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BIOMASS – A SOURCE OF CHEMICALS AND ENERGY FOR SUSTAINABLE DEVELOPMENT

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Abstract

Nowadays, energetic utilization of biomass, biotechnology attracts a big attention not only from the environmental point of view but also have a social, political and economical impact. According to the Directive 2003/30/EC of the European Parliament and the European Council the emission of greenhouse gases can be reduced by 49% using bioethanol produced by a manufacturing process based on corn, instead of crude oil based fuels. Moreover in Hungary from 1st of July 2007 only gasoline with at least 4.4% bioethanol content is commercialized. In this article, some concrete examples of successful developments and/or implementation of biomass projects in Hungary are given such as: production friendly raw synthetic material at "Nitrokémia" chemical plant, manufacture of bioethanol by "Hungrana" and "Győr Distillery" companies, bio-ethyl-tert-buthyl-ether production by MOL Pls. Danube Refinery, research on new generation of biofuels.
The main advantages and disadvantages as well motivations for further research and development of Hungarian bio-industrial and bio-consumer sectors are discussed.

Keywords: agrorefinery, biorefinary, biofuels, environmental friendly materials, Hungarian bio-industries

1. Hungarian developments of biomass projects

Recently, the utilization of the renewable energy sources can hardly reach a ratio of 3.6%. Simultaneously, renewable energy sources get more and more important role in the national energy-policy. By the year of 2010, 3.6% of electric power and 6-7% of the total energy is planned to come from renewable resources. This requires the energetic utilization of biomass in the first place. Previously, the use of mainly primer-biomasses (wood and agricultural waste from agricultural areas) was typical.

During the first phase, in 1980s, there were large improvements in the Hungarian wood processing and agricultural plants. A total capacity of 100 MW heat power had been established, based on burning solid biofuels (wood waste, agricultural residuals). In the second period of program development, improvements began to be made in public heat supply system. Woodchip-based small and medium scale heat plants were built, with a total capacity of 40 MW. In the past 5 years, there was no significant development in heat production. Furthermore - because of the special economical conditions of public heat supply - the profitableness of wood-chip based heat power has been decreasing.

As a result of the changes occurred in the Hungarian wood industry and agricultural plants, some biomass-based heat power plants were closed.

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At the same time, a most meaningful development has begun in electric power production on wood base. Between 2003 and 2005, three of the former coal-based power plants had been changed over to wood-chips. Their total capacity is 100 MW.

The waste heat generated in the process of power production is used in public heat supply. The fuel-demand of the tree power plants is about 800 000 t/year energy-wood. By the building of these plants, Hungary made a large step ahead in the "green" development of the national energy-sector.

In the next period, large improvements are expected. With regard to the EU-regulation on renewable sources, the right valuation of biomass-based energy production and its correct recognition (as a way of contribution to proper land use, rural development, new places of work, etc.) may be realised in the near future in Hungary. In the developments advised by the scientists, the utilization of secondary and tertiary biomasses is also included.

The results of analyses show that Hungary has a large potential of biomass, which can be even enlarged by growing energy plants (wood and other agricultural products). Besides, there is a major potential of secondary and tertiary biomass sources. The role of the technologies by which waste problems can be also solved (e.g. biogas production from waste biomass), is also expected to grow. The recently available biomass would be enough to reach the ratio of 12% of it in the domestic energy supply. In the long term, even the ratio of 17-20% seems to be realistic (Marosvölgyi and Vityi, 2004).

2. Agriculture for industry: the agrorefinery

Hungarian agriculture can increase its output in industrial feedstock in two ways, by:

1. The promotion of existing agro-feedstock, mostly by improving the quality and decreasing the costs. However, this, in general, will not lead to any breakthrough, but may only result in a slow growth of the markets.
2. The development of completely novel kinds of feedstocks, including the required infrastructure.

Usually a crop, „as it is ", will not be applicable for industrial use. Industry is only interested in a certain part, or in a chemical or physical component of the crop, which therefore has to be processed in the agrorefinery. The different „fractions" produced by the agrorefinery are to be sold to various industries, or partially recycled to agriculture, as cattle feed or as organic fertilizer.

The feedstock prepared for industrial application may be chemicals (bulk chemicals like oils, carbohydrates, rubber and gums and fine chemicals like essential oils and intermediates for chemical specialties, pharmaceuticals, pesticides and special polymers) or physicals (like fibres for textile, papermaking pulp, as a major reinforcement element in „wood extenders", like fibreboard, building materials etc., or as a filter in rubber, plastics, adhesives and printing ink).

Biopolymers for industrial programmes have been developed by the University of Pannonia.

Depending on its „function", the agrorefinery may apply simple mechanical and physical processes and may operate on a large scale. Occasionally, the first phase of the processing may begin with mobile total harvesting units, pretreating the crop in the field, separating fractions of interest like crude juices, fibrous fractions etc., which can be transported efficiently to regional plants for further processing. The agrorefinery has to fill the gap between agriculture and the agroindustrial production chains.

The new Hungarian bio-based economy is being established under the following criteria: use of renewable bio-resources (mostly cereals), eco-efficient (bio)-processes and eco-industrial clusters. The latter ones, as the Integrated Regional Bio-refinery, will provide the basis for state, provincial and municipal governments which, together with the industrial and research communities, will stimulate innovation at a local level using local biomass feedstocks and capabilities. These clusters link local research organizations headed by the University of Pannonia in the Transdanubian Region of Hungary, they will provide the infrastructure for the development of bio-products consortia focusing on eco-efficient processing of biomass into an array of value-added bio-products, as a refinery does with petroleum. Special interest should be put in the Transdanubian region regarding the use of glycerol and lactic acid as platform chemicals from which many types of products could be obtained (glycerol esters, ethers and glycerol-carbonates, etc.). Additional (mostly SMEs) companies would co-locate to take advantage of cost savings and synergies with companies and research organizations already in the cluster. As a result, it would be easier for companies in the cluster to attract investment because of improved access to services, technology and opportunities for strategic alliances.

An integrated regional biorefinery model on “lactic acid platform” is under development by the University of Pannonia and the Basque Country Universities for the region using 200 000 t/year grain of wheat as feedstocks.

3. Implementation of biotechnology at “Nitrokémia” Chemical Plant

“Nitrokémia” industrial complex situated near to Lake Balaton was one of the most important Hungarian chemical plants in the last century. Nowadays the main strategy of the Nitrokemia, *Closed Share Company, by Hungary,* is the implementation of environmentally safe industrial technologies such as biorefinery. The biorefinery project aims at the manufacture of lactic acid, environmentally friendly raw synthetic material, obtained from bio-processing of national agricultural crops, for lactic ester solvents production with utilization of all technology by-products.

3.1. Advantages of the biotechnology

- bio-products are environmental friendly materials;
- wrapping material made from poly-lactic acid can be recycled;
- poly-lactic based materials are suitable for full substitution of existing wrapping materials made from PET, polyethylene, polystyrene;
- residues of the non-recycled wrapping material decompose into CO_2 and H_2O under ambient condition; the degradation time is about 3-4 months under composting conditions;
- the energy consumption for production of lactic acid is at least by 30 % lower than that one for production of concurrent synthetic materials;
- poly-lactic based solvents can replace existing toxic hydrocarbon solvents by non-toxic ones.
- the products can be utilized for biogas production and as a fertilizer for agricultural utilization.

3.2. Short description of applied biotechnology

The starch suspension for usage in saccharification is produced with wet separation of the gluten in flour processing unit connected to the mill. The bran obtained from milling of corn is utilized as an energy source. The glucose is produced with a help of lactic acid bacterium after the saccharification and the dissolution process of the starch suspension in the presence of enzyme. The lactic acid fermentation of glucose is achieved by ammonium hydroxide neutralization. The ammonium lactate solution of high purity is obtained by applied several stages separation method including micro-, ultra-, nano-filtration. The collected bacteria after filtration, dissolved proteins, oligosaccharides and other non recyclable by-products are used for biogas production. The three-stage evaporator is applied for concentration of filtrated ammonium-lactate solution. It should be mentioned that the concentrated ammonium-lactate itself is already a market product. The addition of butanol to the concentrated ammonium-lactate produces the butyl-lactate. The obtained solution is purified by the distillation process or could be converted to ethyl-lactate by esterification.

High purity lactic acid solution is generated by hydrolysis of butyl-lactate.

It is worth to mention that the polymer manufacturing is planned to produce up to 20 000 t/year biodegradable poly-lactic acid and the polymerization technology as well as whole polymer manufacture is ready for implementation.

Moreover, the water treatment facilities, the cooling system, bran remained from milling process and all liquid wastes for utilization in biogas production as well as the power facility for generating biogas are additional units of the biorefinery plant. The dehydrated sludge or bio-manure is another product of the biogas plant which can be used in the agriculture.

The chosen technology combines the advantages of existing processes. The technology developed allows establishing cost-effective production and can be used easily for further improvement of plant structure.

4. Production and utilisation of bioethanol in Hungary

In Hungary bioethanol is produced by two enterprises, the HUNGRANA Co. Ltd. (Szabadegyháza) and the Győr Distillery Co. Ltd. At the second one, 27-30 thousand tons of food quality alcohol is produced a year.

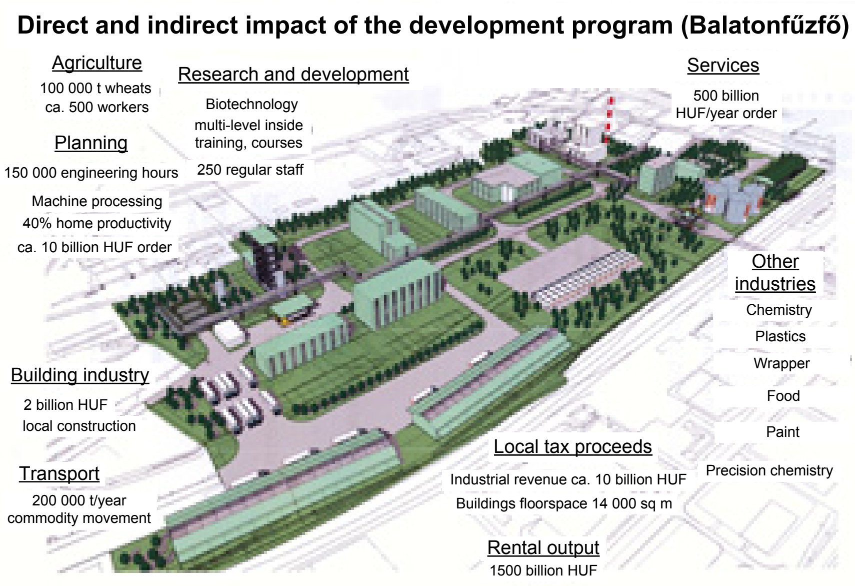


Fig. 1. The planned biorefinery plant in Balatonfűzfő

The Hungrana Co. Ltd., which is owned by the British Eaststarch and the Austrian Agrana-team in 50-50% ownership, produces principally starch, isosugar and alcohols from corn. The corn processing capacity of the plant, which was enlarged, updated and delivered in the summer of 2008, is more than 1 million t/year. From a part of this amount of corn, 135 thousands tons of bioethanol is produced. The rest of the products is mainly the starch (to food and packaging industry and to the production of corrugated paper) and the isosugar (that is the natural sweetening agent of soft drinks, milk and fruit products). From the corn cooking oil, from the high fibre and protein containing part of the corn forage can be produced. The Hungrana Co. Ltd. has the biggest isosugar quota of the European Union (27%, 220 thousand t/year).

One of the most important environmental programmes of the European Union is the reduction of the rate of consumption of fossil fuels. One of the possible solutions is the utilisation of bioethanol in transportation, which is dehydrated alcohol, produced from renewable organic material. The biggest environmental advantage of biofuels is that burning them does not result in extra carbon dioxide because during the reproduction of the plant it is consumed. Considering vehicles with average consumption and the complete process of alcohol production, by the utilization of bioethanol, the global carbon-dioxide emission can be reduced by 50% compared to the use of fossil fuels.

According to the operative European and Hungarian standards, bioethanol can be blended into the gasoline. One alternative (MSZ EN 228:2004) is the blending of low quantity alcohol, the other one is (MSZ CWA 15293) the E85 fuel, which approximately contains 85 % of bioethanol and 15 percent of gasoline.

In Hungary from the 1^{st} of July 2007 only gasoline with at least 4.4% bioethanol content is commercialised (In case of lower bioethanol content extra excise tax has to be paid). The bioethanol can be blended stand-alone or as a component part of molecule (e.g. bio-ethyl-tert-buthyl-ether). From the middle of 2005 the MOL Plc. Danube Refinery (Százhalombatta) produces 55 thousand tons of the latter.

According to the directive 2003/30/EC of the European Parliament and of the European Council the emission of greenhouse gases (GHG) can be reduced by 49% by using bioethanol produced by manufacturing process based on corn, instead of crude oil based fuels. The 49% is a basic value accepted by the EU, but by means of the favourable Hungarian agricultural facility and the front-rank manufacturing process of the Hungrana Co. Plc., the company in Szabadegyháza could realise more favourable GHG-savings, than the average value of 56% of the similar European plants. By the utilisation of 135 thousands tons of bioethanol produced, and the replacement of gasoline with the same energy content, the carbon dioxide emission of Hungary would be lower by some 150 thousand ton per annum.

4.1. Bio-ethyl-tert-buthyl-ether

In Hungary, Bio-ethyl-tert-buthyl-ether is produced at MOL Plc. Danube Refinery from the middle of the year 2005. The plant (55 thousands t/year capacity) had been established by the conversion of a former methyl-tert-buthyl-ether plant. The synthesis is carried out on acidic ion exchange resin catalyst under mild reaction conditions (<100°C, near atmospheric pressure), the feedstock is bioethanol and isobutylene from the C_4-fraction of the fluid catalytic cracking (FCC). Table 1 contains the properties of the bio-ETBE, of the ethanol and of an average gasoline.

The main performance advantages of bio-ETBE are:

- increase of octane number
- internal source of oxygen
- less soluble in water than ethanol
- emission reducing effect

Table 1. Properties of the bio-ETBE, of the ethanol and of an average gasoline

Property	***Gasoline***	***Bio-ETBE***	***Bioethanol***
Molecular mass, g/mol	-	102.18	46.07
Density (20°C), g/cm^3	0.73-0.77	0.747	0.7893
Boiling point, °C	30-220	71.7	78.5
Reid vapour pressure (37,8°C), kPa	45-60	27.6	16.2
Stoichiometric air-fuel mass ratio	14.7	12.1	8.97
Research octane number	88-98	118	111
Motor octane number	80-88	102	92
Energy content, MJ/kg	42-44	36.2	27.7
Evaporation heat, kJ/kg	349	321	839
Solubility in water (20°C), %	-	2.0	in every ratio
Mass ratio of biocomponent, %	-	45.1	100

5. Production and utilisation of fuels from vegetable oil derivatives

In Hungary, there is near 200 thousand tons of fatty acid methyl ester (FAME, biodiesel) production capacity per annum. There are two small plants (<10.000 t/year), one middle plant in Bábolna (>15.000 t/year), and a 150.000 tons/year capacity plant operates in Komárom. Their feedstock is sunflower oil, rapeseed oil, used frying oils and fats, and triglycerides from some other sources. In every plant the alcoholysis (transesterification) is carried out on alkaline catalyst. Approximately 80% of the production is blended into diesel gas oil at the MOL Plc.

The biodiesel plant in Komárom was established by Rossi Biofuels Plc. The MOL Plc. has 25% share of the plant, the other 75% is owned by the Austrian ROSSI Beteiligungs GmbH. The cost of the investment is 40 million Euros. Estimated by MOL, vehicles using (approximately 5v/v%) biodiesels (produced from renewable energy sources) containing fuels emit to the atmosphere 200 thousand tons less CO_2 than vehicles using conventional diesel fuel.

In Hungary, from the 1st of January 2008 diesel fuel has to contain at least 4.4v/v% biodiesel, otherwise extra excise tax has to be paid.

6. Research and development of new generation biofuels

To eliminate the numerous disadvantages (high installation cost, unfavourable properties in use (Tables 2 and 3), not unequivocally positive energy balance related to whole life cycle, insecurity of feedstock, etc.) of conventional biofuels (bioethanol produced from "sugar plants" and cereals, fatty acid methyl esters which are transesterified vegetable oils, called biodiesel), the recognition, the research and development and the adaptation of a new generation of biofuels is needed.

Table 4 summarised an arbitrary classification of biofuels (DOE, 2004; Hancsók, 2005; Hancsók et al., 2005a,b; Hancsók et al., 2006b) according to chronology of recognition, production or rather probable introduction of these. The four generations delineated, the system of short, middle and long term economical producible and usable biofuels are represented on Fig. 2, it shows, that all known fuels can be produced from biomass (Hancsók , 2005).

According to the previous facts the EU has developed and found naturally step by step the expectations related to the production and utilisation of biofuels (Table 5).

In Hungary bioethanol production based on conventional feedstock, and also on lignocelluloses could play an important role in the future, because there is 6-8 million t/year cereal crops.

Table 2. The main disadvantageous properties of bioethanol and gasoline/ bioethanol mixtures

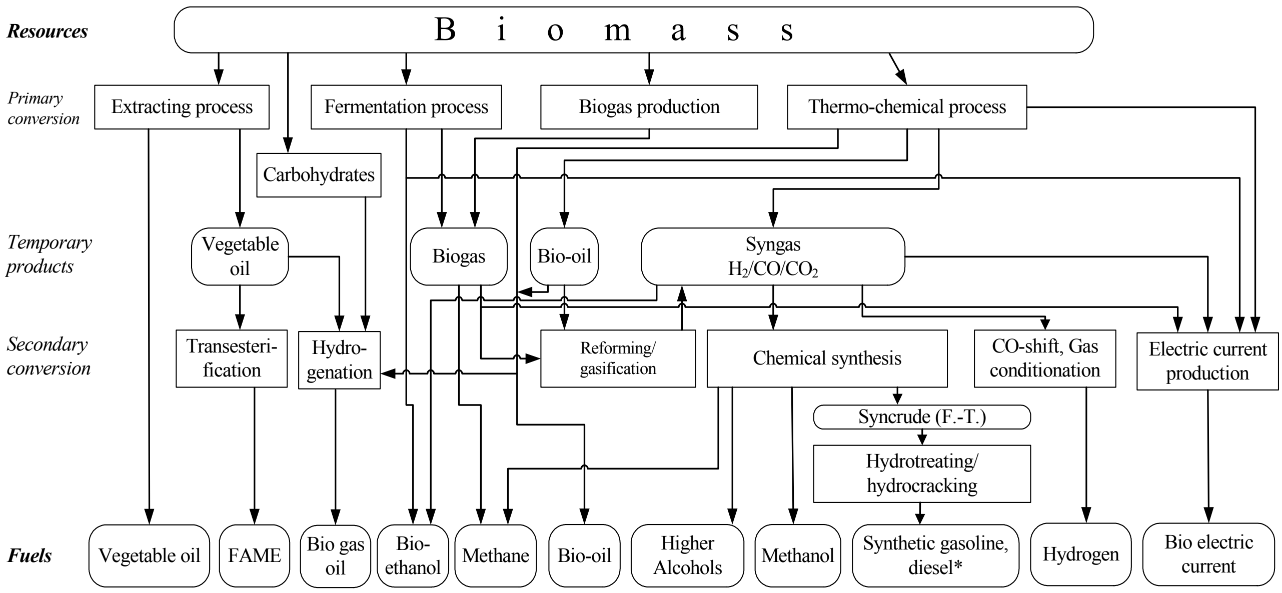
- Lower heat value related to mass,
- Higher consumption in case of working with pure ethanol, and worse mechanical efficiency,
- High hydrocarbon emission, due to evaporation
- Cold start problems in case of working with pure ethanol (low vapour pressure, high evaporation heat),
- Higher ethane, ethylene and acetaldehyde but lower formaldehyde emission,
- Poor lubricating properties (abrasions, surplus lubricant additives),
- Corrosion (iron, steel, zinc etc., more corrosion inhibitor needed),
- In gasoline/ethanol mixtures the presence of water cause phase stability problems,
- Attacks gaskets (elastomers), plastics,
- Fuel tank has to be made of special material,
- Requirement of higher degree of dopping (for example because of sulphate deposits, corrosion, low lubricating ability).

Table 3. The main disadvantageous properties of biodiesels

- For producing NOME significant amount of fossil energy is needed (for example methanol synthesis, heat and electrical energy), and there is significant emission during their production,
- High iodine number (high unsaturated content, poor heat and oxidation stability),
- High water content (biological degradation, corrosion),
- Sensibility at hydrolysis (corrosion),
- Negative effect of phosphorus content on three-way catalyst,
- Methanol content (poison),
- Higher fuel consumption (~10-15%),
- Higher CFPP and viscosity (cold start and spray problems),
- Can not be used in smog danger area because of the high NO_X- and acrolein emission
- In case of commercial vehicles extra costs (motor oil, filter, inactivation of used oil) due to the shorter oil change period; these are valid in case of passenger cars and buses, but only in a small compass; the long, undisturbed service is guaranteed with only proper composition of motor oil
- FAME-resistant fuel piping and gaskets have to be used,
- Higher pressure is needed in the fuel system,
- Storage problems after 5 months,
- Because of the penetration smell of exhaust gas in commercial vehicles additional oxidant catalyst has to be produced in (extra cost) and/or flavour is needed,
- To reduce the disadvantageous properties of FAME-s surplus additive is definitely needed (for examples: flow improvers, oxidation inhibitors),
- Because of the significantly higher production cost, relevant subsidies (for example tax allowance) are needed

Table 4. Classification of biofuels according to chronology of recognition and their introduction

First	***Second***	***Third***	***Fourth***
Generation			
• bioethanol • vegetable oils • biodiesels • blends of previous and petroleum-based fuels	• biocomponent as molecular consituents (bio-ETBE) • bio gas oils (hydroisomerised vegetable oils) • bioethanol from lignocelluloses • biobutanol • biomethane (biogas) • etc.	• higher (>C_2) bioalcohols • biogasoline and bio gas oil (hydrocracking of biooils produced by biomass pyrolysis • biofuels from bio synthesis gas • bioparaffins from carbohydrates • biodimethyl-ether • etc.	• biohydrogen • biomethanol • bio electric current (indirectly for fuel cells) • etc.



FAME: Fatty acid methyl esters (MSZ EN 14214/2004)
F.-T.:Fischer-Tropsch
*High isoparaffin containing gasoline, diesel, baseoil, etc.

Fig. 2. Production possibilities of motor fuels from biomass

Table 5. Changes of the European Union's directions, expectations related to biofuels

Directives	***Main directions, expectations***
Directive 2003/30/EC	Up to 2005 2.0 %, to 2010 5.75% biofuel content proposed, relative to energy content
COM (2006) 34 „EU startegy for biofuels"	Second generation biofuels (for examples bioethanol from lignocelluloses, synthetic liquid fuels: bio gas oil, BtL) research-development, utilisation
COM(2006) 848 „Renewable energy road map"	Up to 2020 in the EU countries average biofuels ratio have to be at least 10 %

Regarding the oilseeds the case is different. After satisfying the domestic frying oil demand, there are approximately 300-400 thousand t/year of vegetable oil which can be used for other goal.

There are also 40-60 thousand t/year of used frying oil and fat, in addition significant quantity of triglyceride containing feedstock from other sources (e.g. slaughterhouse's adiposes). The high feedstock price of vegetable oils, the expensive processing and conversion of other cheap feedstock into FAME, the disadvantageous properties of the utilisation of biodiesels lead our attention to recognise more valuable (than biodiesel) products with better performance properties, and work out new processes to produce them.

Rsearch and development activities were based on system approach recognition, accordingly the most favourable fuels of Diesel engines are n-paraffins having high cetane number (Fig. 3.).

At the same time flow properties of n-paraffins having high carbon number are bad. (The C_{17} and higher carbon number hydrocarbons are solids at 20°C and ambient pressure (Table 6).

The iso-derivatives of these n-paraffins have lower freezing-point by 15-30°C, although their cetane numbers are lower by 10-20 units. So that at the University of Pannonia, at the Department of Hydrocarbon and Coal Processing, the main aim of our research and development activity was to produce mixtures of n- and i-paraffins from vegetable oil and/or trigylerides, which have high cetane number (>75-90) and good cold flow properties (CFPP value: from -10 to -20°C).

The new product was named bio gas oil (Hancsók et al., 2006a, Hancsók et al., 2007a, b).

The definition of bio gas oil is: a mixture of iso- and n-paraffins, which is produced by catalytic hydrogenation from triglyceride containing renewable sources (vegetable oils, used frying oil, fats, slaughterhouse's adipose etc.). Fig. 4 demonstrates the reactions taking place under the catalytic hydrogenation of triglycerides, which have been determined in our experiments (Hancsók, 2007; Krár et al., 2007; Krár and Hancsók, 2007).

Table 7 summarises the main properties of the product mixture (bio gas oils), in comparison of the winter grade diesel fuel, and of an average biodiesel.

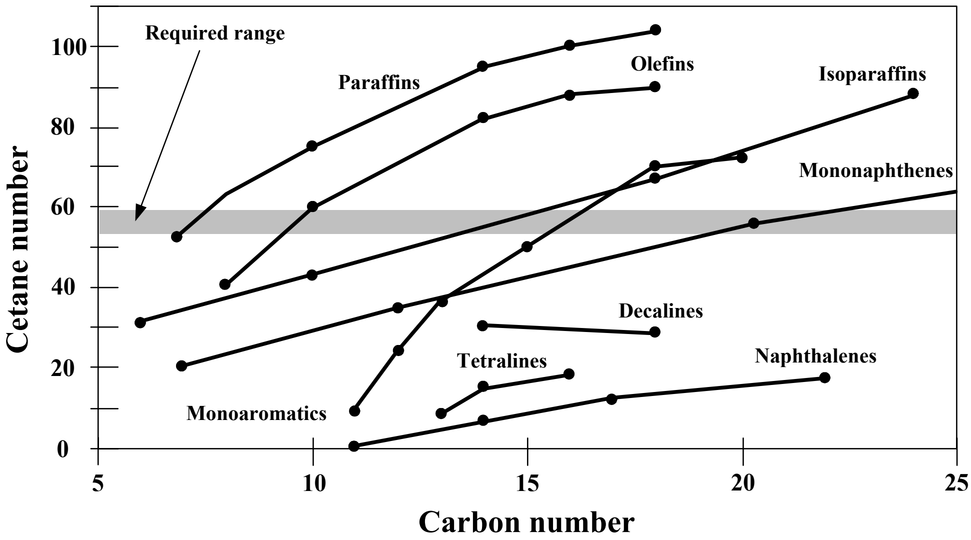


Fig. 3. Changing of the cetane number of different compound types in function of carbon number

Table 6. Some properties of open chained paraffins

Carbon number	*Branch*	*Boiling point, °C*	*Freezing point, °C*
12	-	216	-10
12	2-methyl	211	-46
12	5-methyl	206	-70
13	-	235	-5
13	2-methyl	230	-26
13	5-methyl	227	-69
16	-	287	18
16	2-methyl	281	-10
16	5-methyl	273	-31
18	-	317	28
18	2-methyl	308	6
18	5-methyl	307	-20
20	-	342	37
20	2-methyl	334	18
20	5-methyl	335	-7
24	-	388	51
24	2-methyl	383	39
24	5-methyl	380	18
24	2,4-dimethyl	-	10
24	2,4,6-trimethyl	-	-7

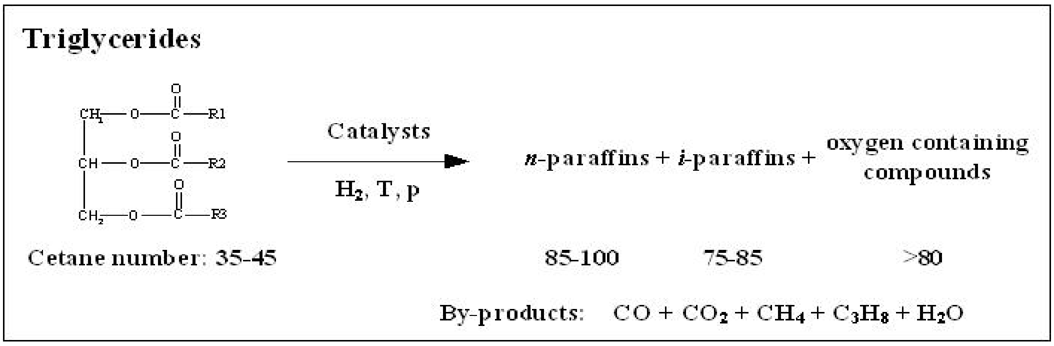


Fig. 4. The reactions taking place under the catalytic hydrogenation of triglycerides

Table 7. Properties of bio gas oil, Diesel fuel and biodiesel

Property	*Bio gas oil*	*MSZ EN 590:2004 diesel fuel (winter grade)*	*MSZ EN 14214:2004 biodiesel (winter grade)*
Density, g/cm^3	0.775-0.785	0.820-0.845	0.860-0.900
Viscosity 40°C-on, mm^2/s	2.9-3.5	2.00-4.50	c.a. 4.5
Cetane number	75-85[a]	min. 51	c.a. 51
Destillation properties			
10%, °C	c.a. 260-270	c.a. 200	c.a. 340
90%, °C	c.a. 295-300	c.a. 350	c.a. 355
Cold filter plugging point, °C	c.a. (-15)-(-35)[b]	< -20[c]	< -20[c]
Heat value, MJ/kg	c.a. 44	c.a. 43	c.a. 38
Heat value, MJ/dm^3	c.a. 34	c.a. 36	c.a. 34
Poliaromatic content, %	0	max. 11	0
Oxygen content, %	0-1	0	kb. 11
Sulphur content, mg/kg	< 1	< 10	< 10
Estimated total life cycle CO_2 emission, kg CO_2/kg	□ 0.9-1.8	□ 3.6-3.8	□ 1.3-2.2

(a: blending cetane number; b: without additives; c: with additives)

The data demonstrate well the numerous advantageous properties of bio gas oils (high cetane number: 75-85, high energy content: approx. 44 MJ/kg, aromatic content: 0; sulphur content <1 mg/kg, CFPP: -15 (-) -30°C, etc.).

To realise the research and development project (the whole innovation chain), the MOL Plc. supported by the NORT (National Office for Research and Technology) established a consortium (2006 December). Members of this consortium are:

- MOL Plc. (Head of consortium)
- OLAJTERV Plc.
- KITE Agricultural Service and Trade Co.
- Biodiesel Ltd.

University of Pannonia, Faculty of Engineering, Institute of Chemical and Process Engineering, Department of Hydrocarbon and Coal Processing

Chemical Research Centre of the Hungarian Academy of Sciences

Hungarian Institute of Agricultural Engineering Department of Mechanization of Plant Production

Regional Innovation Centre of Veszprém Public Utility Company

7. Synthetic bio gas oils

Beside bio gas oils, synthetic bio gas oils have to be mentioned as well. These could be produced from bio synthetic gas of biomass origin. The bio synthetic gas is extracted from bio origin feedstock (including waste) by some different gasification technologies (Hancsók, 2004; Tippe, 2005; Sentenac, 2003). From this cleaned mixture of gas, the product mixture containing also bio gas oil is produced by Fischer-Tropsch synthesis. Fig. 5 contains the summarised block scheme (Hancsók et al., 2005a).

Fig. 6 demonstrates the product yields of a plant which process heavy residue (>360°C) by also isomerisation hydrocracking compared to that of an average European oil refinery. Meanwhile the main properties of synthetic gas oil can be found in Table 8. Based on the foregoing data it could be stated, that bio gas oil could be produced in better quality and higher yield from synthetic gas than from crude oil. This is very important because of the growing demand of middle distillate and of the strict quality expectations (free of sulphur and of aromatic compounds, high cetane number, clean burn etc.).

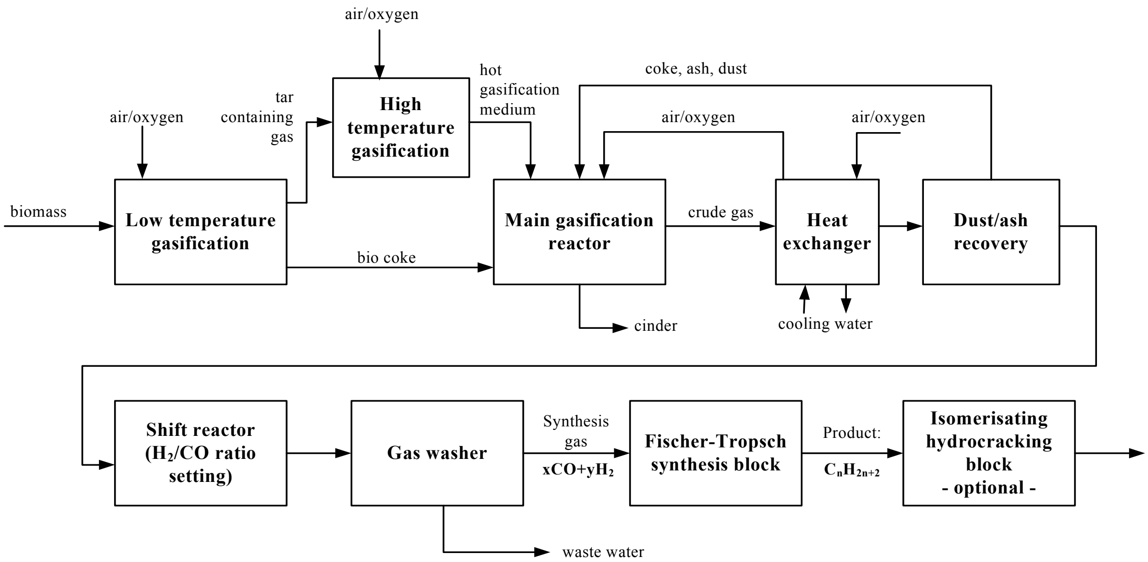


Fig. 5. Block scheme of the Carbo-V® process and of the hydrocarbon synthesis

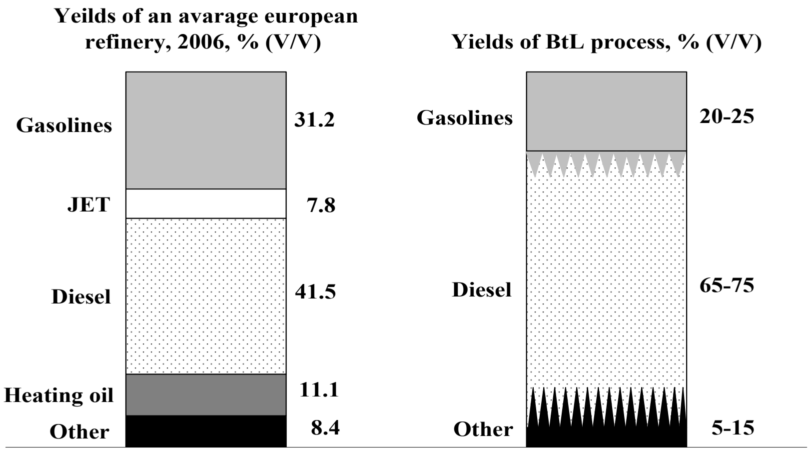


Fig. 6. Comparing the product yields from crude oil and of BtL technology

Table 7. The main properties of synthetic bio gas oil and of crude oil origin diesel fuel

Property	Synthetic bio gas oil *	Bio gas oil	MSZ EN 590:2004 diesel fuel (winter grade)	MSZ EN 14214:2004 biodiesel (winter grade)
Density, kg/m^3	770-785	0.775-0.785	0.820-0.845	0.860-0.900
Viscosity at 40°C, mm^2/s	2.4-4.5	2.9-3.5	2.00-4.50	c.a. 4.5
Cetane number	73-81	75-85**	min. 51	c.a. 51
Distillation properties				
10%, °C	c.a. 209	c.a. 260-270	c.a. 200	c.a. 340
90%, °C	c.a. 331	c.a. 295-300	c.a. 350	c.a. 355
Cloud point, °C	c.a. 0-(-25)	c.a. (-15)- (-35)	< -20	< -5
Heat value, MJ/kg	c.a. 43	c.a. 44	c.a. 43	c.a. 38
Heat value, MJ/dm3	c.a. 34	c.a. 34	c.a. 36	c.a. 34
Poliaromatic content, %	0	0	max. 11	0
Oxygen content, %	0	0-1	0	c.a. 11
Sulphur content, mg/kg	< 10	< 1	< 10	< 10

* gas oil by Fischer-Tropsch synthesis (synthetic crude oil from different origin, synthetic gas) and isomerisation hydrocracking;
** blending cetane number

In Diesel engines, because of numerous performance disadvantage and high installation cost of the first generation biofuels (vegetable oils, biodiesels) it is needed to produce and apply more valuable new generation products with better quality. In short and middle term the spread of bio gas oils (mixture of n- and i-paraffins produced from triglycerides by catalytic hydrogenation) and of synthetic bio gas oils (mixture of n- and i-paraffins produced from bio synthetic gas) is expected. Performance properties of these are significantly more favourable (cetane number: 70-85, CFPP without additives: -10°C (-) -35°C, free of sulphur, nitrogen and olefin, higher energy content, etc.) compared to those properties of first generation vegetable oils and their derivatives. In a refinery the production cost of the bio gas oil is not higher than the production cost of biodiesel, considering its value and net cost it is uniquely competitive with diesel fuel, moreover…! Nowadays the production cost of synthetic bio gas oil exceeds the production cost of others, but around 2015-2020 it would be competitive in a further stage of development.

In case of biofuels, there are different possibilities according to geological regions and nations. Everybody has to make decision considering his own national interest to import the feedstock of fuels or insure oneself at least part of proper feedstock. In Hungary 16 million tons of grains have been grown in an average year, approximately half of it is used in food industry. In case of the rest 8 million t/year, we have to take the decision to what ratio is it economical to export or to produce biofuels. In case of growing of oilseeds, the main problem is that a remarkable quantity of non-food rapeseed oil and used frying oil is exported. After satisfying the total demand of Hungarian food industry, there is approximately 400-500 thousand t/year of oilseed available.

Keeping the principles, that while elaborating development programmes, special attention must be paid for the initiation of home and foreign contractors being interested in this subject and we judge necessary to elaborate a national agro-energetical developing programme because of the importance of developing tasks. Central state support must be assured, too, for professional basement of developments containing state tasks. It is important to bring together environmental-, land-, economical-, agro-, energy-and employment political conceptions. Organizing national agro-energetical coordination is important for coordinating works of state bodies interested in realizing prospective developing tasks, research and developing institutes, industrial, agricultural enterprises and contractors.

Evaluating home results and international developing trends of agriculture originated renewing energy-carrier production, agrotechnical possibilities and technical-economical conditions, the next comprehensive conclusions have to be made:

Looking at natural endowments, potential stocks of Hungary and evaluation of their practical use, biomass can be considered as the most important energy-resource in Hungary;

The country's fire-wood production is 0.32MtOE (Million ton of oil equivalent), which can be increased to 0.7MtOE with energetically use of timber industrial and forestry byproducts, with energetic forests plantation to 1.5MtOE;

Recently 0.1MtOE agricultural byproducts are used for thermoenergetical purposes, which can be increased to 1.0- 1.5 MtOE by proper technologies;

Renewing potential energy-resource produced by anaerobic fermentation of animal water manure and other wastes is significant (0.3-0.5MtOE), complex technologies serving environmental protection and energy-generation purposes need development;

Further potential liquid bioenergy carrier producing ability is about 0.5-1.0MtOE of agro-sectors depending on the size of areas given for that purpose;

Future potential energy generating ability of agro-sectors is 3.0-4.0MtOE without any deleterious effect on food-supply and conditions of soils;

Energetically use of agricultural and forestry byproducts in 10-15% measure does not endanger the organic content and structure of soil;

Energetically use of biomass, plantation of energetic forests and energetic plant production significantly repairs the energetic factors micro- and macro regions;

Technologies for economical use of biomass firing are available, however the technical-economical effectiveness of energy producing and conversion technologies need improvement;

Biomass based fuel production, producing and processing methods, producing technologies and their profitability need further technological development;

Economically operating water manure and waste-water treatment technologies serving environmental protection purposes are to be developed in connection with biogas production direction;

Biomass energy-carrier production extension is reasonable for improving environmental factors and extending application of renewing energy-resources;

For evaluation of biomass energy-resource efficiency, considering economical effect of environmental factors new methods would be required;

While strategic evaluation of biomass originated energy-resource production and utilization, consideration of rational leasehold and employment in the county has got special role;

Technological and economical substantiates of biomass originated energy-carrier production representing the same order as crude oil production, requires significant central developing resources;

Elaboration of this extremely complicated ecological - biological - technical - economical tasks can be realized only within the frame of a national agro-energetically strategic R+D programme, while certain processes, application of equipment and investments can be done only if we know the exact local endowments in detail and we have evaluation and analysis of it. EU-FP-7 seems to be a powerful tool for the development.

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