IEA Bioenergy Task 40
Country report 2011 for Japan

Shinichi Goto
Mitsuharu Oguma
National Institute of Advanced Industrial Science and Technology (AIST)

Yuji Iwasaki
Oji Paper Co. Ltd.

Yoshihiro Hayashi
NEDO

December 2011
***Up dated in April 2012**

Contact Person: Shinichi Goto, Ph.D.
Email: goto.s@aist.go.jp
1-2-1, Namiki, Tsukuba, Ibaraki, 305-8564, Japan

Table of Contents

1． General information

1.1 General overview

Japan is located on the east side of Asia, East Asia, and Eurasia, surrounded by water bodies such as the Pacific Ocean, the Sea of Japan, East China Sea, Philippines Sea, and the Sea of Okhotsk. Geologically speaking, Japan is located at a collision point of four plates (Eurasian Plate, North American Plate, Philippines Sea Plate, and Pacific Ocean Plate), which are among about ten plates covering the earth. Thus, Japan is in one of the worlds leading earthquake-prone zones as well as a volcanic activity band.

Japans land area is about 380,000m^2, consisting of 6,852 islands[1-1)] in total. Main regional divisions consist of 5 regions, such as Honshu or a main island (61% of total area, 3,194 islands), Hokkaido (22% of total area, 509 islands), Kyushu (11% of total area, 2,160 islands), Shikoku (5% of total area, 626 islands), and Okinawa (0.6% of total area, 363 islands). Japan is made up of various administrative units consisting of 47 provinces called *to (Tokyo-to), do (Hokkaido), fu (Osaka-fu, Kyoto-fu),* and Prefectures. The population is 127,510,000 [1-2)], and more than 10% is concentrated in Tokyo (12,860,000 people).

As for Japan's climate, most of the land is warm and wet. The annual average temperature in Tokyo is 15.9°C[1-3)], and the annual rainfall is 1,467mm. There is a great difference between cold and hot extremes throughout the year in the East, West, South, and North of Japan. Thus Japan is blessed with four seasons of spring, summer, fall, and winter. For example, abundant snow falls in winter, centered around the Sea of Japan side. A definite rainy season occurs due to front stagnation around June and July, while typhoons from southern seas sweep in every summer and autumn.

Across Japan, 66 % of the land is forested[1-4)], and in addition to the well-known Mt. Fuji at 3,776m, the highest point above sea level, but there are also many steep landforms in the many mountains and forests (or woodlands). Moreover, rivers originating in the mountains flow down through mountains and forests. In the narrow flat grounds and alluvial fans where these rivers exit the mountains, many local cities and villages have formed over the centuries. Most of the flat grounds in Japan are alluvial plains formed by river sedimentation, and Tokyo is in the largest, called the Kanto Plain. Others in Honshu include the Sagami Plain where Kanagawa Prefecture is located, and the Osaka Plain where Osaka-fu is located. In these plains many populations and metropolitan areas have developed.

Manufacturing is the main industry, specifically the automobile, steel and materials industries have been foremost, however in 2005 manufacturing's fraction of the nominal gross domestic product (GDP) was eclipsed by the service industry. Thus manufacturing and industry have switched places.

The nominal GDP was ¥515 trillion in 2007, however due to the economic downturn triggered by the Lehman collapse, GDP contracted to ¥492 trillion in 2008, then to ¥474 trillion in 2009. Although there were signs of recovery to the ¥475 trillion GDP in 2010, the East Japan Great Earthquake hit Japan in

March, 2011.

1.2 Description of main industries, and which are relevant for biomass

In the "Comprehensive Nippon Biomass Strategy" by the Ministry of Agriculture, Forestry and Fisheries, outlines nine major biomass types in Japan. These are livestock waste, sewage sludge, black liquor, waste paper, food waste, scrap lumber, construction scrap, agricultural waste, and wood left in forests. Details are shown in the table below.

From characteristics of the generation process, these are classified into "waste biomass" and "unused biomass" for convenience. In "unused biomass" a classification of "resource crops" is designated besides non-edible parts of crops and wood left in forests. However, specific utilization efforts are few and production volumes are scarce.

Table 1-1 Status of utilization of major biomass types[1-5)]

Biomass types	Generation per year (tonnes)	Utilization ratio	Wastes/Unused	Relevant industry	Relevant ministry
Live stock wastes	88,000,000	90%	Wastes	Livestock industry	MAFF
Sewage sludge	78,000,000	77%	Wastes	Sewerage management	MILT
Black liquor	14,000,000	100%	Wastes	Paper industry	METI
Waste paper	27,000,000	80%	Wastes	Service industry	ME
Food waste	19,000,000	27%	Wastes	Food industry	ME
Scrap lumber	3,400,000	95%	Wastes	Lumbering	MAFF
Construction scrap	4,100,000	90%	Wastes	Building industry	MILT
Agricultural waste	14,000,000	30%	Unused	Agriculture	MAFF
Wood left in forest	8,000,000	0%	Unused	Forestry	MAFF

Note 1: Remaining materials like black liquid and saw mills and forest wood residue are dry weight, and others are wet weight.
Note 2: Numbers are approximate, and non-edible crop parts include that which is not plowed under.

Summary of industry trends related to biomass is described below.

① Dairy and animal husbandry industries

Japan's dairy industry is spread out nationwide. Almost all dairy farms also raise dairy cattle, while other animal husbandry includes beef cattle, pigs, and chickens. Manure occurring from these industries is requires by law to be properly managed, and the farmer must provide a facility in order to process and utilize it[1-6)]. At present, most of it is composted, and an effort to collect biomass energy (methane fermentation) started more than 10 years ago (after enactment of the law), however it has not become widespread yet.

② Paper industry

The paper industry generates so-called black liquor, a biomass resource from wood chip waste materials. At the same time other efforts involving consumers and businesses to enable the paper industry itself to utilize biomass energy has been in progress.

③ Food processing industries

Residue generated from manufacturing industries like food processing, crop processing, and seafood processing is considered as important biomass. Particularly, after the introduction of Japan's "Food Recycling Law" (established in 1990), generation suppression and recycling have been requested. In the 1997 revision, "hydrocarbon products", "ethanol" and "heat recovery" were designated as recycling, and it was expected that efforts to stimulate specific energy conversion would be encountered. However, the utilization rate has been sluggish.

④ Sawmill industry

Japan's sawmill industry has been active due to the abundant forest resources and also imported raw forestry materials. Remaining materials generated in processing are effectively used as energy and for production of other materials.

⑤ Construction industry

Japan's construction industry generates waste wood from dismantling buildings and from harvested new wood. Recycling of this material is currently performed. After being processed to wood chips, the wood is used for power generation as biomass fuel.

⑥ Agriculture

In Japan's utilization of land for rice cultivation account for about 54% (2,506,000ha, 2009) of total cultivated area[1-7)] (4,609,000ha, 2009). Looking at the ratio of rice and vegetable output to the total output value (¥58,204 billion, 2010), vegetables account for about 36% (¥21,105 billion, 2010), rice accounts for about 33% (¥19,014 billion, 2010).

In Japan's agricultural system, chaff and rice straw from traditional rice cultivation have been used as feed and fertilizer for centuries. Recently, an effort towards ethanol production rather than feeds has been initiated. However, Japan has four distinct seasons, crops are harvested once a year, and so without considerable storage facilities the availability of agricultural biomass is limited. Thus it becomes a barrier to commercialization. Agricultural biomass other than rice, however, has not been used appreciably. In addition, rice and rapeseed (canola) have been investigated as crop resources. However, it strongly implies agriculture activation measures, and their potential impact as resources and energy measures is small.

⑦ Waste treatment related business

In Japan, "Waste" is legally classified into "General Waste" and "Industrial Waste". General waste is then required to be processed under the prevailing administration's responsibility, and industrial waste must be

processed by the generating businesses or entities. Actually, many specialized businesses of waste collection, processing and disposal are commissioned by the waste generating businesses. It is necessary to get various permits in order to contract and carry out such a businesses.

In Japan, most actual handling of waste products mentioned above is performed by specialized businesses. In reality, even though one tries to start a business converting waste biomass into energy, procurement of raw biomass material is significantly limited because of various laws. In almost all cases it is required to purchase biomass raw material as a "valuable resource", which is not a small barrier.

Entrepreneurs and/or businesses which have necessary permits sometimes work by themselves for biomass utilization projects, however there is still much room for growth. Due to increased incentives and risk reduction, it is now a challenge of promotion.

1.3 CO_2 Reduction requirements

(1) Policy

In Japan the Kyoto Protocol states that overall 2008 to 2012 average greenhouse gas emissions should be reduced by 6% compared to the 1990 value. (Japan's 1990 greenhouse gas exhaust emissions totaled 76 million tonne, or 1,261 million tonne CO_2 equivalents)

When the first commitment period of the 2008-2012 Kyoto Protocol arrived, the "Kyoto Protocol Target Achievement Plan" was developed in 2005. Some of it was revised in 2006, and all of it was revised on March 28, 2008. It has been a major goal to achieve the 6% reduction set out in the Kyoto Protocol.

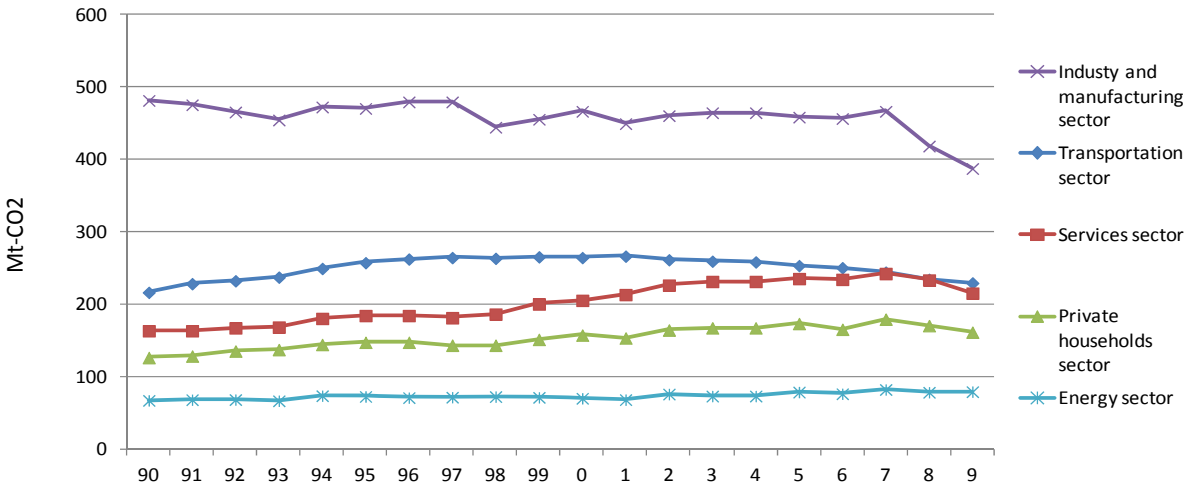

Figure 1-1 CO_2 emissions by sector (energy-origin)

(2) Energy-origin CO_2 emissions[1-8)]

Energy-origin CO_2 emissions for 2009 were significantly reduced to 1,075 million tonnes compared to the previous year, for a 5.5% reduction. This is because of a slowdown in production activities from

continuing from fiscal 2008, reduced activity in the commercial sector, decreased levels of transportation, and so forth. Compared to fiscal 1990, this represents an increase of 1.5%.

By breakdown of the sectors, the industry and manufacturing sector showed a remarkable decrease of 7.3% (31 million tonnes), compared to the previous fiscal year. The business sector also showed a 7.8% reduction (18 million tonnes), compared to the previous fiscal year. The transportation sector had a 2.4% reduction (6 million tonnes), the private household sector had a 5.5% reduction (9 millions tonnes), and the energy conversion sector showed a 1.1% increase (1 million tonnes). These energy-origin CO_2 emission decreases are largely due to the effects of the economic downturn.

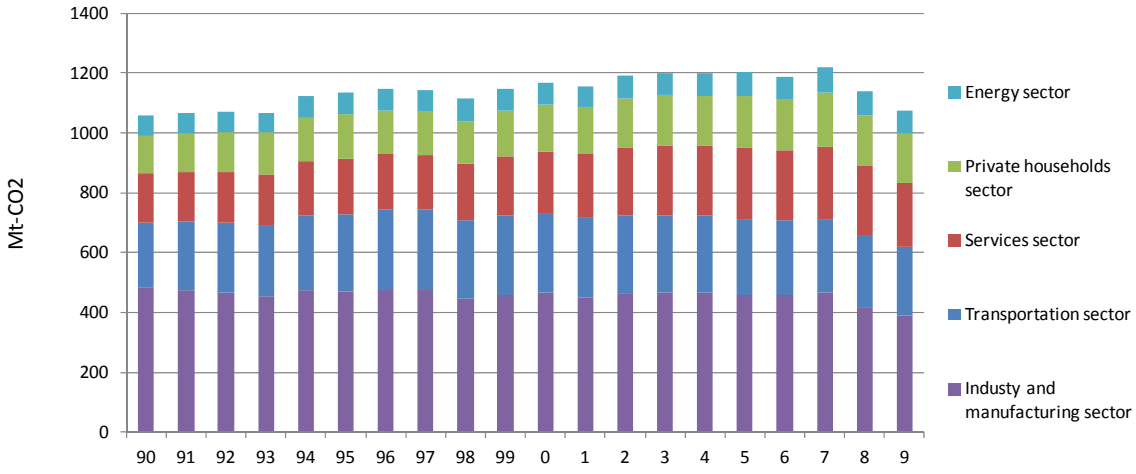

Figure 1-2 CO2 emissions (energy-origin)

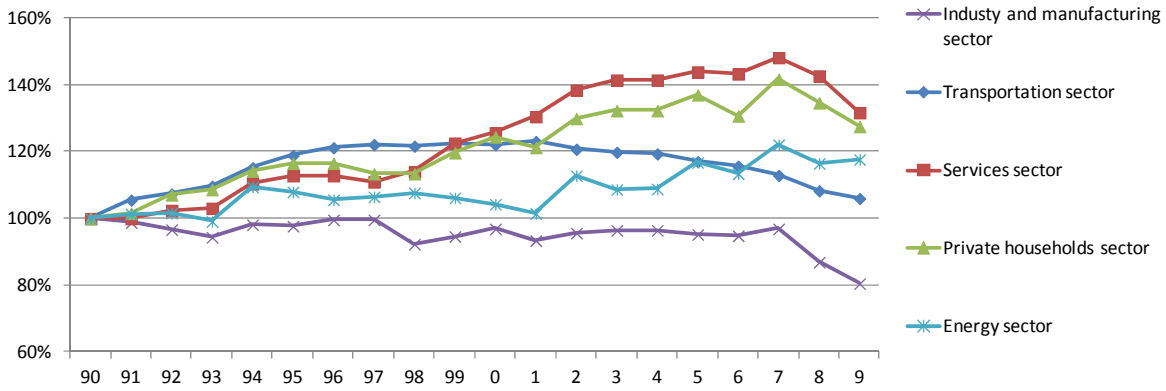

Figure 1-3 Variation of CO2 emissions from 1990 by sector

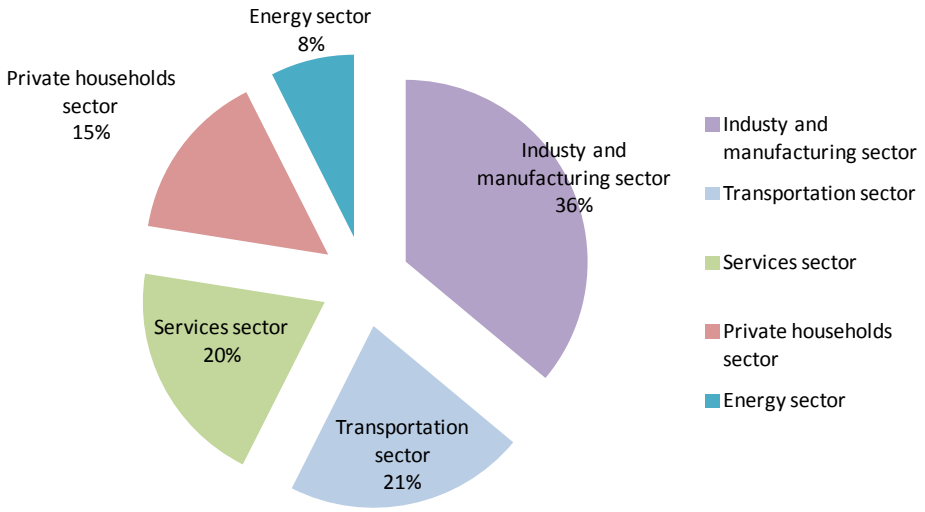

Figure 1-4 Breakdown of CO2 emissions by sector

1.4 Total domestic energy production

(1) Total supplies of primary energy

The total supplies of primary energy[1-9] (primary energy domestic production + imports) in fiscal year (FY) 2009 amounted to 21,752PJ (crude oil conversion 562 million kl), which was a 6.3% decrease compared to the previous fiscal year. Compared to 1990, it represents an increase of 7.8%. Looking at energy production by source, all sources show a decrease, similar to the domestic primary energy supplies, except nuclear power.

These data also appear to be largely affected by the concurrent economic downturn, similar to CO_2 emissions. Renewable energy and underutilized energy supplies like biomass only total 655PJ, which is 3.0% of total supplies.

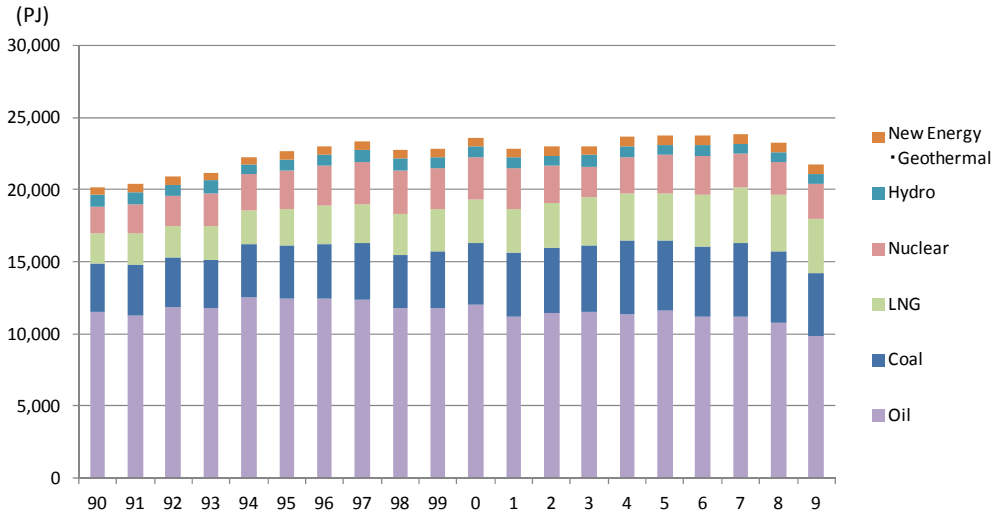

Figure 1-5 Energy production by source from 1990 to 2009

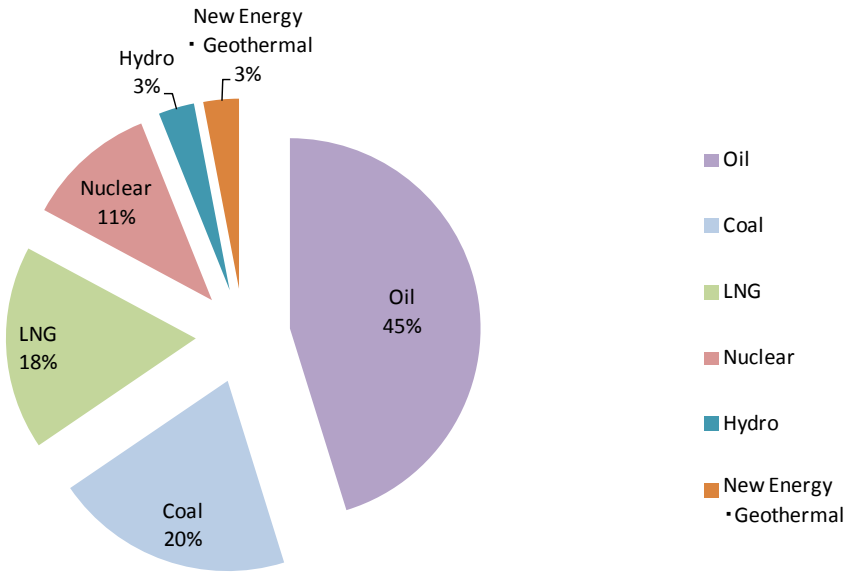

Figure 1-6 Breakdown of energy production by source (2009)

(2) Energy self-sufficiency ratio [1-11)]

Japan relies greatly on energy imports, including 99.6% of its petroleum supplies, 96.7% of its natural gas, and all (100%) of its coal[1-12)]. As such, Japan's energy self-sufficiency ratio in 2008 was only 4% [1-13)], which resulted from production of hydro-electric power, geothermal power, solar power, biomass energy, and so forth.

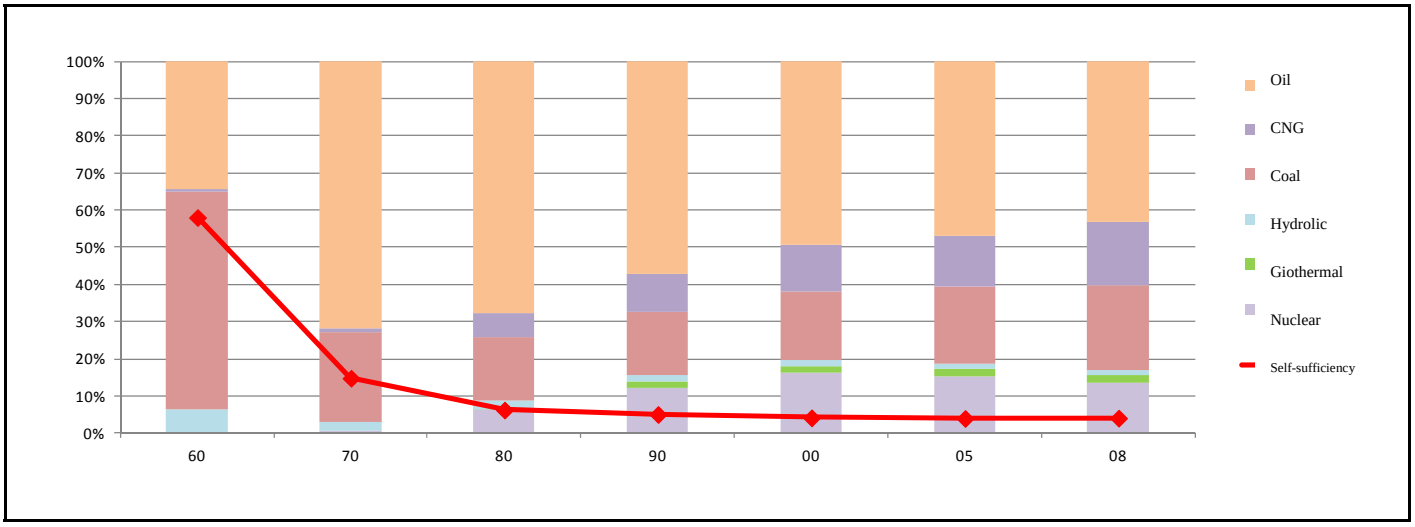

Figure 1-7 Energy self-sufficiency ratio and breakdown of energy production by source

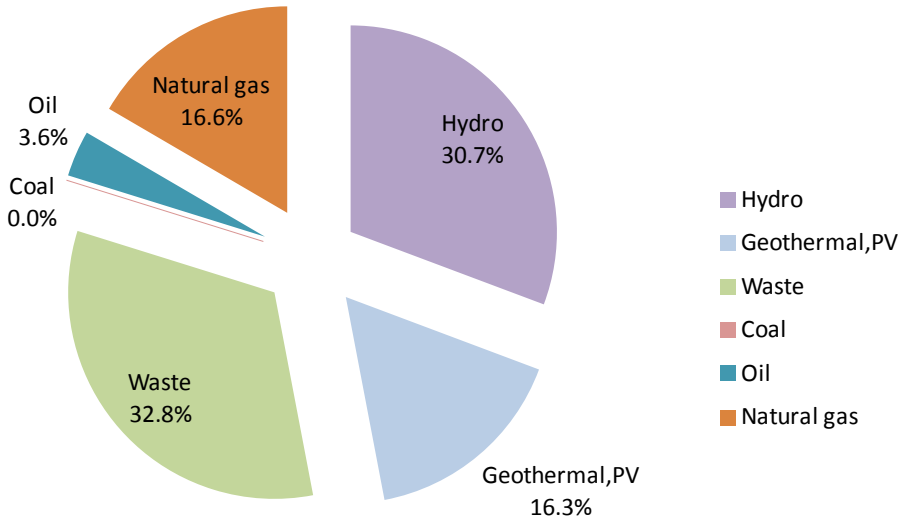

Figure 1-8 Breakdown of domestic energy production

1.5 Total domestic electricity production

The total electrical energy supplied in Japan was 955TWh in 2009. Electricity generated from renewable sources (hydro-electric and new energy sources) was 88TWh in 2009. Of this 88TWh, 18TWh was produced from new energy sources.

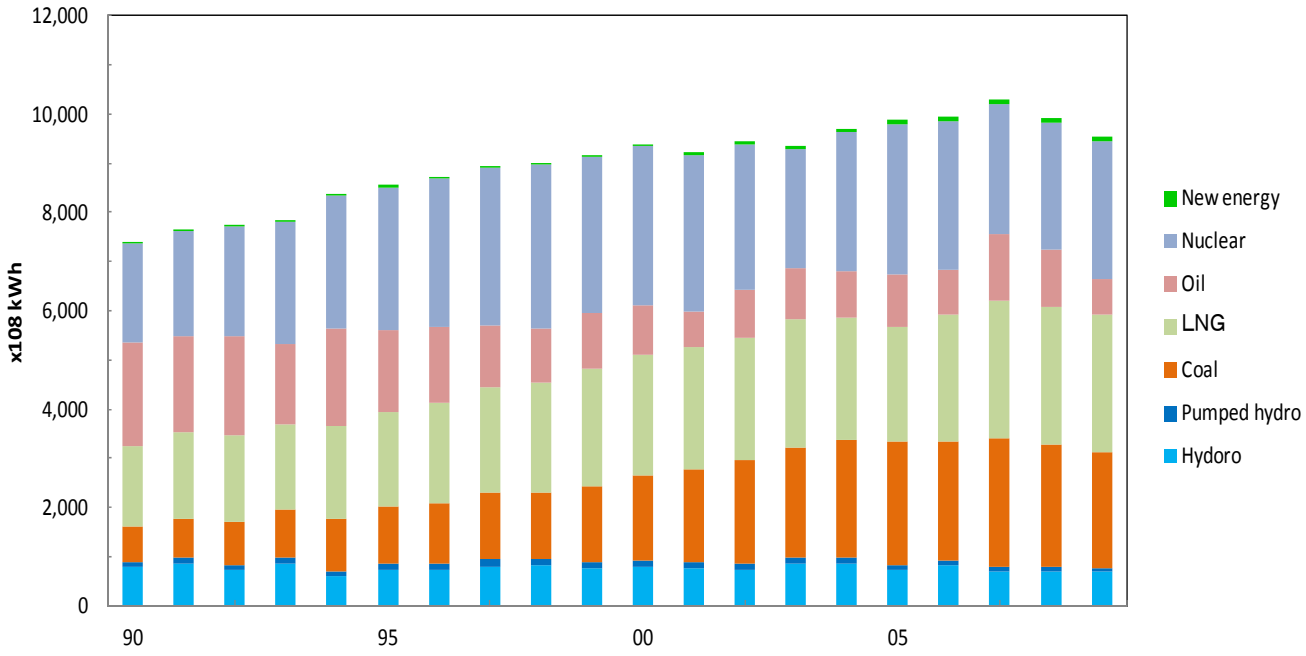

Figure 1-9 Total domestic electricity production

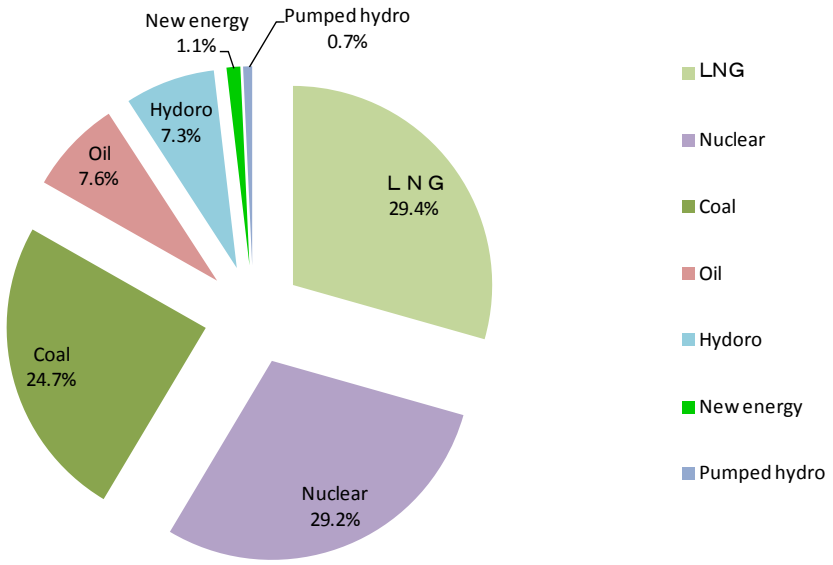

Figure 1-10 Total domestic electrical energy production (2009)[1-14)]

1.6 Domestic energy consumption [1-15)]

The latest energy consumption data for FY2009 showed a decrease of 2.2% to 14,394PJ (crude oil equivalent = 372 million kl), compared to the previous year, due to the ongoing economic downturn carrying over from 2008. Compared to 1990, this represents an increase of 3.6%.

By sector we see the following results. Due to a significant reduction in production activities (8.9% decrease in the mining and manufacturing production index), energy consumption by the industrial sector declined by 1.9%. In the civilian sector, which is easily influenced by seasonal temperatures, the mean temperature was slightly lower both in summer and winter, compared to 2008 averages. Thus air-conditioning needs decreased, heating and hot water supply loads increased, which all resulted in a 1.0% decrease due to introduction of energy saving appliances and a decrease in basic usage due to the economic downturn.

Moreover, the business sectors were also influenced by the crude oil price hikes and the economic downturn. In particular, the drop in demand for petroleum products was so severe that the transportation sector showed a 3.9% decrease.

In the passenger transportation sector, energy consumption showed a 0.2% decrease 8 years in a row, because traffic volume (passenger kilometers traveled) decreased by 3.6%. In the cargo transportation sector the amount of freight transport volume (tonnes, kilos) decreased by 6.4%, thus energy consumption of this sector decreased by 5.1%.

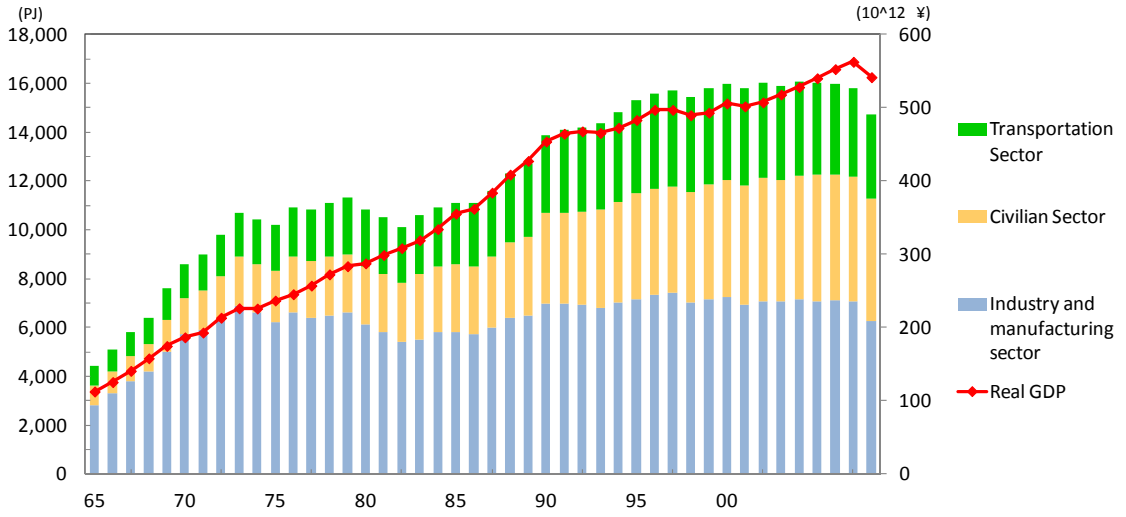

Figure 1-11 Domestic energy consumption (by sector) and real GDP

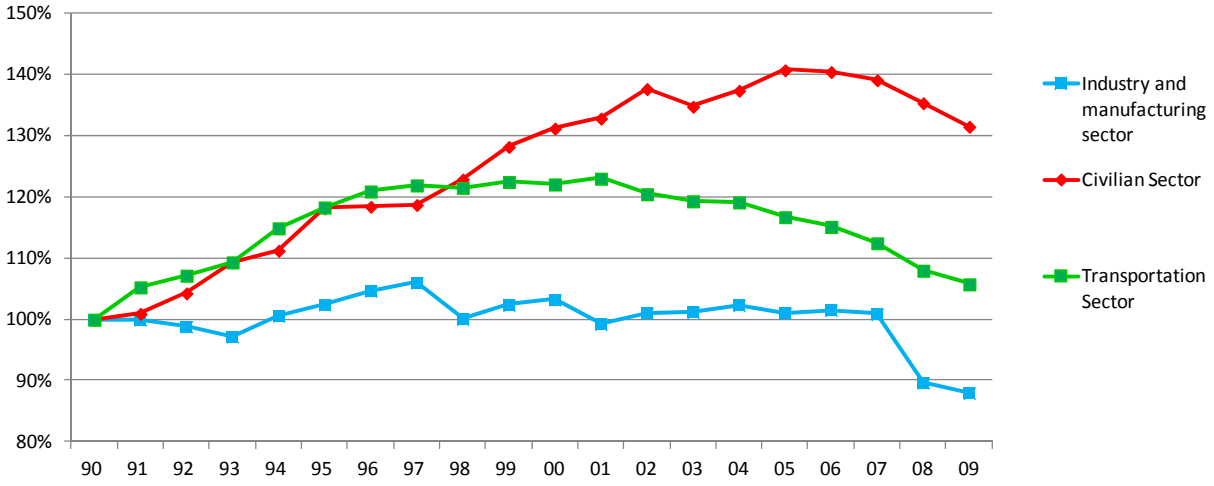

Figure 1-12 Variation in domestic energy consumption by sector

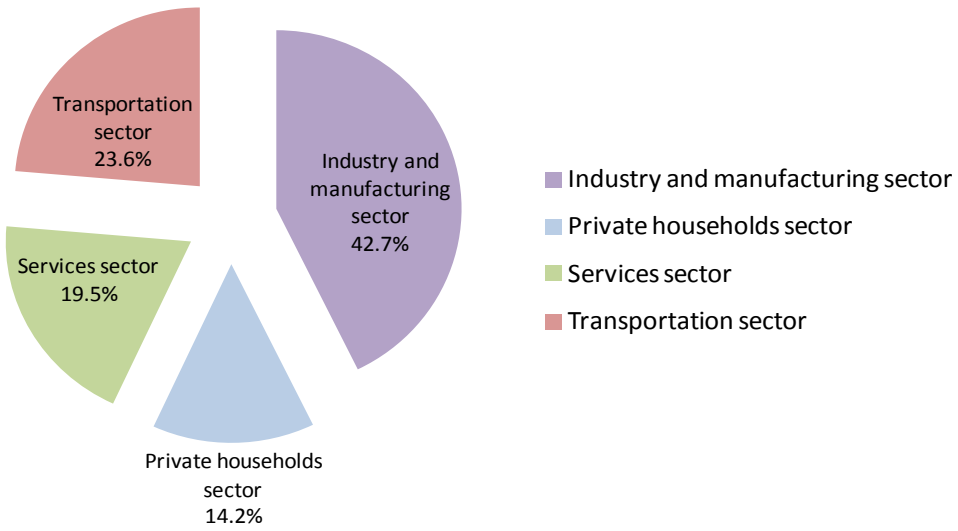

Figure 1-13 Breakdown of domestic energy consumption by sector

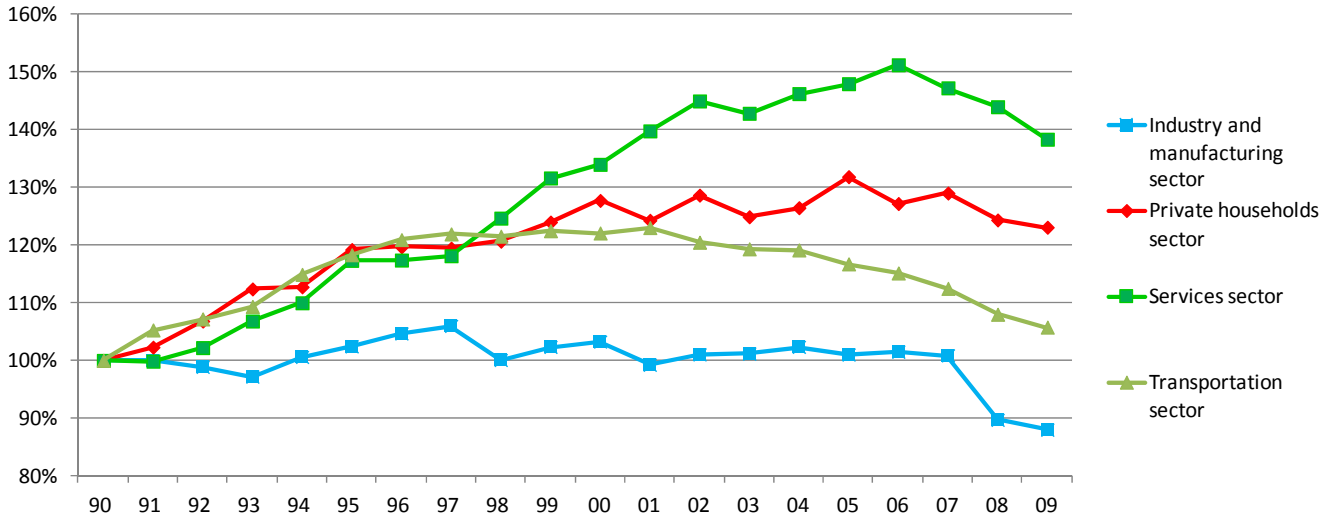

Figure 1-14 Variation in domestic energy consumption by sector

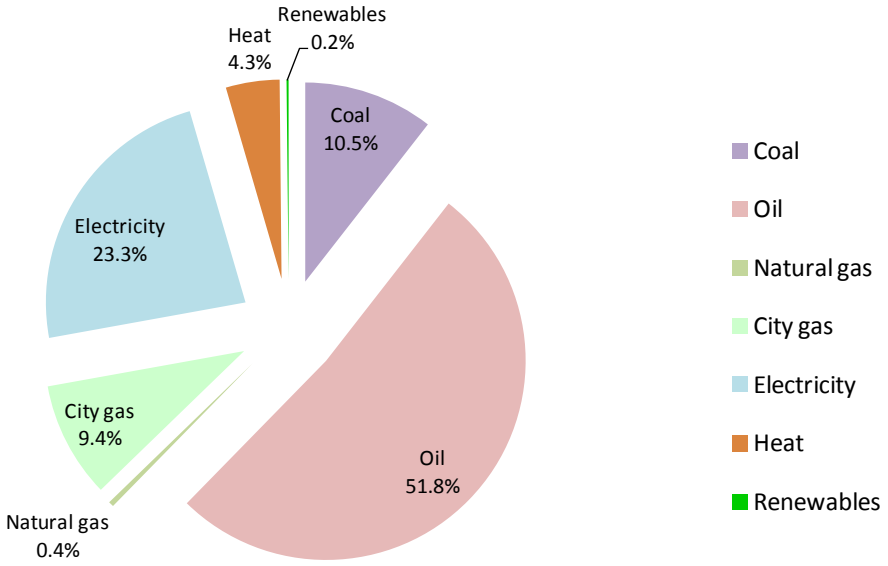

Figure 1-15 Breakdown of domestic energy consumption by energy source

References

1-1) http://www.stat.go.jp/data/nihon/, p2
1-2) http://www.stat.go.jp/data/nihon/, p8-9
1-3) http://www.stat.go.jp/data/nihon/, p6-7
1-4) http://www.stat.go.jp/data/nihon/
1-5) http://www.maff.go.jp/j/shokusan/biomass/b_kihonho/pdf/keikaku.pdf ,p10
1-6) http://law.e-gov.go.jp/htmldata/H11/H11F03701000074.html
1-7) http://www.stat.go.jp/data/nihon/, p93,7-10
1-8) http://www.enecho.meti.go.jp/info/statistics/jukyu/resource/pdf/110426_honbun.pdf ,p48
1-9) http://www.enecho.meti.go.jp/info/statistics/jukyu/resource/pdf/110426_honbun.pdf
1-10) http://www.enecho.meti.go.jp/info/statistics/jukyu/resource/pdf/110426_honbun.pdf
1-11) http://www.enecho.meti.go.jp/info/statistics/jukyu/resource/pdf/110426_honbun.pdf, p47
1-12) http://www.enecho.meti.go.jp/topics/hakusho/2011/2-1.pdf, p93,96,99
1-13) http://www.enecho.meti.go.jp/topics/hakusho/2011/2-1.pdf, p82

1-14) http://www.enecho.meti.go.jp/info/statistics/jukyu/resource/pdf/110426_honbun.pdf
1-15) http://www.meti.go.jp/press/2011/04/20110426003/20110426003.html

2. Energy policy

Reffer the website of New Energy Fundation.
http://www.nef.or.jp/

3. Biomass resources

Most biomass energy generation in Japan is derived from livestock waste, followed by sewage sludge. However, as crude oil equivalent, the greatest energy generation is from waste paper, then livestock waste. The largest unutilized existing waste energy stream is sewage sludge, followed by food waste. In terms of crude oil equivalent unutilized waste energy, wood left in forests is first, followed by waste paper.

Table 3-1 Biomass potentials in Japan

Biomass types	Generation per year(tonnes)	Oil equivalent(0000kl)	Contemporary utilization ratio	Target utilization ratio
Live stock wastes	88,000,000	909	90%	90%
Sewage sludge	78,000,000	64	77%	85%
Black liquor	14,000,000	456	100%	100%
Waste paper	27,000,000	1082	80%	85%
Food waste	19,000,000	273	27%	40%
Scrap lumber	3,400,000	157	95%	95%
Scrap of houses	4,100,000	189	90%	95%
Agricultural waste	14,000,000	413	30% (85%)	45% (90%)
Wood left in forest	8,000,000	347	0%	30%
Total	255,500,000	3,890	75%	81%

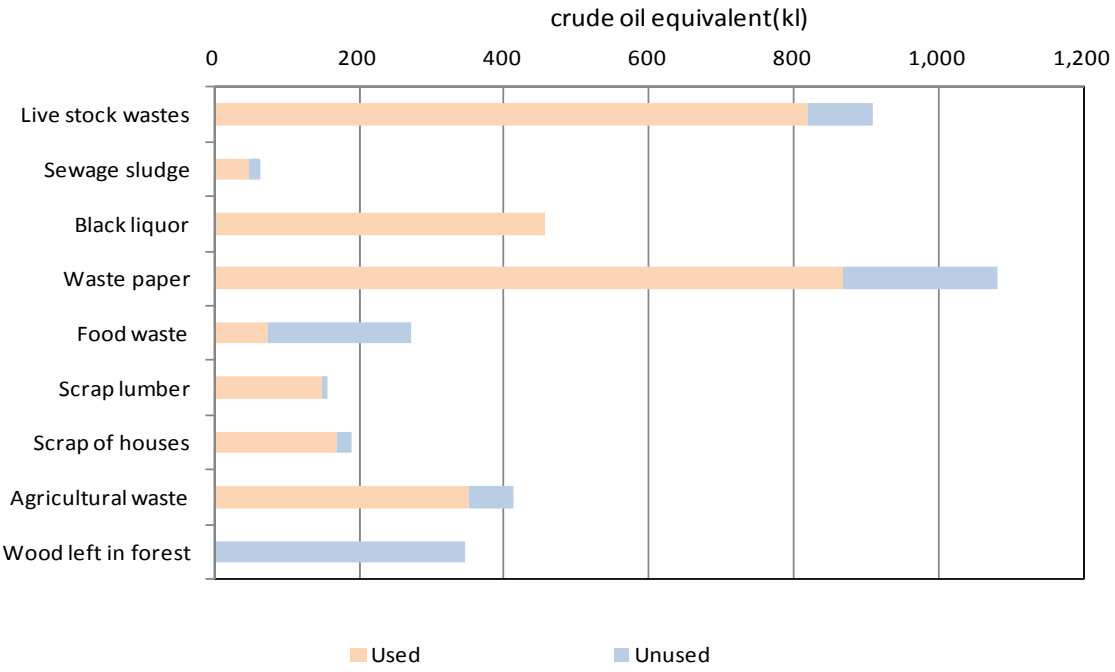

Figure 3-1 Utilized and unutilized biomass energy potential in Japan

Moreover, based on the New Energy and Industrial Technology Development Organization (NEDO) public report entitled "Biomass abundance, usable water ~ GIS database" the amount of potential energy resources is summarized in Figure 3-2.

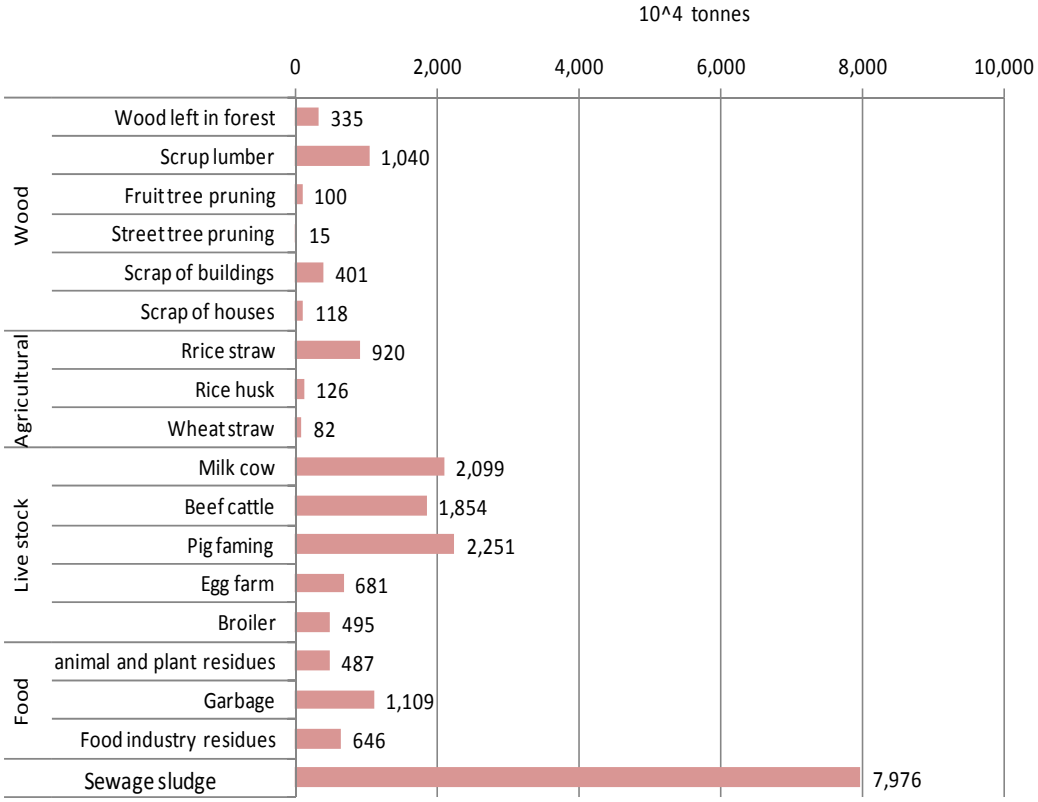

Figure 3-2 Biomass potential energy sources in Japan[3-1)]

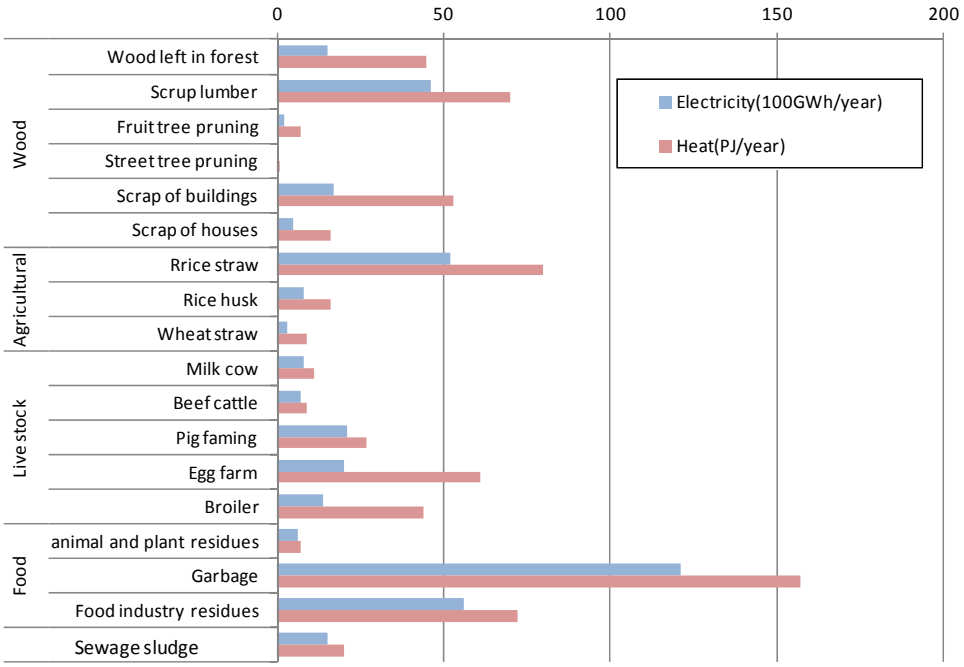

Figure 3-3 Electrical and heat equivalent potential biomass energy sources

References

3-1) http://www.maff.go.jp/j/shokusan/biomass/b_kihonho/pdf/keikaku.pdf, p11-12
3-2) http://www.env.go.jp/earth/report/h22-05/chpt3.pdf, p150-151

4. Current and expected biomass energy utilization

4.1 Current biomass energy usage

(1) Energy Usage

Regarding biomass energy utilization, 2009 data showed thermal usage was 171kL crude oil equivalent, and power generation totaled 186kL crude oil equivalent, for a total of 357kL. Power generation usage benefited from enactment of the Renewable Portfolio Standard, or RPS law (2002), after which it reached about eight times the 2002 value. Thermal utilization has been expanding up to 2006, after which it plateaued.

Biomass energy utilization tends to be low-density in nature[4-1)], but it also has the characteristic of being spread over a wide range. Energy sources compatible with "local production for local consumption" applications related to agriculture, forestry and fisheries, or other labor-intensive practical uses, have also been studied.

In order to promote ongoing expansion of biomass energy usage, several efforts must be made. Cost constraints must be overcome (collection and transportation cost), high added value of energy consumption, efforts must be made in both regulatory measures and support measures, positive

positioning of distributed type energy utilization, and regional labor-intensive tasks must be supported.

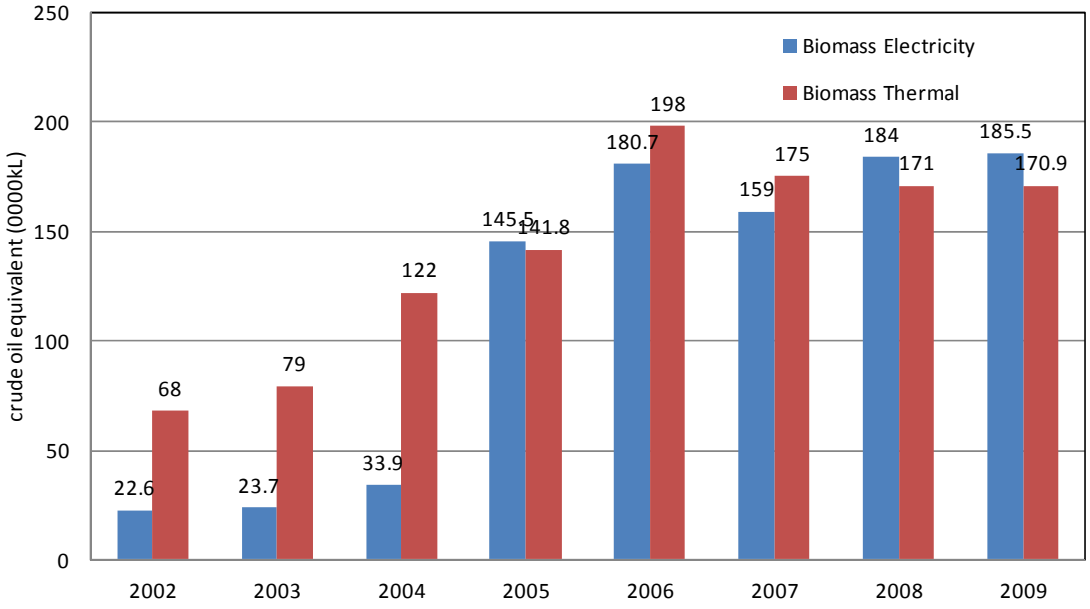

Figure 4-1 Crude oil equivalent electrical and thermal biomass energy utilization

(2) Breakdown of energy usage

① Biomass power generation

Actual utilization of biomass power is broken down as follows. General municipal waste power generation (accounting for the biomass portion only) accounts for 53%. Next, the power generation industry accounts for 13%, scrap lumber power generation accounts for 3%, and the paper industry (excluding black liquor and waste materials) accounts for 2%. In addition, biomass power generation by equipment that was certified under the RPS law accounts for another 36% of the total[4-2)] (this excludes solar power generation equipment).

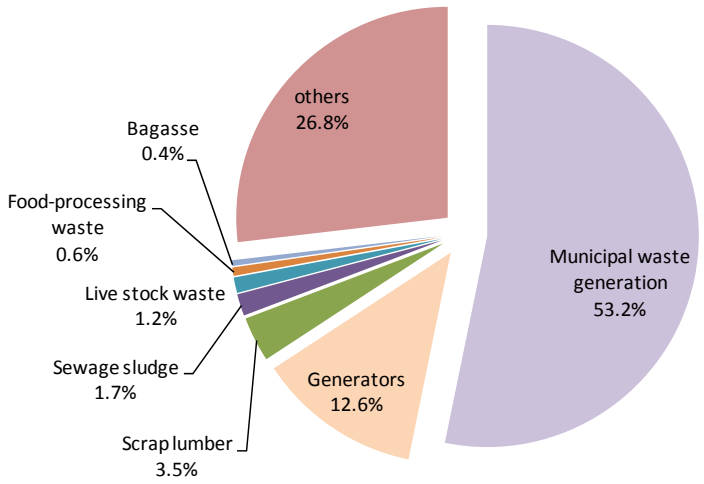

Figure 4-2 Electrical biomass energy sources (2009)

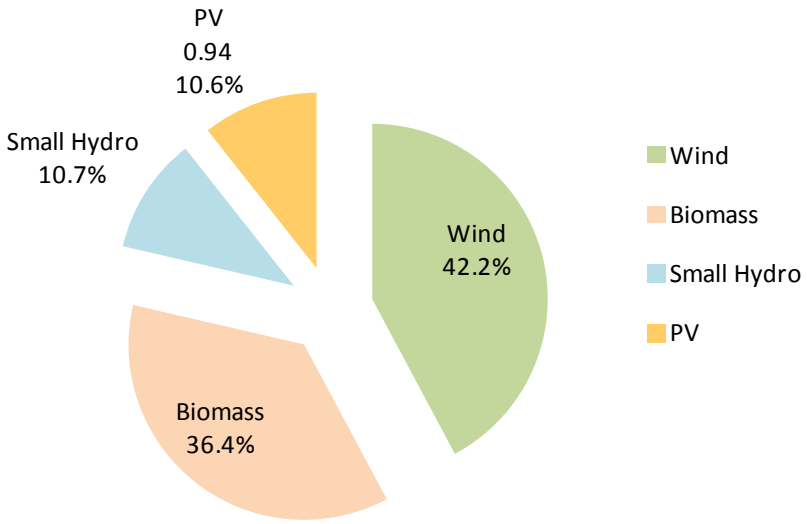

Figure 4-3 New energy sources (2009)

②Thermal biomass energy utilization

Looking next at a breakdown of thermal biomass energy utilization, general waste power generation amounts to 31% of the total. Next, scrap lumber based energy accounts for 18%. Other sources account for smaller amounts.

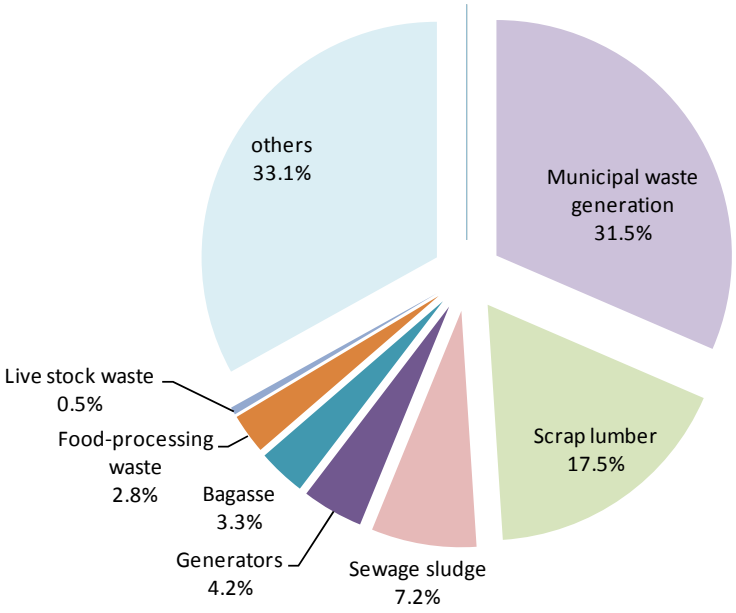

Figure 4-4 Thermal biomass energy sources

③ Biofuels

The majority of biofuels distributed in Japan are bio-ethanol (ETOH) and biodiesel fuel (BDF). Production volume of bio-ethanol totals about 30kL/year as of year-end 2005, while BDF production is estimated at 4,000~5,000kL/year[4-3)].

4.2 Trend analysis of domestic production and consumption for 2010 to 2015

(1) Biomass power generation for thermal utilization

In the Japan Environment Ministry document "A Proposal for Low Carbon Energy Sources to Enable a Low Carbon Society"[4-4)] the Low Carbon Energy Investigation Committee outlines many ways to create a low carbon society. This overall medium-term to long-term road map generated by the Energy Supply Working Group includes global warming countermeasures, and was introduced in March, 2010. Formal implementation is expected in 2020 with medium-term (2030) and long-term (2050) implementation targets included. Additionally, in order to achieve these medium-long targets, a fixed purchase price system is one measure planned to support proliferation of renewable power. The "Green Heat" certification system is another planned support measure for renewable thermal energy. Then in order to achieve our targets, necessary support measure costs (purchase prices, "Green Heat" certification, etc.) and other necessary costs are estimated.

The fixed price acquisition system has already been implemented for solar power, beginning November, 2009. Other renewable electric power sources are also expected to be initiated in fiscal year 2012.

Table 4-1 Required level of financial support

	Required level of feed-in tariff	Total amount of finance expenditure (2010 value)
Biomass and municipal waste energy generation	21.8 yen/kWh (2010-2020)	0.9 trillion yen
Thermal biomass, Biomass fuel production	2.0 yen/MJ	1.07 trillion yen

(2) Domestic biofuel production limits[4-5)]

In effort entitled "Production Expansion of Biofuel" by the Biomass Nippon Total Strategy Promotion Meeting, February of 2007, the maximum possible production in an ultra-long-term perspective is predicted. The document states that "If development of collection and transportation methods for raw materials like rice straw, along with development of crops to produce large quantities ethanol, and development of technology to produce large volumes of ethanol from rice straw and wood are all achieved, it is expected that 600 million kL (crude oil equivalent 360 million kL) of domestic biofuel production is possible by 2030". This corresponds to about 10% (by volume) of gasoline sales[4-6)] in Japan. The breakdown by feedstock and concept are shown in Table 4-2.

Table 4-2 Possible quantity of domestic biofuel production (MAFF)

Raw materials	Possible quantity in 2030 (EtOH equivalent)	Possible quantity in 2030 (Crude oil equivalent)
1. Sugars, Starch (low-cost off-specification materials, etc)	50,000kl	30,000kl
2. Herbaceous biomass (Rice straw, wheat straw, etc)	1,800,000～2,000,000kl	1,100,000～1,200,000kl
3. Energy crops	2,000,000～2,200,000kl	1,200,000～1,300,000kl
4. Woody biomass	2,000,000～2,200,000kl	1,200,000～1,300,000kl
5. Biodiesel fuel (BDF)	100,000～200,000kl	60,000～120,000kl
Total	6,000,000kl	3,600,000kl

References

4-1) http://www.meti.go.jp/committee/materials2/data/g90213dj.html
http://www.meti.go.jp/committee/materials2/downloadfiles/g90213d06j.pdf
4-2) http://www.nedo.go.jp/library/ne_hakusyo_index.html, p195
4-3) http://www.maff.go.jp/j/shokusan/biomass/b_energy/pdf/kakudai01.pdf, p4
4-4) http://www.nedo.go.jp/library/ne_hakusyo_index.html, p193
4-5) http://www.env.go.jp/earth/report/h22-05/chpt3.pdf , p157-164
4-6) http://www.paj.gr.jp/statis/

5. Current biomass consumption

5.1 Biomass usage patterns

Classification of biomass resources and main energy usage patterns are represented in the following discussion[5-1)].

As consumers of biomass energy resources, on the one hand we have energy generators (who use biomass resources as raw materials for energy conversion), and on the other hand we have final energy users. Energy generators include electrical power generation companies (regional electric companies, wholesale electric power companies, smaller scale electric companies, and so forth[5-2)]), solid fuel producers (e.g. wood pellets), liquid fuel producers (e.g. ethanol, biodiesel). Bioenergy manufacturing companies are included in this category.

As final consumers, electricity is transmitted to homes, businesses, and industrial sectors through regional electric companies, solid fuels go to residential and business sectors, and liquid fuel is mainly used as transportation fuel. One must also not overlook the relatively large-scale biomass energy use by the paper-making and lumber industries since this is self-generated usage. Other biomass energy forms are solid fuels (wood chips and pellets) and liquid fuels (BDF) which are utilized mainly by small-scale consumers.

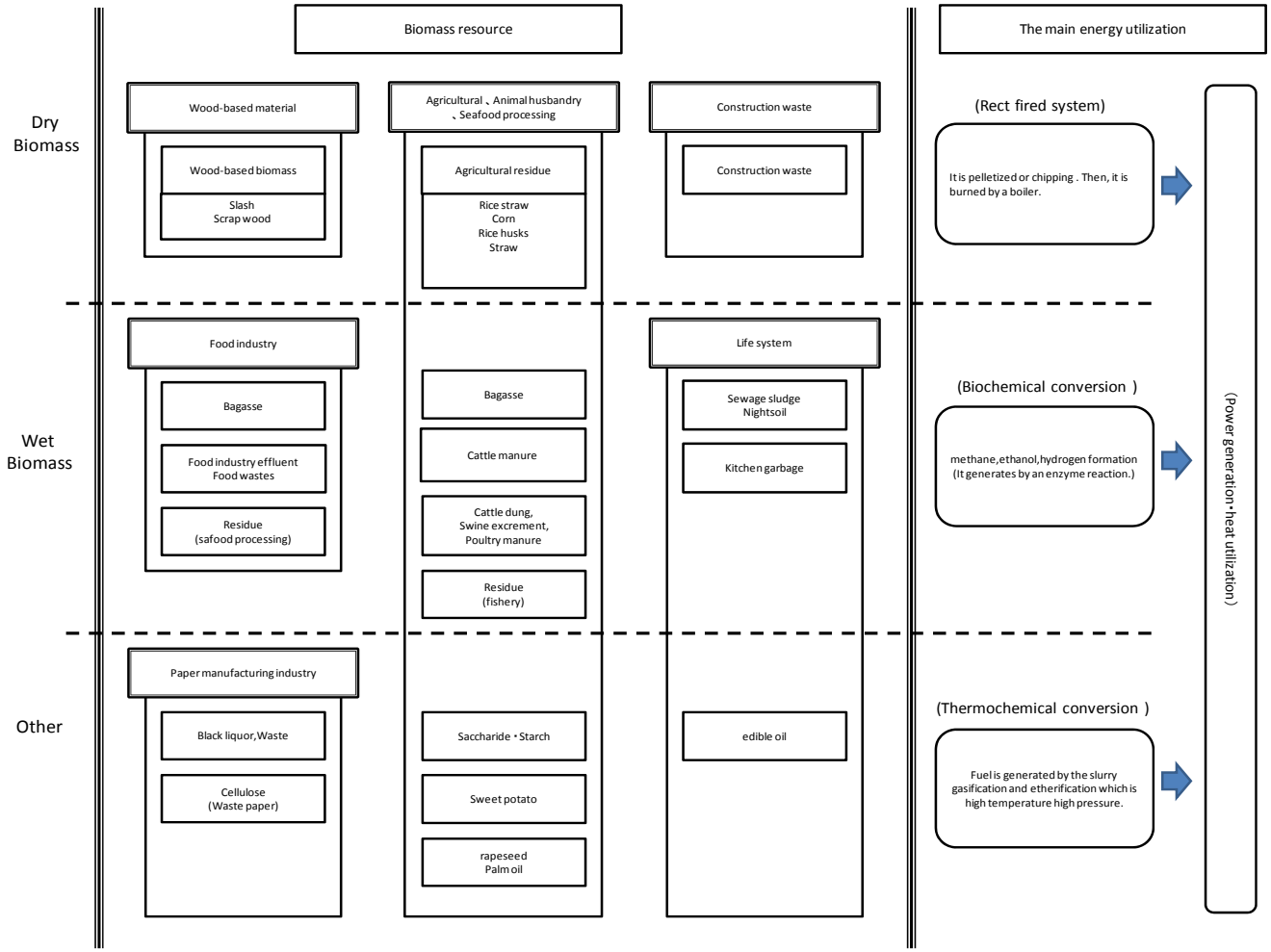

Figure 5-1 Biomass resources and energy utilization[5-3)]

5.2 Biomass energy utilization by main purpose

(1) Biomass Power Generation

Several forms of biomass power generation have been traditionally utilized in Japan. Direct power generation by combustion of general waste, power generation from methane fermentation of sewage sludge, and power generation by direct combustion of black liquor waste in the paper-pulp industry. More recently we have power generation by direct combustion of sawmill waste materials and construction waste or forestry thinnings, power generation by methane fermentation of livestock manure, and power generation by methane fermentation of food waste [5-4)].

Utilization of woody biomass has mainly revolved around power generation (direct combustion power generation) using construction waste at medium to large scale sawmills, and in power generation via gasification of biomass. Case studies have been gradually coming out on these applications.

Moreover, methane fermentation systems for livestock manure have recently been developed. The standard installation is a small-scale self-contained system that can process livestock manure into biogas and digestate. However, there are other systems that allow food waste to be added. In addition, there are

other digester systems that process sewage sludge, human waste, and kitchen waste[5-5].

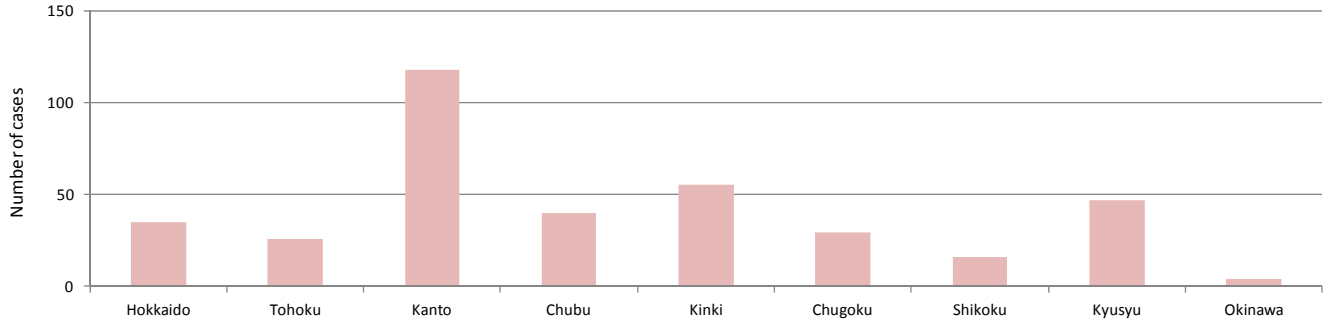

Figure 5-2 Number of biomass power generation plants (by region)

(2) Number of certified installations and breakdown by region

The total number of facilities certified under the Renewable Portfolio Standard (RPS) law, as of October 31, 2011, is shown in Fig. 5-2 and 5-3. The plots show how the plants are distributed in Japan by number and generating capacity[5-6]. The total number of RPS certified biomass power generation plants was 370 at the time of writing. The corresponding total output of 2,246,915kW is obtained by multiplying the calorific proportion of the biomass fuels by the total mass of biomass fuels consumed. By region, the Kanto region has the most both in the number of plants and the total output. This is because waste power generation will be concentrated in regions of higher population density, in this case around the Tokyo metropolitan area.

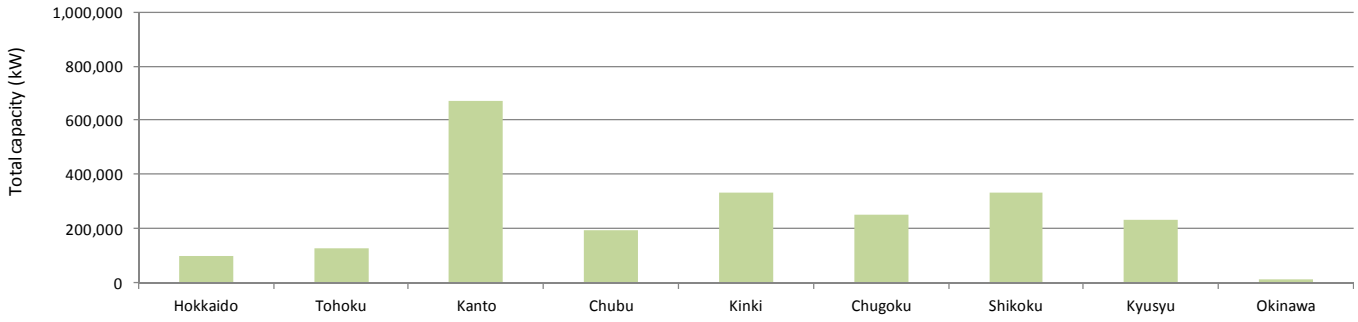

Figure 5-3 Total capacity of biomass power generation plants (by region)

(3) General waste power generation plants

In Japan, "waste" is defined by the law (Law on Processing and Cleaning of Waste[5-7]) and waste material is classified into two categories of "general waste" and "industrial waste". "General waste" must be collected, processed, and disposed by the local municipality. There are instances that power generation is carried out at these general waste-processing installations. These power generation systems employ captive-consumption within the plants, while surplus power is sold to the local electric company and is supplied to general public through the power grid. There are about 250 RPS certified facilities, accounting for about 2/3 of the total certified number of plants.

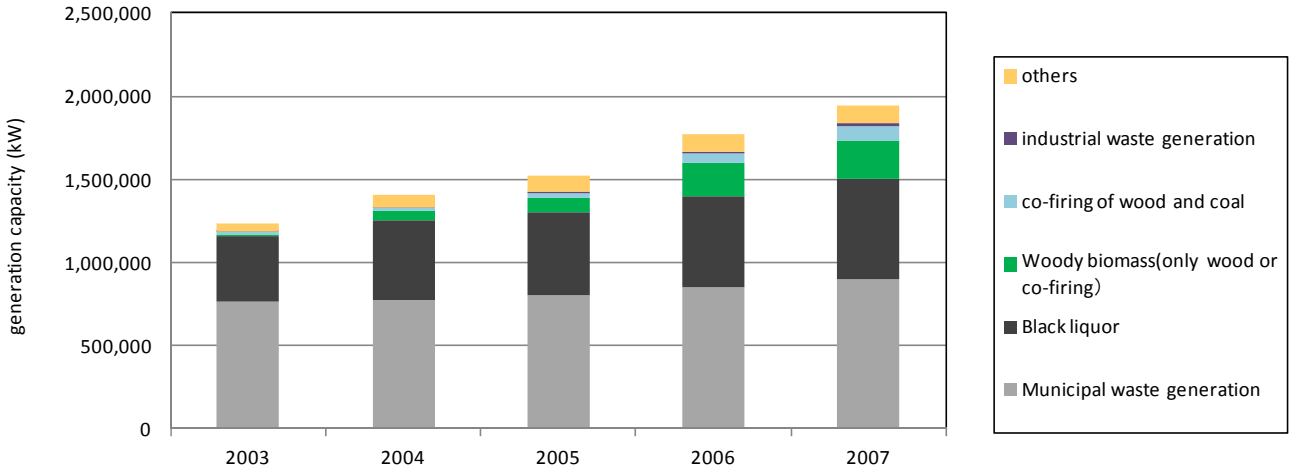

Figure 5-4 Development of total capacity of biomass power generation plant (certified by RPS)[5-8)]

(4) Woody biomass power generation plants

Forests account for more than 60% of Japan's land area, and forestry and wood processing industries have been carried out nationwide. These forestry and wood processing industries generate scrap material and other woody biomass, such as construction and demolition waste. Power generation is carried out using these materials and woody biomass. Particularly, after the RPS law was enacted (April 1, 2003), growth of woody biomass power generation and mixed wood/coal-fired thermal power generation has been remarkable [5-9)].

When biomass is used for power generation, the business structure can take on several forms. When the plant uses scrap materials produced by a number of wood processing plants, the power output tends to be several hundred to several thousand kilowatt. Surplus electric power, over and above self-generation needs, is typically sold on the grid. In case of woody biomass fired power generation, there are many cases that electric power companies (like specific electric companies) take on the principal role, provide construction waste as the raw material, and perform power generation on a scale of several thousand to 10,000kW.

In some cases, wood chips or pellets are mixed with coal, and used as fuel. These power plants are typically owned and operated by electric companies. In most cases the biomass fuel mix ratio is several percent based on energy content. However, several thousand tons per year of biomass is typically necessary for power generation, thus in order to ensure stable supply of fuels, it is not uncommon to import it from abroad. Moreover, sewage sludge has also been investigated as a mixed combustion biomass fuel[5-10)]. Technically, a majority of power plants utilize the direct combustion steam turbine power generation method. In addition, a number of the smaller hundred to thousand kilowatt size power plants utilize a gasification method[5-11)].

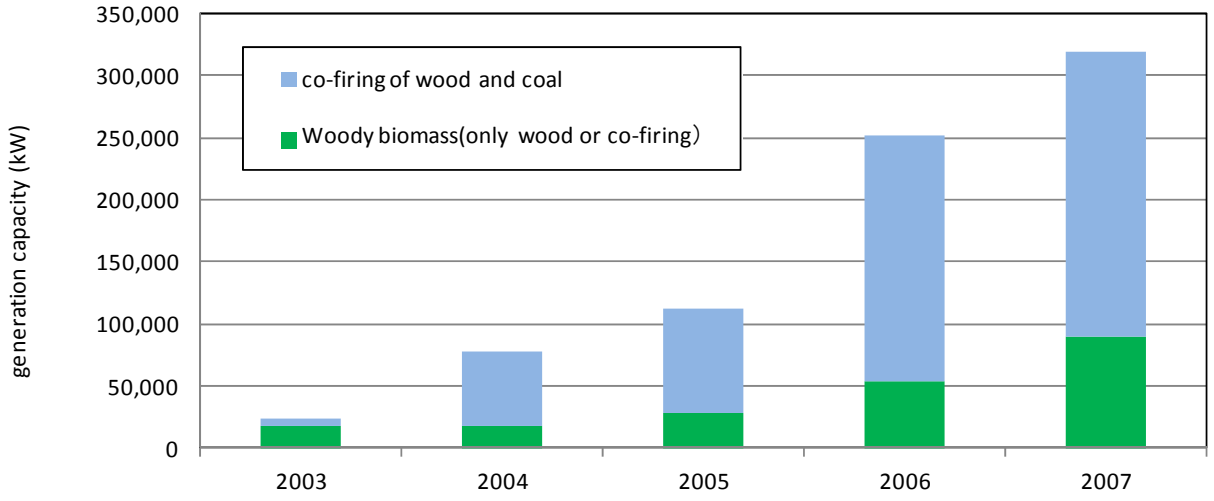

Figure 5-5 Growth in total capacity of RPS certified woody biomass power generation plants[5-12)]

Table 5-1 Co-fired power generation in Japan using wood and coal

	Electric power company	Site	Capacity(kW)	Mixing rate	Biomass amount	Type of material
①	Tokyo Electric Power Co.,Inc.	Hitachinaka	700,000	3wt%	70,000t	Wood pellets、Vegetable oil pomace pellet
②	Chubu Electric Power Co.,Ltd.	Hekinan	4,100,000	2 wt%	300,000t	Wood chip
③	Hokuriku Electric Power Co.	Tsuruga	700,000	3 wt%	15,000t	Bark、Waste wood
④		Nanao Ota	700,000	3 wt%	20,000t	Bark、Waste wood
⑤	Kansai Electric Power Co.,Inc.	Maizuru	900,000	3 wt%	60,000t	Wood pellet
⑥	Chugoku Electric Power Co.,Inc.	Misumi	1,000,000	3 wt%	30,000t	Slash
⑦	Chugoku Electric Power Co.,Inc.	Shin onoda	1,000,000	3 wt%	25,000t	deforestation tree 、Slash
⑧	Shikoku Electric Power Co.,Inc.	Saijo No. 1	406,000	2 wt%	15,000t	The bark of the cedar and cypress which occur at the Forest owner's cooperative and sawmill in Shikoku
⑨		Saijo No. 2		3 wt%		
⑩	Kyushu Electric Power Co.,Inc.	Reihoku	1,400,000	1 wt%	15,000t	Slash
⑪	Okinawa Electric Power Co. Inc.	Gushikawa	312,000	3 wt%	20,000t	Scrap wood、Pruned branch pellet
⑫	Electric Power Development Co.,Ltd	Matsuura	2,000,000	0.4 wt%	25,000t	Scrap wood chip、Slash pellet

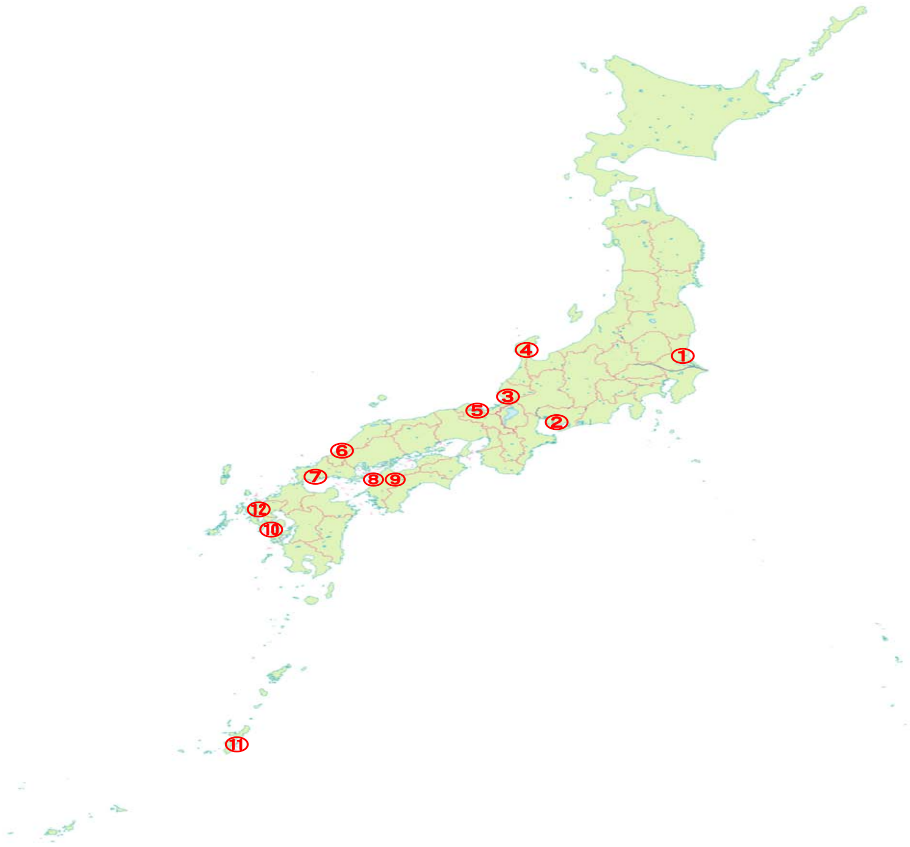

Figure 5-6 Co-fired power plants in Japan using wood and coal

Table5-2 Major wood biomass power generation plants in Japan

	Prefecture	Contractor	Power plant name	Starting operation	Output
①	Kanagawa	Kawasaki biomass Power Co.	Kawasaki biomasspower plant	2010	33,000
②	Ibaraki	Gonoike Bioenergy Corporation	Gonoike Bioenergy power plant	2008	21,000
③	Gunma	Agatsuma Bio Power Co.,Ltd.	Agatsuma biomass power plant	2010	13,600
④	Oita	Hita Wood Power Company	Hita power plant	2006	12,000
⑤	Fukushima	Shirakawa Wood Power Company	Daishin power plant	2006	11,500
⑥	Yamaguchi	Iwakuni Wood Power Company	Iwakuni power plant	2005	10,000
⑦	Osaka	Japan novopan industrial Co.,Ltd.	Japan novopan woody biomass power plant	2007	6,500
⑧	Hiroshima	WOOD ONE CO.,LTD.	Wood one power plant	1998	5,900
⑨	Hiroshima	Cyuugoku wood Co.	(Cyuugoku wood)Head Office Factory woody biomass power plant	2005	5,300
⑩	Ibaraki	Katsutakankyoh Corporation	Katsuta woody biomass Power plant	2005	4,990
⑪	Hokkaido	Tubetu tanita cooperative	Tubetu tanita cooperative Biomass Energy Centre	2007	4,700

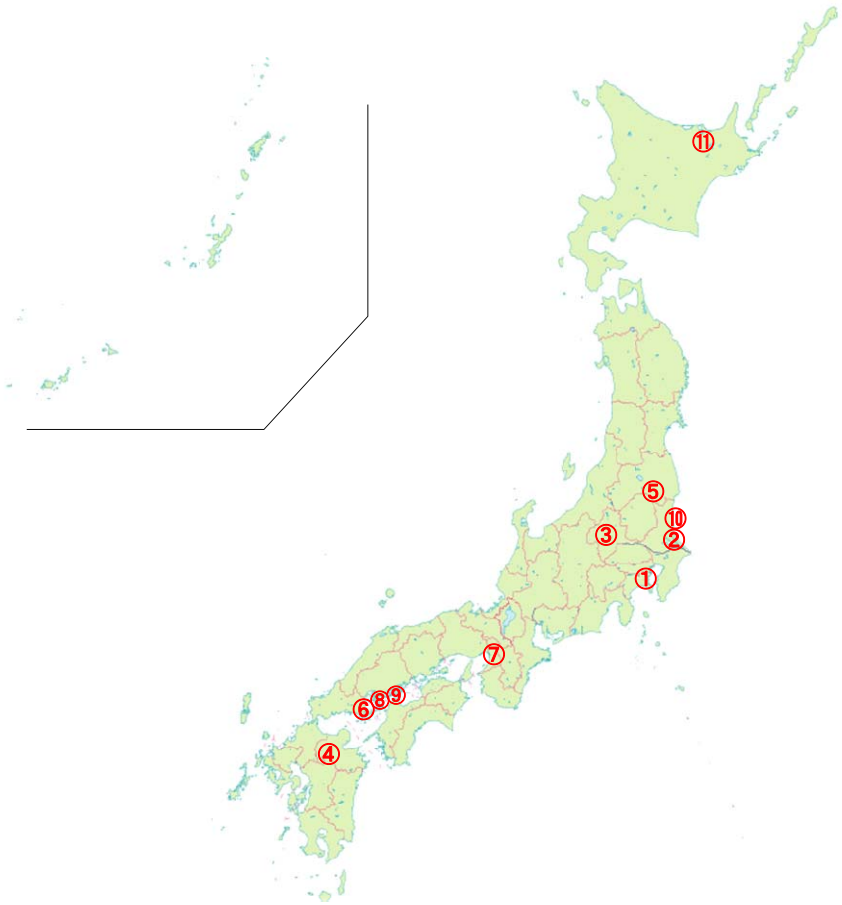

Figure 5-7 Major wood biomass power generation plants in Japan

(5) Black liquor power generation

Black liquor generated in Japan's paper industry is utilized for energy at a rate of almost 100%. It is self-used by collecting, preparing, and burning the black liquor by-product in a steam boiler, which then generates power and heat (for drying the paper, for instance). Actual results from fiscal year 2010, 35% of the energy requirements of the paper pulp industry is supplied by black liquor combustion[5-13]. In addition, power generation using other waste materials is also carried out.

Table 5-3 Major black liquor power generation plants in Japan

	Prefecture	Contractor	Power plant name	Starting operation	Output
①	Ehime	Daio Paper Corporation	Daio Paper Corporation Mishima plant power plant	2001	524,110
②	Hokkaido	Oji paper Co., Ltd. Tomakomai plant	Oji paper Co., Ltd. Tomakomai plant steam power plant	2005	268,150
③	Ehime	Marusumi Paper Company	Ooe plant 汽力 power plant	1980	145,900
④	Tottori	Oji paper Co., Ltd. Yonago plant	Oji paper Co., Ltd. Yonago plant power plant	1998	119,000
⑤	Shizuoka	Tokai-Pulp&Paper Co., Ltd.	Shimada plant steam power plant	1968	101,250
⑥	Hiroshima	Oji paper Co., Ltd. Kure plant	Oji paper Co., Ltd. Kure plant power plant	1996	82,600
⑦	Hyogo	HYOGO PULP Co.,Ltd.	Tanikawa plant steam power plant	1993	70,700
⑧	Miyazaki	Oji paper Co., Ltd. Nichinan plant	Nichinann steam power plant	2006	60,800

⑨	Ibaraki	HOKUETSU KISHU PAPER CO., LTD.	HOKUETSU KISHU PAPER CO., LTD Kantou plant katuta power plant	2006	48,100
⑩	Oita	Oji itagami Co., Ltd. Ooita plant	Oji itagami Co., Ltd. Ooita plant power plant	2009	42,800
⑪	Fukushima	IWAKI DAIO PAPRER COPORATION	IWAKI DAIO PAPRER COPORATION steam power plant	2010	40,760
⑫	Shizuoka	TAIKO PAPER MFG.,LTD.	Secundo steam power plant	1994	35,000
⑬	Fukushima	Nippon Paper Group, Inc. Nakoso plant	Nippon Paper Group, Inc. Nakoso plant	2004	26,500
⑭	Saga	Oji itagami Co., Ltd. Saga plant	Saga plant steam power plant	2006	25,200

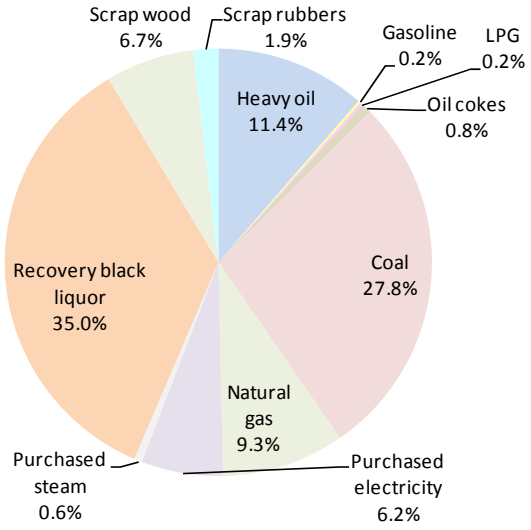

Figure 5-8 Energy sources for paper manufacturing[5-14)]

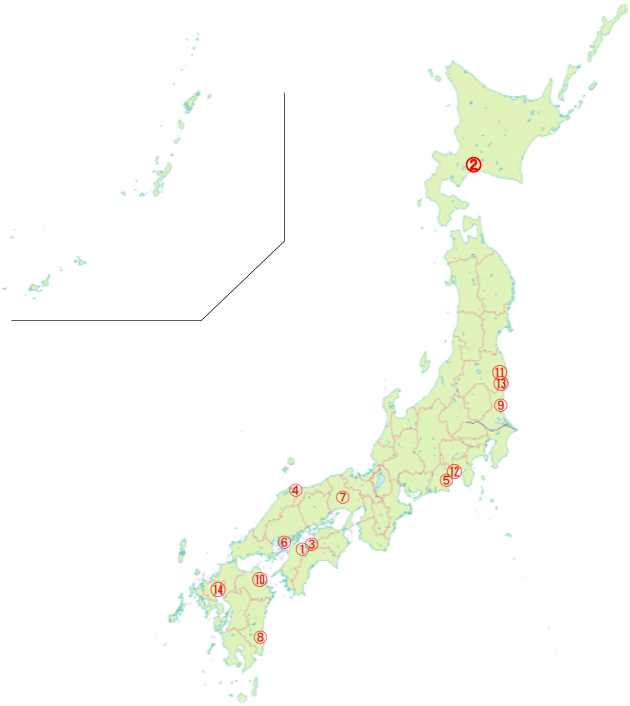

Figure 5-9 Major black liquor power generation plants in Japan

(6) Biogas power generation (methane fermentation)

Significant biogas is produced by sewage sludge digestion at sewage processing plants in Japan[5-15)] Besides this, there are other biogas sources, such as processing wastewater and other waste at food processing plants, livestock manure, and general food waste. Comparing power generation and heat utilization, the energy fraction used to generate power is about 20% [5-16)].

Table 5-4 Trends of biogas utilization (2006) [5-17)]

(x1000 kl)

Source	Power generation	Heat utilization	Total
Sewage sludge	28	117	145
Food waste	15	39	54
Live stock wastes	1	2	3
Total	44	158	202

Table 5-5 Methane fermentation and power generation plants in Japan

	Number of cases
Anaerobic digestion process Night soil treatment plant	66
Sewage-treatment plant with the digestion tank	347
Sludge Recovery Center	30
Food industry effluent	47
Solid food wastes	68
Livestock waste	66
Total	624

5.3 Thermal utilization of woody biomass

As well as power generation, in heat utilization, a use of woody biomass of remaining materials and construction waste materials that are generated from forestry and wood processing industries has been performed.

When woody biomass is used for heat generation, the business structure can take on several forms. With self-generated scrap materials, many wood processing industries generate steam with a boiler, and use the heat energy to dry incoming wood. Moreover, in some cases these processing industries convert edging, scrap material, and saw dust generated by some production lines into chips and pellets for fuel. These are sold in the surrounding area. In addition, there are some cases that forestry organizations use slash, trimmings, and other remaining materials generated by forest management to produce chips and pellets. Many consumers of these chips and pellets are small-scale thermal energy consumers like residences and public facilities who use the energy for heating and humidification. There are many cases here that fall within the "Local Production for Local Consumption" strategy.

In Japan the Tohoku Region is located around 37~41° north latitude and the summer non-heating period is

about 100 days. Further north, Hokkaido is located at 41~46° north latitude and some areas are quite cold, with a summer non-heating period less than 100 days. Even in these climates, however, district heating strategies are rarely carried out.

5.4 Bio-fuels for transportation

(1) Outline

Japan's petroleum dependency of the transportation sector is currently almost 100%[5-18]. The Japan Agency for Natural Resources and Energy (ANRE), under the Ministry of Economy Trade and Industry (METI) released its "New National Energy Strategy" in May of 2006. This plan targets an 80% reduction of petroleum dependency by 2030. Moreover, the Japan government cabinet's "Energy Base Plan" of June 18, 2010 aimed to introduce at least 3% equivalent replacement of the nation's gasoline by 2020[5-19] Amid this situation, transportation biofuels like bio-ethanol, ETBE, and bio-diesel (BDF) are being introduced in Japan. Other liquid biofuels like biogas-to-liquid (via Fischer-Tropsch synthesis) are under current research and development efforts.

(2) Bio-ethanol and ETBE

Bio-ethanol is considered as one of the most important renewable energy sources in Japan[5-20]. Under the 2009 "Sophisticated Methods of Energy Supply Structures Law", the fiscal 2017 target overall bio-ethanol utilization level by the petroleum refining industry is 500,000 kL[5-21]. Only 3% of Japan's bio-ethanol is domestically produced (2007), thus most is imported[5-22]. Thus, supply expansion by domestic capacity increase is desired, in order to ensure stability of supply.

Japan's maximum ethanol to gasoline blend ratio is 3% according to the "Law of Quality Assurance of Volatile Oils". Current domestic production of bio-ethanol is from rice, sugar beets, and wheat. In addition, cellulosic bio-ethanol demonstration projects have been carried out[5-23].

Table 5-6 Major ethanol production plants in Japan

	Prefecture	Contractor	Raw Material	Output
①	Hokkaido	Hokkaido Bioethanol Co. , Ltd	Sugar beet, Wheat	15,000 kL/y
②	Hokkaido	OENON Holdings, Inc.	Rice (high-yielding variety)	15,000 kL/y
③	Hokkaido	Taisei Corporation 、SAPPORO BREWERIES LTD.	Rice straw	1,040 kL/y
④	Akita	Akita Agriculture Public Corporation 、Kawasaki Heavy Industries, Ltd.	Rice straw	200L/d
⑤	Akita	Forestry and Forest Products Research Institute. etc	Akita cedar	yield goal 250l/raw material 1t
⑥	Niigata	ZEN-NOH	Rice(high-yielding variety)	1000 kL/y
⑦	Osaka	DINS sakai Co.,ltd.	Construction waste	1400 kL/y
⑧	Ehime	Ehime Beverage Inc,	Tangerine juice residue	5000L/d
⑨	Fukuoka	NIPPON STEEL ENGINEERING CO.LTD. etc	Food wastes	500L/d
⑩	Okinawa	RYUSEKI CORPORATION	Sugar cane molasses	2t/d

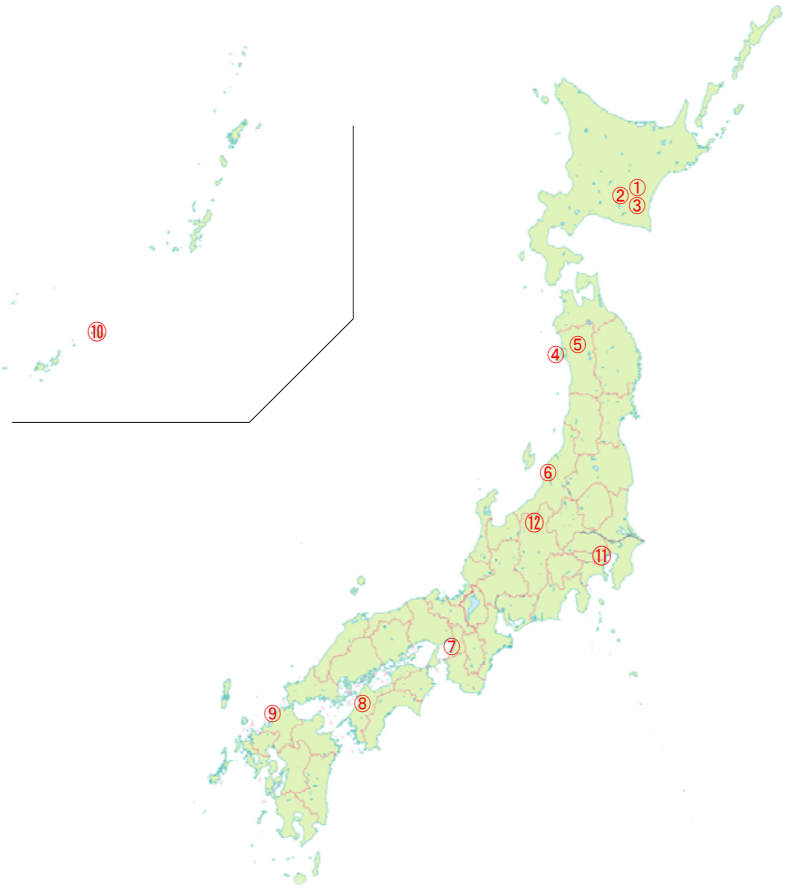

Figure 5-10 Major ethanol production plants in Japan

(3) Biodiesel fuels

Biodiesel fuels in Japan have proliferated mainly as citizen initiatives in many local regions. For example, individual citizens collect waste cooking oil and processe it into bio-diesel fuel to be used by local government units[5-24)]. Waste cooking oil is currently the main raw material used for BDF[5-25)] but a new oilseed source is being studied. The "Rapeseed Project[5-26)]" is an effort to cultivate oilseed crops like rapeseed (canola) on fallow land. Thus far however, the oil obtained has generally been used for food, and little BDF has been produced from this new oil.

The amount of generated waste cooking oil in Japan is 400,000 tons/year[5-27)]. As to the source, 260,000 t/year comes from commercial establishments, while 140,000 t/year is generated by residences. The commercial waste cooking oil is effectively used as raw material for feed and soap, while the residential sourced waste oil is typically used as raw material for BDF. However, the amount of generated is so scarce and time-consuming to collect that the utilization ratio is very low. The amount collected and used as BDF in 2006 is estimated to be about 5,000 kL/year crude oil equivalent[5-28)].

The maximum biodiesel blend ratio in Japan is currently 5% according to the "Law on Quality Assurance of Volatile Oils", and such fuel is sold as "B5" blend light oil (diesel fuel). As an exception to this law, it is admitted tacitly that one may use B100 (100% biodiesel) as an alternate fuel under the owner's self-

responsibility. There are a few small scale production facilities in operation.

(4) Other biofuels

Other biofuels are in the research and development stage. Engine tests have been carried out with hydrogenated bio-fuel oil (BHD) [5-29)] and other work with development of biogas-to-liquid (BTL) [5-30)].

5.5 Characteristics of final bioenergy consumption

(1) Residential (Consumer) Sector[5-31)]

Energy consumption by the residential sector in Japan accounts for about 12% of total energy usage. By energy source, we have electric power, gas, and kerosene as the main sources.

Power, lighting, air conditioning, and water heating are the top four usages. Electric power consumed by the residential sector is mainly used for power and lighting, air conditioning, and also water heating in urban areas. Electricity accounts for about 50% of the total energy consumption in Japan's residential sector. Its almost entirely supplied by electric companies, thus introduction of biomass energy in this field mostly depends on biomass introduction as the primary energy source that these electric companies use. In addition, gas is mainly used for water heating, cooking, and home-heating. Like electric power, it is almost entirely supplied by gas companies. So again, biomass energy introduction in this field depends on biomass introduction by these companies.

In every region of Japan there are mountainous forests a short distance from nearly every resident. These woodlands used be mainly hardwood (a type of Japanese oak, among others), and it was common to cut and collect firewood from these mountain forests for cooking and heating. For quite some time however, the supply and distribution networks of electricity, gas, and fuel nearly covers the whole country. The old customs remain to some degree, such as in high-elevation areas of Tohoku and Hokkaido where the annual average temperature is low with a long heating period. In these cooler climate regions like Tohoku and Hokkaido there are homes using wood pellet fueled pellet devices for heating, however the production volume and distribution are limited. Prices are also high compared to fuel oil, so these devices are not popular.

District heating, wherein a central heating station supplies multiple residences via underground plumbing is rarely seen in Japan, because inexpensive and convenient fuel and its utility equipments have proliferated. District heating infrastructure maintenance is also challenging.

(2) Business Sector[5-32)]

The amount of energy consumption by the business sector in Japan accounts for about 19% of the total. Businesses have been split into nine business classifications, including "office building", "department store", "wholesale and retail trade", "restaurant", "school", "hotel/inn", "hospital", "theater/entertainment", "other services (e.g. health and welfare facilities)". Among these, the usage of "office building" basically accounts for about 21% of the total. By energy consumption purpose, building heating and cooling

accounts for about 31%, since floor areas have been increasing and office automation (OA) has been proliferating. Lighting accounts for about 21%, and office equipment tallies up to about 21%.

Analyzing business sector consumption by energy source, electric power accounts for 44%, petroleum 29%, and gas 25%, which sum to 99%. Nearly all the energy for the business sector is supplied by electric power utilities, gas companies, and petroleum suppliers. Hence, biomass energy introduction largely depends on upstream efforts by these supply companies. For thermal energy sources, public facilities and health/welfare facilities have made recent efforts to utilize small type wood chip and pellet boilers as an energy source for building heating and hot water.

(3) Industrial Sector

Energy consumption by the industrial sector in Japan accounts for about 43% of the total. Within this sector the manufacturing subsector accounts for about 90% of the total. Looking at energy sources within manufacturing, petroleum growth was remarkable until the first oil shock in 1973. After that the materials industries led the conversion to coal energy. More recently, introduction of renewable biomass energy sources have proceeded. There are many examples of mixed combustion of woody biomass and introduction of biomass boilers at coal-fired power plants operated by manufacturing industries.

(4) Transportation Sector

The transportation sector accounts for 23.6% (2008) of Japans total energy consumption. In this breakdown, two sectors are noteworthy: the passenger transport sector (passenger cars and buses), and the cargo sector (ground transportation, sea transportation and air cargo). The passenger sector accounts for 61.4% of the total consumption by the transportation sector. Looking next at a breakdown by energy source, gasoline accounts for 57.0%, and then comes light oil (diesel fuel) at 29.3%. Others include heavy oil for ships at 4.5%, jet fuel at 4.4%, electric power consumed by railroads at 2.0%, LPG used by taxis at 1.8%. Introduction of biomass energy in this sector is centered on bio-ethanol as a gasoline substitute. For others, BDF introduction is considered as a diesel fuel (light oil) substitute.

References

5-1) http://www.nedo.go.jp/content/100079692.pdf, p1

5-2) http://www.enecho.meti.go.jp/denkihp/index.html
http://www.enecho.meti.go.jp/denkihp/genjo/seido.pdf

5-3) http://www.nedo.go.jp/content/100079692.pdf, p1

5-4) http://www.env.go.jp/earth/ondanka/mlt_roadmap/comm.html
http://www.env.go.jp/earth/report/h22-05/index.html
http://www.env.go.jp/earth/report/h22-05/01_full.pdf, p139

5-5) http://www.env.go.jp/earth/ondanka/mlt_roadmap/comm.html
http://www.env.go.jp/earth/report/h22-05/index.html
http://www.env.go.jp/earth/report/h22-05/01_full.pdf, p141

5-6) http://www.rps.go.jp/RPS/new-contents/top/toplink-5.html

5-7) http://law.e-gov.go.jp/htmldata/S45/S45HO137.html
5-8) http://www.meti.go.jp/committee/materials2/data/g90213dj.html
5-9) http://www.meti.go.jp/committee/materials2/data/g90213dj.html, p6
5-10) http://www.chuden.co.jp/energy/ene_energy/newene/ene_torikumi/tor_bio/index.html
5-11) http://www.city.chichibu.lg.jp/menu3734.html#itemid5456
http://www.jbmd.co.jp/bus_results/yamagata.html
5-12) http://www.meti.go.jp/committee/materials2/data/g90213dj.html
5-13) http://www.jpa.gr.jp/file/release/20111228105907-1.pdf
5-14) http://www.jpa.gr.jp/file/release/20111228105907-1.pdf
5-15) http://eneken.ieej.or.jp/report_detail.php?article_info__id=3763,p11
5-16) http://eneken.ieej.or.jp/whatsnew_op/101018saiseikanou.htm,p51
http://eneken.ieej.or.jp/report_detail.php?article_info__id=3763
5-17) http://eneken.ieej.or.jp/whatsnew_op/101018saiseikanou.htm,p51
http://eneken.ieej.or.jp/report_detail.php?article_info__id=3763
5-18) http://www.neeco.co.jp/business/keifun.php
5-19) http://www.meti.go.jp/committee/summary/0004657/energy.html
http://www.meti.go.jp/committee/summary/0004657/energy.pdf, p23
5-20) http://www.meti.go.jp/committee/summary/0004657/energy.html
http://www.meti.go.jp/committee/summary/0004657/energy.pdf, p23
5-21) http://www.enecho.meti.go.jp/topics/koudoka/index.htm
http://www.enecho.meti.go.jp/topics/koudoka/resource/101118haikei.gaiyou.pdf, p9
5-22) http://www.meti.go.jp/press/20090414004/20090414004.html
http://www.meti.go.jp/press/20090414004/20090414004-1.pdf, p16
5-23) http://www.nedo.go.jp/news/press/AA5_100073.html
5-24) http://www.env.go.jp/earth/ondanka/mlt_roadmap/comm.html
http://www.env.go.jp/earth/report/h22-05/index.html
http://www.env.go.jp/earth/report/h22-05/01_full.pdf, p145
5-25) http://www.jora.jp/biodz/index.html
http://www.jora.jp/biodz/pdf/jittai_tyousa_h21.pdf, p4
5-26) http://www.nanohana.gr.jp/index.php?%BA%DA%A4%CE%B2%D6%A5%D7%A5%ED%A5%B8%A5%A7%A5%AF%A5%C8%A4%CE%A4%B7%A4%AF%A4%DF
5-27) http://www.env.go.jp/earth/ondanka/biofuel/materials/rep_h1805.html,2-111
5-28) http://www.env.go.jp/earth/ondanka/biofuel/materials/rep_h1805.html
5-29) http://www.kotsu.metro.tokyo.jp/newsevent/news/bus/2007/bus_p_200702061_h.html
5-30) http://www.nedo.go.jp/
5-31) http://www.enecho.meti.go.jp/topics/hakusho/2010energyhtml/2-1-2.html
5-32) http://www.enecho.meti.go.jp/topics/hakusho/2010energyhtml/2-1-2.html

6. Biomass Prices

6.1 Overview

Until the 1990's, boilers installed in Japan were relatively inexpensive fossil fuel burning units, compared to current biomass fueled units. Moreover, since most boilers were only for fossil fuels, there was little demand for biomass fuels. Biomass that was generated at saw mills and building sites was incinerated on the spot or disposed of at external sites via fee-paid processing.

In the late 1990s, as global warming countermeasures appeared, Japan aimed for positive introduction of renewable energy, and undertook promotions of various types of biomass. As a result, proliferation of biomass boilers has rapidly advanced. Amid this situation, saw mill byproducts were found to have many good characteristics as a domestic woody biomass energy source. The transportation distance to consumers is short, thus costs can be kept relatively low. Therefore, this material has been used for fuel from early stages. On the other hand, low quality biomass materials like construction waste mixed with large volumes of bark or other impurities was avoided. In this way, biomass generators have controlled transportation and processing costs up to the processing facilities. However, for construction waste, separation (classification) is mandatory due to the Waste Recycling Act. Thus, only wood can be collected. The source must still be close to consumers, and even so, due to high crude oil (fuel) prices, the overall process is currently not typically energy-positive. On the other hand, forestry slash, residue, thinnings, and fallen trees are all still costly to collect and transport. Therefore, this material is typically left in mountain forests and usage has not progressed.

Biomass prices are influenced by usual supply and demand trends, trends of related business fields like forestry and wood recycling, and trends of fossil fuel prices. Thus biomass fuel prices vary, depending on the biomass type. Price trends will be described below by splitting the biomass into solid fuels and liquid fuels.

6.2 Solid biomass fuels

Looking first at solid biomass fuels in Japan, woody biomass (chips, pellets, and a small amount of firewood), accounts for the majority, particularly wood chips and wood pellets. Markets of these woody solid biomass fuels can be largely classified into four areas as shown in Table 6-1. Because of differences in lot size, supply route, and a use, price ranges correspondingly vary.
Price trends will be mentioned for each major case in the table below.

Table 6-1 Major solid biofuels in Japan

No	Biomass	Demand scale	Major user	Utilization	Supply
(1)-①	Chip	Quantity lots	Electric utility	Power generation	Domestic, Import
(1)-②		Small lot	Service sector	Boiler	Domestic
(2)-①	Pellet	Quantity lots	Electric utility	Power generation	Domestic Import
(2)-②		Small lot	Private household sector Service sector	Stove Boiler	Domestic Import

6.3 Wood chips

① Large consumers

Mixed fuel thermal power plants (e.g. electric utilities) and single-fuel biomass power plants are the major large-scale consumers of wood chips in Japan. The level of wood chip consumption is 15,000 ~ 300,000 t/year for the mixed fuel thermal power plants, and about 15,000 ~ 100,000 t/year for the single-

fuel biomass power plants. The consumption scale of wood chips is not much different for mixed fuel plants compared to single-fuel plants. However, due to differences in scale of the entire facility, in power generation efficiency, and in freedom of fuel procurement, different trends in procurement and pricing do appear.

Regarding wood chips for mixed fuel combustion there are some cases in which the raw material is imported to Japan. For both imported and domestic procurement, a choice of substitute mixed fuels are available, therefore consumer needs tend to be prioritized. Single-fuel combustion users source their fuel almost exclusively from domestic suppliers. Raw material prices are influenced by storage and capacity concerns at power plant locations, and competition with other wood chip uses like chipboard and OSB. In any case, fuel prices paid are not generally in the public domain.

In Japan there are many recycling companies which specialize in construction waste materials. These entities supply some of the wood chip biomass fuel in Japan. The price range of wood chips for large consumers of mixed and single-fuel combustion power plants is often around 4 yen/kg delivered.

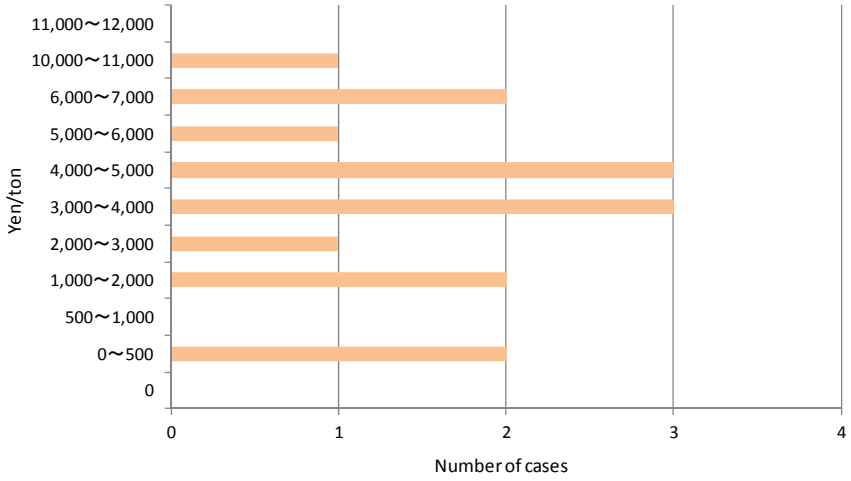

Figure 6-1 Woody biomass price (raw material)[6-1)]

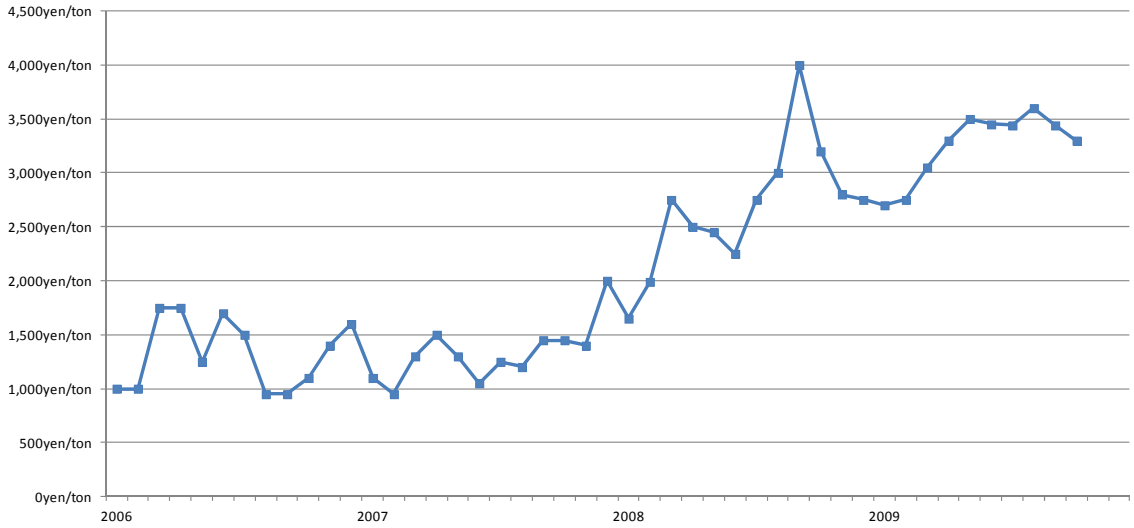

Figure 6-2 Variation in woody biomass price[6-2)]

② Small consumers

The isolated mountainous areas of Japan have become known for hot springs and related short-term accommodation facilities. Certain public sectors like cities and municipalities engage in promotion of tourism and sightseeing to better the welfare for local residents. Introduction of small-scale wood chip boilers designed for these facilities has recently been progressed. These small-scale chip boilers have a thermal outputs ranging from 100 to 500kW, the majority with annual wood chip consumption of several hundred tonne per year. These small-to-mid scale consumers often purchase wood chip fuel from local saw mills and forestry cooperatives. For pricing, the main consideration of these consumers is how quickly they will recoup the new boiler cost via lower fuel costs (including price difference from fossil fuel). Undried raw chips (~50% moisture) produced from green wood are often priced around 3 to 5 yen/kg, and dried chips are priced at 5 to 10 yen/kg plus delivery.

6.4 Wood pellets

① Large consumers

Mixed-fuel coal fired power plants are the main large-scale consumers of wood pellet fuel in Japan. This industry consumes tens of thousand of tonnes of wood pellets per year. Two main factors support this fairly large consumption scale, namely 1) Procurement of imported pellets, 2) Large scale domestic production. Wood pellet prices paid are not public domain, however pellets imported from Canada seem to be a major source, and one finds their unit price ranges from 15 to 20 yen/kg (cost/insurance/freight , CIF[6-3)]). Domestic large-scale production pellets sell at about 20 yen/kg, corresponding roughly to imported pellets.

② Small consumers

Other than large consumers (mixed fuel coal fired power plants) the demand for wood pellets in Japan derives from the residential sector (home heating), business sector (boilers), public sector (boilers), and a portion of the industrial sector (agriculture, greenhouse). It can be concluded that there are a wide variety of users of domestic pellets. Small-scale production of these domestic wood pellets causes the production cost to be high. Here are several examples: A survey of retail prices found a range from 25 to 63 yen/kg[6-4)], with an average price for small quantities at 44 yen/kg, larger quantities at 38 yen/kg, and bagged pellets for a boiler at 36 yen/kg (2006) [6-5)].

6.5 Bio-fuels for transportation

(1) Bio-ethanol

Looking first at bio-ethanol production in Japan, bio-ethanol uses feedstock such as starchy grains and blackstrap molasses generated in sugarcane processing. Other minor fuels include a few demonstration studies using food residue and orange juice processing waste. However, in any case, these are still in the small-scale pilot plant level, and ethanol production from these domestic raw materials is not cost competitive[6-6)].

Bio-ethanol utilization in Japan is achieved by blending with gasoline (direct or ETBE[6-7)]). Recall that ethyl tert-butyl ether (ETBE) is derived from bio-ethanol. Nearly all blending and sales are carried out by petroleum companies, and petroleum companies procure the bio-ethanol and ETBE base materials for blending. However, since the domestic supply capacity of bio-ethanol is low and there are price challenges, 97% of bio-ethanol used in Japan is imported from overseas.

A comparison of bio-ethanol costs is shown in Fig. 6.3. To support a target consumer price for the bio-ethanol/gasoline blend, subsidies and tax incentives are used to offset differences in manufacturing and procurement costs. Gasoline prices should generally be maintained within a target range based on the bio-ethanol price, the wholesale price of gasoline, and current gasoline tax (53.8 yen/L) to avoid large price fluctuations. Bio-ethanol imported from abroad is currently priced at around 70 yen/L (CIF, hydrous alcohol).

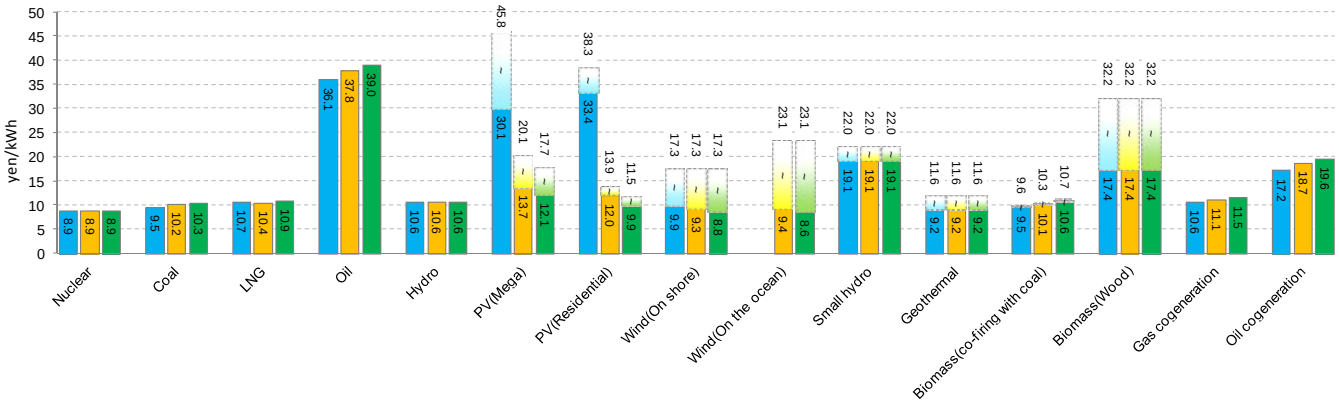

Figure 6-3 Trial calculation cost of power generation[6-10)]

(2) Biodiesel fuel

Nearly all domestic biodiesel production is from waste cooking oil. Many manufacturing companies have only a small scale processing capacity of around several hundred liter per day. Biodiesel manufacturing cost is considered to be about 100 yen/L[6-8], depending on the price of feedstock waste cooking oil.

Current imports of biodiesel fuel are at a preliminary stage and somewhat limited. It can be expected that imports from Southeast Asia will increase as raw oil supplies are developed and procured. However, if the raw oil or oilseed crop competes with edible oils (e.g. palm oil), its market price is easily influenced by many factors, making an unstable business foundation. Estimates have shown a fairly wide-ranging 38 to 91 yen/L[6-9] CIF price. This has provided motivation for investigation into non-edible oilseed crops like Jatropha.

Since supplies are mainly provided by small-scale manufacturing entities, biodiesel fuel has taken on a final consumer price range below light oil (petroleum diesel fuel) but more than the manufacturing cost. It is thought that B5 (5% biodiesel blend) should be distributed at the same consumer price range as light oil market prices.

6.6 Gaseous biofuels (biogas)

(1) Outline

For gaseous biofuels, methane biogas derived from fermentation of waste accounts for the majority of production volume. Its usage is basically onsite (boiler, cogeneration), and it not often generated with the intent to purify and distribute via pipelines and cylinders like natural gas and LPG. In a few cases biogas is sold. For example, offices within or near the biogas manufacturing facility may use the gas. It is typically a barter or exchange type transaction and prices are not public domain. However, it is logical for the parties to use price ranges corresponding to similar fossil fuels (natural gas, LPG). In other cases, with enforcement of the Energy Supply Structure Sophistication Law, an effort to send biogas to gas companies via pipelines has been done on a trial basis.

(2) Biomass power generation

In the wake of the 2011 East Japan Great Earthquake and the nuclear reactor accident, many discussions have taken place on cost and supply of each kind of energy. Including the power supply system, maintenance of supply infrastructure, and an institutional framework like FIT, there is a possibility to perform a comprehensive review. Biomass power generation has been drawing attention as an important part of the solution.

6.7 Matters related to other costs

(1) Costs to require biomass utilization of forest resources

Forest resources exist abundantly in Japan, and they are considered important as raw materials of solid

wood biomass fuel and liquid biofuels. However, the challenge in utilization is that collection costs are high, and transportation costs to the processing facility and end user are also high.

As shown in Figure 6-4, the biggest cost component of forest resources is collection. There is not enough volume to produce substantial energy by using only the other five woody biomass sources. In addition, since waste type biomass can generate processing fee income, unit price reduction is possible, and they are easy to distribute.

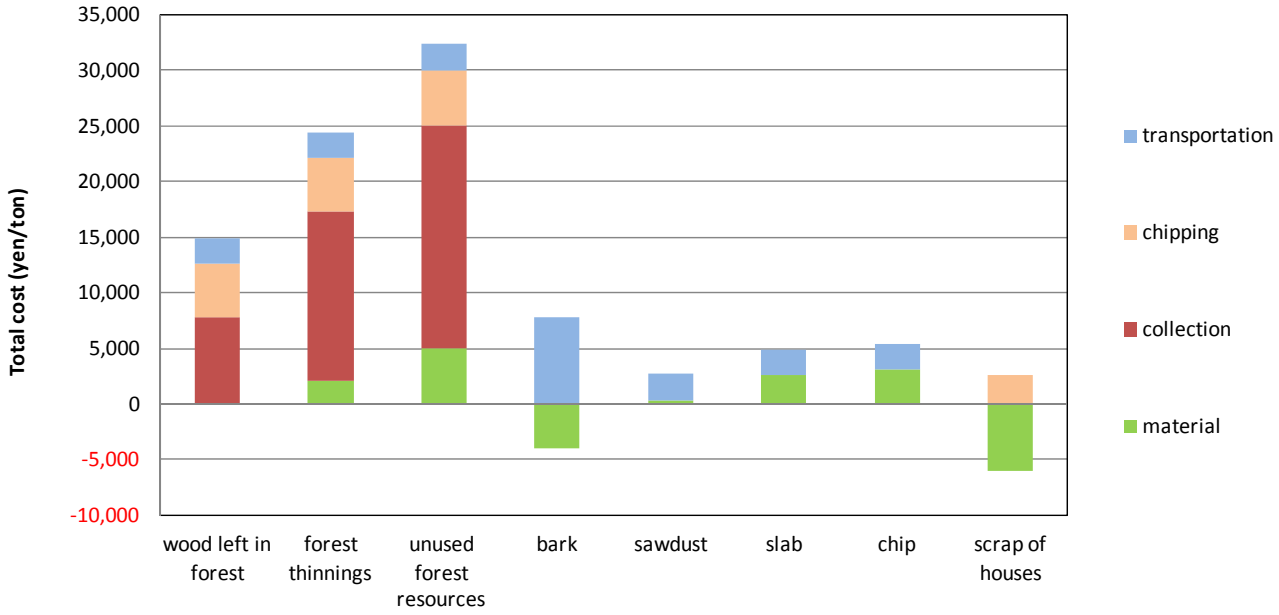

Figure 6-4 Cost breakdown of woody biomass materials

(2) Comparison with fossil fuel

Biomass energy sources currently on the market are similar or cheaper than fossil fuels, compared on an energy-content basis. However, the data actually show biomass prices for current quantities supplied. Biomass supplies are partially limited by price and other conditions, such as the type of biomass waste, and so forth. It can also be pointed out that it is hard to reduce the prices of domestic wood pellets. Therefore, there are currently some cases where the biofuel tends to be more expensive than competing fossil fuel, which makes biofuel usage become unpopular.

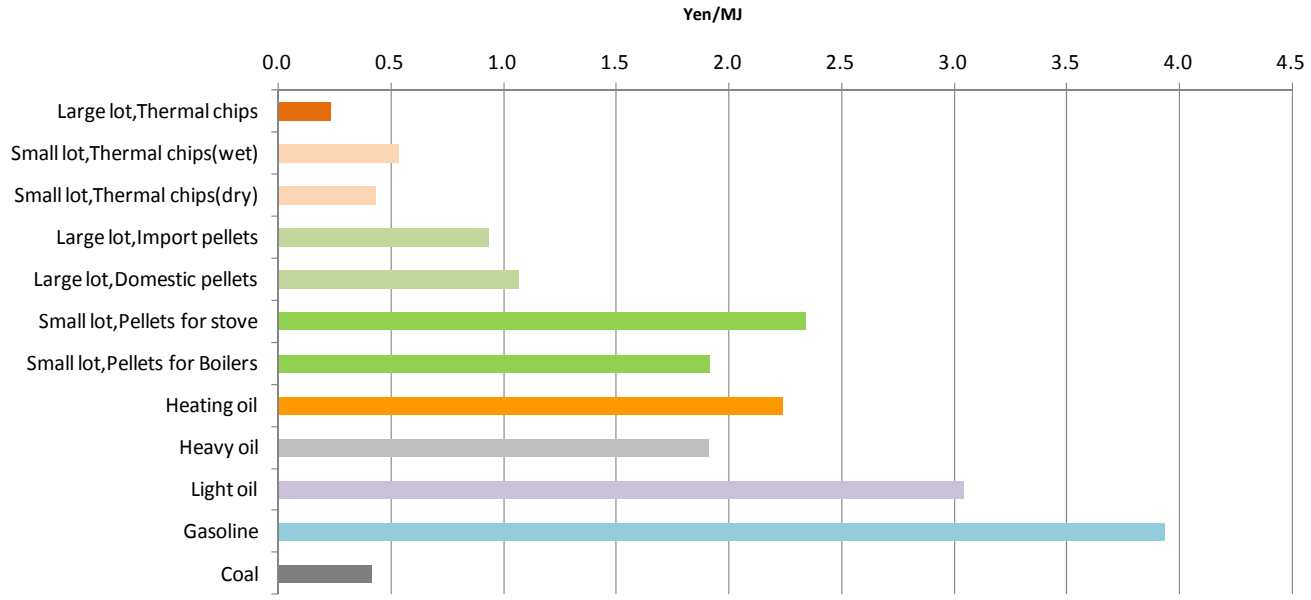

Figure 6-5 Comparison of prices for various renewable and nonrenewable fuels[6-11)]

References

6-1) http://www.chugoku.meti.go.jp/research/kankyo/pdf/biomass_h22fy/110411_all.pdf
6-2) http://www.meti.go.jp/committee/materials2/data/g91210aj.html
http://www.meti.go.jp/committee/materials2/downloadfiles/g91210a05j.pdf
6-3) http://www.customs.go.jp/toukei/srch/index.htm
6-4) http://www2.hokurikutei.or.jp/aizu-imatto/event/archives/data/03.pdf, p5
6-5) http://www.howtec.or.jp/pellet/unit1/pdf/18.pdf, p29
6-6) http://www.nedo.go.jp/library/ne_hakusyo_index.html, p224-225
6-7) http://www.houko.com/00/01/S51/088.HTM
6-8) http://www.jora.jp/biodz/index.html
http://www.jora.jp/biodz/pdf/jittai_tyousa_h21.pdf, p5
6-9) http://www.meti.go.jp/committee/summary/0001895/index.html
http://www.meti.go.jp/report/downloadfiles/g30922b41j.pdf, p18-19
6-10) http://www.npu.go.jp/policy/policy09/archive02_shisan_sheet.html
6-11) http://oil-info.ieej.or.jp/

7.Biomass imports and exports

7.1 Overview

Currently, biomass fuels produced in Japan are not price competitive with corresponding fossil fuels. Because of this, the majority of biomass fuels are being imported to achieve mandated targets for energy supply entrepreneurs to use for global warming countermeasures. As imported biomass energy sources, solid wood biomass fuel (chips and pellets) that major electric power companies use with mixed coal combustion, and bio-ethanol account for the majority. Bio-ethanol is the raw material for ETBE, and major petroleum wholesalers blend ETBE with gasoline. These are all imported by ship. The major types of biomass fuel imported to Japan, as mentioned above, are solid wood biomass fuels and bio-ethanol.

7.2 Import volume and import route

① Wood chips

Imported wood chip biofuel is used for power generation, and are used at mixed-fuel coal fired power plants. About 300,000t/year are used at the Hekinan Power Plant (located near Nagoya), operated by Chubu Electric Power. These are imported from Canada[7-1)].

② Wood pellets

Domestic wood pellet production is about 50,000t/year (2009)[7-2)], while import wood pellets reached about 60,000 t/year in 2009. Imports reached about 73,000 t/year by 2010, which equates to a four-fold increase in 6 years, from 2004 to 2010. As shown in the Figure 7-1, wood pellet consumption has rapidly increased since 2008, corresponding to levels prescribed by the RPS law. The reason behind this large steep increase is that use by mixed combustion coal fired power plants has started. About 75% of the imports in 2010 were from Canada, and recently imports from Vietnam have also been increasing.

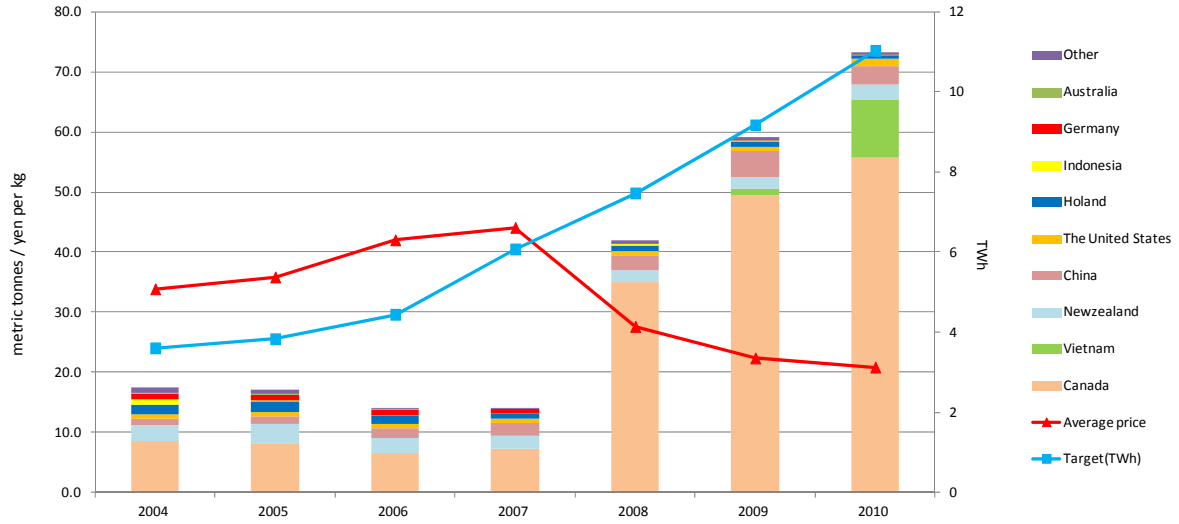

Figure 7-1 Import of wood pellets (source country, price, target)

③ Bio-ethanol

As mentioned above, 97% of Japan's bio-ethanol is imported. Importation is mainly carried out by business cooperatives[7-3)] that were established by multiple companies like major petroleum wholesalers. Bio-ethanol mostly sourced from Brazil and bio-ETBE is sourced from the USA[7-4)], where these biofuels are produced.

Looking next at import quantities and procurement of bio-ethanol, a long-term purchase agreement was signed with Brazilian companies for about 200,000kL/year)[7-5)]. A long-term bio-ETBE purchase agreement was signed with US companies for about 20,000kL/year[7-6)] to maintain a stable supply. Specifically, bio-ethanol is shipped from Brazil to the US to be made into bio-ETBE. Then the bio-ETBE

is shipped to Japan. The import terminals for these fuels are located in Chiba[7-7)] and Wakamaya prefectures[7-8)]. Total ETBE imports to Japan in 2010 were 560,138,000t from the U.S. and 5,000,000t from Brazil, total 565,138,000t[7-9)].

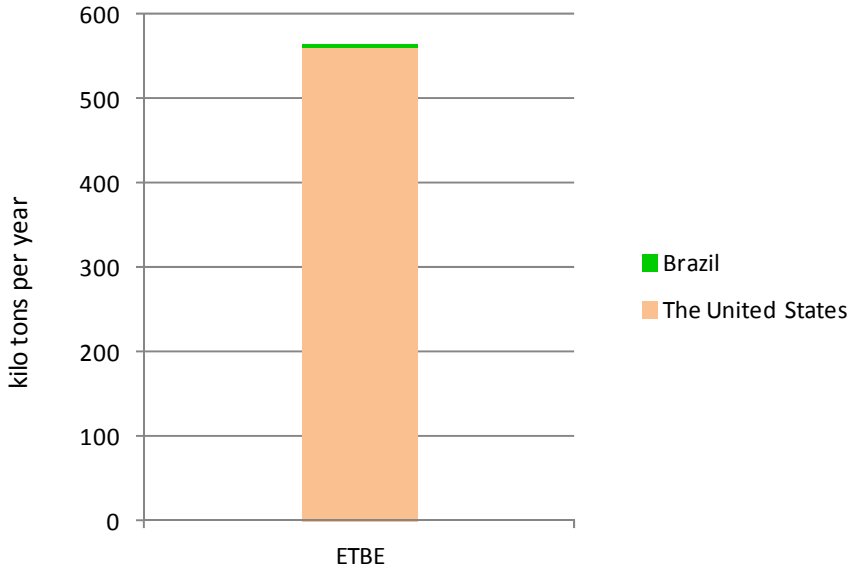

Figure 7-2 Imports of ETBE to Japan (2010)

7.3 Other biofuels

An effort to produce briquette chaff abroad and import it has been carried out on a trial basis. A target use is for mixed combustion coal fired power plants in addition to wood chips and pellets. Assumed import countries (production countries) are mainly in East Asia and an import route would be via ship.

Import of BDF is still at a pilot study stage, however rapid expansion is possible. Japan's energy self-sufficiency rate is low, and the supply-demand structure is weak, which is a policy issue. To enhance future biomass imports, expansion of import development to manage and participate in bio-fuel production activities abroad is expected. Development of biodiesel raw material imports based on inedible oils and fats like Jatropha has been drawing attention.

7.4 Biomass export

Finally, regarding biomass exports, one needs to be mindful of the data mentioned above, such as Japan's low energy self-sufficiency ratio, the limited amount of resources, and high transportation and personnel expenses. Thus, a biomass export industry is not under favorable conditions to establish. There are a few very limited cases of biofuel export, however. A small amount (200 t/month base plan) of wood pellets were shipped to Korea by enterprises seeking to perform pellet production, using *Ogako* (sawdust) that is generated from laminated lumber production as raw materials[7-10)].

References

7-1) http://sangaku-cons.net/document/event_houkoku/20111111_keieisenryaku8.pdf, p11
7-2) http://www.rinya.maff.go.jp/j/kikaku/hakusyo/22hakusho/pdf/h22hakusyo_1-3.pdf,p31
7-3) http://www.jbsl.jp/index.html
7-4) http://www.jbsl.jp/content/index.html
7-5) http://www.jbsl.jp/press/press081008.html
7-6) http://www.jbsl.jp/press/press080729.html
7-7) http://www.jbsl.jp/press/press080604.html
7-8) http://www.jbsl.jp/press/press080804.html
7-9) http://www.jbsl.jp/pdf/jbsldata120116.pdf, p2
7-10) http://www.j-fic.com/category/news/%E6%9C%A8%E8%B3%AA%E3%83%90%E3%82%A4%E3%82%AA%E3%83%9E%E3%82%B9/page/2

8. Barriers and Opportunities

8.1 Barriers of economic efficiency

(1) Barriers caused by inexpensive petroleum fuel

Compared to biomass fuel, crude oil is currently inexpensive and taxation of heavy oil and kerosene is low, therefore conversion to biomass fuels is not proceeding. On the other hand, biomass fuel like domestic wood pellets and forestry residue (slash), which are abundant in availability, are expensive to collect and transport. This pushes up their production cost and prevents them from being price competitive with fossil fuels. Moreover, domestic pellet producers are currently caught in a price-volume trap. Namely, their production scale is so small that their costs cannot be reduced. Since costs are high, customer pricing is high, hence sales volume expansion becomes difficult. As a result, the production utilization rate is low and costs cannot be driven down. Even Canadian imports are challenged by their large total shipping distance and resulting high cost of transportation.

(2) Cost of utilization equipment

Biomass utilization equipment is more expensive than petroleum type fuel utilization equipment, and the overall initial investment is bigger as well. Since petroleum based fuels are inexpensive and price reduction of biomass fuels does not occur, customer payback on initial investment is delayed. The price difference with respect to petroleum fuels also makes it difficult to justify equipment replacement with biomass burners. This leaves little incentive for biomass introduction.

8.2 Supply base barriers

(1) Supply stability

Biomass fuel markets are not fully mature, and thus prices and business deals are not stable. In addition, sufficient domestic biomass fuel for the markets is not being supplied, and this creates a challenge that supplies are not stable.

(2) Delays in development of supply infrastructure and distribution networks

Japans proportion of mountains and forests is high and only small areas are plains. Therefore, there are many cases that houses and commercial buildings are crowded in relatively narrow plains. Because of that, compared to fossil fuel utilization equipment, it is sometimes difficult to physically maintain biomass utilization equipment, which may require larger installation space, fuel storage places, and access routes. Moreover, the domestic distribution network for wood pellets is undeveloped, and the basic distribution unit is small, therefore transportation costs tend to become large, which exacerbates problems of economic efficiency[8-1)]. For efficient thermal biomass utilization in Japan, it is necessary but difficult to develop and maintain infrastructure like piping systems for local distribution of thermal supplies. Thus there is a challenge that even in cold regions of Japan, introduction of these systems has not proceeded as well.

8.3 Institutional barriers

(1) Bio-fuel blend ratio for ethanol

With the nationwide law regarding Quality Assurance of Volatile Oils (Law No. 88 in 1976, referred to as QA below), the current maximum bio-ethanol gasoline blend ratio is 3%. This arises from a safety view point, considering fuel system parts of existing vehicles on the road in Japan, and assurance of exhaust emissions characteristics.

Among new cars currently produced by domestic automobile companies, some vehicles are capable of operating on up to a 10% bio-ethanol gasoline blend (E10). However, some existing vehicles were not designed to operate on gasoline containing bio-ethanol. By paying attention to supply challenges, market stability of bio-ethanol, and maintaining economic efficiency, the regulated upper limit of oxygenated compound (including ethanol) determined by the QA Implementation Regulations is to be reviewed by 2020. At that time, oxygenated fuel capabilities of vehicles on the road will be taken into account.

(2) Bio-fuel blend ratio for biodiesel fuel

Fatty acid methyl ester (FAME), which is widely used as biodiesel fuel, has been regulated for a maximum 5% blend ratio in base petroleum oil since March 2007. In addition, all the other necessary fuel performance specifications must meet or exceed the light oil (petroleum based diesel fuel) standards of quality assurance.

8.4 Opportunities

(1) Establishment of the national Energy Supply Structure Sophistication Law

The "Energy Supply Structure Sophistication Law" (ESSSL) was established in July of 2009, affecting mainly energy supply businesses like electricity, gas, and petroleum companies. It was aimed at promotion of renewable energy sources like sunlight, wind power, the use of non-fossil energy sources like nuclear, and more effective use of fossil energy raw materials. Due to this, it is expected that implementation of bio-ethanol fuels and an increase of zero emission electricity sources will be

progressed. Moreover, based on the ESSSL law, " Law on Special Countermeasures for Procurement of Renewable Electrical Energy by Power Companies" (Renewable Energy Solid Price Purchase System) was ratified in August of 2011. It is planned to take effect in July of 2012. Because of this, one expects that renewable energy power generation (e.g. biomass) will emerge as a solid business trend.

(2) Environment and Energy Super-Power Strategy by Green Innovation[8-1)]

The "New Growth Strategy" (cabinet decision in June 2010) establishes policies and guidelines for an "Environment and Energy Super Power." This future society is to be achieved by innovation in the environmental energy field, and is a total policy package, making maximum use of Japan's strengths in the environmental field. Based on this, a proliferation of renewable energy and expansion of support measures like low carbon finance are expected. Policies aim for development of not only domestic renewable energy sources, but also expansion of joint overseas projects, such as development of imports making use of Japanese technologies.

(3) Effort towards a structure of a new community system from the earthquake disaster reconstruction

The East Japan Great Earthquake of March 2011 and resultant nuclear power plant accident caused enormous damage to Japan. However, this also provided an opportunity to construct a new energy system using a smart grid, and increased introduction of renewable energy (e.g. biomass) utilization. Moreover, a large quantity of wood debris became available from damaged houses (about 25,000,000 t[8-3)]). This material cannot be easily processed like forest products, but it can still be used as feedstock material for biomass power generation. After processing all the earthquake wood debris, an idea has been discussed to switch over to long-term biomass power generation using conventional raw materials like forest resources. With this trend, a renewable energy source like biomass power generation will be viable candidate as a future new business.

References

8-1) http://www.maff.go.jp/j/biomass/b_advisory/ad_dai9/pdf/data01b.pdf