Renewable energy

Lectures

L5.1

Biogas plant in the biorefinery concept

Janusz Gołaszewski

Centre for Renewable Energy Research of the University of Warmia and Mazury in Olsztyn; Baltic Ecoenergy Cluster in Gdańsk, Gdańsk, Poland
e-mail: Janusz Gołaszewski <janusz.golaszewski@uwm.edu.pl>

Agro-biotechnology and agro-bio-chemical sciences will play a crucial role in building the future bioenergy portfolio and the resulting bio-based industry, which means that biotechnologists and chemists will focus their research on efficient processes of energy bioconversion from renewable resources and will support developing biomass-based product lines for industrial and agricultural sectors in an efficient and sustainable way. Being confronted with limited and successively depleted reserves of fossils, it is high time to reorient research from petro-chemical conversion processes to bio-chemical ones. Many processes of converting biomass to energy and bioproducts were developed but during the industrial era, due to the enormous pressure on fossil conversion, they have not been implemented. Implementation of the concept of a biochemical refinery (or a biorefinery) as an analogue to a petrochemical refinery is a challenge for the present time. The philosophy of a biorefinery is quite simple. It is a facility which produces a spectrum of bioproducts, including intermediates, bioenergy and biofuels, and all the biorefinery products contribute significantly to the global economy. As a result, a new market of bioproducts appears, which will require a special economic approach that will consider all and any elements of sustainable development, including environmental and social aspects. In other words, it will need a bio-based sustainable economy or simply bio-economy.

Two hypotheses related to development of the biorefinery concept have been stated in this paper: 1) sustainable development needs sustainable energy, and 2) sustainable energy needs sustainable agriculture. Both are discussed in the context of bioconversion products and agri-energy complexes, including such facilities as a biogas plant, as well some elements of biorefinery production.

In the conclusions it was stated that (i) biomass has a chance to be the main source of energy in the 21st century but it needs some changes in agriculture (ii) biogas plant is an environmental necessity and (iii) biorefinery — biofuels today, but the goal is to maximize the value of biomass.

L5.2

Reneweable energy sources in agriculture

Mariusz Matyka, Jan Kuś

Institute of Soil Science and Plant Cultivation - State Research Institute in Puławy, Department of Systems and Economics of Crop Production, Puławy, Poland
e-mail: Mariusz Matyka <mmatyka@iung.pulawy.pl>

Increases oil price and growing concerns about the national security implications of country dependence on foreign energy sources together with concerns about the threat of global climate change caused by fossil fuel use have created a momentum for developing domestic, renewable energy sources [1, 2]. One of important renewable energy sources is biomass especially from agriculture. In last years, the interest in biomass energy has increased considerably worldwide. There are several reasons for this: biomass is widely available and it has the potential to produce modern energy carriers such as electricity and liquid transport fuels that are clean, convenient and easily used in the present energy supply system. Biomass energy can also by produced in a carbon-neutral way and can contribute to (local) socio-economical development [3]. The lecture will be presented the potential of biomass from agriculture in Poland. Also there are characterized the basic agricultural raw materials usable for energy purposes. It will be determined usefulness and the selection of crops species for soil conditions and their agronomic requirements. The whole is complemented by economic analysis specifying the cost-effectiveness and competitiveness of this new direction of agricultural production. It will by presented environmental and social controversies related to renewable energy sources. Will also signaled the possibility of utilization renewable energy in farms. Presented information's allow to the characterization of renewables in the context of their opportunities for development in agriculture.

References

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L5.3

Conversion of biomass to solid biofuels

Jarosław Frączek, Bogusława Łapczyńska - Kordon, Krzysztof Mudryk, Marek Wróbel

University of Agriculture in Krakow, Faculties Production and Power Engineering, Kraków, Poland
e-mail: Marek Wrobel <mrkwrobel@interia.pl>

Biomass resources include three sources of biomass. Primary biomass resources are produced directly by photosynthesis. They are taken directly from the land and include perennial, short-rotation woody plantations, herbaceous crops, the seeds of oil crops, and residues resulting from the harvesting of agricultural crops and forest trees (e.g., wheat straw, corn stover, bark from trees ect.). Secondary biomass resources result from the processing of primary biomass resources either physically (e.g., the production of sawdust in mills), chemically (e.g., black liquor from pulping processes), or biologically (e.g., manure production by animals). Finally tertiary biomass resources are post-consumer residue streams including animal fats, used vegetable oils, packaging wastes, and construction and demolition debris.
Biomass utilization through direct combustion or combustion with coal is simultaneously cheap solution. Production of heat and electricity in cogeneration process in biomass fueled heat and power stations, need higher investment costs, but considering fluidized combustion, combined heat and power cogeneration systems, etc. the efficiency increases as well as the economical and ecological effects improve.
Because of specific properties of biomass, especially low bulk density, transport through far distances is unprofitable. Therefore energy plantations and other biomass sources should be placed in a radius of 100 km from energy adaptive plant. To increase the area, from which biomass will gain economically justified, it is necessary to its densification. In this process, there are various techniques that allow to obtain solid biofuels as briquettes or pellets. Despite the large variety of equipment, the final product must have high quality.
This paper includes review of present modern technologies densification of biomass to form of briquette and pellet. Were discussed the advantages and disadvantages of different solutions. The article presents also an overview of existing quality standards for biomass and solid biofuels.

L5.4

Energy use of solid biomass in Poland — problems and solutions

Adam Guła[1,2], Tomasz Mirowski[1], Anna Polak[1,2]

[1]AGH University of Science and Technology, Kraków, Poland; [2]The Krakow Institute of Sustainable Energy, Kraków, Poland
e-mail: Adam Guła <gula@agh.edu.pl>

It is argued that the present practice of using biomass for power generation contradict the very goal it is assumed to achieve, as it leads to either: (i) a net increase of CO_2 emissions or (ii) largely suboptimal emission reduction compared with other possible ways of using the available biomass resources for energy purposes. It is shown that using biomass locally for heat production in small-to-medium installations is much more efficient from the environmental point of view and involves much lower costs. Such installations can satisfy their fuel needs by using supplies from an area of a small radius, i.e. their "embedded" transportation emissions are lower than in the case of bringing it to power stations, typically from distances exceeding 300–500 km or, very often, from thousands of kilometers. If the life-cycle emissions criterion were introduced to reward the energy industries for the environmental effect of burning biomass, which is actually done by the existing financial instruments, based on "end of pipe" calculations, many of the present investments would have no economic justification. Results obtained using the Altener model, Invert show that, if only a fraction (ca 4%), of money used to support electricity production from biomass were transferred to farmers to help them cover part of the costs of their biomass investment, the demand for individual biomass boilers (in the range of 20–100 kW) would grow sharply, and the same amount of public money would give an environmental effect about 25 times larger. In this connection it is suggested that "Green Heat Certificates" are introduced and granted the same status as the "Green Electricity" ones. However, the problem faced in Poland is that millions of Euro have already been channeled in the "Green Electricity" investments, which are senseless from environmental point of view. A growing number of experts claim that this practice should be stopped as soon as possible, because the volume of the potential stranded costs grows very quickly.

Posters

P5.1

The effect of alkali pretreatment of lignocellulosic substrates on the conversion of polysaccharides to fermentable sugars

Magdalena Świątek, Małgorzata Lewandowska, Włodzimierz Bednarski, Karolina Świątek

Chair of Food Biotechnology, University of Warmia and Mazury in Olsztyn, Olsztyn, Poland
e-mail: Magdalena Świątek <magdalena.swiatek@uwm.edu.pl>

The use of lignocellulosic biomass for the production of biofuels will be essential if fossil fuels are to be substituted by renewable and sustainable alternatives. Utilization of lignocellulosic materials as a source of renewable energy could help to enhance energy security, significantly reduce greenhouse gases emission and improve prices stability. Pretreatment of lignocellulosic substrates, which involves cellulose amorphization, removal of lignin and breaking of hemicellulose structures affects the course of subsequent technological stages and determines the final efficiency of the process of bioethanol production.

This work presents research evaluating the effect of pretreatment of lignocellulosic materials on the effectiveness of their enzymatic hydrolysis. Two kinds of material were used: rape straw and *Miscanthus giganteus* biomass. Numerous attempts of pretreatment were performed with different process conditions: proportion of alkali 0.1÷0.15 g/g d.m. of substrate, temperature 72÷170ºC and time 1÷6.6 h. The effectiveness of the pretreatment methods was evaluated on the basis of the amount of reducing sugars released during subsequent 72 h enzymatic hydrolysis with the use of a fixed composition of enzymes. Two experiments of control hydrolysis of untreated materials were also conducted.

The efficiency of 72 h enzymatic hydrolysis of untreated materials was relatively low — 15.2% for *M. giganteus* and 13.8% for rape straw (on the basis of cellulose and hemicellulose content in raw materials). Materials after alkali pretreatment were more susceptible to enzymatic hydrolysis than untreated, resulting in 3.3÷4-fold and 2.7÷3.4-fold higher efficiency, for *M. giganteus* and rape straw, respectively. The highest conversion efficiency was obtained when *M. giganteus* was pretreated under conditions: temperature 121ºC; time 1.5 h; 0.1g NaOH/g d.m. of substrate and rape straw: temperature 170ºC; time 1.5 h; 0.1g NaOH/g d.m. of substrate. Under these conditions the concentration of released reducing sugars (expressed as glucose) was 49.5 g/dm^3 and 32.4 g/dm^3 of reaction medium and this was 61.6% and 47.5% of theoretical value, for *M. giganteus* and rape straw, respectively.

The results of the conducted research show the necessity of pretreatment in utilization of lignocellulosic substrates. The conditions of alkali pretreatment should be experimentally adjusted to the properties of the lignocellulosic material used, depending on the chemical composition and ripeness degree.