TL 044

# NEW POLICY FOR REDUCTION OF GHG EMISSION IN DEVELOPING COUNTRIES; FEASIBILITY STUDY ON APPLICATION OF BIOFUELS AND THEIR ENVIRONMENTAL PERFORMANCE

**REZA RAHIMI; NAVID MOLLAEE**

*PETROLEUM UNIVERSITY OF TECHNOLOGY, ABADAN-IRAN*
*UNIVERSITY OF SCIENCE AND CULTURE, TEHRAN-IRAN*

***Abstract***
The topic of biofuels has drawn increased interest worldwide in the wake of steeply-climbing fossil fuel prices in 2005-2006. In late 2006/early 2007 prices began to subside, but are unlikely to return to their former levels. The painful experience of national economies at the mercy of decisions taken far from their shores left a lasting impression on policymakers, and many nations now have a strong desire to increase energy self-reliance. By substituting biofuels partially for imported oil, cash-strapped developing countries can invest their scarce capital in their own farms and industries rather than exporting it to wealthier oil producing nations. If that reinvestment can be made in ways that help the poor escape poverty without degrading their lands, biofuels could contribute to equitable economic development, energy self-reliance and reducing carbon emissions into the atmosphere. Biofuels are renewable fuels that are predominantly produced from domestically produced biomass feed stocks or as a byproduct from the industrial processing of agricultural or food products, or from the recovery and reprocessing of products such as cooking and vegetable oil. Biofuel contains no petroleum, but it is simple to use, biodegradable, non-toxic and essentially free of sulfur and aromatics. Biofuels offer a potential source of renewable energy and possible large new markets for agricultural producers. But few current biofuels programs are economically viable, and most have social and environmental costs: upward pressure on food prices, intensified competition for land and water, and possibly, deforestation. This Article brings an in-depth coverage for Understanding importance of Biofuels in developing countries. Also it looks at the basics of biofuels, the different types of biofuels available, the various uses, advantages, and disadvantages of biofuels, along with the critical factors influencing demand and supply scenarios in the global biofuel industry, the regulatory policy initiatives, vehicle compatibility, and the current and proposed production capacity of biofuels.
***Keyword***: Biofuels, Biodiesel, GHG Emission, Sustainble Development, Global Warming

## *Introduction*

The biofuels market is booming: after more than 20 years of industrial development, global biofuel production is growing fast. Willingness to reduce their oil dependence and necessity to promote low-carbon energies are the two main drivers for states to support biofuels development.

The production of biofuels worldwide is increasing sharply. The United States, Brazil and Europe account for most of this growth, although many other countries are also showing interest in motor fuels of vegetable origin. The painful experience of national economies at the mercy of decisions taken far from their shores left a lasting impression on policymakers, and many nations now have a strong desire to increase energy self-reliance. By substituting biofuels partially for imported oil, cash-strapped developing countries can invest their scarce capital in their own farms and industries rather than exporting it to wealthier oil producing nations. If that reinvestment can be made in ways that help the poor escape poverty without degrading their lands, biofuels could contribute to equitable economic development, energy self-reliance and reducing carbon emissions into the atmosphere. Biofuels are renewable fuels that are predominantly produced from domestically produced biomass feed stocks or as a byproduct from the industrial processing of agricultural or food products, or from the recovery and reprocessing of products such as cooking and vegetable oil. Biofuel contains no petroleum, but it can be blended at any level with petroleum fuel to create a biofuel blend. It can be used in conventional healing equipment or diesel engine with no major modification.

Biofuels are derived from plant and animal materials. These materials can be converted into liquid fuels (ethanol or biodiesel) or solid fuels (wood chips or other organic waste burned for heat and electricity). Biomass can also be gasified with oxygen to produce synthesis gas, which can be used directly as a fuel, or made into methanol, ammonia and diesel fuel. This ENE Issues Summary focuses on liquid biofuels and their potential to substitute for traditional transportation fuels. It also outlines recent research on the environmental implications of biofuels. Using biofuels in the place of fossil fuels has the potential to reduce pollution and greenhouse gas emissions because the plant materials they are derived from (feedstocks) sequester carbon from the atmosphere as they grow. Biofuels can also reduce our dependence on foreign oil because feedstocks can be grown and refined in the United States. Though they have multiple potential benefits, biofuels can also have disadvantages, and their net environmental benefit depends greatly on how they are produced.

**Biofuels Benefits**

Biofuel is simple to use, biodegradable, non-toxic and essentially free of sulfur and aromatics. Ethanol and biodiesel are the most widely recognized biofuel sources for transport sector. Biofuels offer a potential source of renewable energy and possible large new markets for agricultural producers. But few current biofuels programs are economically viable, and most have social and environmental costs: upward pressure on food prices, intensified competition for land and water, and possibly, deforestation.

National biofuel strategies need to be based on a thorough assessment of these opportunities and costs Today, biofuels are regarded as a real alternative to petroleum based motor fuels, even if they probably can never fully replace them. For one thing, they reduce the chronic oil-dependence of the transport sector. They also reduce greenhouse gas emissions due to their mode of utilization. Since biofuels are blended with petroleum-based motor fuels, they are easier to introduce than gaseous replacement fuels: there is no need to install new distribution infrastructure or convert existing vehicles. Every day, current events bring confirmation of this boom and motor fuels of vegetable origin are now to be found all over the world.

In the last five years, global biofuel output grew at a rate of about 15% a year. More recently, the rate of increase has accelerated: 2005 biodiesel production was up by more than 60% year on year. In 2005, world biofuel output totaled 22 Mtoe (about 31 Mt), a figure that is expected to more than double by 2015, in light of the growth targets set by many countries. Today, the development of biofuel pathways is closely associated with targets for the reduction of greenhouse gas (GHG) emissions in the transport sector. Well-to-wheel assessments indicate that the use of these automotive fuels of vegetable origin yield definite benefits in terms of GHG emissions and fossil energy consumption compared to petroleum-based automotive fuels.

***Green House Gas Reduction Policy***

In recent years, there has been a strong revival of interest in biofuels, mainly due to their potential for reducing oil consumption and GHG emissions in the transport sector. Assessments of biofuel performance that bear on these two criteria are therefore critical: public authorities rely on them in designing and implementing systems to support the development of the pathways concerned.
Today, most of the relevant existing or planned regulatory texts concentrate on minimizing GHS emissions (in line with the Kyoto Protocol at global scale and the “Plan Climate” in France). They all compare biofuels with petroleum-based automotive fuels (gasoline and diesel) to evaluate the potential of biofuels for reducing GHG emissions in the transport sector.

Let us recall that the transport sector currently generates about 14% of GHG emissions worldwide (about 5.9 billion C02 eq–tons/year) with a growth rate of about 2% a year that is particularly hard to curb. The current leader on the world biodiesel market, Europe is, after the United States and Brazil, one of the regions driving the production and utilization of biofuels. Its

ambitious biofuel content targets for motor fuels (5.75% by 2010 and 8% by 2015) encourage Member States to significantly develop those pathways. This raises certain questions, especially about available biomass resources. It is likely that, beyond 2010, technologies other than those in existence today, using lignocellulosic biomass, will have to be implemented.

Biofuels, resulting from programs launched in the late 1970s to reduce oil dependence, have been in industrial development for more than twenty years. Today, there is strong renewed interest in biofuels: in the transport sector, they could lead to a reduction in oil consumption and greenhouse gas emissions. This is especially obvious in Europe, where directives adopted early in the decade set ambitious biofuel content targets for motor fuels (5.75% by 2010 and 8% by 2015) and oblige Member States to develop these technologies.
New pathways are emerging in the wake of the boom in the biofuels market. Their development is driven by the search for improved product quality and a broader range of natural plant feedstock. Interested in these new pathways, the oil companies are seeking to differentiate themselves on a market that promises to be very competitive in future. This is a turning point in a sector that has historically been dominated by agrifood companies.

***Biofuels Resources***

One key factor in ensuring the success of biofuel technologies, which are expected to see high growth, is the availability of biomass resources. Although the targets set in Europe and France for the replacement of petroleum products in the transport sector by 2010 can be met by converting farm surpluses into biofuels, in order to proceed further, it will be necessary to mobilize a resource that is more abundant and potentially less costly: lignocellulosic materials, i.e. wood or straw. The future of biofuels depends on establishing the much-awaited "second generation" biofuel pathways able to convert lignocellulosic materials to ethanol, biodiesel and biokerosene.

The fourth-ranked source of primary energy consumed in the world after oil, coal and gas, biomass is the leading renewable energy today. Available reserves are even larger still, a non-negligible percentage of which could be converted to energy and more specifically to motor fuels.

The environmental costs and benefits of biofuel production and use have been found to vary greatly according to the production method and feedstocks used. In general, the use of biodiesel produced in world has been found to provide greater environmental benefits than ethanol, both in terms of reduced greenhouse gas (GHG) emissions and reduced air pollutant emissions. In this paper, estimates of GHG and air pollutant emissions arising from biofuels and petroleum fuels production and use are employed to calculate the change in environmental externalities when substituting biofuels for petroleum fuels in world. These estimates of externalities highlight the need to better understand the environmental implications of biofuel production and use.

Interest in biofuels as an alternative fuel source has grown in recent years and global biofuels production has increased rapidly, largely motivated by government support. Governments around the world have introduced biofuels support policies as a result of a number of considerations: climate change; air quality and human health; liquid fuels supply security; and, rural and regional industry growth. Despite the rapid increases in production, biofuels remain small contributors to global transport fuel supply, with a market share of around 2.8 per cent (IEA 2008). Biofuels currently comprise only 0.5 per cent of world’s petrol and diesel supply. world fuel ethanol production is estimated at 112 million liters and biodiesel production at 59 million liters in 2007, compared with petrol sales of 19 320 million liters and diesel sales of 17 015 million (DRET 2008). Petrol and diesel represent around 70 per cent of the liquid fuels sold in world and are the direct competitors to biofuels.

Mandates and excise exemptions or subsidies are the most common form of biofuels support around the world. The two main forms of support for the world biofuels industry are a goverments fuel excise tax exemption and a state consumption mandates in other area. As in other countries, these policy measures do not distinguish between feedstocks used or

production methods, despite significant differences in the environmental impacts of biofuels produced from different feedstocks. The environmental impacts of biofuels relate to greenhouse gas (GHG) emissions, air pollutant emissions, soil erosion, reduced biodiversity, and reduced water availability and quality. In this paper, estimates of GHG and air pollutant emissions from biofuels will be used to highlight the need to better understand the environmental implications of biofuel production and use.

**Biofuels factsheet**

Most famous companies are committed to maintaining a reliable supply of high quality fuel to world consumers. As part of the US and state and territory governments' Cleaner Fuels Program, the world petroleum refining industry has invested well over $200 billion to produce petrol and diesel fuels that will help to dramatically reduce motor vehicle emissions, particularly emissions contributing to urban smog. This industry focus on both high quality fuels and the environmental performance of fuels is applied to all fuels supplied to consumers, including biofuels. Most famous companies have consistently stated that there is a sustainable role for biofuels in the World fuels market provided biofuels are competitively priced, have a reliable supply and are acceptable to consumers.

Biofuels are derived from sources such as wheat, sugar, tallow, oil crops and waste vegetable oils. There is also the possibility, in the future, that biofuels may be produced on a commercial basis from woody (cellulose) parts of plants and wood wastes.

The major types of biofuels are:

- **Ethanol**—an alcohol produced from fermented feedstocks

- **Biodiesel**—Fatty Acid Methyl Esters (FAME)—esterified oil produced from a variety of sources such as waste cooking oil, tallow, palm oil and canola

- **Renewable diesel**—a product derived from tallow that is co-produced with petroleum-derived diesel and is chemically indistinguishable from petroleum-derived diesel.

***Liquid Biofuels: Ethanol and Biodiesel***

- **Organic ethanol** is produced by fermenting sugars derived from plant materials with yeast. The most common source of ethanol in the United States is corn grown in the Midwest. Brazilian sugarcane is another important source of ethanol. Sugars for ethanol can also be derived from the cellulose in plant materials to produce cellulosic ethanol.

- **Biodiesel** can be produced from vegetable oils or animal fats using the process of transesterification, which removes the glycerin from the oil. In the United States, soybean oil is the most common source of biodiesel. In Europe, rapeseed oil is more commonly used, and palm oil is another important source internationally. Waste oils from restaurants have been converted to biodiesel on a small scale, but the overall availability for waste oil, no more than 100 million gallons annually, is low compared to other sources.

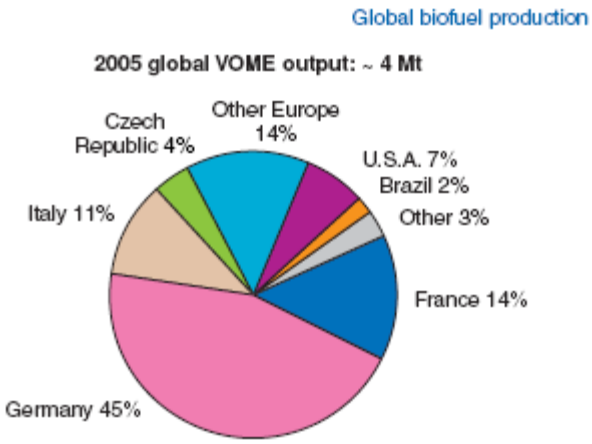
- **Advanced Biofuels.** Concern about the potential impact of increased biofuel production on food prices and land use is driving research into advanced biofuels. Advanced biofuels typically refer to ethanol and biodiesel derived from non-food crops, or waste streams such as waste oil, agricultural and forestry residues, and the organic portion of municipal solid waste. These biofuels may be more efficient and sustainable because they require fewer inputs to grow, such as fertilizer, energy, irrigation and herbicides. Fuels derived from waste or grasses grown on marginal land also will not compete directly with productive agricultural land. However, the technologies to convert these feedstocks into fuel are still in the development stage, and it is unclear how much energy will be required to convert these crops into ethanol and biodiesel.

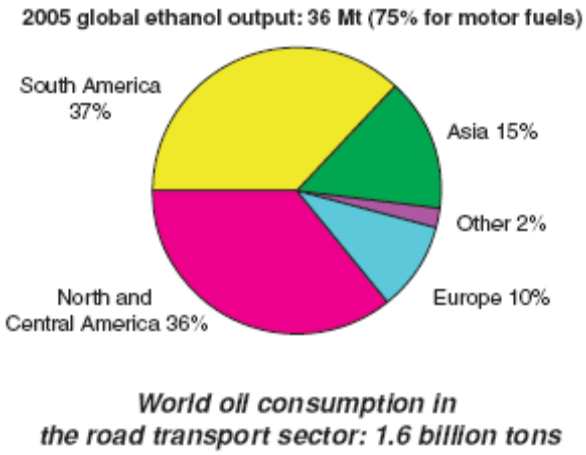
- **Cellulosic ethanol** is commonly referred to as an advanced biofuel; its potential sources include wood, switch grass and corn stalks. Non-food sources of biodiesel include jatropha, castor oil and algae. Jatropha is a tropical plant that is very resistant to drought, with seeds that are 37% oil, making it very efficient in terms of energy output per acre. Some algae species also have very high oil content (over 50%) and very high growth rates.

***Are there environmental benefits from using biodiesel?***

Emission performance of diesel fuelled vehicles has improved dramatically since 2002 because of the rapid and significant impact of the Cleaner Fuels Program for conventional fuels. Most pollutants, including particulate matter, are expected to decrease by at least 70 per cent by 2020 as vehicles using engine technologies which can take full advantage of these higher quality fuels are introduced. The environmental performance conclusions in the Prime Minister's Biofuels Taskforce report for biodiesel are:

- **Greenhouse benefits:** on a full life cycle basis the greenhouse benefits are significant for B100, with reductions in greenhouse gas emissions of 90 per cent for waste cooking oil and around 25 per cent for tallow and canola, compared to petroleum-derived diesel
  - B5 greenhouse emissions are 2 per cent lower than petroleum-derived diesel.
- **Air quality benefits:** on a full life cycle basis B100 has significantly lower emissions of carbon monoxide (26 per cent–46 per cent) and VOCs (22 per cent–46 per cent) compared to petroleum-derived diesel (the range of emission benefits depending on the feedstock)
  - B5 has a reduction in carbon monoxide emissions of almost 12 per cent and a reduction in VOCs of 5 per cent.
- Particulate emissions from vehicles using B100 are reduced by 11 per cent–14 per cent compared to petroleum-derived diesel
  - B5 has similar particulate emissions compared to petroleum derived diesel.
- NOX emissions from B100 are 16 per cent to 30 per cent higher than from petroleum-derived diesel
  - B5 has around an 11 per cent increase in NOX emissions.




*World oil consumption in the road transport sector: 1.6 billion tons*

**Average Biodiesel Intermittent Combustion Emissions Compared to Petro-Diesel According to EPA**

| Emission Type | Pure Biodiesel (B100) | B20 blend |
|---|---|---|
| Total Unburned Hydrocarbons | -67% | -20% |
| Carbon Monoxide | -48% | -12% |
| Particulate Matter | -47% | -12% |
| Nitrogen Oxides | +10% | +2% |
| Sulfates | -100% | -20%* |

***Conclusion & Recommendation***

Based on the growth forecasts for production capacity and on the consumption targets in the geographic areas mainly concerned by the use of biofuels, namely the European Union, the United States and Brazil, global biofuel consumption could reach a total of 60 Mtoe by 2015. This would represent slightly more than 3% of world motor fuel consumption in 2015, compared to 1.3% today. To take production levels higher, it will be necessary to turn to second-generation biofuels based on lignocellulosic materials (wood, straw). One might think that lignocellulosic biomass, more abundant, would not to compete with biomass derived from food crops. Two main options are possible: the first yields ethanol and the second is used to produce synthetic diesel motor fuel using the Fischer-Tropsch process. The second can also be used to produce biokerosene, offering an opportunity to reduce greenhouse gas emissions in the air transport sector, which still has few alternatives to petroleum based products.

As the results, potential biodiesel production from palm oil for Iran is highly positive; however, the price of extracted oil palm is higher than the final competing product, petroleum diesel. Therefore, the ways to minimized cost of biodiesel is to review taxation system, develop the market of its high value co-product (glycerin) and improve the industrial crop yield and management. Currently, in UK, the market price of glycerin is £ 1300 ton- 1 for purified product, and is predicted to be between £ 1000 and 1300 tonne-1 in the year 2004 (William son and Badr, 1998). Nevertheless, within this initial stage, another market for biodiesel would be a fuel additive because of more stringent regulation on sulfur content in diesel fuel. Biodiesel's high lubricity and CN properties are comparable with today's diesel-fuel additives, which their prices are normally substantially higher than petroleum diesel itself.

Given the uncertainty over the benefits of using biofuels to replace transportation fuels, policies such as minimum blending requirements or a low carbon fuel standard should be tied to strict life-cycle analyses that include an assessment of indirect impacts on land use. While advanced biofuels may hold promise, experience has shown that a sober consideration of the impacts of bringing production up to a global scale must be done before mandatory policies are put into place.

It has been amply demonstrated that the use of biofuels to replace conventional automotive fuels can lead to reductions in terms of GHG emissions and NRE consumption. This is one of the prime arguments in favor of large-scale implementation: when used pure, they can induce GHG emissions gains that can exceed 90% for the most efficient pathways (ethanol from sugar cane or second-generation biodiesel).

The NRE consumption gains are on the same order of magnitude. Under present circumstances, biofuels are most often used in blends at relatively low contents, therefore the total benefit with regard to the greenhouse effect can seem small.

Given a conventional automotive fuel with a 5-10% biofuel content, the emissions benefit is lower than 5%. This may seem low at first glance. However, it must be stressed that these are obtainable gains in a sector where growth is very difficult to control and few solutions offering the same benefit are available in the relatively short term. Biofuels may not be THE solution to the problem of GHG emissions in the transport sector, but it is one component of the solution that, taken in combination with others (changes in motor technologies, behaviors, etc.), can help make a good start.

**Acknowledgements**

We would like to express our sincerest appreciation to **Professor Dr. Geert Duysters** for his kind encouragement, valuable advice and constant support. Devotion such as his allows us to have some attempts in the innovative topics. We send him our best wishes.

***References***

1. Environmental Assessment: DET R
2. Good practice guide 115: An Environmental Guide to Small-Scale Combined Heat and Power; ETSU 1996
3. Good practice guide 116: Environmental Aspects of Large-Scale Combined Heat and Power; ETSU (currently unavailable)
4. D Hart, G Hormandinger; Environmental benefits of transport and stationary fuel cells;
5. Journal of Power Sources 71, 1998
6. T Spiro, W Stigliani; Chemistry of the Environment; Prentice-Hall 1996
7. Properties of elements; Spectrum Labs
8. Platinum 1999; Johnson-Matthey
9. DOE, 2006. *Energy Efficiency and Renewable Energy, Biodiesel Handling and Use Guidelines*, 3rd Edition, U.S. Department of Energy.
10. Ministry of Plantation, Industries and Commodities, 2006. *The National Biofuel Policy,* Kuala Lumpur, Penerbitan Nasional Berhad.
11. Cheng Sit Foon, Choo Yuen May, Yung Chee Liang, Ma Ah Ngan and Yusof Basiron, 2005. *Palm Biodiesel: Gearing Towards Malaysian Biodiesel Standards,* MPOB, pg 28-34.
12. Choo Yuen May, Ma Ah Ngan, Chan Kook Weng and Yusof Basiron, 2005. *Palm Diesel: An Option for Green House Gas Mitigation in The Energy Sector*, Journal of Oil Palm Research Vol. 17, MPOB June, pg 47-52.
13. Economic Planning Unit, 2006. *Ninth Malaysian Plan 2006-2010, Prime Minister's Department,* Putrajaya, Penerbitan Nasional Berhad, pg 393-411.
14. Mohd. Jaafar, M.N., 1997. *Modulated and Staged Low NOx Burner*, PhD Thesis, Department of Fuel and Energy, University of Leeds.
15. Börjesson P. 2008. Good or bad ethanol from a greenhouse gas perspective – what determines this? Accepted for publication in *Applied Energy*.
16. Börjesson P & Tufvesson L. 2008. Agricultural crop-based biofuels – resource efficiency and environmental performance. Submitted to the *Journal of Cleaner Production.*
17. Berndes, G. (2002). "Bioenergy and Water - the Implications of Large-Scale Bioenergy Production for Water Use and Supply", Global Environmental Change, 12(-): 253-271.
18. de Fraiture, C., M. Giordano, and L. Yongsong. (2007). "Biofuels: Implications for Agricultural Water Use", Colombo, Sri Lanka: International Water Management Institute.
19. Dufey, A. (2007). "International Trade in Biofuels: Good for Development? And Good for Environment? " London: IIED, IIED Briefing.
20. Graveline, N., M. Casper, J. Grimm-Strele, R. Koller, H. Lambrecht, J.-D. Rinaudo, and P. Van Dijk. (2006). "Integrated Modelling of Nitrate Contamination of a Large Scale Aquifer: Economical Modelling and Scenario Development". Paper presented at the International symposium Aquifers Systems Management, Dijon, France, 30 May-1 June 2006.
21. Hill, J., E. Nelson, D. Tilman, S. Polasky, and D. Tiffany. (2006). "From the Cover: Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels", PNAS, 103(30): 11206-11210.
22. Keeney, D. and M. Muller. (2006). "Water Use by Ethanol Plants Potential Challenges", Minneapolis, Minnesota: Institute for Agriculture and Trade Policy. 7 pages.