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Bob Skelton, Stephen Etheridge. *Special Issue Energy from Waste*. Pages 155-156.

Jorge M. Marchetti. *A summary of the available technologies for biodiesel production based on a comparison of different feedstock's properties*. Pages 157-163.

Biodiesel production is mainly done by carrying on the transesterification reaction while using refined oil, methanol and a homogeneous base catalyst. When using refined oil, a competition between oil for food and oil for fuel is then presented. Even more, the conventional technology has the disadvantage that the raw material has to be very pure, with no traces of other impurities. Otherwise, undesirable products will be produced decreasing the productivity of the process and making a large amount of waste treatment.

Because of this, other technologies appear as possible sources for biodiesel production, mainly from refined oil, but also allowing less pure raw material to be used, such as waste oil, frying oil, soapstocks, and animal fats.

In this work, a comparison of all these different raw materials, their physicochemical properties and how they can have an influence, and the magnitude of this phenomenon, in the biodiesel production will be presented and compared. Based on the previous analysis, a short summary of the technological possibilities to produce good quality biodiesel from low price raw material will be discussed with the aim of showing their advantages and disadvantages when using different feedstocks.

Highlights: ► Different processes for biodiesel production have been compared based on the quality of the raw material. ► The major vegetable oils physical–chemical properties have been presented due to the quality of the oil. ► The biodiesel composition and properties based on the original vegetable oil was presented.

- **Keywords:** Biodiesel production; Edible and non-edible oils; Technological process

Basheer Hasan Diya'uddeen, A.R. Abdul Aziz, W.M.A.W. Daud, M.H. Chakrabarti. *Performance evaluation of biodiesel from used domestic waste oils: A review*. Pages 164-179.

Global warming, high-energy demand and availability of new technologies are among the factors catalyzing the search for alternative sources of energy. Currently, there is renewed interest in obtaining energy from wastes hitherto meant for disposal. Increased costs of disposal and their attendant problems of heavy environmental loading are some aspects making the disposal option unattractive. These wastes are sources of energy and among the several sources of generating this energy are the waste-to-energy (WTE) categories with potentials for useable fuel production. The WTE materials are mainly used domestic waste oils (UDWOs), municipal solid waste (MSW), agricultural and industrial wastes. However, the latter wastes are not attractive as they consist of innumerable hazardous contaminants. The UDWOs are arguably a safe and cost effective source of useable fuel. Their conversion offers the merits of a reduction in greenhouse gas emission (GHG), enhancing fuel diversification and a qualitatively comparable energy output to fossil diesel fuels. Thus, UDWOs could significantly contribute towards achieving the 2020 and 2030 goals of substituting approximately 20% and 30% of petro-diesel with biofuels in US and EU, respectively. Moreover, attaining the forecasted annual production rate of 227 billion liters of biofuel by most active stakeholders in the biodiesel industry could be easily achieved.

This review aims to analyze the performance of biodiesel fuels obtained from UDWO and to demonstrate the suitability of applying these fuels as substitutes to mineral diesel in various industries. Benefits of UDWO as a biodiesel feedstock were as well highlighted.

- **Keywords:** Biodiesel; Biodiesel feedstock; Used domestic waste oil; Waste treatment

John McNeil, Paul Day, Felix Sirovski. *Glycerine from biodiesel: The perfect diesel fuel*. Pages 180-188.

Glycerine supply currently exceeds its demand by a significant margin as it is formed as by-product in biodiesel production. Different routes for its utilisation are currently being looked into, especially ones that would allow its use as a fuel addition. However these routes are not as energy efficient as its direct combustion.

Previously glycerine and other very low cetane number calorific liquids were thought impossible to be used as fuels in compression ignition engines. We have developed a combustion cycle that permits the utilisation of glycerine as a fuel in a compression ignition engine without the need for pilot fuels or cetane improving additives. The paper discusses the results of glycerine combustion in standard unmodified Lister-Petter and Deutz compression ignition engines.

- **Keywords:** Glycerine; Combustion; Compression ignition engine; Emissions

Carolina Conde-Mejía, Arturo Jiménez-Gutiérrez, Mahmoud El-Halwagi. *A comparison of pretreatment methods for bioethanol production from lignocellulosic materials.* Pages 189-202.

Lignocellulosic materials, which consist mainly of cellulose, hemicellulose and lignin, are among the most promising renewable feedstocks for the production of energy and chemicals. Bioethanol is a major biofuel that can be produced from lignocellulosic materials. Its production typically involves a hydrolysis-fermentation route, which has three main steps: pretreatment to get fermentable sugars, fermentation to produce bioethanol, and a separation process to obtain highly concentrated bioethanol. The pretreatment step has been recognized as a technological bottleneck for the cost-effective development of bioprocesses from lignocellulosic materials. In this work we analyze the potential of several pretreatment methods for bioethanol production from lignocellulosic materials. Simulations based on stoichiometric relations and yield data

were conducted to evaluate the energy requirements of each pretreatment method. Other parameters were also considered such as the cost of chemicals, consumption of water, and constraints on the composition of inhibitors. Performance benchmarks were identifies using targeting techniques and these benchmarks were used to assess the actual performance of the alternatives. The combination of the evaluated parameters with target production values obtained from reported yields served as the basis for identifying the most promising pretreatment options and for defining areas of opportunities. This approach uses limited information, but it provides reliable results in order to reduce the number of pretreatment alternatives. The target production usage gives an estimation of the global process efficiency without the completed flowsheet defined.

Highlights: ► Lignocellulosic materials are promising renewable feedstocks for the production of chemicals and energy. ► Bioethanol production requires three main steps, pretreatment, fermentation and separation. ► In this work, several pretreatment methods for bioethanol production from lignocellulosic materials are compared. ► The impact of process integration is analyzed. ► The most promising pretreatment methods are detected.

- **Keywords:** Bioethanol; Biorefineries; Pretreatment; Energy; Fermentation yields

George M. Hall, Joe Howe. *Energy from waste and the food processing industry*. Pages 203-212.

The provision of a secure, continuous energy supply is becoming an issue for all sectors of society and the food processing industry as a major energy user must address these issues. This paper identifies anaerobic digestion as an opportunity to go some way to achieving energy security in a sustainable manner. However, a number of energy management and waste reduction concepts must also be brought into play if the environmental, social and economic aspects of sustainability are to be balanced. The reporting of such activity will help to promote the green credentials of the industry. Cleaner production, supply chain and life cycle assessment approaches all have a part to play as tools supporting a new vision for integrated energy and waste management. Our reliance on high-energy processing, such as canning and freezing/chill storage, might also need re-assessment together with processing based on hurdle technology. Finally, the concepts of energy and power management for a distributed energy generation system must be brought into the food processing industry.

- **Keywords:** Anaerobic digestion; Energy management; Life cycle assessment; Supply chain

Ruby Ray, Richard Taylor, Chris Chapman. *The deployment of an advanced gasification technology in the treatment of household and other waste streams*. Pages 213-220.

The Gasplasma® process developed by APP is an advanced thermal conversion (ATC) technology which has been developed for the treatment of household and trade wastes and has also been successfully applied to the handling of wastes derived from landfill and would be capable of achieving effective energy conversion when utilised as an integrated part of the Enhanced Landfill Mining (ELFM) concept.

The core Gasplasma® technology comprises a two-stage thermal treatment system—firstly, a fluidizing bed gasifier which converts the wastes to a crude syngas using oxy-

steam and, secondly, a plasma converter that efficiently cracks problematic tars in the raw syngas to produce a reformed and clean syngas suitable for generating electrical power in gas engines and also recovering an environmentally stable vitrified product for use as a secondary aggregate material. The utilization of oxy-steam as a gasifying agent greatly reduces the syngas volume compared to other ATC processes and incineration and hence reduces the cost of the gas cleaning system while improving the efficiency of the process. By adopting this two-stage approach, high energy conversion (74–90%) and carbon conversion (95 ± 1.6%) efficiencies were achieved with the Gasplasma® plant that compare favourably with published efficiencies data. The calculated net exportable power generation efficiency for a commercial scale plant is significantly in excess of 25%. This compares well with the published figures of 17.7–23% for fluidized bed technologies processing MSW.

Highlights: ► The Gasplasma® process is designed to treat household and trade wastes. ► It can also be successfully applied to treat wastes derived from landfill. ► Produce syngas suitable for power generation or use as chemical precursor. ► Conversion efficiencies >92% for carbon and >85% for energy. ► Net electrical efficiency is constantly above 25% for the prepared waste.

- **Keywords:** Plasma gasification; Oxy-steam; Thermal efficiency; Slag vitrification; High energy conversion; Advanced thermal conversion technology

Yen-Hui Lin, Hong-Xiang Zheng, Mu-Ling Juan. *Biohydrogen production using waste activated sludge as a substrate from fructose-processing wastewater treatment*. Pages 221–230.

Biohydrogen production by dark fermentation in a series of batch tests under different environmental control conditions was evaluated to determine the optimal initial cultivation pH and temperature for a continuous-flow kinetic test to validate the kinetic model system. The waste activated sludge (WAS) from fructose-processing manufacturing was used as the model substrate for biohydrogen production. The batch experiments for biohydrogen production were conducted in a 6 l bioreactor. Fifteen batch kinetic tests were investigated when pH was controlled at 6, 7, 8 and 9 as well as the temperature was controlled at 37 °C, 45 °C and 55 °C, respectively. The experimental results indicated that the optimal operational condition for hydrogen production occurred while pH was 7 and temperature was 55 °C with the highest hydrogen production of 7.8 mmol. The optimal recovery time for hydrogen was 25 h in the batch experiments. Furthermore, the kinetic test of biohydrogen production was performed by anaerobic mixed microbial culture in the continuous-flow experiment when pH and temperature was maintained at 7 and 55 °C. Approximately 60% and 7% of substrate solution was converted into acetate and hydrogen, respectively, at the steady state. Roughly only 0.77% and 2.7% of substrate solution was converted into propionate and butyrate, respectively, at a steady-state condition. The experimental and modeling approaches presented in this study could be employed for the design of pilot-scale and full-scale anaerobic biohydrogen fermentors using food-processing waste activated sludge (WAS) as a substrate solution.

- **Keywords:** Biohydrogen production; Waste activated sludge (WAS); Fructose-processing; Batch experiments; Continuous-flow experiment

J. Hunter Long, Tarek N. Aziz, Francis L. de los Reyes III, Joel J. Ducoste. *Anaerobic co-digestion of fat, oil, and grease (FOG): A review of gas production and process limitations*. Pages 231-245.

The addition of readily available high strength organic wastes such as fats, oils, and grease (FOG) from restaurant grease abatement devices may substantially increase biogas production from anaerobic digesters at wastewater treatment facilities. This FOG addition may provide greater economic incentives for the use of excess biogas to generate electricity, thermal, or mechanical energy. Co-digestion of FOG with municipal biosolids at a rate of 10–30% FOG by volume of total digester feed caused a 30–80% increase in digester gas production in two full scale wastewater biosolids anaerobic digesters ([0035] and [0330]). Laboratory and pilot scale anaerobic digesters have shown even larger increases in gas production. However, anaerobic digestion of high lipid wastes has been reported to cause inhibition of acetoclastic and methanogenic bacteria, substrate, and product transport limitation, sludge flotation, digester foaming, blockages of pipes and pumps, and clogging of gas collection and handling systems. This paper reviews the scientific literature on biogas production, inhibition, and optimal reactor configurations, and will highlight future research needed to improve the gas production and overall efficiency of anaerobic co-digestion of FOG with biosolids from municipal wastewater treatment.

Highlights: ► Description of FOG generation and disposal options. ► Discussion of high rate anaerobic technologies and its relevance to anaerobic co-digestion of FOG. ► Summary of results of effective co-digestion implementations. ► Highlight critical areas needed for future research.

- **Keywords:** FOG; Anaerobic digestion; Methane; Wastewater; Grease; Biogas

M. Dellavedova, M. Derudi, R. Biesuz, A. Lunghi, R. Rota. *On the gasification of biomass: Data analysis and regressions*. Pages 246-254.

The use of solid wastes as a way to produce energy and chemicals is one of the frontiers in chemistry. One of these methods is the biomass gasification. In this thermal treatment the biomass is heated in a partially oxidising environment using different process conditions.

The variability of both biomass composition and process conditions can lead the thermal treatment to several different results. In order to find a methodology for the classification of all the involved data a dataset containing biomass characterization, gasification process conditions and obtained syngas properties have been gathered from the literature.

This dataset has been analysed through multivariate analysis. Principal component analysis (PCA) and a partial least square analysis (PLS) have been performed. Several correlations among different biomass and their gasification products have been found among input parameters, such as biomass properties and process conditions, and output variables like products composition and properties.

Highlights: ► Literature data of biomass gasification were analysed through multivariate analysis. ► Biomass composition and process conditions were considered as independent variables. ► Syngas composition and properties were considered as dependent variables. ► Several correlations among different biomass and their gasification products were found. ► The steam to biomass ratio (SB) and the syngas characteristics were strongly related.

- **Keywords:** Biomass; Gasification; Multivariate analysis; PCA; PLS

C. Patel, P. Lettieri, A. Germanà. *Techno-economic performance analysis and environmental impact assessment of small to medium scale SRF combustion plants for energy production in the UK*. Pages 255-262.

This paper investigates a techno-economic analysis on small and medium scales: 50 kilo tonnes per annum (ktpa) and 100 ktpa combustion plants with steam turbine technology utilising solid recovered fuel (SRF). Energy and efficiency calculations for the technical assessment are performed. The economic viability of the two processes is investigated through a discounted cash flow analysis. The levelised cost is used to calculate the cost of production of one unit of electricity. A life cycle assessment (LCA) of the 100 ktpa scale SRF plant is performed, where the foundations of LCA calculations reside in energy calculations carried out for the technical analysis. Life cycle inventories were developed using inventory analysis and impact assessment. The results of the LCA are compared with those from equivalent scale coal, natural gas and electricity-mix plants. The LCA is also compared with a landfill reference system. Both scales are economically and technically viable. The SRF plant has a lower global warming potential emission (*EGWP*) compared with the coal, natural gas and electricity-mix plants and the reference landfill system.

Highlights: ► We examine two combustion plants for energy recovery from solid recovered fuels SRF. ► We perform a techno-economic and environmental assessment of the plants using LCA. ► Environmental burdens are compared with coal, natural gas and electricity-mix plants. ► SRF combustion is environmentally promising compared with non renewable alternatives.

- **Keywords:** Solid recovered fuel; Combustion; Life cycle assessment; Techno-economic analysis

Zsófia Fodor, Jiří Jaromír Klemeš. *Waste as alternative fuel – Minimising emissions and effluents by advanced design.* Pages 262-284.

This paper reviews the utilisation of waste as an alternative fuel, commonly referred to as Waste-to-Energy (WTE). The paper contains a comprehensive survey of the literature published in this field with comparative analysis of different approaches and methods. The main features and properties of municipal and industrial waste have been analysed as these can vary significantly from location to location and year to year. The paper discusses the applicability and limitations of current and developing WTE technologies as well as new and emerging WTE technologies and the recent developments in design of for producing heat, power and fuels. Methodologies that are considered include criteria for technology selection, together with procedures that comply with the environmental EC regulations Best Available and Best Applicable Techniques (BREFs).

Highlights: ► The main features and properties of waste as a fuel (Waste to Energy – WTE). ► The role of EU guidelines and LCA methodologies. ► Municipal and industrial solid waste and sludge have been analysed. ► The recent developments in design and technologies of waste treatment are discussed.

- **Keywords:** Waste to energy; Minimising emissions and effluents; Environmental regulations; Advanced design