CHAPTER 7

New Development Strategies for MRBCs: A Possibility of Biomass Energy Development

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CHAPTER 7

NEW DEVELOPMENT STRATEGIES FOR THE MRBCS: A POSSIBILITY OF BIOMASS ENERGY DEVELOPMENT

Mitsuhiro Kagami

INTRODUCTION

Energy is a key issue for any country. Fossil fuel is being exhausted while the Earth is facing greenhouse gas (GHG) emissions and global warming. The accident at the Fukushima Nuclear Plant caused by the Great East Japan Earthquake added a question mark to the idea of atomic energy safety. What is an alternative energy solution? This paper recommends that biomass energy is one answer to the problem because (1) biomass energy is carbon-free, (2) biomass crops can be replanted, i.e. they are renewable, and (3) of particular importance, the Mekong River Basin Countries (MRBCs) have vast and fertile land for biomass crops.

Section 1 explains the present general energy situation and the urgent need to look for alternative energy sources. The Japanese situation is also described, particularly the policy changes by the present Democratic Party cabinet after the Fukushima Nuclear Plant accident caused by the Great East Japan Earthquake. The merits of biomass energy for MRBCs are detailed in Section 2. Possible applications of biomass energy

in Thailand will be analyzed in Section 3. Thailand is unique in that it is the first country in Asia to introduce and make practical use of biofuels. In this regard, we should not forget the initiative of HM King Bhumibol Adulyadej to promote biomass energy. A 15-year Renewable Energy Development Plan (2008-2022) has also been introduced. Tentative conclusions and recommendations follow.

1. SEARCH FOR ALTERNATIVE ENERGY SOURCES

1.1. Energy as an Urgent Issue

At present, fossil fuels are the main energy sources in the world. However, reserves are limited and in the future they will be exhausted. Moreover, oil, coal, and natural gas produce carbon dioxide (CO2) when burned. This action contaminates the air and causes global warming. Nuclear energy has also been problematic. Due to the accident of the Fukushima Nuclear Plant in Japan at the time of the Great East Japan Earthquake on March 11, 2011 (3.11 hereafter), people are reluctant to accept nuclear reactors as an energy source. Radioactivity, of course, is more dangerous than CO2. Alternative energies such as solar power and wind power are also problematic, although Japan recently declared an intention to develop these sources. However, the sun does not provide energy during earth's night and wind does not blow continually. Their efficiency is also questionable.

Coal as an energy source is increasing. The depletion period of coal reserves is longer than that of petroleum and today clean coal technologies, such as Carbon dioxide Capture Storage (CCS), are available. However, these new technologies are expensive and, thus, developing countries such as China and India use coal in a

traditional way and continue to emit CO2.

Biomass energy seems to be suitable if a country has vast land and is agriculture-oriented. In reality, the world average of biomass share to primary energy supply is 9.5%, while it is 47.0% in Africa and 24.5% in Asia, except China (2007). This share is only 1.2% in Japan (Table 1).

Table 1. Proportion of Biomass Use in 2007

		Biomass (Mtoe)	Primary Energy Supply (Mtoe)	Share (%)
OECD	Europe	92.58	1,827.00	5.1
	North America	96.01	2,793.57	3.4
	The Pacific	13.70	876.56	1.6
	Total	202.29	5,497.13	3.7
Non-OECD	Africa	295.68	629.04	47.0
	Latin America	108.34	550.38	19.7
	Asia except China	336.70	1,376.65	24.5
	(Japan)	6.39	513.52	1.2
	China	194.55	1,969.51	9.9
	Russia	8.96	1,018.54	0.9
	Non-OECD Europe	6.18	105.85	5.8
	Middle East	1.19	551.63	0.2
	Total	951.60	6,201.61	15.3
World Total		1,141.19	12,029.27	9.5

Source: The White Paper on Energy 2010, METI, Japan.

Biomass energy has two beneficial qualities: one is that it is renewable energy (maize, sugarcane, cassava, etc. can be planted repeatedly); the other is that it is carbon neutral (plants absorb CO2 during their growth). One deficiency is that it affects prices of derived products, such as corn as a food crop as opposed to ethanol production and sugarcane production for sugar instead of ethanol. (There is a discussion that the sudden high price increases of food in 2009 and 2010 were caused by the shift of production towards biomass crops. However, the author thinks the real reason for high food prices was that a vast amount of speculative money went into the food market in

order to evade the subprime mortgage crisis. Another factor is increasing demand for human food and feed for animals in developing countries, such as China and India). In any event, it is important to recognize mutual price influences among cross-products of biomass crops.

1.2. Japan's Changing Course in Energy Policy

Due to 3.11, the Japanese government under Prime Minister Kan (Democratic Party) announced a negative policy for the development of nuclear energy. For electricity generation, Japan depended on nuclear energy for approximately 24% of its total needs in 2008 (oil was 13%, coal 27%, natural gas 26%, hydropower 8%, and others 2%). Because of the explosion at the Fukushima Nuclear Plant, P.M. Kan decided to stop construction of new nuclear plants. He also added that all existing nuclear plants have to pass a so-called "stress test" given by the Government. This is a drastic policy change in Japan since the country has enthusiastically promoted nuclear plant construction for many years, especially under the Liberal Democratic Party.

P.M. Kan promoted instead the development of alternative energies, such as solar and wind. Unfortunately, Japan does not have vast amounts of land for biomass energy crops. According to the FAO (Food and Agriculture Organization), Japan has only 12.6% of its land area suitable for agriculture, while 68.5% remains forested area (mainly mountainous, see Table 2). It is quite difficult to cultivate biomass energy crops in mountain regions. That is why P.M. Kan emphasized solar and wind energy. But these energies, as previously noted, are not particularly efficient.

Table 2. Japan: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	37,780.0	37,794.7		
Land area*	36,450.0	36,450.0	100.0	
Agriculture area	5,271.0	4,609.0	12.6	-1.35
- Cultivated area**	4,866.0	4,609.0	12.6	-0.54
- Permanent meadows and pastures	405.0	-	-	-
Forest area	24,883.4	24,970.2	68.5	0.03
Other land	6,295.6	6,870.8	18.8	0.88

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

The author suggests that Japan can utilize greater amounts of geothermal energy because it has large geothermal energy potential due to its volcanic environment. Its energy reserve in this area is No. 3 in the world, after Indonesia and the U.S.A. It is reported that the initial investment in a geothermal plant is relatively expensive. However, it is less costly than that of a nuclear plant. Electricity companies in Japan have ignored geothermal construction because the Government emphasized nuclear plants. Another reason is that geothermal reserves are mainly situated in national parks. There are regulations preventing construction of large facilities in those areas. But this situation may change quickly when we think of the importance of energy, especially after the Fukushima disaster.

Coal has enormous potential if we use clean coal technology (CCT) in order to emit less CO2, as previously mentioned. In this area of energy usage, Japan is one of the most advanced countries. CCT includes Ultra-Super Critical pressure power generation (USC), Integrated coal Gasification Combined Cycle (IGCC) as well as Carbon dioxide Capture Storage (CCS).

One recent discovery concerns oil from seaweed or algae. One type of algae (*aurantiochytrium*) can produce oil and diesel oil. The University of Tsukuba and

Tohoku University started an experimental farm in 2011 to produce oil from seaweed. A pond (or coastal area) is needed for cultivation. Furthermore, with these alternatives there is little need to worry about price changes in crops. This development might be a viable and increasingly important opportunity to find a substitute for fossil oil.

2. BIOMASS ENERGY: COMPARATIVE ADVANTAGE OF THE MRBCS

Biomass has two energy applications: one for electricity, the other for biofuel. As a fuel for electricity production, wooden materials (fallen trees, scrap wood, wood-related industrial waste, abandoned home furniture, etc.), paddy straw, and sugarcane bagasse can be burnt. Biogas can be also utilized for electricity generation. Organic waste such as dead plant and animal materials, animal dung, and municipal waste can be converted to gaseous fuel. It contains mainly methane, carbon dioxide, and hydrogen sulphide.

Usually bio-ethanol can be produced from such crops as maize (corn), sugarcane, cassava (tapioca), and wheat. Barley, rye, sorghum, and sugar beet also can be utilized. In addition, by-products such as bagasse, paddy straw, corncobs, and waste from pulp can be utilized for ethanol. On the other hand, biodiesel can be produced from palm oil, soybeans, coconuts, rape seeds, sunflowers, and jatropha. Used edible oil can also be exploited for biodiesel.

Aside from rice or paddy, the main crops in the MRBCs are sugarcane, maize, cassava, coconuts, and palm oil. It is quite suitable for these countries to produce biomass energy. In 2009, the production of sugarcane reached 66.8 million tons in

Thailand, 15.2 million tons in Vietnam, and 8.5 million tons in Myanmar (Table 3). Thailand produced 30.1 million tons of cassava, Vietnam 8.6 million tons, and Cambodia 3.5 million tons in the same year. In addition, Thailand produced 1.3 million tons of palm oil while it produced 1.4 million tons of coconuts according to the FAO.

Table 3. Agricultural Production Related to Biofuels in 2009 (MT)

	Cambodia	Lao PDR	Myanmar	Thailand	Vietnam
Sugarcane	350,000	433,500	8,500,000	66,816,400	15,246,400
Cassava	3,497,000	152,590	355,000	30,088,000	8,556,900
Maize	924,000	848,745	1,226,000	4,616,120	4,381,800
Palm Oil	*	*	*	1,310,000	*
Coconuts	71,000	*	420,393	1,380,980	1,128,500

Note: * This item is not in the top 20 products in the country concerned.
Source: FAOSTAT, FAO.

Presently only Thailand among the MRBCs is producing biofuels: ethanol from sugarcane and biodiesel from palm oil. In fact, Thailand is the fifth largest ethanol producer in the world. In 2009, the U.S.A. produced 10.6 billion gallons of fuel ethanol, Brazil 6.6 billion gallons, the EU 1.0 billion gallons, China 542 million gallons, and Thailand 435 million gallons (Table 4). Sugarcane has another benefit aside from sugar. After being crushed to extract the juice, the cane residue, called *bagasse,* is used as fuel to generate electricity.

Table 4. Fuel Ethanol Production in 2009

	(Millions of Gallons)
USA	10,600.00
Brazil	6,577.89
EU	1,039.52
China	541.55
Thailand	435.20
Canada	290.59
Colombia	83.21
India	91.67
Australia	56.80
Other	247.27
TOTAL	19,534.99

Note: * 1 G=3.785 L.

Source: Renewable Fuels Association, USA.

The author thinks that, for two reasons, the MRBCs have enormous potential to produce biofuels. First, these countries can increase biofuel-related crops because land is available. According to the FAO, agricultural areas in 2009 were about 38.7% of the total land area in Thailand, 33.1% in Vietnam,[1] 31.5% in Cambodia, 19.0% in Myanmar, and 10.2% in Lao PDR. There is always competition between food and biofuel application from the same crop. However, if the country has the possibility to expand crop areas, it can satisfy both requirements. For example, the agricultural area of the UK in 2009 was 71.6% and that of New Zealand 43.6% (Tables 5-11). Crop areas can be expanded to meadows and pastures and, especially, forested areas turned into cultivated farmland. Second, this region has two seasons: dry and rainy. Usually, irrigation is not common in these countries but droughts and floods are headaches for local farmers. If we have sound water control or irrigation systems, we can continually produce more food and biofuel crops.

[1] For example, the planted area of main annual crops in Vietnam in 2009 is as follows (unit: thousand hectares): paddy 7437.2, maize 1089.2, sugarcane 265.6, peanut 231.0, soybean 147.0, and cotton 9.6, respectively (Statistical Handbook, Vietnam, 2010).

Table 5. Thailand: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	51,312.0	51,312.0		
Land area*	51,089.0	51,089.0	100.0	
Agriculture area	20,017.0	19,795.0	38.7	-0.11
- Cultivated area**	19,217.0	18,995.0	37.2	-0.12
- Permanent meadows and pastures	800.0	800.0	1.6	0.00
Forest area	19,058.5	18,957.2	37.1	-0.05
Other land	12,013.5	12,336.8	24.1	0.27

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 6. Vietnam: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	33,111.0	33,105.1		
Land area*	32,549.0	31,007.0	100.0	
Agriculture area	8,413.0	10,272.0	33.1	2.02
- Cultivated area**	7,771.0	9,630.0	31.1	2.17
- Permanent meadows and pastures	642.0	642.0	2.1	0.00
Forest area	11,488.8	13,653.0	44.0	1.74
Other land	12,647.2	7,082.0	22.8	-5.97

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 7. Cambodia: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	18,104.0	18,104.0		
Land area*	17,652.0	17,652.0	100.0	
Agriculture area	4,640.0	5,555.0	31.5	1.82
- Cultivated area**	3,840.0	4,055.0	23.0	0.55
- Permanent meadows and pastures	800.0	1,500.0	8.5	6.49
Forest area	11,685.8	10,221.4	57.9	-1.35
Other land	4,904.2	1,875.6	10.6	-10.09

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 8. Myanmar: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	67,659.0	67,659.0		
Land area*	65,354.0	65,352.0	100.0	
Agriculture area	10,609.0	12,440.5	19.0	1.61
- Cultivated area**	10,285.0	12,135.0	18.6	1.67
- Permanent meadows and pastures	324.0	305.5	0.5	-0.59
Forest area	35,303.0	32,082.6	49.1	-0.96
Other land	19,442.0	20,828.9	31.9	0.69

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 9. Lao PDR: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	23,680.0	23,680.0		
Land area*	23,080.0	23,080.0	100.0	
Agriculture area	1,805.0	2,346.0	10.2	2.66
- Cultivated area**	955.0	1,468.0	6.4	4.39
- Permanent meadows and pastures	850.0	878.0	3.8	0.32
Forest area	16,610.2	15,829.2	68.6	-0.48
Other land	4,664.8	4,904.8	21.3	0.50

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 10. United Kingdom: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	24,361.0	24,361.0		
Land area*	24,193.0	24,193.0	100.0	
Agriculture area	17,219.0	17,325.0	71.6	0.06
- Cultivated area**	5,968.0	6,092.0	25.2	0.21
- Permanent meadows and pastures	11,251.0	11,233.0	46.4	-0.02
Forest area	2,774.8	2,873.8	11.9	0.35
Other land	4,199.2	3,994.2	16.5	-0.50

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Table 11. New Zealand: Land Use (1,000 ha)

	1999	2009	Share in 2009 (%)	Annual growth rate 99-09 (%)
Country area	26,771.0	26,771.0		
Land area*	26,331.0	26,331.0	100.0	
Agriculture area	14,903.0	11,490.0	43.6	-2.63
- Cultivated area**	1,603.0	542.0	2.1	-11.45
- Permanent meadows and pastures	13,300.0	10,948.0	41.6	-1.97
Forest area	8,211.4	8,277.4	31.4	0.08
Other land	3,216.6	6,563.6	24.9	7.39

Notes: * Land area=Country area - Inland water. ** Cultivated area=Arable land + Permanent crops.
Source: ResourceSTAT 2011, FAO.

Palm oil is a well-known product from Indonesia and Malaysia as well as Thailand. Thailand found a new variety which can be planted in its northern areas. This new variety, which resists cold, can be planted in Lao PDR and Myanmar, too. Of course, there is strong competition among oil palm growers in Asia, especially concerning production costs. It should be noted also that the Philippines uses coconuts to produce biodiesel. The MRBCs have sufficient coconut resources to do the same thing. Simply put, we always have to keep cost reduction in mind and experiment with new methods and technologies.

3. THAILAND AS A CASE STUDY

3.1. Energy Situation in Thailand

According to *APEC Energy Statistics 2008,* the primary energy supply in Thailand in 2008 was 84,895 kilotons of oil equivalent (ktoe). It increased from 60,372 ktoe in 2000. Thus, the annual average growth rate between 2000 and 2008 was 4.35%. On the other hand, final energy consumption in 2008 was 55,180 ktoe and in 2000, 38,675 ktoe, respectively. The annual growth rate in the same period was 4.54% (Table 12). It

is interesting that energy supply and demand grew at nearly the same rate as GDP growth in the same period (4.76% between 2000 and 2008).

Table 12. Thailand: Major Energy Indicators (ktoe)

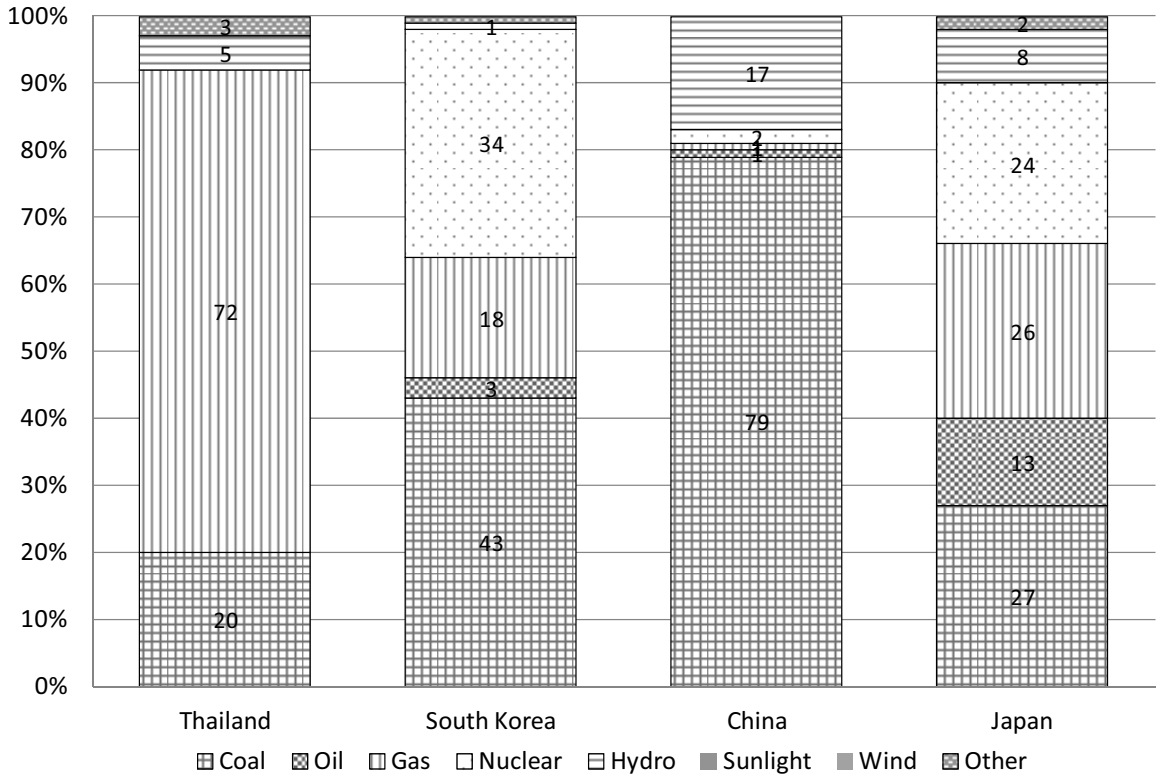
	2000	2008	Annual Average Growth Rate in 2000-08 (%)
Total			
Primary Energy Supply	60,372	84,895	4.35
Final Energy Consumption	38,675	55,180	4.54
Coal, Coal Products			
Primary Energy Supply	7,838	14,953	8.41
Domestic production	5,196	4,787	-1.03
Import	2,655	10,119	18.20
Export	-	47	-
Final Energy Consumption	3,660	7,459	9.31
Crude Oil			
Primary Energy Supply	39,400	50,327	3.11
Domestic production	5,159	11,954	11.08
Import	34,062	40,893	2.31
Export	-514	-2,520	21.98
Petroleum Products			
Primary Energy Supply	-7,243	-8,340	1.78
Import	1,179	366	-15.75
Export	-4,919	-9,071	7.95
Final Energy Consumption	24,420	29,785	2.51
Natural Gas			
Primary Energy Supply	19,620	25,497	3.33
Domestic production	17,685	17,236	-0.32
Import	1,935	8,261	19.89
Export	-	-	-
Final Energy Consumption	1,389	3,204	11.01
Electricity			
Power Generation	8,254	12,679	5.51
Thermal	7,735	10,360	3.72
Hydro	518	612	2.11
Others	0	1,707	-
Final Energy Consumption	7,562	11,608	5.50

Source: APEC Energy Statistics 2008, APEC.

Thailand also produces crude oil. It pumped 11,954 ktoe while importing 40,893 ktoe in 2008. As far as petroleum products are concerned, Thailand exported 9,071 ktoe and imported a much smaller amount (366 ktoe) in 2008. Coal production seemed to be declining while its importation significantly increased from 2000 to 2008 at the annual rate of 18.2%, reaching 10,119 ktoe. The same situation can be seen in natural gas. Thai production of natural gas seemed to have reached a peak and declined while its importation increased (mainly from Myanmar) at an annual rate of 19.9%.

In regard to electricity generation, *The Nation* (Special Report in a Thai English language newspaper) noted on August 22, 2011 that Thailand produced 30 GW in 2008 and the proportion of fuel utilization was coal at 20%, natural gas 72%, hydropower 5%, and others 3% (Figure 1). Thailand depends heavily on natural gas fuel for electricity generation. As seen in Table 12, Thai domestic natural gas production reached 68% of the primary energy supply in its category in 2008 and its importation is increasing. Which choices will Thailand select concerning alternative energy utilization in the future?

Figure 1. Fuel Utilization for Electricity Generation in 2008



Source: The Nation, August 22, 2011.

3.2. Energy Policy in Thailand

In 2009, the Ministry of Energy (2009) established programs based on five basic guiding principles. These are:

(1) To establish suitable energy security

A target has been set to increase domestic crude oil production to 250,000 barrels per day by 2011 (from 225,000 barrels per day in 2009). The supply of natural gas from the Malaysia–Thailand Joint Development Area (JDA) will also be accelerated to help meet this goal. Nuclear energy will also be an option to include one plant producing 1,000 MW in the energy outline toward 2020 and a second plant producing another 1,000 MW in 2021.

(2) To expedite and promote alternative energy

The government established a 15-year Renewable Energy Development Plan

(REDP) 2008-2022 which encourages the production and use of alternative energy, particularly biofuel, biogas, and biomass. Examples include gasohol (E10, E20, and E85), biodiesel (B5), and municipal solid waste.

(3) To monitor energy prices and ensure appropriate levels in line with wider economic and investment situations

The Government has supervised and maintained energy prices at appropriate, stable, and affordable levels by creating a fuel price structure which supports the development of energy crops by reflecting true production costs.

(4) To effectively save energy and promote energy efficiency

Four main energy-saving initiatives have been launched to raise awareness, i.e. the Revolving Fund for EE/RE, the ESCO venture capital funds, Tax incentives for energy saving, and DSM Bidding.

(5) To support energy development while simultaneously protecting the environment

Thailand has a firm policy to protect the environment from the negative impact generated by both energy production and consumption processes, especially from oil refineries and power plants, and from the transportation sector. The Government also takes into account the importance of the climate change issue and supports the Clean Development Mechanism (CDM) projects. The intention is to bring about a reduction of CO2 emission to at least 1 million tons per year.

In this statement, two points need emphasis. One is the 15-year Renewable Energy Development Plan. Thailand will face a large gap between energy demand and domestic supply by 2022 due to its expected constant economic growth and, therefore, imports of energy sources will dramatically increase. In order to avoid this situation, the Government has decided to increase the energy supply by using alternative energy

sources, particularly biomass energy, which is to Thailand's comparative advantage.

The other is the nuclear power plant issue. Thailand has a plan to construct the first nuclear energy plant of 1,000 MW in 2020 and the second one of the same size in 2021 due to energy demand that will exceed supply and concerns of global warming (almost zero emission of CO2 by nuclear energy plants). If the two plants start operations during 2020-2021, they will produce around 5% of the total installed electricity capacity. The construction of the first 1,000 MW plant is to be decided in 2011.[2]

3.3. Fifteen-Year Renewable Energy Development Plan (REDP)

Considering the facts that (1) domestic energy supply is lagging behind its rapidly increasing demand, Thailand has to develop alternative energy supply sources, (2) Thailand must import more energy from abroad, and (3) Thailand seeks to reduce the emission of greenhouse gas (GHG) in order to avoid global warming, the Government created the 15-Year Renewable Energy Development Plan 2008-2022 (hereafter REDP) through the Ministry of Energy in 2008.

According to the REDP, the objectives of the plan were as follows:

- To replace petroleum with renewable energy (hereafter RE) as the main national energy source
- To increase national energy security
- To promote holistic green local energy usage
- To support the domestic RE production industry
- To research, develop, and promote high-efficiency RE technology

The implementation period was divided into three phases: short-term (2008-2011), mid-term (2012-2016), and long-term (2017-2022). Targets were set for the end year of

[2] During his research trip to Thailand in August, 2011, the author heard that this decision was postponed further by the new Government under P.M. Yingluck Shinawatra.

each period along with the types of energy involved.

For example, total energy consumption will be 97,300 ktoe in 2022,[3] while total energy from RE plus natural gas for vehicles (NGV) is planned to reach 19,799 ktoe, setting a ratio of 20.3% of the total energy consumption (Table 13). In the total alternative energy production (RE+NGV, i.e. 19,799 ktoe), electricity occupies 11.7% (2,313 ktoe), thermal 37.5% (7,433 ktoe), biofuel 20.1% (3,986 ktoe), and NGV 30.7% (6,090 ktoe) in 2022.

Table 13. Thailand: 15-Year REDP Goals (ktoe)

	2011	2016	2022
Electricity	1,587	1,907	2,313
Solar	6	11	56
Wind	13	42	89
Hydro power	43	73	85
Biomass	1,463	1,682	1,933
Biogas	27	40	54
Municipal solid waste	35	58	96
Hydrogen	0	0	1
Thermal	4,150	5,582	7,433
Solar thermal	5	18	38
Biomass	3,660	5,000	6,760
Biogas	470	540	600
Municipal solid waste	15	24	35
Biofuel	1,755	2,831	3,986
Ethanol	805	1,686	2,447
Biodiesel	950	1,145	1,415
Hydrogen	0	0	124
Total Renewable Energy (TRE)	7,492	10,319	13,709
Natural Gas for Vehicles (NGV)	3,469	5,260	6,090
TOTAL (TRE + NGV)	10,961	15,579	19,799
Total Energy Consumption (TEC)	70,300	81,500	97,300
(TRE+NGV)/TEC (%)	15.6	19.1	20.3

Source: 15-Year Renewable Energy Development Plan, Ministry of Energy, Thailand.

[3] The existing total energy consumption in 2008 was 66,248 ktoe and total energy from RE plus NGV was 4,345 ktoe, i.e. the ratio of 6.6%.

It is interesting to note that biomass energy (ethanol, biodiesel, biomass, and biogas) usage in electricity and thermal production will be 66.7% (13,209 ktoe) of total alternative energy (RE+NGV) in 2022. This suggests that the Thai Government understands that the country has an appropriate climate, vast land available, and well-prepared farmers to support this energy source. In other words, the country has comparative as well as competitive advantage.

Thailand is one of the most advanced countries in terms of biofuel usage for cars in Asia. Presently, the Government emphasizes production of gasohol E10 (ethanol 10% and gasoline 90%) and E20 (ethanol 20% and gasoline 80%). The Government intends to increase the mix ratio to E85 (ethanol 85% and gasoline 15%). Furthermore, there is a plan to implement the use of biodiesel: initially, B2 (biodiesel 2% and diesel oil 98%), B3 (biodiesel 3% and diesel oil 97%), and B5 (biodiesel 5% and diesel oil 95%), and finally B10 (biodiesel 10% and diesel oil 90%). In the REDP, ethanol production by 2011 is targeted at 3.0 million liters per day, 6.2 million liters/d by 2016, and 9.0 million liters/d by 2022 from the current production level of 1.24 million liters per day. Biodiesel production is targeted to increase to 4.50 million liters per day in 2022 from the current 1.56 million liters per day.

The Government has formulated an investment plan for the REDP. The total investment of both public and private sectors is estimated to be THB488,257 million with THB382,240 million from the private sector and THB106,017 million from the public sector, of which THB52,968 million will come from the public budget and THB53,049 million from state enterprises. It is again worthy of note that out of THB382,240 million from the private sector, biomass-related energies are to receive THB238,740 million, the largest amount equal to 62.4% (biomass 40.1%, biogas 7.3%,

ethanol 10.1%, and biodiesel 4.9%). On the other hand, it is planned that solar energy investment will be THB63,320 million (16.6%) and wind power THB55,930 million (14.6%).

3.4. Thailand as No.1 in Asia in the Use of Gasohol Cars

The use of gasohol for cars is a widespread phenomenon in Thailand.[4] The author undertook a research trip to Thailand in August, 2011 and found that drivers generally use gasohol.[5] The prices of gasohol at a gasoline station in Nana, Bangkok on August 24, 2011 were as follows:

E20 (octane 95)	33.04 baht/liter
E10 (octane 91)	34.54 baht/liter
E10 (octane 95)	37.04 baht/liter
Gasoline (octane 91)	41.94 baht/liter
Diesel oil	29.99 baht/liter

(Exchange rate: THB30.0 =USD 1)

Only the wealthy use pure gasoline, but otherwise all car users buy gasohol or diesel oil (if their car engine is for diesel use). Gasohol cars are common in Thailand because the country can produce its own gasohol cars now. It has become a major automobile production center in Asia and is sometimes called the Detroit of Asia. Estimated production of gasohol cars is around 3,300,000 and there are about 5,120

[4] The initiative of HM King Bhumibol is very important in this respect. The King requested the study of the cost of producing alcohol from sugarcane in 1985. The first gas station was opened at the Palace to observe the use of gasohol with a variety of blends in 1996. The Bangchak Petroleum Company began the production of gasohol and test sales of E10 at its gas station in 2001. The same company operated 99 gas stations selling E10 in 2003. The production of biodiesel started in 2007.

[5] China started E10 in 2004-05 in 5 provinces and 27 cities.

gasohol service stations in Thailand.[6]

It is reported that ethanol will corrode metal and other materials such as aluminum, plastics, and rubber. Ethanol is also dissolved by water so that fuel tanks may contain water which causes rust. As a consequence, E85 has to wait for further technological progress in car manufacturing.[7] There are now E85 cars in Thailand, but not in widespread use. The Ministry of Energy plans to have one million E85 cars by 2018.

The gasohol price includes excise taxes and contributions to the Oil Fund levied on gasoline and diesel prices.[8] The Energy Minister Pichai Naripthaphan, a member of the new Government, indicates that these levies will be reduced within this year. He also mentioned that all energy prices will be freely floated by 2015 due to an ASEAN Economic Community accord (*The Nation*, August 23, 2011).[9]

With respect to ethanol from sugarcane, its price is closely related to sugar and liquor prices. Palm oil is also used as cooking oil so that by-product prices are mutually affected by supply and demand. Usually, the palm oil price is influenced by the Thai Oil Palm and Palm Oil Association, which has rigorous lobbying power. Internationally, in addition, the ethanol price is strongly affected by the Brazilian ethanol price (it is actually used as a base price in Thailand). Thai palm oil prices are also affected by those extant in Malaysia and Indonesia.

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[6] Vehicle sales in Thailand in 2010 were around 752,900 cars (passenger and commercial vehicles).

[7] In Brazil, a 100% alcohol car was produced at the beginning of the 1980s due to the oil shock during the 1970s. It is said that biodiesel also affects the fuel tank by corroding its metal.

[8] For example, levies for the Oil Fund in 2011 were as follows: gasoline (octane 95) THB7.50/liter, gasoline (91) 6.70 THB/liter, E10 (95) THB2.40/liter, and Diesel 1.27 THB/liter, respectively.

[9] According to PTT (Petroleum Authority of Thailand), recent gasohol prices are as follows (October 19, 2011): E10 (octane 91) 33.34 THB/liter, E10 (95) THB36.37/liter, E20 (95) THB32.34 /liter, E85 THB21.92 /liter, Gasoline (91) 36.37 THB/liter, Diesel THB27.99 /liter, and NGV THB8.50/kg.

3.4.1. Thai ethanol industry

According to the Thai Ethanol Manufacturing Association (Siamphakdee, 2009), tapioca production in the crop year 2010/11 was estimated to be 33.58 million tons of which domestic demand, except for ethanol, was 8.21 million tons and exports 21.42 million tons. The rest was available for ethanol production, i.e. 3.95 million tons which can be converted to 1.84 million liters of ethanol per day. In the case of sugarcane and molasses, Thailand produced 82.50 million tons of sugarcane in the crop year 2010/11 of which 3.71 million tons of molasses can be produced.[10] Domestic demand from liquor is 1.00 million tons of molasses, for animal feed 0.40 million tons, and for exports 0.50 million tons, respectively. The remaining 1.82 million tons can be converted to 1.24 million liters of ethanol per day.[11]

In Thailand, maize and sweet sorghum are also grown, but are not, at present, used to produce ethanol.

3.4.2. Thai oil palm situation

The oil palm plantation area in Thailand was estimated to be 628,800 ha in 2009 of which 512,000 ha were cultivated. In the same year, around 8.6 million tons of oil palm (FFB or fresh fruit bunch) were harvested and 1.46 million tons of crude palm oil (CPO) was produced. The provincial distribution of the cultivated areas (512,000 ha) is: Krabi 135,000 ha, Surat Thani 132,700 ha, Chumphon 111,045 ha, Satoon 15,000 ha, others 118,255 ha, respectively. Oil palm growers are estimated to be 108,000 households, while estate-type farming includes around 155 units.

Crushing mills are situated mainly in the southern part of Thailand, amounting to

[10] Molasses is extracted at 4.5% of sugarcane production.

[11] In the case of Brazil, 72 liters of ethanol can be produced from 1 ton of sugarcane.

70 mills. Their installed capacities total around 2,850 million tons of FFB per hour. Refineries are located in the Bangkok metropolitan area and have a production capacity of 3,600 million tons of CPO per day (Boonyaprateeprat, 2010).[12]

4. TENTATIVE CONCLUSIONS AND RECOMMENDATIONS

First, renewable energy is highlighted because the safety of nuclear power energy has become problematic due to the Fukushima Nuclear Power Plant accident and the near-exhaustion of future oil reserves. Among other sources, biomass energy seems to be the most promising in the MRBCs because the region has a comparative advantage. MRBCs are endowed with vast land to cultivate such crops as sugarcane, corn, soybeans, cassava, oil palms, coconuts and jatropha. In addition, the tropical or semi-tropical climate is also appropriate for these crops and the region has accumulated know-how to grow them. In fact, the region has more room to expand total agricultural area as indicated by FAO statistics (Thailand 38.7%, Vietnam 33.1%, Cambodia 31.5%, Myanmar 19.0%, and Lao PDR 10.2% as compared with New Zealand 43.6% and U.K. 71.6% in 2009).

Second, energy efficiency is another factor. In order to produce energy, we have to consider the energy used in the production process. The cultivation of sugarcane or corn needs chemical fertilizers, agricultural equipment, transport machines, etc. These things consume fossil fuel so that we have to deduct energy usage in production from the total energy obtained. Biofuel energy as compared to one unit of energy which is needed in production is calculated as follows (*Nihon Keizai Shimbun*, September 27,

[12] Biodiesel can be produced from oil palm as follows: 100kg of FFB → 23kg of CPO → 2kg of glycerin and 23kg of biodiesel added by methanol and caustic soda.

2011):

Sugarcane in Brazil	7.9
Corn in the U.S.A.	1.3
Bagasse (molasses) in India	32-48

It is interesting that the more mechanized the process, the less efficient the energy obtained from biomass crops. This suggests that extensive agriculture or labor intensive agriculture is more energy efficient. Therefore, MRBCs are currently suitable for biomass crop cultivation.

Third, regarding electricity, we have to compare construction and power generation costs among different energy producing plants. According to *The Nation* (August 23, 2011), these costs are as follows:

	Construction cost per megawatt	Power generation cost per unit
Large hydropower plant	USD 3.5 million	5.7 cents
Coal-fired power plant	USD 1.5 million	7.3 cents
Natural gas power plant	USD 0.8 million	8.2 cents
Solar cell power plant	USD 2.3-3.6 million	28.6-37.1 cents
Wind power plant	USD 1.7-2.4 million	14.3-17.1 cents
Micro-hydropower plant	USD 2.0 million	5.7-28.6 cents
Biomass power plant	USD 1.1-2.0 million	8.6-10.0 cents
Nuclear power plant	USD 3.3 million	7.0 cents

As previously noted, Thailand depends heavily on natural gas for electricity generation (72%). In the case of China, the highest energy ratio is coal (79%), while the U.S.A. and Korea also depend heavily on coal (49% and 43%, respectively). Coal might be a future choice if we can reduce CO2 emissions by high-tech plants. However,

these clean coal technologies (CCS, USC, and IGCC) are quite expensive for developing countries. Biomass power plants are good alternatives for MRBCs because they can use local raw materials such as husks, bagasse, palm oil residues, and wood scraps, etc.

Fourth, Thailand is the most advanced country in Asia in terms of vehicle biofuel usage. The mixture of ethanol and gasoline, such as E10 and E20, is common in daily use while biodiesel, such as B2 and B5, has also been widely available. Thailand produces sugarcane and tapioca (for ethanol) and palm oil (for biodiesel) and, at the same time, is a center of car manufacturing. A good combination of agriculture and manufacturing helps Thailand benefit from these biofuels. Of course, the King's initiative to promote gasohol should not be ignored.

Fifth, water controls to cushion effects from droughts and floods or irrigation systems to grow biomass crops remain an immediate need. The flooding of the Chao Phraya River in October, 2011 heavily damaged not only car manufacturing factories, but also crops. Suitable irrigation systems will help to increase productivity of biomass crops in MRBCs.

Sixth, the prices of biomass crops should be stabilized. These crops are used to satisfy many objectives: food, feed, fuels, and industrial uses such as soap, cosmetics and pharmaceuticals. The prices of these products are mutually dependent, especially between food and fuels. We need relevant mechanisms to stabilize these prices.

Seventh, supportive policies, such as subsidies for biomass crop farmers and biofuel producers, tax reductions in fuel prices, electricity buying mechanisms of electricity distribution companies, and consumer policies to encourage the use of biomass energy, are necessary.

Finally, technological catch-up and innovation in biomass energy is essential. For instance, new varieties of biofuel crops, problems of biofuel oxidation, efficient biofuel vehicles, including E85 and B100 cars, etc. are issues to be addressed. In this context, the newly established international research organization, ERIA (Economic Research Institute for ASEAN and East Asia) in Jakarta is trying to establish biodiesel standards in Asia (see Shi and Goto, 2011) as well as dealing with other biomass-related studies. It would be a positive step to utilize these study results.

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