

Introduction of Bio-Fuels as an Alternative to Petroleum in Europe, America, and Asia

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1. Background and Goals

In recent years, awareness of environmental issues such as global warming has grown and studies and research have been done on a variety of environmentally harmonious and renewable energy sources from the viewpoint of the depletion of petroleum resources. Introduction of such alternatives is going on. Among these, interest in bio-fuels has grown high throughout the world, particularly in Europe and the United States. Under government leadership, efforts are being made to promote the R & D, and spread of bio-fuels in such ways that make the most of the situation of each individual country.

This survey aims to provide a review on the status of efforts to introduce bio-fuels as an alternative to petroleum in Europe, the United States, and Asia, as well as the situation in Japan regarding initiatives related to bio-fuels (bio-energy).

2. Findings

(1) Definition of Bio-Fuels

As used here, “bio-fuels” refers to fuels produced by processing biomass, which consists of organic matters from life.

The term “biomass” can be subdivided into the following categories:

- Agricultural [waste (straw, rice chaff, bagasse) and energy crops (rice bran, rapeseed, soybeans, plants of various types, fast-growing timber, etc.)]
- Forestal [waste (paper manufacturing waste, waste lumber, timber offcuts, trees removed through thinning, etc.), trees planted for energy resource (forests planted for firewood, etc.)]
- Stockbreeding and Marine products derived
- General and Industrial

(2) Findings

Active efforts have been underway for some time in Europe and the United States to promote the introduction of bio-fuels, and the importance of such initiatives is likely to grow in Asia, where energy demand is expected to increase significantly in the years ahead. On the other hand, there has been little progress in turning bio-fuels into a practical alternative in Japan, where there is an emphasis on economics. There is a need for the government, private, and academic sectors to work together in the coming years on well-rounded efforts in this area. (See Appendix 1.)

(3) Situation by Region

1) Western Europe

In the “Green Paper on Renewable Sources of Energy” of November 1996 and “White Paper on Renewable Sources of Energy” of November 1997, the EU declared its intention to “increase the share of total energy consumption accounted for by renewable sources of energy from the 5.4% in 1995 to 11.5% in 2010 (equivalent to a saving of 20 million tons of petroleum), of which three-quarters shall be obtained from biomass.”

In addition, a Green Paper entitled “Towards an European Strategy for the Security of Energy Supply” adopted in November 2000 by the European Commission identifies, as specific energy strategy and policy ideas for the region, the promotion of energy conservation and diversification of energy sources as well as fiscal measures aimed at expanding the share accounted for by renewable energy sources. Also, continuing efforts to promote renewable energy sources are proposed.

Northern European countries such as Finland, Sweden, and Denmark are expected to be involved in active efforts to promote bio-fuels.

(a) Germany

The use of renewable energy sources is spreading, encouraged by the Electricity Feed Law of 1991 (which mandates the purchase of electricity generated from renewable energy sources at a fixed price) and the Renewable Energy Law of February 2000 (a detailed review of purchase prices for different types of energy).

At present the use of “bio-diesel” fuel (80% fossil fuel based and 20% rapeseed based) for automobiles is required. In 1996 annual sales of bio-diesel fuel totaled 80,000 tons, equivalent to 0.4% of all diesel fuel consumed for road transport. The area under cultivation for non-food rapeseed is 230,000 hectares.

(b) Finland

At present, 47% of Finland’s timber production, in forms such as black liquor, bark, and scrap wood, is used for bio-fuels (equivalent to an annual timber volume of 30 million square meters). This accounts for 19.5% of the country’s primary energy sources. Current plans aim to increase the volume of biomass used by 25% by the year 2005. Biomass energy plants employing timber receive subsidies of up to 30%.

(c) Sweden

Since the passage of a national referendum calling for the elimination of nuclear power generation in 1980, efforts are concentrated in regional heat supply by biomass. At present, timber-derived biomass energy accounts for some 20% of Sweden’s primary energy supply. The biomass industry is said to have created some 30,000 new jobs. This process has been promoted through revisions in the tax system (1991: carbon tax, sulfur tax, environmental impact fees, 1992: NOx surcharge).

Guidelines call for the use of energy crops such as straw and rice bran as sources of energy in the years ahead, in addition to forestry resources.

The city of Växjö is one of five Swedish municipalities that are competing to eliminate the use of fossil fuels altogether.

— Växjö (located in southern Småland, population 73,000) has adopted “Fossil Fuel Free” as its slogan and aims to reduce carbon dioxide emissions by half the 1993 level by 2010.

Also, all 270 city buses running in central Stockholm consume ethanol produced from organic feedstock such as wine imported from Italy.

(d) Denmark

The use of biomass from sources such as stockbreeding waste, straw, discarded food, and kitchen refuse is being actively promoted.

The island of Samsø (population 4,000) has been designated a model “energy island” and is endeavoring during the period from 1998 to 2007 to become 100% energy self-sufficient through the use of renewable energy sources (solar heat, wind, and biomass).

2) U.S.A.

The Public Utility Regulatory Policy Act (PURPA) of 1978 requires electric power companies to purchase power generated from biomass at its cost. As of 1991, energy from biomass totaled 9 million kilowatts, accounting for 3.6% of the primary energy supply (approximately equivalent to hydropower) and 2.4% of the total electricity.

Under President Clinton, an executive order was issued in August 1999 calling for “development and promotion of bio-products and bio-energy”. It set forth guidelines aimed at increasing the usage of biomass resources threefold [currently it accounts for 3% of total energy use (cf. 1% in Japan)] by the year 2010. It was hoped that this measure would help create new jobs in the agricultural sector, reduce dependence on foreign supply of petroleum, spur the development of conversion technologies for biomass energy, provide assistance to developing countries, and help prevent global warming.

During the Bush administration, a task force headed by Vice President Cheney announced a National Energy Policy (1. energy conservation, 2. strengthening energy infrastructure, 3. expansion of the energy supply, 4. acceleration of environmental safeguards, 5. enhancement of energy security) in May 2001. It recommends active efforts to develop renewable sources of energy such as hydropower, wind, solar power, and generation of electricity from methane gas produced from compost, etc.

Due to the plans to introduce reformulated gasoline and oxygenated fuel under the provisions of the Clean Air Act (originally passed in 1963 and amended in 1990) and due to the effects of federal ethanol subsidies (amounting to 54 cents per gallon), which remain in effect through 2008, mixed ethanol fuel accounted for 12% of all motor gasoline sold in the United States in 1998.

Against the 120 billion gallons of gasoline consumed in the United States in 1998, ethanol production totaled 1.4 billion gallons or 1.2%. This figure is expected to increase to 2% by 2020.

There are presently some 550 biomass electric power plants currently in operation that use timber harvested for fuel and scrap wood from lumber mills, etc. (They are generally small plants with an average capacity of 20 megawatts.) Together, they produce a total of 7,000 megawatts of electricity, which accounts for 1% of the total generation in the United States, and this figure is expected to double by 2010.

3) Brazil

Due to the 1979 National Alcohol Plan [promotion of E10 fuel (10% ethanol, 90% gasoline) and ethanol (E85 or E95 fuel) powered vehicles following second oil crisis] and the 1992 Energy Policy Law which mandates the use of E85 and E95 fuel for the federal government and states as well as the alternative fuel industry, ethanol now accounts for 41% of transportation fuel demand.

Price of ethanol, which is produced from sugarcane and cassava, is twice that of gasoline. However, the Brazil decided that it is economically more beneficial to produce alcohol from agricultural products and use it as fuel and as a raw material for chemicals, rather than purchase petroleum, the price of which is expected to rise, with the proceeds from exports of agricultural products.

It is estimated that by 1999 the above plan had created new jobs for some 1.85 million people. These included approximately 1 million jobs in agricultural regions, 300,000 jobs in some 350 private companies, 50,000 jobs in sugarcane farming, and 500,000 jobs at a total of 132 sugar and alcohol plants.

4) Asia

In Asia both petroleum and wood are important fuels. Approximately 50% of total energy usage is accounted for by wood. The latent economic value of the wood fuel used annually in the 16 developing countries in Asia listed below is estimated to be equivalent to U.S. \$30 billion.

[Share of total energy consumption accounted for by wood (%)]

Laos: 90, Bhutan: 86, Cambodia: 85, Myanmar: 82, Nepal: 69, Maldives: 55, Sri Lanka: 49, Vietnam: 41, Philippines: 39, Thailand: 32, India: 30, Indonesia: 29, Pakistan: 26, Bangladesh: 20, China: 11, Malaysia: 9

Biomass use in the nine ASEAN countries accounts for some 40% of total energy consumption. Of this, wood used as fuel is the main component. Though there is a great deal of latent potential, modern methods of making use of timber as an energy resource are yet to be sufficiently developed. In addition to lumber, waste from the agriculture and forestry industries as well as timber harvested specifically as an energy source also has latent potential. (The latent annual economic value of timber for fuel is estimated at U.S. \$7 billion.)

The Asian countries where biomass plays a particularly important role are Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. Biomass fuels in these countries include timber (coconut, gum, and oil palm trees), sawdust, bagasse, and rice chaff and husks. These are used for cogeneration in the lumber and agriculture related industries.

(a) China

Consumption of biomass energy in 1993 was estimated to be equivalent to approximately 185 million tons of petroleum. Of this, 57.5% was accounted for by agricultural refuse, 39.2% by timber harvested as fuel, and 3.2% by animal waste. It is estimated that approximately 213 million tons (petroleum equivalent) of agricultural refuse and approximately 200 billion kilograms of dry animal waste are available annually as sources of energy.

Presently some 94% of biomass energy consumption takes place in household (fueling cooking stoves).

Demand for timber for use as fuel is expected to reach the equivalent of approximately 89 million tons of petroleum by 2010. Potential biomass substitutes such as ethanol produced from corn, a major cereal grain, and sugarcane are expected to become increasingly important as energy sources in the years ahead.

(b) South Korea, Taiwan

Both countries are heavily dependent on imports of crude oil since neither possesses sufficient energy resources domestically. Imports of petroleum are expected to continue to grow in the years ahead due to factors including population growth and increasing use of automobiles. Thus, sooner or later, biomass fuels are sure to become an important alternate energy supply resource.

(c) Vietnam

Biomass energy from sources such as timber, manure, and rice chaff is estimated to account for some 7% of total energy consumption.

(d) Philippines

Electricity generation using urban trash as fuel is being planned.

(e) Thailand

Biomass energy is the largest primary source, accounting in 1997 for the equivalent of approximately 20,503,000 tons of petroleum or about 44.2% of the nation's total energy consumption. The above biomass figure breaks down to 64% from bagasse, 22% from timber harvested as fuel, and 14% from rice chaff.

(4) Japan

1) Present Situation and Future Prospects

A report issued in June 2001 by the New Energy Subcommittee of the Commission on General Resources and Energy identifies the role of bio-fuels (energy) in Japan in terms of "biomass power generation," "biomass heat and power generation," and "black liquor, scrap wood, etc."

Bio-energy accounted for 0.8% of the primary energy supply (equivalent of 593 million kiloliters of crude oil) for fiscal year 1999, or the equivalent of 4.624 million kiloliters of crude oil. This contrasts with a target figure for 2010 of 1.0% (5.95 million kiloliters of crude oil equivalent) of the projected total primary energy supply of 602 million kiloliters crude oil equivalent. (See Appendixes 2 through 4.)

When the energy issue is looked at from the demand side, the transport sector in particular, it is thought that there is a need to secure alternatives to petroleum as fuel sources. A commissioned study carried out by Yale University found that there are limitations to the practicality of alcohol as fuel, particularly ethanol derived from biomass, in terms of maximum power and acceleration, etc. As such, the report concluded that only a limited contribution could be anticipated from this source.

— An analysis of the statistical data of Brazil between 1981 and 1990 reveals the following.

- The market share of alcohol fueled automobiles increases by between 2.7 and 7.7 percentage points if the price of alcohol fuel is lowered by 40%, and by between 7.1 and 16.5 percentage points if the price of alcohol fuel is lowered by 40% and the price of gasoline doubles.
- The market share of alcohol fueled automobiles increases only by 0.12 percentage point if a subsidy equivalent to 10% of the purchase price is provided while the cost to the federal government is some \$200 million.

2) Initiatives

The central and local governments, assisted by the private sector, are presently engaged in active efforts to promote the use of bio-energy.

The central government has been subsidizing wood fueled power plants through the Regional New Energy Vision Policy Project started by the Ministry of Economy, Trade and Industry (METI) in fiscal 1995 [presently involving 294 prefectures and municipalities (usage rate: 9.0%)] and the Forestry Structural Improvement Project launched in 2000 by the Forestry Agency.

Local governments have been engaged steadily in a series of bio-energy projects. Examples include an initiative to use manure from dairy cows in Bekkai-cho in Hokkaido, efforts to use wood biomass in Iwate and Tokyo Prefectures, and the development of “bio-diesel fuel” made from rapeseed oil in Shiga Prefecture.

Works in the private sector include surveys, research, and educational activities to promote the use of wood biomass such as the Woody Biomass Forum underwritten by the Green Fund, which is managed by the National Land Afforestation Promotion Organization.

Appendix 1

Projected Overall Energy Consumption and Renewable Energy Consumption Worldwide by Region

(Unit: Quadrillion British thermal units)

	Overall Energy Consumption							Hydropower and Renewable Energy						
	1999		2010		2020		1999 / 2020	1999		2010		2020		1999 / 2020
	Share of Total (%)	Share of Total (%)	Share of Total (%)	Share of Total (%)	Share of Total (%)	Share of Total (%)	Ratio (%)	Ratio (%)	Ratio (%)	Ratio (%)	Ratio (%)	Ratio (%)	Ratio (%)	
Japan	21.7	5.7	23.5	4.8	26	4.3	120%	1.2	5.5	1.3	5.5	1.6	6.2	130%
Developing Countries in Asia	71.0	18.6	113.3	23.1	162.2	26.7	230%	4.6	14.1	7.4	17.7	10.5	21	230%
China	32.0	8.4	55.3	11.3	84.1	13.9	260%	2.3	7.2	4.4	8	6.6	7.8	290%
India	12.2	3.2	18.4	3.8	26.1	4.3	210%	0.9	7.4	1.2	6.5	1.7	6.5	190%
South Korea	7.3	1.9	10.3	2.1	13.2	2.2	180%	0	0	0.1	1	0.2	1.5	—
Other Asian Countries	19.5	5.1	29.3	6	38.8	6.4	200%	1.4	7.2	1.7	5.8	2	5.2	140%
Asia Total	92.7	24.3	136.8	27.9	188.2	31	200%	5.8	6.3	8.7	6.4	12.1	6.4	210%
Germany	14.0	3.7	15.9	3.2	16.9	2.8	120%	0.4	2.9	0.7	4.4	1	5.9	250%
France	10.9	2.9	12.6	2.6	13.7	2.3	130%	0.8	7.3	1.1	8.7	1.1	8	140%
Britain	9.8	2.6	11.1	2.3	12.1	2	120%	0.1	1	0.2	1.8	0.3	2.5	300%
Italy	7.6	2	8.8	1.8	9.5	1.6	130%	0.6	7.9	0.7	8	0.9	9.5	150%
Other	23.7	6.2	26.2	5.4	28.5	4.7	120%	3.7	15.6	4.3	16.4	4.9	17.2	130%
Western Europe Total	66.0	17.3	74.6	15.2	80.7	13.3	120%	5.6	8.5	7	9.4	8.2	10.2	150%
U.S.A.	96.7	25.3	114.1	23.3	127	20.9	130%	7	7.2	8.1	7.1	8.5	6.7	120%
Brazil	8.1	2.1	11.5	2.3	16	2.6	200%	3.3	40.7	3.6	31.3	3.7	23.1	110%
Subtotal	263.5	69	337	68.8	411.9	67.8	160%	21.7	8.2	27.4	8.1	32.5	7.9	150%
Other	118.3	31	152.7	31.2	195.2	32.2	170%	11	9.3	14.5	9.5	17.5	9	160%
World Total	381.8	100	489.7	100	607.1	100	160%	32.7	8.6	41.9	8.6	50	8.2	150%

Note: Hydropower and Renewable Energy figures for "Ratio (%)" are relative to Overall Energy Consumption.

Prepared by PEC based on Energy Information Administration (EIA): *International Energy Outlook 2001*, Reference Case Projection, Tables A1 and A8.

Appendix 2

Primary Energy Supply, Past and Future

(Unit: Crude Oil Equivalent, millions of kl)

Item	FY	FY1990		FY1999		FY2010					
		Standard		Target		No Additional Nuclear					
Primary Energy Supply		526		593		622		Approx. 602		Approx. 580	
Energy Category		Actual Figure	Share of Total (%)	Actual Figure	Share of Total (%)	Actual Figure	Share of Total (%)	Actual Figure	Share of Total (%)	Actual Figure	Share of Total (%)
Petroleum		307	58.3	308	52	280	45	Approx. 271	Approx. 45	Approx. 261	Approx. 45
Coal		87	16.6	103	17.4	136	21.9	Approx. 114	Approx. 19	Approx. 126	Approx. 22
Natural Gas		53	10.1	75	12.7	82	13.2	Approx. 83	Approx. 14	Approx. 83	Approx. 14
Nuclear		49	9.4	77	13	93	15	93	Approx. 15	70	Approx. 12
Hydro		22	4.2	21	3.6	20	3.2	20	Approx. 3	20	Approx. 3
Geothermal		1	0.1	1	0.2	1	0.2	1	Approx. 0.2	1	Approx. 0.2
New Energy Sources		7	1.3	7	1.1	10	1.6	20	Approx. 3	19	Approx. 3
Renewable Energy*		29	5.6	29	4.9	30	4.8	40	Approx. 7	40	Approx. 7

* Figures for renewable energy include new energy sources and hydro.

Prepared by PEC based on the report *On Future Energy Policy* (July 2001, General Study Subcommittee and Supply and Demand Subcommittee of the Commission on General Resources and Energy).

Appendix 3

New Energy on the Supply Side, Past and Future

	1996 FY Performance		1999 FY Performance		2010 Forecast/Target				2010 / 1999
	Crude Oil Equivalent (10,000 kl)	Share of Total (%)	Crude Oil Equivalent (10,000 kl)	Share of Total (%)	Current Policies Continue		Target		
					Crude Oil Equivalent (10,000 kl)	Share of Total (%)	Crude Oil Equivalent (10,000 kl)	Share of Total (%)	
(Electric Power Generation Category)									
Solar	1.4	0	5.3	0.01	62	0.1	118	0.2	Approx. 23 times
Wind	0.6	0	3.5	0.01	32	0.05	134	0.22	Approx. 38 times
Waste Products	91	0.15	115	0.19	208	0.33	552	0.92	Approx. 5 times
Biomass			5.4	0.01	13	0.02	34	0.06	Approx. 6 times
(Heat Use Category)									
Solar	130	0.22	98	0.17	72	0.12	439	0.73	Approx. 4 times
Unused Energy (Including Refrigeration)	3.3	0.01	4.1	0.01	9.3	0.02	58	0.1	Approx. 14 times
Waste Products	4.4	0.01	4.4	0.01	4.4	0.01	14	0.02	Approx. 3 times
Biomass	-		-		-		67	0.11	-
Black Liquor, Scrap Wood*	477	0.8	457	0.77	479	0.77	494	0.82	Approx. 1.1 times
New Energy Supply Total	708	1.19	693	1.17	878	1.41	1,910	3.17	Approx. 3 times
Primary Energy Supply Total	Approx 597 millions kl		Approx 593 millions kl		Approx 622 millions kl		Approx 602 millions kl		

* Treated as a subcategory of biomass, and including a portion of the total used for electric power generation.

Prepared by PEC based on *New Energy Subcommittee Report* (June 2001, New Energy Subcommittee of the Commission on General Resources and Energy).

Appendix 4

Renewable Energy, Past and Future

(Unit: Crude Oil Equivalent, Millions of kl)

	1996 FY Performance		1999 FY Performance		2010 FY Forecast/Target				2010 / 1999
	Crude Oil Equivalent	Share of Total (%)	Crude Oil Equivalent	Share of Total (%)	Current Policies Continue		Target		
					Crude Oil Equivalent	Share of Total (%)	Crude Oil Equivalent	Share of Total (%)	
New Energy Supply Total	7	1.2	7	1.2	9	1.4	19	3.2	Approx. 2.7 times
Hydro (General Hydro)	NA	NA	21	3.5	20	3.2	20	3.3	Approx. 1.0 times
Geothermal	NA	NA	1	0.2	1	0.2	1	0.2	Approx. 1.0 times
Renewable Energy Supply Total	NA	NA	29	4.9	30	4.8	40	6.7	Approx. 1.4 times
Primary Energy Supply Total	597		593		622		602		

New Energy Demand Side Past and Future

	1996 FY Performance	1999 FY Performance	2010 Forecast/Target		2010 / 1999
			Current Policies Continue	Target	
Clean Energy Automobiles ^{*1} (cars)	12,000	65,000	890,000	3,480,000	Approx. 53.5 times
Natural Gas Cogeneration ^{*2} (kw)	1,000,000	1,520,000	3,440,000	4,640,000	Approx. 3.1 times
Fuel Cells (kw)	16,000	12,000	40,000	2,200,000	Approx. 183 times

*1 Includes electric automobiles, fuel cell powered automobiles, hybrid automobiles, natural gas powered automobiles, methanol powered automobiles, and automobiles powered by liquefied petroleum gas as an alternative to diesel as components of the demand side for new energy.

*2 Includes systems incorporating fuel cells.

Prepared by PEC based on *New Energy Subcommittee Report* (June 2001, New Energy Subcommittee of the Commission on General Resources and Energy).

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