PFI Biotechnology

OptiCell Project

More Biogas from Alternative Feed-stocks

The search for alternatives to maize and other energy plants is currently a hot topic in the biogas sector. High prices and an increasingly critical public opinion are prompting plant operators to re-think their position. Moreover, amendments to the German Renewable Energy Sources Act (EEG) demand new substrates, for example perennial grasses, cup plant (Silphium perfoliatum), or tall wheatgrass (Agropyron elongatum). Many plant operators are switching to residual and waste products such as agricultural by-products like green waste, straw, manure, or poultry dung, which can prove to be challenging for process engineering and process biology. High cellulose contents, nitrogen load, and in some cases a very high degree of lignification have a detrimental effect on the degree of degradation and process stability. This is where the OptiCell Project comes in: Pre-treatment of the substrate at temperatures in excess of 60 °C is reported to enhance the growth and activity of particularly effective cellulose-degrading bacteria and to attain a greatly improved degree of degradation of the substrates.

New Substrates as Alternatives to Energy Plants

The German biogas sector currently faces enormous challenges. Among other things, this has to do with the amendment of the German Renewable Energy Sources Act (EEG), which is making economic plant operation on the basis of classical substrates, especially energy plants such as maize and cereal crops, increasingly difficult. In addition, in the years to come many of the existing plants will no longer comply with legal requirements although they did so when they were commissioned.

A change to the currently valid tendering model offers a prospect for continued operation. Yet even these plants will be compelled to turn to alternative substrates owing to future reduced feed-in tariffs and other regulations (including a maximum maize content of 51 percent); it was precisely because of the high percentage of maize used in agricultural biogas plants that acceptance of energy production from biomass proved so problematic (“food versus fuel” controversy). The use of alternative substrates is therefore of key importance for the future of biogas production and for continued operation of existing plants in Germany (there are currently about 9200 agricultural biogas plants in the country).

Compared to maize and other energy plants, many alternative substrates contain relatively large amounts of cellulose and hemicellulose. That applies to various grasses (perennial grasses, cup plant, or tall wheatgrass), to residual and waste materials (including landscape conservation materials) as well as to straw-containing farm manure (from cattle, turkeys, and chickens). These substrates typically have a significantly lower specific biogas potential than

maize. The above-mentioned grasses also have a significantly lower yield per unit area. Particular importance therefore attaches to the development and optimisation of processes for increasing the extent of degradation of cellulose-rich substrates.

Improved Degree of Degradation by "High-temperature Hydrolysis"

The goal of the OptiCell Project is to significantly improve the degree and rate of degradation of cellulose-rich substrates by subjecting them to a special thermophilic pre-hydrolysis. Here the hydrolysis stage has been specially designed to increase the cell counts and the activities of particular cellulose-degrading bacteria.

Operation of the hydrolysis stage in the temperature range of 60 to 70 °C is intended to greatly reduce the activity of methanogenic archaea and other non-hydrolytic bacteria. Cup plant, tall wheatgrass, and grass from landscape conservation were studied as model substrates in this project.

Cup plant (Silphium perfoliatum) (Photo: FNR / Zdenka Hajkova)

Cup plant and tall wheatgrass are examples of perennial plants which place relatively modest demands on their growing conditions yet give high biomass yields per hectare. Moreover, the long flowering period of the cup plant, which extends from June to September, provides a supply of pollen and nectar for bees and other insects.

These substrates are therefore interesting alternatives to maize although their specific methane yields are 15 to 35 % lower. Grass from landscape conservation represents a cellulose-rich residual material with a low biogas potential.

A successful outcome of this project would indicate that the process is also applicable to other poorly degradable substrates and residues.

Tall wheatgrass (Agropyron elongatum) (Photo: Landwirtschaftliche Lehranstalten Triesdorf)

In order to assess the practical viability of the newly developed process a scale-up to the engineering laboratory scale is envisaged. The experimental plants in PFI's engineering laboratory permit experiments to be performed under near real-life conditions (Fig. 1).

Fig. 1: Static fermentation test (above) and automated continuous fermenter on a 100-litre scale (below) in the PFI engineering lab

The extent to which certain particularly effective bacteria could be isolated from the hydrolysis mixture and cultivated was also examined. Starter cultures could be developed on this basis for subsequent inoculation of hydrolysis stages.

Experiments were conducted on a pilot scale in the engineering laboratory to determine the principal process engineering parameters and characteristic data. These will provide a basis for analysis of the technical and economic feasibility. Both implementation of the process in new plants and retrofitting of existing plants are considered.

Further information:
Dr. Stefan Dröge
Head of Biotechnology and Microbiology Department
Tel: +49(0)6331 24 90 846
E-Mail: stefan.droege@pfi-germany.de

The industrial cooperative research (IGF) project reported here is funded by the Federal German Ministry of Economics and Energy through the German Federation of Industrial Research Associations (AiF) under the funding code 43 EWN. Responsibility for the content of this publication rests solely with the author.