Bioethanol Production and Applicability

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Rising CO2 emission levels, energy dependency and oil dependency also affect the transport sector. The application of alternative fuels offers one way to tackle global challenges. Among alternative fuels the application of biofuels has caused worldwide concern. The evaluation of biofuels depends on a lot of factors, such as applied production technology, feedstock and location. However, the debate on food versus energy production still remains, first generation biofuels are competitive in some regions of the world. With the application of second generation biofuels most of the problems concerning biofuels are expected to be overcome. However, second generation biofuels are unlikely to become commercial before 2015.
The aim of this paper is to give an overview of the current status of biofuels worldwide and to introduce the situation and future possibilities in Hungary.

A növekvő szén-dioxid-koncentráció, az energia- és olajfüggőség a közlekedési szektort is érinti. A globális problémák kezelésére egy megoldást jelenthet az alternatív tüzelőanyagok alkalmazása. Az alternatív tüzelőanyagokon belül a bio-tüzelőanyagok alkalmazása világszerte nagy aggodalmat váltott ki. A bio-tüzelőanyagok értékelése számos faktortól függ, úgymint az alkalmazott előállítási technológiától, a nyersanyag típusától és a helytől. Annak ellenére, hogy az élelmiszer kontra energia vita az első generációs bio-tüzelőanyagok esetében még mindig fennáll, ezen tüzelőanyagok a világ bizonyos részén versenyképesek. A második generációs bio-tüzelőanyagok alkalmazásával a bio-tüzelőanyagokat érintő problémák várhatóan megoldódnak. Kereskedelmi forgalomban való elterjedésük azonban 2015 előtt nem valószínű. Cikkünk célja a bio-tüzelőanyagok jelenlegi helyzetének áttekintése világviszonylatban és a jelenlegi helyzet és jövőbeli perspektíva bemutatása Magyarországon.

1 INTRODUCTION

Global problems such as CO_2 emission, energy dependency and oil dependency urge for solutions in all affected sectors and therefore also in the transport sector. The biggest challenge for the transport sector is that CO_2 emissions energy dependency and oil dependency have to be reduced at the same time when increased mobility needs have to be met. The increase of energy efficiency and the application of alternative fuels are alternatives to tackle global problems in the transport sector. [1]

Several countries have introduced policies for encouraging the production and use of biofuels, including the United States, where the Energy Independence and Security Act 2007 mandates a significant increase in the use of both first and second generation biofuels by 2020. China has a target to 2020 and the European Union has a target for biofuels to meet 10% of road transport demand by 2020. [2]

Australia, New Zealand, Colombia, South Africa, Thailand, Japan, Indonesia, Mexico and Canada also have mandates for ethanol blends. [2]

2 GLOBAL STATUS OF BIOFUELS

Projections concerning future biofuel output are very sensitive to assumptions.

The IEA's World Energy Outlook 2008 Reference Scenario projects the world biofuels output to meet 5% of road-transport fuel demand by 2030 **(Figure 1)**, while in the WEO Alternative Scenario output reaches 7% of road-fuel use in 2030. The IEA's Energy Technology Perspectives (2006) suggests bioethanol and biodiesel could meet some 13% of global transport fuel demand and contribute some 6% of global emission reductions by 2050. [2]

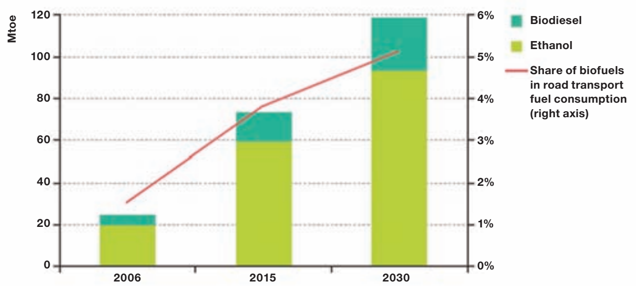

Figure 1: World biofuels consumption [2]

The world's largest producers of bioethanol are Brazil and the United States.

As it can be seen in **Figure 2**, compared to Brazil and the United States, the European Union's fuel alcohol sector is rather small. Nowadays the United States produces more every month than the EU in a year. The biggest EU producers of ethanol are France, Germany, Spain, Poland followed by Sweden and the UK. [3]

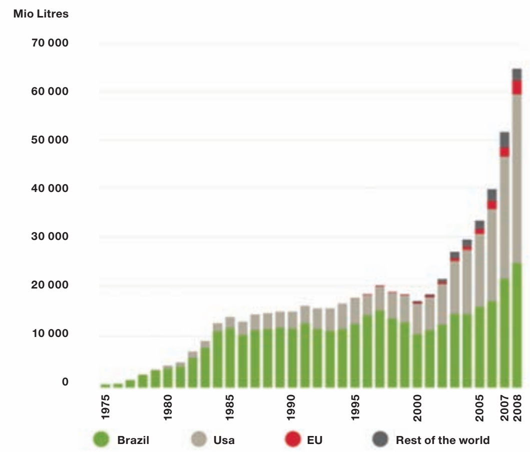

Figure 2: The world's bioethanol production [3]

3 BIOETHANOL PRODUCTION

The conventional production of bioethanol is based on the conversion of 6-carbon sugars to ethanol by fermentation. If the sugar content is present in forms of polymers then the sugar content of the polymer must be released, which is mostly done with the application of enzymes. The production process is finished with the distillation step, where ethanol is distilled to fuel grade. In practise, this process is used to produce ethanol from starchy biomass. A wide range of available feedstocks exist for conventional ethanol production: cereal crops, corn (maize), sugar cane, sugar beet, potatoes, sorghum, cassava. [4]

The world's largest producers of bioethanol are Brazil and the United States. In Brazil, bioethanol production is based on sugar cane, while in the United States, it is based on corn.

While conventional bioethanol production uses only sugar and starch components, advanced bioethanol production processes may utilize all available cellulosic materials, such as energy crops, agricultural residues (straw, corn stover), waste streams (MSW, food waste) and forestry resources. [4]

Lignocellulosic feedstocks are heterogeneous both in structure and chemical composition. This heterogeneity has a strong influence on the production process design. [5]

Ethanol production of lignocellulosic feedstocks is composed of pretreatment, hydrolysis, fermentation, separation and distillation steps. The role of pretreatment to release the cellulose and hemicellulose became more relevant. In some feedstocks 5-carbon sugars might also be present. [4]

The possible presence of 5-carbon sugars influences the hydrolysis and fermentation steps, since appropriate enzymes have to be chosen to hydrolyse the polymers containing 5-carbon sugar and in the fermentation step, appropriate microorganisms have to be selected, which are capable of the co-fermentation of both 6 and 5-carbon sugars. [5]

4 ENERGY REQUIREMENT AND EMISSIONS

Fossil energy input and emission levels from biofuel production depend on a lot of factors, such as the applied process, the feedstock and local conditions. In Brazil, the production of bioethanol from sugar cane is energy efficient, due to the fact that sugar can be easily extracted, and crop yield per hectare is high. If bagasse is used for providing heat and power to the process, the fossil energy input required for each ethanol energy unit can be very low. This results in a low well-to-wheel CO_2 emission, 0.2-0.3 kg CO_2/litre ethanol. Compared to 2.8 kg CO_2/litre for conventional gasoline, this means a 90% reduction. In the case of sugar beet, more energy input is needed and therefore only 50-60% emission reduction can be reached compared to gasoline. [4]

Ethanol production based on cereal and corn feedstock can be even more energy intensive, since fossil energy input can reach 60-80 % of the energy contained in the final fuel. As a result, CO_2 reductions compared to gasoline are around 15-20 %. [4]

CO_2 emission reductions from ligno-cellulosic feedstock can be 70% compared to gasoline and there is a further possibility of improvement with the application of electricity cogeneration.

5 PRODUCTION COSTS

Ethanol energy content by volume is two-thirds that of gasoline, so in the literature costs mostly refer to litre of gasoline equivalent (lge).

Main factors contributing to the cost of biofuels are feedstock types, applied production processes, labour costs, credit for by-products, agricultural subsidies, food and oil markets.

In Brazil, ethanol made from sugar cane ($0.30/lge) is cost-competitive with gasoline ($0.3–$0.4/lge). However, in other regions, costs can be more than $0.40-$0.50/lge.

Ethanol made from maize, sugar beet and wheat costs $0.6-$0.8/lge, with a potential to be reduced to $0.4-$0.6/lge.

Ethanol made from ligno-cellulosic feedstock cost around $1.0/lge at the pilot scale. The costs of ligno-cellulosic ethanol are projected to decrease in the future, due to process improvement, the application of low-cost waste feedstock and co-production of other by-products. **Figure 3** shows possible biofuel cost ranges in the future. [4]

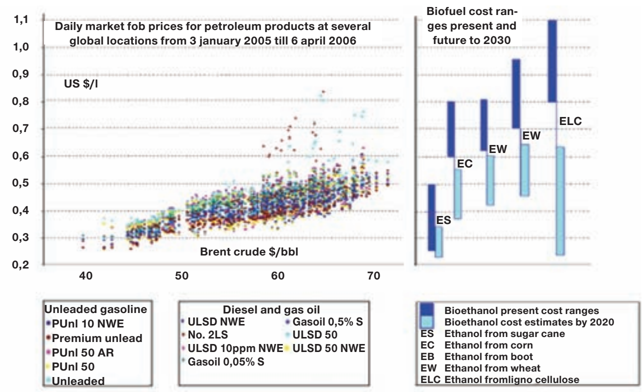

Figure 3: Projected cost of biofuels compared to gasoline [4]

6 CONCERNS REGARDING BIOFUELS

The application of first generation bioethanol has raised worldwide concern. The food versus fuel production debate still remains an issue. First generation biofuels are accused to rise food prices due to competition with food crops. They are considered to be an expensive option for energy security and they can only provide limited GHG reduction benefits. An effect on accelerating deforestation and a negative impact on biodiversity are also often mentioned drawbacks. [6]

It must be mentioned though that not all drawbacks refer to every type of first generation biofuels, since the evaluation of biofuels depends on a lot of factors.

Most of the problems associated with the first generation biofuels could be overcome with the application of second generation biofuels.

However, second generation biofuels are relative immature and projections for second generation fuels to become commercial are wide-ranging, but considered to be unlikely to occur before 2015. As it can be seen in Figure until 2007, second generation biofuels have remained around 0.1 % of total bioethanol production. [6]

7 SECOND GENERATION DEMONSTRATION PLANTS

Integrated research programmes deal with combining process development units with pilot or demonstration-scale facilities around the world.

Main operating process development units are at University of British Columbia, at Lund University (Sweden), at RISO/DTU

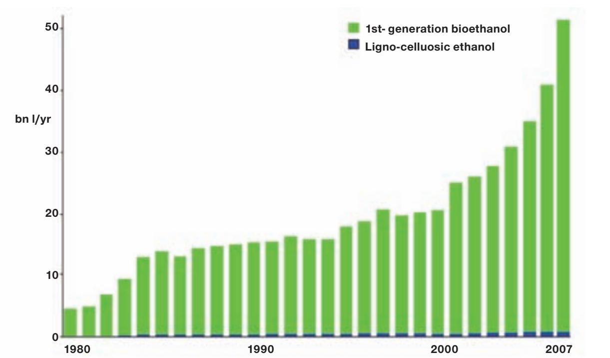

Figure 4: The world's ethanol production deriving from first generation and ligno-cellulosic feedstock. [6]

(Denmark) and at the US National Renewable Energy Lab. Pilot facilities can be found in Sweden (Etek Etanolteknik), in Spain and the USA (Abengoa) and in Canada (Iogen) **(Figure 4)**. [6]

8 APPLICATION IN VEHICLES

Ethanol has a high octane number and therefore it is unlikely to cause knocking in spark ignition engines.

5-10% ethanol blends can be used in conventional spark ignition engines without significant technical changes.

In more complex engines with injector, alcohol can damage the high-precision injection unit. This might also happen to the intake valve and to the valve seat. New flex-fuel vehicles can run on up to 85% ethanol blends. New flex-fuel vehicles are mainly running in Brazil, in the United States and in Sweden. [4]

9 STATUS IN HUNGARY

Table 1 gives an overview about the current Hungarian biofuel potential. Possible feedstocks for bioethanol production are primarily maize and wheat. To a smaller extent, other sugar and starch-containing plants, such as sugar beet, potato and artichoke can also be taken into account. [7]

The wide-spread use of ligno-cellulosic second generation biofuels is only expected by 2012-2015. Among industrial waste streams, paper sludge could be an alternative feedstock for bioethanol production. 50000 tonnes of paper sludge are produced in Hungary yearly. [8]

The Hungarian ethanol production capacity is 210 million litres/year in two factories. The US-based ethanol giant Fagen is going to construct a bioethanol factory (with a capacity of 200 million litres) in Hungary based only on corn.

As a member of the Europen Union, the target set by the Directive 2003/30/EC also applies to Hungary. According to the directive, fuels should contain 5.75% biocomponents. [9]

	THOUSAND TONNES/ YEAR	ENERGY CONTENT PJ/YEAR
Biofuels		55,8
corn (maize)	2000	24
wheat/rye	1800	21,6
rapeseed	460	7
sunflower	200	3,2

Table 1: Hungarian biofuel potential [7]

10 CONCLUSION

Global problems such as CO_2 emission, energy dependency and oil dependency urge for solutions in the transport sector. One way to mitigate the global problems is the application of biofuels. First generation biofuels have caused concerns worldwide. Most of the problems of first generation biofuels are expected to be overcome when second generation biofuels will be commercially available. However, this is unlikely before 2015.

The evaluation of biofuels is difficult and no general rules can be applied, since the evaluation depends on a lot of factors, such as location, production technology and feedstock.

Main factors in the evaluation are energy balance and cost-competitiveness. Although first generation biofuels have a lot of drawbacks, they are now commercially available and are also cost competitive with fossil fuels in some regions of the world.

Projections for biofuel output are also very sensitive to assumptions, but the growing tendency for biofuels is common in all assumptions.

More and more countries start to introduce aggressive policies for the promotion of biofuels.

In Hungary, the current bioethanol production capacity is 210 million litres/year. In the future, a new factory is going to be built based on corn.

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