GREATER MEKONG SUBREGION
ECONOMIC COOPERATION PROGRAM

Myanmar: Country Assessment on Biofuels and Renewable Energy

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This report is prepared by U Hla Kyaw, Department of Agriculture and Planning, Ministry of Agriculture and Irrigation; Thandar Kyi, Yezin Agricultural University; San Thein, Myanma Industrial Crop Development Enterprise, Ministry of Agriculture and Irrigation; U Aung Hlaing, Department of Agricultural Planning; and U Tin Maung Shwe, Myanma Academy of Agriculture, Forestry, Livestock and Fishery Sciences

CURRENCY EQUIVALENTS
(as of April 2009)

Currency Unit	–	kyat
MK	=	$
$1.00	=	1080 MK

ABBREVIATIONS

ACMECS	–	Ayeyarwaddy-Chaophraya-Mekong Economic Cooperation Strategy
bcf	–	billion cubic feet
CSO	–	Central Statistical Organization
FAO	–	Food and Agriculture Organization of the United Nations
GDP	–	gross domestic product
ICRISAT		International Crops Research Institute of the Semi-Arid Tropics
ktoe	–	thousand tons of oil equivalents
Lao PDR	–	Lao People's Democratic Republic
MEC	–	Myanmar Economic Corporation
MIC	–	Myanmar Investment Commission
MICDE	–	Myanmar Industrial Crops Development Enterprise
MOAC	–	Ministry of Agriculture and Cooperatives of Thailand
MOAI	–	Ministry of Agriculture and Irrigation of Myanmar
UNESCAP	–	United Nations Economic and Social Commission for Asia and the Pacific

NOTES

(i) The fiscal year (FY) of the government start on 1st April and ends on 31 March in following year. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2007 ends on 31 March 2007.

(ii) In this report, "$" refers to US dollars.

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I. INTRODUCTION

A. Agroecological Zones and Administrative Divisions

Myanmar covers an area of 678,500 km^2 (261,789 square miles), making it the largest mainland country in Southeast Asia It can be divided into five broad physiographic regions: the Shan Plateau in the eastern part, the northern and western folded hills, the landlocked Central belt, the long coastal strips of Rakhine and Tanintharyi, and the fertile delta area. Agricultural development has been mainly concentrated in the delta and extensive fertile alluvial plains of the Central Belt, which comprises the lower and middle basins of Ayeyarwady River, the lower reaches of Chindwin River, the Sittaung River and the Bago River basins. Myanmar is endowed with rich natural forest cover. The 1989 Landsat Thematic Mapper images indicate that closed and degraded forests cover 343,767 square kilometers (km^2), or approximately 51% of the total land area of the country. The principal river basins constitute a catchment area of 737.8 km^2 and offer vast water resources amounting to 1,081.89 km^3 of average annual surface water, and 494.7 km^3 of estimated ground water potential[1] .

The country is divided administratively into seven states and seven divisions. These are subdivided into 64 districts, which are further divided into 324 townships. The townships are subdivided into 13,759 village tracts, which form the basic administrative unit in Myanmar.

B. Land Use

In 2007 11.38 million hectares (ha) (28.12 million acres) of the country were sown to crops (Table 1). About 6 million ha[2]—or 8.8% of the total land area—is still available for the expansion of the arable area. A substantial portion of this could be used to grow biofuel crops. The distribution of cultivable wasteland in the country by state and division is shown in Figure 1. Kachin, Eastern Shan, and Chin states possess land resources for potential area expansion. Much of the fallow lands and cultivable wastelands are gradually being brought under cultivation in the remaining divisions of the country. Between 1996 and 2001, the Ministry of Agriculture and Irrigation (MOAI)

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[1] Water Resources Utilization Department, Ministry of Agriculture and Irrigation

[2] Settlement and Land Records Department

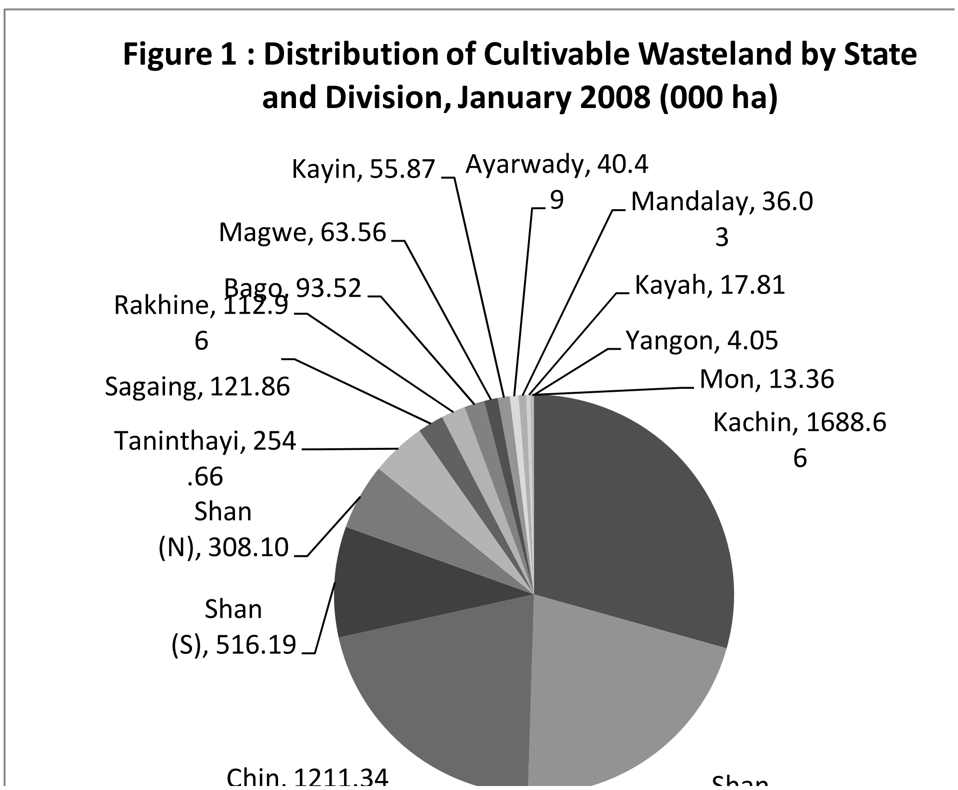
laid down plans to reclaim 0.28 million ha of fallow land. The total gross sown area is also targeted to reach about 15.93 million ha.

Table 1: Land Use in Myanmar, FY2007

Land Use	Million Acres	Million Hectares
Net sown area	28.12	11.38
Fallow land	0.73	0.29
Cultural wasteland	14.76	5.97
Reserved forests	40.68	16.47
Other forests	41.97	16.99
Other lands	40.92	16.57
Total	**167.18**	**67.68**

Source: Myanmar Agriculture in Brief 2008, Ministry of Agriculture and Irrigation.

Figure 1: Distribution of Cultivable Wasteland by State and Division, January 2008 (000 ha)



Source: Tin Htut (2008)

- Total 5755060 ha
- Kachin, Shan(E), and Chin still have potential for horizontal expansion

C. Workforce in Agriculture

Official government statistics for fiscal year (FY) 2002 estimated a population of 51.1 million and a growth rate of 2.02%. The Asian Development Bank (ADB) estimate for the same year was at 52.2 million, with a growth rate of 2% per annum. Population in Myanmar in FY2007 was estimated at about 54.5 million. In 1995 the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) estimated that Myanmar's population will reach 61.5 million in 2010. The population density is 76 people per km^2.

Of the total population in FY2002, about 18.36 million (39.4%) made up the workforce, of which 11.51 million (63%) were engaged in agriculture. Almost 75% of the population lives in rural areas[3] . The ratio of arable land per person is 0.34 ha, and farms average 2 ha in size.

The size of the labor force and the rate of unemployment by sex were projected on the basis of information collected in the 1990 Labour Force Survey[4] (Table 2) With changing economic conditions and labor mobility patterns, the reliability of the projected labor force and unemployment rates is in question.

Table 2: Projected Labor Force, Labor Force Participation Rate, and Unemployment Rate

Indicator		FY2004	FY2005
Total labor force (million)	Male	16.29	16.75
	Female	10.06	10.34
	Total	26.35	27.09
Labor force Participation (%)	Male	80.05	80.57
	Female	48.60	48.84
	Total	64.17	64.56
Unemployment rate (%)	Male	3.62	3.64
	Female	4.67	4.64
	Total	4.02	4.02

Source: Ministry of Labour

Although the aggregate labor force can be projected, its characteristics—such as labor force by education level, employed population by occupation and industry and employment status—are rather difficult to project. In light of this, the structural

[3] Soe Win Maung, 2001, "Overview of Agriculture Sector in Myanmar", Paper contributed to National Seminar on Food and Agricultural Statistics in Myanmar. GCP/ RAS/ 171/ JPN. Yangon, Myanmar. 29-30 January, 2001

[4] Ministry of Labour

characteristics of the labor force, i.e., the employed population by occupation and industry groups, projected from the 1990 Labour Force Survey, are presented in Tables 2, Table 3 and Table 4.

Table 3: Employed Population by Occupation

Occupation	Number ('0000)	%
Legislators and senior officials and Managers	39.2	0.4
Professionals	294.1	2.8
Technical and associate professionals	211.0	2.0
Clerks	221.5	2.1
Services, shop and market sales workers	1,078.6	10.1
Skilled agricultural and fishery workers	3,503.7	32.8
Craft and related workers	1,235.5	11.6
Plant and machine operators and assemblers	367.0	3.4
Elementary occupation	3,717.1	34.8
Total	**10,667.7**	**100.0**

Source: Ministry of Labour

Table 4: Employed Population by Industry Group

Industry	Number ('000)	%
Agriculture, hunting, forestry, and fishing	6,024.3	56.5
Mining and Quarrying	101.7	0.9
Manufacturing	1,212.4	11.4
Electricity, gas, and water	18.9	0.2
Construction	281.1	2.6
Wholesalers, retail trade, restaurants and hotels	1,686.7	15.8
Transport, storage, and communication	403.3	3.8
Financial institutions	28.5	0.3
Community, social and personal services	824.4	7.7
Activities not adequately defined	86.4	0.8
Total	**10,667.7**	**100.0**

Source: Ministry of Labour

D. Expansion of the Irrigation Network

At present, less than 10% of the total water resources of 870 million acre-feet available annually is used. Since 1988, following dramatic economic changes, the government invested in dams, reservoirs and pump irrigation facilities throughout the country using available domestic resources and expertise. The total irrigated area reached 3.2 million ha following the completion of 211 irrigation projects, 307 pumping stations, and 7,578 tube wells between FY1989 and FY2007 (Table 5). The total irrigable area reached 17.8% of the total net sown area in FY2007, rising from 12.6% in FY1989.

Table 5: Changes in Irrigated Area by Crop, 1996–2007

(thousand hectares)

Crop	1997	2006	2007
Paddy	1,535	2,100	2,419
Wheat	17	53	44
Maize	5	37	44
Pulses	40	154	156
Groundnut	6	23	28
Sesame	57	76	95
Sunflower	5	26	18
Cotton	21	13	15
Jute	30	18	11
Sugarcane	6	10	10
Kitchen crops	59	152	142
Other crops	83	214	252
Total	**1,866**	**2,877**	**3,232**

E. Food Security Situation

Rice is the main calorific food crop for the people of Myanmar, with an annual per capita consumption rate of 190 kilograms (kg)–the highest rate of consumption in Asia. In FY2007, out of a total production of 30.5 million tons (t), about 17 million t of paddy is consumed domestically. The self-sufficiency ratio[5] is 179.4%. Edible oil is the second most important food item in the traditional diet of Myanmar. Per capita consumption in FY2008 was about 9.8 kg[6] , and the total demand for edible oil was estimated to be 643,103 t. Total production from oilseed crops was 337,208 t. The uncovered demand is about 305,895 t, which was partially supplemented by the importation of 282,673 t of palm oil. The self-sufficiency ratio for edible oil is 52.4%[7] .

Pulses are the third most important food, with an estimated annual per capita consumption of 13 kg. The change to the market economy system led to an increase in the total land area planted to pulses from 0.73 million ha in FY1989 to 4.02 million ha in

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[5] Self-sufficiency ratio=Total Production / total consumption (seeds, waste, other use, consumption by local population) * 100

[6] Tun Saing.2002. Oil -seed Crops Production: prospects and Potential in Myanmar. (in Myanmar Version). Mimeographed copy. Ministry of Agriculture and irrigation, Yangon

[7] OPEC-funded edible oil project appraisal, 2008

FY2007. Three pulse crops—green gram, black gram, and pigeon pea—account for 80%–90% of total export crops by value.

Rice, oilseed crops, and pulses dominate agronomic activity in Myanmar. At the national level, Myanmar produces a surplus of food; but due to geographical differences, there are pockets of food-deficit in the country. The regional demand and supply analysis[8] indicates rice-deficit areas in some parts of the central dry zone and Shan and Chin states.

Little work has been done to access food security in Myanmar, with the exception of a study undertaken by the Food and Agriculture Organization of the United Nations (FAO) and the World Food Programme for the Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) program (UNOP–MYA, Report no. 03/059, 2003). The report indicated that out of the national total number of 324 townships, of 52 townships were classified as being very highly vulnerable, 49 were classified as highly vulnerable, 62 as moderately vulnerable, and the remaining 122 were classified as having a relatively low level of vulnerability. Of the 52 very highly vulnerable townships, 29 are located in Shan State. All townships in the state of Chin and two-thirds of townships in the state of Kachin are also reported to be highly vulnerable. Bago, Mon, and Yangon were reportedly the least vulnerable townships. Townships which were well served with infrastructure, were less likely to be vulnerable compared with remote townships.

F. Rationale and Objectives

Myanmar relies mostly on domestic energy resources to sustain its economic development. Myanmar's energy resources are crude oil, natural gas, hydropower, coal, biomass, wind, and solar power. These energy sources (with the exception of wind and solar) play an important role in fulfilling domestic energy requirements.

Under the new economic policy, infrastructure development, construction, and investment in all sectors of economy are growing at a faster pace, and the demand for energy has risen correspondingly. To boost crop production, farm machinery is increasingly being used in the rural areas for land preparation, cultivation, threshing,

[8] FAO Representative Office in Myanmar

and harvesting. Consequently, demand for fuel—mostly in the form of diesel—is also increasing. With the growing fuel demand from industry, machinery, and motorized vehicles, it is estimated that 524 million gallons of gasoline and 1,392 million gallons diesel will by needed annually by FY2030. Because of rising world fuel prices, biodiesel has become a focus of interest in Myanmar. The country plans to produce biodiesel as a substitute for imported diesel oil to help reduce its reliance on imported fuel.

Potential crops for biofuel production in Myanmar fall into two categories—those for biodiesels and those used to make bioethanol. Biodiesels are processed from vegetable oils derived from edible and non-edible crops. Edible crops include oil palm, coconut, Thit-seit, Sie-tha-pyay (*Simarouba gluca*), rapeseeds, sunflower, sesame, groundnut, rice brand oil, niger, soybean, safflowers, and moringa (*Moringa oleifera*). Non-edible crops include *Jatropha curcas*, the castor oil plant, the neem tree, and Indian beech (*Pongamia pinnata*). Bioethanol is processed from sugarcane, cassava, and other suitable crops such as maize, sweet potato, yam, sorghum, and rice.

Taking into account the need to increase fuel supplies without endangering food security, plantations of the non-food crop, jatropha, are targeted to reach 3.44 million ha (8.5 million acres) by 2010. The promotion of jatropha cultivation for biodiesel production is intended to help rural households reduce their dependence on diesel fuel. Its potential as cooking oil and lighting fuel will also be investigated. Although the oil content of jatropha seeds is high (36%–38%), and there is experience in Indonesia, India, and Africa to draw upon, the economics of growing and processing jatropha requires further study especially in the Myanmar context.

This study aims to provide recommendations to decision makers to assist in the development of a national biofuel program for the commercial development and long-term viability of biofuels. The study is intended to help strengthen existing activities and institute a country biofuel system that would support energy security without adverse effects on food security.

The objectives of this study are to:

(i) identify the energy market outlook, biofuel characterization, and policy gaps in biofuel development planning and legislation;

(ii) determine the appropriate regulatory measures and institutional framework;

(iii) determine the priority feedstocks for biofuel production and the necessary market-enabling measures;

(iv) specify the appropriate business options relevant to the Greater Mekong Subregion, and to the fostering of business ventures involving private–public partnerships; and

(v) specify the strategic activities for the long-term well-being of the rural poor.

During the course of the study, issues related to environmental concerns and food security versus energy security were reviewed. Other issues investigated included the existing energy supply and demand, energy balances, potential alternative sources, risks and benefits characteristics of resource base, and business models in practice and their related policies. Regulations related to energy and institutional arrangements were also reviewed to determine the policy levers and to suggest a sound regulatory and institutional environment for biofuel development. The biofuel development policy, regulations, and institutional arrangements of other countries were observed to assist in the formulation of the recommendations.

The study assesses the existing national program for large-scale growing of biofuel crops, and the policy support to encourage the growers, to determine its impact on the well-being of the rural poor. It investigates the feasibility of establishing small-scale extraction plants that can generate income and job opportunities in rural areas. Existing medium- and large-scale biofuel processing plants were observed to understand the process of establishing plants in view of business arrangement and mechanism toward the public–private participation in biofuel production and distribution. Sector-based existing supply and finance arrangement is observed in order to find out possible ways to mitigate hindrance in business operation and coordination mechanism to streamline the energy security of the country. The study also considers opportunities for cooperation with neighboring countries in the areas of Bio-fuel development, transfer of technologies and cross-border contract farming etc., in the Greater Mekong Subregion.

The study also reviews the efforts of various agencies to boost the development of biofuel technology, with a view to improving integration and establishing coordination in research and development in order to mitigate existing technical problems and reduce economic, environmental, and social risks.

The outcome is a biofuel country assessment report that presents the results of a review and analysis of the policy options and institutionalization, prioritization, business options, market outlook, and characterization of the resource base, and identifies recommendations and a master plan for a national strategy for biofuel development.

G. Outline of the Report

Section II describes the country's energy consumption, energy supply, energy balances, and potential alternative sources of energy. It also describes the obstacles to the marketing of biofuel and discusses the future direction of the biofuel market in Myanmar. Section III analyzes the scope for biofuels, potential feedstocks for biodiesel and bioethanol production, the methods of processing biodiesel and bioethanol, and biomass energy consumption from fuelwood. Section IV describes the prioritization of feedstocks for biofuel production. Section V evaluates the biofuel business options facing stakeholders from the farm level to the final consumer. This section also highlights the opportunities and constraints to biofuel business development, and the different scenarios and models of contract farming for biofuel production. Section VI explores the national strategies and policies that support biofuel development, the biofuels development program, and measures to address the policy objectives. The institutional framework and market and investment options are also highlighted. Finally, the report puts forward suggestions and recommendations to develop the biofuel industry. The expected projects and support measures are also highlighted in this section.

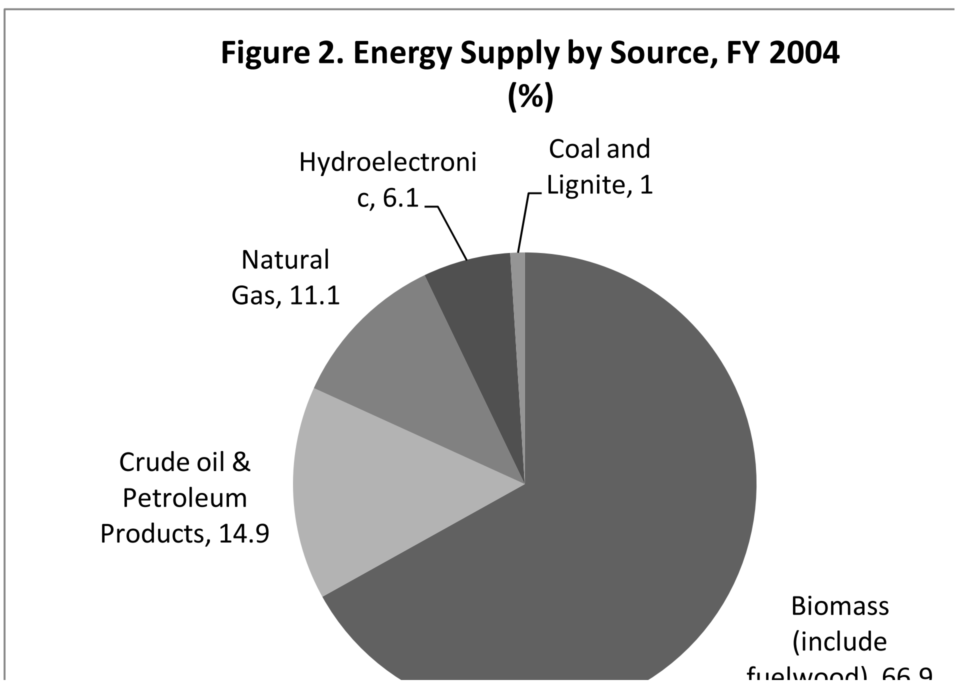
II. ENERGY MARKET AND OUTLOOK

A. Energy Supply and Demand

1. Energy Supply

The diverse energy resources of Myanmar consist of crude oil, natural gas, hydropower, coal, and renewable energy sources (such as biomass, geothermal, biofuel, wind, and solar energy). Biomass accounts for 66.9% of the estimated annual energy consumption of Myanmar, crude oil and petroleum products (chiefly diesel and gasoline) account for 14.9%, hydropower[9] 6.1%, natural gas 11.1 %, and coal and lignite 1% (figure 2).

Figure 2 Energy Supply by Source, FY 2004



Source: Ministry of Energy, 2002

Biomas. Energy use in Myanmar traditionally depends upon energy sources such as fuelwood, charcoal, and biomass. An area of 344,232 km^2 is covered with forest amounting to 50.8% of total land area. Potential available annual yield of wood-fuel up to 19.12 million cubic tons and 18.56 million acres of land could generate residues, by-products, or direct feedstock for biomass energy. Agricultural by-products, such as pigeon pea stocks, sugarcane burgesses, rice straws, rice husks, sesame stalks, and

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[9] Hydropower will be discussed in section B – potential alternative sources of energy of this chapter.

palm leaves, offer limited sources of energy. However, the use of energy sources, such fuelwood and charcoal, aggravates deforestation, and consequently threatens the environment.

Table 6: Energy Resources in Myanmar

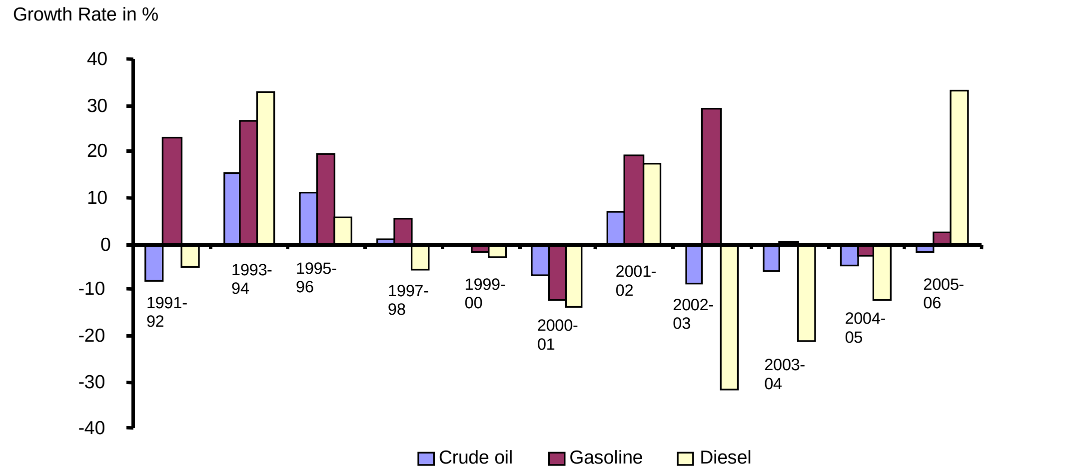
Crude oil (offshore and onshore, proven + probable)	648.59 million barrels
Natural gas (offshore and onshore, proven + probable)	122.5391 trillion standard cubic feet
Hydropower	108,000 megawatts
Coal	711 million tons
Biomass	344,232 km^2 covered with forest amounting to 50.8% of total land area Potential available annual yield of wood-fuel up to 19.12 million cubic tons 18.56 million acres of land could generate residues, by-products, or direct feedstock for biomass energy 103 million head of livestock could generate animal waste for biogas
Wind	365.1 terawatt hours per year * Coastal strip of 2,832 km with Southwesterly wind: 9 months Northeasterly wind: 3 months
Solar power	51973.8 terawatt hours per year *

* NEDO estimate, 1997.
Source: Energy Planning Dept., Ministry of Energy, 2005.

Crude oil. The production of crude oil declined by 0.15% during FY1992–FY2007. In the same period the domestic production of gasoline increased by 9.9%, but the production of diesel declined by about 0.3%. There is a shortfall in the domestic supply of crude oil, especially in the transport sector, where the number of vehicles is increasing at a rate of 19.3% per annum. Domestic consumption far exceeds production, and Myanmar needs to emphasize the development of crude oil and gas to develop its economy.

In 2008 about 10,000 barrels per day of crude oil were produced from onshore fields. The country's three refineries have a combined capacity of 57,000 barrels per day, although they operate at one third of this level due to old age. Petroleum products produced locally from crude oil include motor spirit, diesel, liquefied petroleum gas, furnace oil, aviation turbine fuel, kerosene, and petroleum coke. There is a downward trend in the domestic production of these petroleum products, with the exception of motor spirit and aviation turbine fuel.

Figure 3: Percentage Rate of Growth in Production of Crude Oil, Gasoline, and Diesel



Source: Ministry of Energy.

Natural gas. The Yadana gas field holds reserves of 7.84 trillion cubic feet of natural gas, and the Yetagon gas field contains an estimated 4.35 trillion cubic feet. Total production of natural gas increased more than ten fold from about 33.6 billion cubic feet (bcf) in FY1991 to 377.4 bcf in FY2005. Onshore gas production is, on average, 0.1 bcf, while more than 12,000 barrels of condensate are produced from offshore area of the Yetagon gas field and more than 1,200.0 bcf per day of natural gas from the Yadana and Yetagon gas fields[10] (.

Coal. There are 16 major known coal deposits the country, located along the Ayeyarwady and Chin-dwin river basins, and in the south. The production and consumption of coal were insignificant in the past due to the remoteness of coal reservesand the lack of sufficient investment for exploitation, The Myanma Mines Law of 1994 allows private sector participation in the mining industry. The efforts of seven companies operating under large-scale mining permits have yielded coal reserves to 711 million t (Table 6), and an increase in coal production from 0.99 million t in FY2005 to 1,12 million tons in FY2008 (according to the Ministry of Energy). Coal is used in domestic industries or exported. Several coal-fired cement plants are in operation in the coal mining area, and a new one recently opened in Shan State.

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[10] MOE. 2007. Ministry of Energy. Document from Energy Planning Department, Ministry of Energy.

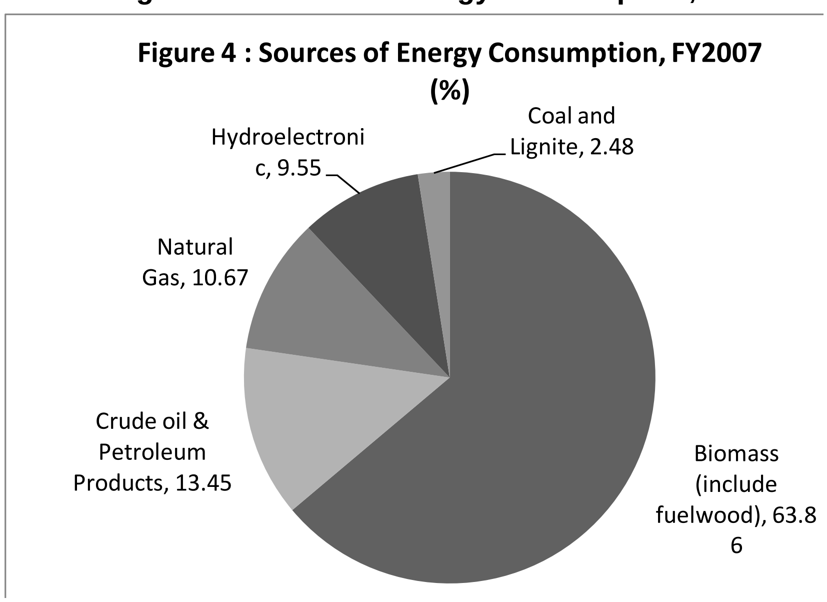
2. Energy Consumption

The total energy consumption in Myanmar in FY2008 was about 14,889 thousand tons of oil equivalent (ktoe). Crude oil accounted for 1,789 ktoe, natural gas 1,721 ktoe, and hydropower generated 1,541 ktoe of electricity. The remaining energy consumed—principally biomass and coal—accounted for 9,838 ktoe,

Biomass is the most important national energy source in terms of consumption. In FY2007, renewable energy from biomass sources—predominantly fuelwood, charcoal, agricultural waste, wood waste, and animal dung—amounted to 63.9% of energy consumed and 36.1% of energy consumption came from energy generated from fossil fuels and water resources (known as commercial energy) (Figure 4), Biomass energy is predominantly derived from fuelwood and agricultural wastes, such as cotton and pigeon pea stalks, sugarcane biogases, rice straws, rice husk, sesame stalks, and palm leaves. It was estimated in 1999 that the use of primary solid biomass (including fuelwood) in Myanmar was equivalent to 9,504 thousand MT oil equivalent (www.earthtrends.wri.org).

A survey of annual biofuel consumption per household in rural areas indicated about 8.8 dry ton biomass, of which fuelwood constitutes 3.7 t, pigeon pea stalks 2.3 t, and sesame stalks 1.2 t (Table 7).

:Figure 4 Sources of Energy Consumption, FY 2007



Source: Ministry of Energy, 2007.

Table 7: Biomass Primary Energy Consumption per Household per Annum in Rural Areas

Sr. No.	Biomass Source	Dry Ton	Percent (%)
1.	Fuelwood	3.76	42.7
2.	Pigeon pea stalk	2.3	26.2
3.	Cotton stalk	0.5	5.6
4.	Sesame stalk	1.2	13.6
5.	Coconut or palm leaves	0.6	6.8
6.	Rice husk	0.3	3.0
7.	Sawdust	0.07	0.8
8.	Bamboo	0.12	1.3

Source: Regional Wood Energy Development Programme in Asia Report No. 33, 1997, The National Training Workshop on Woodfuel Trade in Myanmar, Forest Research Institute, Yezin, 1996.

The population of Myanmar is projected to increase from an estimated 57.65 million in FY2008, to 60 million in 2010. Approximately 1,000 kilograms of oil equivalent of energy are needed per capita per annum to ensure an acceptable standard of living (UNDP, 2007). The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) estimated that per capita energy consumption in Myanmar was about 430 kilograms of oil equivalent, while the Ministry of Energy's estimate for 2000 was at about 240 kilograms of oil equivalent. This consisted largely of fuelwood, agricultural residue, and animal waste.

Energy consumption by sector (Table 8) gives an insight into the current level of development of the country. Households used about 74.3% of the total energy consumption, followed by the transport sector with 10.1%, while services and industries only accounted for some 7.0% of Myanmar's energy consumption in 2005. The low level of energy consumption by industry explains the slow growth in that sector. As industrial development expands, the energy supply needs to be expanded dramatically to meet the greatly increased demand. Agriculture consumed 1.1% of the total energy in 2003, and its share declined to almost 0.01% in 2005.

Table 8: Energy Consumption by Source and Sector in 2005

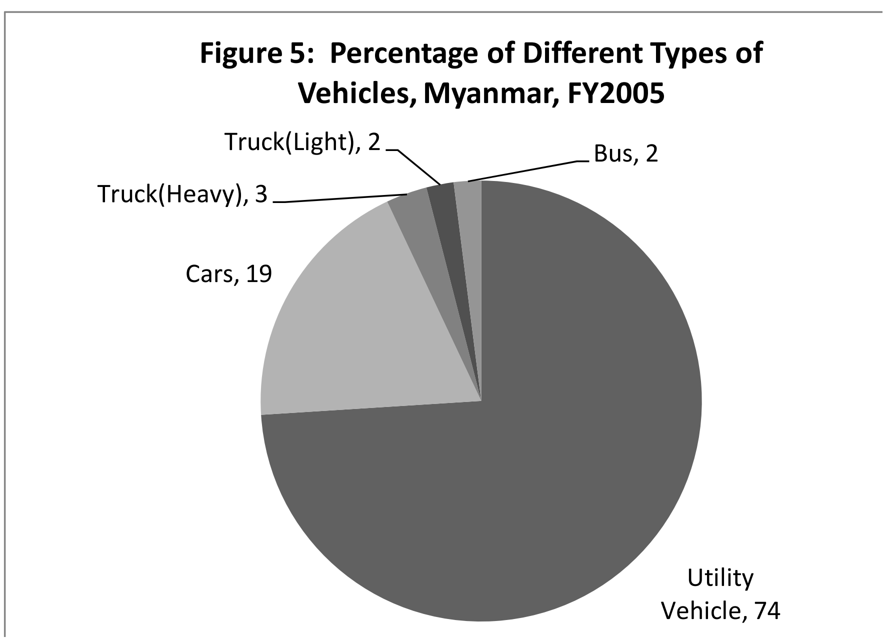
(thousand tons of oil equivalent)

Sector	Petroleum Products	Natural Gas	Coal	Renewable and Waste	Electricity	% Consumption
Industry	187	441	82	304	121	7.0
Transport	1,334	3	—	—	—	10.1
Other sectors	219	605	9	9,566	194	
Residential	153	—	—	9,566	126	74.3
Commercial and public service	—	—	—	—	68	0.5
Agriculture and Forestry	1	—	—	—	—	0.01
Others	65	605	9	—	—	6.6

Source: International Energy Agency, 2007.

Transport data show that approximately 74% of vehicles are motorcycles, tricycles, and *trawlergi* (utility vehicles) (Figure 5). The annual growth in the number of motorcycles was 46.23%, and tricycles posted an annual growth of 22.56%. Therefore much of the total growth could be attributed to the increased purchase of motorcycles and tricycles during the period. A high rate of increase of utility vehicles would lead to increased fuel consumption in the future.

Figure 5 Percentage of Different Types of Vehicles, Myanmar, FY 2005



Source: Ministry of Energy.

The Central Statistical Organization (CSO) conducted a household income and expenditure survey in 1997 to determine the levels and patterns of household expenditure in urban and rural areas, and the standard of living of the households. Fuelwood was found to be the main source of cooking fuel, followed by charcoal and gas (CSO, 1999). Fuelwood was the major energy source for 73% of households. It was the major source of energy for 42% of urban households and 93% of rural households. 17% of the households surveyed—42% urban households and 4% rural households—used charcoal as a source of energy for cooking. Less than 1% of the country's total households used gas.

The use of electricity or kerosene for cooking is mainly limited to urban areas. The proportion of households using fuelwood for cooking is much lower in the capital city than in the rural areas of Myanmar where wood is still the major energy source. Fuelwood consumption for cooking purposes results in deforestation of large areas, creating severe ecological and socioeconomic problems. The introduction of fuel-efficient stoves can significantly reduce firewood consumption. The use of solar cookers and biogas are still limited due to technical and handling problems.

The survey conducted by the CSO[11] (1999) found that around 37% of households in the country have access to electricity for lighting. 72% of urban households and 18% of rural households had access to electricity. About 10% of urban households and 32% of rural households used batteries for lighting. Electricity is the main source of light of urban households. Battery charging and generators are also used to provide electricity within households. More than 70% of the rural population still has difficulty accessing electricity. A UNESCAP (2008) study found that the electrification rate was only around 11%, and only 5.7 million people have access to electricity: while 45.1 million people were without access to electricity.

The Household Income and Expenditure Survey was conducted by the CSO in 1989, 1997, and 2001. The survey investigated the level and patterns of expenditure of households in urban and rural areas and provided data on the standard of living of households. The survey also revealed how households in Myanmar use different kinds

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[11] Survey was conducted in 1997 but outcome is published in 1999.

of energy sources for cooking. Fuelwood is a major energy source for cooking for 73.3% of households. Charcoal—also a source of energy for cooking in Myanmar—accounted for 23.0%. Gas accounted for 0.4%, electricity 1.5%, fuelwood substitutes 0.4%, and other energy sources accounted for 1.8%. Together their combined use accounted for only 4.2%.

To improve living standards, Myanmar needs to make greater use of energy in the form of electricity, gas, petroleum, or fuel oil. Data on the production and distribution of petroleum oil and natural gas should be examined to help assess the country's energy security. Myanmar is in the favorable position of being able to produce a substantial amount of natural gas from both inland and offshore reserves totaling 454,799 million cubic feet. Annual exports of natural gas to neighboring countries are increasing. Gas exports jumped from 65,359 million cubic feet in FY2001 to 335,525 million cubic feet in FY2005. There might be a trade-off between the purchase of diesel and export of natural gas. Table 9 shows the annual production, refining and distribution of petroleum and diesel.

Table 9: Annual Production, Refining, and Distribution of Petroleum and Diesel

(million gallons)

Fiscal Year	Refining and Production			Distribution	
	Crude oil	Petroleum	Diesel	Petroleum	Diesel
1996	241.607	65.133	116.564	63.48	175.68
1998	268.234	77.738	123.096	75.90	210.57
2000	270.628	82.005	116.128	93.07	198.55
2001	270.111	80.597	112.595	102.76	325.60
2002	251.988	70.771	97.153	92.07	334.24
2003	269.845	84.316	113.950	97.84	334.71
2004	246.649	109.020	77.925	113.26	314.59
2005	232.285	109.433	61.591	115.08	303.39
2006	221.519	106.704	54.078	113.36	271.51
2007	217.721	109.327	72.040	112.28	293.31

Source: Energy Planning Dept., Ministry of Energy, January 2008.

Electricity Production

Between 2000 and 2004, electricity production in Myanmar grew at an average annual rate of 5.9%. Per capita consumption of electricity was 45 kilowatt hours in 2004. Total installed capacity increased from 1,173.3 megawatts (MW) in FY2000 to 1,718.56 MW at the end of FY2008. The share of diesel as energy input in power stations decreased to 4.1% in FY2008 from 5.6% in FY2000.

The share of electricity generated by hydropower increased from 30.7% in FY2000 to 46.7% in FY2008. The share generated by gas and steam turbines was 42.2% in FY2008 (Table 10). Net production[12] narrowly meets consumption (Figure 6). The generation, transmission, and distribution of electricity had historically been a government responsibility; however, the heavy costs incurred in constructing power plants prompted the entry of the private sector into electricity generation.

Table 10: Installed Electric Capacity

(megawatts)

	Installed capacity	**Hydro-electric**	**Gas and Steam Turbines**	**Coal**	**Diesel**
Before 1988					
Grid system	504.65	224.00	280.65	—	—
Isolated	147.11	4.26	59.35	—	83.50
Total	**651.76**	**228.26**	**340.00**	—	**83.50**
Percentage	100.00	35.02	52.17	—	12.81
1999–2000					
Grid system	1032.57	327.00	680.60	—	24.97
Isolated	140.73	33.32	66.99	—	40.42
Total	**1,173.30**	**360.32**	**747.59**	—	**65.39**
Percentage	100.00	30.71	63.72	—	5.57
2007–2008					
Grid system	1601.90	767.00	714.90	120.00	—
Isolated	116.66	35.97	10.90	—	69.79
Total	**1,718.56**	**802.97**	**725.80**	**120.00**	**69.79**
Percentage	100.00	46.72	42.23	6.98	4.07

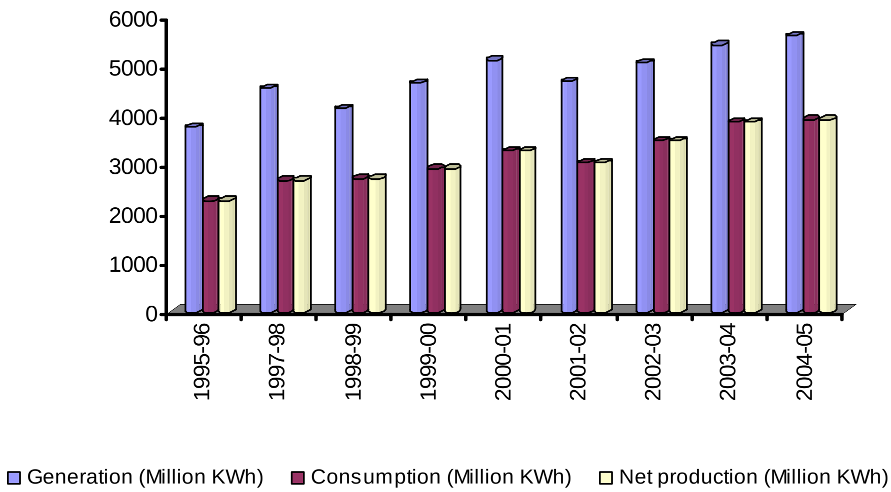
MW = megawatt
Source: Myanma Electric Power Enterprise, Myanmar Aline, 7 April 2008.

[12] Generation minus losses = net production.

Private-sector participation in rural electrification is limited, except for a few private diesel generators, gasifiers, biogas, and solar vendors in the rural areas. The rural electrification program aims to supply electricity to homes and villages located beyond the operational areas of local authorities. Rural electrification forms part of efforts to enhance the quality of life and living standards among the rural communities. The increasing use of electricity, which is expected to raise productivity and income in agriculture, industry, and commerce, is also expected to affect modernization and create an attitudinal change in rural areas.

Figure 6: Electricity Generation, Consumption, and Net Production in Myanmar

(million kWh)



KWh = kilowatt-hours

Source: Central Statistical Organization, 2005

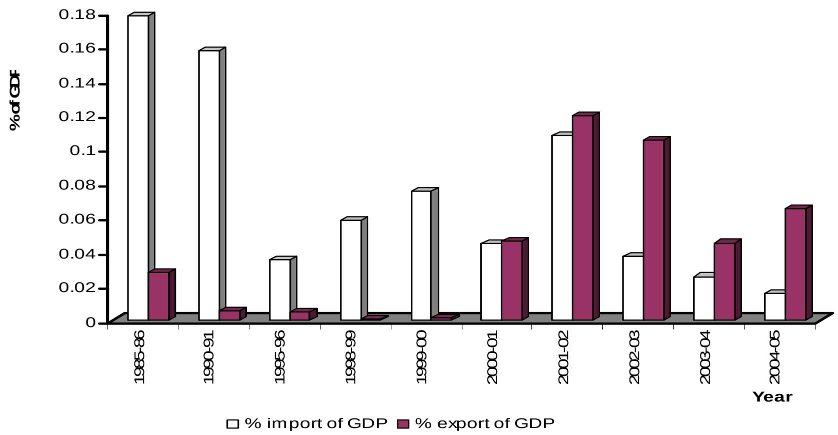
Fuel Exports and Imports

Figure 7 shows energy trade as a percentage of gross domestic product (GDP) for Myanmar from FY1986 to FY2005. Fuel imports**,** which accounted for about 0.17% of GDP in FY1986, declined to 0.04% in FY2001, increased by 0.1% in FY2002, and again decreased by 0.01% in FY2005. The United Nations Conference on Trade and Development (2005) reported that Thailand and India had imports in the range of 3%–5% of GDP in FY2004. China's oil imports, although a significant factor in the world energy market, constituted only 2.5% of the country's GDP. The energy exports of Myanmar were 0.03% of its GDP in FY1986 and increased to 0.12% of GDP in FY2002.

By comparison, Malaysia's energy exports amounted to more than 10% of GDP, while Indonesia's energy exports were equivalent to 4.5% of GDP FY 2004(UNCTAD, 2005.

Figure 7: Energy Import and Export of Myanmar as a Share of Gross Domestic Product for Various Years

(% of GDP)



Source: International Energy Agency, 2005

Table 11 shows Myanmar's annual production, consumption, export, and import of fuel in thousand tons of oil equivalent (ktoe) in FY2005. Total fuel exports accounted for about 8,704 ktoe, including 399 ktoe of crude oil, 7,712 ktoe of natural gas, and 593 ktoe of coal. The amount of crude oil exported was very low compared to the amount of natural gas exported. Imports of energy consisted exclusively of 1,289 ktoe of petroleum products. The value of crude oil imports for the period FY1991 to FY2005 is shown in Figure 8. Imports can be seen to decine after FY2002.

Table 11: Production, Export, and Import of Fuel of Myanmar in FY2005

(thousand tons of oil equivalent)

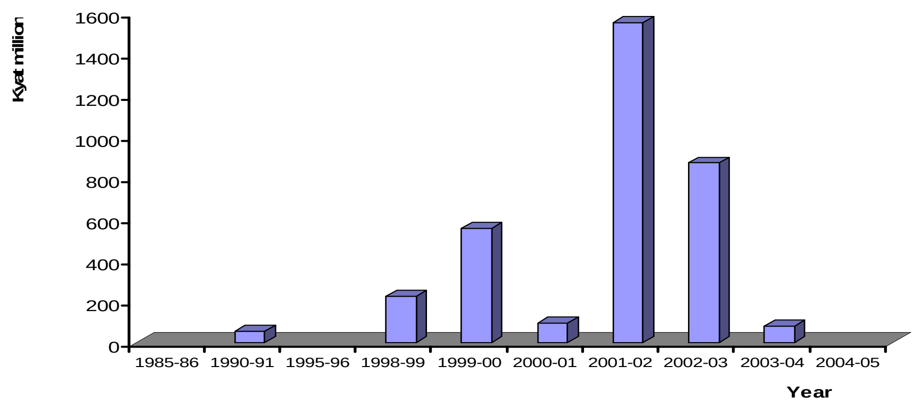
	Total Energy	Crude Oil	Natural Gas	Electricity	Coal	R-Waste*	Petroleum Product
Production	22,143	1,123	9,830	258	684	10,249	—
Consumption	14,725	725	2,118	258	91	9,870	
Export	8,704	399	7,712	—	593	—	—
Import	1,289	—	—	—	—	—	1,289

* Combustible renewable and waste.
Source: International Energy Agency, 2007.

The amount of petrol oil and lubricants exported and imported in various years is shown in Figure 9, indicating that imports of petroleum products are comparatively higher than the export of those products. Figures 9, 10 and 11 illustrate the amount and value of refined mineral oil, lubricants, and related materials exported and imported. In FY2002, about 295,972 thousand gallons (5,919.44 thousand barrels) of refined mineral oil were imported. The amount imported shrank to 94,706 thousand gallons (1,894.12 thousand barrels) in FY2004 and rose again to 176,388 thousand gallons (3,527.76 thousand barrels) in FY2005. The amount imported fluctuated depending on the government budget and domestic demand.

Figure 8: Crude Oil Imports, FY1996–FY2005

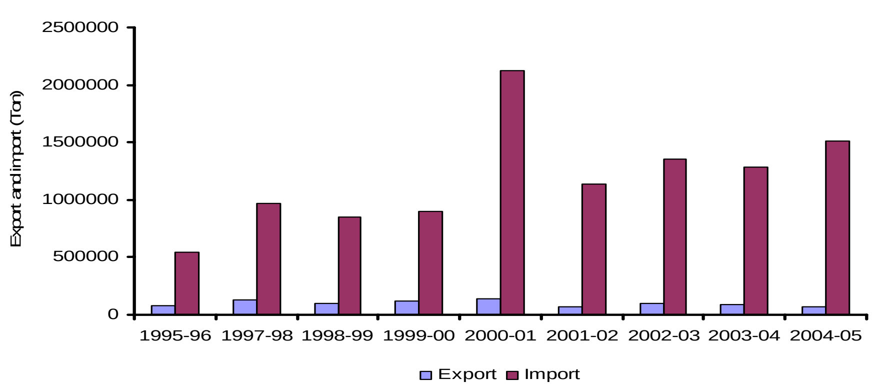
(million kyats)



Source: Central Statistical Organization, 2005.

Figure 9: Exports and Imports of Petroleum Oil and Lubricants, FY1996–FY2005

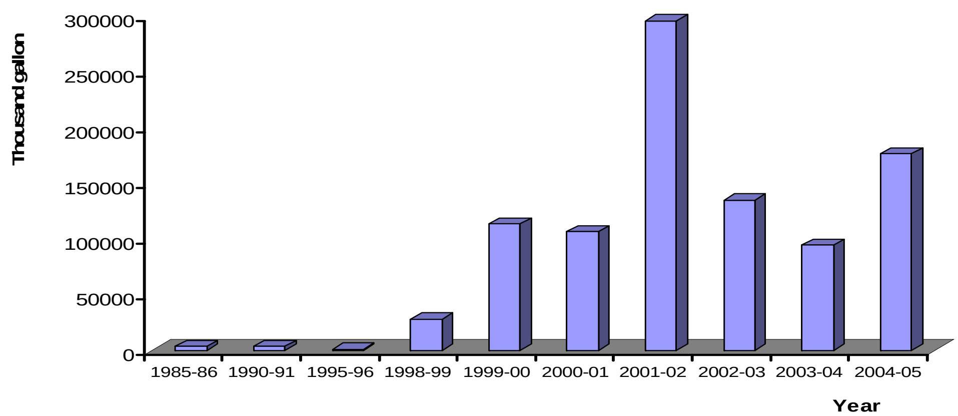
(tons)



Source: Central Statistical Organization, 2005.

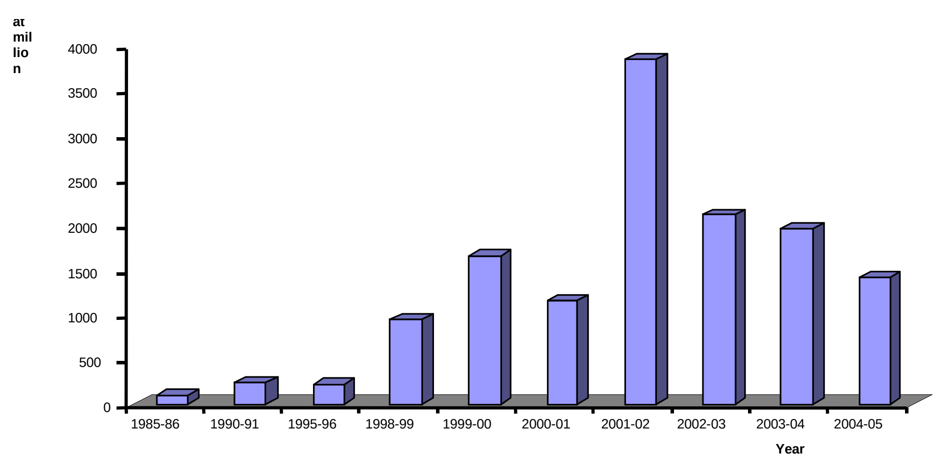
Figure 10: Imports of Refined Mineral Oil, FY1996–FY2005

(thousand gallons)



Source: Central Statistical Organization, 2005.

Figure 11: Import Value of Mineral Fuels, Lubricants and Related Materials, FY1996–FY2005



Source: Central Statistical Organization, 2005.

1.2 billion cubic feet per day of natural gas produced from offshore areas are exported to Thailand. According to BP Statistical Review 2007, Myanmar ranks 10th in pipeline export. A pipeline connection has already been installed to transport the host's country entitlement from the present reserves and its entitlement from future discoveries to domestic consumers for industrial establishments and power-generating facilities (Ministry of Energy, 2008).

Projected Energy Production and Consumption

According to the Ministry of Energy, the demand for petroleum products has been increasing rapidly. Demand for diesel is projected to increase by 25% per annum and demand for motor gasoline is expected to rise by 20% per annum (www.energy.gov.mm). Tables 12 and 13 show the projected energy consumption and production by source of energy (www.aseanenergy.org) in Myanmar. The trend between 1980 and 2030 under a base case showed that energy demand will increase by 12.6%–21,102 ktoe by 2030. However, energy supply for the same period will increase by 10.49%. There could still be a supply–demand gap, and Myanmar needs to be concerned about its energy security since limited supplies and high prices may constrain economic growth.

Table 12: Projected Energy Consumption by Source of Energy in Myanmar

(thousand tons of oil equivalents)

Year	Coal		Crude Oil		Natural Gas		Electricity		Others		Total	
	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case
1980	126	126	1,167	1,167	84	84	90	90	—	—	—	**1,467**
1990	37	37	594	594	225	225	149	149	8,389	8,389	**9,393**	**9,393**
2000	72	72	1,518	1,518	324	324	281	281	9,010	9,010	**11,205**	**11,205**
2010	64	66	2,764	2,757	537	570	745	875	10,069	10,090	**14,179**	**14,307**
2020	109	117	4,057	4,312	787	942	1,202	1,966	11,122	11,198	**17,257**	**18,535**
2030	169	190	5,783	6,528	1,074	1,756	1,790	4,454	12,286	12,420	**21,102**	**25,348**

Source: Ministry of Energy, mentioned in www.aseanenergy.org.

Table 13: Projected Energy Production by Source of Energy in Myanmar

(thousand tons of oil equivalents)

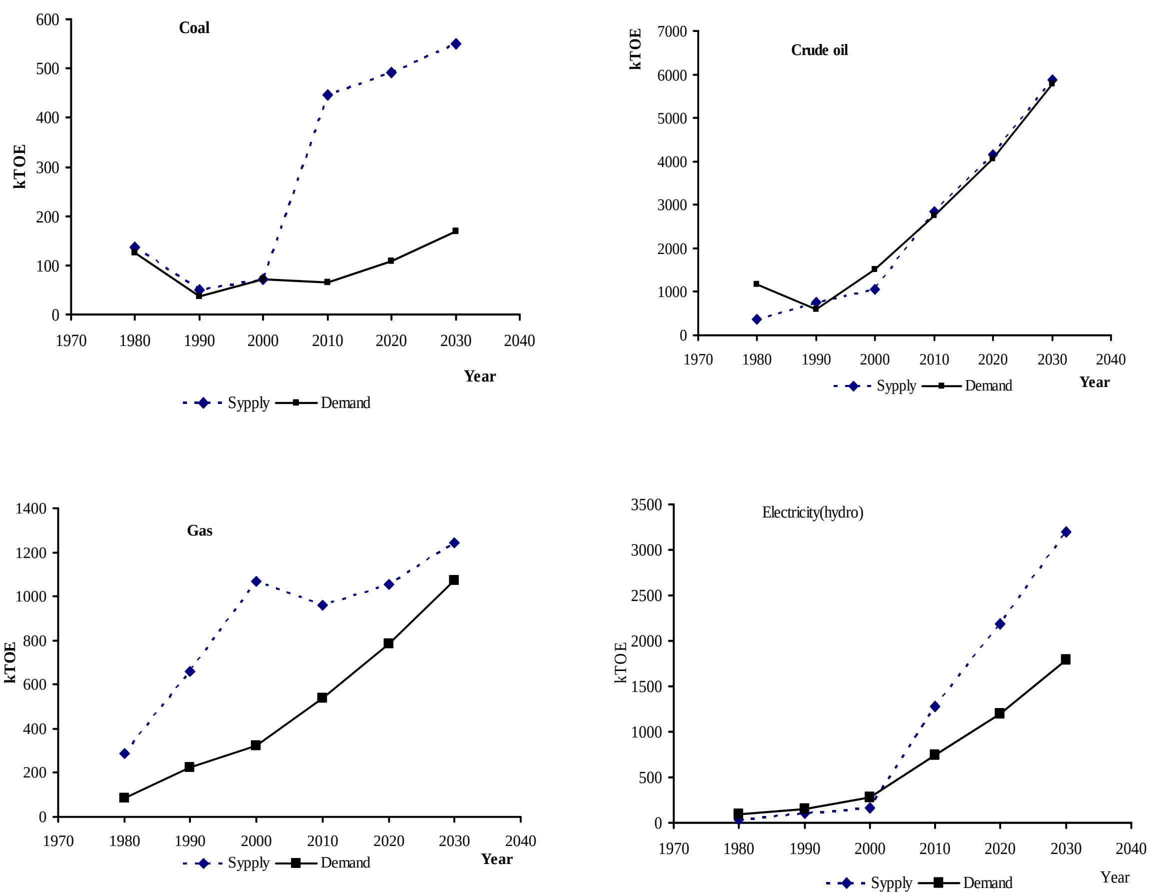
Year	Coal		Crude Oil		Natural Gas		Hydro		Biomass		Total	
	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case	Base Case	High Case
1980	136	136	368	1,368	286	286	30	30	7,572	7,572	9,392	9392
1990	49	49	762	762	659	659	103	103	9,021	9,021	10,594	10594
2000	72	72	1,055	1,055	1,068	1,068	163	163	9,175	9,175	11,533	11533
2010	446	312	2,852	2,870	960	982	1,281	1,570	10,069	10,099	15,618	15583
2020	491	363	4,150	4,372	1,054	1,133	2,184	3,217	11,122	11,198	19,011	20283
2030	551	512	5,871	6,603	1,244	1,899	3,192	6,364	12,286	12,420	23,144	27798

Source: Ministry of Energy, mentioned in www.aseanenergy.org.

Data on the supply and demand for coal, crude oil, gas, and electricity are shown in Figure 12. The projected supply of coal, gas, and hydropower electricity are significantly higher than their projected demand, whereas the projected supply of crude oil just satisfies the projected demand for this fuel.

Figure 12: Projected Supply and Demand of Coal, Crude Oil, Natural Gas and Electricity in Myanmar

(thousand tons of oil equivalent)



Source: Ministry of Energy.

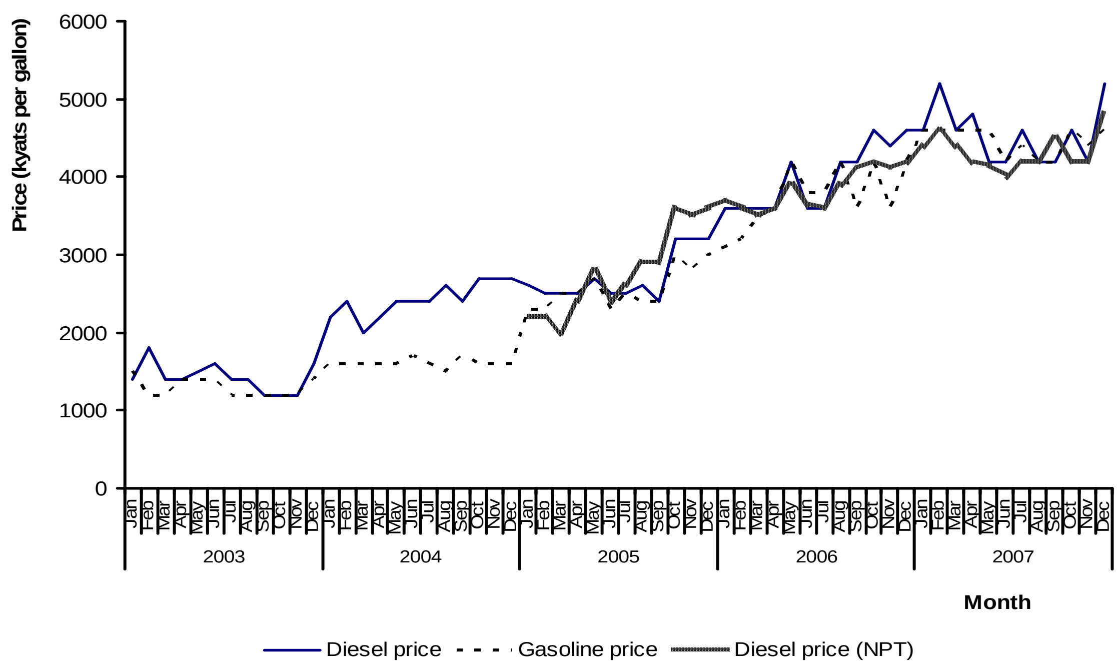
Rising Fuel Prices

Energy deprivation is a defining characteristic of poverty and a formidable barrier to its resolution. The role of energy in the lives of the poor needs to be considered in order to understand the impacts of oil prices on the poor. In Myanmar, the majority of the population lives in rural areas with little or no access to electricity and is unable to afford fuels, such as kerosene, for essential lighting. Although the urban poor may appear to have better access to fuels and electricity, many continue to rely heavily on inferior biomass for cooking. Biomas remains the single largest source of energy especially among the poor who cannot afford modern energy alternatives.

Fuel prices increased from kyat (MK)1,400 [13] (US$1.42) in 2003 to MK5,200 [14] (US$4.62) per gallon in 2007 for diesel and MK1,500 (US$1.52) in 2003 to MK4,600 (US$4.08) per gallon in 2007 for gasoline, (Figure 12). Figure 13 illustrates the change in world monthly market prices of crude oil, diesel, and gasoline, indicating that fuel prices fluctuated between 2005 and 2006 and started to increase in 2007.

Figure 13: Change in Collected Monthly Market Prices of Oil Products at Two Locations in Myanmar

(kyat per gallon)



Source: Personnel Interview (unofficial source), 2008

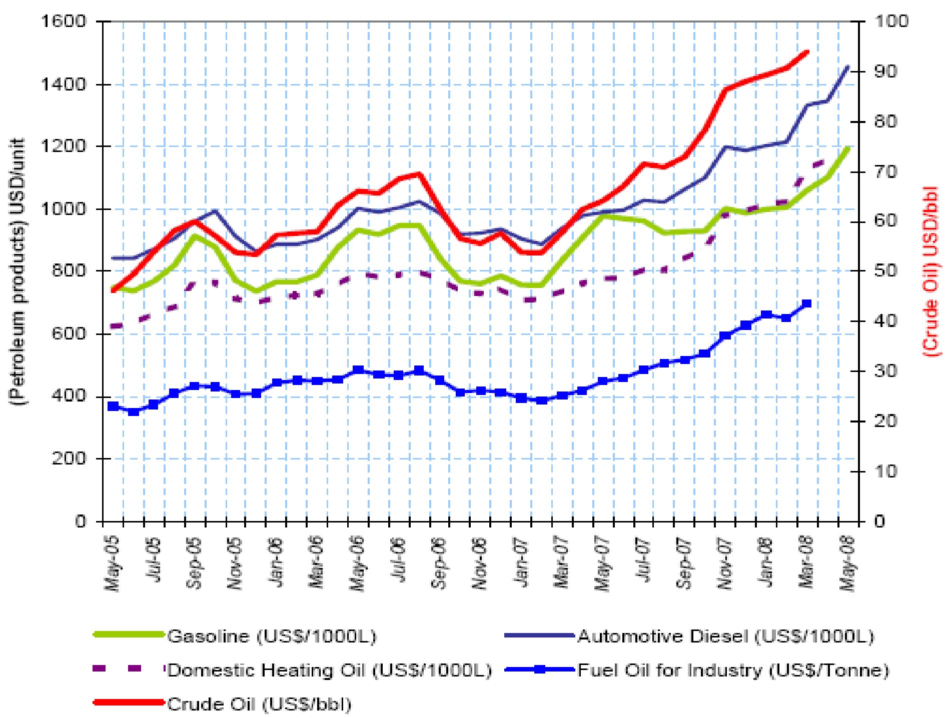
The rising cost of domestic fuels and public transport have severely affected poor households. Before oil prices began their upward trend in 2003, the government

[13] US$1 = 983 kyats in 2003.

[14] US$1 = 1,125 kyats in 2007.

regulated the prices of many oil products, subsidizing their prices to ensure the poor could afford them. However, as the price of crude oil in world markets surged (Figure 14), and the gap between the international cost and the domestic price of oil products widened, the capacity of the government to maintain subsidies at the same level as in the past has been stretched. The government is therefore moving domestic product prices closer to the world market prices, approaching the process of price liberalization.

Figure 14: Change in World Monthly Market Prices of Crude Oil, Diesel and Gasoline($)



Source: IEA (2007). International Energy Agency. Energy statistics. www.iea.org**, 2008.**

However, mounting pressure from world markets has forced the government to hike domestic prices in larger increments and on 14 August 2007, without prior announcement, it officially increased the price of compressed natural gas by 500% and gasoline and diesel by more than 100% to MK2,500 per gallon ($2.17) for gasoline and MK3,000 per gallon ($2.61) for diesel. Nevertheless, these official prices are still lower than international prices. The government continues to subsidize petroleum products, especially kerosene and liquefied petroleum gas, which are commonly used in household cooking and lighting, and by the transport sector. This can be very costly. The fuel price hike triggered an increase in bus fares and sent prices of essential commodities soaring. Retail prices jumped sharply and a public backlash occurred, posing a dilemma for the government. However, at the last quarter of 2008 price of fuel in the domestic unofficial market was low compared to the last year so that price of commodities went down.

B. Potential Alternative Sources of Energy

Greater use of renewable energy technologies is one of the promising ways to reduce oil price vulnerability. In recent years, the country has begun to exploit a wide array and scale of renewable energy sources, particularly solar, wind, small hydropower, geothermal, and biomass. Investments in these renewable energy sources have been growing rapidly because of significant oil price increases and climate change concerns.

1. Hydropower Resources

The electric power sector plays a major role in the supply of electricity that is crucial for social, commercial, and industrial purposes. The government plans to develop about 2,000 MW of hydropower in the 2012. Hydroelectric power is generated and distributed through the national grid system, which connects the major cities and strategic areas in the central and southern regions of the country. During the past decade, major efforts were made to expand the power system in the grid areas as well as in the off-grid area. Local and foreign private power companies have been allowed to participate. However, private sector participation failed because of low tariff rates, and heavy line losses. Recently, the local private sector has again begun to show interest in selected power projects that would be of mutual benefit to the state and the private sector.

Myanmar has abundant resources for electricity generation by small hydropower plants and turbine generators. Appropriate renewable energy technologies exist, and the skills to design and build such systems are available. A relatively small hydroelectric power development can play a significant role not only in providing local electrification, but also in enhancing local prosperity. It contributes to the local community, for example through the electrification of hospital and schools, which in turn improves the local economy and uplifts the living standard of local population. Paletwa township, for instance, has a diesel generator station with an output of 75 kW, which operates only 3 hours per day and provides electricity 24 hours per day. Nearly 160 sites are suitable for small hydropower with a total potential output of 170 MW. There are also numerous potential village sites for hydropower generation of less than 50 kilowatts (kW) and turbine generator installations of 1 kW or less in hilly regions.

2. Solar Power

Myanmar's tropical location allows it to enjoy abundant sunshine year-round, especially in the Central Myanmar Dry Zone Area. The potential available solar energy of Myanmar is estimated at 51,973.8 terrawatts per year. Experimental measurements by the Myanmar Electric Power Enterprise indicate that irradiation intensity of more than 5 kilowatt-hours per square meter per day was observed during the dry season. Of the many kinds of solar technology available, wind and solar hybrid home systems have the advantage of 24-hour electricity generation. However, the technology has drawbacks including barriers to information awareness, the high initial investment cost, and high customs duty on imported parts of the solar home system.

3. Wind Energy

Potential available wind energy is estimated to be 365.10 terawatt-hours per annum (NEDO, 1997). A diesel and wind energy hybrid community power system and wind energy power system was installed in two locations (Chaungthar hybrid power supply system project under the Ministry of Electrical Power and hybrid system at Chaungthar by NEDO). The project can be used for street lighting, clinic lighting, and other economic and social activities.

4. Alternative Biomass Fuel

In FY2005 around 49.5% of the total land area of Myanmar was forested (CSO, 2005). Fuelwood has been the main source of energy for households and is still the dominant energy source in the country. It occupies a share of approximately 63% in the commercial and noncommercial energy mix and has the advantage of being cheaper than commercial fuels. The majority of the rural population can easily access traditional fuelwood. Although fuelwood production increased from 16,741 thousand cubic tons in FY1986 to 20,467 thousand cubic tons in FY2005, the area of fuelwood plantations decreased. Charcoal production decreased to 225 thousand cubic tons in FY2005.

5. **Biogas**. As an agriculture-based economy, Myanmar has many cows, particularly in Mandalay, Sagaing, and Magway divisions in the central region of the country. On the average, a medium-sized animal produces 10 kg of dung per day—enough to produce 0.5 m^3 of biogas through anaerobic digester/ bio-gasification. The biogas produced can be used for cooking, lighting, preservation of grains, preparation of fodder, and driving internal combustion engines. There are two types of biogas plant: plants with a movable gasholder; and plants with built-in, fixed dome gasholder.

In 1980 the government launched a program to promote the use of biogas. A total of 867 floating-type biogas plants, family-size digesters were constructed in 134 townships in all 14 states and divisions, with highest figure in the central Myanmar region where fuelwood is rarely used. The main drawbacks of the floating-type biogas plant are the high capital investment, intensive maintenance, and short life span of the floating drum.

Yangon Technological University, under the Ministry of Science and Technology, has taken an active part in the dissemination of biogas technology for rural development. Biogas digesters are introduced to generate biogas from animal waste. If there are about 100 cows in a village, approximately 50 m^3 of biogas can be provided by 50 m^3 fixed dome-type biogas plant. The total estimated cost for a 50 m^3 fixed dome type biogas plant is about MK2.5 million (US$4,034)[15], including the cost of 25 horsepower, 15 kilovolt-ampere engine and other accessories for lighting (Figure 15). In a village of 300 households, each paying MK600 per month (US$0.96) for one fluorescent tube, the investment needed for the biogas plant would be repaid within 1 or 2 years.

[15] US$1= 619.75 kyats in 2001.

Figure 25: Fixed Dome-Type Biogas Plant

Source: own photo

Animal excreta, crop stalks, vegetable waste, and leaves become thoroughly decomposed after fermentation when sealed in airtight biogas pits. Their nitrogen content is transformed into ammonia, which is easier for plants to absorb, thereby improving fertilization. From a 50 m^3 size fixed dome type biogas plant, 420 gallons or 8 barrels per day of effluent slurry are produced, and the digested effluent slurry can be applied as organicfertilizer in place of chemical fertilizers. About 2.87 t of nitrogen, equivalent to 125 bags of urea; 1.15 t of P_2O_5, equivalent to 50 bags of superphosphate; and 2.87 t of K_2O, equivalent to 96 bags of potash are derived from effluent slurry per annum. This amounts to savings of approximately MK2.3 million per annum (US$3,711). According to the research by the Ministry of Science and Technology this could increase the yield of wheat by 16%, rice by 15%, and vegetables by 25%. Therefore, the exhaust slurry provides ample fertilizer and a good base on which to grow crops (Personnel Interview with staff from Ministry of Science and Technology).

Biogas technology is not new and it has reached the stage of technological maturity. Its further uptake will require an effective promotional and dissemination strategy that focuses on capacity building to enhance skills; to create awareness—particularly among local people—on the use of biogas; and to create awareness and expertise in ecosystem management; conservation of biodiversity, and the sustainable use of natural resources. The services of social scientists, in addition to scientists and engineers, are essential to remove the skepticism and socio-cultural barriers hampering mass propagation and acceptance of biogas technology among the rural masses.

6. **Rice Husk and Sawdust Gasification**. Another alternative is to use a gasifier—in which biomass is only partially combusted—to generate producer gas. Producer gas is composed of hydrogen, carbon monoxide, and carbon dioxide. It is another low heating-value gaseous fuel that can be used for high-temperature heating applications. All types of biomass, including rice husk and sawdust, can be used to generate producer gas. Although the cost of grid electricity operated by the government is the cheapest source of electricity, the electricity produced by gasifiers is cheaper than that produced by diesel generators (Table 14). Because grid electricity cannot provide 24-hour electricity, small-scale industries in Mandalay are using gasifiers instead of diesel generators to generate electricity. The model used in a private sugar mill in Mandalay is imported from India. The rice husk gasifier consumes nine baskets of rice husk per hour to generate 100 kilovolt-amperes of electricity.

Table 14: Comparison of Cost of Electricity from Different Sources

(kyats per hour)

Source of Electricity	Kyats per Hour
Diesel generator	15,000 ($13.33)
Rice husk gasifier	7,000 ($6.22)
Grid electricity (EPC*)	2,500 ($2.22)

* Electric Power Corporation.
Source: Interview with private entrepreneur.

C. Justification of Biofuel as an Alternative Energy Source

Modern energy services are an essential element of developing the enabling conditions that can allow a country to meet the Millennium Development Goals. Myanmar still needs a large amount of energy to supply energy for its growing population and to meet the needs of its expanding vehicle fleet. A substitute for fossil fuel needs to be developed to meet this demand. In addition, the Government of Myanmar needs to (i) strengthen oil exploration and extraction, and increase the capacity of refineries; (ii) raise the share of natural gas for power generation and transport; and (iii) develop clean coal technology as an option to generate energy. The development ofment of some of the these non-renewable sources of energy is costly and requires huge investment.

Renewable energy sources offer some of the most promising means of fuel diversification. These include small hydro, biomass, wind, solar, geothermal sources, and biofuels. These options are becoming increasingly viable. The technology is developing fast, and in many contexts small-scale renewable energy is now the cheapest option for the poor (Figure 16). Renewable energy technologies are already being used to provide power to electrical grids. Most of this is supplied by large hydropower systems, but increasingly Myanmar is considering small hydropower installations and wind energy.

The other main source for grid electricity is biomass, using agricultural wastes, such as bagasse[16], rice husk, and wood wastes. The national grid does not, however, always extend to the poor in the more remote areas, who typically have to rely on gasoline- or diesel-powered generators for electricity.

Figure 16: Rural Electrification with Solar Power

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Source: Myanmar Engineers Society, 2008

Another important renewable option is the use of biofuels—either bioethanol, derived from maize or sugarcane, or biodiesel from refined vegetable oils, such as rapeseed,

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[16] The term ‘bagasse” is a kind of sugarcane stalk after pressing in the roller

soy, palm, and coconut. One of the newer feedstock options for biodiesel is *Jatropha curcas*, a fast-growing, drought-resistant perennial. Pilot studies show it has a high oil content and can be burned in a simple diesel engine without being refined. However, the economic viability and the ecological, environmental, and social impacts of jatropha need to be assessed as experience of cultivating this plant for commercial use has been limited. Some biofuels are already competitive with petroleum-based products. Others can compete only with the help of subsidies, though with improved technologies and economies of scale, prices generally are coming down.

The development of biofuels can result in significant savings in foreign exchange due to lower fossil fuel imports, hence it is expected to provide significant welfare gains to society. The creation of a biofuel market will also result in added costs such as the investment cost of biodiesel and ethanol plants, the cost of developing feedstocks, and the costs of hauling and delivery. Biofuel development will have repercussions on the main sources for ethanol and biodiesel production: sugar and jatropha. Increased demand for these feedstocks is expected to lead to a rise production.

D. Obstacles to Development of Biofuels in Myanmar

Myanmar is in the process of evaluating the costs and benefits of biofuel development. Given that Myanmar will require energy sources to meet the demand of its growing population, biofuels represent a clean alternative with many possible benefits. The main market obstacles to the development of biofuels include:

(i) a lack of awareness about biofuels in the mainstream market;
(ii) the lack of specific knowledge about biofuel as a fuel for heat, power, and transport;
(iii) its status as an unknown product;
(iv) a lack of consolidated demand;
(v) limited availability of feedstock;
(vi) high price relative to other fuel;
(vii) the absence of buyback arrangements from any company to procure biodiesel crops since these crops do not have any other market value;
(viii) the lack of a minimum support price for the biodiesel crops;

(ix) the limited research into biodiesel crop varieties in the country to identify high-yielding varieties suited to the agro-climatic zones of the country;.

(x) the lack of training or workshop to create awareness among farmers and the alcohol industry about the alternative substrates and their economic importance; and

(xi) The need to provide capital subsidies to processing industries, subsidized interest rates to set up biofuel plant, and tax concession for biodiesel producers.

The keys to a stronger biofuel market are the provision of a guaranteed demand, the promotion of competition between suppliers; the establishment of more points of distribution; and the granting of fuel tax exemptions.

III. BIOFUEL CHARACTERIZATION

A. Energy Security and Sustainability

Myanmar possesses modest reserves of fossil fuel energy and a relatively large renewable energy resource endowment (Table 6). The development of wind and solar energy is still at an early stage. Data on wind energy sources are insufficient to enable the evaluation of suitable sites for the construction of wind turbines. Moreover, initial investment to tap such energy sources is exceedingly high. Hydroelectricity exploitation requires huge initial investment, yet due to the government's commitment, its contribution now reaches 10.35of total power generation.

The production of petroleum matches consumption in any given year, but diesel production falls short of distribution by about four to five times in most years Table 9. The Ministry of Energy projected the use of both petroleum and diesel in its 20-year plan. It is estimated in 2006-07 that the petroleum demand will double by 2010and quadruple by 2030. This projection may be very conservative if the rate of industrialization increases. Of the additional energy resources to be explored, the most important options are the renewable energy resources, including biomass.

B. Scope of the Biofuel Option

Biofuel resources can be divided into three categories:

(i) **crop resources**, including sugar- and starch-based crops, such as sugarcane, sweet sorghum, cassava, palm jaggery (obtained from palmyra tree, *Borassus flabellifer* L.), maize, switch grass, rice, and wheat, and oil-bearing crops, such as palm oil, coconut, jatropha, rapeseeds, and groundnut;

(ii) **unused biomass**, such as rice husk, straw, corn stover, corncob, biogases, coconut husks and shells, and palm oil fiber, including empty fruit bunch, sawdust, thinned wood, and wood waste;

(iii) **waste biomass**, such as animal dung, food waste (e.g., used cooking oil), peeling and scrap waste from the fruit and vegetable industry, waste paper from municipal waste, construction waste, pulp black liquor and sewage sludge.

In 2008 the Ministry of Energy submitted a draft statement to the government which states the type of biofuel that private entrepreneurs, state, and cooperative agencies can produce, procure, transfer, blend, and deliver[17]. The five types of biofuel are defined as follows:

(i) Bioethanol: a substitute for gasoline, produced from sugar- and starch-based crops, such as sugarcane and cassava.

(ii) Gasohol or Ethanol: a gasoline blend, referred to as anhydrous alcohol (at least 99.96%) blended with gasoline at a specified blended ratio.

(iii) Biodiesel: referred to as diesel fuel obtained from non-edible oil plant (jatropha, for example) and edible oilseed crops (such as palm oil, coconut, rapeseed and soybean) through a chemical reaction process.

(iv) Biodiesel blend: biodiesel blended with diesel at a specified blended ratio.

(v) Diesohol or Ethanol: a diesel blend obtained from mixing bioethanol and diesel.

C. Biodiesel Production

1. Crops for Biodiesel Production

Annual and perennial crops are oil palm (*Elaeis guineensis*), coconut (*Cocos nucifera*), jatropha or the physic nut (*Jatropha carcus*), castor (*Ricinus comminus* L.), neem seeds, thit-seit (*Bastard myrobalan*), Pongamia, Sie-tha-pyay (*Simerrula gluba*), Mese (Madhuca tree), rapeseed (*Brassica campestris* L. and other species), niger (*Guizotia abyssinica*), soybean (*Glyxine max* L.), and safflower (*Carthamus tinctarius* L.). Jatropha will be reviewed in detail as this non-edible oil crop is a promising resource for the development of biofuels in Myanmar.

2. Jatropha

Domestic demand for edible vegetable oil is increasing, and 200,000 t of palm oil are imported every year for domestic consumption. Therefore the feedstock for biodiesel production in Myanmar must come from non-edible oil crops. Among the different bioenergy sources, jatropha is considered a priority crop. The country is actively pursuing the cultivation of jatropha and has made it a government priority. About 0.5 million ha (1.86 million acres) have been planted to jatropha, and the 3-year plan of

[17] Advisory Committee to the Ministry of Energy for Issues of Production, Procurement, Transfer, Delivery, and Marketing of Biofuels (2008)

2006 to 2008 calls for the expansion of jatropha over 3.4 million ha of land in all states and divisions of Myanmar.

For optimum production, jatropha requires between 900 and 1,200 millimeters (mm) of rainfall per year. It can, however, be grown in areas of low rainfall (600 mm per year) and in poor and degraded soils. Jatropha is easy to establish either from seeds or stem cutting, grows relatively quickly, and is hardy. It lends itself to cultivation in low fertility, marginal, degraded, fallow, or waste land, such as roadsides, railway tracks, and field borders, where it can form a boundary fence or live hedge.

Jatropha is not browsed by animals. Being rich in nitrogen, the seed cake is an excellent source of organic manure. Seed cakes are, however, poisonous to animals and should not be fed to livestock without detoxification. Jatropha trees reach maturity and start to bear fruit 4–5 years after planting. Furthermore the crop vegetativeis environmentally beneficial as it sequesters carbon, storing it in its woody tissues, and assists in the build-up of soil carbon.

The seeds of the jatropha tree can not only be processed into biodiesel, but also into press cake and glycerine. It can therefore meet a number of objectives, such as meeting domestic energy needs, including cooking and lighting; providing an additional source of household income and employment through the marketing of fuel, organic manure, animal feed, medicine, and an industrial raw material for soap and cosmetics; and protecting crops or pasturelands by serving as a windbreak. It could be produced under the Community Development For Improving the Living Conditions of the Rural People.

Biodiesel is being processed under a pilot project run by the research team of Myanmar Industrial Crops Development Enterprise (MICDE), Ministry of Agriculture and Irrigation (MOAI), in Yangon. The output capacity of the pilot plant is 100 gallons of biodiesel per day. Parallel attempts to fabricate prototype or model pilot biosiesel pants are being carried out at the Myanmar Agriculture Service (MAS), the MOAI and the Ministry of Industry No.2, and the Ministry of Science and Technology, and the Ministry of Energy.

The oil content of the jatropha cultivars was found to vary from 26% to 41% (Table 15). Genotypes with a high seed yield, high harvest index, high oil content, and resistance to pests and diseases need to be sought. The economic yield is expected to be obtained starting in the 5th year (Table 16). Based on seed yield of 1,000–1,200 kg per acre, processed seeds could yield 50–60 gallons of oil per acre.

The government's drive to increase biodiesel production from jatropha under the direction of the regional commanders was so forceful and extensive that the cultivated area of the crop increased to more than 1.8 million acres within 4 years of the campaign's initiation[18]. To avoid possible conflict with the expansion of food crops, jatropha cultivation has been restricted to roadsides, farm boundaries, and all possible perimeters of villages and towns[19]. The rapid area extension has led to high demand for seeds for new planting areas. There is no surplus generation of seeds for processing into biodiesel.

.

Table 155: Oil Content of Jatropha Seeds from Various Locations throughout Myanmar, 2006–2007

(%)

Location	Oil Content (%)
Kayah	41.25
Shan (south), Banyin	39.59
Mandalay, Pyawbwe	39.46
India	36.95
Kayin (Thai var:)	36.12
Shan (south), Namlatt	35.06
Shan (north)	34.80
Sagaing (Monywa)	34.05
Sagaing	33.95
Magway	33.90
Big-M	32.82
Bago	31.04
Shan (east)	29.90
Ayeyarwady (Kyankhin)	27.10
Yakhine (Myaypon)	27.06
Sagaing (Tamu)	26.08

Source: Department of Agricultural Research.

[18] Myanmar Farms Enterprise had initiated jatropha cultivation in 2005

[19] The reported figures of jatropha cultivated area were thought to be calculated in terms of prescribed number of plants per acre. The standard plant population is 1,200 plants per acre

Table 166: Onset of Productive Years and Oil Yield of Jatropha

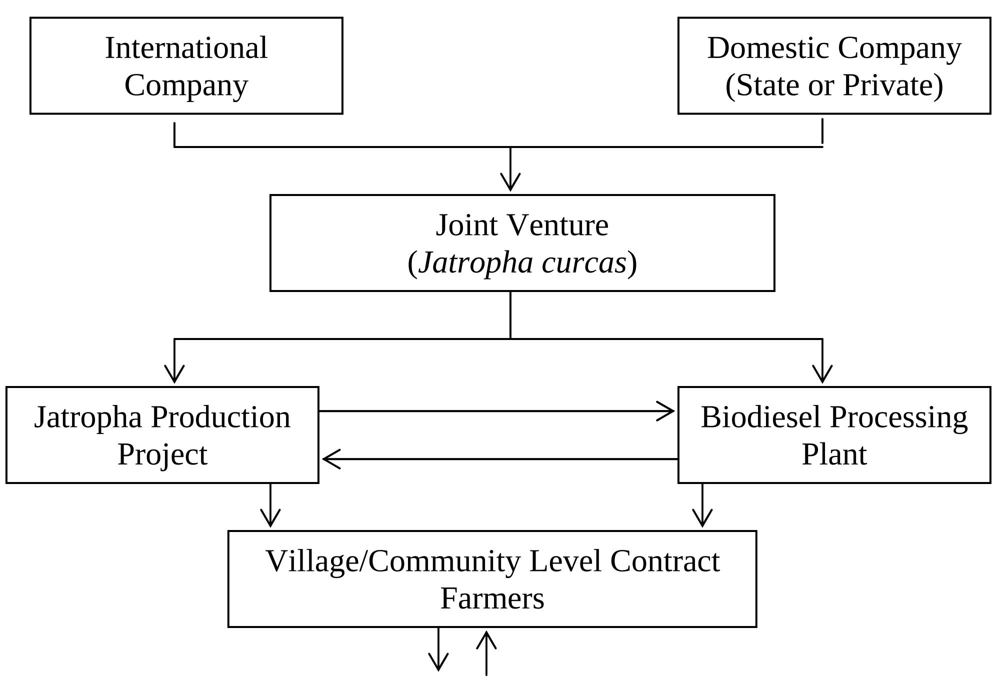
Plant Age (Years)	Seed Yield (Kg/acre)	Oil Yield (Gallons/acre)
1–2	32	1.6
2–3	280	14
3–4	600	29
4–5	4,800	40
5–onward	1,000–1,200	50–60

Source: Myanmar Industrial Crops Development Enterprise, Ministry of Agriculture and Irrigation.

The actual consolidated measurable planted acreage is estimated by some authority to be not more than 30,000 acres in the whole country.

The government's drive to expand the area planted to jatropha has focused on both community-level and large-scale production business; however the place of development for commercial processing, marketing and utilization has been slow. Three or four prominent companies have established jatropha plantations. In order to accelerate the process, the partnership program shown in Figure 17 is proposed to carry out joint-venture contract farming projects.

Figure 37: Joint Venture Contract Farming Project: Multi-Partner Model



Individual Contract Farmers

3. Other Crops for Biodiesel Production

Another source of non-edible, oil-based feedstock for biodiesel production is rubber seed, which contains up to 26% oil. Seed production per acre of rubber plantation at a specified age needs to be assessed. Leaving aside the seed requirement for replanting purposes, the seeds from existing rubber plantations could provide the basis for biodiesel production.

Under current conditions, edible oils are unlikely to become a source of feedstock for the biofuels industry in Myanmar, as the edible oil supply is always insufficient to meet demand. Although area extension of oil palm was started 8 years from the commence of the program in 2001 to 2002, the price of crude oil palm still shows an upward trend. The domestic price is about five times higher than the world price. In 2003 the domestic retail price of palm oil was MK1,000,000 per ton ($1,032). At this price level, the feasibility of diverting palm oil for the production of biodiesel is extremely low.

4. Sown Area and Production of Oilseed Crops in Myanmar

Oil crops constitute about 16% of the total crop sown area (28.98 million ha) in Myanmar, and cereal crops—mainly rice—occupy 40% of the crop sown area. In FY2007, of the 3,089,260 ha area sown to oil crops, sesame accounted for 47%, groundnut 25%, and sunflower[20] 10% . The production of groundnut increased at 7% per annum between FY1996 and FY2006, and sesame production increased by 10% per annum during the same period[21] . Sunflower and soybean production increased at an average rate of 11% per year, and palm oil production grew at 76% per annum, increasing from 5,000 t in FY1996 to 49,000 t in FY2007. In FY2007, the domestic oil supply (including rice bran and cotton oil) was estimated to be 302,051 t. The estimates of edible oil supply in FY2007 by an OPEC[22] Project (OPEC funded “Oil Seed Crops Development Project in Myanmar”, MAS, 2007-2008) has been made, taking into account the percentages of losses, seed requirement, snack and other uses,

[20] Department of Agricultural Planning 2007

[21] Department of Agricultural Planning 2007

[22] Organization of Petroleum Exporting Countries

seed export, percentages of oil extraction and oil cakes. The study excludes the informal import and export data of oilseeds.

5. Supply–Demand Balance Analysis of Edible Oil in Myanmar

The agriculture policy objectives of Myanmar, especially for the major crops (rice and oil crops), are to produce surplus in rice and to achieve self-sufficiency in oil crops. These crops are the national crops as the household budget expenditure is mainly used in rice (about 16% of total budget) and edible oil (about 8% of total budget). In order to maintain the stability of food prices in the country, Myanmar has adopted restrictive policies on the import and export of rice and oilseeds by the private sector. However, large quantities of palm oil are imported annually to cover the shortfall in supply of edible oils. Palm oil is important for the majority of low-income consumers because it is usually mixed with other edible oils (such as groundnut, sesame) and sold at an affordable price. Despite long-term effort for self-sufficiency in edible oil, it is still a deficit commodity in Myanmar.

The Food and Agriculture Organization of the United Nations (FAO) (2006, p. 203) calculated a 3-year (2001–2003) average food balance for edible oil in Myanmar, and estimated the self-sufficiency ratio to be 65% (Table 17).

Table 17: Food Balance of Edible Oil, 2001–2003

(thousand tons)

Production	(-) Export	(+) Import	(-) Other Uses	For Consumption	Self-sufficiency
527	11	264	394	386	65%

Source: Food and Agriculture Organization of the United Nations (FAO), 2007 calculated by FAO contractor (Dr Dolly Kyaw, Assistant Professor, Yezin Agricultural University)

According to the estimates conducted under an edible oil project[23] by the Myanmar Agriculture Service, the balance sheet of edible oil demand and supply calculated for the FY2007 yields a self-sufficiency ratio of 47%, and a ratio of 52% for FY2008 and FY2009.

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[23] Dolly Kyaw (2008). Feasibility study for multi-oil crops processing plant at Mandalay and CPO complex at Kawthaung. Oil crops Development Project, FAO, Yangon. FAO/TCP/MYA/2904, OPEC-MAS

D. Bioethanol Production

Encouraging results are noted in research and development and the pioneering work of bioethanol entrepreneurs. Alcohol distillation technology is well established in Myanmar. Several participants are entering the sugar production business and the resultant surplus sugar output is being diverted to bioethanol production. Feedstocks for bioethanol production include sugarcane, maize, cassava, potato, sweet potato, yam, and sweet sorghum.

1. Sugarcane: Meeting the Dual Purpose of Food and Fuel

Sugarcane production is being expanded primarily by horizontal expansion. Sugar production increased remarkably after FY1998, following its emergence from import substitution and shift to export-oriented production,. New participants joined the industry while the domestic sugar price was highly attractive; but in 2006, with the fall in the domestic sugar price from MK800 per kg to MK430 per kg, producers accumulated stockpiles. The declining sugar price may become an opportunity for diversion of the crop to ethanol production.

In 2000, the Myanmar Sugarcane Enterprise (now the Sugarcane Development Department) set up the first gasohol plant in the country, with a capacity of 500 gallons of 99.5% ethanol per day. It was too early to start production as there was no market for the factory's output. At that time, the government-controlled price of gasoline was MK1,500 per gallon. The production cost of gasohol at the factory was MK3,000—equal to the black market price. Accordingly, there was little demand for the factory's product. Subsequently, this gasohol plant was converted into a business that produces beverage alcohol. This occurred before the time of renewed interest in bioethanol.

Table 18 indicates the production of sugar in Myanmar. In recent years, overproduction has caused a sugar surplus. The emergence of two standard sugar mills in the private sector had led to production in excess of domestic consumption. Direct consumption of sugar appeared to reach saturation point. This is an indication that sugarcane could be diverted to producing bio-ethanol. A regulatory mechanism could be exercised to compromise sugar with bioethanol in order to avoid conflict with food security. At a certain level, production of bioethanol from sugarcane will not conflict with food security.

Table 18: Estimated Balance of Sugar Stock at End of Fiscal Year 2008

(million tons)

Sugar Producer	Production	Sale	Balance
Ministry of Agriculture and Irrigation	28,316	4,198	24,118
Myanmar Economic Corporation	40,972	18,727	22,245
Union of Myanmar Economic Holdings	15,000	4,000	11,000
Ministry of Industry No.1	Self-used	—	—
Private (Estimated)	120,000	60,000	60,000
Total	**204,288**	**86,925**	**117,363**

Source: Sugarcane Development Department, Myanmar Industrial Crops Development Enterprise.

The Myanmar Economic Corporation (MEC)—a military-based commercial entity—established two large bioethanol plants with a total capacity of 1.8 million gallons per annum of sugarcane-based anhydrous ethanol. Commercial production, distribution, and use commenced in April 2008. The Great Wall company—a large private company—is completing the establishment of a factory with a capacity of 3,700 gallons of sugarcane-based anhydrous alcohol per day. Another new factory will be constructed by Shwe Li Energy Company in Katha township.

Regional commanders are assigning degraded forestlands and arable lands to private entrepreneurs and army camps for bioethanol production. In some cases the land has been cleared and factories are under construction. The primary feedstocks selected are sugarcane, maize, sweet sorghum, and cassava. There is room for further extension of arable lands. On the equipment supply side, Myanmar Chemical engineering group in local entrepreneurs started designing, fabricating in manufacturing bio-ethnol plants in gasifiers. The technology is based on the method of azeotrophic distillation. Some entrepreneurs employ the molecular sieve method. The German company, Fritz Werner, offered bioethanol plants with state-of-the-art technology but at a high price. The present technology is in its infancy.

The area under sugarcane cultivation in FY2007 was estimated at almost 240,000 acres (97,560 ha), and cane production was about 5 million t per annum. Based on these figures, the amount of molasses by-products available from both large factories and small and medium-sized sugar plants was 122,500 t. If one third of the molasses were converted into bioethanol, about 1.65 million gallons of 95.5% ethanol would be produced. But the actual production from large-scale factories would not be more than 50,000 t of molasses because capacity is under-utilized in most sugar factories. Recently, private companies had established bio-ethnol plant by annexing with the existing sugar factories in the same compound.

If the sugarcane pricing system could be improved with equity ratio in favor of sugarcane growers, and if the government could formulate and lay down an appropriate sugar policy and sugarcane act, the cane supply could be increased; and molasses-based ethanol production could increase to reach the potential capacity of the aging sugar factories.

The existing bioethanol plants operated by the Great Wall company and military-based companies could produce 2.3 million gallons of bioethanol using molasses as the feedstock. No additional cane area is required. Nevertheless, private entrepreneurs are now opening up the assigned lands, mostly in Mandalay and Sagaing Divisions. Even if these lands are brought under cultivation, bioethanol will be produced from crops grown on newly opened land. Therefore, conflict between food security and energy security would be avoided.

In a proposal submitted to the Ministry of Energy for the formulation of bioethanol price, sugar was equated to ethanol based on the current sugar price and the conversion standard of sugar and bioethanol from cane. The suggested sugar-to-ethanol conversion rate is 90 kg sugar = 60 liters of bioethanol, (or 55 viss of sugar = 14.25 gallon of ethanol in the local units of measurement).

In this proposal, 10 factors that could affect price of bioethanol were identified:

(i) the government-controlled price for gasohol (currently 2,500 kyats per gallon) (approximately 1,100 kyats per US$);

(ii) the market price (petroleum outlet from the government gas stations are sold in the informal market) of gasoline of 3,500 kyats per gallon;

(iii) the raw food price of competition crops (e.g., the use of maize for animal feed and biofuel);

(iv) the equity ratio between miller and grower for producing feedstock;

(v) the technological level of crops and conversion ratio of feed stock to bio-ethnol;

(vi) Anhydrous level of bioethanol 95.5%, 99.9%;

(vii) the blending ratio (e.g., E 20, E 25);

(viii) non-price factors, such as infrastructure, electricity, and fuel feedstock;

(ix) user acceptance of the new product; and

(x) the retaill price of beverage alcohol.

There are other routes, besides molasses, for bioethanol production from sugarcane. Sugarcane can be crushed and the cane juice converted into ethanol directly. The conversion rate is about 14.25 gallons anhydrous alcohol per ton of sugarcane. If sugarcane processing is directed to the production of both sugar and ethanol, the primary juice (first expressed juice) from the mill could be processed into sugar, while the second and third expressed juice and some of the molasses could be processed into bioethanol.

Bagasse output as by-product of sugarcane processing is about 250 kg (50% moisture) per ton of cane. The gross calorific value is 4,600 kilocalories per kg. A rapid assessment of cogeneration potential[24], which has been made for all existing large sugar factories, is as follows:

Cogeneration potential assessment

1. Installed capacity of 17 sugar factories = 27100 TCD
2. Potential crushed cane per year = 4.336 million t
3. Potential steam generation = 732,784 mt
   (1 kg of burned bagasse 1,000 kg cane produced 260 kg bagasse fiber) = 5 kg production of steam
4. Potential electrical power output = 38,567 GWh
   (steam 19 kg per hour = 1 kW)

Cogeneration actual assessment based on present cane crushing

5. Actual sugarcane crushed = 1,071,241 t
   (in 2006–2007)

[24] Co-organization is referred to systems sequentially generating electrical power and thermal energy

6. Actual output steam = 181,040 t
7. Actual electrical power output = 9,528 GWh
   (steam 19 kg per hour = 1 KW)
8. Potential excess electrical power = 29,039 GWh

The large discrepancy in cogeneration is primarily attributed to the amount of available cane to be crushed. If the present declining boiler efficiency is considered, there will be a large power gap. The industry needs to be strengthened to improve the energy input–output system. Myanmar's sugar industry is small compared other countries, thus sugarcane can offer one energy source, and the country needs to rely on multiple feedstocks.

Current activity in the bioethanol industry is dominated by companies and large-scale entrepreneurs; however since this is a new industry early access should be made available to small growers at the community level. A scheme for community-level production of bioethanol has been proposed by Sein Thaung Oo of the Myanma Engineering Association[25]. The area of sugarcane required to produce a specified level of bioethanol has been computed and an ethanol plant of appropriate capacity has been designed and fabricated for custom-made, small-scale production (Table 19).

If sugarcane is directly processed into bioethanol, the conversion ratio at the present state is about 14.25 gallons of anhydrous ethanol per ton of sugarcane.

Table 19: Required Planting area for Sugarcane for Desired Amount of Bioethanol that could be Produced at Community Level[26]

Particular	Bioethanol Production per Day (gallons)				
	100	**200**	**300**	**400**	**500**
Sugarcane requirement for bioethanol production per day (ton) (Ethanol production rate per 1 ton of cane stalk is 8 gallons)	12.5	25.0	37.5	50.0	62.50
Sugarcane requirement for syrup production per day (ton) (100 kg [0.1 ton] of syrup per 1 ton of cane)	21.3	42.6	63.9	85.2	106.5
Total cane requirement per day (ton)	**33.8**	**67.6**	**101.4**	**135.2**	**169**
Syrup requirement for bioethanol production per day (ton)	2.13	4.26	6.39	8.52	10.65
Total syrup production (ton)	383.4	766.8	1150.2	1533.6	1917

[25] Myanmar Chemical Engineering Group

[26] The table is modified from the proposal of Sein Thaung Oo (2007).Practical experience on bio-ethanol production. Myanmar Chemical Engineering Group, Yangon

Sugarcane area requirement for 1 day production (acre) (Cane yield = 20 tons/acre)	1.69	3.38	5.07	6.76	8.45
Sugarcane area requirement for 1 year production (acre)	**202.8**	**405.6**	**608.4**	**811.2**	**1014**

The processing methods are application of azeotrophic distillation using cyclohexane. The method could be found in gasohol plants of Myanmar Sugarcane Enterprise (now reformed as Sugarcane Development Department) and Taungzinaye Plant under Myanmar Economic Corporation. Some entrepreneurs use molecular sieve technology in producing anhydrous alcohol.

2. Ethanol from Rice By-Product

Rice is grown almost everywhere in Myanmar. Broken rice—a by-product of rice milling—offers a good source of feedstock for bioethanol production at the current conversion rate of 87 gallons bioethanol per ton of broken rice. The total output of broken rice in FY2006 was 2,350,615 t. It is customarily used as animal feed. About 623,000 t of broken rice were sold during FY2003[27]. Unrecorded data from informal channels indicates that 1.00 million t of broken rice was allotted to animal feeds and a further 1.35 million tons was used for the production of beverage alcohol and as an input for other traditional rice-based food delicacies. Of this amount, 0.5 million t of broken rice could be diverted to produce 43.5 million gallons of bioethanol per year.

Paddy rice is the political crop or national crop in Myanmar, and the rice trade is a sensitive issue. Rice and its by-products must be used for food; hence only broken rice may be processed into beverage alcohol. The government tightly monitors rice use and restricts its transfer (including broken rice) from rice-producing areas to deficit areas. Furthermore, the cost of moving bulky feedstock is high and would add to the cost of bioethanol production. For this reason most of the beverage alcohol plants are situated near the rice producing belt. The processing of broken rice to bioethanol awaits a definitive pronouncement from the government.

3. Ethanol from Maize

Maize is another potential feedstock for bioethanol. Myanmar's total maize production in FY2007 was around 1 million t (Table 20). A significant increase in maize production

[27] Tin Htut Oo and Toshihiro KUDO. ed.2003. Agro-based Industry in Myanmar :Prospects and Challenges. Institute of Developing Economic, Japan External Trade Organization, Chiba, Japan, ASEPD No.67 (Please see Rice Industry Chapter and Feed Industry Chapter).

has been achieved through the introduction of high-yielding hybrid maize and the provision of financing for contract farming. According to a report from the Livestock Department, Ministry of Livestock Breeding and Fisheries, about 13,000 t of maize were used as livestock and poultry feed in FY2003. The livestock industry continues to expand and it is most likely that that the annual feed usage is much more than the amount reported. A portion of maize production is also exported (Table 21). The annual surplus of maize production is estimated at about 300,000 t. This amount could be diverted to fuel alcohol production. Using a rate of 70 gallons of ethanol per ton of maize feedstock, the expected bioethanol production from this volume of maize is 21 million gallons. If maize is cultivated close to the ethanol plants, the maize stover would be available as boiler feedstock. Although its efficiency is lower than sugarcane bagasse, maize stover could partially supply the fuel need to power the bioethanol plant.

Table 20: Maize Production by State and Division, FY2007
(tons)

State/Division	Production (t)	% of National Level
Kachin State	26,695.23	2.64
Kayah State	23,575.03	2.33
Kayin State	47,683.86	4.71
Chin Stae	66,538.62	6.58
Sagaing Division	206,280.63	20.39
Tanintharyi Division	0.00	0.00
Bago Division(East)	3,768.94	0.37
Bago Division (west)	1,809.64	0.18
Magway Division	104,018.61	10.28
Mandalay Division	51,578.11	5.10
Mon State	0.00	0.00
Yakhine State	61.16	0.01
Yangon Division	5.04	0.00
Southern Shan State	174,638.32	17.26
Northern Shan State	238,323.67	23.55
Eastern Shan State	29,462.39	2.91
Ayeyarwady Division	37,375.23	3.69
Total	**1,011,814.48**	**100.00**

Source: Settlement & land Record Department, Ministry of Agriculture and Irrigation, 2007

Table 21: Maize Exports
(tons)

Fiscal Year	Export	Fiscal Year	Export	Fiscal Year	Export
1997	102,540	2000	88,846	2003	219,000
1998	49,972	2001	148,000	2004	151,000

1999	174,375	2002	90,000	2005	255,000

Source: CSO 2000,2001,2002 Statistical Year Book. Central Statistical Organization, Ministry of National Planning and Economic Development, the Government of the Union of Myanmar..

4. Bioethanol Production from Sweet Sorghum

In the dry zone areas of Myanmar, sweet sorghum is also a promising new crop for bioethanol production. It was assessed at the Pyinmana Sugarcane Research Center, Taung-twin-gyi and Hmaw-bi Township in November 2007 (Table 22) An evaluation of sweet sorghum varieties developed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, showed that NTJ-2, E 36-1 and S-35 varieties possessed both high stalk yield and high sugar content. The variety NTJ-2 would perform well in both wet and dry seasons. The varieties from the United States- M 81E and Della showed good stalk yield and high sugar content (Table 22).

Table 22: Quantitative and Qualitative Evaluation of Exotic Sweet Sorghum Varieties at Pyinmana, Taungdwingyi and Hmawbi in Nov 2007[28]

Sr	Name of varieties	Pyinmana (19–28 Nov 2007)					
		Yield		Qualitative Characters			
		Stalk Stripped (ton/acre)	Seed (kg/acre)	Brix (%)	Pol (%)	Purity (%)	Total sugar (%)
	Sweet Sorghum						
1	M 81E	15.88	1,738	13.49	5.94	43.86	8.81
2	Della	10.1	1,750	14.3	6.91	48.16	9.32
3	NTJ -2	14.57	1,731	13.15	4096	37.82	8.07
4	E 36-1	14.6	1,156	13.61	7.17	52.68	9.07
5	S-35	14	1,280	13.8	7.41	53.7	8.88
6	ICSR 93034	13.4	816	10.49	4.51	43.4	5.78
7	ICSR 93091	15.6	880	11.59	5.48	46.39	6.68
8	ICSV 93046	9.9	865	10.45	4.76	45.47	6.02
9	ICSV 700	9.6	764	13.2	5.69	43.14	7.42
10	SPV 1411	10.89	1,279	13.79	7.16	50.98	8.11
11	SPV 422	10.6	1,082	13.52	6.43	47.53	7.43
	Sugarcane						
	Guitang-11	20	—	19.15	16.19	84.56	17.68
	Taungdwingyi (15–30 Nov 2007)						
	NTJ -2	21.93	1,530				
	Hmawbi (1–15 Nov 07)						
	E 36-1	15.75	2,500				

[28] Pyinmana Sugarcane Research Center, Sugarcane Development Department, Pyinmana, Napyitaw. Research report.2007

The ratooning ability[29] of the two American varieties was found to be 5–7 t per acre (Table 23). Despite its low stalk yield, the ratoon plant gave enough seed yield for the next season's planting.

Table 23: Ratoon Productivity of Two American Varieties[30]

Particular	Unit	M 81 E	Della
Yield per acre			
Stripped stalk	ton	6.8	5.2
Seed	kg	491	382
Qualitative character			
Brix	%	15	16
Pol	%	6.3	6
Purity	%	42	37
Total sugar	%	9.11	9.71

The commercial test run to determine the feasibility of producing bioethanol from sweet sorghum yielded encouraging results (Table 24). All sweet sorghum varieties produced an alcohol outturn in the range of 5.3%–6.0% per ton stalk. This level could be increased with improved technology. If the juice extraction were increased from 40% to 60% (see Table 25 and Table 26), the ethanol outturn would be much improved.

Table 24: Laboratory Analysis of Fermentation Process Using Sweet Sorghum and Sugarcane as Feedstocks, Pyinmana, 2007[31]

Feedstock	Juice Extraction* %	Juice pH	Initial Brix %	Fermentation Duration (hr)	Final Brix[32] %	Alcohol Output %
Sweet sorghum						
M 81 E	28.5	5.5	13.2	48	5	6.3
Della	15	5.6	15.2	48	5	5.3
NTJ-2	26.22	5.5	14.5	48	7	6.83
Sugarcane						
Guitang-11	26.69	6.2	18.7	48	10	8.33

29 Regrowth from the stubble of the harvested sugarcane or sweet sorghum

30 Pyinmana Sugarcane Research Center, Sugarcane Development Department, Pyinmana, Napyitaw, research Report 2007

31 Footnote reference: Pyinmana Sugarcane Development Department, Pyinmana, Napyitaw. Research Report 2007

32 Initial brix is the brix (total soluble solids) in the expressed juice. Final brix is the brix content after the juice is fermented

***Juice extraction % is computed from the first juice extracted.

Table 25: Comparative Results of Distillation of Sweet Sorghum and Sugarcane by Pot Still Equipment

Particular	Sweet sorghum	Sugarcane
	NTJ-2	Guitang – 11
Stalk weight (kg)	4,500	290
Juice production Volume (liter)	1,502	120
Juice weight (kg)	1,260	117
Juice extraction (%)	28	40
Juice brix (%)	14.36	16.13
Initial brix (%)	10	10
Fermentation duration (hours)	44	44
Final brix (%)	6	5
50% Ethanol production (gal)	28.8	2.29
95% Ethanol production (gal)	15.15	1.21
95% Ethanol production (gal) per 1 ton of stalk	3.37	4.16

Source: Pyinmana Sugarcane Development Department, Pyinmana, Napyitaw. Research Report 2007

Table 26: Comparative Results of Distillation of Sweet Sorghum and Sugarcane by Mini Vacuum Pan Boiling and Distillation Plant in Pyinmana

Particular	Sweet Sorghum			Sugarcane
	M 81 E	Della	NTJ_-2	Guitang-11
Stalk weight (kg)	2785	560	277	900
Juice production volume (liter)	996	310	117	400
Juice weight (kg)	976	303	115	352
Extraction (%)	35.05	54.25	41.5	39.2
Juice brix (%)	14.25	16	13.5	16
Initial brix (%)	9.5	14	12	16
Fermentation time (hours)	48	48	60	48
Final brix (%)	6	7	5	6
95% Ethanol production (liter)	40.7	17.5	4.75	19.3
95% Ethanol production (liter) rate per 1 ton of stalk	3.22	6.88	3.79	4.72

Source: Pyinmana Sugarcane Development Department, Pyinmana, Napyitaw. Research Report 2007

The detailed cost-benefit computation is shown in Table 27. Out of the net profit per acre of MK147,475, the farmer's share is calculated to be MK68,225 per acre and processor's share is MK43,900 per acre.

Table 27: Cost of Production of Bioethanol from Sweet Sorghum, 2007

Sr	Particular	Number	Rate (kyat)	Total Cost (kyat)
I	**<u>Income</u>**			
	Stalk yield per acre x 95% ethanol production per 1-ton of stalk 20 ton/acre x 5.05 gal per 1-ton x sale price, kyats/gallon	101	3,500	353,000
II	**<u>Cost</u>**			**206.025**
(a)	**Cost of cultivation per acre**			**120,775**
	Land preparation		15,200	
	Cultivation		3,800	
	Maintenance		6,200	
	Harvest cost		60,000	
	Input cost		35,575	
(b)	**Cost of bioethanol distillation**			**105,550**
	(i) Crushing	20	2,000	40,000
	(ii) Distillation	101	250	25,250
	(iii) Handling			2,000
III	**Net profit per acre**			**147,475**
IV	**Operating ratio**			**57.30**

E. Biomass Energy Consumption from Fuel Wood

The Forest Research Institute, Yezin conducted a survey in Yamethin District[33] to access the annual consumption and cost of wood fuel. The total annual quantity of wood fuel consumed by cottage industries (excluding food stalls and state-owned industries) in the study area was estimated at 9,179 t, and the cost was calculated to be MK11.5 million (Table 28). If wood fuel consumption of state-owned sugar mills is included, the amount wood fuel consumption was 18,418 t and the cost was MK21.0 million. The total production value of cottage industries was estimated to be MK588.8 million per year.

Wood fuel requirements vary for different types of industry. In order to compare the different requirements of the various industries, a cost analysis was made (Table 29). Variations in the cost of fuel used per unit value of each product were calculated. The

[33] Regional Wood Energy Development Program me in Asia. Report No.33,1997, The National Training Workshop on Wood fuel Trade in Myanmar, Forest Research Institute, Yezin,1996

results showed that the lime industry had the highest fuel costs in proportion to value produced (45.5%). When a comparison was made of the types of biomas fuels used by the sugar industry, those using plum kernels as a biomas fuel were found to have lower fuel costs (0.7%) than those using wood fuel (1.1%). Bamboo, was found to be a cheaper biomass fuel (1.1%) than wood fuel (1.8%) in two different milk industries. Thus, it was evident that wood fuel was more expensive than other biomass fuels.

Table 28: Total Annual Consumption and Cost of Wood Fuel by Cottage Industries in Yamethin District with Corresponding Production Values

Industry	Wood Fuel Consumption (ton)	Cost of Wood Fuel (kyat)	Total Production	Units	Production Value (Kyat x 1000)	Remark
Lime	4,122.4	3,508,657	2,805	ton	7,714	
Sugar	3,411.4	5,757,557	6,455	ton	457,858	
			3,277	ton	60,235	Molasses
Condensed milk	533.3	899,998	252,000	viss[34]	504,000	
Alcohol	355.5	599,999	216,000	bottle	7,128	
					70	Either
Brick	636.0	665,905	1,925,000	piece	3,766	
Ceramic	80.0	75,758		piece	300	Production N.A
Cook stove	40.0	37,879	8,000		800	
Total	**9,178.5**	**11,545,753**			**588,271**	
State Sugar Mill (1)	6,600.0	6,749,952	12,600	ton	893,278	
			7,200	ton	4,352	Molasses
State Sugar Mill (2)	2,640.0	2,699,981	15,000	ton		Supplemented with FO
Total	**9,240.0**	**9,889,933**				
Grand total	**18,418.5**	**20,995,686**				

Source :Ministry of Forestry

[34] Viss equals 1.63 kg.

Table 29: Comparison of the Fuel Costs of Different Types of Industry

Industry	Annual Production Value (kyat million)	Biomass Fuel Used	Unit Cost of Biomass Fuel (kyat)	Total Annual Cost of Fuel (kyat million)	Cost of Fuel as a Percentage of Value Produced
Lime	7.7	Wood	851.1/ton	3.51	45.5
Sugar (private)	518.1	Wood	1,687.8/ton	5.68	1.1
Sugar (state)	1,028.1	Wood	1,687.8/ton	6.75	0.7
Condensed milk	50.4	Wood	1,687.8/ton	0.90	1.8
Alcohol	7.1	Wood	1,687./ton	0.60	8.4
Brick	3.8	Wood	350.1/ton	0.67	17.7
Ceramic	0.3	Wood	947.0/ton	0.08	25.3
Cook stove	0.8	Wood	947.0/ton	0.04	4.8
Alcohol	51.8	Rice husk	75.0/cart	0.69	1.3
Sugar	131.5	Rice husk	75.0/cart	0.43	0.3
Evaporated milk	6.3	Bamboo	7,000.0/truck	0.07	1.1
Sugar (private)	24.6	Plum kernel	20.0/basket	0.18	0.7

Source :Ministry of Forestry

IV. PRIORITIZATION

A. Feedstock Priority for Biodiesel

In terms of oil yield per acre, oil palm has the highest potential, followed by coconut, avocado seed, macadamia nut, jatropha, rice bran oil, safflower, sesame, mustard, soybean, cotton seeds, and rapeseeds (Table 30). Biodiesel can be produced from high-yielding oil crops, such as oil palm, coconuts, rapeseeds, and non-edible crop such as jatropha, pongam, which may not compete with food crops in Myanmar.

The edible oil self-sufficiency ratio for Myanmar was estimated at 52.4% in FY2007 and 52.0% in FY2009. The edible oil deficit was 23,220 t in FY2007 and 23,100 t in FY2009. Although edible oil production from domestic oil palm increased by 25% from the level in FY2008 (in 2007 and 2008, production represents 8,400 t and 10,500 t, respectively), increasing demand has necessitated the importation of 230,000 t of palm oil annually. Consequently, palm oil is not an appropriate feedstock for biodiesel production in Myanmar.

Table 30: Oil Yield of Oil-Bearing Crops

(gallons/acre)

Sr.	Name of Crop	Latin Name	Oil Yield (gallons/acre)
1	Oil palm	*Elaeis guineensis*	610
2	Coconut	*Cocos nucifera*	276
3	Avocado	*Persea americana*	270
4	Macadamia nut	*Macadamia terniflora*	230
5	Jatropha	*Jatropha Curcas*	194
6	Castor bean	*Ricinus communis*	145
7	Rapeseed	*Brassica napus*	122
8	Opium poppy	*Papaver somniferum*	119
9	Peanut	*Ariachis hypogaea*	109
10	Sunflower	*Helianthus annus*	98
11	Tung oil tree	*Aleurites fordii*	96
12	Rice	*Oriza sativa* L.	85
13	Sesame	*Sesamum indicum*	71
14	Mustard	*Brassica alba*	59
15	Soybean	*Glycine max*	46
16	Cotton	*Gossypium hirsutum*	33
17	Kenaf	*Hibiscus cannabinus*	28
18	Rubber seed	*Hevea brasiliensis*	26
19	Cashew nut	*Anacardium occidentale*	18
20	Maize	*Zea mays*	18

Remarks: 1 gallon oil = 7.3 pounds.

Source: Adapted from Joshua Tickell, From the Fryer to the Fuel Tank: The Complete Guide to Using Vegetable Oil as an Alternative Fuel, 3rd Ed. 2000.

Coconut

Coconut production (raw coconut fruit) in Myanmar increased by 4.5% from 1.243 t in FY2008 to 1.299 t in FY2009. Some copra is exported, but most is retained for domestic use. If the technology for biodiesel processing were available, coconut might be second in priority—after jatropha—for biodiesel production in Myanmar.

Cotton Seed

Cotton is grown mainly along the Ayeyarwaddy River in the central dry zone. The total area planted to cotton averaged about 325,000 ha[35];. Cotton seeds contain about 22% oil and the residual cake contains about 27% protein. Cotton seed—the by-product of the ginning process—makes a significant contribution to the stocks of oilseed that are crushed for oil and protein meal. However, the oil yield is only 33 gallons/acre, so it may not compete with oil palm and jatropha. in 2008In 2008, the cotton seed surplus after seed utilization for cultivation comprises about 180,000 t, most of which are crushed and used for edible oil, particularly for deep frying. Domestic demand for this long-lasting frying oil is high, so it too may not be available for biodiesel production in Myanmar.

Jathropa

Jatropha ranks fifth among oil-bearing crops in terms of oil production at 194 gallons per acre (Table 30). The use of jatropha as priority feedstock has a number of clear advantages: it can be grown in different ecological areas and under different soil conditions; it can be cultivated up to 5,000 feet of altitude; it can easily be propagated; seed crushing and oil extraction are not complicated since this can be done with simple expeller; processing biodiesel from the seed can be easily done by using the transesterification method; and the biodiesel produced can be easily blended with fossil diesel.

Jatropha is currently cultivated in various states and divisions, primarily in the dry zone areas. A large area of jathropa cultivation is found in the southern Shan states. Further expansion of jathropa can occur in other marginal areas of the country, especially in the Magwe Division, and upper part of Bago Division[36].

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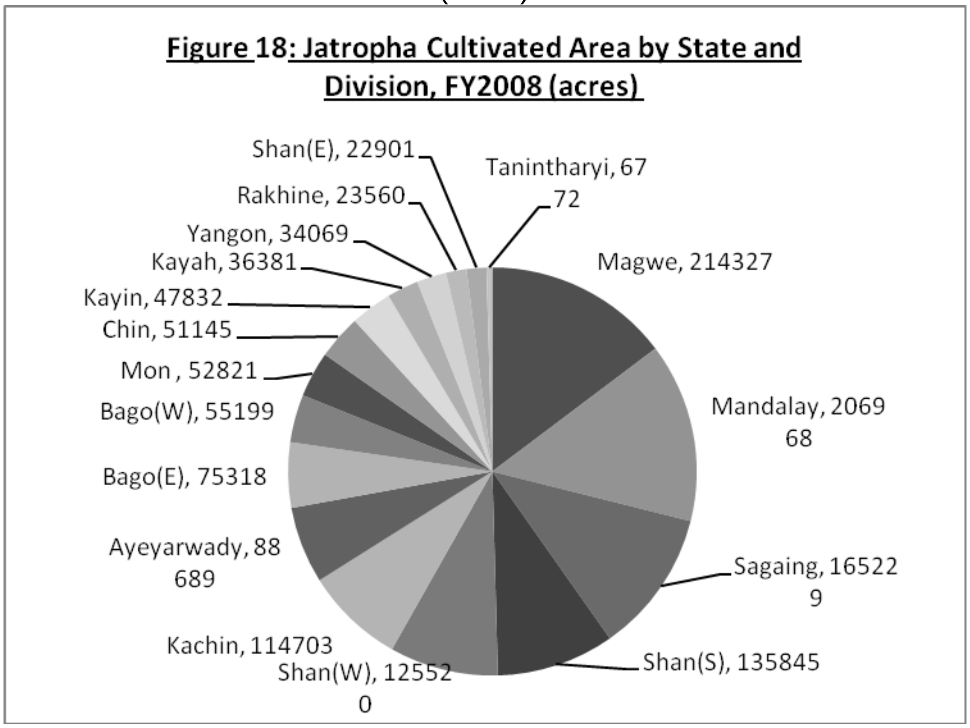
[35] Averaged for last 5 years

[36] as suggested by the Department of Agricultural Research, MOAI

Figure 18 Jatropha Cultivated Area by State and Division, FY 2008 (acres)



Source: Department of Agricultural Planning.

Research findings from the Department of Agricultural Research show that the Taungngyu (Eastern Bago) land race has the highest oil content (as much as 46.41%) among the varieties grown in Myanmar. Land races from Magwe Division have an oil content of 32%–44%, Mandalay land races 23%–42%, and Southern Shan State land races 21%–41%. Among the exotic varieties, Thailand (D-2) has been found to have the highest oil content (43.40%). The 72 land races were planted in a field nursery, where characterization of each variety, including oil content and yield, is being carried out. The oil content of the different germplasms is given in Appendix I.

Pongam

Another potential oil-bearing crop, which is well-know and has shown promise in India, is pongam (*Pongamia pinnata) (Thin-win Phyue* in Myanmar language*)*. It can be grown in humid and subtropical environments, and thrives in areas with an annual rainfall ranging from 500 to 2,500 millimeters. Pongam can grow in most soil types ranging from stony to sandy to clay, including Vertisols. Highest growth rates are observed on well-drained soils with assured moisture. Natural reproduction is by seed or by root suckers. It is a medium-sized tree that generally attains a height of about 8 meters and a trunk diameter of more than 50 centimeters. The tree is generally short, with thick branches spreading into a dense hemispherical crown of dark green leaves. The leaves are eaten by cattle and readily consumed by goats. However, in many areas, it is not commonly eaten by farm animals. Its fodder value is greater in arid regions. The oil cake, which remains when oil is extracted from the seeds, is used as poultry feed. Oil yield of pongam is 25% of volume and this is obtained using a mechanical expeller; however, manually run crushers at the village level have an average yield of 20%. The oil can also be used as a lubricant, water-paint binder, pesticide, in soap-making and tanning industries. It can easily be processed into biodiesel using transesterification method for use as a substitute for fossil diesel.

Pongam can support the growth of other plants though its ability to fix nitrogen. It matures and bears fruit after 10 years. Pongam are already grown in several areas of Myanmar, such as the Ayeyarwaddy delta, the coastal areas and some parts of Mandalay, Sagaing and Bago divisions. Some of the areas planned to jatropha cultivation may be planted to pongam instead of, or intercropped with, jatropha.

B. Feedstock Priority for Bioethanol

Sugarcane, maize, cassava, potato, sweet potato, yam, and sweet sorghum are some of the promising energy-yielding crops for bioethanol production.

Sweet Sorghum

Sweet Sorghum is recommended by ICRISAT for cultivation in the countries of the Greater Mekong Subregion. Since all of the crops for bioethanol production are seasonal, it is important to keep feedstock available during off-season period. According to the work of the Department of Agricultural Research, feedstock can be made available year-round by concentrating either sweet sorghum juice or sugarcane juice during their respective season. It is appropriate to grow and harvest sweet sorghum during the off-season period of sugarcane production. Sweet sorghum could be introduced easily outside the sugarcane area following the existing farming system, particularly in the dry zone of Myanmar. Small growers at the community level could produce bioethanol from sweet sorghum. The planting area requirements of sweet sorghum are presented in Table 31.

Table 31: Requirement of Sweet Sorghum Planting Area

Particular	Bioethanol Production per Day (gallons)				
	100	**200**	**300**	**400**	**500**
Sweet sorghum requirement for bioethanol production/day, ton (Ethanol production rate per 1 ton of cane stalk is 5.05 gallons)	19.8	39.6	59.4	79.2	99.0
Sweet sorghum area requirement for 1 day production (stalk yield = 20 tons/acre)	1.0.	2.0	3.0	4.0	5.0
Sweet Sorghum area requirement for 1 year production (acre)	118.8	237.6	356.4	475.2	594.0

Source: Myanma Sugarcane Enterprise, Myanmar Industrial Crops Development Enterprise, 2008.

Comparison of Bioethanol Feedstocks

A comparison of feedstocks for bioethanol production is shown in Tables 32 and 33. In terms of land area requirement and input cost, sugarcane is found to be the most promising feedstock for bioethanol in Myanmar. However, potential feedstocks, such as sweet sorghum and cassava, will be introduced in the coming years for large-scale commercial production. Maize is used to produce many products, such as edible oil, corn powder, and corn-based products, by the Ministry of Industry at Taun-dwin-gyi Township of Magwe Division. In addition, demand for maize in the livestock sector is increasing, so it can not be considered a potential feedstock for bioethanol production in Myanmar. The export of this crop to China (Muse) and Thailand (Mesauk, Bayar-thone-su) is also increasing yearly. Similarly, demand for broken rice from the ever-growing livestock and aquaculture sectors is also increasing. Consequently, bioethanol production may not be a suitable option for Myanmar. by using feed-stocks, that may compete with animal feeds both domestic and requirements of neighboring countries.

Table 32: Crop Acreage Requirement for Production of 1 Million Gallons of Bioethanol

Feedstock	Crop or By-product Yield (ton/acre)	Bioethanol Productivity gallon/ton of feed stock	Bioethanol Productivity gallon/acre	Acreage Required for 1 million gallons of bioethanol
Sugarcane	20–25	14.25	285–356	3,509–2,809
Maize	1.75–2.50	70	123–175	8,130–5,714
Cassava(Tuber)	5	—	—	—
Cassava(Powder)	3	100	300	3,333
Sweet Sorghum	18	7	126	7,936
Paddy (broken rice)	0.113	87	9.8	102,041

Source: Myanma Sugarcane Enterprise, Myanmar Industrial Crops Development Enterprise, 2008.

Table 33: Cost of Feedstock Component for the Production of 1 Gallon of Bioethanol with Respect to Different Types of Feedstock (FY2008)

Feedstock	Bioethanol Outturn gallon/ton of feed stock	Market Prices of Raw Material ($) (2007–2008)		Cost of Feedstock Component in 1 Gallon of Ethanol ($)	
		Low	High	Low	High
Sugarcane (direct)	14.25	10.71	14.29	0.75	1.00
Sugarcane (by-product–molasses)	50	67.46	107.14	1.35	2.14
Maize	70	128.8	136.09	1.84	1.94
Cassava	100	79.37	198.41	0.79	2.00
Sweet Sorghum	7	—			
Paddy (broken rice)	87	150.63		1.73	

Source: Myanmar Sugarcane Enterprise, Myanmar Industrial Crops Development Enterprise, 2008.

V. AGRIBUSINESS MODELS IN PRACTICE

A. Existing Biofuel Business Model

Based on the findings under the rapid appraisal of the team, rural industries and the agribusiness model for biofuels in Myanmar could be categorized according to scale into

(i) community-based small-scale industries,

- For example, biogas projects in the villages, proto type jatropha crude oil processing machines which, with the improved R&D and learning carve with time, could possibly be applied as village level bio-diesel sources, small scale ethanol plants using sugarcane, cassava and corn etc. as feedstock, and bio-digesters (gasifiers) using rice husk and wood chips available easily in the villages. (see **Case 1**: Biogas, **Case 2**: Jatropha crude-oil processing machine, **Case 3**: Pilot ethanol plant)

(ii) small- and medium-scale industries, and

- Determined to be the ethanol plants crushing sugarcane, molasses and sugar syrup with the capacity (300-2000TCD) (Ethanol 3600-25,000 tons/year) studied in Northern Shan State and Sagaing Division. (see **Case 4**: SME ethanol plants). Gasifiers with the capacity of 100 KVA using rice husk and gasifier using wood chip with the capacity of 5 assorted generators (220-500 KVA) found in Mandalay Industrial Zone. (see **Case 5**: Gasifiers used in SMEs).

(iii) large-scale industries.

- Such as Great Wall Ethanol Factory and Shweli Swan In Factory (Ethanol 36,000 tons/year) in Sagaing Division and Shan State. (see **Case 6**: Large Scale Ethanol Plants).

B. Opportunities and Constraints to Biofuel Business Development

1. Legal Framework and Agribusiness Environment

In the decade that followed the introduction of a market-oriented economic system in 1988, 27 new business-related laws were promulgated and 9 existing laws were amended to encourage the development of private and state-owned enterprises. Prominent among them are the Union of Myanmar Foreign Investment Law (1988), the State Enterprises Law (1989), the Private Industrial Enterprise Law (1990), the Promotion of Cottage Industries Law (1991), and the Myanmar Citizens Investment Law (1994).

Prerequisite laws for small and medium-sized enterprises. A characteristic feature of the pattern of industry in Myanmar is the predominance of small-scale agro-based industries in general and food processing in particular. However, in order to encourage such small-scale agribusiness industries to be properly developed and, to enhance the spirit of entrepreneurship and competitiveness among them, the government still needs to develop pragmatic laws governing small and medium-sized enterprises.

Lack of special privileges for biofuel pioneers. At the time of writing, special privileges are yet to be considered for those engaged in the biofuel business. In Myanmar it is usual for incentives for the pioneer entrepreneurs to be awarded in a reactive rather than proactive manner. For example, the 36,000 ton per year ethanol plant in Sagaing Division was due to begin operations in March 2008, even though the permit from Myanmar Investment Commission (MIC) is yet to be released. Investors do not expect the incentives and support normally given to biofuel business in neighboring countries, such as China and Thailand (e.g., price support per ton of ethanol, classification as special interest business, free excise tax, free income tax for 8 years, and freedom from tariffs on imported equipment).[37]

New laws for foreign investors*.* According to officials from the MIC, there will be some modifications and improvement to foreign investment law in the future as it was enacted since 1988. The preparation of the draft Special Economic Zones Law (10th edition) is also under way.

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[37] Biofuel Policies and Future Direction in GMS by Dr. Nattapon Nattasombon, Deputy Director-General, Office of Industrial Economics, Ministry of Industry, Bangkok, Thailand, 28 February 2008.

Since 2007, foreign investors from China, Korea, Malaysia and Singapore, who are interested in investing in the biofuel business in Myanmar, have discussed with the Ministry of Agriculture and Irrigation (MOAI) the need to conduct initial feasibility studies. One company from Korea signed a memorandum of understanding with the MOAI to establish a center in Yangon for research and development into biofuel crops, such as jatropha, cassava, and sugarcane. This initial project is to be incorporated into a future project that envisages development of a large-scale biofuel plantation of 150,000 ha in Myanmar.[38]

2. Contract Farming, Cross-Border Linkages and Trading Environment

Local contract farming practice in the sugarcane and ethanol production business is well established in Myanmar. To promote domestic and cross-border trade in contract farming for the biofuel business, it is important to consider carefully the present trade and investment policies that are the sole facilitators of trade flows and for stakeholders involved in the biofuel market chains.

Trading environment. The Trade Council is responsible for the current trade policy. It is also the decision-making body for the granting of export and import permits . The Ministry of Commerce issues export and import permits based on the decision of the Trade Council. The subcommittees of the Trade Council—the Export Import Coordinating Committee (EICC) and Export Import Supervising Committee (EISC), organized by the Ministry of Commerce—check the export and import applications submitted by private and government organizations and recommend them to the Trade Council for approval. In general, the principal export policy is to allow a surplus beyond the domestic consumption level in order to maintain the stability of domestic prices.

Besides dealing with export and import matters, the Trade Council also handles the cases submitted by MIC relating to domestic and foreign investment. Special cases, such as tax incentives, use of large tract of land by an investor, and the importation of machinery and equipment for an investment project before and after MIC approval, are handled by the Trade Council.

[38] Trade & Investment Section, Department of Agricultural Planning, MOAI.

3. Cross-Border Trade and the Ayeyarwaddy-Chaophraya-Mekong Economics Cooperation Strategy

The Department of Border Trade, under the Ministry of Commerce, is tasked with the export-import affairs of 13 border posts set up at the borders between Myanmar and neighboring countries—Bangladesh, China, India, and Thailand.[39] China has the largest share of border trade with Myanmar compared to other neighboring countries.

Under the Ayeyarwady–Chaophraya–Mekong Economics Cooperation Strategy (ACMECS), which involves Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Viet Nam, and Thailand, Myanmar is responsible for the sectoral working group and is a coordinating country for agriculture and industrial cooperation among the members. Activities identified as common projects under the group's agricultural and industrial cooperation include a feasibility study on cooperation in agriculture, particularly cash crops, such as soybean, maize, coffee, beans, and livestock; contract farming in agricultural products, including biofuel crops; a feasibility study on the establishment of national accreditation boards, including the creation of verification centers; and cooperation between the standard bodies of group of countries.

Contract Farming under the Ayeyarwaddy-Chaophraya-Mekong Economic Cooperation Strategy (ACMECS). Among the common projects, a framework agreement for contract farming to be implemented between Myanmar and Thailand was approved by the Foreign Affairs Policy Committee of Myanmar in 2007, and negotiation between two countries is still under process. The framework agreement includes cooperation in the area of biofuel crops, such as jatropha, sugarcane, cassava, and soybean. Scenarios are summarized as follows and may be considered not only for Myanmar and Thailand, but also for other neighboring countries, such as Bangladesh, China, India, and Lao PDR, since the nature of their investment and trading environments do not differ greatly from those of Myanmar.

[39] Number of Border Trading Posts: China (5), Thailand (3), India (2), Bangladesh (1), Rakhine Coastal Post (1), Tanintharyi Coastal Post (1) (Source: Department of Border Trade, Ministry of Commerce)

Scenario 1. Cross-border contract farming under conventional trade: contract farming deals between the two parties are done under the present trade policy:

(i) Thai entrepreneurs stay in Thailand and make contractual deals with Myanmar entrepreneurs in Myanmar. Thai entrepreneurs have their ACMECS special privileges given by the Government of Thailand. Myanmar entrepreneurs do not have special privileges given by the Government of Myanmar.

(ii) Myanmar entrepreneurs then do contractual deals with Myanmar farmers who have their own land, or on the virgin land to be developed by Myanmar entrepreneurs.

(iii) Products of the contract farming, whether raw or processed, are exported to Thailand by Myanmar entrepreneurs according to the contract terms under the present trade policy, i.e. Myanmar exporters apply for export/import licenses through the Trade Council.

(iv) The Ministry of Agriculture and Cooperatives (MOAC) of Thailand and the MOAI of Myanmar of Myanmar act as focal ministries to coordinate and facilitate the arrangement.

Scenario 2. Cross-border contract farming under the MIC Law of Myanmar. Contract farming deals between the two parties are done under the Union of Myanmar Foreign Investment Law (1998):

(i) Thai entrepreneurs enter Myanmar and form a company under the MIC Law.

(ii) Thai entrepreneurs make contractual deals with either Myanmar entrepreneurs or Myanmar farmers who acquire the land and incentives provided under the MIC Law.

(iii) The products of contract farming, either raw or processed, are exported to Thailand by Thai entrepreneurs according to the contract terms under the present trade policy.

(iv) The MOAC of Thailand and the MOAI of Myanmar act as focal ministries to coordinate and facilitate the arrangement.

Scenario 3. Cross-border contract farming under the ACMECS Special Privileges of Myanmar (A): contract farming deals between the two parties are done under the ACMECS Special Privileges to be given by the Government of Myanmar.[42]

(i) Thai entrepreneurs enter Myanmar and form a company under the ACMECS Special Privileges to be given by Myanmar Government.

(ii) Thai entrepreneurs make contractual deals with Myanmar entrepreneurs. Myanmar entrepreneurs then make contractual deals with Myanmar farmers on the farmers' own land or on the virgin land to be developed by Myanmar entrepreneurs.

(iii) The products of contract farming, either raw or processed, are exported to Thailand by Thai entrepreneurs according to the contract terms under the ACMECS Special Privileges to be given by Myanmar Government.

(iv) MOAC of Thailand and MOAI of Myanmar act as focal ministries to coordinate and facilitate the arrangement.

Scenario 4. Cross-border contract farming under the ACMECS Special Privileges of Myanmar (B): contract farming deals between the two parties are done under the ACMECS Special Privileges to be given by the Government of Myanmar.

(i) Thai entrepreneurs enter into Myanmar and form a company under the ACMECS Special Privileges to be given by Myanmar government.

(ii) Thai entrepreneurs make contractual deals with Myanmar farmers on the farmers' own land or on the virgin land to be developed by Thai entrepreneurs.

(iii) Products of the contract farming, either raw or processed, are exported to Thailand by Thai entrepreneurs according to the contract terms under the ACMECS Special Privileges to be given by Myanmar Government.

(iv) The MOAC of Thailand and the MOAI of Myanmar act as focal ministries to coordinate and facilitate the arrangement.

. Due to the facts that special privileges to be given by Myanmar government to businessmen from both sides are still to be formulated by the government, the best

[42] ACMECS Special Privileges to be given by Myanmar" is imaginary (i.e. yet to be considered by the policy maker), which should be similar to those of Thailand.

possible option would be under the MIC Law for the time being or under the Special Economic Zones Law which is now under draft and to be adopted in the future.

C. Integration of Small Farmers into the Agribusiness Chain

1. Bioethanol Business

Because agribusiness depends heavily on agricultural raw material production, there is considerable scope for small farmers to be integrated into the production chain of community-based small-scale industries, and small-, medium-, and large-scale industries.

The integration of small farmers into bioethanol business is practiced in the sugarcane-based ethanol industries since the local factory owners erected their plants nearby sugarcane fields and have controlled over the supply of small farmers primarily because of their proximity. For example, in large-scale sugar and ethanol plants in Sagaing Division, farmers calculate whether or not to take the advance payment from the mill according to the terms and conditions of the contract for growing sugarcane (at 2% interest rate per month). In 2006, sugarcane farmers seemed satisfied with the contracted cane prices (MK18,000 per ton, paid by the mill, compared to the MK13,500 per ton paid to farmers in areas of government mills); however, falling domestic sugar prices spurred sugar mill owners and speculators to look for opportunities for export, which has been banned by the government previously. At the time of writing, a case-by-case initial permit for the export of 350 t of sugar (industrial white) was allowed to a private company. Nevertheless, rural small farmers can be easily integrated into the current agribusiness models in the biofuel market chain due to their well-established relationship with mill owners.

2. Biodiesel Business

The similar situation is not yet available in the biodiesel industry due to (i) the lack of research and development for both feedstock production and the commercial processing of jatropha oil; (ii) the lack of clustered plantations; and, most importantly, (iii) the lack of government support to create an environment to organize community-level enterprises, such as farmers' cooperatives or organizations. The formulation of a national biofuel development policy and regional biofuel development policies will need the following support from the government in order to promote and sustain both community-based biodiesel and bioethanol production and use initiatives:

(i) research and development on plantations and oil refining,

(ii) extension services for both feedstock production and oil processing,

(iii) subsidies and credit,

(iv) enabling policies to promote small business development,

(v) the formation of genuine cooperative societies at the community level,

(vi) market access and an enabling trade environment, and

(vii) policies to strengthen public-private sector partnership to help establish business initiatives.

D. Potential Options for Promoting Biofuel Business Ventures

The potential options for the promotion of biofuel businesses should consider both the perspective of small farmers in the rural community engaged in energy self-sufficiency (for example, through the introduction of community-level biogas plants or biodigesters), and the need to promote large-scale biofuel business ventures—such as large-scale ethanol plants—which are the only option that will meet the nation's fuel needs. The strategy, therefore, must be two-pronged, and the community-based and large scale elements should not conflict with each other. A list of strengths and weaknesses (internal appraisal) and opportunities and threats (external appraisal) for Myanmar biofuel business ventures is provided below.

Box-1 Internal Appraisal (Strengths and Weaknesses)

Strengths	Weaknesses
(i) Resource endowment: large tracts of unutilized agricultural land, water, cheap labor, diverse agro-ecological conditions that are favorable for production of biofuel crops (ii) Attractiveness of those resources to initially establish factor-driven industries by local and foreign investors (iii) Fair size domestic market: population of 50 million (iv) Established legal framework, i.e. English language, English law, for doing the business (v) Moderate infrastructure facilities (e.g. transport, telecommunications, and utilities)	(i) Data difficulties for doing economic and social assessment (ii) Weak interconnectedness and cooperation among the government entities in formulating a sound biofuel policy (iii) Weak public–private interface (iv) Lack of encouragement to small- and medium-scale enterprises (lack of pragmatic laws for small- and medium-scale enterprises) (v) Lack of incentives for pioneer entrepreneurs (both local and foreign investors) (vi) Unhealthy investment environment for foreign investors who can bring capital and technology into the country (vii) MIC Law needs to be modified (viii) Rigid and tedious trade policy for export and import (ix) Weak in forward and backward linkages of marketing, and cluster industry (x) Distorted financial policy—multiple exchange rates, fixed and unrealistic interest rate, high inflation (xi) Poor research and development facilities and budget for promotion of biofuel crops

Source: Aung Hlaing

Box-2 External Appraisal (Opportunities and Threats)

Opportunities	Threats
(i) Strategic geographic location with cross-border trade market access to neighboring Bangladesh, China, India, and Thailand and strong energy demand from these countries (ii) Free Trade Pacts (including AFTA, Early harvest scheme of ASEAN+3, BIMSTEC, ACMECS, GMS, and WTO) (iii) Highly interested foreign investors who want to come in for biofuel business along with their financial and technical capacities (iv) Clean Development Mechanism and Certified Emission Reduction	(i) Fuel security versus food security (ii) Vulnerable local infant industries (iii) Negative attributes of multinational corporationgs: interest of the company versus interest of the local community; new breed global company versus multi-domestic company (iv) Transparency, consistency, accountability, and stability

Source: Aung Hlaing

Almost every country neighboring Myanmar has begun to formulate long-term visions and a sound policy framework, has started to invest in research and development, and has begun to encourage business development and attract foreign direct investment. Myanmar, however, has yet to fully embark of biofuels development, and still needs to analyze factors such as food price hikes that will have serious impacts on urban and rural poor, conservation of biodiversity, deforestation, potential for depletion of land and water resources, and the potential negative effects of greenhouse gas saving.

Case Studies

Case 1: Community-based Biogas Projects

Ministry of Science and Technology (MOST) started research on biogas projects since 1995 in a bit to fulfill the sufficiency of community level energy needs where fuel-wood supply is depleting. Actual project was started in 2002 at the cost of Kyats 2,000,000 (approx. US$ 7,000) per unit, 50 m^3 fixed dome type, in a village nearby Kyaukse Township, Mandalay Division under the supervision of Kyaukse Technology University. MOST showed up the initial projects with financial supports to be paid back with installments, including the price of cement at government subsidized price. The project used a 30 HP generator with the output 15 KVA enabling to supply electricity for 160-household village. The initial unit supported by MOST is still under operation which is able to provide electricity for two hours in the morning and four hours in the evening. According to the lecturer who implemented the project, electricity yield of Myanmar biogas unit is higher than the Chinese one she studied in PRC.

Fixed dome type biogas tank (50 m^3) being constructed. (Courtesy: MES)

A committee was also formed with the community elders that would charge every household based on the number of florescent lights, televisions (black/white or color) and VCD/DVD players used. The monthly charged rates are: Kyats 1,000 for a color TV, Kyats 500 for a black and white TV, Kyats 500 for a VCD/DVD, Kyats 500 for a florescent light (2') and Kyats 1,000 for a satellite dish. The project is having monthly income approx. Kyats 150,000 since its implementation making it break-evened after 3 years period. By-products, waste liquid of cow dung, are also returned back in order of sequence to the villagers who have supplied their cow dung for the unit, to be used as organic manual in their fields.

MOST has already implemented altogether 126 biogas units--98 in Mandalay Division, 8 in Magway Division, 19 in Sagaing Division and 1 in Shan State. Due to the increasing cost of the construction materials, cost for a biogas unit rose up to Kyats 8,000,000 at present and MOST is no longer supporting financial programs but on technical support. Also in the markets are the steel tanks, instead of concrete tanks introduced by MOST, which are imported from India used by private users.

Almost completed biogas unit.

It was also learnt that another initiator of biogas projects during 1980s was former Agricultural Research Institute (now reformed as Department of Agricultural Research) under Myanmar Agriculture Service of MOAI. Biogas projects during that period were implemented under the guidance of Socialist Government, which were later grounded to a halt.

At present, a total of 867 floating type biogas plants, family size digesters have been constructed and utilized in 134 townships in all 14 States and Divisions of Myanmar with highest figure in central Myanmar Region where fuel-wood is rarely used. If there are about 100 nos. of cow in a village, approximately 50 m3 of biogas can be provided by 50 m3 in size, fixed dome type biogas plant.[43]

For the time being, present strategy to expand the rural energy sufficiency based on the availability of animal waste seems to be reasonable in the face of environmental concern. However, due to the fact that the use of draught cattle in the village level are decreasing because of the increase use of small scale farm machines in place of them and more and more cattle being smuggling out to neighboring countries for food purpose such as Thailand and China, utilization of other alternatives biomass rather than animal waste should be considered for a longer term.

Case 2: Jatropha Crude-oil Processing Machines

At the time of assessment study[44], it was found only the pilot-cum-research stage jatropha crude oil processing machines and no commercial scale biodiesel factory was found in Myanmar. The study team visited a few pilot jatropha crude-oil processing plants located at:

- Hline Tet Farm, Myanmar Agriculture Service, Mandalay Division;
- North-Eastern Military Command, Lashio, Shan State; and
- Jatropha and Rubber Plantation in Man Pan Project (Hill 5), Lashio, Shan State.

Pilot Jatropha Crude-Oil Expeller and Processing Plant (Continuous Type), Hline Tet Farm, MAS, Mandalay Division (23-2-08)

[43] Presentation by Myanmar Engineering Society (MES), (20-3-08)

[44] Biofuel Assessment Study Team (Myanmar)

A pilot plant for jatropha crude-oil expeller and processing plant was donated to Myanma Agriculture Service (MAS) by the Thailand International Cooperation Agency (TICA) under the bilateral technical cooperation scheme between the governments of Myanmar and Thailand for the purpose of demonstration reflecting the 3-year R&D experience of producing biodiesel from jatropha seeds in Thailand. The mini-machine was installed in Hline Tet Farm of MAS in Mandalay Division where more than 400 acres of jatropha plants were grown last 2 years ago under the management of five farm managers. Jatropha plants, as it was in similar condition with most other locations of Myanmar, were found to be in 2 groups: one without leaves and one with leaves. It was said that plants grown from seeds were found to be with leaves and those grown from stem cuts remains without leaves during the dry season.

The small demonstration plant is able to refine 100 litres of jatropha crude oil in six hours with the output of 97 litres refined biodiesel. The cost of the small plant is about US$ 50,000 (equivalent Kyats 55,000,000). The farm managers are conducting trainings and demonstration for jatropha plantation and processing to nearby farmers and staff of MAS from other locations.

Under the same shed, another small demonstration plant for jatropha processing was also installed which was constructed by Myanma Industrial Crops Development Enterprise (MICDE). The machine is larger than the one donated by TICA but the type is manual batch type that needs labor to transfer semi-finished product from one tank to another. TICA donated machine is continuous type though it is smaller in capacity. Processed refined jatropha oil was said to be used in small hand tractors for demonstration purpose.

Pilot Jatropha Crude-Oil Expeller and Processing Plant (Batch Type), Hline Tet Farm, MAS, Mandalay Division (23-2-08)

Another jatropha crude oil processing machine was located in the compound of North-Eastern Military Command, Lashio. The demonstration machine is also in batch type and able to refine 240 gallons of jatropha crude oil per 24 hour day. Estimate cost of the machine was calculated to be Kyats 10,000,000 and its refined jatropha oil was said to be used in hand tractors, trawler-G and even in Toyota Land Cruiser.

Jatropha Crude Oil Expeller in North-Eastern Military Command, Lashio, Shan State (25-2-08)

Mini Jatropha Refine Oil Processing Machine made in China, North-Eastern Military Command, Lashio, Shan State (25-2-08)

Refined Jatropha Oil from the plant of North-Eastern Military Command, Lashio.

Newly built Jatropha Oil Processing Plant (Batch Type) in Man Pan Project (Hill 5), Lashio, Shan State (25-2-08)

Other jatropha oil refining machine was found also in Man Pan Project (Hill 5) of North-Eastern Military Command area, which was being implemented by Shan Yoma Peace Company. About 1250 acres of rubber, jatropha and macadamia plants are grown in the area.

Case 3: Pilot Ethanol Plant

A pilot ethanol demonstration plant was located at integrated farming project (Hill-1) in Lashio, Shan State, (See photo), which is being implemented by the North-Eastern Military Command. Cultivation of sugarcane, cassava, rice, vegetables and livestock were included in the integrated farming project in addition to the ethanol pilot plant which is constructed with the technical assistance supported by Myanmar Engineering Society (MES). The plant has the capacity to produce 140 gallons of ethanol (96%) per day.

It was informed that issue of licences for altogether 20 three-wheel motorbikes, with the capacity to load about ten passengers, has been made with the conditions for specific use of 100% ethanol (96%). A small pump station was also erected in front of the plant. According to the drivers of motorbikes and engineer from the plant, they have to modify the fuel distribution system of engines appropriately so as to balance with the low combustion ratio of bio-ethanol (1:9) compared to gasoline (1:12).

The plant had only initial outturn of ethanol 8-12 gallons per a ton of sugarcane which was quite low compared to commercial scale of at least 20 gallons owing mainly to the efficiency of the rollers.

Passenger Motorbike using bio-ethanol

Rollers of the demonstration ethanol plant

Due to the early stage of research which does not fully reflect the international technology and practical applications; it seemed that most of the drivers were quite reluctant to use the bio-ethanol because of some technical problems, lower performance of the engine and higher volume of fuel use compared to gasoline.

Military Engineer adjusting the fuel system of the motorbike for ethanol

Case 4: SME Ethanol Plants

Ngwe Yi Pale sugar factory, 1500 TCD, operated by the private limited company, is located in Naungcho Township, on the way from Mandalay to Lashio motor road. Shareholders of the company were expected to expand the present factory employing 400 staff both permanent and seasonal, with injected investment of Kyats 7 billion, to a sugar-cum-ethanol factory, if the market is right. The factory had raw material sugarcane purchased from the farmers around the fields of 30-mile radius. Contract farming between the factory and farmers seemed quite efficient as the small trucks carrying sugarcane kept coming into the factory in line (photo) with neat and tidy cane bundles day and night.

The price of sugarcane paid to the farmers at the time of interview was Kyats 15,000 per ton, reduced from Kyats 18,000 paid at the beginning of the cane crushing season,

because of the plummeting sugar price in the domestic market. The price of sugar fell from Kyats 1500 per viss last year to Kyats 600 this year mainly due to the reasons:

- influx of sugar in domestic markets due to the expansion of local small scale (sugar syrup) industries;
- establish of large scale dual purpose (both sugar and ethanol) factories;
- release of government owned sugar factories to the profit driven private sector such as Myanmar Economic Holdings, Myanma Economic Corporation which are run by the ex-military personnel and other private companies;
- relatively lower demand for sugar from local foodstuff industries whose outputs are being downsized by the incoming of sugar-based foodstuff from neighboring countries mainly from China and Thailand.

Cane being received at Ngwe Yi Pale sugar factory in Naungcho, Shan State.

It was also learnt that there also was one small scale sugar factory (100 TCD) utilzing sugar syrup as raw material nearby Ngwe Yi Pale factory. It seemed that the future of this small factory was not so bright along with the expansion of Ngwe Yi Pale and deterioating of domestic sugar market and cane syrup industry.

Another small scale ethanol plant, with 300 TCD capacity (photo) to produce ethanol (96%), was being constructed at Tagaung Township, Sagaing Division by a yound entrepreneur from Mandalay, only 40 miles away from an ethanol-cum-sugar factory with 2000-2500 TCD aiming to produce 10 million gallon ethanol per year. The situation pointed to the fact that appropriate location selection policy in line with the national industrial and investment plan should be seriously considered by the authorities, who are in a position to allow permits for such industries, in order not to overlap false competitiveness for raw material demands between the small and large scale factory owners.

Cane juice boiling tanks of 300 TCD ethanol (96%) plant under construction in Tagaund Township.

Case 5: Gasifiers in Small and Medium Enterprises (SMEs)

Mr. Soe Min Naing, owner of the "Man Myo Daw" sugar factory (24 tons per day) in Mandalay Industrial Zone, started his business since 1998, manufacturing sugar using raw material sugar syrup[45] purchased from brokerage houses in Mandalay. Even though the "cane-syrup-sugar" process had a lot more transaction cost (30%) than the conventional "cane-sugar" process, the business was still good since the domestic sugar price then was quite higher than international prices. With the flourishing of large scale sugar factories away from the area of government sugarcane planned area and recent government's policy on releasing state-own sugar factories to the private sector,

[45] Sugar syrup, "Pwat Yay", is obtained from boiling sugarcane juice at the sugarcane farm, in this case, about than 100 miles away north from the factories in Mandalay. This kind of industry appeared since state control cane pricing system was practiced during Socialist era and is continued up to present time. Private sugar factory owners, in this way, could be able to stay away from the government's mechanism on fixed cane prices though the transaction cost going through "cane-syrup-sugar" process instead of "cane-sugar" is quite high.

the price of sugar in domestic market was no longer favourable enough for small scale factories.

That is why Mr. Soe had to cut his production cost of the factory first, mainly on energy cost, by turning into gasifier using rice husk instead of pure diesel engine generator. Importing India made gasifier with 200-225 KVA and the present diesel engine generator was modified to be used by both diesel and gas last three years ago, he was able to operate his factory with gasifier at the running cost Kyats 6,800 per hour compared to Kyats 15,000 with pure diesel engine. Per hour cost using government's electricity, which is very limited, is only Kyats 2,500 which is very cost efficiency but is limited.

Since he had good experiences on using gasifier and knows all the mechanism, he was accepting gasifier orders from other industrial colleagues.

Small scale rice husk gasifier in a "Pwat Yay" factory, Tagaung.

Gasifier at "Mann Myo Daw" Sugar Factory, Mandalay.

Another fine example using the alternative energy for the electricity was learnt at JLC Company[46] that manufactures ply-woods also in the industry zone, Mandalay. Being the ply-wood industry that has a lot wood waste, the company's engineers were able to modify gasifiers using wood chips. With five gasifiers using wood chips, the factory was operating five generators (from 250~500KVA) since 2006. According to their research result, a kilogram of wood chip can produce 1 kilo watt hour while 1.8 kg rice husk

[46] Jewellery Work Luck Co. Ltd., Mandalay Industrial Zone.

produce the same energy. However, the availability for commercial use of wood chip for the industry is quite limited compared to rice husk which is abundant in Myanmar up to these days.

Making wood chips from ply-wood waste in JLC Company.

Wood chip gasifiers and generators in JLC, Mandalay.

Case 6: Large Scale Ethanol Plants

100 tons per day ethanol (99.8%) plant was under construction at Maunggone village, Tagaung Township, Sagaing Division, which was going to be commissioned on March 2008 (Photo). The crushing capacity was 2000 TCD at the time of construction in 2005 but now

under expansion for 2500 TCD. The plant was the biggest in Myanmar that produces ethanol directly from sugarcane. Ethanol from molasses will also be produced out of cane season so that total year round production will be about 10 million gallons.

Since its operation in early December 2007, the plant has been producing 500 (30 viss-bags) of sugar per day and crushing cane is to be terminated on middle of May. Up to the end of February, 2008 altogether 130,000 tons of cane had been crushed out of 230,000 tons which were already contracted with the farmers. The recovery of the plant this year was 10.53 at the end of February 08 and last year recovery was 11.17. The managing director of the Great Wall Company said that he was also thinking the use of other potential raw materials such as corn and cassava as alternatives. Up to August 08, the plant has already produced 80,000 gallons of anhydrous ethanol since June 08. Distribution scheme for bio-ethanol was not yet clear cut due to the lack of national biofuel policy and differentials among the government's quota prices on fossil fuels, outside market prices on fossil fuel and privately produced ethanol prices[47].

Another large scale ethanol project was also under construction about 50 miles away, on the bank of Shwe Li River, in the northern part of first plant. The second plant was under the Shwe Li Swan In Company and cane crushing capacity was 5000 TCD but planned to produce the same volume of ethanol as the first plant, i.e. 10 million gallons.

These ethanol projects were being implemented under the guidance of Prime Minister in 2005. Altogether 6 cane-based ethanol projects were allowed to be implemented in the area where the sugarcane lands were not complicated with (away from) the state-owned sugarcane areas. At present negotiations are under way between the Ministry of Energy and Great Wall Company to draw the plans for selling out the ethanol to motorbikes in Mandalay City.

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[47] Government's quota prices: Ks. 2500 (US$ 2.17) per gallon of gasoline and Ks. 3000 (US$ 2.61) for diesel.

Outside market prices: Ks. 4800(US$ 4.17) for gasoline and Ks. 5500 (US$ 4.78) (2 Aug 08)

Ethanol (99.8%) price (Ex-factory): Ks. 2500 (US$ 2.17) (Estimates only)

Pricing of ethanol in the background of government fixed price on gasoline, i.e. Kyats 2500 per gallon (approx. US$ 2.27[48] per gallon), was found to be a major obstacle in negotiation because the outside market price of gasoline was more or less Kyats 5000 per gallon (approx. US$ 4.54 per gallon). At present, the price of ethanol (96%) in the market is Kyats 2500~3000 per gallon and according to the sources from Great Wall Company the cost of ethanol (99.8%) in large scale production is calculated to be Kyats 2300 per gallon without consideration the tax free status, government support and other import/export incentives which are being given to the biofuel businesses by the governments of neighboring countries such as China and Thailand.

Sugarcane trailers carrying cane and unloading at the delivery section.

Model sign post of the ethanol plant.

[48] Kyats 1100 for 1 US$ in black market exchange rate (March 08) and Kyats 1180 in Aug 08.

VI. POLICY REGULATORY AND INSTITUTIONAL SUPPORT FOR BIOFUEL DEVELOPMENT

A. National Policies and Strategies for Biofuel Development

1. Agricultural and Rural Development Policy and Strategy

Food security, export promotion, and enhancing income and welfare of farmers are the three major components of the national agricultural policy goals of Myanmar. To improve the agriculture sector and to uplift the national economy, an agriculture policy was established in 1992. The policy seeks to:

(i) promote the production of food crops and industrial crops without restriction,
(ii) permit the production of industrial and plantation crops on a commercial scale,
(iii) allow private investors and farmers to expand agriculture production on cultivable waste land,
(iv) encourage the participation of the private sector in the distribution of farm machinery and other farm inputs, and
(v) use agriculturally unproductive land for other production programs.

The implementation of the policy involves five strategic approaches: (i) the development of new agricultural land, (ii) the provision and adoption of agricultural machinery, (iii) the provision of irrigation water, (iv) the development and adoption of modern agrotechnology, and (v) the development and use of modern crop varieties. The agricultural development strategy supports the biofuel development program by, allowing the cultivation of biofuel crops without restriction on new agricultural land and promoting the introduction of modern biofuel processing technology. The agricultural policy also clearly states that the production of industrial crops on a commercial scale is permitted. The planting of jatropha on hillside fallow land in northern Shan State supports the development of land and also reduce or even prevent soil degradation.

In its pursuit to eradicate poverty among urban and rural poor and promote sustainable food security, the government has laid down agricultural policies, including free choice of crop production, provision of rights to cultivate to those who develop new agricultural land; provision of land for cultivation of perennial crops to commercial growers; encouraging increased participation of the private sector in the distribution of agricultural machineries and other inputs; and provision of permit to do other businesses.

2. Energy Development Policy and Strategy

The current energy policy aims to reduce energy imports and prevent deforestation to support national economic development.

Electric power is a core power source for industrial development. Myanmar, with its rich water resources, is considering electric power generation from hydropower for its long-term development plan for energy. To reduce the demand for fossil fuel, the Myanma Oil and Gas Enterprise arranged the distribution of compressed natural gas to some motor vehicles from state-owned enterprises and city public transport motor vehicles since Myanmar is rich in natural gas. The government has also formed a national advisory group, composed of representatives from concerned organizations, which is tasked to find ways to develop, produce, and market biofuels for use in transport. This would substitute for a proportion of the oil requirement that the Ministry of Energy projects will increase twofold by 2020 and fourfold, assuming the current rate of industrialization, and hence reduce the importation of fossil fuel.

3. Environmental Policy and Strategy

Myanmar Agenda 21, which was formulated and published by the National Commission for Environmental Affairs, was adopted in 1997 to serve as a blueprint for the promotion of sustainable development in the country. Other directives and notifications related to the environment, particularly greenhouse gas emissions, have yet to be explored. Currently, the most attainable option for curbing greenhouse gas emissions is the development of renewable energy resources, based on sound national environmental policy and strategies to encourage the efficient use of renewable energy, including biofuel and biomass. There is no specific energy plan for the production, supply, and distribution of biofuels in the medium and long term.

B. Development Program and Plans to Address Agriculture Sector Objectives

1 Agricultural Development Program

The current low yield levels of major crops and the existence of large areas of fallow land and cultivable wasteland encourage the participation of the private sector in large-scale farming developments. 136 private companies had been granted 2.04 million acres of these lands for commercial farming.

Since 1988, when the market-oriented policy was adopted, the government has laid down the foundation of the new economic policy by instituting drastic changes in production, manufacturing, and trade policies to maximize private sector participation and foreign investment. In agriculture**,** the production and marketing of crops have been deregulated This has allowed farmers freedom of choice in crop production and enabled them to sell their farm produce at prevailing market prices. These measures are conducive to the social and economic welfare of farmers whose livelihood heavily depends on agricultural production. Moreover, it has also created favorable conditions for the implementation of community development programs in rural areas.

In the context of biofuel development, the government is pursuing a national plan to expand the area planted to jatropha for biodiesel production to 3.44 million ha by 2012. The use of fallow and marginal lands for jatropha cultivation has been allowed since 2006.

2. Rural Development Program

The first national program of integrated rural development was implemented in the border areas of the country in 1989. Its activities were coordinated and implemented by the Central Committee for the Development of Border Areas and National Races, formed in 1989. After achieving successful results in the border areas, the government adopted a rural development policy and strategy in 2001, and a nationwide rural development program was launched in all regions of the country with the following themes:

(i) to strengthen and develop the agriculture, livestock, and fishery production for economic development;

(ii) to provide proper social services, such as health care, education, nutrition, and sanitation;

(iii) to provide irrigation water by available means;

(iv) to build roads and bridges for better communication and transportation within the region and outside the region; and

(v) to develop rural industry based on agricultural products and other available materials within the area.

3. Development of Agro-Industry

The Government of Myanmar established the Myanmar Industrial Development Committee in 1995 to encourage rapid industrialization through:

(i) the development of agriculture-based industries,
(ii) enhancement of the quantity and quality of industrial products,
(iii) the development of new machinery and equipment,
(iv) the production of machinery and equipment for industrial use, and
(v) the creation of condition to transform the country into an industrialized state.

In order to develop the private sector, the state allotted suitable plots of land scattered around the cities to private industry. Manufacturers of gasifiers in Mandalay enjoy these production advantages. Their products are in high demand by the small sugar mills from upper Myanmar.

4. Biofuel Development Program

Because of rising world fuel prices, biodiesel and bioethanol have become an important concern in Myanmar and interest in renewable energy, particularly biogas, and biofuels, has grown dramatically during the past few years. Besides their potential to reduce reliance on fossil fuels and enhance energy security, additional advantages of biofuels include their superior environmental performance, the greening of wastelands, and the creation of job opportunities.

There are plans to produce biodiesel as a substitute for fossil fuel. The area under jatropha cultivation is expected to reach 3.44 million ha (8.5 million acres) between FY2010 and FY2012. The promotion of jatropha cultivation for biodiesel production aims to help rural households reduce their dependence on diesel fuel. The potential of jatropha oil as a cooking and lighting fuel is also being investigated. Research and development into oil extraction and refining of jatropha oil are being conducted by the Ministry of Agriculture and Irrigation (MOAI), the Ministry of Science and Technology, Ministry of Energy, and the Myanmar Engineer Society.

The government has also encouraged national private companies currently producing sugar with its capacity of existing sugar mills to produce bioethanol. Biogas generation from animal residue is also encouraged in the rural areas. Since 1980, biogas generation has been implemented in order to alleviate fuelwood scarcity in the Central Myanmar region. Biodigesters have been introduced for generation of biogas from animal waste. Benefits from biogas development include the promotion of family-sized digesters in rural areas of the country, the reduced use of fuelwood to aid forest conservation, the use of biogas residue as fertilizer; and the control of pollution.

5. Program for Environmental Sustainability

To achieve the Millennium Development Goals, Myanmar aims to integrate the principles of sustainable development into its policies and programs and reverse the loss of environmental resources. However, the greater use of solid fuels, including charcoal, firewood, and their substitutes, is exerting increasing pressure on the country's natural resource base.

The linkages between household solid fuel use, indoor air pollution, deforestation, soil erosion, and greenhouse gas emissions are well known. With the majority of the population in Myanmar using solid fuel (92%),[49] the greening of the dry zone areas and the introduction of efficient fuelwood stove programs are significant efforts to promote environmental sustainability.

C. Institutional Analysis for Biofuel Development

1, Administering Institutions

There are no laws and regulations directly related to biofuel development. However, the Petroleum Act of 1934 defined petroleum to mean "any liquid hydrocarbon or mixture of hydrocarbons, and any inflammable mixture (liquid, viscous, or solid) containing any liquid hydrocarbon". Thus, bioethanol and biodiesel are included in this definition.

Petroleum Rules, promulgated in 1937 and amended up in 1 January 1946, are primarily concerned with the storage and refining and blending of petroleum. They state taht no one shall store any petroleum except under a license granted under these rules, and that no person shall refine or blend petroleum unless the plans showing the general arrangement of required facilities have been approved by authority from concerned agency (the Myanma Oil and Gas Enterprise). Because bioethanol and

[49] Integrated Household Living Conditions Survey in Myanmar, UNDP, Ministry of National Planning and Economic Development and UNPOS, June 2007.

biodiesel are included in the category of petroleum, they are covered by the same rule which would require private sector to get the permission for storage, refining, and blending.

An expert group, composed of representatives from government agencies, has been formed to review the existing conditions and explore the possible ways to facilitate biofuel production, blending, storage, delivery, and distribution. However, specific regulations or directives are needed to administer the import, export, storage, transport, handling, blending, and distribution of bioethanol and biodiesel under the market economic system. A working committee has also been formed to supervise research and development for jatropha cultivation and biodiesel production. The advice of the expert group and the working committee will be valuable in setting up appropriate regulatory measures and institutional arrangements for the sustainable development of the biofuel industry.

A central steering body and working bodies are required to set up a long-term development program and to integrate and coordinate sector activities. They can give the guidance to help set up the biofuel energy policy, establish concerned institutions, direct appropriate regulatory measures to encourage the business investment, and set effective mechanisms for public–private partnership.

Various organizations and companies from the private sector are also involved in research and development. Some of the significant organizations and groups initiating research and development in renewable energy, including biofuels, are Myanma Chemical Engineering Group, Kaung Kyaw Say Engineering Company, the Renewable Energy Association Myanmar, the National Renewable Energy Group, Myanmar Industrial Crops Development Enterprise (MICDE); the Myanma Agriculture Service, Department of Agricultural Research, Technological Universities Yangon, Mandalay, Kyaukse (Ministry of Science and Technology); the Ministry of Industry 1; and the Ministry of Energy.

The integration of research findings will help speed up the development of biofuel technology. Knowledge sharing should be arranged to acknowledge the effort of researchers and develop further research activities. Collaboration with other countries in biofuel technology is being sought and assistance from international organizations is needed for the development of biofuel technology in Myanmar.

2. Market Institutions

To liberalize trade and open up private sector investment opportunities, Myanmar established a new economic system based on the market-oriented economy. The government promulgated the Union of Myanmar Foreign Investment Law and its related procedure in 1988. Currently, state-owned enterprises are the agencies solely responsible for the production, handling, delivery, and distribution of fossil fuels, natural gas, and electricity. Only the Myanmar Oil and Gas Enterprise—a state-owned enterprise—is allowed to import fossil fuels. The government subsidizes petrol and diesel fuel prices. Currently, the Myanma Economic Corporation (MEC) is the only agency established for biofuel distribution. MEC is the sole distributor of bioethanol (E 25) blended in Taung Zin Aye sugar mill.

3. Business Opportunities

The Government of Myanmar is undertaking measures to increase private sector participation, attract foreign direct investment, and accelerate the growth and development of the agriculture sector. Efforts are being made to attract local and foreign investors to invest in mutually beneficial trade and business in the form of joint ventures or 100% investment. It means that any investors are allowed in the form of joint venture with state enterprises or national companies. With regard to the land use, state economic enterprises, joint ventures, cooperatives, and other organizations and private individuals are being granted the right to cultivate fallow lands and cultivable wastelands. The Central Committee for the Management of Culturable Land, Fallow Land and Waste Land was formed to prescribe the procedure for the right to cultivate or use land for agriculture and livestock production. Foreign investors can also apply for utilization of land at the Myanmar Investment Commission (MIC) through the MOAI. Depending on the type of investment, larger land areas of up to 50,000 acres can be allotted with the approval of the Cabinet through the MIC. The government provides exemptions and incentives to investors, such as exemption of land revenue for 2–8 years depending on the type of project, and 3 years of income tax exemption starting from the commencement of commercial run of the business.

The MICDE, which is under the MOAI, is initiating the establishment of small-scale biodiesel plants that can be operated at the community level. The plant can extract 100 gallons/day of bidiesel from jatropha, in 3 shifts with 3 hours per shift . In 2008 12 plants have been constructed. One Korean company has submitted a proposal to establish a biodiesel crop plantation and a biodiesel control laboratory. The company has applied for rights to cultivate 0.2 million–0.5 million ha of fallow land in Magwe Division and Kachin State.

D. Investment and Financing Arrangements

Some private banks provide credit for establishing small- and medium-scale industries. Myanma Industrial Bank, for instance, provides loans for industrial development. Investors need other sources of funding to establish large-scale industries. The absence of international finance institutions in the country slows investment in biofuel development. The possibility of receiving financial support for research and development from international nongovernment organizations, donor agencies, and bilateral arrangement needs to be explored.

Seasonal loans are provided by the Myanmar Agricultural Development Bank for the cultivation of major crops, such as rice, groundnut, sesame, rapeseed, pulses, long staple cotton, sugarcane, jute, and maize. These seasonal crop loans, which are the major source of funding for farmers, are repayable within 1 year. The coverage of crops and the amount loaned for each farm household differ from region to region and from year to year. The amount of credit received per unit area remains low and cannot cover the cost of cultivation. The Myanmar Agricultural Development Bank also provides short- and long-term loans for perennial crops and farm machinery. Utilization of such loans has not progressed because of risk without collateral. Currently, perennial crops (such as tea, coffee, orchids, rubber, and oil palm) and farm machinery (such as water pumps and hand tractors) are eligible for the loans. Development of biofuel will call for the financial program or loan for investment in processing machines.

E. The Way Forward

The future development of the biofuel industry will require the following institutional, policy and regulatory actions:

(i) the establishment of a national authorized body or central steering body to guide policy on a national biofuel development framework, bioenergy development program and plans;

(ii) the formulation of the long-term biofuel development plan;

(iii) the review of existing regulations to determine the need to amend or supplement them or to formulate new regulations as necessary in the context of the national energy development plan to invigorate the biofuel development program;

(iv) the strengthening of public awareness programs to promote the use of biofuels through demonstrations, exhibitions, and media discussions;

(v) the integration of the research and development activities of various agencies to improve biofuel production efficiency and product quality through the establishment of the biofuel research and development institute;

(vi) the establishment of small- and medium-scale biofuel plants in rural areas;

(vii) the government support program to include incentives such as tax exemption; tax holidays; and credit and loan for biofuel crop production and processing industries;

(viii) the promotion of public–private partnerships in production, distribution, marketing, and research on biofuel and biomass energy development;

(ix) the establishment of a pricing policy for bioethanol blend and biodiesel blend products to enable fair competition;

(x) the formulation of projects which support the development of biofuels through research and development on variety improvement, agronomic practices, and biofuel processing; human resource development and technology; the development of laboratory facilities; standardization and quality control; and research into the marketing and distribution of biofuels.

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APPENDIX I:

OIL CONTENT OF DIFFERENT LAND RACES OF JATROPHA CURCAS

(%)

Sr	Land Race	Division/ State	Oil Content %	Sr	Land Race	Division/ State	Oil Content %
1	Kyaukpandaung	Mandalay	23.87	26	Kyinpontaung	Magwe	34.99
2	Kyaukcheck	Mandalay	24.91				
3	Leiway	Mandalay	27.62	27	Watphyuye	Southern Shan	38.34
4	Yelepauk	Mandalay	28.40	28	Naunglay	Southern Shan	35.41
5	Myaingyang	Mandalay	31.41	29	Pinngyo	Southern Shan	34.15
6	Nyaungoo	Mandalay	37.32	30	Nantse	Southern Shan	32.71
7	Tatgone	Mandalay	40.04	31	Sarlaein	Southern Shan	37.04
8	Nyaunglaybin	Mandalay	31.92	32	Banyinn	Southern Shan	36.19
9	Pyawbwe	Mandalay	38.06	33	Sesai	Southern Shan	40.70
10	Zeebwar	Mandalay	41.50	34	Pinmhyie	Southern Shan	30.55
11	Mile 57/4	Mandalay	35.73	35	Kyuneywa	Southern Shan	25.99
12	Kyatpyityar	Mandalay	38.91	36	Pinyintaw	Southern Shan	33.17
13	Nwgahtoegyi	Mandalay	35.35	37	Nyaunggone	Southern Shan	28.65
14	6 mile	Mandalay	23.01	38	Latpanpin	Southern Shan	23.48
15	**Shawphyu**	**Mandalay**	**42.39**	39	Yongtaung	Southern Shan	20.84
16	Kyauktadar	Mandalay	31.59	40	Mintaipin	Southern Shan	35.90
				41	**Banyin farm**	**Southern Shan**	**41.27**
17	**Watkya**	**Magwe**	**43.87**	42	Taunggyi	Southern Shan	39.06
18	Yenangkyaung 36	Magwe	39.16	43	Nammalat	Northern Shan	36.23
19	Magwe	Magwe	35.56				
20	Gyaycho	Magwe	30.73	44	**TaungNgyu**	**Eastern Bago**	**46.41**
21	Payapyo	Magwe	37.25	45	Iapandan	Western Bago	38.70
22	Tamanntaw	Magwe	35.99				
23	Watmasaut	Magwe	35.79	46	Africa	Exotic	35.73

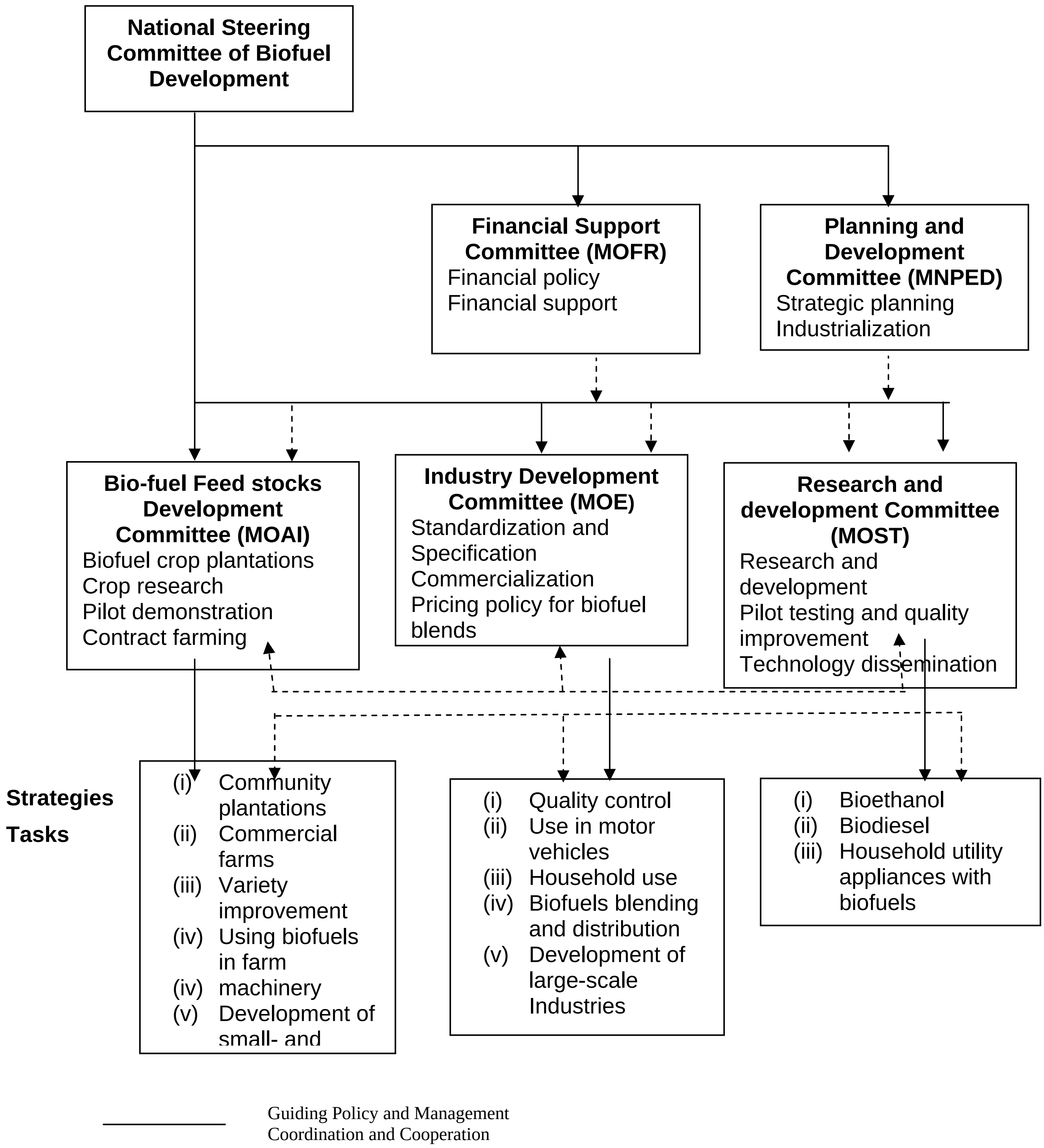
24	Mindone	Magwe	32.80	47	Thailand	Exotic	37.55
25	Yesagyo	Magwe	41.56	48	Laos	Exotic	39.54
				49	Thai	Exotic	**43.40**
				50	Indonesia	Exotic	35.54

Source: Department of Agricultural Research.

APPENDIX II

PROPOSED INSTITUTION AND IMPLEMENTATION MECHANISM FOR BIOFUEL ENERGY

(The responsibility of each leading government agency in the development of biofuel energy)



APPENDIX II:

INDICATIVE NATIONAL BIOFUEL PROGRAM

Vision	The country's energy security generated by renewable energy resources and competitiveness of the biofuel industry in the region
Mission	Towards the realization of the vision, the country will accelerate the development of biofuel industry in the country in order to achieve energy security without affecting food security, maintain environmental sustainability, and develop national economy.
Objectives	To reduce dependency on imported fossil fuels To increase economic activities in the country To improve energy efficiency To generate rural employment To augment farmers' income

Indicative National Bio-fuel Program Framework

Feedstock Development, production & extension

Sugarcane, cassava, sweet sorghum & jatropha prioritized and other potential feed stocks
Expansion of biofuel crop area
Allocation of fallow land to national and foreign investors
Encourage contract farming and joint ventures
Variety improvement
Crop research and development
Mechanization
Fertilization
Community awareness and participation

Bio-fuel Industry development

Biofuels road map
Construction of large-scale plants and expansion of medium-sized and small plants in rural areas
Competitive pricing
Storage, transport, handling, and blending
Distribution and sales
Application development

Policy Formulation and Regulatory Framework

Enact Biofuels energy law
Pertains to enabling rules & regulations to comply the enacted Laws
Covers all major areas and strategies of the program

Investments, Incentives and Promotion

- Government financing to establish industry
- Credit facilitation services
- Tax exemption, holidays and incentives
- Market development services
- Human resources development
- Seminars, conferences, exhibitions and workshops
- Media information
- Information technology

Research and Development

- Production process development
- By-products development
- Integration of research findings from research agencies
- Development of blend performance tests and standards
- Utilization efficiencies
- Pilot plants and showcase projects

Standard and Quality Assurance

- Cover technical and environmental compliance in the following areas
    - Production facilities
    - Utilities and services
    - Bio-fuels and blends
    - Utilization technologies
- Enforcement
    - Inspection and monitoring
    - Penalties