centre Pro-Akademia, Poland; Delft University of Technology, the Netherlands; Fresh World Int. Sp. z o.o., Poland.
Total funding:	357.000 €
Website:	https://projects.au.dk/faccesurplus/research-projects-2nd-call/supervalue/

FACCE SURPLUS
SUSTAINABLE AND RESILIENT AGRICULTURE FOR FOOD AND NON-FOOD SYSTEMS

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BACKGROUND

During the SUPERVALUE project we worked to answer the need for knowledge about the possibilities to use a small-scale biorefinery concept to solve the problem of locally produced wet organic residues. Drying of these waste streams is economically not feasible and energetically irresponsible, while the most common and established conversion technology (anaerobic digestion, AD) has non-negligible operational issues and also produces a waste stream itself: digestate. Moreover, AD does not reduce certain bio-active organic compounds, e.g. antibiotic residues. As an alternative a biorefinery concept based on supercritical water gasification (SCWG) was proposed and investigated, focusing on the achievable process efficiency, possibility of the recovery of resources and the economic aspects (required investment and the payback time).

METHODOLOGY

The following methodology was applied:

- Obtain real samples of four different wet organic residue streams of interest: cow manure, fruit&vegetable residue (FVR), cheese whey and sewage sludge;
- Perform (subcontract) lab-scale SCWG gasification experiments of these residue streams (feed rate 1 ml min-1) to obtain actual process data and real process products, namely gas, effluent and char for further analysis;
- Investigate the optimization boundaries of SCWG process by means of mathematical modelling and simulations using ASPEN Plus OLI combined with FactSage™ simulations, in order to propose a theoretically optimal process layout of an SCWG plant, as well as a Life Cycle Analysis (LCA);
- Investigate the recovery of Phosphorus and other elements from the SCWG char by leaching experiments;
- Prepare a spreadsheet-based decision support tool to evaluate different SCWG gas valorisation pathways, taking into the account combustion in a boiler, a gas engine, an absorption cooling unit and the synthesis of DME/methanol;
- Perform four case studies at companies producing different waste streams of interest. The case study on FVR was performed at Fresh World Int. sp. z o.o. The goal was to calculate the payback time of an investment in SCWG-based conversion system for wet organic residues and to identify a gas valorization pathway optimally matching the company's energy consumption pattern.

RESULTS

Simulations showed, that compared to AD the fraction of methane in SCWG product gas is lower, below 50% by volume. Process temperature of 650°C instead of 500°C favors the carbon conversion efficiency, but the amount of gas produced is lower. The max. process efficiency in terms of chemical energy transfer calculated for FVR with 20% dry mass content was 57%. Simulation results were in reasonable agreement with the experiments, although more and longer tests at larger scale are needed to check the repeatability. The Phosphorus recovery experiments showed up to 90% recovery, however long (24h) residence times are needed to achieve this. Case studies showed an economic viability of SCWG-based systems with prognosed payback times of less than 10 years for the FVR and sewage sludge case, and 10 to 17 years for the manure and whey case, depending on the selected valorization pathway. The highest uncertainty in this analysis is however the investment cost of SCWG and the reliability of the installation. Nonetheless, with biochar instead of digestate at the process outlet, and the destruction of bacteria and antibiotics during the SCWG process, this method offers advantages that could complement the range of waste converting technologies.