Biofuels

towards a greener and secure energy future

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Foreword

Biofuels: a responsible, sustainable energy solution

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The world's increasing dependence on foreign oil poses problems for the economy that go far beyond those associated with our deficit in reserves, its price, and volatility. Tenuous links to geopolitics have been made in the debate about our ability to quench our thirst for oil. There is no need for any of it. If the national imperative is to reduce our energy dependence and create cleaner, more cost-effective transportation solutions, one already well-established solution to the problem is biofuels. This is not new technology, or a 'pie-in-the-sky' idea that will take years to get to market. It is already here.

Ethanol is currently used in vehicles across the world, both in 'low blends' of gasoline such as E10 and in 'high blends' like E85. Its use does not require major modifications to existing engines, transportation, delivery, or storage infrastructure, and it is a clean source of energy, getting cleaner by the day. Changes required for existing engines to run on ethanol are minimal, with engine technology nearly mirroring that in use today, meaning re-training of the mechanic at the corner garage is not an arduous task, nor is maintaining a readily available supply of spare parts to service such engines.

Counter arguments to the adoption of ethanol are many, and generally are issued from large, influential interest groups like the oil industry lobby and environmentalists—many of whom call

into question ethanol's 'green' credentials. On closer inspection these arguments are largely empty. Whilst emissions from ethanol engines and the refining process are higher than hydrogen, this argument fails when the entire hydrogen production process, including the source of hydrogen, is considered. Further harming the hydrogen argument is the length of time, development risk, and investment required for it to be a viable solution (we have to re-train all those mechanics mentioned earlier). The US Department of Energy forecast is that we might have something workable in a hydrogen-based transportation sense by 2040. Ethanol is available NOW.

The move to ethanol will also provide the much-needed boost to the agricultural sector. It has also been argued that we simply do not have the land for these energy crops. But the argument again is based on old corn ethanol technologies. If we use agricultural waste like sugar-cane bagasse to produce cellulosic ethanol and start developing new energy crops like elephant grass (*Miscanthus*) and switch grass, we have more than enough land. Further, new energy crops like elephant grass for biomass and jatropha for bio-diesel will dramatically improve the land availability picture over time. And, these are much 'greener' technologies than even corn ethanol.

And, let us not forget the automakers who are, unknown to many, quietly embracing the ethanol change through development of the flex-fuel vehicle, or FFV. They cost no more to produce and give consumers a choice in fuels, either ethanol or gasoline. Globally, growth of FFVs is burgeoning, to a point where Volkswagen in Brazil is giving serious consideration to phasing out gasoline-powered vehicles. It is easy to see why so, with FFV sales in December 2005 accounting for 71% of overall new car sales in Brazil. Why can't we do the same in the rest of the world? Ethanol and bio-diesel are the only near-term solutions. Once ethanol and bio-diesel are established, many new technologies – from biochemical to thermo-chemical, from chemical process technology to bioengineering, from new agricultural crops to crop rotation schemes – will appear to improve availability and reduce cost.

Introduction

Moving towards biofuels for a secure and clean energy future

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Major changes have taken place recently in the global energy market. The most prominent among these is the unexpected increase in oil prices during the past few months, which went beyond the predictions and expectations of most analysts who are knowledgeable about oil market developments. While the US (United States) continues to be the largest consumer and importer of oil, China and India – while registering rapid rates of economic growth – have also increased their imports of oil. These trends and expectations of growth in the future have had an impact on the oil market, which generally exhibits extreme sensitivity to changes on both the demand and the supply sides. Combined with increased oil prices, the increasing awareness on the global impacts of climate change, which is influenced by the increasing concentration of greenhouse gases in the atmosphere, has led to concerns about increasing the worldwide consumption of fossil fuels. These and other factors have, therefore, recently created growing interest in the possibility of large-scale production and use of biofuels.

If biofuel crops are cultivated and used on a sustainable basis then this option not only becomes environmentally preferred but also reduces threats to the security of energy supply in the future. At a basic level, the production of biofuels represents efficient conversion of solar energy for use in human activities, because the energy produced from crops

is basically a process, which results from photosynthesis that draws on the energy of the sun. India is not only a large importer of oil with the prospect of increased imports in the future, but also has significant potential for production of biofuels in the country. India actually has large areas of wasteland, which could be utilized for the production of biofuels, but there is also a substantial quantity of biomass residue from agriculture and other activities, which presents a scientific and organizational challenge for conversion to usable forms of energy for a variety of applications.

This publication provides an assessment of the state-of-the-art knowledge on the production, conversion, and use of biofuels, which is the collective result of experiences provided by a diverse group of distinguished persons who have been dealing with this subject for some time now. In this era of information flow and knowledge sharing, it is important that any country that embarks on the path of innovation in any field builds on the experience and existing know-how and avoids the danger of reinventing the wheel. Since India and many countries in the world are on the verge of devising and implementing programmes for production, conversion, and use of biofuels, it is essential to base these on the rapidly expanding knowledge that already exists in this area.

Currently, there are a number of liquid biofuels that can be used for various purposes.

Biologically produced alcohols

- Ethanol produced from sugar cane is being used as transport fuel in Brazil and to a very small extent in India. On the other hand, states in the USA are using ethanol produced from corn. A new technology uses cellulosic biomass from plants for ethanol production, but efforts in this field need substantial development and scaling up.
- Methanol is being currently produced from natural gas, but technically it can also be produced from biomass. This technology has significant potential, although the process is not commercially viable at present. The methanol option is an interesting alternative to the hydrogen option, but

again requires considerable R&D (research and development) efforts.

- Butanol is another fuel formed by ABE (acetone, butanol, ethanol) fermentation by the bacteria *Clostridium acetobutylicum*. It can be burned directly in existing gasoline engines without any modifications; can produce larger quantities of energy (higher octane fuel value); and is less corrosive and less water-soluble than ethanol. Also, it dramatically reduces vehicular emissions and can be distributed through existing infrastructures.

Biologically produced oils (bio-oils)

These can be used in diesel engines either directly or after transesterification.

However, not all these fuels are commercially viable at present. Our country has chosen two main biofuels for large-scale deployment— bio-ethanol based on ethanol produced from sugar cane (molasses) as a substitute for petrol (gasoline) and bio-diesel produced from oil-bearing seeds of jatropha (*Jatropha curcas*) as a substitute for HSD (high-speed diesel). The challenge here is to produce large quantities of these biofuels at prices competitive with those of currently used fossil fuel products.

For a country like India, biofuels, especially bio-diesel production promises a number of economic, environmental, and social benefits, such as large-scale employment generation, particularly in the rural sector. The bio-diesel programme will open up a large number of land-based employment opportunities through the raising of plantations and their subsequent maintenance, collection of seed, the processing of jatropha seeds into oil, and transesterification. It is estimated that raising a plantation of jatropha over one hectare of land would generate an average employment of 116 to 122 person-days. Large-scale jatropha plantations will also help the country to achieve high agricultural growth, which is essential if the economy is to achieve and maintain the projected overall growth rate of 8%.

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