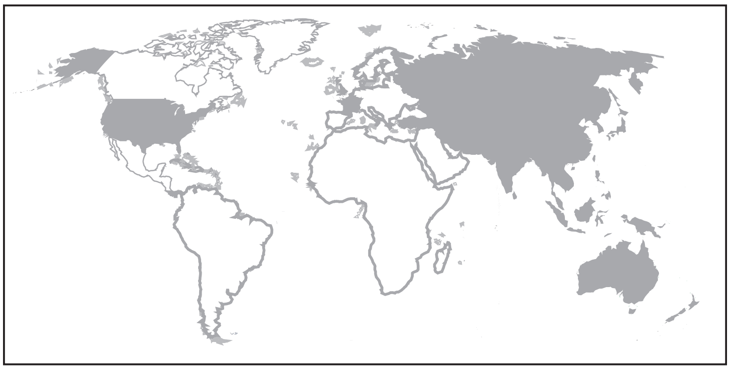
Agricultural Biotechnology-based (Green) Enterprise Development for Sustainable Rural Livelihoods and Economic Growth:

Opportunities with Biofuel in Selected Asian Economies

United Nations
ESCAP

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) is the regional development arm of the United Nations and serves as the main economic and social development centre for the United Nations in Asia and the Pacific. Its mandate is to foster cooperation between its 53 member countries and 9 associate members. ESCAP provides the strategic link between global and country-level programmes and issues. It supports the governments of the region in consolidating regional positions and advocates regional approaches to meeting the region's unique socio-economic challenges in a globalizing world. The ESCAP headquarters is located in Bangkok, Thailand. Please visit the website at www.unescap.org for further information.



The shaded areas of the map indicate ESCAP members and associated members.

APCAEM is a regional institution of ESCAP, located in Beijing, China. Its mission is to assist member countries in achieving their Millennium Development Goals (MDGs) through capacity building / training, agricultural policy analysis, agro-technology transfer and facilitation, and information networking. The Centre focuses on three thematic cluster programmes: agricultural engineering and machinery, food chain management, and agro-enterprise development. For more information, please visit its website at www.unapcaem.org

United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery

Agricultural Biotechnology-based (Green) Enterprise Development for Sustainable Rural Livelihoods and Economic Growth: Opportunities with Biofuel in Selected Asian Economies

United Nations
ESCAP

APCAEM

Beijing, 2007

Foreword

Agriculture and rural development strategies are a critical component of an inclusive growth strategy for Asia and the Pacific region. In particular, the production and use of bioenergy in its modern forms can have a major and positive impact on agricultural development and the environment. If bioenergy becomes a major source of energy, it could have a profound influence in many rural areas of developing countries. It could possibly speed up socio-economic development, and a large number of farmers could increase food production and their own energy in a sustainable manner.

The world biofuel production is on a sharp rise since 2000; biomass currently supplies about a third of energy in developing countries. It is now increasingly realized that there is considerable potential for the modernization of biomass fuels to produce convenient energy carrier, such as electricity, gases and transportation fuels, while continuing to provide for traditional uses of biomass. The potential socio-economic benefits of modern biomass energy arise from the fact that agriculture could face enormous demand for feedstock. This feedstock will need to be produced, harvested, transported, converted into biofuels, and distributed for final utilization. The modernization of biomass and the necessary industrial investment is already happening in many countries. Since the biomass-based energy is a labour-intensive sector, particularly favorable for rural development, agro-energy employment could be a large source of employment in the future. It is important, however, to note that the future use of bioenergy must be strongly linked to high energy efficiency, environmentally-sustainable production and use.

Policy-makers must assess the impact of producing biofuels on food security due to potential change in land use and switch in plantation of agricultural crops; that is, economic and environmental tradeoffs in terms of food/feed/fuel production and security should be carefully evaluated. Furthermore, the processing and conversion technology dimension of biofuel development and production is another important aspect to be considered by the policy-makers at the country level.

As countries move to strengthen their energy security by increasing their use of biofuels, they should also work to ensure poor people's and small farmers' participation in the creation of a more sustainable energy system. With sound technology and trade policies, win-win solutions are possible with biofuels in developing countries and positive outcomes for the poor as well as for energy efficiency.

In order to make a difference in the lives of poor people as both energy producers and consumers, and to make strong environmental and economic contributions, biofuel technology needs further advancement, and investments and polices facilitating agricultural innovation and trade will have to be considered.

Innovative economic instruments such as the Clean Development Mechanism (CDM) and the carbon market trading should be more utilized in order to leverage additional private and public funding for bioenergy production in developing countries under the Kyoto Protocol, and to reduce the greenhouse gas emissions causing climate change. In addition, supportive measures for the establishment of a CDM infrastructure and the creation of CDM-friendly regulatory and business environments are required to leverage carbon finance and payments for ecosystem services and sustainable agriculture development.

Joong-Wan Cho
Head / Senior Economic Affairs Officer
UNESCAP / APCAEM, Beijing

Acknowledgements

The author, Dr. Sachin Chaturvedi, expresses his sincere thanks to Dr. Nagesh Kumar of the Research Information System (RIS), India; and Dr. Joong-Wan Cho of UNESCAP/APCAEM in Beijing for providing direction and guidance during the research and writing and revision of the draft study. Special thanks are due to Dr. S. R. Rao, Department of Biotechnology, Government of India; Dr. S. K. Mohanty; Dr. Ronald Steenblik, IISD, Geneva/OECD, Paris; Dr. S. K. Mohanty, RIS, New Delhi, for their comments on an earlier draft. This study is particularly benefited by the information and insights provided by Dr. B. Anil Kumar, Winrock International, India; Dr. Elma T. Kurunungan; Dr. Arnel Mathew C. Garcia; Dr. Anderestio F. Ulgado and Dr. Nina Gloriani of The Philippines; Dr. Nares Damrongchai; Dr. Samai jai-in, Dr. Paritud Bhandhubanyong; Dr. Siriluck Nivitchanyong; Ms. Peesamai Jenvanitpanjakul, Thailand; Mr. Jayakumar, UNESCO, China; and Mr. P.K. Mudbhary, FAO-RAPP Bangkok Office for all their help and insights during the research for this study. The author wishes to acknowledge the proof, secretarial and layout support from Mr. Tish Malhotra, Ms. Ritu Parnami, and Mr. Pradeep Kumar, respectively. Ms. Maggie Bai and Mr. Sunny Lee of APCAEM provided editorial assistance and worked on formatting of the study report in line with the UNESCAP publication guideline.

APCAEM gratefully acknowledges the funding of this research project by KECF (Korea-ESCAP Cooperation Fund).

Executive Summary

Biofuels have a long history of use in different parts of the world but they were always found to be expensive and inconsistent in their quality and supply. In the mean time, crude oil as an option is falling out of favour because of the continuous increase in the crude oil prices, its adverse environmental impact and the international commitment to the Kyoto Protocol. The situation has motivated a growing number of countries to implement "bio-energy policies". In terms of energy-equivalence, there is no major difference between petrol and ethanol as 1 litre of petrol has the same energy content as 1.5 litre of ethanol. This has prompted keen interest in the development of biofuels across the world. On a global level, production of biofuel is spearheaded by Brazil and the United States followed by China. Currently, about 70 per cent of global ethanol production comes from Brazil and the United States. In these two countries, biofuels have become part of the national strategy for economic development with a sharper focus on agricultural development. Such transition is also the result of environmentally conscious initiatives, including the U.S. oxygenated fuels program. Recently, the EU has also launched a major programme on biofuels, enumerated in the EU Biofuels Directive for development and import of biofuels.

The demand for biofuel is set to expand in the Asia-Pacific region, as more and more governments are establishing mandatory requirements for blending biofuels with gasoline. To some extent, this move is also a result of environment-based initiatives such as the Kyoto Protocol. Therefore, there is a need to launch Asia-specific forums to help developing economies to assess their own biofuel potential, work out local-specific programs and facilitate investment. These forums may also help promote intra-regional exchanges by sharing and learning from each country's experiences and overcome non-tariff barriers for their exports of biofuel-related and finished products. In this context, efforts should also be exerted to identify innovative financing mechanisms, such as loan guarantees and the Clean Development Mechanism (CDM). This, however, may be problematic with "low-intensity" biofuels such as rapeseed oil that require several chemical inputs and have relatively low energy yields. The new technological advances should be able to address such downside of biofuel production. At the regional/sub-regional level, joint efforts will ensure a proper quality of products are available for planting purposes. The non-prescription of standards for the jatropha seeds/seedlings have been useful for the new entrants allowing them to take advantage of the situation. Furthermore, a more pragmatic yet future oriented view has to be applied for the R&D expenditure on biotechnology for biofuels development.

Finally, there is a need to identify such opportunities for all the stakeholders to share the cost of advanced technology in biofuel development. This will eventually prove to be an important investment for the Asian region. In this study report, the specific country experiences of selected Asian economies are illustrated, including China, India, the Philippines, Malaysia, Republic of Korea and Thailand in terms of devising an initial framework for developing "green" enterprises for rural development through enhanced bio-energy production in a sustainable way. There are important lessons to be learned from the US and Brazilian experiences, largely in their overcoming the limitations of the first generation biofuels, while eyeing the second generation biofuels as a long-term strategy.

Contents

List of Tables

List of Boxes

Abbreviations

ABI	Agri-Business Incubator
ABP	Agri-Biotech Park
BIG/GT	Biomass-Integrated Gasifier/Gas Turbine
CAAS	Chinese Academy of Agricultural Sciences
CAMPI	Chamber of Automotive Manufactures of the Philippines Inc.
CDM	Clean Development Mechanism
CEN	European Committee for Standardization
CEPA	Comprehensive Economic Partnership Agreement
CNOOC	China National Offshore Oil Corporation
COMESA	Common Market for Eastern and Southern Africa
CROs	Contract Research Organisations
CSMCRI	Central Salt and Marine Chemical Research Institute
CTL	Coal-to-Liquid
DA-BAR	Department of Agriculture's Bureau of Agricultural Research
DBT	Department of Biotechnology
FFVs	Flex-Fuel Vehicles
FICCI	Federation of Indian Chambers of Commerce and Industry
GAVL	Godrej Agrovet Limited
GBEP	Global Bioenergy Partnership
GM	Genetically Modified
ICRISAT	International Crop Research Institute for Semi Arid Tropics
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
IPR	Intellectual Property Right
KIER	Korean Institute of Energy Research
LBP	Land Bank of the Philippines
M&As	Merge and Acquisitions

Abbreviations (continued)

MOCIE	Ministry of Commerce, Industry and Energy
MOE	Ministry of Environment
MPOB	Malaysian Palm Oil Board
NBB	National Biofuel Board
NBC	National Biofuel Committee
NBDB	National Biofuel Development Board
NLS	North Luzon Super-region
NOVOD	National Oilseed and Vegetable Oil Development Board
NRCS	National Research Centre for Sorghum
OMCs	Oil Marketing Companies
OPEC	Organization of the Petroleum Exporting Countries
PBB	Philippines Biofuels Board
PCARD	Philippines Council for Agricultural Research
PNOC	Philippines National Oil Company
PPMs	Process and Production Methods
RITE	Research Institute of Innovative Technology for the Earth
SHGs	Self-Help Groups
SMEs	Small and Medium-sized Enterprises
TERI	The Energy and Resource Institute
TNCs	Transnational Corporations
TOEs	Tonnes of Oil Equivalent
TPY	Tonnes Per Year
USDA	United States Department of Agriculture

1. Introduction

Biofuels have a long history: Henry Ford envisioned his early Model T car to run on ethanol; Rudolph Diesel ran his first engine on peanut oil. Ethanol was used in rural areas of Australia and the United States in the early 20th century, but prohibition ended its production. In the 1970s, ethanol began to be produced on an industrial scale, first in Brazil and then in the United States. Biodiesel also began to be produced on an industrial scale in Germany and France in the 1990s.

For much of their history, biofuels have been more expensive to produce than their petroleum-based counterparts. However, the recent sharp increase in the crude oil price, and concerns about the adverse environmental impact of fossil fuels, especially with regard to carbon emissions and global warming, have motivated a growing number of countries to look to biofuels as a new strategic option.

About 70 per cent of global ethanol production comes from Brazil and the United States. China is the third largest producer. In Brazil and the US, biofuels have become part of the national strategy for economic development with a sharper focus on agricultural development. In Brazil, biofuels are also considered an important vehicle for rural development. Environmental policies, such as the U.S. Oxygenated Fuels Program launched by the US Environmental Protection Agency, have also played a part. Recently, the EU has also launched a major programme on biofuels enumerated in the EU Biofuels Directive for development and imports of biofuels. In these countries, biofuels are favored by blending mandates, exemptions from or reductions in fuel taxes, or supported by subsidies. In the United States, all three policy options are exercised.

Although ethanol production from 2000 to 2005 more than doubled, it still represents just 2 per cent of the world's petrol supply. In the same period, the biodiesel consumption increased four- fold. Yet, that still accounts for just 0.2 per cent of global diesel consumption.[1] This suggests that if biofuel producers are ever going to contribute significantly to the world's voracious demand for liquid transport fuels, new technologies have to be developed to increase the supply. Currently, around the world, numerous research projects are funded to identify less expensive and more cost-effective raw material and production techniques for biofuels. The growing application of new technologies is helping to reduce production costs and improve quality. The technology frontier is also expanding as it moves from the first generation biofuels based on food crops, to second generation biofuels that are produced from cellulose, waste and other biomass. The hope is that tapping into these bio-resources will increase their availability without adversely affecting food security and forests.

In Asia, this has assumed additional importance as the oil import bill across the Asia-Pacific region has sharply risen. Even the OPEC members in the region such as Indonesia have been struggling with high oil bills. As a result, several governments in Asia have launched programmes to promote the production of crops that can yield biofuels as a way to cut costly fuel imports and create new, value-added products for exports. Production of biofuels is also encouraged as it contributes to improving rural livelihoods and creating new employment, notably in the processing sector.

However, at the same time, many economies in Asia are also grappling with food security issues. Policy-makers are thus compelled to look into other options for expanding the area for energy crops or look for technological options to increase yields to accommodate the expected rise in demand. In this context, it may be worth analysing whether these countries have access to sufficiently high technology expertise and research and development (R&D) to upgrade their biofuel production technology. How can the private sector's engagement help in this regard? Are there possibilities to learn from the experiences within the region? For instance, India is promoting biodiesel production through the cultivation of jatropha, while the Philippines has mastered the biodiesel production from coconut. This brings up the issues related to international trade and transfer of technology.

In this study report, we look into the specific country experiences in selected Asian economies, including China, India, Republic of Korea, the Philippines and Thailand, in devising an initial framework for developing biofuel enterprises for rural development through enhanced energy production in a sustainable way, and suggest ways and means for regional cooperation in this area. Section 2 sets out a conceptual framework to analyze the possible linkages between agricultural biotechnology and biofuel enterprise development. Section 3 suggests a new institutional structure and policy framework for promoting agricultural biotechnology in these selected countries. The specific issues related to the development of biofuel are covered in Section 4, while the impact of this structure and framework on trade and investment patterns are examined in Section 5. Policy recommendations and concluding remarks are provided in section 6 of this study report.

2. Conceptual Framework on Agricultural Biotechnology and Green Enterprise Development: Examining Different Dimensions of Macroeconomic Linkages

There is a growing interest in developing a bio-based economy to address the challenges emanating from the environmental problems. The United States Department of Agriculture (USDA) is likely to establish a voluntary bio-based product-labeling programme for providing such products a distinct identity. The US Farm Security and Rural Investment Act of 2002 defines the bio-based products as “commercial or industrial products (other than food or feed) that are composed in whole or in significant part of biological products, renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials”.

Recently, the scope for bioproduct development based on agricultural biotechnology has expanded to a great extent. This has drawn attention to many issues at different levels. At the institutional level, it raises issues such as developing synergistic mechanisms for facilitating multi-state, multi-institutional collaboration and for building strong regional and national support. At the policy level, it raises issues ranging from the role of genomics in developing the emerging bioenergy and bioproduct economy, to the involvement of private institutions and economic development activities. In the context of developing countries where the agricultural economy is largely struggling with the productivity stagnation in key crops and adversely affecting income levels in the rural areas, the bioproduct-based agro-revolution offers a new development paradigm.

The wide adoption of bioenergy and other bioproducts may provide a new stimulus to the economic growth in rural areas. Given the wide resistance to food and feed that are produced using GM technology, an appropriate application of this technology would be to facilitate agriculture and industry convergence based on biomass. The term, biomass, indicates any organic matter that is available on a renewable or recurring basis, including: dedicated energy crops and trees, agricultural food and feed crop residues, wood, wood wastes and residues, aquatic plants, grasses, fibers, and animal wastes, municipal wastes and other waste materials.[2] The industry based on biomass utilization is expected to help create new employment opportunities. This would also help reduce dependence on imported fuel and emission of greenhouse gases. Entrepreneurs entering these areas, however, would initially need support in both policy and finance for innovation in green enterprise development and management.

2.1 Scope and Contours of Green Enterprise

The biofuel industry, which in several countries is confined to small farmer's cooperatives, is undergoing major changes in terms of the magnitude of investments involved in the production. Interest from socially responsible investors, corporations, private equity funds and venture capital is growing rapidly.[3] New investors are changing the scale and magnitude of the green enterprise. As a result, the trend for consolidation in ethanol production has already begun. The larger plants require lower production costs and have greater economies of scale, which makes them more competitive than the cooperatives.[4]

There are a growing number of firms establishing forward and backward linkages in addition to some new entrants in the scene. Table 1 shows the agriculture giant, Archer-Daniels-Midland company that recently entered ethanol production. The company now makes up almost 25 per cent of the US market. The rest of the production market is made up of small producers such as farmers' cooperatives, which have also entered the ethanol production business. There is also a trend emerging in the US market where oil-refining firms are establishing backward linkages, as they are entering the alliances for ethanol production. This situation may also emerge in many Asian economies where large companies would enter the scene with high production capacity plants for which feedstock would be supplied by farmers directly or through their cooperatives. In this way, the contours of the green enterprises would be defined also as part of the path dependency model in which firms would continue their ongoing work for biofuel production.

Table 1. Emerging Contours of Green Enterprise for Biofuels Production

Types of Production Linkages	Emerging Instances	Sources
Firms Establishing Forward Linkages	Grain producing companies such as Archer Daniels-Midland company are entering bio-ethanol production	Procure the feedstock for production of bioethanol from existing sources
	Groups constituted for marketing of grains such as Farmers' Cooperatives have also entered bioethanol production	Procure the feedstock from members of the Cooperatives
	Many oil firms entering the bioenergy crop production or refining to retain their fuel share in the market, for instance, firms producing polypropylene in India are abandoning current products and upgrading their plants for ethanol production	Procure the feedstock through Cooperatives or open market

Table 1. (Continued)

Entry at the Middle of Value Chain	Several new start-up firms, including Green Sprit Fuel in Europe, have entered biofuel production business	Procure the feedstock from dealers in futures market; This firm has agreement with *Euronext.Liffe*

Note: In 2006, Archer Daniels-Midland owned 25 per cent of US bioethanol refining capacity.
Source: Chaturvedi, Sachin (2006).

However, there are examples of even some start-up biofuel firms adopting measures in their initial stage to safeguard their long-term interests and ensure their viability. For instance, Green Spirit Fuels, a bioethanol start-up firm representing cooperatives of small ethanol producers in Europe called Wessex Grain, linked its production plans with Euronext.Liffe, which operates Europe's largest agricultural futures market. This linkage may help the firm to overcome price and production volatility, as the EU is moving to reduce support for crop production. Green Spirit Fuels plans to produce 130 million tonnes of bioethanol a year from wheat and to use 1 million tonnes of wheat from the United Kingdom each year from 2009. The United Kingdom currently produces nearly 15 million tonnes of wheat but none is used for ethanol production.

2.2 Unfolding New Generation of Biotechnologies: Biomass and Agriculture

Among the key issues that developing countries grapple with in biofuels is the high cost of an alternative fuel option. Unlike developed countries, they are in no position to provide huge subsidies for the promotion of biofuels except a few tax concessions. In that situation, developing countries would be keen to explore technological options. It is often suggested that the biotechnology could be utilized in different ways.[5] One way could be to genetically modify plants to increase the yield. An alternative option could be to create new enzymes, bacteria or funguses that would be used to convert the biomass into biofuels more efficiently. In Asia, the options for producing ethanol are limited. Many Asian countries face frequent droughts and are finding it difficult to replicate Brazil's success with sugarcane, which needs a huge volume of water. Thailand and Indonesia are tapping palm oil as a potential fuel. Indian scientists, meanwhile, have high hopes for jatropha, which tolerates drought well.[6] The three major options available for bioenergy in Asia are biodiesel, bioethanol and biomass gasification, which have huge potential among Asian economies for the development of viable biotechnologies.

There are new additions to the knowledge in biotechnology as the efforts have begun to produce more oil from the limited number of plants. Recently, researchers from the School of Biological and Biomedical Sciences at Durham University in the UK found a gene in a weed, which could significantly increase the yield of crops such as oil-seed rape by promoting massive oil and starch accumulations in plant parts such as leaves and stems.[7] The technology is also facilitating the selection of new sources of biofuel. Earlier the impression was to have biofuel from two major sources. One is from grain-based feedstock such as corn, wheat, rice and the other is the non-grain-based feedstock such as cassava, sugar cane and sorghum. The new source eventually identified was cellulose, which may derive from any organic matter.

Second Generation Biofuels

The second-generation biofuel would largely involve the development of biofuels with the help of cellulosic biomass. This largely covers the fibrous, woody, and generally inedible portions of the plant matter. Given the current level of technological advancements, it may take another 10 years or so to develop these as viable options.[8] In the United States, a roadmap for achieving competitive production cost for biofuels by 2012 is underway. This targets at US$1.07 per gallon of ethanol, and offers the potential to replace up to 30 per cent of the nation's current gasoline use by 2030.[9] The plan hopes that rapidly incorporating new biology approaches via significant R&D investment will spur the use of these technologies for expanded processing of energy crops and residues. The ethanol production capacity in the United States was 4.34 billion gallons in January 2006, which grew to 4.8 billion gallons by the end of September 2006. Another 2.8 billion gallon production capacity would soon be added, raising the total capacity to 7.5 billion gallons.

Efforts with Biotechnology

International Crop Research Institute for Semi Arid Tropics (ICRISAT), a CGIAR institute at Hyderabad, India, has launched a major research project to identify possible options for feedstock so that the cost of ethanol production may be reduced without affecting the food security concerns. The ICRISAT has identified a little-known dry land crop called sweet sorghum, which stores large quantities of energy as sugar in its stalks while also producing reasonable grain yields.[10] ICRISAT proposes to supplement efforts made at India’s National Research Centre for Sorghum (NRCS) which has developed excellent open-pollinated varieties and some hybrids of sweet sorghum. Many of these hybrids are also less photoperiod sensitive so they can be grown year-round, smoothing out supply variations for the ethanol production facilities.[11]

In an initial attempt to test the R&D outcome, ICRISAT signed an agreement with a private company, Rusni Distilleries Ltd., to ensure that the seeds of the highest-sugar sorghum varieties identified by ICRISAT and NRCS reach farmers so they can increase their productivity. Rusni also helps farmers by transporting the stalks from farms within a 30 kilometre radius of the plant, and providing more distant farmers with technologies to crush the stalks and reduce the juice into syrup that can be transported cost-efficiently to the ethanol production plants. As part of this, a 40,000-litre per day fuel ethanol and extra-neutral alcohol re-distillation plant at Mohammed Shahpur village in Medak district in Andhra Pradesh, India, was established to convert the juice from the sweet sorghum stalk into bio-ethanol. The cost of the distillery for ICRISAT is about US$ 7 million. The pioneering venture is expected to benefit not only the 3,000 farmers of the Medak district who grow the crop, but also generate employment for many more farm families.

ICRISAT in collaboration with the Department of Agriculture's Bureau of Agricultural Research (DA-BAR) of the Philippines has also developed a sweet sorghum hybrid called SSH 104.[12] The first sweet sorghum seeds field trials is taking place in central Luzon and parts of Mindanao, where the soil and the weather suits the cereal's requirements. Regional agricultural research centres funded by DA-BAR will conduct the research. The Philippine government is considering including sweet sorghum on the list of priority commodities for research and development because of its numerous uses aside for food.

ICRISAT has further strengthened its partnership with other private firms. For example, it signed an agreement with Nandan Biomatrix Ltd. to scale up its natural resource management technologies.[13] Nandan Biomatrix is a Rs2.5 million company engaged over the past decade in a gamut of agro-biotech activities such as direct and contract farming of various herbs, aromatic plants and biofuel plants. The ICRISAT will extend infrastructure support to the project through its state-of-the-art laboratories, farms and seed material propagation facilities while the company contributes to the Agri-Biotech Park (ABP), an Agri-Business Incubator (ABI), established by the ICRISAT. Nandan Biomatrix joined with Synergy Foundation (UK) to incorporate a joint-venture company. The new company will bring together wasteland owners, landless poor and green investors to provide better livelihoods for the rural poor in a profitable and sustainable way.

2.3 Dynamic Factors Influencing the Development of Biofuels in Asia

There are many factors, which may influence the introduction and production of biofuels in Asian markets. These factors are both external and internal in nature (Table 2). Some may have positive effects like the emergence of rewarding export markets and facilitating fast upward movement, while others may retard the adoption rate. For instance, the lack of additional resources required to produce the energy crops, lack of R&D strength to explore alternative sources and more importantly, the standard-related issues apart from producing at a competitive cost against the highly subsidized crops in many developed markets may slow the adoption rate. The additional challenge may come from the entry of transnational corporations, which may promote consolidation, that is being increasingly witnessed in the US market.

Table 2. Plausible External and Domestic Factors Affecting Production in Asia

External Factors	Price of Fossil Fuel (Pull factor)	This is the most important exogenous factor which drives the research on alternative fuels
	Subsidy Regime (Push factor)	The emerging subsidy regime in the US and the EU, abetted by high tariff barriers, is already adversely affecting export opportunities from developing countries
	External Demand (Pull factor)	The growing demand in the EU and other developed markets has already stimulated several Asian economies to develop biofuels to export to that region
	Standards (Push / Pull factor)	This may continue to be the biggest challenge globally as there is yet no agreement to govern international standards for ethanol and biodiesel
	IPR Regime (Push factor)	Given the growing need to explore alternative bioenergy, crop developments in agrobiotechnology may limit the access to technology
Internal Factors	Food Security Concerns	Asian economies would need to resolve the trade off dilemma of food/feed security vs. bioenergy crop production
	Domestic R&D Advances	Since food security is likely to be opted for, the domestic R&D agenda for cellulosic biomass-based sources would have to be given due consideration
	General Preparedness such as Emphasis on Flex-Fuel Vehicles	Many Asian economies themselves are keen to opt for biofuel for self consumption but a lack of preparedness by the vehicle producing firms remains a big challenge
	Managing Resource Gap	One of the reasons behind the lack of interest shown by the firms is the absence of adequate incentives for which governments would have to identify resources
	Economics of cost	This is one of the key factors on the basis of which farmers and business community would make their decisions

Source: Chaturvedi, Sachin (2006).

Impact of External Factors

The key external factors influencing the biofuel adoption may well be classified into push and pull factors. The pull factors include prices of fossil fuels, external demand and commitment to international environmental agreements such as the Kyoto Protocol, and the stimulus from outside the system. However, at the same time, the push factors such as subsidy regime, standardization and IPR regime may also adversely affect the growth of the biofuel industry. Among them, the subsidy regime may prove to be a deterring factor for many developing countries, compared with that of the Untied States where the subsidies to the biofuel sector have expanded many folds.[14] The United States implements tax credit for biofuels and the Federal government provides US$ 0.51 subsidy per gallon of ethanol produced (see section IV.1). In addition, many states provide additional tax incentives and subsidies, typically around 20 cents a gallon. As the current target for ethanol production in the United States is 7.5 billion gallons by 2012 (a target expected to be reached by 2008), the total public expenditure, including state-level support, is soon expected to reach US$ 8 billion to US$ 11 billion a year (Koplow, 2006). The EU supports biodiesel and ethanol production mainly through fuel-tax exemptions. Some of the developing countries have also joined the initiatives. For example, Indonesia proposed US$ 110 million state subsidy for biofuel development for its 2007 budget.[15]

One of the other key external pull factors is the growing instability of the crude oil prices. This has caused major economic pressure on developing countries and as a result, most of them are keen to have alternative energy options. India and China are most eager to have such an option for domestic energy security. India was ranked sixth in the world in 2001 in terms of energy demand, accounting for 3.5 per cent of the total energy consumed globally, and is expected to grow at 4.8 per cent in the future. India imports 70 per cent of the oil it consumes, and the country has been hit hard by increasing oil prices, uncertainty and environmental hazards in connection with the consumption of fossil fuels. Therefore, bioenergy constitutes a suitable alternative energy source for India, as large amounts of raw material are available to be harnessed.

Impact of Domestic Factors

Among the key concerns at the domestic level which may have profound implications on the growth of the biofuel sector include the choice of cropping pattern for the energy crops vis-à-vis the food security concerns, domestic R&D allocations and keeping up with new advances in biotechnology. There may also be a need to consider the availability of biomass, which would play a key role in second-generation biofuels. Developing countries would have to ensure a large supply of various biomass resources such as agricultural crop residues, herbaceous energy crops, oilseeds, and agro-processing residues.

In many countries, the consultation among the government agencies and the private sector on the adoption of biofuel as a viable option is so low that the private sector is not at all enthused to take it up as a challenge. This has made public policy adoption in this area a difficult proposition. The private sector, especially the small domestic companies find it difficult to coordinate the new design adoption, which is not very difficult for multinational corporations as they are already adapted to it in other major economies. As a result, the mandatory introduction of biodiesel from November 2006 had to be postponed to November 2007. Similarly, in the Republic of Korea, many private firms were reluctant to cooperate with the government plan of biodiesel introduction in 2003 and as a result, it could not be introduced earlier than 2006.[16]

The Asian economies would have additional challenge at the domestic level in terms of mobilising and managing the resource gap for the promotion of biofuel. Existing infrastructure and agroindustrial linkages would require additional focus and financial support. Transition from a total reliance on petroleum-based liquid fuels to partial reliance on ethanol and biodiesel will require a significant expansion of the infrastructure for the distribution of the renewable fuels. The economics of production is of equal importance to the developing countries (Table 3).

Table 3. Economics of Biofuel Production in India, 2003

Production Costs	Rate (Rupee / Kg)	Quantity (Kg)	Cost (Rupee)
Seed	5.00	3.28	16.40
Cost of collection & oil extraction	2.36	1.05	2.48
Less cake produced	1.00	2.23	(-) 2.23
Trans-esterification	6.67	1.00	6.67
Less cost of glycerin produced	40 to 60	0.095	(-) 3.8 to 5.7
Cost of Biodiesel per kg			19.52 to 17.62
Cost of Biodiesel per kg (Specific Gravity 0.85)			17.28 to 15.60

Source: www.pcra-biofuels.org/biodiesel.htm.

Jatropha plant bears fruits from the second year of its plantation and the economic yield stabilizes from the fourth or the fifth year onwards.[17] However, the fact that the plant has an average lifespan of up to 50 years may provide some support to the scale of economies. Jatropha gives about 2 kg of seed per plant. In relatively poor soils, the yields have been reported to be 1 kg per plant while in some other soils, the seed yields have been reported as 0.75 - 1.00 kg per plant.[18] The economic yield can be considered as 0.75 - 2.00 kgs./plant and 4.00 - 6.00 million tonnes per hectare per year depending on agro-climactic zone and agricultural practices. One hectare of plantation on average soil will give 1.6 million tonnes of oil. Plantation on poorer soils will give 0.9 million tonnes of oil per hectare. The cost of production in India per hectare is around Rupee 20; nearly 85 per cent is the cost of the feedstock.[19]

3. Institutional and Policy Frame work in Agricultural Biotechnology for Enhancing Development in Selected Asian Countries

Genetic modification of plants to make biofuel production more efficient and environmentally sound seems to be a great possibility with the advancements in biotechnology. The options available with recombinant technology may help enhance ethanol yield and also reduce environmental damage from feedstock. The genetic manipulation of enzymes may also help in improving bioprocessing efficiency at refineries.

Biotechnology may also help convert wood chips, farm wastes and willow trees into bioethanol more cheaply and cleanly.[20] The USDA's Advisory Committee on Biotechnology and 21st Century Agriculture identified genetic engineering as an option to add traits to food crops such as corn and soybean, and non-food crops such as grasses and trees, to enhance energy production. At Stanford University, a project is underway to study microbial synthesis of biodiesel at the Department of Chemistry and Chemical Engineering. This research aims to genetically engineer a specific bacterium to improve biodiesel production. The resulting organisms would take in a stream of biomass carbon and produce long-chain hydrocarbon fuel. If this research is successful, it can lay the scientific foundation for new types of liquid fuels from biomass.

3.1 Initiatives and Status of Agriculture Biotechnology in Selected Asian Economies

The swift movement of the technology frontier in biotechnology has led to rapid progress in understanding the genetic basis of living organisms and the ability to develop products useful to human and animal health, food, and related industries. Several of these developments have originated from the United States and other developed countries. However, in recent years, developing countries in Asia and the Pacific, including China, India, Indonesia, Malaysia, the Philippines and Thailand, have begun to invest heavily in biotechnology. They are closely following the OECD members in Asia, including Japan and the Republic of Korea, in terms of investment and resource allocation.

The fact that the nation states of the developing world have succeeded in harnessing the development potential of biotechnology has dispelled the earlier notion that only the transnational corporations (TNCs) would monopolise this technology. Also highlighting the growing expertise within the Asian region is the emergence of small start-up biotechnology companies in Asia such as those in Singapore, Taiwan, the Republic of

Korea and India, serving as Contract Research Organisations (CROs) and other small companies linked with academic institutions. Some of these CROs have been working very closely with TNCs.

Several developing countries have now in fact embarked on the path of employing second generation biotechnologies. This would help tapping plant resources as energy crops in a major way. Many of these developing countries were earlier advised to try simpler techniques of plant tissue culture, meristem and organ culture, in order to achieve rapid vegetative propagation[21]. However, now the global synergies developed over the years have helped in bridging the gap between North and South over biotechnology. In India, several research projects are underway on oil seeds and soybean, some of them initiated by the private sector. In Singapore, Archer Daniels has initiated a major research programme on palm oil. In China, the Chinese Academy of Agricultural Sciences (CAAS) has full genomic knowledge about several key energy crops.

Another interesting feature of the biotechnology revolution in the Asian economies is the fact that it has largely been a public sector-led effort. Accordingly, the early 1990s witnessed a sharp increase in the budgetary allocations focused primarily on the establishment of infrastructure, laboratories and manpower training. Now, however, some of the Asian countries face a major challenge of prioritizing their endeavours in biotechnology as per their socio-economic requirements.

At the outset, some very basic propositions would have to be raised about the additional inputs being expected from biotechnology, which differ from the traditional techniques already available. Since most of the countries have benefitted from Green Revolution, there is already a decent R&D set-up and a network of extension agencies that are currently in operation. It is equally important to identify possible areas of research where blending of the two streams of technologies can be achieved. The hybridisation techniques and other agricultural practices may well supplement the biotechnology methods[22]. This would not only augment the technical capabilities but would also help in reducing the capital cost which generally goes up with the adoption of new biotechnology.

The policy framework would also have to make adequate provisions for the promotion of the private sector in biotechnology. The technological and financial support would have to come from the Government to bring into play its entrepreneurial skills to further develop this sector. In this regard, the Public-Private Partnership (PPP) would be encouraged. In the case of India, the Indian Institute of Science in Bangalore supports the entrepreneurial skills of their faculty members by allowing them to launch their own biotechnology start-up firms. This example shows the attitude change that is coming in the publicly-supported institutions; yet this would have to be introduced as a policy thrust at a much wider level so as to facilitate a systemic change for the diffusion of biotechnology. As many of these economies have a predominant role in agriculture, the efforts in biotechnology have also been confined to this sector only. The governments and public research laboratories have launched agricultural biotechnology research programmes, and in some of the Asian countries, agricultural biotechnology products have reached commercialisation stage. The commercialisation signifies another emerging area for cooperation between the public and private sector. This is different from what was being envisaged in the late 1980s when biotechnology remained within the private sector alone and in a proprietary regime while the public sector would lose out. The dynamics of this relationship have now added new economic value to this emerging technology.

3.2 Specific Policy Initiatives for Biofuel and Emergence of the Private Sector in Selected Asian Economies

In this section, we summarize the specific initiatives launched by selected Asian countries chosen for the study, to advance production and adoption of biofuels.

India

In India, the primary energy supply grew at an annual rate of 3.6 per cent from 1991 to 2001.[23] In the same period, the primary commercial energy supply growth was at 5 per cent and the non-commercial energy supply grew at 1.3 per cent.

India set up the National Biofuel Development Board (NBDB), headed by the Prime Minister.[24] The NBDB would fix a minimum support price for non-edible vegetable oil seeds required for conversion into biodiesel and other biofuels such as ethanol. In India, there have been discussions and debates on the proposed policy statement surrounding the recently announced 5 per cent blending of ethanol with gasoline,which was to be implemented by November 2006.[25] The oil marketing companies (OMCs) would require 500,000 kilolitres of ethanol for implementing this nationwide programme.[26] According to the estimates available from the Wasteland Development Board, around 107 million hectares of land are available for reclamation. This land may be put into use for growing energy crops such as wood and leafy biomass.

India decided to make 5 per cent ethanol blending in petrol mandatory in nine selected States from January 2003. The plan, however, ran into trouble in 2004 due to a poor harvest of sugarcane and a subsequent shortage in ethanol supply. As a result, the government made ethanol doping conditional, highlighting the need for an assured supply of ethanol.[27] Unlike Brazil, India's sugarcane juice is not directly used for ethanol production. Ethanol is made from molasses, a by-product of sugar production. It is estimated that utilisation of all the molasses produced in India can yield 2 million kilolitres of alcohol every year, of which about 0.8 million kilolitres of ethanol can be spared for blending in petrol. If all the 0.8 million kilolitres of ethanol is made available, it can replace around 9 per cent of the current petrol requirements.[28]

There are specialized agencies that are also taking a keen interest in developing biofuels. For instance, the National Oilseed and Vegetable Oil Development Board (NOVOD) launched several support programmes for biofuels. It has developed quality planting material and improved jatropha seeds to increase the oil contents up to 1.5 times over ordinary seeds. The target area for jatropha plantation identified by NOVOD is 1,719 hectares in various states. It also provides support for the development of improved oil expellers.

Policy Initiatives

The draft, "New and Renewable Energy Policy Statement" of 2005, from the Ministry of Non-Conventional Energy Sources proposes a direction and strategic vision for developing renewable energy sources to meet the medium to long-term requirements. The statement proposes a policy direction for making the new and renewable energy sector a net foreign exchange earner by the year 2021 or 2022.

Some resource allocations are made at different levels, which may help facilitate the production process. The Indian government has earmarked 500 million rupees (US$ 10.7 million) to support the cultivation of jatropha. In addition, the government is also providing support to nine states for the production of jatropha seeds. The estimation is that by 2009, India will have 3.1 million hectares of jatropha plantations. However, with the growing emphasis on jatropha plantation for biofuel production, the prices of jatropha seeds have gone up.[29] In 2004, the price of jatropha purchased from tribal areas was Rupee 6 per kg. Now, it is Rupee 26 per kg. The proposed policy statement also plans to initiate a program on biomass-integrated gasifier/ gas turbine (BIG/GT) systems for electricity generation with the aim of producing electricity at under Rupee 2.50/kWh by the year 2021 or 2022. This may require elaborate R&D efforts to overcome certain technological barriers for which adequate allocations are suggested in the document. Since biomass fuels have high nitrogen content, control of this has to be addressed. Development of this technology will be carried out through the public-private partnership. Biomass electricity play a major role by 2051 or 2052. Under an optimistic scenario, its share in the electricity-mix could be as high as 27 per cent.[30]

There are several State Governments (see Table 4), which have been far more active in promoting biofuel than the Federal Government. These States have established institutional programmes to oversee the development plans. Most of the States have identified a clear role for the development of the private sector. In fact, some of them joined the public sector banks to support jatropha plantation. For instance, Tamil Nadu joined the Indian Overseas Bank to support the private enterprises in the state for jatropha production. One of the first firms to receive such support is Classic Jatropha Oil Limited.[31] The State of Chattisgarh is taking the lead in several ways in terms of establishing the use and production of biodiesel. This State established the Biofuel Development Authority with clear guidelines for the private sector participation. The other leading state is Andhra Pradesh.

Table 4. Independent Initiatives Launched by Selected States in India

Proactive States	Strategy and Objective	Institutional Structure
Chattisgarh	20,000 hectare under jatropha. Clear plantation guidelines for the private sector	Biofuel Development Authority
Andhra Pradesh	728,000 hectare land under jatropha	Multiple departments to monitor and guide
Tamil Nadu	To derive full diesel requirements from jatropha	

Source: Chaturvedi, Sachin (2006).

The Indian government also launched a major cooperation plan with Brazil on biofuel (see Box 1). The forum chosen is India, Brazil, South Africa trilateral summit (IBSA), but different modalities are being adopted as well. In some cases, major Indian public sector oil corporations are investing in the agricultural farms to produce biofuel crops.

Box 1. IBSA and COMESA to Promote the Use of Ethanol and Biodiesel

The recently held India, Brazil, South Africa trilateral summit, attended by heads of state, discussed ways and means to promote ethanol as IBSA members announced their joining of the International Ethanol Initiative launched by Brazil. The leaders from the three countries agreed to boost cooperation on energy, including the development of alternatives to oil and possibly nuclear power. The Summit was held in Brasilia, the capital

Box 1. (Continued)

of Brazil, after the trio established the IBSA Forum to serve the interests of emerging markets.

Indian state-owned oil companies have shown a keen interest in acquiring sugarcane acreages either on their own or in collaboration with Brazilian state firms to produce bioethanol. Indian state-run Bharat Petroleum Corporation Limited is all set to buy stakes in Brazilian sugarcane projects to secure ethanol imports. There is also an interest in Common Market for Eastern and Southern Africa (COMESA) led by Mauritius to come up with a proposal of feed production for ethanol and biodiesel. India is likely to sign a Comprehensive Economic Partnership Agreement (CEPA) with COMESA, which includes Egypt, Zimbabwe, Seychelles, Madagascar, Uganda, Kenya and Libya. India would help the transfer of techniques for jatropha cultivation.

In light of this, the Asian economies should also consider initiating similar programmes and consolidating the ongoing efforts, based on the complementary nature of the region for their collective advancement.

Source: Chaturvedi, Sachin (2006).

R&D Initiatives

The research on biofuels is still at a nascent stage and commercial production has yet to begin.[32] The Department of Scientific and Industrial Research (DSIR) took some initiatives to produce biofuel, especially from Jatropha curcus plant in large tracts of wasteland in the country. The farmers are expected to benefit greatly from the commercial production of this plant.

The Department of Biotechnology (DBT) of the Government of India has also launched the Mission programme on Bioenergy and Biofuel and a project for developing quality planting material of jatropha.[33] As part of the project, the collection and characterization of germplasm and the establishment of nurseries and demonstration plots using superior quality material based on yield and oil content has been initiated. Over 770 accessions have been collected so far from different parts of the country and they are growing in an area covering nearly 185 hectares.[34]

In the case of bioethanol, the DBT initiated some support programmes. At Madurai Kamraj University, DBT supported-project is looking into the possibilities of constructing novel recombinant cellulolytic bacteria for ethanol production from the cellulosic material.[35] The success of this project would place India in the league of the countries producing second-generation biofuels. Projects are also underway to produce ethanol from alternate feedstock such as lignocellulosic material at IMTECH Chandigarh, fruit and vegetable waste at the Energy and Resource Institute (TERI), and sugarcane/sorghum bagasse at the Indian Institute of Technology (IIT) Delhi. Moreover, a network program is underway to efficiently process the lignocellulosic wastes. Several of these institutes are members of this network, and are also working on ways to reduce the enzyme production cost.

The DBT has also launched a major study on the isolation and production of the hydrogenase gene with the help of recombinant technology to produce hydrogen-based biofuels.

At the Central Salt and Marine Chemical Research Institute (CSMCRI), Bhavnagar successfully cultivated good varieties of jatropha curcus on marginal land to assess seed yields. The Daimler Chrysler (DC) India signed an agreement with CSMCRI to develop biofuel for their C-Class Mercedes-Benz. This would take place at the 30 hectares being cultivated by DC in Orissa and Gujrat at a cost of Euro 600,000. Indian Oil worked on establishing the production parameters of transesterified jatropha oil and the use of biodiesel in its R&D Centre at Faridabad.

Private Initiatives

Several Indian companies launched various initiatives for export and domestic production of ethanol and biodiesel (see Table 5). One of them, Godrej Agrovet Limited (GAVL), signed a memorandum of understanding with a Malaysian Company, IJM Plantations Berhad (IJM) to set up a joint venture to promote oil palm plantation in India.[36] This joint venture is eventually targeting biodiesel production in three to four years in India. IJM already has a license to produce biodiesel in Malaysia. GAVL has palm plantations in Andhra Pradesh, Goa, Karnataka, Gujarat and Mizoram. The joint venture would benefit GAVL with the expertise and technical know-how of IJM, which has been in business since 1985. This is also beneficial to IJM since India has placed high tariff rates on crude and refined palm oil to protect domestic producers. As a result, imports from Malaysia declined by 70 per cent in the period from 1999 to 2006.[37] India plans to increase its use of renewable energy from the current 5 per cent to 25 per cent by 2030. About half of Indian cars drive on gasoline with 5 per cent ethanol, and the government aims to increase that to 20 per cent in the next decade.

BP is spending US$9.4 million (euro 7.6 million) to study jatropha in India and announced in March 2006 it would produce 110 million litres (29 million gallons) of ethanol a year by 2007 in Australia, which aims to substitute 2 per cent of oil use by 2010 with ethanol. British-based D1 Oils is investing up to US$20 million (euro16.1 million) mostly in jatropha in India, Indonesia and the Philippines. The Mysore-based Labland Biotechs signed an agreement with D1 to supply 100 million tissue-cultured jatropha plants and about 150,000 tonnes of jatropha crude oil, worth about US$50 million.[38] Auto companies like Ford and General Motors are ramping up their promotion of flex vehicles, which run on E85. Tata Motors in India is exploring the feasibility of manufacturing vehicles, which also use E85.

The euphoria for ethanol is also catalysing several takeovers in the industry. Dollex Industries Limited has taken over Godavari Manar Sugar Mills at Nanded in Maharashtra to double ethanol production volume by using moasses produced at this unit. Bajaj Hindustan became the first Indian sugar company to export ethanol. In the period of 2005-2006, it exported 5 million litres of biofuel to the Republic of Korea and Japan. It also invested US$500 million to acquire sugar mills in Brazil. The current ethanol production capacity of Bajaj Hindustan in India is 800 kilolitres a day, equivalent to 10 per cent of the total national production. It produces ethanol from sugar molasses and bagasse.

Table 5. Emerging Biofuel Firms in India and Their Operations

Name of the Company	Type of Fuel	Investment	Area/Interest
D1 Mohan Bio Oil Limited	Biodiesel		Invested 10,000 hectare of jatropha production in Tamil Nadu
Bajaj Hindustan	Ethanol	US$500 million	Exports of 5 million litres of Ethanol
Reliance	Biodiesel		200 acres of Land at Kakinada,
Industries Limited			Andhra Pradesh
Emami	Biodiesel	15 billion Rupees	Invested in Jatropha plant at Haldia, West Bengal
Godrej Agrovet	Biodiesel	5 billion Rupees	Jatropha cultivation at Gujarat and Mizoram
British Petroleum	Biodiesel	9.4 billion Rupees	Invested alongwith TERI for Jatropha Projection
Vinod Khosla	Biodiesel	1170 billion Rupees	Invested alongwith Praj Industries biofuel project for production of Jatropha

Note: US$500 million is tentatively equivalent to 20 billion Rupees.
Source: Chaturvedi, Sachin (2006).

Meanwhile, several industrial groups are also actively providing policy inputs on these issues. The Federation of Indian Chambers of Commerce and Industry (FICCI) Core Group on Biofuels suggested that the government should grant a 10-year exemption of excise and customs duties as well as on all central and state levies on biodiesel or jatropha oil.[39]

Thailand

The Government of Thailand has taken several measures to promote biofuel production and its use. The government commissioned the National Biofuel Committee (NBC) to lay out a roadmap for biofuel production. The Ministries of Finance, Agriculture, Energy, Industry and Science and Technology support the NBC in its endeavours. The statutory requirement for developing gasohol is gasoline with 10 per cent ethanol. The government has provided tax breaks for the sugar industry to produce ethanol.

The target is to achieve an ethanol production capacity of 4.11 million litres a day by the end of 2006 and a biodiesel output of 8.5 million litres by 2012. Thailand, the world's top cassava producer, already converts some of the vegetable into fuel ethanol. However, since the coup of 19 September 2006, some changes have been made in the biofuels programme.

The National Biofuel Board, formerly known as the Ethanol Board, was dissolved and a subcommittee was assigned to review the biofuel targets and promotion measures[41]. The sub-committee, consisting mostly of civil servants within the Ministry of Energy, is now giving a very generous incentive package to oil refineries to distribute biofuel-blended gasoline (E10) and biodiesel (B5). The policy makers insist that they should adhere to free market mechanism with regard to the promotion of biofuels and should not use mandatory requirements for biofuel blending.

These new initiatives, purely relying on market mechanisms to encourage the adoption of biofuels often at a higher price than crude oil, may give confusing signals to consumers and investors in the industry. It may be interesting to further follow the developments in Thailand as new policy unfolds.

Policy Initiatives

Thailand announced its policy to promote foreign investment for ethanol production. The main target is the Brazilian firms, along with their technology and production machinery. Thailand's Foreign Minister, while visiting Brazil, invited Brazilian firms to invest in Thailand and transfer technology for the production of bioethanol. In Thailand, the goal for the consumption of biofuel is 1,600 million tonnes of oil equivalent by 2011. That is 3 .85 million litres per day of ethanol and biodiesel respectively. In the case of biodiesel, the blending of diesel with 10 per cent biodiesel by 2012 is the target for which consumption of biodiesel required would be 8.5 million litres per day.

The roadmap as being worked out by Thai authorities considers a timeframe from 2005 to 2012 (Table 6). The idea is to work on several fronts at the same time. In the period 2005-2009, efforts would be made to plant 4 million rais of palm oil and invest 1 million rais in the neighbouring countries. In the first year of this period, efforts will be made to enhance the oil palm productivity from 2.7 to 3.3 ton/rai/year. There is also a proposal to work on physic nut productivity and make it more rewarding for the growers.

Private Sector Initiatives

There are several private companies which are actively involved in the production of ethanol and biodiesel. Bangchak Petroleum Plc. established a pilot plant with Bt 20 million (US$530, 000) to produce 20,000 litres of biodiesel with the use of vegetable oil.[41] This would be mixed up with regular diesel at a ratio of 5 per cent.

Table 6. Biodiesel Consumption and Sales Targets in Thailand

Year	Consumption (Million Litre/Day)	Sales Target	Raw Material supply (Million Rais/Year)
2005	0.03	0.6	0.26
2006	0.06	1.2	0.60
2007	0.36	7	0.67
2008	0.46	9	1.07
2009	0.76	15	1.40
2010	1.76	35	-
2011	3.96	79	-
2012	8.50	85	-

Note: Formulated targets are announced by the National Biofuel Board.
Source: http://www.biofuelasia.com/currently.htm.

China

As the supply-demand gap of energy availability in China is widening, the Chinese government is engaged in identifying new sources of supply. The economy, which has been growing at more than 9 per cent each year, has energy demands growing at 15 per cent annually and oil imports are growing at 30 per cent.[42] China is now the world's second largest consumer of energy and it constitutes 12 per cent of the global energy demand. Coal continues to be the main source of energy (65 per cent).[43]

In China, the government is promoting ethanol and is financing nuclear, hydroelectric and solar power, aiming to increase renewable energy sources from 7 per cent currently to 15 per cent by 2020. This also includes efforts to produce coal-to-liquid (CTL) technology. The ethanol production also expanded in a major way. In 2006, China exported 500,000 tonnes of ethanol. The main export destination was the United States. Domestically, however, China is proposing to address the increased fuel demand with the help of biofuels. According to the IMF, China's car fleet will expand 267 vehicles per 1,000 people by 2030 from the current figure of less than 20 vehicles.[44]

Policy Initiatives

The major policy statement by the government came in 2003 with the "Twenty-First Century Oil Strategy", a US$100 billion futuristic programme.[45] The government worked out a plan to promote biofuel in China under its five-year industrial plan. As part of this, the government is aiming to replace 5 per cent of the total gasoline used within the next five years. To accomplish this goal, nearly 5 million tonnes of ethanol will be required.[46] The government devised a plan to provide tax incentives to ethanol producers, which would cover exemptions on 5 per cent of consumption tax and on 17 per cent of value added tax. China is set to increase its production of ethanol to 4 million tonnes by 2010 from a record output of 920,000 tonnes in 2005.[47] In the eleventh Five Year Plan (2006-2011) document, China proposed to place aside US$101.1 billion by 2020 to meet 15 per cent of its transportation energy needs through the use of biofuels, which corresponds to 12 million tonnes.[48]

The government subsidises production at four plants with a combined annual capacity of 1.02 million tonnes, or about 0.5 per cent of projected corn and wheat output in 2006. In China, there are four major ethanol plants, located in Henan, Anhui, Jilin and Heilongjiang Provinces.

R&D Initiatives

The government has taken a policy decision to promote non-food stock crops for biofuel production, as there is a concern in China about the food security implications of using food crops for biofuel production. They include cassava, sweet sorghum and agricultural residue. There is a plan to set up a plant in the Guangxi Zhuang autonomous region, based on Cassava plant by the end of 2007, which would be the fifth biofuel production plant in China.[49] This plant would have a capacity of 200,000 tonnes per year (tpy) and would be managed by the state-owned grain trader COFCO. The National Offshore Oil Corporation (CNOOC) would be constructing 100 biodiesel plants across the country with different materials as feed stocks.[50] Cassava production in China at present is estimated at 13.3 million tonnes. Guangxi already produces over 60 per cent of China's total Cassava output. Cassava alone, some scholars predict, could supply as much as 4 million tonnes of fuel ethanol in China. Production is estimated to expand greatly in the next few years: Guangxi expects to expand its acreage planted for cassava from 260,000 ha to over 660,000 ha. China could grow Cassava on 2.471 million acres of barren land, adding 21 million tonnes to the crop. Technological advances alone could help raise yields by 7 million tonnes. Meanwhile, Cassava imports into China have expanded in a major way.

Private Sector Initiatives

In the production of bioethanol, state corporations like PetroChina have a much lesser role as compared with several local and small producers. The private sector is also showing a keen interest in ethanol production. Tianguan Group, for example, set up an ethanol production plant with the capacity of 100,000 tpy, based on rice as feedstock. Another major player, Gushan Environment Energy, went public and generated US$200 million from the Hong Kong market for its biodiesel production facility.

Some of the Chinese companies, with the help of the national government, are establishing biofuel production facilities in many other counties. One such company invested about US$90 million in Nigeria for the production of 150,000 metric tonnes of Cassava-based bioethanol. The Chinese government would provide 85 per cent of the project cost to the Chinese company while 15 per cent would come from the Nigerian government.[51]

The Philippines

In the Philippines, the debate on the use of biofuel has intensified over the years. The Lower House of the Parliament and the Senate have come up with their views on the Biofuels Bill. The Senate Bill (SB No. 226) proposes to make it mandatory to use ethanol as 10 per cent of the blend to gasoline, and biodiesel B1 from coconut as an additive to diesel.[52] It is estimated that the 5 per cent blend would save the country US$160 million while 10 per cent blend would save as much as US$354.[53] Two years from the passage of the law, all fuels to be sold will contain ethanol blend. As part of the bill, it is proposed to create a Philippines Biofuels Board (PBB) that will oversee production and use of alternative fuels. However, critics argue that the mandatory provision may adversely affect prices of agriculture commodities such as sugar, which would go in as inputs for ethanol production. The group, led by the Chamber of Automotive Manufactures of the Philippines Inc. (CAMPI), also raised doubts about the technical viability of the ethanol mandate by the government.[54]

The law was signed by the President on 12 January 2007. The bill mandates that all bioethanol-blended gasoline shall contain a minimum of 5 per cent bioethanol fuel by volume within two years from the effectivity of the Act. Within four years from the effectivity of the Act, the National Biofuel Board (NBB) will be empowered to determine the feasibility and thereafter recommend to mandate a minimum of 10 per cent blend of bioethanol by volume into all gasoline fuel distributed and sold in the country. Within three months of the Act's commencement, a minimum of 1 per cent biodiesel by volume shall be blended into all diesel engine fuels sold in the country and within two years from effectivity of the Act, the NBB is empowered to determine the feasibility and recommend to mandate a minimum of 2% blend of biodiesel. A National Biofuel Board was also created to monitor the supply and utilization of biofuels and biofuel-blends, and to review and recommend the adjustment in the minimum-mandated biofuel blend. To encourage investments in the production, distribution and use of locally produced biofuels at and above the minimum mandated blends, and without prejudice to enjoying applicable incentives and benefits under existing laws, rules and regulations. the following additional incentives were provided, including zero tax on local or imported biofuels component. Additional incentives were provided, including zero tax on local or imported biofuel component. Similarly, the sale of raw materials used in the production of biofuels shall be exempted from value-added tax. It has also been announced that the government and the financial institutions shall set a high priority to extend financing to citizens and entities that shall engage in activities involving production storage, handling and transport of biofuels and biofuels feedstock.

Policy Initiatives

The government recently announced setting up of a 100 billion Peso(US$2 billion) infrastructure focused on a five year pump-priming programme for promoting biodiesel production in North Luzon Super-region.[55] The Philippines is also making efforts for generating resources to promote facilities for biofuel production. The Land Bank of the Philippines received a loan of US$100 million from the World Bank and US$150 million from the Japan Bank for International Cooperation.

The bill requires the Tariff Commission to create a tariff line for bio-ethanol fuel. The bill also has a provision to encourage entry of new investors in the biofuels sector, as it contains a wide range of fiscal and non-fiscal incentives, including exemption from tariff duties on importation of equipment and machinery. Another incentive is the classification of all investments in ethanol production and blending as "pioneering" or "preferred areas" of investment, which entitle them to financial incentives. Bioethanol producers would also have easy access to financing from the government.

R&D Initiative

In the Philippines, biodiesel is produced from coconut, which is a source of food in the country. With the mandated 1% biodiesel blend, present coconut oil production will be enough to supply the biodiesel requirement without competing with the food supply. However, an increase in the mandated blend may indirectly compete with food supply. As a result, the government is keen to identify other alternative sources of biodiesel such as jatropha. At present, there are different species of jatropha with which biodiesel can be produced. However, the feasibility of using jatropha as a biodiesel source has yet to be established.[56] In order to overcome this constraint, the Philippines Council for Agricultural Research (PCARD), under the Department of Science and Technology (DOST) and the University of the Philippines Los Banos, launched extensive research projects. They are also working on alternative sources for bioethanol, as most of the bioethanol is imported from Brazil. The Philippine Government pressed bagasse, or sugar cane pulp, into service to relieve the oil-poor archipelago's chronic power shortage. About 267,000 tonnes of raw sugar are slated to fire power plants in 2007.

Private Sector Initiatives

It is very likely that almost 3.5 million farmers would benefit when the Bill for Alternative Fuels becomes effective. Most of them are coconut producers and also grow improved varieties of jatropha. The private sector is showing a keen interest in developing joint venture alliances for production and exports of bioethanol and biodiesel (Table 7). Chemrez Inc. has exported 500,000 litres of coconut-based biodiesel to Germany and to other Asian markets including China, Taiwan, Republic of Korea and Malaysia.[57] Chemrez Inc. is one of the leading coconut biodiesel-producing companies with just half a dozen other companies. This year, Chemrez proposed to increase its production capacity to 150,000 litres of coco-biodiesel.[58] There are some oil firms which are entering the biofuel market, including Flying V which invested US$1 million in the Clark Special Economic Zone to produce pre-blended biodiesel.

There is also a considerable interest in bioethanol emerging, but primarily led by the transnational corporations from the United States. The subsidiary of Pioneer, called Pioneer Hi-Bred Philippines Inc., proposed a drought-resistant high-oil content corn variety for ethanol production in an area of 2.5 million hectares.[59] The area under corn cultivation in the Philippines is around 600,000 hectares. This prompted Ford to announce a major flex-fuel production plant in Manila with the cost of 2 billion Peso.

Table 7. Emerging Biofuel Firms in the Philippines and Their Operations

Local Company	Foreign Partner	Nature and Objective of Joint Venture
Far East Biofuels LLC		US$20 million to produce 150,000 litre ethanol a day
National Development Corporation, Manila	Bronzeoak, United Kingdom	San Carlos Bioenergy Plant
PNOC Alternative Fuels Corporation	Samsung, Republic of Korea	Jatropha-based biodiesel production in 120,000 hectare costing 6 billion Peso, financed by Samsung
Philippine Coconut Authority (PCA)	Mitsui and Co. Ltd. Toyo Engineering Corp. (TEC), Japan	Biodiesel production using coconut oil as feed stock from a site covering 600,000 hectares

Source: Chaturvedi, Sachin (2006).

Republic of Korea

The interest in the Republic of Korea (ROK) for the use of renewable energy sources is rapidly expanding. Given the constant rise in fuel prices, the emphasis for alternative sources is naturally on the rise. At the end of 2005, ROK generated 5.01 million tonnes of oil equivalent in reusable energy, accounting for 2.2 per cent of the total consumption of the existing energy resources.[60] The corresponding figures for Denmark and France are 13.2 per cent and 6.4 per cent, respectively. The Korean government plans to raise the ratio of reusable energy consumption to 5 per cent by 2011 by focusing on the development of gas hydrate deposits and the development of alternative energies such as biodiesel and hydrogen fuel cells. The Republic of Korea, entirely dependent upon imports to meet its oil needs, is the world's fifth largest importer of oil.

Policy Initiatives

The Republic of Korea recently issued a decree that all domestic diesel must have at least 0.5 per cent biodiesel content, which is proposed to increase to 5 per cent by 2008 for lighter vehicles and 20 per cent for heavy vehicles. At this point, two large firms, Ecosolution Co. Ltd. and Golden Hope, are producing 8,000 barrels per day (bpd) of the total demand of 2.2 million bpd of diesel in the Republic of Korea. The Ministry of Environment (MoE) and the Ministry of Commerce, Industry and Energy (MoCIE) began working on biodiesel in 2002 as a solution to environmental pollution, global warming and energy supply issues.[61] MoCIE built a full-scale commercial plant at the end of 2002. Work on a Korean biodiesel standard began in 2003, resulting in a draft in September 2004. The Korean standard is close but not identical to EN14214, the European

Committee for Standardization (CEN) biodiesel standard.

Biodiesel for private vehicles has been on sale since July 2006. The introduction of biodiesel, a mixture of diesel and 5 per cent rapeseed oil, accords with a voluntary pact among local refiners to supply more eco-friendly fuel.[62] The agreement calls for local gas stations to sell the biodiesel. Although the cost of producing this type of eco-friendly fuel is higher than the cost of refining crude oil, the measure will help reduce crude imports and contribute to a reduction in the amount of carbon dioxide. The government gives tax waivers to clean fuel and people can expect to pay about 7 Korean won (US$0.008) less per litre of biodiesel compared with regular diesel.

Private Sector Initiatives

The Republic of Korea initiated a few joint ventures with Malaysian firms for biofuel production. The Malaysian Palm Oil Board (MPOB) of Malaysia and the Korean Institute of Energy Research (KIER) signed a Memorandum of Understanding (Mou) for collaboration in research and development (R&D) relating to biofuels, particularly based on palm oil.[63] As part of the deal, both institutions would explore specific R&D projects that will enhance the use of palm oil-based biodiesel in the Republic of Korea. The raw diesel would come from Malaysia and would be adapted to fit for the Korean environment and automobile engines.

Similarly, another MoU was signed between Ecosolution Co. Ltd of the Republic of Korea and POIC Sabah Sdn Bhd for the production of biodiesel. Ecosolution Co., Ltd emerged as a major player for biodiesel production with the help of palm oil. It invested US$64 million (RM 236 million) at Sabah in Malaysia for biodiesel production.[64] Ecosolution decided to expand its production capacity to 500,000 tonnes per year (tpy). This led to a series of cross investments by Malaysian companies in the Republic of Korea. The Malaysian leader, Golden Hope Plantations Bhd, which is building facilities in Malaysia and the Netherlands, announced plans to build a 150,000 tpy biodiesel plant in Yeosu region with Korea's H-Plus Bio Ltd.[65] Ecosolution is already marketing a 40,000 tpy multi-feedstock plant in the Republic of Korea. The major multinational corporation, Samsung invested in the Philippines for a jatropha-based biodiesel production plant in collaboration with the Philippines National Oil Company (PNOC).

Malaysia

Malaysia has emerged as an important catalytic agent in the process of adopting biofuels in Asia. It drew an elaborate plan to promote palm oil-based production of biodiesel. The government decided to make a 5 per cent blending mandatory from October 2006. The Malaysian government proposed to set up a RM 500 million (US$136.7 million) fund to assist in the development of palm oil-based biodiesel production.[66] It also envisages a major role in terms of supplying feedstock to the processing units in the neighbouring countries. For example, the Illinois-based Archer Daniels Midland last year announced plans to build a US$29 million (euro 23.3 million) biodiesel facility in Singapore for which a raw material agreement was signed with one of the firms from Malaysia.

Policy Initiatives

In order to keep a due balance between the various end-uses of palm oil, licenses for biodiesel production were issued to a selected few companies (Table 8). In the first phase, only 52 companies who were supposed to be investing in biodiesel plants were given these licenses.[67] The government launched a project of establishing biofuel parks in different parts of Malaysia. One is in Tanjung Langsat Port in the palm oil-rich Johor State for promoting research on biodiesel production methodologies. Malaysia already has two more such biofuel parks, Pasir Gudang and Tanjung Pelepas Ports. The idea is to promote biofuel research and refinery plants in geographical proximity.

Private Sector Initiatives

There are several leading private actors that play a major role in terms of leading the palm oil production for biodiesel purposes. The plantation industry is in the phase of consolidation where bigger firms are taking over smaller ones or expanding the total area under cultivation. The Integrated Oil Palm Plantation in Malaysia has taken over Rinwood Pelita Miri Plantation Sdn to add 9,040 hectares to its existing 140,000 hectares of palm plantation. The PPB Group Bhd has added another 30,000 hectares to its existing plantation area of 363,000 hectares.[68] Some of the other players are Kumpulan Guthrie Bhd and Golden Hope Plantations Bhd. Companies such as Carotino Sdn Bhd are differentiating their products on the basis of summer grade and winter grade palm biodiesel with low cold filter plugging points. This company recently invested US$27 million to upgrade palm biodiesel to produce 180,000 tonnes, a large amount of which is exported to the European Union.

Table 8. Emerging Biofuel Firms in Malaysia and Their Operations

Local Company	Foreign Partner	Nature and Objective of Joint Venture
Golden Hope Plantations, Bhd	H-Plus Bio Ltd., Republic of Korea	Biodiesel production plant in the Republic of Korea to produce 150,000 tonnes of biodiesel annually, using palm-based products
	The Netherlands	Palm-based biodiesel production unit in the Netherlands
	Venezula	Exported 34 million tonnes to Venezuela
Kulim Bhd	Peter Cremer Gruppe (Germany)	Production plant for biodiesel with a capacity of 200,000 litres in Singapore to export to US, EU and China; The German partner to invest US$50 million for the construction of a biodiesel-processing plant at Jurong Island
IJM Plantations Bhd (IJMP)	Indonesia	Purchased 400,000 hectares for biodiesel production with a RM 74 million (equivalent to US$ 22 million) investment
PPB Oil Palms Bhd	Indonesia	Invest RM300 million (equivalent to US$ 89 million) to RM400 million (equivalent to US$ 119 million) annually from 2006 to 2010 to develop plantation infrastructure and processing facilities for bioethanol production

Source: Chaturvedi, Sachin (2006).

4. Challenges and Policy Options for Developing Green Enterprises for Biofuel: Learning from Successful Cases

In order to develop rural vitalization programmes, it is possible to invest in green small and medium-enterprises (SMEs) through loans and equity finance designed specifically for the adoption of new technologies. There may be several sources for finance identified for faster delivery of resources. These may include institutions like cooperatives, self-help groups (SHGs), alternative public offerings, community development finance and social and venture capital. These institutions should be committed to green enterprise development and are sustainable independent financial institutions that provide capital and support to individuals and/or organizations. Their members may be part of the SHGs or other cooperatives in order to avail maximum support. In the case of biofuel, it may be easy given the increased political and economic interest in the sector.. These enterprises may take advantage of the situation and contribute to generating "green commerce". In many Western markets, the preference for production environment is growing under campaigns such as, "People, Planet and Profits".[69] Environment-friendly production would provide an instant market in such a setting as that would encourage consumers and businesses to buy goods and services from other members, based on their shared commitment to these values.

This may also encourage entrepreneurs to make energy and environmental practices a core competency among the enterprises, producing and investing in clean energy technologies and driving for innovation. In recent years, several US firms undertook interesting ventures, which were environmentally promising and rewarding as well. For example, even though ethanol generates five per cent of its revenue, Archer-Daniels-Midland (ADM) increased its investment by more than 50 per cent in 2006. ADM produced about one billion gallons of ethanol fuel in 2005, about 25 per cent of the industry's production. The company has plans to construct a corn-to-ethanol mill in Nebraska, which would be able to produce 275 million gallons annually.[70] Similarly, VeraSun Energy of Brookings in South Dakota and Aventine Renewable Energy Holdings of Pekin in Illinois, the second and third-largest ethanol makers, respectively, launched initial public offerings. The fourth largest producer is Cargill in Minneapolis, which also has expansion plans. Andersons of Maumee, Ohio, is reported to have special interest of approximately US$36.1 million in three ethanol plants.[71] The stock price of Pacific Ethanol of Fresno, California, nearly tripled since it announced in November that Bill Gates of Microsoft would invest US$84 million to build five ethanol plants on the West Coast.

Some US state governments have also come forward to promote biofuel production in the private sector, advocating its benefit to the environment. The New York state government announced that it would provide nearly US$6 million to assist Western New York Energy to develop the first dry mill ethanol plant, expected to be an US$87.4 million facility. In addition to ethanol, the facility will generate two by-products to be marketed: carbon dioxide for beverage carbonation and freeze-drying, distiller's dried grains and a high-protein livestock feed. Similarly, the Washington state government is allocating US$17.5 million in low-interest loans to the private biofuels industry. They are requiring a minimum of 2 per cent biodiesel, helping companies such as Seattle Biodiesel to expand its oilseed crushing and refining capacity. In addition, several other enabling policies have been launched to facilitate the sector's growth.

4.1 Enterprise-enabling Policies

The idea of green enterprise development would be filled with challenges unless adequate institutional and policy measures are put in place. At the outset, economic incentives for the infant industry to generate sufficient market pull, may be the most important step to overcome the logistic constraints such as the lack of adequate infrastructure for processing and manufacturing biofuels in countries such as Brazil, or lack of policies for the development and production of flex-fuel vehicles (Box 2). A high level of scientific input would be required to facilitate technology support systems where support from legal and other agencies is also required. Since most of these units would be close to farms, the governments may consider providing support for extending property tax exemption for ethanol or biodiesel production facilities up to a certain period of time. The governments may take interest in promoting regionally or internationally acceptable standards for the biofuels. ASEAN is currently considering a draft for such regional standards.

As mentioned earlier, a few key states in the United States launched substantive support measures to advance biofuel in their respective areas. The State of New York also announced that it would allocate US$20 million for the development of a cellulosic ethanol facility. The investment in cellulosic ethanol illustrates a strong commitment to a long-term energy plan that would expand the use of alternative fuels. Cellulose materials are the most common organic sources and may be derived from willow, switch-grass, and forestry residues, pulp and paper mill wastes, and corn stalks. Their use will significantly increase the volume of ethanol production. The Sacramento Municipal Utility District is moving forward with its goal of a 23 per cent renewable energy by 2011 by constructing an anaerobic digester for collected food residuals. In Oregon, biodiesel enterprise development could improve rural economies, protect national security and decrease greenhouse gas emissions. The Oregon Department of Energy manages tax credit and low-interest loan programmes for all types of renewable resource projects. The Energy Trust of Oregon provides an estimated US$10 million each year through 2012, at above-market costs, of renewable generating resources that benefit Pacific Gas and Electric and Pacific Power customers. In Oregon, canola, rapeseed, mustard and a few other crops are most applicable to production and conversion, along with waste grease from the food service or processing industry.[72]

The production of jatropha for biodiesel production may be considered as a Clean Development Mechanism (CDM), one of the market mechanisms of the Kyoto Protocol to yield carbon credits. Japan signed CDM projects worth Sh300 million in Kenya for jatropha cultivation. However, on a macro level, many of these initiatives have a minor impact as the gasoline consumption is close to 1.2 billion m^3/year (7.7 billion barrels/year). It becomes clear that fuel-ethanol consumption is relatively very small, representing only about 2.5 per cent of the current gasoline consumption.[73] Similarly, about 4 billion litres/year of the ethanol produced worldwide is traded internationally. This represents almost 10 per cent of the total world production and is largely of industrial and potable brands. With regard to fuel usage, about 700 million litres (4.4 million barrels) was traded in 2004, representing less than 20 per cent of the market. This was seen as a very low volume, considering its market potential.[74]

The developing countries' governments may also consider what the Indian government is emphasizing on the selection of feedstock based on the use of the byproducts. The framework for enabling policies may have this as a major determinant. The business models are coming up in a way that takes into account the economic utilization of the byproducts such as seed meal, the crop fiber, and glycerine, a lower value by-product of biodiesel production that accounts for 20 per cent of the total oil, extracted from the seeds. Biolubricants and other bio-based products may also be considered.[75]

4.2 Financial Incentives

In several countries, different measures are being introduced to ensure the rapid adoption and large-scale production of biofuels. In the United States, most comprehensive and detailed measures are undertaken (Table 9). In Germany, measures are also underway for the promotion of biodiesel too, while several Canadian provinces are eliminating or reducing taxes on biodiesel fuel production to stimulate demand. In European Union as a whole, a recent proposal for a council directive to promote the use of biofuels offers member States the option of applying a reduced rate of excise duty to pure or blended biofuels, when used either as heating or motor fuel.[76]

Table 9. Financial and Tax Incentives on Biofuel in Selected Countries

Country	Financial Incentives	Tax Incentive	Source of Biofuel
Australia		•No mineral oil tax (since 2000) on production; •No tax on sales of Biofuel	Pure Rape Methyl Ester (RME) used in engine
Belgium		•Tax relief (100%) adopted for experimental projects	Sunflower, Maize, Olive Methyl Ester and frying oils Methyl Ester on pilot tests
European Union	Public funding of Euro 91 million for R&D Total support of Euro 3.7 billion	•Excise tax exemption •High tariffs to check import from other countries, particularly, Brazil	Biodiesel (75%) and ethanol (25%) from various sources
France		•Tax incentive adopted for VOME mixed with diesel (0.35 Euro/L) and for bioethanol (0.50 Euro/L)	Rape and sunflower FAME used in engines; Sunflower Methyl Ester used as a domestic fuel blender

Table 9. (Continued)

Germany		•No excise tax for biodiesel substituting standard fuels, either unblended or blended with fossil diesel in the vehicle tank	Pure RME used in all kinds of vehicles
United States	US$ 7.3 billion for providing support at various points at value chain	•Tax deduction is available apart from breaks from local sales and use taxes on continuing activities for 5-12 years; •Fuel delivery vehicles and machinery, equipment; •Investments in buildings, equipment and labour for the purpose of manufacturing biodiesel, biodiesel feed stock; •Qualifying buildings, equipment and land used in the manufacturing of alcohol fuel, biodiesel, or biodiesel feed-stocks; •Infrastructure and services that support the use of auxiliary power for heavy-duty vehicles; •High tariffs to check import from other countries, particularly, Brazil	
China		Deliberating a cost-sharing and risk-sharing mechanism.	
India		•Excise duty exemption proposed for pure biofuel and also for the blended form; •Exemption is also proposed for the machines/ equipments used for oil extraction	
Philippines	Bioethanol producers would also get easier access to financing from the government's financial in stitutions	Wide range of fiscal and non-fiscal incentives: •Exemption from tariff duties on importation of equipment and machinery; •Another incentive is classification of all investments in ethanol production and blending as "pioneering" or "preferred areas" of investment, which entitle them to financial incentives	

Source: Chaturvedi (2006), Koplow (2006) and Steenblik (2007).

In the United States, the Federal Government in consultation with several state governments has worked out a detailed plan.[77] As part of this, proposals for tax deduction on the sale or distribution of biodiesel or alcohol fuels is suggested. The plan is to also include in this concession regime, fuel delivery vehicles, machinery, equipment and related services that are used for the retail sale of a biodiesel or alcohol fuel along with buildings, equipment and labour for the purpose of manufacturing biodiesel, biodiesel feedstock or alcohol fuel. The government also proposed to finance the buildings, equipment and land used in the manufacturing of alcohol fuel, biodiesel, or biodiesel feedstock for another six years. The business and occupation tax rate has also been reduced by 0.138 per cent for the individuals engaged in the manufacturing of alcohol fuel, biodiesel fuel, or biodiesel feedstock. In the case of heavy vehicle movements, the time period available with incentives is also very long; it would be in effect until 1 July 2015. Tax incentives are available for the infrastructure and services that support the use of auxiliary power for heavy-duty vehicles weighing more than 14,000 pounds through on-board or stand-alone electrification systems.[78]

These incentives offer tax deduction or exemption for machinery and equipment integral to providing auxiliary power at truck stops. The United States appears to be the only country in the world that currently offers large-scale grants to promote research on alternative sources of biofuel. A new scheme is launched called Energy Freedom Loan Account with an initial amount of US$100 million for providing low-interest loans and grants in R&D of new and renewable energy sources.

In the case of China, the government is deliberating a cost-sharing and risk-sharing mechanism for biomass energy to encourage its development.[79] The risk-sharing mechanism allows biomass energy companies to reserve risk funds before taxation during oil price hikes. Those funds will be used to compensate losses and sustain companies' operations if oil prices plummet.

Box 2. Emergence of Flex-Fuel Vehicles

In many developing economies including India and initially the Republic of Korea, the governments were not in a position to make the biofuel-based vehicles mandatory, as local automobile industry found it difficult to accept the idea, but in many other countries the industry responded well and advanced the technology frontiers. In some cases, it went far beyond what had been expected. For instance, Honda automobile company from Japan said it would launch 100 per cent ethanol-based models in Brazil by the end of 2006.

Box 2. (Continued)

The Research Institute of Innovative Technology for the Earth (RITE) of Honda announced that it produced an ethanol-based soft biomass, including cellulose and hemicellulose found in leaves and stalks of plants, and also in rice.[80] Similarly in the US market, Japanese automakers focussed on diesel and hydrogen-powered vehicles as alternatives to gasoline models as a yet another alternative to Flex-Fuel Vehicles (FFVs).

Toyota Motors also announced its launching of FFVs in the early 2007 in Brazil.[81] Peugeot SA in France announced that it would support the government's efforts to promote the use of FFVs, and said it would introduce in 2007 two models able to run on gasoline as well as E85, a biofuel consisting of 85% ethanol. Peugeot is already producing flex-fuel versions of its cars in Brazil, representing 80% of its total sales in the country. The Peugeot 307 and the Citroen C4 will be offered with flex-fuel motors from mid-2007 throughout Europe.

In 1992, General Motors introduced "Flex-Fuel" technology in North American market. It is estimated that more than 5.5 million such vehicles now run in the United States. In Brazil, studies for the application of this technology were launched by Bosch in 1994, aiming eventually to have the "Flex-Fuel" vehicles replace the exclusively alcohol vehicles, which were undergoing a decrease in sales at the time. In August 2002, the Brazilian government announced IPI tax reclassification for vehicles that provided an assurance that "Flex-Fuel" vehicles would receive the same fiscal treatment as alcohol vehicles. This gave a major boost to the industry. Soon, Ford introduced a "Flex-Fuel" prototype in 2002 and "Flex-Fuel" Fiesta in mid-2003. This also encouraged the vehicle manufacturers to consider the possibility of turning Brazil into a production centre for "Flex-Fuel" vehicles, both for the domestic and export markets.

Sources: Alfred Szwarc, "The flex-fuel vehicle option", (UNICA, 2006);
"Toyota eyes Growth in Brazil through FFV Plan", (Reuters, 20 September 2006);
"Carmaker Honda produces Ethanol from Novel Feed Stock", (Manila Bulletin, 20 September 2006, Manila).

5. Agricultural Biotechnology and Bioenergy Development: Implications for International Trade and Investment

There is a need to address environmental goods as a priority in the Doha Round from the point of streamlining the related tariff regime.[82] Though tariffs on biodiesel are already quite low, they are still high for ethanol. For instance, the US tariff is 54 cent per gallon. The constraint is that ethanol is covered currently by the WTO Agreement on Agriculture and thus is not taken in the environmental goods negotiations.[83] It is eligible according to the Doha Ministerial Conference, but OECD countries stonewalled it. It is also suggested that the subsidies to biofuel crops may be placed in the 'green box' in the agricultural negotiations, which would make them exempted from payments that distort production and trade.[84] However, apart from trade, it is also the question of increasing cross investments in the sector as seen in the case of Brazil where there are several foreign companies that have acquired sugarcane farms and processing units to produce bioethanol for their home markets.

In international trade, there are three issues that deserve further analysis. These are the Intellectual Property Rights (IPR), the impact of standards (or lack there of) and the trade classification of biofuels.

5.1 Intellectual Property Regime

Lack of access to technology is most likely the biggest challenge facing developing countries. They may have farms, producers, legal rights and a desired environment for production but not the access to the gene technology. This technology would be an important determinant for producing biofuels at a lower cost from non-edible crops, such as the second generation crops. As most of the major agro-giants, the transnational corporations (TNCs), have an increasingly large share of the bioenergy crops. It is very likely that the developing countries may end up paying huge royalties to access the technologically improved crops. The growing consolidation in this sector may pose several challenges in terms of price cartels, broad patenting of gene sequences, and the selection of similar genetic combinations for hybrid development. In the last couple of years, the global seed industry has gone through a very dynamic transformation. It is increasingly focusing on agricultural biotechnology and the introduction of new products with a particular emphasis on the core strength of the firm, which is leading to unprecedented mergers and acquisitions (M&As). As a result, firms with competitive advantage in agricultural biotechnology research such as Monsanto, DuPont, Syngenta, Bayer, Dow and BASF, have a dominant share in the global seed market.

The size of the global seed market is estimated to be close to US$21 billion and the top ten companies' shares compose more than 51 per cent of the total market.[85] Leading seed companies have a keen interest in production and marketing of pesticides. These companies control close to 70 per cent of the US$28 billion agrochemical market.[86] Monsanto and DuPont alone now control 90 per cent of the corn seed market in the United States and 70 per cent of the Asian corn market, which are major energy crops in the region. Monsanto alone covers the market share of 59 to 97 per cent of GM crops, including GM soybean (91 per cent), GM maize (97 per cent), GM cotton (64 per cent) and GM canola (59 per cent).

Monsanto, through its local knowledge and M&A, has become the front runner in this race of high technology products. It has made massive investments in agricultural biotechnology R&D, which is well reflected in the number of patents filed by Monsanto. The R&D expenditure by Monsanto in 2005 was more than US$500 million, which accounted for nearly 10 per cent of its sales. The expenditure was largely on new biotech traits, elite germplasm, breeding, new variety and hybrid development, and genomics research. The developing economies, which grow most of the feedstock crops for future sources of biofuels, are to work towards reducing the trade-off between bioenergy crops and food production, apart from ensuring that it is for the small-scale and rural-based production so that the agri-community remains involved. Given the fact that most of the technology development efforts are carried out by the leading private companies in the energy sector, it would be most appropriate to develop agreeable mechanisms for the open sourcing of technology for the improvement and production of energy crops. Furthermore, since the race is on for the identification of new varieties for better oil yields, there is a good possibility that the issues related to biopiracy may come back on the centre stage. There is a reported case of such a piracy from one of the Indian universities where a company collected germplasm from 18 local varieties of the oil-yielding jatropha plant, including the high-quality pendra variety.[87]

5.2 Implications for SPS/TBT Measures

As the trade in the agricultural energy products derived from biotechnology expands, the issues related to the sanitary and phyto-sanitary measures (SPS) and technical barriers to trade (TBT) assume importance. As the European Union, the Republic of Korea and Japan have been viewing the development in the biotechnology sector with caution, these issues may act as a deterrent to the countries taking a policy decision in this context. These countries have been exercising their options, as per the Article 5.7 of SPS, providing scope for members to take provisional health measures when relevant scientific evidence is insufficient. The EU has asked for the inclusion of precautionary principle in the ambit of the SPS agreement. In this context, the recently announced WTO ruling on the import ban by the EU of GM products becomes relevant. It is important to note that the United States, Canada and Argentina raised this dispute as per the Article 5.2 of the SPS and not as violation of the Article 5.7 of SPS.[88] This may have major implications for those countries, which are contemplating to explore options within this line of argument. As the Para. 7.428 of the interim report on the dispute clearly states, the dispute comes under SPS and not under any other agreement such as TBT.

SPS is one agreement which is very narrowly defined, hence provides very little maneuvering space for the defending parties. Moreover, the view that Article 5.7 of SPS, under which precautionary principles are justified, is actually an exception to the Article 2.2 and 5.1, which expects members to base and maintain SPS measures on sufficient scientific evidence.[89] Moreover, biofuels are a highly processed product not intended for human or animal consumption. According to the SPS provisions of the WTO, trading partners cannot discriminate against products based on their process and production methods (PPMs).[90] Under these rules, it is unlikely that a ban on biofuels would occur because the use of biotechnology would be found compliant to the WTO. In this context, the international agencies would have to launch initiatives to establish the standards so that the non-tariff barriers are not imposed. The developing countries should be assisted in reviewing and updating existing standards also to develop and notify standards for new and renewable systems/devices for which standards have not yet been laid down at par with international levels. With the growing movement among the developing countries to emerge as key exporters of several of these products, there is a need to set guidelines for product specification and performance parameters which should be developed and institutionalized for the larger interest. As of now, there are three major producers, which have already come out with programmes related to standards. They are the United States, Germany and Austria.[91] The ASEAN has also launched a regional discussion forum based on such a framework.

6. Policy Recommendations

The demand for biofuel is set to expand in the Asia-Pacific region, as more and more governments are identifying mandatory limits that require blending of biofuel with gasoline. This motivation has also come from environment-based initiatives, such as the Kyoto Protocol. There is a need to launch an Asia-specific forum to help developing economies assess their own biofuels potential to work out their specific goals and facilitate resource mobilization efforts. These forums may also help in terms of promoting and learning from each other's experiences, and overcome non-tariff measures for their exports of biofuel-related products and finished products. In this context, efforts would also have to be made to identify innovative financing mechanisms, such as loan guarantees and CDM.

6.1 Major Barriers

Food Security Concerns

Biofuel provides a major policy option in terms of ensuring a sustainable fuel provision over the fossil fuels on which most of the Asian developing countries are spending astronomical amounts of expenditure. However, one would have to adopt a cautious strategy to follow as the growing demand for both biofuels and food would put extraordinary pressure on land and price increases for agricultural products, which may have a negative impact on the net food-importing developing countries.

Environment and Biodiversity Impact

Adoption and production of biofuel on a large scale may also have an impact on biodiversity, as is being discussed at various forums on deforestation of rainforests in Brazil and the Borneo Island in Malaysia.[92] This may be problematic with "low-intensity" biofuels, such as rapeseed oil, that require several chemical inputs and has relatively low energy yields.

There are serious reservations about the possible implications of adopting biofuel as a major alternative. The apprehension is that biofuel could end up damaging the natural environment, as it would promote monoculture on the farmland, completely devoid of biological diversity.[93] Calculations from the OECD show that Europe would need to convert more than 70 per cent of arable land in order to raise the proportion of biofuel used in road transport to 10 per cent.[94]

Lack of Access to Relevant Technology

As discussed earlier, new technological advances are required to address the downside of biofuel production, as that may require new strategies for technology development. Under the current standard of intellectual property rights, which are driven largely by the private sector, and have heavily invested in the technology development, they may adversely affect the interests of those very governments that provide support to the emerging industry. Efforts are needed to pursue technology development and create open source technology access in this important area of environmental management.

Trade Barriers, Subsidies and Tariffs

There are measures to be adopted in South-South cooperation framework for technology development and its open sourcing so that the trade-related intellectual rights regime does not pose major hurdles for the developing economies in terms of their access to technology. However, excessive subsidies, provided by the United States and other developed economies, may end up perpetuating the North-South divide. Government support for biofuels should focus instead on R&D, and should promote biofuel only as long as they make a net positive environmental impact. The possible result would be having to safeguard against economic losses that might emerge from the withdrawal of subsidies under a new WTO agreement on agriculture.

The emergence of a huge subsidy regime in the United States and in the European Union for the production of bioenergy crops would also render most of the produce from the developing countries uncompetitive and may potentially harm the endeavours of these countries. The main pieces of the US policy are a flat subsidy of 51 cent per gallon of ethanol used in fuel (about a third of the production cost), a mandate to use 7.5 billion gallons of biofuels a year nationally by 2012, and a 50 cent or US$1-per-gallon subsidy for biodiesel.[95] The European Commission has also set up plans to extend subsidies paid to energy crop farmers to the eight member states that joined the European Union in 2004.[96] Under the proposal, farmers who grow energy crops for use in bioenergy in the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Poland, and Slovakia would be able to access the EU funding of Euro 45 per hectare from 2007. Other member states have been distributing these subsidies since 2004. In addition, the Commission is calling for member states to grant subsidies of up to 50 per cent of the costs of establishing energy crops on new land.

There are some developing countries that have also decided to embark on the same path. For instance, Indonesia plans to seek as much as 23 trillion rupiah, or US$2.5 billion, to kick-start its nationwide program to produce, distribute and export fuels made from crops like oil palms and sugarcane.[97] The government will offer 2 trillion rupiah in capital to a company that will finance biofuel projects.

It may be relevant to identify existing mechanisms within the WTO to protect the interests of developing countries, for instance, by designating bioenergy crops as products of special interest from the standpoint of national energy security.

6.2 Recommendations

Regional/Sub-Regional Level

Right Quality Seeds for Energy Crops

Given the growing importance of feed crops as the main determinant of the cost of biofuels, it is of key importance that the quality and cost of crop is kept under check. In Asia and the Pacific, countries may launch joint efforts to ensure a proper quality of planting material available for production purposes. As discussed, cases show supply of uncertified seeds as "hybrids" at higher prices in many rural areas in India. The non-prescription of standards for the jatropha seeds/seedlings has come in handy for the new entrants to take advantage of the situation. In this context, institutions like ICRISAT may play a crucial role in terms of setting the standards for the region for selecting energy crop seeds apart from making available quality parentage for further multiplication. The seed companies will do this for quality seed production. The initiative may help in terms of ensuring a positive nature of marketing incentives for private companies to market their seeds at the regional or sub-regional level. Sometimes in the agricultural endeavours, it is not the technology per se that matters, but the peculiarities associated with plantation style that counts. ICRISAT in India is working with the underprivileged women and their Self-Help Groups (SHGs) to start Pongamia enterprises in remote tribal areas of Andhra Pradesh, and working with the country's national research system to identify high-oil varieties as well as better cultivation methods for biodiesel production at the village level.

Regional Initiative on Harmonisation of Standards and Classification

In the absence of any international standard for quality of biofuels, Asian countries at the ASEAN and other forums may consider launching standardization of specifications to enable the products to actually become an energy commodity and be easily traded, as is the case of gasoline or diesel. The United States and a few other countries have already launched their own standards. Apart from ensuring the quality of products, such exercise would also help identify proper product groups, as some countries have a complex tax regime that ethanol producers and importers have to face due to the improper classification of products. There is no clarity as to which category renewable energy products belong. For instance, ethanol comes in the product category marked for agriculture, while biodiesel comes in the category for industrial products.

Technology Collaboration: Innovations and Machines

As the cost of biofuel is a key determinant in public acceptance, the installation of cost-effective processing machinery becomes an important factor. This may eventually prove to be an important investment for the region. There is also a need to examine innovation prospects in the automotive and supplier industry, in particular, biofuel production technology, and address cooperation prospects in the field of machines, equipments and informatics. In addition, there must be a more pragmatic view developed for the R&D expenditure incurred for developing biofuels. The case of IBSA is discussed earlier, but there is further need to identify such opportunities for all the members to share the cost of advanced technology development.

National Level

"Lands of Great Hope"

The advances in biotechnology offer a unique opportunity for the tropical countries that are being described as the "lands of great hope".[98] The biomass-based option to produce biofuel enables the developing countries in the region to produce it at a much lower cost than any developed country may attempt to do so. As pointed out earlier, ethanol production in Brazil costs 20 euro-cents per litre, compared with 30 euro-cents in the United States and 50 euro-cents in the European Union. In the case of some Asian countries, this cost may be even less, for instance, in Malaysia with palm oil-based biofuel production. Since there are possibilities for two to three rounds of crop harvests in the Asian region per year, appropriate research priorities may help in identifying alternative biomass-based source materials.

Balancing with Food Security Concerns: Non-Food Markets for Agriculture

Once the adequate attention is paid to develop ways and means for non-food markets for agriculture, it may facilitate and induce producers for biofuel crop production. The Asian economies would have to design measures to cope with the pressures that the conversion to bioenergy crops may exert on them. Food security concern is one of the most important dimensions of this. Since Malaysia and Indonesia announced setting aside 40 per cent palm oil for biofuel production, the global prices of palm oil have gone up by 20 per cent.[99] Similarly, prices of rapeseed, an important ingredient of biofuels, have also gone up 20 to 30 per cent in 2005.[100] Once a clear switchover is announced by a country to strategically use biofuel resources, such as wheat or soybean, the implications for food security may become serious in the long run.

Providing Financial and Technical Support

Since the biofuel industry is in a nascent stage of development, it requires policy and financial support along with economic incentives. Governments may consider launching financial support programmes for funding infrastructure, facilities, technologies and R&D that will move forward biofuel development. Financial assistance may be awarded for R&D of new and renewable energy and biofuel sources, including biomass and biofuel development infrastructure and facilities; furthermore R&D to develop markets for alternative fuel byproducts. In the United States, the government has spent US$1.5 million to provide 1,000 conversion pumps to enhance the availability of biofuel.[101]

Biofuel and Rural Development

The growing support from the respective governments may help generate a large number of jobs in the rural areas where backward linkages would be established for a stable and secure supply of biofuel. It is estimated that the yield level for biodiesel is 1 million tonnes/ hectare. In some Asian countries, many villages still have no access to power and electricity. In India, for instance, nearly 0.125 million villages and 56 per cent of the households lack access to electricity. The Indian Government has announced the coverage of these entire villages, lacking electricity, with 100 per cent household coverage by 2009. Grid electricity might not be universal as several remote villages are not likely to be covered by grid extension because it is either not cost-effective or feasible to do so. In covering such remote villages, the aim shall be to make available supply of a minimum lifeline consumption of 1 kwh/household/day of reliable and quality power of specified standards at reasonable rates. In this context, options with biobased electricity generation may be explored for rural electrification.

South-South Cooperation

As many of the developing countries enter the market for biofuel both as producers and as consumers, it would be beneficial to identify areas for cooperation. They may set the agenda for cooperation in a pragmatic manner. At the outset, efforts should be made to recognise the wider challenges emanating from the technological barriers in the usage of energy crops vis-à-vis food security related concerns.

Further, the flexibilities in the rules related to market access play a special role in the European and other agricultural markets, the regulation and harmonization of the SPS standards and norms, as well as regulations concerning biofuels, should be addressed as top priority. The Asian and Pacific economies may launch joint initiatives for education and outreach activities, a state procurement preference that favours biobased products, as well as new and improved ways to help spur consumer acceptance of the biobased products. This is important as developing markets for new products or for existing products from alternative materials. The recent launching of a program by the United Nations to support biofuel promotion may go a long way in this direction.[102] The UN promotion of bioenergy sources, such as sugar cane or sunflower seeds to replace fossil fuels and reduce poverty while producing clean, low-cost power, gained new momentum with the inauguration of the Secretariat of the Global Bioenergy Partnership (GBEP) at FAO in Rome. The Secretariat will be the principal coordinator of Partnership communications and activities and will assist international exchanges of know-how and technology, promote supportive policy frameworks and identify ways of fostering investments and removing barriers to the development and implementation of joint projects. In the short term, the Secretariat will update the inventory of existing networks, initiatives and institutions dealing with bioenergy and identify any gaps in knowledge.

References

Andrews-Speed, P. (2005). "China's Energy Woes: Running on Empty", Far Eastern and Economic Review, Vol. 168 No.6, pp. 13-17, June.

Asahi, S. (2006). "Agriculture Ministry to Designate Biofuel Districts", 13 September, Tokyo.

AsiaNews (2006). "Brazil's Petrobras to Supply Ethanol to Japan in 2010", 21 September, available at < http://www.biofuelsmarketplace.com/page/view/sianews>, September, 2006.

Biswas, S., N. Kaushik and G. Srikanth (2005). "Biodiesel: Technology and Business Opportunities", Technology Information, Forecasting and Assessment Council (TIFAC) Department of Science & Technology, New Delhi.

Carvalho E.(2004). "The Whereabouts of a Fuel- Ethanol World-Market", 4 August (Brazil, UNICA).

Chaturvedi, S. (2006). "Agricultural Biotechnology-based (Green) Enterprise Development for Sustainable Rural Livelihoods and Economic Growth", paper presented at the Second Session of Technical Committee of APCAEM, November 20-21, 2006, Suwon, Republic of Korea.

China Daily (2006). "Target of 3 Million Tonnes of Ethanol Consumption Eyed", 21 September, Beijing.

Commission of the European Communities (2001). "Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions on Alternative Fuels for Road Transportation and on a Set of Measure to Promote the Use of Biofuels", 7 November, Brussels, available at <www.biodiesel.org/ resources/reportsdatabase/reports/gen/20011107_gen-312.pdf>, 31 August.

Cornelius, P. and J. Story (2005). "China Revolutionizes Energy Market", Far Eastern Economic Review, Vol. 168 No.9, pp. 21-24, October.

Dalton, M. (2006). "Investors: Where the Money Is", The Wall Street Journal, 17 October.

Dar W. D. (2006). “Biofuel Crops: Power to the Poor”, International Crops Research Institute for Semi Arid Tropics (ICRISAT), Hyderabad, September.

DaSilva, L. I. Lula (2006). "Fuel for Thought", Presidential Address at G-8 Summit, St. Petersburg.

Department of Biotechnology (2006). "Annual Report 2005-06", DBT, Government of India, New Delhi.

Deshpande, R. S. (2006). "Biofuels and WTO: An Emerging Context", Asian Biotechnology and Development Review, Vol. 8 No. 2, March.

DuPont (2006). "DuPont Scientists Outline Company's Biofuels Strategy at World Congress on Industrial Biotechnology and Bioprocessing Conference", Press Release, 17 July, Wilmingon, Dallas.

Environmental Protection Agency (1992). "New Oxygenated Fuels Program", 30 October, the U.S., available at <http://www.epa.gov/history/topics/caa90/09.htm>, August 2007.

Financial Times (2004a). "Market Insight: Use Of Crops for Fuel Production Helps Trading Volume Soar", July 12.

Financial Times (2004b). "Plant Gene Offers Hope for Biofuels", July 12.

Financial Times (2006). "EU Plans to Extend Energy Crop Subsidies to Accession States", September 26.

Fresco, M. C. (2004). "Biofuel Sorghum to Be Tested in Philippine Fields: Sorghum, A Source of Ethanol for Biofuel Production", 22 October, available at < http://www.scidev.net> , July 2007.

Hornby, L. (2005). "Asia Pushes Ahead on Biofuel, Despite Cost", 28 February, (Shanghai, Reuters News Service).

House of Lords (2006). Oral Submission by Malcolm Shepherd, Managing Director Green Spirit Fuels Ltd. in the European Union-Forty-Seventh Report, European Union Committee Publications, 7 November, London.

House of Representatives (2002). "Farm Security and Rural Investment Act of 2002", 1 May, the U.S., available at <http://www.ers.usda.gov/Features/FarmBill/2002FarmAct.pdf> , August 2007.

Indo-Asian News Service (2006). "E-5 to be sold Nation wide by November 2006", 11 September, available at <http://www.biofuelsmarketplace.com/page/view/sianews> , September 2006.

International Herald Tribune (2006). "Indonesia Subsidises Biofuels", International Herald Tribune, 3 October.

International Rice Research Institute (1984). "Report of Inter-Centre Seminar on IARCs and Biotechnology", 23-27 April, (the Philippines, IRRS), p. 47.

Jakarta Post (2006). "Policy to Allow Sale of Biofuels by Foreign Firms", 9 August.

Koerbitz, W. (2004). "Newest Trends in Developing Biodiesel World-Wide", presented at Biological Futures II, 19 May 2004, Saskatoon.

Koplow, D. (2006). "Biofuels - At What Cost? Government Support for Ethanol and Biodiesel in the United States", (Geneva: Global Subsidies Initiative of the International Institute for Sustainable Development), available at <www.globalsubsidies.org/IMG/pdf/biofuels_subsidies_us.pdf> , May 2007.

Korea Times, (2006). "South Korea seeks Renewable Energy", 16 May, Seoul.

Korten, D. C.(2006). "The Great Turning: From Empire to Earth Community", (San Francisco, Berrett-Koehler and Kumarian).

Loppacher, L. J. (2004). "Using Biotechnology to Lower Production Costs of Biofuels: Will it Hinder the Growth of an Export Industry?" Paper presented at Annual Canadian Agricultural Economics Society Workshop Quebec City, August 23-24.

Maithel, S.(2006). "A Lot Needs to Be Done to Ensure Sustainable Supply", Financial Express, 15 May.

Manila Bulletin (2006a). "Carmaker Honda Produces Ethanol from Novel Feed Stock", 20 September, Manila.

Manila Bulletin (2006b). "Biodiesel Project Included in US$ 2 Billion Infrapump Priming Programme", 11 September, Manila

Manila Bulletin (2006c). "Research Firm Developed High-Yielding Corn Variety", 7 September, Manila.

McCormick, K. (2005). "Bioenergy Potentials and Dynamic Factors", proceedings of the Beijing International Renewable Energy Conference, 7 - 8 November 2005, Beijing.

McNeely, J. A. (2006). "Biofuels: Green Energy or Grim Reaper? ", Green Room, BBC News, 22 September.

Miller, R. L. (2006). "In Search of China's Energy Authority", Far Eastern Economic Review, Vol. 169 No.1, pp38-40, January/February.

Ministry of Non Conventional Energy Sources, Government of India (2005). "New and Renewable Energy Policy Statement", (New Delhi, MNCES).

Nonis, J. (2006). "South Korea Pips Japan, China as Asian Biodiesel Market", The Edge Daily, 28 September, Kuala Lumpur.

O'Hare, M. (2006). "Subsidies are the Wrong Road to Biofuels", San Francisco Chronicle, 30 July.

Padma, T. V. (2005). "India's Biofuel Plans Hit Roadblock: Red Tape and Rising Costs Are Choking India's Biofuel Plans", 5 September, available at < http://www.scidev.net>, September 2006.

Plant Ark (2006). "Licenses for 52 Biodiesel Projects Approved", 17 August.

Rajaya, S. (2005). "Department-Related Parliamentary Standing Committee on Science and Technology, Environment and Forests, One Hundred Forty-Second Report", proceedings from Parliamentary Standing Committee on Science and Technology, Environment and Forests, Parliament of India, New Delhi, 25 April.

Raju, K. V. (2006). "Biofuels in South Asia: An Overview", Asian Biotechnology and Development Review, Vol. 8, No. 2, March.

Reuters (2006a). "Bio-crops may be created for Biofuels: US Report", 31 August, available at <http://www.checkbiotech.org/blocks/dsp_document.cfm?doc_id=1341722>, September 2006.

Reuters (2006b). 'Toyota eyes Growth in Brazil through FFV Plan', 20 September, available at <http://www.biofuelsmarketplace.com/page/view/sianews>, 25 September 2006.

Saches, I. (2005). "Biofuels are Coming of Age", Keynote Address at the International Seminar on Assessing the Biofuels Option, IEA Headquarters, 20 June, Paris.

Sasson, A. (1988). "'Biotechnology and Sustainable Agriculture' in Biotechnology Revolution and The Third World: Challenges and Policy Options", (New Delhi, RIS).

Shapiro, I. (2005). "Re-Thinking the Energy Paradigm", WTO public symposium, 21 April, Geneva.

Steenblik, R. (2006). "Biofuel and Doha Round quoted in Bridges", Weekly Trade News Digest, Vol. 10, No. 31, 27 November, (Geneva, ICTSD).

Steenblik, R. and J. Simón (2007). "Biofuels - At What Cost? Government support for Ethanol and Biodiesel in Switzerland", the Global Subsidies Initiative (GSI) of IISD, Geneva.

Sun Star (2006a). "Solon Worries Ethanol Plan May Jeopardize Local Sugar Industry", 21 September, Manila.

Sun Star (2006b). "Media War between Automakers and Ethanol Producers", 25 August, Manila.

Sunday Times (2006). Food Prices Would Soar in Biofuels Switch Says Unilever", 7 August, New Delhi.

Sydney Morning Herald (2006). "China Set to Boost Ethanol Output", 14 August.

The Associated Press (2006). "Agribusiness Giants Hold Different Philosophies: ADM Pursuing Biofuels, While Cargill Makes Food its Priority", 23 May.

The Hindu Business Line (2006a). "Jatropha Seed Prices Rally on Entry of New Players", 6 September.

The Hindu Business Line (2006b). "Prices Surge of Jatropha Seeds Worries Cultivators", 15 September.

The Hindu Business Line (2006c). "Godrej, Malaysian Company Sign MoU for Palm Plantation", 25 September.

The International Centre for Trade and Sustainable Development (2006). "Ted Turner Promotes Biofuels at WTO Forum: Urges Governments to 'Fight One More Round' For Doha", Bridges Weekly Trade News Digest, vol. 10, No. 31, 27 November, (Geneva, ICTSD).

The Nation (2006). "Oil Refiner to Buy Used Vegetable Oil for Biodiesel Project". 13 September, Bangkok.

The Philippines Daily Inquirer (2006). "Coco Biodiesel Producers Exports to Germany", 11 September.

The Star (2006a). "Non-committal Firms to Lose Biodiesel Licenses", 15 September, Kuala Lumpur.

The Star (2006b). "Plantation Stocks Boost Stock Market Index to Six Year Height", 13 September, Kuala Lumpur.

The Star (2006c). "China's Biodiesel Plant Makes Trader Wary", 14 August, Kuala Lumpur.

Trindade, S. (2005). "Brazil: The Driver of Sustainable International Markets for Fuel Ethanol", Paper Presented at the International Conference on Assessing the Biofuels Option, IEA, 20-21 June, Paris.

UN Press (2006). "UN Efforts to Promote New 'Green' Fuels Move Ahead", 26 September.

UNCTAD (2005). "United Nations Conference on Trade and Development: Biofuels - Advantages and Trade Barriers", UNCTAD/DITC/TED, January 2005.

United States Department of Energy (2006). "Breaking the Biological Barriers to Cellulosic Ethanol: A Research Roadmap Resulting from the Biomass to Biofuels", Background Paper Presented at the United States Department of Energy Workshop, 7-9 December, 2005.

Xinhuanet (2006). "Nigeria and China sign Agreement on Ethanol Production", 12 August, available at <http://www.xinhuanet.com/english/2006-08/12/content_4951866.htm>, August 2006.

Yonhap News (2005). "South Korean Refiners Reluctant to Introduce Korean Biodiesel", 21 December, Seoul.

Endnotes

1 *Reuters, October 05, 2005*
2 *www.bioscienceworld.ca*
3 *Dalton (2006).*
4 *ibid.*
5 *DBT (2006) Loppacher (2004).*
6 *Padma (2005).*
7 *Financial Times (2004a).*
8 *USDE (2006).*
9 *ibid*
10 *Dar (2006).*
11 *ibid*
12 *Fresco Mary Charlotte (2004).*
13 *Business Standard (2005) Bio-fuel to be grown on wasteland, March 26th .*
14 *IISD (2006).*
15 *Ardi (2006).*
16 *Yonhap News (2006).*
17 *Biswas et.al (2005).*
18 *Biswas et. al. (2005).*
19 *ibid.*
20 *McNeely (2006).*
21 *Sasson (1988).*
22 *IRRI (1984).*
23 *India (2005).*
24 *July 7th The Hindu Business Line*
25 *This has been postponed for the time being*
26 *Indo-Asian News Service (2006).*
27 *Maithel Sameer (2006).*
28 *ibid*
29 *The Hindu Business Line, September 15, 2006.*
30 *India (2005).*
31 *Indian Express October 1st 2006.*
32 *Rajaya Sabha (2005).*
33 *DBT (2006).*
34 *ibid.*
35 *ibid.*
36 *The Hindu Business Line, September 25, 2006.*

37 *Ibid.*
38 *Deccan Herald April 23rd 2005, 'Mysore Firm to Export Jatropha'.*
39 *FICCI August 5, 2006*
40 *Based on inputs from colleagues in Thailand.*
41 *The Nation (2006).*
42 *Andrews-speed (2005).*
43 *ibid.*
44 *Cornelius et.al. (2005).*
45 *Miller (2006).*
46 *China Daily (2006).*
47 *Sydney Morning Herald (2006).*
48 *Financial Express October 4th 2006*
49 *ibid*
50 *The Star (2006b).*
51 *Xinhuanet (2006).*
52 *Sun Star (2006).*
53 *Manila Bulletin October 12 2006, 'Senate okays Biofuels Bill'.*
54 *Sun Star (2006a)*
55 *Manila Bulletin (2006a).*
56 *Interviews at Department of Energy, Manila*
57 *The Philippines Daily Inquirer (2006).*
58 *BioLife September-October 2006.*
59 *ibid.*
60 *Korea Times (2006).*
61 *Yonhap News (2005).*
62 *Korea Times (2006) Biodiesel on Sale in July, February 2nd.*
63 *Bernama (2005).*
64 *Nonis (2006).*
65 *ibid*
66 *The Star (2006a).*
67 *The Star (2006) and Plant Ark (2006).*
68 *The Star (2006a).*
69 *Korten David C. (2006).*
70 *In Business: May-June, 2006, Vol. 28, No. 3, p. 4;*
71 *In Business: January-February, 2006, Vol. 28, No. 1, p. 2;*
72 *In Business, September-October, 2004, Vol. 26, No. 5, p. 15*
73 *Carvalho Eduardo de (2004).*
74 *ibid.*
75 *ibid.*

76 *COM,(2001) pp.547.*
77 *http://www.eere.energy.gov/afdc/progs/view_ind_mtx.cgi?user/FLEET/WA/0*
78 *ibid.*
79 *World Watch Institute June 19, 2006.*
80 *Manila Bulletin (2006).*
81 *Reuters (2006).*
82 *Steenblik Ron (2006).*
83 *ibid*
84 *Shapiro Ira (2004).*
85 *ETC Group (2005).*
86 *Inouye, Kimiko (2003).*
87 *www.uniindia.com, January 31, 2006 ; http://www.scidev.net, January 24, 2006*
88 *CIEL (2006).*
89 *CIEL (2006).*
90 *Loppacher (2004).*
91 *ASTM International, 2003; Koerbitz, 2004.*
92 *ICTSD (2006).*
93 *McNeely (2006).*
94 *Sunday Times, (2006).*
95 *O'Hare (2006).*
96 *Financial Times (2006).*
97 *IHT (2006).*
98 *Saches (2005).*
99 *Sunday Times, (2006).*
100 *ibid*
101 *The Wall Street Journal October 2nd 2006.*
102 *UN Press (2006).*