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Problems and potential of biofuels application at sea and land

Problemy i potencjał zastosowania biopaliw w morzu i na lądzie

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Key words: biofuels, production, usage, pros. and cons.

Abstract
Renewable and CO_2 – natural liquid fuels – biofuels such as vegetable oils, palm oils, coconut, sunflower and rape seed oils are today very appreciated in more and especially more European countries as the green energy sources for land and sea electrical power generation. The paper in the first part discusses the various controversial opinions on the rapidly growing production of vegetable oils for biodiesel production and the possibilities that this may cause higher food prices and spread famine in many countries. The second part of the paper highlights various technical issues of biofuels application on marine diesel engines. The pros and cons of biofuels application are given.

Słowa kluczowe: biopaliwa, produkcja, stosowanie, za i przeciw

Abstrakt
Odnawialne i CO_2 neutralne płynne paliwa – biopaliwa, takie jak: oleje roślinne, oleje palmowe, oleje kokosowe, słonecznikowe i rzepakowe są aktualnie wysoce doceniane zwłaszcza w krajach europejskich, jako źródła zielonej energii, do produkcji energii elektrycznej na lądzie i morzu. W artykule omówiono różne kontrowersyjne opinie na temat szybko rozwijającej się produkcji olejów roślinnych do produkcji biopaliw i związane z tym możliwości przyczyn wzrostu cen żywności powodujące rozprzestrzenianie się głodu w wielu krajach. W drugiej części artykułu przedstawiono różne techniczne problemy związane z zastosowaniem biopaliw w silnikach okrętowych. Podkreślono zalety i wady stosowania biopaliw.

General review of biofuels application issues

Ecogasolin should stop the greenhouse effect. However, due to it there is a lack fields to grow corns (fig. 1) [1].

Biofuels suppose to be a salvation for the human kind: cheap, easy in production and friendly for the environment. They suppose even to replace crude oil which stock in the next 30 years will start to be exhausted. But yesterday the world again has been warned that actually the ecologic gasoline is the cause of increasing famine. In the UN about those facts the presidents of Bolivia and Peru did talk. Their words confirm the UN and World Bank reports from which it is clear that biofuels are a dead end of development. We have to ask ourselves what is for us more important the cars or human life? asked Evo Morales. The President of Bolivia did mention that production of biofuels is first of all affecting the Third World. President of Peru Alan Garcia also launched an appeal in the UN to stop production of biofuels from maize or palm oil. Of the same opinion is the majority of experts – 60% of people in the world are suffering from malnutrition and these forces us to ask about the ethics of further biofuels production. Land and water should be used for food production and not for making fuel says a specialist of ecology David Pimentel from the American Cornell University. The UN representative for food Jeana Ziegler says that production of biofuels is a “crime against the human kind”. With the grain needed to produce only one fuel tank of a sport car one person can be

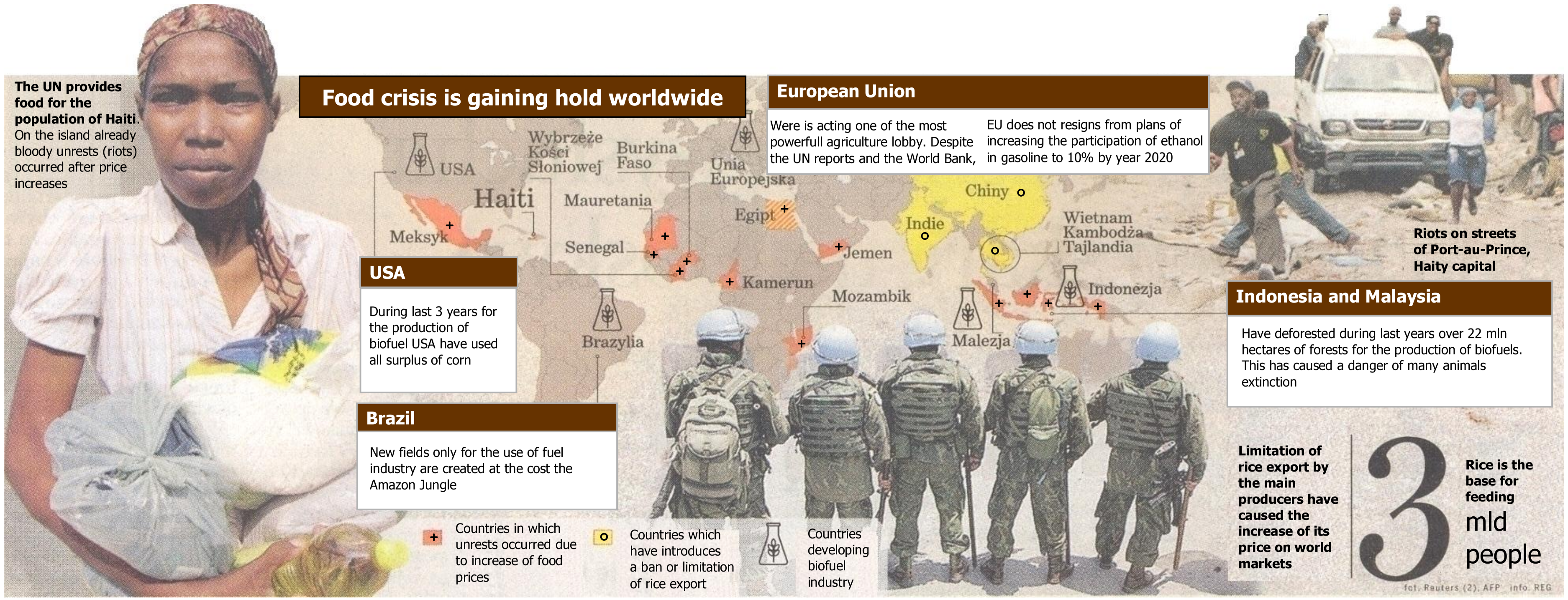

Fig. 1. Illustration of the world wide land usage for production of biodiesel fuel [1]
Rys. 1. Ilustracja miejsc na świecie, gdzie produkowane są biopaliwa [1]

fed throughout the whole year she states. According to the latest World Bank report the increase of biofuels production is lowering the amount of corn available on the world markets, what in turn causes the increase of food price.

The World Bank is warning that due to this fact, 100 mln people in the whole world may suffer hunger. In Haiti already riots have started, because the food prices have increased drastically. Not so long ago I could for 1.25 $ buy vegetables, rice, coal and a bit of oil. Now a small tit of rice costs already 65 cents. I am not able to feed the family – was complaining to the newsmen Hernite Joseph from Port-au-Prince, who earns daily 3 $ and has to upkeep a 5 person family. Being afraid of turmoils, India and China – two most populated countries in the world, have limited the export of rice, to keep on the home markets the lowest prices. But this in turn is lifting its value on the world markets.

The World Bank document is also stating that the production of biofuels are forcing countries which at the same time benefit from the increasing food prices like USA, France and Brazil. These are countries in which the agriculture lobbies are acting exceptionally intensive. On top of that governments of these countries are subsidizing the produced from corn ethanol still considering it as a cheap and ecological alternative for the increasing gasoline prices. In the USA the production of biofuels is increasing in a fast pace. In 2004 year it was 12 mld ltr. but in 2007 year it has increased to 35 mld. During the last three years the USA has assigned for the production of biofuel its whole surplus of maize. On the Old Continent also prevails an opinion concerning the benefits of biofuel production.

Up to year 2010 the European Union plans to increase the content of ethanol in fuel to 5.75% and in 2020 its share supposes to reach 20%.

There are many reasons of food prices increase, but the influence of biofuels production is not large – last week (April 2008) Jose Manual Borroso the UE Commission head was convincing the public. At present the UE must more and more often reject accusations of causing famine in the Third World. As a matter of fact Brussels does not intend to resign from biofuels production but is already announcing the revision of policy. The 10% goal will be up kept. However, the European Commission plans to issue a directive promoting only the production of those biofuels which allow a significant limitation of CO_2 and will not harm the environment, states Johan Reyniers from the UC.

The production of biofuels is also causing large apprehension of the ecologists. They point out that growing plants from which ecological fuel is made is devastating the soil, and artificial fertilizers and toxic pesticides are reaching the rivers waters. Next during soya, rape or sugarcane processing a great amount of CO_2 gas is emitted into the atmosphere which is the cause of climate warming. This is enemy number one with whom for already several years the UN tries to fight.

In Indonesia and Malaysia the production of biofuels has caused a deforestation of over 22 million hectares of forests, in Brazil with great intensity ruined is the Amazon Jungle called as the green lungs of the whole earth. The ecologists have already proclaimed the biofuels by a disgraceful name “forests destroying diesel”. However, Brazil does not intend to resign from its production which brings huge profits.

For goodness sake do not tell me that food is expensive because of biofuel. Food is expensive because the world was not prepared for the growing appetite of the milliards of Chinese, Indians, Africans and Latinos said the Brazilian president Luiz Inacio Lula da Silva. So until hunger will not afflict the Brazilians nothing will change.

Biofuels have still more advantages then disadvantages. When the cultivation of plants for their production will be properly balanced nothing threatens us said to the newsmen Ricardo Salgado Rocha from the Institute of Earth. A completely different view on the effects of biofuels production is expressed by David Pimentel. They do not minimize our dependence on crude oil. This is pure fiction. Biofuels cause high prices on the food markets and contribute to ecological problems. It’s high time that the politicians should be aware of these facts.

But does this mean that biofuels have no potential for using them at sea and ashore? The controversial opinions on biodiesel application have to be carefully considered.

Let’s consider some real statistical figures concerning biofuels. Domestic US production of fuel ethanol rose from 6 billion liters, using 6% of the country’s corn crop in 2000 to 19 billion liters, using 20% in 2006. Annual US production capacity is set to grow 43 billion liters by 2009, a level which would consume about 45% of current US corn production. Looking further ahead, the present administration envisages an annual US ethanol consumption of 130 billion liters in 2017 a volume that would require 140% of the current US corn production. Thus, there will have to be either a significant rise in US corn production or large volumes of ethanol imported. A combination of the two solutions is the most likely outcome and Brazil has already started to step up exports of its sugar cane-based ethanol to the US.

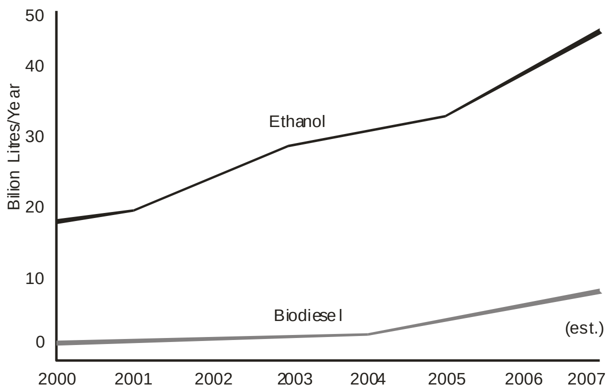

Fig. 2. Ethanol and biodiesel production, 2000–2007 [2]
Rys. 2. Produkcja etanolu i biodiesla w latach 2000–2007 [2]

Brazil produces about 425 million tons of sugar cane annually, of which 50% is used for ethanol production, yielding 17.5 billion liters. Brazil exported about 20% of this ethanol production or some 3.4 billion liters, last year, mainly to the US.

Notwithstanding the merits of replacing a certain percentage of hydrocarbon fuels with renewable sources of energy, the volumes of biofuels required in these replacement programmers are so great that the potential knock-on effect itself could disrupt the global ecology and impinge on the quality of life, especially in poorer regions. The use of many of these biofuel materials as foods inevitably raises the ethical question of whether land should be used to provide fuel or to feed people.

Global biofuel consumption, which hit the 900,000 barrels per day (bpd) mark in 2006, is expected to double to 1.8 million bpd by 2012. However, as is currently the case with fossil fuels, the costs of corn, sugar, soya beans, wheat and palm oil are rising.

Corn prices in the US for example, are now 50% higher than they were in 2005. At the same time some 27% of US corn production in 2007 was expected to be given over to fuel ethanol, considerably up on last year's 20% level. The fact that the US is a traditional exporter of grain highlights how these rising prices and growing commitments to biofuels can adversely impact the ability to feed people in poorer countries. Higher prices for the principal grain crops also mean higher animal feed costs.

The issue of competition for arable acreage is likely to remain unresolved until a larger share of biofuels can be produced from non food crops that do not compete for the same acreage. Crops under consideration include the drought-resistant oil seed jatropha and the fast growing switch grass found on the North American prairies.

It is evident that the potential drawbacks to the surging use of biofuels have to be analysed at the international level because the benefits and risks of developing biofuels on a grand scale have to be appreciated by biofuel producers and consumers alike. Without a global consensus, uniform standards and an agreed understanding that biofuels are no panacea, a difficult task is made that much harder, if not impossible. Many agricultural experts believe that there is room for biofuel production in significant quantities alongside the cultivation of food stuffs and those two end-markets need not be mutually exclusive.

However, the issue of large-volume biofuel production has significant implications and the current headlong drive to boost biofuel production worldwide warrants close control and monitoring to ensure a mutually beneficial end result for the consumers of both foodstuffs and fuel. This is especially relevant in view of the fact that automobile owners are relatively more affluent than the average Third World food consumer. Also much of the current biofuel production is heavily subsidised by governments. The broader risk is that rising food prices could spread hunger and generate political instability in poor countries that import food such as Indonesia, Egypt, Nigeria and Mexico.

Are biofuels a viable solution to replace fossil fuels on board ships?

"The use of vegetable oils for engine fuels may seem insignificant today but such oils may become in the course of time as important as petroleum and the coal tar products of the present time" – Rudolf Diesel, 1911. Biofuels are obviously not a new concept.

The first diesel engines constructed by Rudolf Diesel could run successfully on peanut oil and the Ford Model T engine ran on hemp-derived biofuel.

Historically first generation biofuels refer to those made from sugar or starch (producing bioethanol) and vegetable oil or animals fats (producing biodiesel). These fuels provoked wide criticism, because of their production depending on food crops and issues of biodiversity land use and human rights.

Technical problems exist in blending them effectively with conventional petrol or diesel, most biofuel blends today being no higher than 5–20 per cent. They can, however be burned in 100 per cent blends if required. Second generation bifuels can be the solution to some of the problems associated with first generation products. They do not comply directly with food crops since they are made from waste biomass from agriculture and forestry, fast growing grasses and trees specially grown as energy crops.

With technology sustainability and cost issues to overcome, second generation biofuels remain several years away from commercial viability, and many such mass – produced biofuels are still under development (including the biomass-to-liquid Fischer-Tropsch production technique). Technology may promote greater use of biomass or second-generation fuels in power generation.

Last, third generation biofuels are green fuels and products made from energy and biomass crops that have been designed in such a way that their structure or properties conform to the requirements of a particular bioconversion process. Another example is algae fuel, which is formed solely from waste material, such as sewage, and can be grown on ponds. The production and use of biofuels has increased significantly in recent years, the focus mainly on bioethanol blended into fossil motor gasoline (petrol) or used directly, and biodiesel or Fatty Acid Methyl Ester diesel blended into fossil diesel or also used directly.

The Fischer-Tropsch process is a catalysed chemical reaction to produce a synthetic petroleum substitute, typically from coal, natural gas or biomass, for use as synthetic lubrication oil or synthetic fuel. Synthetic fuel runs (so far) only on diesel engines and some aircraft engines as typical gasoline – burning engines ignite the vapours at much higher temperatures, rendering the synthetic for unusable. While the use of biofuels in land-based transport is becoming commonplace, usage at sea is still under investigation but promises some technical merits.

Marine engine are generally of lower speed and more tolerant to burning alternative fuels than smaller, high speed automotive designs.

Royal Caribbean Cruise Lines has trailled a palm oil-based biodiesel since 2005. Reportedly optimistic results encouraged the operator to contract last August for the delivery of a minimum 15 million gallons and for the four years after a minimum of 18 million gallons of biodiesel for its fleet. The contract represented the signal largest long-term biodiesel sales deal in the USA.

Greener fuels are also targeted by the US Coast-Guard, whose chief of staff, Vice Admiral T.W. Allen reported in early 2007 that his fleet would increase its use of biofuels by 15 per cent over the next four years.

Biomass in the Fischer Tropsch process can also be used to produce bio lubricants, hydraulic oils and grease, whose main advantages are biodegradability and non-toxicity.

Bio lubricants are particularly valuable in the maritime industry from an environmental perspective. Higher viscosity, flash point and better technical properties (such as increased sealing and lower machine operating temperatures) are appearing as additional merits.

The properties of biofuels and the way they behave in the engine vary significantly depending on the source of the fuel, which makes any standardisation in the industry today very difficult. Shipowners must be sure of the quality of biodiesel burnt in their engines.

Currently the fuel standard for marine applications – ISO 8217 – relates solely to fossil fuels and has no provision for biofuels. There are however, a number of available national standards for biodiesel in the automotive sector such as the European EN 14214. The marine bunker supply market would need to work closely with regulators to develop appropriate international marine standards.

„Fuel oil" In the IMO's latest Annex VI regulations, proposed for adoption in October, covers any fuel delivered to and intended for combustion on a ship.

This leaves the door open to biofuels application. Worldwide availability of biodiesel supply is limited, however and such fuels are expected initially to benefit smaller strips operating in areas particularly sensitive to air and water pollution.

For merchant shipping, the way in which biodiesels are delivered to the vessel must also be considered. There are two options either the biodiesel is delivered premixed to the required blend, or the biofuel and diesel are supplied separately and then mixed onboard. Biodiesel blended prior to delivery on board is affected by shelf live. Fuel aging and oxidation can lead to high acid numbers, high viscosity and the formation of gums and sediments.

Fuel management will therefore become ever more complex.

Separate suppliers of biofuel and diesel for onboard mixing enable the operator to obtain the exact blend of biofuel depending on the conditions, but that would require a new technology installed onboard and extra complexity for the crew to handle.

Some operational problems can occur from using biodiesel, related to the Cold Filter Plugging

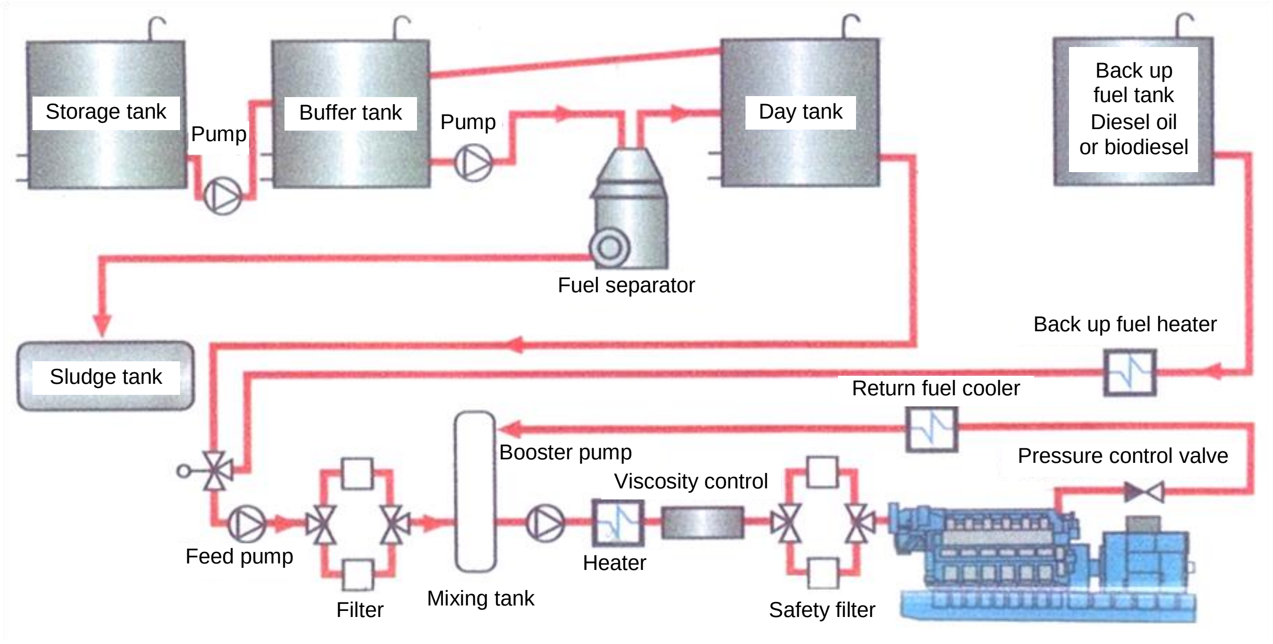

Fig. 3. Fuel system layout for a biofuel Power station (Wärtsilä) [2]
Rys. 3. System paliwowy na biopaliwo w elektrowni (Wärtsilä) [2]

Point (CFPP) at which the fuel starts to turn to gel. Considering operational possibility the CFPP is in the range between 0°C and 15°C for different types of biofuels and can cause problems with filter clogging, which can only be solved by carefully monitoring the fuel tank temperature.

Such a problem could well affect ships operating in arctic (cold) climates, where additional tank heating coils will be required to prevent it happening. Careful choice of biodiesel type can ensure that such problem could be avoided.

Another issue in using biofuels is corrosion caused in the fuel injection and fuel treatment systems as biofuels are hygroscopic and maintain 1.200–1.500 ppm water. It is essential therefore that the fuel is conditioned thoroughly prior injection and also important that the fuel is conditioned to ensure no acidic fuels are introduced to the injection system.

A typical fuel treatment system (fig. 3) should incorporate separators to ensure water free fuel, as well as heaters at various stages to ensure the fuel is at the correct temperature for injection in the engine.

The question arises also how the engine lubricants will be affected by the increased use of biodiesel? The primary concerns for the crankcase lubricant are the impact of biodiesel on engine cleanliness and the possible consequences of fuel dilution. Furthermore, the droplet characteristics and lower volatility of biodiesel, together with spray pattern and wall impingement in contemporary engines may assist non-burned (combusted) biodiesel to get past the piston rings, make contact with the cylinder liner and be scraped down into the oil sump.

Any unburned biodiesel tends to remain in the sump and the level of contamination may progressively build up over time, reduced lubricant viscosity and higher risk of component wear. A serious concern is the possibility that the unburned biodiesel entering the oil sump may be oxidised, thus promoting oil thickening and requiring more frequent oil changes.

Another issue to be considered is fuel injector fouling. Given the increased likelihood for biodiesel to produce deposits, the quality of the biodiesel is critical. The presence of fatty acid and water in the fuel can foster increased corrosion of the injector system. And the presence of glyserid and viscous glyserides can contribute to further injector coking.

It should be also membered that, due to its chemical properties, biodiesel degrades, softens or seeps through some gaskets and seals following prolonged exposure. Such effects clearly become more significant when using higher percentage biofuel blends.

Conclusion

The supply of biodiesel will eventually be limited by available land unless a more efficient and not needed as food feedstock, such as algae is to be used. So the hope is based on algae.

A Spanish company, Bio Fuel Systems, based in Alicante, Spain claims it is on the verge of producing **limitless source** of biofuel based on plankton (algae). It is reported that already in the world power stations are built to run on green fuel made from algae, also part of airlines intends to transfer for that type of fuel.

Finally biofuels pros and cons compared with marine petroleum fuels are listed in tables 1 and 2.

Table 1. Advantages of biodiesel fuel [3]
Tabela 1. Zalety biopaliwa [3]

- 100 per cent biodiesel eliminates sulphur oxide emission
- blends well with petroleum diesels
- no aromatics, resulting in significant reduction in particulate (soot) emissions
- relatively high cetane number, leading to better ignition quality and less combustion noise
- in its 100 per cent form a renewable fuel, with lower life-cycle CO_2 emissions than conventional diesel: a reduction of 78 per cent makes it virtually a CO_2 neutral product
- high flash point of around 150°C compared with the minimum 60°C required for marine diesel fuel standards
- fully degraded from a waterway environment within approximately 28 days, depending on the degree of bio-to-diesel blend
- significant lubricant qualities underwrite a reduction in engine wear represent a solution to the poor lubricity characteristics of ultra low sulphur diesel; a 2 per cent biodiesel blend to replace the lubricity properties of sulphur may be all that is required
- can be used with existing diesel engines with minimal modifications
- positive energy balance from bare ground to finished biodiesel

Table 2. Disadvantages of biodiesel fuel [3]
Tabela 2. Wady biopaliwa [3]

- Higher cold filter plugging and pour point characteristics of some 100 per cent biodiesels and some blends dictate higher storage and handling temperatures; the choice of biodiesel standard should reflect expected operating temperatures and/or ensure trace heating is fitted to fuel piping and storage tanks
- variations in ash content, particularly when using animal-based oils and fats that contain silicon, sodium, phosphorous, potassium and other elements
- its hydrophilic nature means that water will not separate from the biodiesel; good housekeeping is therefore required to keep water levels to a minimum
- some biodiesels can have higher acid numbers (as high as 150 mgKOH/g for some pure vegetable oils; biodiesel standards limit the acid number to a maximum of 0.8 mgKOH/g)
- its solvent characteristics may degrade natural rubber fittings and attack certain materials, such as lead, copper, brass, tin and zinc; this may call for material enhancements for the fuel system components
- slight increase in NOx levels: due to its high oxygen content; biodiesel produces somewhat higher NOx during combustion than conventional diesel fuel; this may require additional measures for engine NOx control
- biodiesel blends with conventional diesel can foster heightened microbial activity in temperatures above 25°C, which can lead to tank fuel system corrosion; existing diesel additives may be used to limit microbial activity
- on a volumetric basis, biodiesel contains 10 per cent less energy than petroleum diesel: for a 20 per cent blend the energy is estimated to reduce by 1–2 per cent; this lower volumetric energy density requires larger fuel volumes (up to 8–10 per cent) to be transported for the same distance travelled
- not suited for long term storage: the recommended maximum is six months in a dark, dry and clean environment; longer storage may raise the acid number.

References

1. Publikacja – Świat, www.dziennik.pl, 23.04.2008.
2. CORKHILL M.: Biofuels – a role to play but not panacea. BIMCO Bulletin 2007, 102, 4, 56–60.
3. WILSON T. AT AL.: Prospects for alternative fuels for ships. 3rd Green Ship Technology Conference, Hamburg, 29–30 March 2006.
4. Biofuels Market – Lloyds List Conferences, 25–26 June 2008.

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