

BIOFUELS – OPPORTUNITIES AND CHALLENGES

Andrzej Piętak

*University of Warmia and Mazury in Olsztyn
Faculty of Technical Sciences, Mechatronic Faculty
Słoneczna Street 46 A, 10-710 Olsztyn
tel.: 089 524 51 01, fax: 089 524 51 50
e-mail: mechatronika@uwm.edu.pl*

Stanisław Radkowski

*Warsaw University of Technology
Narbutta Street 84 02-524 Warsaw, Poland
Faculty of Automotive and Construction Machinery Engineering
tel.: +48 22 2348276, fax: +48 22 2348622
e-mail: ras@simr.pw.edu.pl*

Abstract

Development of alternative energy sources, including biodiesel, leads to growth of threats for the economy and environment issues all over the world. Many research and effort was done during last years to introduce first and second generation biofuels to the market. Besides the first running Diesel engine was supplied by biofuel on this field still is lot to do. The issue of alternative fuels has gained additional importance because of much environmental, financial and political matter.

The paper describes the legacy and achievements of the research work which was carried out in Poland, presents directions of biofuels usage. Presents development of legislation and standards are affecting producing and usage alternative energy sources in Poland and Europe as well as other countries all over the World.

Renewable energy sources, minimal content of biofuel in fuels acc. to EU directive, comparison of properties of alternative fuels, classification of biofuels, simplified systems block diagram of the algae do biodiesel process, development of alternative fuels technologies, European norms in use of bio-fuels and bio-components, biofuel market in Poland, renewable fuels other than biofuels are presented in the paper.

Keywords: *renewable energy sources, biofuels, biocomponents, standards for biofuels, legislation*

1. Introduction

Access to energy and its pricing are the dominant factors which have been influencing economic development during the two centuries of industrial age. According to generally available data [1] 35% of energy consumed globally is produced from oil, 29% from coal (and brown coal), 24% from gas, 6% by hydroelectric plants, 5% from nuclear power plants, while the remaining 1% can well be allocated to alternative sources of energy. From the point of view of balanced transport, a lot of attention has been devoted to the development of biofuels for diesel engines. As has been indicated by the International Energy Agency (IEA) [2], during the past ten years global production of biodiesel has doubled and in 2012 it will reach 21.8 billion liters.

However, development of alternative biofuel technologies, biodiesel included, leads to growth of threats for the economy and for socio-political relations. Heavy criticism was triggered by the disturbance on the food market caused by the 1st generation biodiesel technologies, growth of food prices as well as changes in use of agricultural fields – they have become yet another challenge for the biofuel industry and they have contributed to changes in many governments policies. The issue of alternative fuels has gained additional importance following the German government's decision to accelerate the process of shutting down German nuclear power plants.

Just by the way it is worth mentioning that Rudolf Diesel powered his first engine with a peanut oil. This fact is commemorated by the International Biodiesel Day which is celebrated on August 10th that is the day when Diesel engine was first presented in Augsburg, Germany in 1893. The name biodiesel was introduced by a Belgian, G. Chavanne, who in 1937 secured a patent for fuel made of vegetable oil, while the patent for the first industrial installation was registered in Brazil in 1977.

The first pilot industrial installation was built in Austria in 1987 while the 1990's brought a whole range of international standards, including DIN 51606, while the currently valid European Standard, EN 14214, was published in 2008, replacing the Standard from 2003. Also in 2008 ASTM published its new standards, namely the Biodiesel Blend Specifications Standards.

2. Development of alternative fuels technologies

Renewable energy technologies have already developed in such a degree that they can compete with conventional energy systems. Renewable energy sources are local sources and thus they enhance energy security while reducing import of fossil fuels, and they can create new workplaces, especially in small and medium enterprises, while promoting regional development. Renewable energy sources attract growing numbers of local communities and small investors as well as big international corporations.

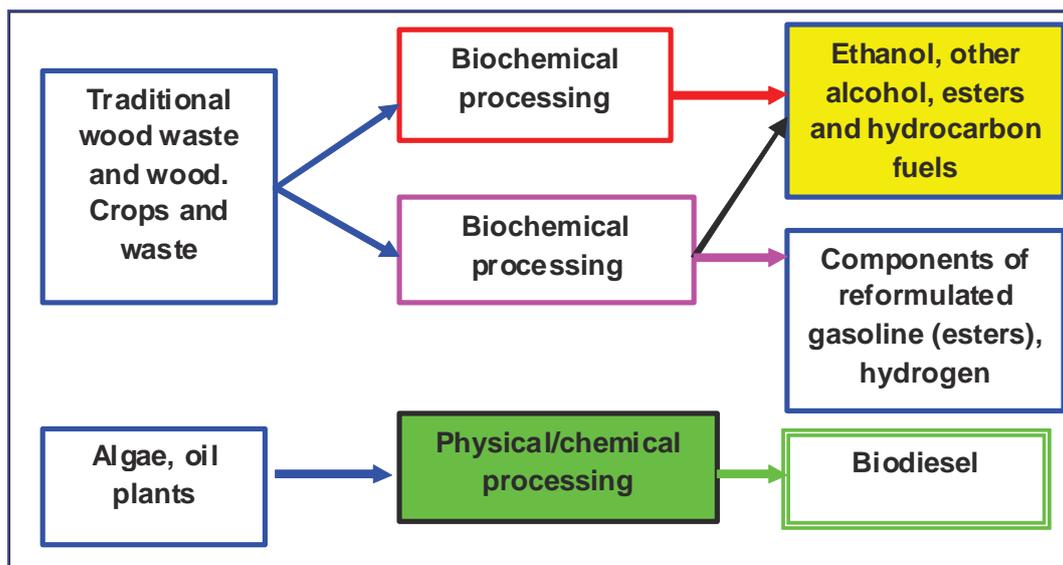


Fig. 1. Renewable energy sources

Rigorous environmental protection regulations fostered use of biodiesel fuel which is characterized by lower emission of toxic components. Preferential regulations have resulted in use of biofuels in specific types of vehicles, which led to development of production of vegetable fuels and their mixtures with diesel oil.

For that reason, many research centres worldwide have started developing technologies of obtaining substitute fuels, such as biodiesel which could be used both, as a component of fossilized oil or as a pure fuel which does not change an engine's parameters. The advantage of biofuels is that rape or other oil plants from which oil is obtained assimilate carbon dioxide from the air as they grow and then carbon dioxide returns to the air as the biodiesel is burned in the engine. Hence a cycle of CO₂ is created in nature, which is very important for protection of the environment.

Numerous cases of research on products of burning demonstrate the advantage of FAME, in whose case the products of burning do not contain methanol radicals and HCOH – very dangerous

for living organisms, over mineral fuels in whose case the products of burning contain polycyclic aromatic compounds.

The 2nd European Engine Biofuel Forum took place in Graz, in Austria, in September 1996. Many scientists, engine and vehicle manufacturers as well as producers and users of biofuels could share their views during the forum.

The conference defined the goals and the intentions of the biofuel-related policy pursued by European Union member states. The European Commission's energy policy is intended to reduce dependence of EU countries on import of crude oil and create own local carriers of energy, such as biofuels. Special research programs were established, e.g. THERMIE, which helped built three installations for biodiesel fuel production: in Italy and Germany. Another program is called AIR. It is a program which provides for allocating 16 M EUR for research on biodiesel. The above listed projects and foundations, etc. are not the only methods of introducing ecologic fuels to global markets. The fuel crisis, reduction of oil production as well as increasingly stringent engine emission standards have given additional stimulus for research centres to introduce new methods of obtaining biodiesel and other ecological fuels.

Most countries which are future-oriented have launched research programs aimed at reducing their dependence on crude oil. Early research and use of Polish rapeseed oil fuel started in the 1990's in the Higher School of Engineering (WSI) in Radom where the Polish technology of production of rapeseed oil fuel was developed and where initial operation of a rapeseed-oil-powered "Tarpan" pick-up started.

The work continued and its scope was further extended in the Air Force Institute of Technology, in the years 1993-1997, where various samples of Polish and foreign fuels were tested. Most engines manufactured domestically as well as several engines from foreign manufactures were tested in testbeds. The test of a Polonez Caro Diesel car, which drove 170000 kilometres on a 100% pure rapeseed oil fuel, confirmed the good properties of Polish rapeseed oil fuel.

Research on use of renewable fuels was also conducted by the Polish Army in the T. Kosciuszko Higher School for Officers in Wroclaw under the leadership of Col. Dr Eng. Mieczysław Struś. Tanks and armoured vehicles powered by ecological fuel drove on the military range near Wroclaw. The tests involving the T-72 tank and BWP-1 armoured vehicle proved successful, however further optimization of physical and chemical parameters of the fuel is required from the point of view its logistics. Also research on fuelling, UTE -20 engine from BMP1- Infantry fighting vehicle, with FEE and its mixtures was conducted by Col. Professor Andrzej Pietak at Military University of Technology-Warsaw.

Since 1994 the Industrial Institute of Agricultural Engineering (PIMR) in Poznan conducted research on use of rapeseed oil fuel in agricultural tractors. PIMR constructed and tested a mini-plant for production of fuel for tractors from rapeseed oil, the so-called agro-refinery which produced biodiesel for service-and-processing plants. The process of esterification of rapeseed oil takes 30 minutes in the device developed by PIMR while gravitational sedimentation is a long process and takes around 16 hours. Refineries with capacities of 160-400 liters will be optimal for transforming rapeseed oil into fuel for tractors in rural conditions. That is why in 1998 the Institute developed construction documentation for a rapeseed oil production plant with output of 400 liters per day. The expected cost of such a device, produced in short series, should not exceed 40 thousand PLN.

While using the oil plants grown by oneself and some know-how as well as the relevant equipment it is possible to produce biofuel for a diesel engine. The process of fuel production, based on safe low-temperature and low-pressure technology, is possible to run on one's own farm.

Ethyl alcohol started being used in the 1980's. In the west it was being added to unleaded gasoline in a proportion of 1 to 10. Today around 3.5 billion liters of this fuel are produced in the USA, mainly from corn. Ethanol was however best adopted in Brazil, a country which is not very rich and has no own oil deposits and no railway system. Currently over a million cars with engines

modified to burn alcohol made of sugarcane drive the roads of Brazil.

More than half of the cars sold in Brazil are cars powered by alternative sources of energy. Traditional gasoline-powered cars account for only 47% of the market while 53% of new cars that are sold run on alcohol. Such vehicles have been produced in Brazil already since the 1980's but the boom came after 2003 when significant tax allowances were introduced. It was also the high prices of oil and the low prices of sugar that had influence on the development of technologies of powering cars with alcohol. While using such methods Brazil produces 12 billion liters of fuel yearly.

Ethanol, or ethyl alcohol has been known since the beginning of history but its history as a fuel is not longer than 30 years, as I have indicated above. Brazil was the first country which started producing the E85 bio-gasoline with the content of 85% of ethanol from sugarcane and 15% gasoline. The United States, where corn was used for producing the fuel, followed next.

Production of bio-gasoline started in Brazil in 1975. In 1984 the output reached around 12.5 million cubic meters per year and production at such level has continued since. In the USA production of bio-gasoline started four years later and has been growing at a much slower pace than in Brazil. The level of 5 million cubic meters per year was reached in the USA only in 2000 while right now it is around 10 million cubic meters a year. EU countries have so far not exceeded the level of 0.5 million cubic meters of yearly production of bio-gasoline. The global production of bio-gasoline was 27.5 million cubic meters in 2004. In Brazil bio-gasoline covers around 30% of demand for gasoline while in the USA it accounts for less than 12%.

3. European norms in use of bio-fuels and bio-components

Legal basis regulating the market of biofuels in the European Union are contained in directive 2003/30/WE which supports use of biofuels or other renewable sources of energy.

DIRECTIVE 2003/30/WE OF THE EUROPEAN PARLIAMENT AND COUNCIL dated 8 May 2003 on supporting use of biofuels and other renewable fuels in transport

It is a framework regulation which leaves substantial degree of freedom to member states in creating their national regulations in this area. EU law regulates only several essential issues which require implementation in the national legislation. Apart from a general definition of the notion of biofuels, Directive 2003/30/WE create a duty for member states to embark on activities aimed at gradual increase of share of biofuels in transportation.

It introduced a requirement of a 2 percent share of biofuels in the fuel market (counted on the basis of energy value of fuel) for 2005. It sets a requirement for the share of biofuels in the total consumption of fuel in each member state to be at the level of 5.75 percent of energy value of fuel by 31 December 2010. For example, in 2005 biofuels had only for 1.4 percent share in EU member states, with only Germany and Sweden meeting the requirement of a 2% share of biofuels in the fuel market.

Directive 2003/30/WE also provides for the duty of development by the member states of programs which ensure actual development of biofuels. Public aid is permitted to this end. To focus the public aid on this specific purpose, EU regulations enabled introduction of allowances and exemptions for biofuels in the areas of excise tax or energy-related taxes. In addition the regulations enabled aid to be granted for research and development, or for support of some agricultural production sections.

Two support systems, most often used by EU member states, are particularly noteworthy. They make up the core of the systems supporting the biofuels market. One of them involves excise tax allowances and exemptions. The other one is the obligation of adding a specified amount of the biomass to liquid fuels.

Production of biofuels and liquid fuels with addition of biomass enjoys a special tax regime. Pursuant to Art. 2, item 3 of Directive 2003/96/WE of 27 October 2003 on restricting the

European Community policy in respect of taxation of energy products and electrical energy (Official Journal of EU L 283, 31.10.2003), all the raw materials for production of liquid fuels, which includes the biomass which as an engine fuel as such or an additive to liquid fuels, are subject to excise tax.

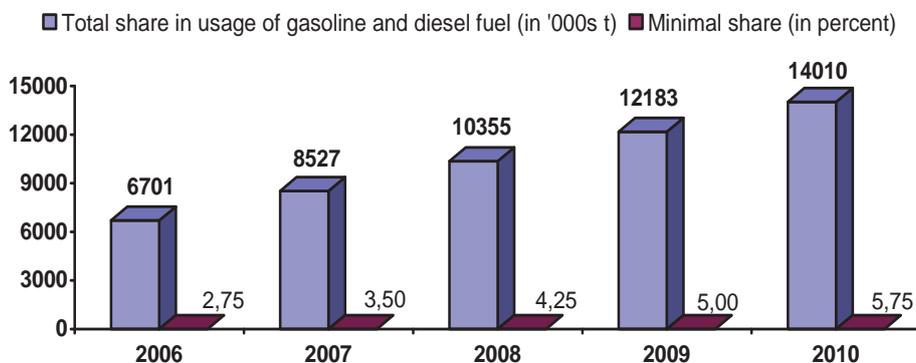


Fig. 2. Minimal content of biofuel in fuels acc. to EU directive

In accordance with Art. 16 of Directive 2003/96/WE member states can grant exemptions or reduce the excise tax for biofuels. This can however be done under certain conditions. The above tax allowance will be treated as state assistance which may not be granted without prior consent of the European Commission. While assessing each case, the European Commission examines whether such aid will not result in unjustified disturbance of competition and whether it will comply with the principles of granting public aid for environmental protection. These regulations assess, among others, the favourable effects of producing energy from biomass as compared with the energy obtained from fossilized fuels.

The Commission also examines whether the granted public aid, having the form of tax exemptions and allowances, will not result in excessive benefits for biofuel producers. Granting aid for this purpose is only intended to compensate for the additional costs associated with production of this type of fuels. The aid as such is not intended to offer additional profit for companies.

The other system used by some EU member states is the duty related to a specified share of biofuels in the fuel which is sold. This system is used by many non-European states worldwide, including the USA and Brazil. The obligation guarantees a market of relevant size for bio-mass and biofuels. If this obligation is introduced, then everybody involved in production of the fuel sold on the market will benefit from it, i.e. both the farmers as well as the companies processing raw materials. The system can co-exist with the system of tax allowances and other forms of support.

It seems justified for such a system to also operate in Poland. It will ensure high level of stability for investments in this sector of economy. One should also remember about the possibilities of support for development of biofuels through support for farming involved in production of the biomass for fuel production-related needs.

EU authorities would most gladly see uniform tax treatment of individual types of biofuel in the European Union. This, however, is difficult due to lack of unanimity among EU countries.

The first of them is to stimulate demand for biofuels. It will be realized by offering privileged treatment for biofuels and by supporting energy-saving and environment-friendly technologies in public procurement. In addition the Commission has encouraged development of national regulations which foster use of fuel mixtures with higher content of biofuels by selected public and private fleets of vehicles. Municipal transport companies or private firms which own car fleets could be the examples of such fleets. Such possibilities could also apply to fishing fleets or tourist vessels.

The other direction will be to exploit the ecological benefits of biofuels for promotion of their

broader use. The activities in this area will serve the purpose of offering diverse incentives for biofuels, depending on the influence they have on emission of greenhouse gases. It is also the aspects associated with the influence that production of energetic plants has on soil and local animal and plant life that will be taken into account.

The third direction will be to develop production and distribution of biofuels. This direction is particularly important for Poland which has high potential in terms of production and processing of biomass in rural areas where cost of labour is proportionately lower while access to raw materials high. Development of production of biomass for production of fuel could contribute to growth of employment and economic development in agricultural areas, which is aligned with the EU cohesion policy. In these areas farmers could have their qualifications changed so as to have their skills accommodated to the requirements related to biofuel production.

The fourth direction concerns extension of the scope of supply of energetic plants. Reform of the common agricultural policy will make production of agricultural raw materials used for energy-production purposes more attractive from financial point of view. Increased use of agricultural raw materials will be also facilitated by reform of the sugar market, new principles of intervention on the wine market and the currently negotiated, in the European Union Council, additional subsidy to production of plants for energy production in the amount of 45 euro per hectare. Extension of supply of energy plants will also be associated with new principles of development and use of wood for energy-production needs, including in particular for production of "second generation biomass". Activities in this area will also include more effective use of organic waste for fuel-production needs.

The fifth direction is intended to stimulate trade more efficiently. Activities will be undertaken to facilitate import of certain volumes of biomass to the European Union. The import is intended to supplement EU internal production. Introduction of separate nomenclature for customs codes for biofuels will be also contemplated in order to improve control of the biomass imported for energy-production purposes.

Ultimately actions will be taken which are aimed at stimulating research and development of technologies associated with biofuels. The activities are aimed at reducing the cost of research by around 30 percent in real terms. Activities aimed at reducing unit cost of fuel will be supported as part of the 7th Framework Program by developing second generation biofuel as well as by indulging in activities which enhance the biomass production process, the so-called bio-refineries.

4. Biofuel market in Poland

In accordance with the EU regulations which are currently valid in Poland, an agricultural producer who invests in production of bio-components for fuel-related needs will receive a uniform direct payment (the so-called SAPS). The payment is granted for well-cultivated agricultural lands. The payment is realized by the Agency for Restructuring and Modernization of Agriculture (ARMiR). In 2005 the payment was 225 PLN for each hectare of land.

In addition payments are granted for agricultural land on which oil plants are grown, e.g. rape, oil-yielding rape, sunflower and soya (note: FAEE and FAME obtained from soya oil do not meet the European norm for quality of bio-components in terms of the iodine number). The payment applies to the agricultural lands covered by this type of cultivation. The payment is realized by the Agency for Restructuring and Modernization of Agriculture (ARMiR). In 2005 it was 282.35 PLN for each hectare of land.

The present principles of the state's policy related to biofuels are set out in the Act on bio-components and liquid biofuels dated 21 July 2006. The act introduces the obligation of adding ethanol or rapeseed esters to each litter of fuel in the amount depending on the "National Indicator Goal" as set for a given year. As a result it has been assumed that in the future every litter of gasoline will contain from 4 to 5 percent of ethanol while every litter of diesel oil will contain from 4 to 5 percent of esters. The government termed as achievable the EU requirement of share of

biofuels being at the level of 5.75% of the energetic value of liquid fuels. Biofuels must be sold from separate, properly marked gasoline pumps.

Business activities involving production, storage or sale of bio-components will be subject to registration in the register maintained by the President of the Agricultural Market Agency. The Act permits farmers, under certain conditions, to produce fuel for own needs, e.g. esters or pure vegetable oil.

Development of the biofuel market is one of the strategic goals of European Union's energy policy. It will be significant for the development of this sector also in Poland. Economic consequences of starting business activities in this area could be favourable for both, the farmers who produce the biomass for energy-production needs as well as for the companies which process the biomass as a component of liquid fuels and biofuels. The regulations related to the possibility of importing of agricultural raw materials for energy production purposes from third-party states will also be important. New domestic regulations in this area are expected in 2006. Their form will be decisive for the direction of this sector's development in Poland. Bearing in mind the duties imposed on Poland by the European Union, one can expect a much more dynamic development of this sector in near future.

The area of the land on which energy-producing plants will be grown will depend on the indicators related to share of biofuels in liquid fuels as adopted for respective years by individual countries. With the adopted national target of 0.5% in 2005 and 1.5% in 2006, the estimated area of land for growing cereals used for production of bio-ethanol should be respectively ca. 56 thousand ha in 2005 and ca. 167 thousand ha in 2006, while the area for growing rape for production of esters should be accordingly ca. 34 thousand ha in 2005 and ca. 102 thousand ha in 2006.

Existing agricultural programs offer the possibility of support for producing agricultural raw materials used for producing fuels as well as for the first stage of processing of these raw materials. The programs also provide for the possibility of granting financial support (as part of NPR) for modernization of the existing ones and for construction of new biocomponents producing plants.

All the interested parties agree that there exist no economic obstacles (the regulations related to excise tax exemptions and allowances and their amounts have been maintained and modified) which would restrict introduction of biocomponents to the market of liquid fuels. Potential investors have concerns as regards lack of legal guarantees of long-term application of these allowances and exemptions – in spite of the fact that they have been applied for a dozen or so years now. The valid three-stage solution promotes higher share of bio-components in liquid fuels (especially the addition exceeding 10%) while its attractiveness has increased further once crude oil prices increased. An entity adding bio-components to liquid fuels enjoys an excise tax allowance in the amount corresponding to the percentage share of bio-components in liquid fuels: 1.50 PLN (for 2.5% share of a bio-component), 1.80 PLN (for 5...10% share of a bio-component) and 2.20 PLN (for more than 10% share of a bio-component) per liter of a bio-component. Unfortunately there is no clear (documented) and practically verified knowledge about the reasons why, in spite of guaranteed (by public funds) economic profitability of introducing bio-components to liquid fuels, the share of bio-components not only has failed to increase in line with the targets resulting from international obligations as well as social and economic interest of the country but to the contrary is has instead decreased to the lowest level in 10 years.

Fulfilment of international obligations, mentioned earlier, calls for quick and bold decisions which will change the approach to renewable fuels as well as actions indicating that use of such fuels is safe and economically justified. Liquid fuels containing a "bio" addition should be sold at lower prices than the prices for the so-called normative fuels – this opinion stems from the fact that support from public funding is granted for production of biofuels in the form of tax rate reductions and also by the fact that biofuels have lower energy value. In my opinion the package of activities which will enable rational use of existing potential of renewable fuels for transportation should be

aimed at exploiting the results of the work done while developing the plan of anti-crisis activities related to the crude oil market, including:

- acceleration of the work on development and implementation of the missing orders of the Minister of Economy and Labour which define the quality requirements and the methods of examining them for esters and diesel oils which contain respectively above 5% and 20% of “bio” component,
- acceleration of the work related to development and implementation of long-term program of promotion of biofuels and other renewable fuels for years 2007-2013,
- starting by the Ministry of Economy and by the fuel industry of work on introducing three-component (multi-component) fuels to sale. For example, in Sweden significant portion of public means of transport runs on B-85 fuel (ca. 80-85% bio-ethanol, a dozen or so percent of gasoline and 1-3% of stabilizers), which however requires some structural changes in the engines, as well as on E 95 fuel (95% of bio-ethanol);
- start of work on “agricultural fuel” which should offer an opportunity for introducing to the market of diesel fuel containing around 10% of bio-ethanol, 25-30% of esters as well as 60-70% of the so-called standard diesel oil. Polish solutions and proposals of standards exist in this area. Such a fuel does not require introduction of any changes to engines and vehicles;
- contemplating the possibilities of starting legislative actions (in a similar way as the actions taken in many states in the USA) which would be associated with introduction in Poland of an obligation to buy, by the persons managing state and public fleets of vehicles (this mainly concerns public transport buses and cars used by state authorities) of vehicles which would be accommodated to operate while using fuel which contains above 5% of bio-components; introduction of the duty of operating these vehicles on bio-fuels (gasoline containing not less than 8-10% of bio-ethanol as well as diesel fuel containing not less than 30% of esters) for which the engines of these vehicles are ready and for which they do not require any technical modifications;
- contemplating some legal possibilities of combing the reduced rates of excise tax on liquid fuels containing bio-components with the prices of such fuels, while making the prices proportionate to the energy-value of such a fuel (basis – public aid and introduction of a safer fuel but having lower energy value);
- contemplating introduction of fees to be paid by fuel producers for introducing to the market of fuels causing higher emission of greenhouse gases. Such a rule already exists in the case of sale of electrical energy. There is a legal obligation of producing a certain share of electrical power from renewable sources of energy – non-fulfilment of the duty results in high financial charges;
- guaranteeing financial support for construction of agro-refineries – ester-producing plants (and consequently the plants which produce bio-ethanol) which would act as important element increasing the country’s energy security and enhancing environmental protection – the agro-refineries should be supported according to the same principles as it is done in other EU countries and rules of their support should be reflected in the National Development Plan for years 2007-2013;
- embarking on and fast completion of legislative work associated with full implementation of regulations of Directive 2003/30/WE.

5. Renewable fuels other than biofuels

According to the statistical yearbook, rape crop amounted 1.45 million tons in 2005. Other sources show that yearly production of rapeseed oil is ca. 1 million tons in Poland! Assuming that efficiency of production of biodiesel is equal to ca. 90% of volume of the oil used to produce it means that ca. 900 of tons of biodiesel can be produced yearly. Ca. 200-250 thousand tons of ethanol are needed to produce this volume of biodiesel. It is more than the yearly production of ethanol in Poland.

The most important issue is to acquire cheap raw materials for producing ethanol. Cellulose-based raw materials offer a high volume future source of raw materials. Various method of processing of cellulose-based materials has to be researched, especially as regards enzymatic saccharification (enzyme-based hydrolysis). We would rather not be able to develop the technology of producing relevant enzymes in Poland, however research could be done as regards use of existing enzymatic preparations as well as development of reactors and technologies of enzymatic hydrolysis of celluloid materials (wood, straw, etc.)

Other alternative fuels:

1. Hydrogen is probably the fuel of the future. It can be obtained with the use of biotechnological methods. But such a process is currently at the stage of laboratory tests. Research has to be done as regards both, development of new, highly-efficient bio-reactors for carrying out the so-called dark hydrogen fermentation as well as development of technologies of exploiting various raw materials, especially use of waste or crops grown specifically for the purpose of hydrogen production. Gathering, storage and distribution of hydrogen as a fuel are separate issue.
2. Methane (biogas) – its production has been technologically mastered around the world but research is needed as regards new, highly-efficient bio-reactors and development of bio-gas production technologies using local raw materials as well as agricultural-and-industrial waste, e.g. brewery decoction, post-slaughter waste and sewage, glycerol created during production of fatty acid esters.
4. Both lab research as well as development works is required in respect of production of bio-fuels: ethanol, ethyl esters of fatty acids, bio-gas and hydrogen. It concerns waste-free technologies – waste from one technology can be used as a raw material for other technologies (e.g. the decoction from production of ethanol can be used for production of hydrogen and methane). This way it is possible to use the special-purpose cultivation of crops as well as put to use various types of waste from the food production industry (e.g. whey from a dairy).

As regards renewable fuels, other than the bio-fuels, it is landfill gas, whose main component is methane that is the only realistically usable fuel at present. Calculation of the cost of putting it to use, along with quantification of the costs, is beyond the scope of this paper due to the amount of work required. Hydrogen fuel has been included here only for formal reasons because in the opinion of the authors of this paper, in the face of the present technology of its acquisition, storage and distribution as well as the technology of building of engines, hydrogen fuel has no chances of being put into use in near future.

Tab. 1. Comparison of properties of alternative fuels

Fuel	User (vehicle – entity)	Circumstances	Benefits: traction-related, ecological, economic, other (e.g. distribution, safety)	Cost (material elements, quantification)
Landfill gas	Urban sanitation company (garbage trucks)	Collection and compressing of gas, accommodating the engines and fuel injection systems as well as tanks	Reduction of environment pollution, fuel for free	High cost of accommodating engines to run on landfill gas
Hydrogen	Public transport in zones of intense environmental protection	Production and storage of the gas as well as its distribution, accommodating the engines and fuel injection systems as well as tanks	Reduction of pollution of the environment, reduction of emission of CO ₂ , CO, HC and PM to negligible amounts, reduction of NO _x emission by ~50%	Very high cost of accommodating the engines to run on the gas

6. Conclusions

The prospects of use of biofuels depend on many factors, e.g. development of alternative fuels, agricultural policy, social benefits, product price, improvement of properties of rapeseed oil esters. A factor of major importance could be the form in which the fuel will be used – will it be rapeseed oil esters, its mixtures with diesel oil, emulsion of esters with diesel oil or oil cracking in refineries. Some of the properties of biodiesel will have to be improved in the production process, e.g. reduction of viscosity, improvement of its properties in low temperature, stability during storage, or reduction of the number of components responsible for sediments. It will be necessary to develop quick methods of production and quality control.

Apart from being familiar with the existing legal regulations related to biofuels, it is also the knowledge of the evolution of these regulations that is an important decision-making factor when contemplating business operations in biofuels industry.

Development of the biofuels market is one of the strategic goals of European Union's energy policy. It will be important for the development of this sector also in Poland. Entering into business operations in this area may have positive impact on both, the farmers who produce the biomass for energy production needs as well as the companies which produce the bio-mass as a component of liquid fuels and biofuels. Also the regulations related to the possibility of importing agricultural raw materials from third-party states for energy-production needs will be important.

In the coming decades of the 21st century, biodiesel will be becoming a small but a very important part of global supply of energy.

Under certain conditions growth of share of biodiesel may contribute to solving many problems, starting from emission of greenhouse gases, to growth of security in terms of energy supply and promotion of balanced development of rural areas.

Relevant energy policy, including international agreements, legal regulations of commercial aspects of energy production business such as distribution, storage and energy bridges are the key success factors. Another aspect of such a policy is the benefits enjoyed by investors, especially in the area of increase of energy efficiency and emission-related norms, fiscal policy and energy focused scientific research.

An item of particular importance is the support for neutral technologies, especially the ones which are environment-friendly, in the context of support for balanced long-term solutions which place social issues in the centre of attention. This is becoming increasingly important because in contrast with the situation the energy crisis, in recent years there has been strong correlation between the prices of bio-diesel and food, which has had increasing impact on the social and political situation in many countries. Recently the situation has led to unrest in many countries in North Africa. Many publications point to the fact that the prices of food and energy will become even more connected in the future.

An additional factor is the high consumption of water by industrial-scale bio-diesel production technologies, which contributes to the growth of global deficit of water.

While taking into account the data published by the International Energy Agency (IEA) [3], energy-related needs of Asian countries will increase by 75% by 2030, which in the face of 60% share of Asia in global population means 45% growth of global demand for energy during that period.

The fact that further countries from Asia, Africa and South America, as can be seen on the examples of China, India, South Africa or Brazil, join the program of greenhouse gases reduction, thus joining development of energy production from renewable sources, demonstrates that one should expect growing dynamics of cutting of tropical forests and acquiring additional land for plant production.

Bearing in mind that for many farmers, especially in developing countries, starting of production of raw materials for biodiesel offers an opportunity for improving their financial situation, thus finding the economically-friendly balance with the requirements of the balanced-

development policy is becoming a new challenge for the countries which shape the global order.

Hence the increasing interest in the attempts of mastering the technology of producing the 2nd and next generation's biodiesel.

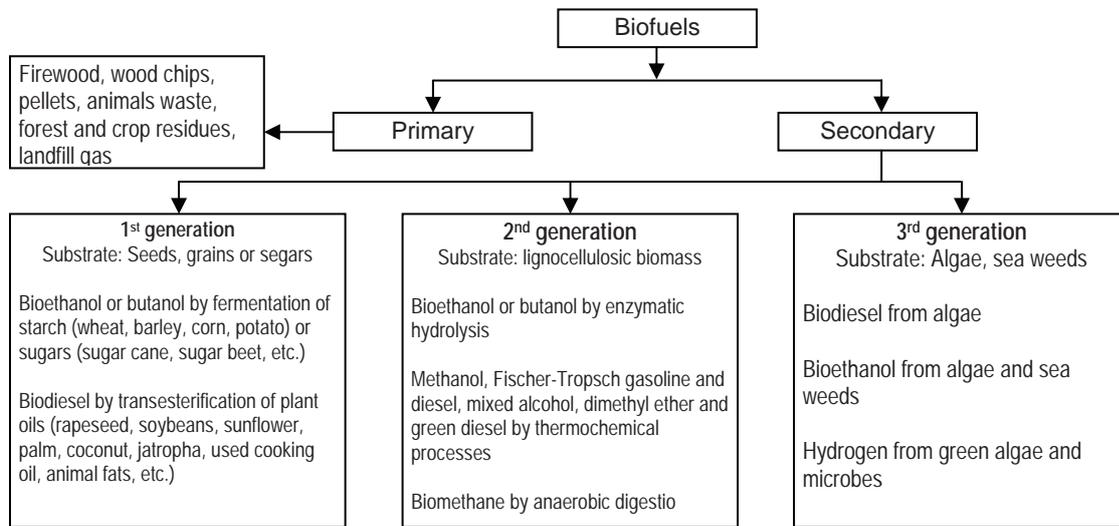


Fig. 3. Classification of biofuels [5]

One of the more interesting examples of such search is the production of biodiesel from algae.

Figure 4 presents the block diagram of growing of algae together with the process of oil extraction and its conversion to fuel.

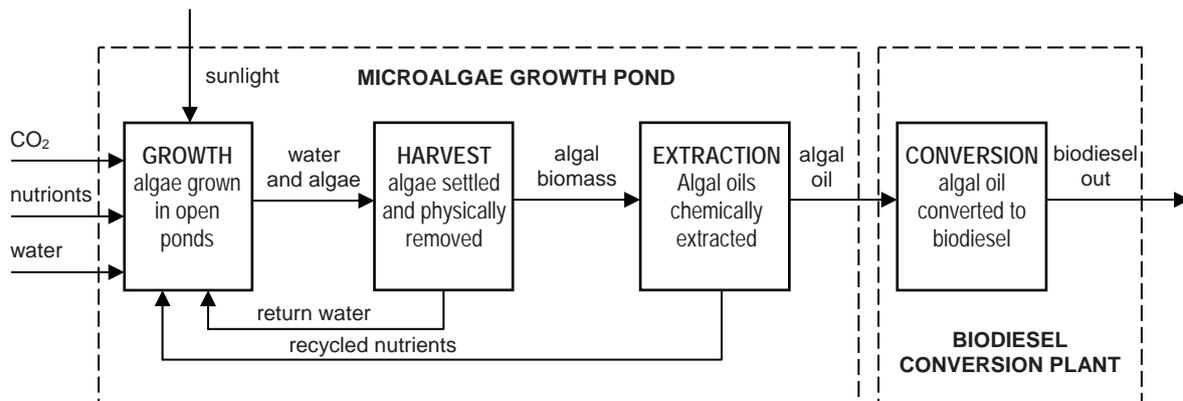


Fig. 4. Simplified systems block diagram of the algae to biodiesel process [4]

It is also worth noting that we are now at the beginning of the energy revolution. The prospects of implementation of intelligent energy grids and intelligent systems which rely on renewable sources of energy, energy-saving or even zero-emission solutions, that realize the idea of pro-consumer energy production, pose new challenges in terms of drive systems for vehicles.

Before the technologies of burning coal in oxygen are developed and before hydrogen-based fuel become generally used, the basic challenge will be to develop the bio-fuel technologies, biodiesel in particular.

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