THE ABOWE PROJECT AIMED TO PROVIDE 'PROOF OF CONCEPT' ON HOW BIOMASS-BASED WASTE MATERIALS COULD BE USED AS RAW MATERIALS FOR BIOREFINERY

Novel biorefinery pilot

Future biorefineries will work according to the principles of Nature, using microbes and enzymes for upgrading wastes and other biomass into biofuels, other energy substances, platform chemicals and organic fertilisers. The concept of 'waste' will become unnecessary in industries, communities, agriculture and forestry, since all materials are refined and recycled. The ABOWE project and pilots, of the EU Baltic Sea Region Programme, have paved the way to this industrial revolution, as introduced in the article in the March 2015 edition of *Pan European Networks: Science & Technology*, which provided test results from the biorefinery tests in Finland.

Here, we provide some further remarks on the sustainability of the technology and explain how it is possible to utilise waste in a sustainable way.

Purpose

The novel biorefinery concept (Pilot A), innovated and developed by Adjunct Professor Elias Hakalehto, Finnoflag Oy and the University of Eastern Finland, was one of the two platforms for ABOWE (Implementing Advanced Concepts for Biological Utilization of Waste, 12/2012-11/2014). The second platform was the biogas dry digestion technology (Pilot B) piloted under the supervision of Ostfalia University of Applied Sciences, Germany.

The goal of the ABOWE project and both pilots was to provide 'proof of concept' on the ways that biomass-based waste materials could be used as raw materials. The production was directed to biofuels, organic platform chemicals, renewable energy, fertilisers and nutrients in an economically feasible way, with the help of micro-organisms. Fig. 1 presented the heart of the Pilot A, novel bioreactor.

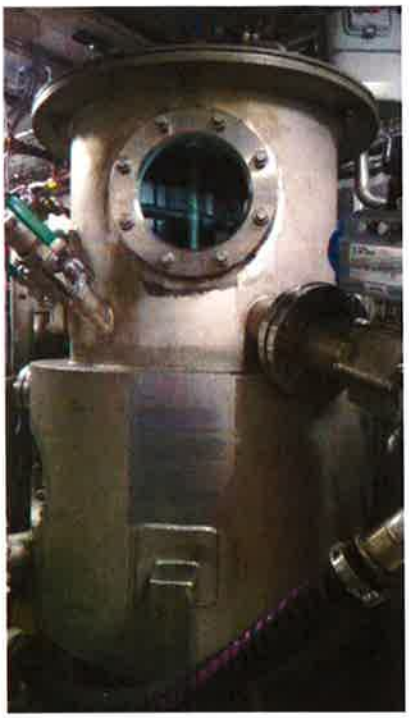
Proof of technology

During the ABOWE Pilot A experiment it was possible to give a three time proof of concept with various biowaste in Finland, Poland, and Sweden. It was thus documented that the process optimisation could take place in the next phase with some tested principles. Furthermore, several improvements to the equipment were also suggested. Consequently, it could be stated that the Pilot A biorefinery pilot could operate as an upstream biorefinery for all kinds of organic wastes.

This overall concept of Pilot A emerged as functional at all three different Baltic Sea countries, and technological co-operation was established between different institutions, as well as with Ostfalia University of Applied Sciences, Germany.

Pilot B was successfully tested in Lithuania, Estonia and Sweden. Many potential testing sites for future studies have emerged during the testing period, and this concept of microbial biorefinery technologies has given the proof of technology during the ABOWE project. The sustainable aspect was also fulfilled.

Fig. 1 The bioreactor of the ABOWE Biorefinery Pilot A



Joint efforts of the EU Baltic Sea Region's six countries (Germany, Poland, Lithuania, Estonia, Sweden and Finland) were focused on testing the novel concepts for biorefineries in their ABOWE project. The impacts of the new technologies on the societies were also estimated.

Since the biorefinery trials with Pilot A and Pilot B used local waste materials as substrates, no transportation or combustion of fossil fuels was required for that element. Moreover, other transportation of substrates becomes unnecessary, provided that the sources were converted into energy at site. Therefore, there is an increasing sense that energy balances, according to the piloting experiments, could be divided into at least five basic parts:

1) Utilisation of biomethane and biohydrogen from the wastes;

2) Solvents and organic mixtures from biorefining are combustible;

3) Co-combustion of some solid fractions from or outside the process;

4) Recirculation of the incineration outflow gases into bioreaction, e.g. carbon oxides; and

5) Collection and re-use of the thermal energies from the industrial or waste treatment processes.

These novel ways should be implemented into the planning and implementation of any new facilities expected to deal with industrial or municipal organic wastes. In such arrangements, the microbes are circulating beside the substances and the chemical energies bound to them. This makes the emissions, their climatological consequences, and environmental burden decline.

The ABOWE piloting has revealed the potential of total planning in biotechnical waste utilisation and bioprocess design. For instance, the residues from the Pilot A type of biorefinery could be effectively used as materials in the Pilot B type of dry digestion biogas unit. Any solid fractions could then be used as organic fertiliser, composted or combusted, depending on the type of the particular fractions. Gaseous emissions could be at least partially redirected into the biorefinery, with the recollection of their thermal and chemical energies. The carbon oxides, for example, could then be bound into the biomass in the Pilot A type of biorefinery.

In recycling the biomasses from industrial, municipal or agricultural sludges, the microbial cell mass load to the environment could be restricted, as the microbial biomass is being reused effectively in the combined biorefinery, biogas production, organic fertiliser output and combustion operations. This would further lower the effects of human activities on ecosystems.

Future plans: three pilot plants

One future idea is to combine upstream process (Pilot A) with a parallel downstream operation(s). This helps to avoid biological regulation mechanisms of the production organisms, since the products are recovered at the same time as they are formed into the process broth or suspension. Fig. 2 depicts the process.

Various biomass rounds need to be re-circulated in the process after the valuables have been collected from them. The entire bioprocess is operated in a continuous or semi-batch mode. This new level of functionality

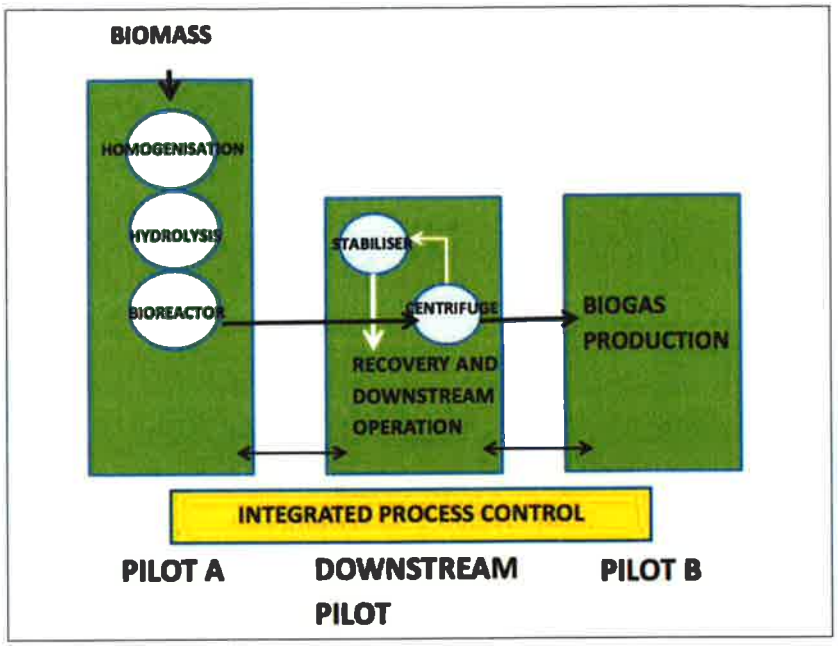


Fig. 2 Combining Upstream Biorefinery (Pilot A), Downstream processing and Biogas production (Pilot B) – Schematic presentation by Dr Elias Hakalehto

requires more advanced planning, selection, and construction (for example of the pumping and other technical equipment), as well as process control systems where the recovery operations for the downstreaming have to be interlinked with the real-time data on the product formation.

As a result, practical solutions where any biomass waste can be converted into valuable energy products, chemical raw materials, or fertilisers can be obtained. Thermal energies are also produced in the process. In the heart of the operations is the consolidation of up and downstream processes under effective automation and operator control. The human factor as the supervisor for the system is required during the runs with biological materials whose behaviour cannot be fully predicted.

Besides achieving this scientifically ambitious objective, the solution also has to be economically feasible and viable in order to obtain the desired objectives of 'valuable products'. Therefore, various sophisticated data-analysis and processing methods must also be used in combination with the ones previously described. In the future, industries will be interlinked with the agriculture and housing sectors on the basis of the networks of circulating substances and of liberating chemical energies, as well as in reducing the gas emissions.

References on the background of Pilot A were provided in the March 2015 edition of this publication.

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