Wood Biomass Energy Data Book 2018

一般社団法人
日本木質バイオマスエネルギー協会
Japan Woody Bioenergy Association

Japan Woody Bioenergy Association

This data book was created as part of the project for establishing a support system for the use of wood biomass subsidized by the Forestry Agency in fiscal 2017.

Introduction

This document was created on the basis of statistical information disclosed by the concerned ministries and agencies and information relevant to the use of wood biomass energy collected by the Japan Woody Bioenergy Association. This data book, systematically organizing information on the use of wood biomass energy, is intended to be used for concerned parties involved in the field of wood biomass energy in their daily work.
We hope this data book will be of help to those working in various sites in the field of wood biomass energy.

The Japan Woody Bioenergy Association does not guarantee the accuracy of information presented in this data book. The contents may subject to change to correct errors or modify information; therefore, if you quote any of the information in this data book, check to verify the source.

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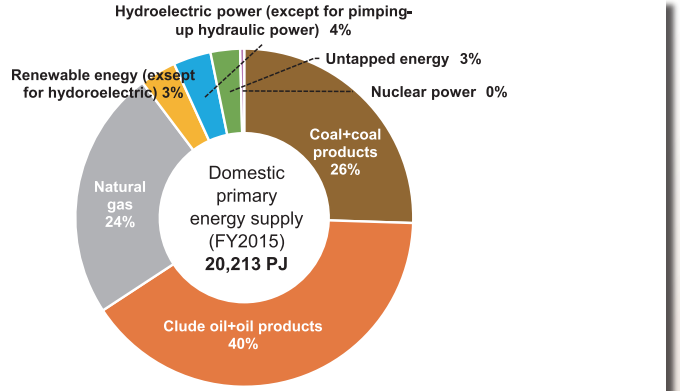
1 Energy Situation in Japan

1.1 Changes of Domestic Primary Energy Supply

①Breakdown of domestic primary energy supply

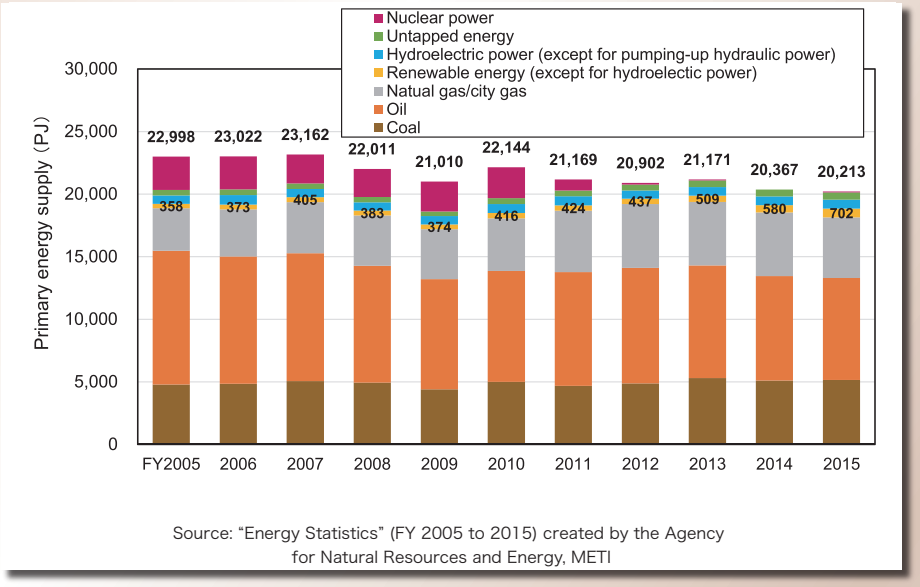
Of the total domestic primary energy supply in fiscal 2015, the fossil fuel (oil, coal, natural gas) accounts for approximately 90%, and non-fossil fuel accounts for approximately 10%.



Source: "Energy Statistics" (FY 2015) created by the Agency for Natural Resources and Energy, METI

②Changes of domestic primary energy supply

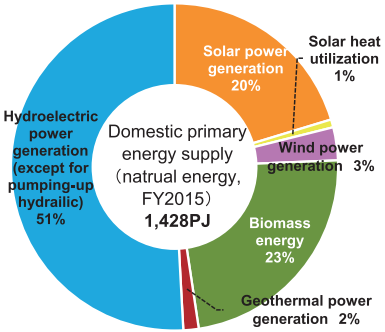
In recent years, the amount of primary energy supply remains at the same level or is slightly decreasing. By type of energy, the supply of oil and nuclear power is decreasing, while that of renewable energy is increasing.



Source: "Energy Statistics" (FY 2005 to 2015) created by the Agency for Natural Resources and Energy, METI

③Breakdown of domestic primary energy supply (natural energy)

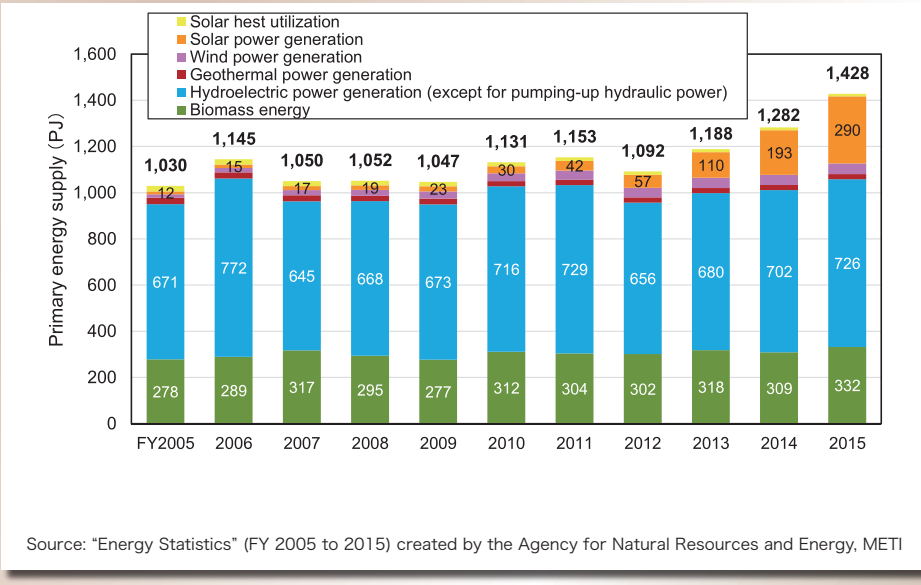
Of the total domestic primary energy supply using natural energy in fiscal 2015, hydraulic power generation accounted for approximately 51%, biomass energy accounted for approximately 23%, and solar power generation accounted for approximately 20%.



Source: "Energy Statistics" (FY 2015) created by the Agency for Natural Resources and Energy, METI

④Changes of domestic primary energy supply (natural energy)

Since the feed-in tariff scheme was introduced in July 2012, the primary energy supply derived from natural energy is increasing. Especially solar power is growing more than other types of energy.

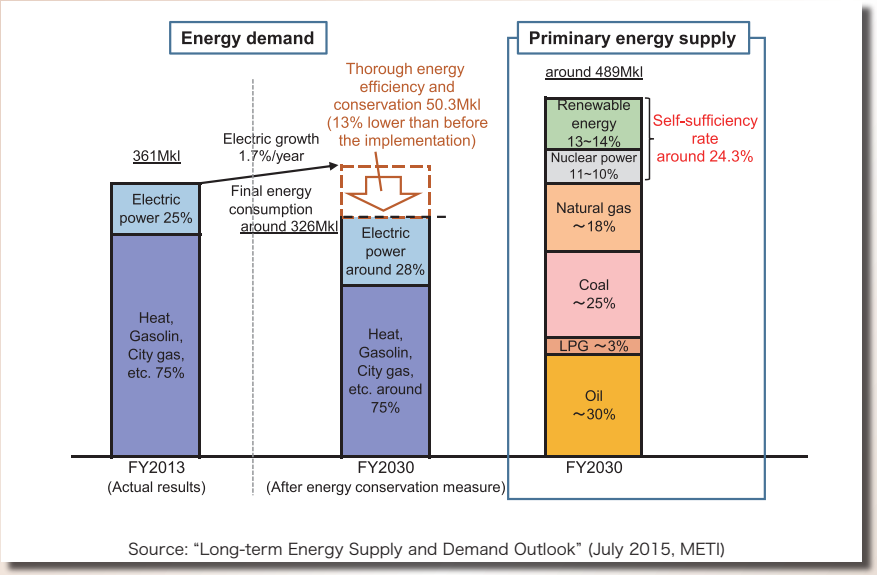


Source: "Energy Statistics" (FY 2005 to 2015) created by the Agency for Natural Resources and Energy, METI

1.2 Future Trend of Domestic Primary Energy Supply

①Domestic primary energy supply in the future

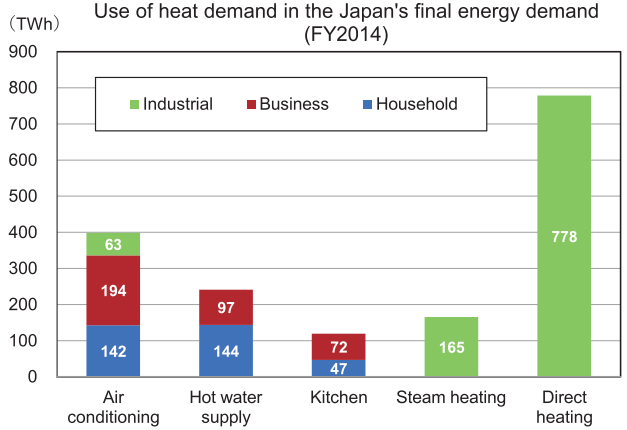
According to the "Long-term Energy Supply and Demand Outlook," renewable energy accounts for 13 to 14% of the total primary energy supply in fiscal 2030.



Source: "Long-term Energy Supply and Demand Outlook" (July 2015, METI)

1.3 Domestic Heat Demand

The industrial applications of domestic heat demand in fiscal 2014 mostly consisted of direct heating and steam heating. As for the business and home use, air conditioning occupied the largest share, followed by hot-water supply and kitchens.

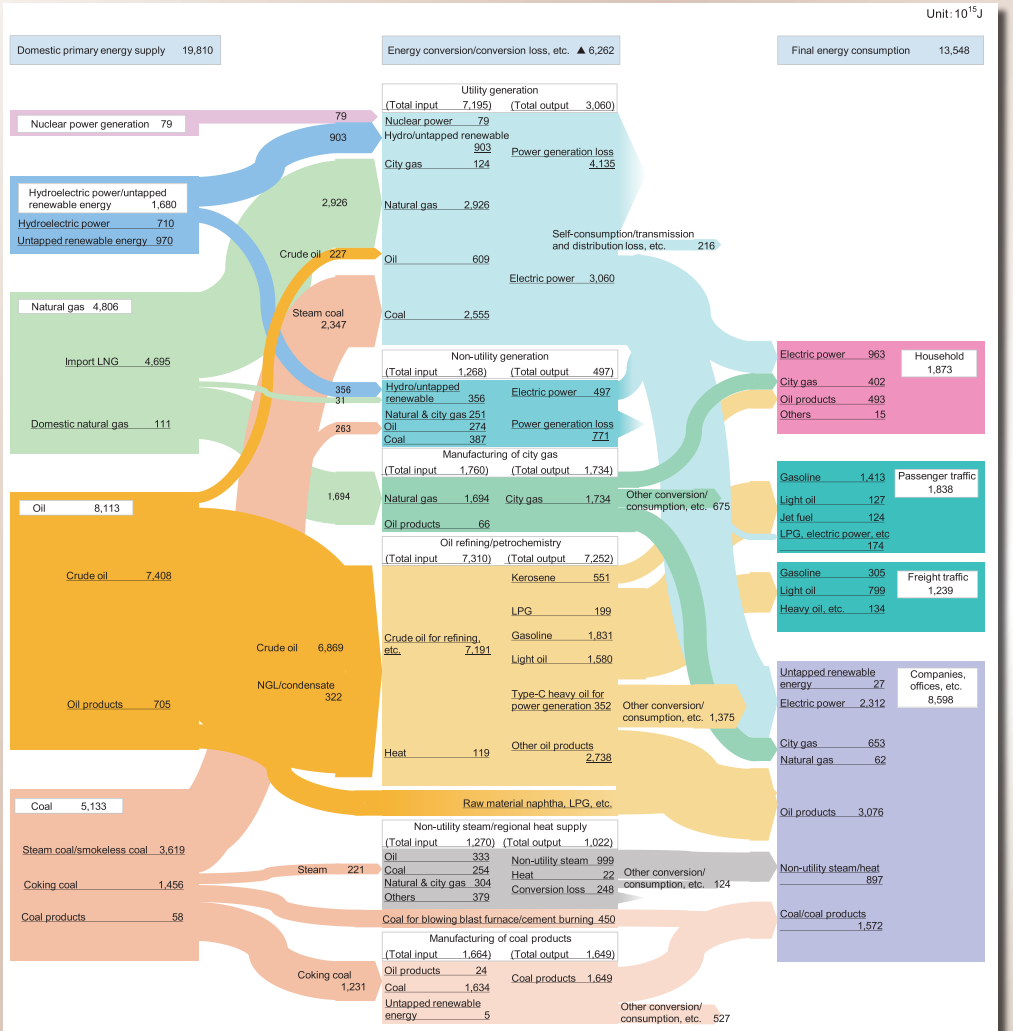


(Note) The use for air conditioning included in steam heating for industrial use is excluded (included in air conditioning)

Source: "Survey Report on Heat Utilization of Wood Biomass" (March 2017, Japan Woody Bioenergy Association)

1.4 Energy Balance Flow in Japan

In fiscal 2015, if we assume domestic primary energy supply in Japan to be 100, the final energy consumption totaled around 68.



(Note 1) This flow indicates the overview of energy flow in Japan and does not express the detailed flow.
(Note 2) "Oil" includes oil products in addition to crude oil and NGL/condensate.
(Note 3) "Coal" includes coal products in addition to steam coal, smokeless coal, and coking coal.

Source: Created based on the "Energy Statics" created by the Agency for Natural Resources and Energy.

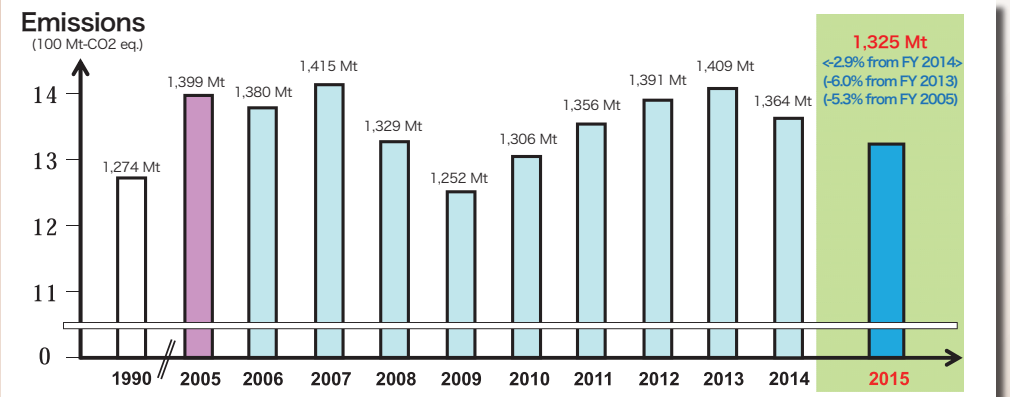
Source: 2016 Annual Report on Energy (Japan's Energy White Paper 2017) (June 2, 2017, approved by the cabinet)

2 Impacts on Climate Change

2.1 Changes of Domestic Greenhouse Gas Emissions

①Changes of greenhouse gas emissions

The total greenhouse gas emissions in fiscal 2015 were approximately 1.325 billion tons (-6.0% compared to fiscal 2013 and -5.3% compared to fiscal 2005). The possible reason that fiscal 2015 marked below fiscal 2013 was that CO_2 emissions from electricity were reduced by the reduction of energy consumption (energy-saving, cold summer/warm winter, etc.) and improvement of power emission intensity (dissemination of renewal energy, reoperation of nuclear power plants, etc.)



Note 1. "Final figures" means the figures officially submitted to the Secretariat of the Convention as Japan's GHG emissions and removals in a national GHG inventory. The final figures compiled this time will be recalculated when annual values in statistical data are updated, and/or estimation methods are revised.

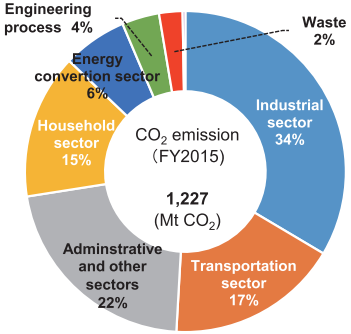
Note 2. There are some differences between the final figures compiled this time and preliminary figures released on December 6, 2016, because some estimation methods were revised for a more accurate estimation, and some recalculation was conducted based on annual values in statistics and other data which were made available after the estimation of preliminary figures.

Note 3. Total GHG emissions in each fiscal year and percent changes from past year (such as changes from FY 2005) do not include removals by forest and other carbon sinks from activities under the Kyoto Protocol.

Source: "Japan's National Greenhouse Gas Emissions in Fiscal Year 2015" (Final Figures) (April 13, 2017, Ministry of the Environment)

②Breakdown of CO_2 emissions by sector

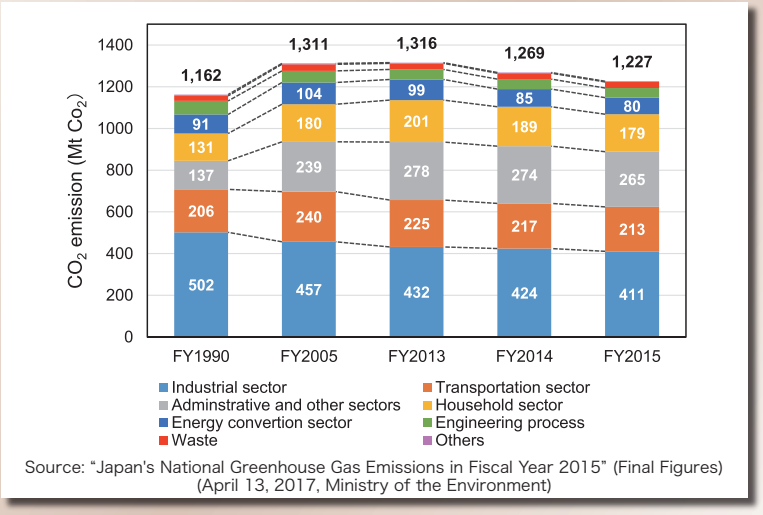
Of the total domestic CO_2 emissions in fiscal 2015 (approx. 1.227 billion tons), approximately 34% came from the industrial sector, approximately 22% came from the administrative and other sectors, and approximately 15% came from the household sector.



Source: "Japan's National Greenhouse Gas Emissions in Fiscal Year 2015" (Final Figures) (April 13, 2017, Ministry of the Environment)

③Changes of CO_2 emissions (by sector)

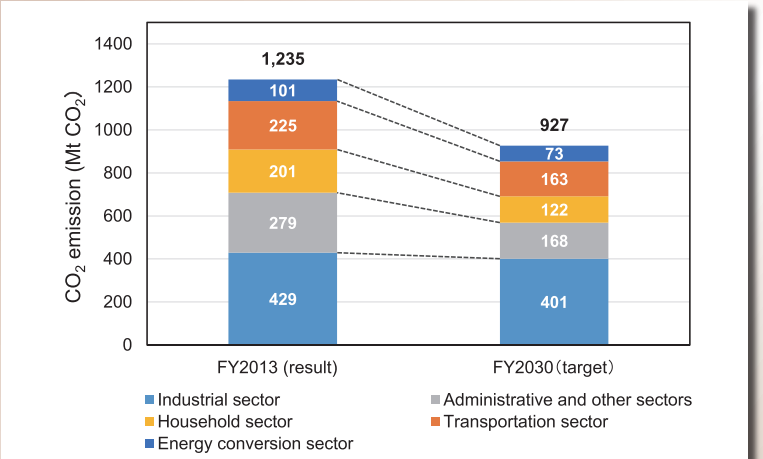
The CO_2 emissions in fiscal 2015, compared to fiscal 2005, were decreased by approximately 10% in the industrial sector and approximately 11% in the transportation sector, while increased by approximately 11% in administrative and other sectors.



Source: "Japan's National Greenhouse Gas Emissions in Fiscal Year 2015" (Final Figures) (April 13, 2017, Ministry of the Environment)

2.2 Future Trend of Domestic Greenhouse Gas Emissions

According to "Submission of Japan's Intended Nationally Determined Contribution (INDCs)," the target value of CO_2 emissions from energy consumption in fiscal 2030 is approximately 927 million tons. The target was set to reduce 25% emissions compared to fiscal 2013.



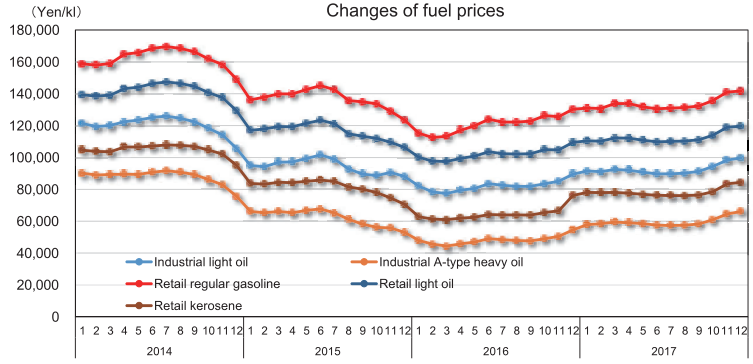
Source: "Submission of Japan's Intended Nationally Determined Contribution" (INDCs) (July 17, 2015, Global Warming Prevention Headquarters)

3 Trend of Renewable Energy

3.1 Situation of Fossil Fuels

①Changes of fuel prices

The fuel prices (light oil, A-type heavy oil, regular gasoline, kerosene) are changing on monthly basis. The fuel prices as a whole continued to decrease from 2014, and they remained at the same level or increased after 2016.



* Prices of industrial light oil and industrial A-type heavy oil are based on the delivery price of large lorry according to the survey by The Oil Information Center (consumption tax excluded)

* Prices of retail regular gasoline, retail light oil, and retail kerosene are according to the survey by The Oil Information Center (prices of kerosene do not include light oil tax) (consumption tax included).

* Prices of LP gas are according to the survey by The Oil Information Center (consumption tax included)

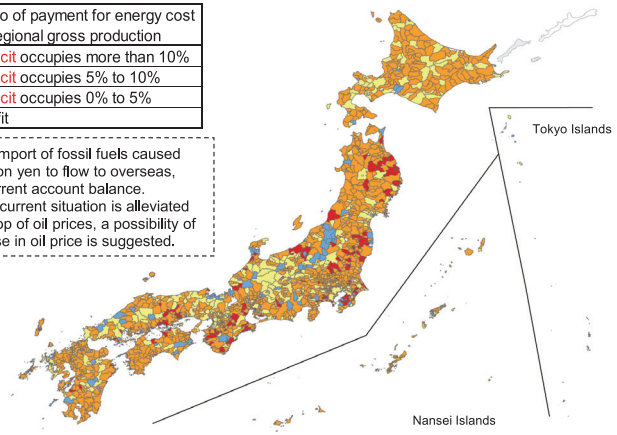
Source: "Oil Price Statistics" created by The Oil Information Center

②Balance of energy cost payments against regional gross production

Looking at the balance of regional energy cost payments in about 80% municipalities, funds equivalent to 5% or above the regional gross production flow outside the region. As most of the energy sources are fossil fuels, it indicated that many energy cost payments that took place in the regions were flowing overseas.

Legend	Ratio of payment for energy cost to regional gross production
	Deficit occupies more than 10%
	Deficit occupies 5% to 10%
	Deficit occupies 0% to 5%
	Profit

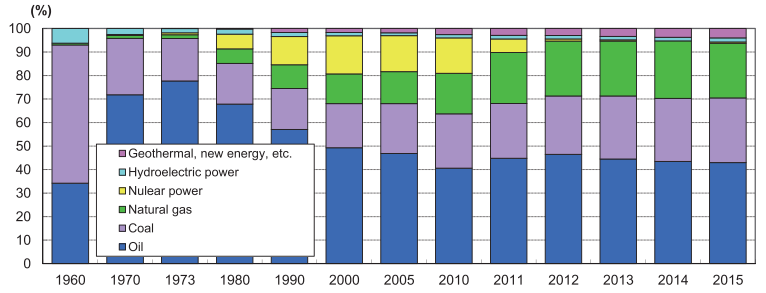
In 2013, the import of fossil fuels caused about 27 trillion yen to flow to overseas, tightening current account balance. Although the current situation is alleviated due to the drop of oil prices, a possibility of future increase in oil price is suggested.



Source: "Long-term Low-carbon Vision" (March 2017, Global Environmental Committee, Central Environment Council)

③Breakdown of Japan's domestic primary energy supply and changes in self-sufficiency ratio

In Japan, as the energy demand increased during the high economic growth period, the conventionally used coal was gradually replaced by oil by the suppliers, and a large amount of oil started to be imported. In the 1960s, a 58.1% energy self-sufficiency ratio was achieved by the use of domestic natural resources, such as coal and hydroelectric power; however, it drastically reduced since that time. In fiscal 2015, Japan's energy self-sufficiency ratio is 7.0% (estimate) thanks to the introduction of new energy and reopening of nuclear power plants.



Fiscal year	1960	1970	1973	1980	1990	2000	2005	2010	2011	2012	2013	2014	2015
Energy self-sufficiency rate (%)	58.1	15.3	9.2	12.6	17.0	20.2	19.1	19.9	11.1	6.2	6.1	6.0	7.0

(Note 1) IEA treats nuclear power as domestically-produced energy.
(Note 2) Energy self-sufficiency rate (%) = Domestic production/Primary energy supply X100
(Note 3) Data of 2015 is an estimate value compiled by IEA.

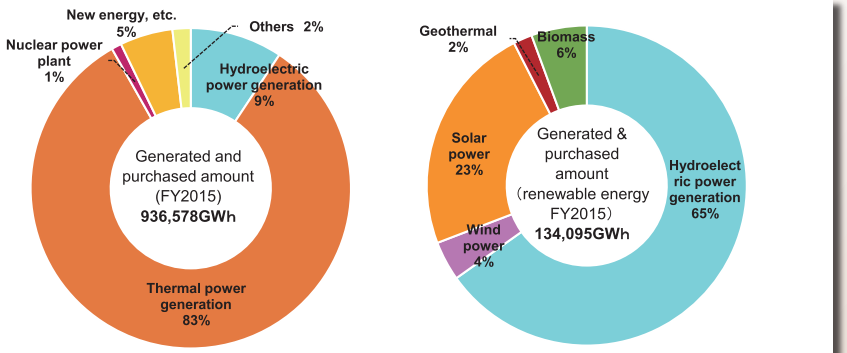
Source: "2016 Annual Report on Energy" (Japan's Energy White Paper 2017) (June 2, 2017, approved by the cabinet)

3.2 Introduction of Renewable Energy in Power Generation

3.2.1 Energy Mix

①Breakdown of generated and purchased electric power

Of the total domestically produced and purchased electric power in fiscal 2015, approximately 83% came from thermal power generation, approximately 9% came from hydroelectric power generation, and approximately 5% came from new types of energy (wind power, solar power, geothermal power, biomass, waste). Of the entire renewable energy, approximately 65% came from hydroelectric power, approximately 23% came from solar power, and approximately 6% came from biomass energy.

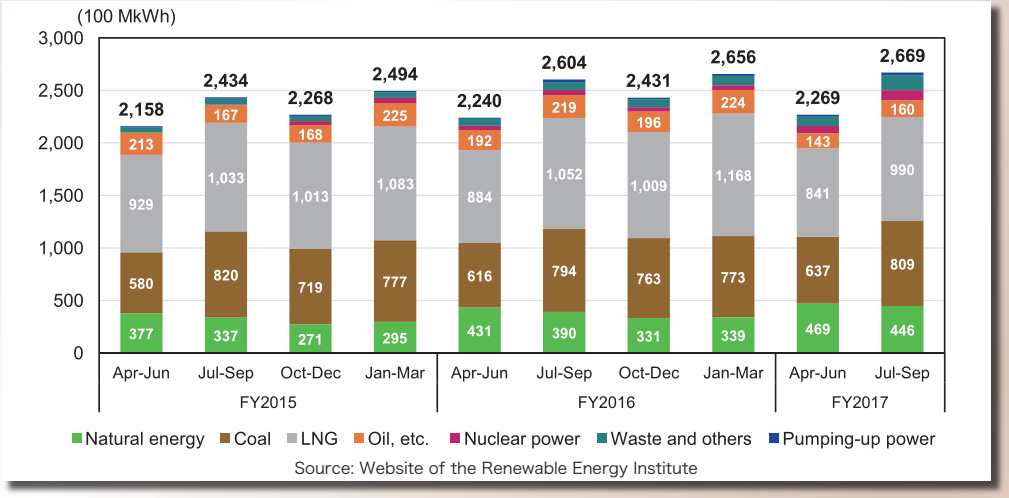


Note: Values indicated as "thermal power" are calculated by subtracting the electric power generated using biomass and waste from the electric power generated and purchased from thermal power plants.
"New types of energy" includes wind power, solar power, geothermal power, biomass, and waste.

Source: "Electric Power Statistics" (FY 2015) created by the Agency for Natural Resources and Energy, METI

②Changes of electric power generation by type of power source

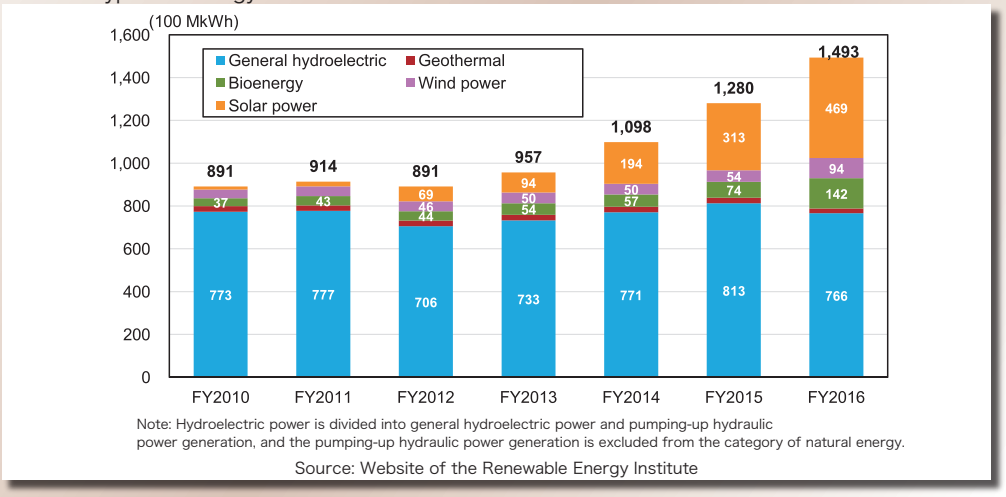
The amount of generated and purchased electric power tends to increase in winter and summer.



Source: Website of the Renewable Energy Institute

③Change in the amount of generated and purchased electric power derived from natural energy

Since the feed-in tariff scheme was introduced, the amount of primary energy supply derived from natural energy has been increasing. Solar power, in particular, is growing more than other types of energy.

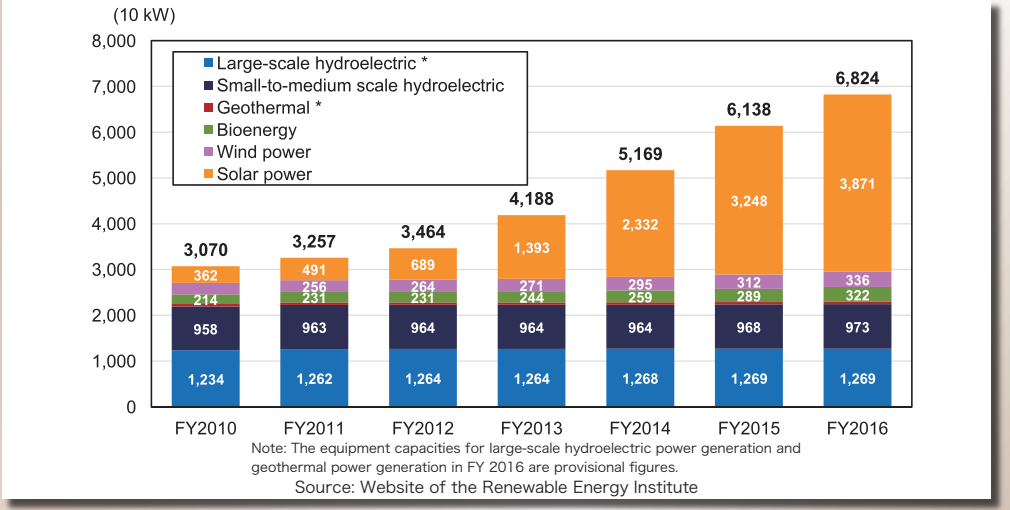


Note: Hydroelectric power is divided into general hydroelectric power and pumping-up hydraulic power generation, and the pumping-up hydraulic power generation is excluded from the category of natural energy.

Source: Website of the Renewable Energy Institute

④Changes in the capacity of natural energy equipment

Since the feed-in tariff scheme was introduced in July 2012, the capacity of natural energy equipment has been increasing. Especially solar power is growing more than other types of energy.

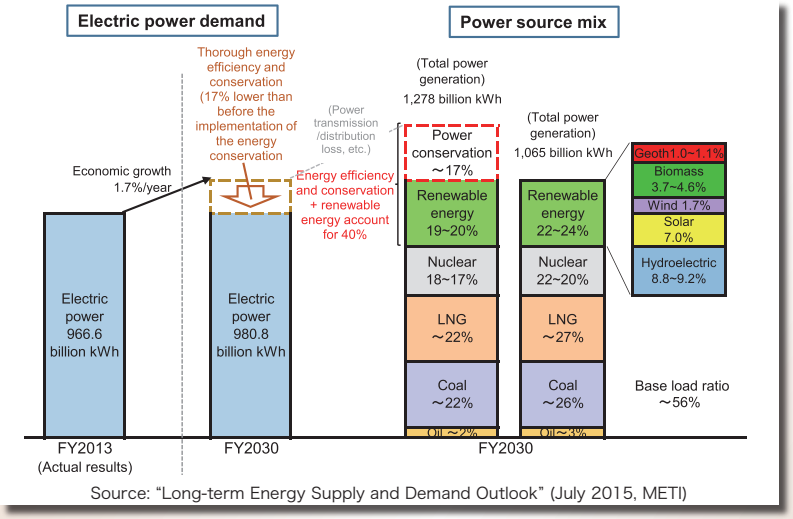


Note: The equipment capacities for large-scale hydroelectric power generation and geothermal power generation in FY 2016 are provisional figures.

Source: Website of the Renewable Energy Institute

⑤Future power source mix (FY 2030)

According to the "Long-Term Energy Supply and Demand Outlook," renewable energy will account for 22% to 24% of the power source mix in 2030, while biomass will account for around 3.7% to 4.6%.



Source: "Long-term Energy Supply and Demand Outlook" (July 2015, METI)

How to Join the Japan Woody Bioenergy Association

Our members include individuals, corporations, organizations, and municipalities who have agreed to the promotion of using wood biomass energy.

You can receive newsletters (wrriten in Japanaese).

We will send members a newsletter issued on a regular basis (1-2 times/months).

You can participate in events and workshops held by the Association (members only).

Members can participate in study members-only meetings and other events hosted by the Association on a regular basis.

We will introduce efforts in your company. (only for corporations and organizations)

Members are offered a booth for introducing their efforts in various events we participate and their company names (with links) are posted on our website.

Annual fee

	Registration	Annual fee
Regular member	Individual member	10,000 Yen
	Corporation/organization member	100,000 Yen

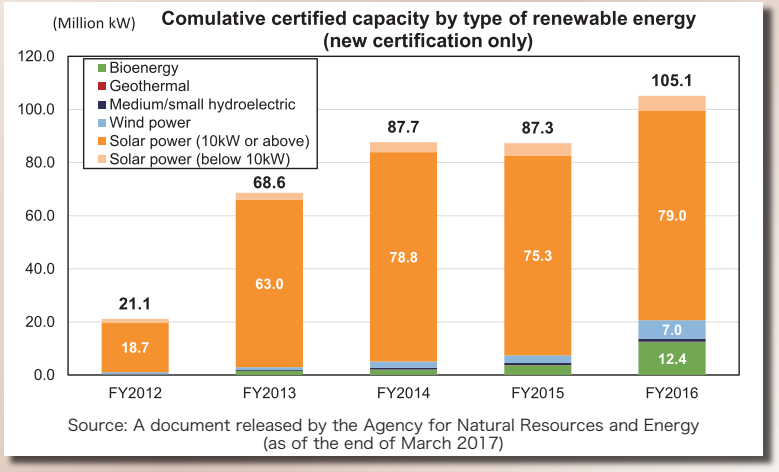
Our members

Unsawn-timber manufacturer	Forestry/lumber businesses	Construction machine manufacturers
Manufacturer of wood biomass fuel	Pellet/chip manufacturers	Fuel manufacturing device manufacturers
User of wood biomass fuel	Paper manufacturers/power plants	Boiler/generator manufacturers
Others	Financial institutions, trade company, engineering, consulting, municipalities, etc.	

3.2.2 Introduction of Renewable Energy by the Feed-in Tariff Scheme

①Certified equipment capacity by type of renewable energy

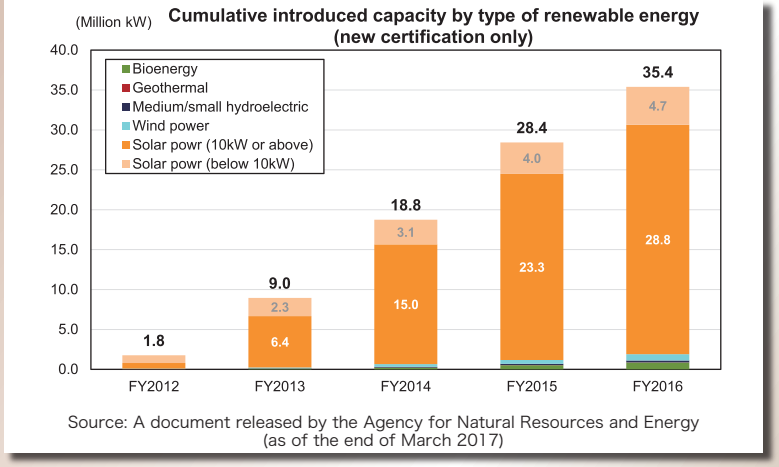
Since the feed-in tariff scheme (FIT scheme) was introduced in July 2012, the certified capacity of solar power generation, which has higher preset procurement price and relatively less technical restrictions in introducing equipment,, has increased rapidly. While solar power accounted for more than 90% by type of energy between fiscal 2012 and 2015, by fiscal 2016, the certified capacity of bioenergy and wind power had increased and now accounts for about 20% of the entire figure.



Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

②Introduced equipment capacity by type of renewable energy

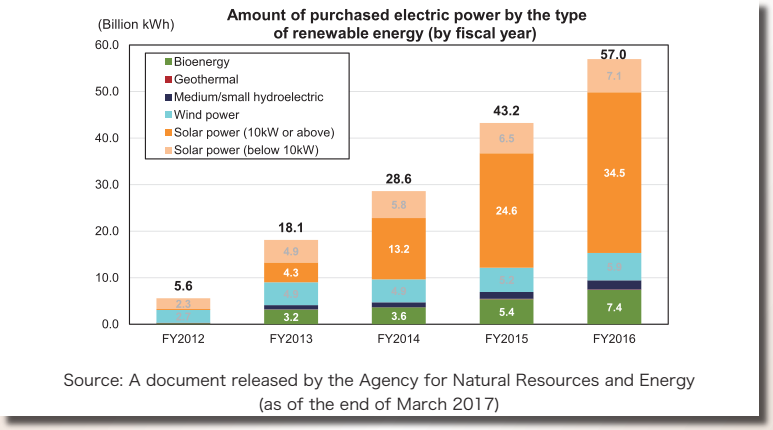
Of the entire amount of introduced renewable energy, solar power generation, which requires relatively less of an equipment installation period, accounted for over 94% in fiscal 2016 since the introduction of the FIT scheme. It is expected that the introduction of other renewable energy than solar power will become more popular as the rate of certified capacity increases.



Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

③Changes of the amount of purchased electric power by type of renewable energy

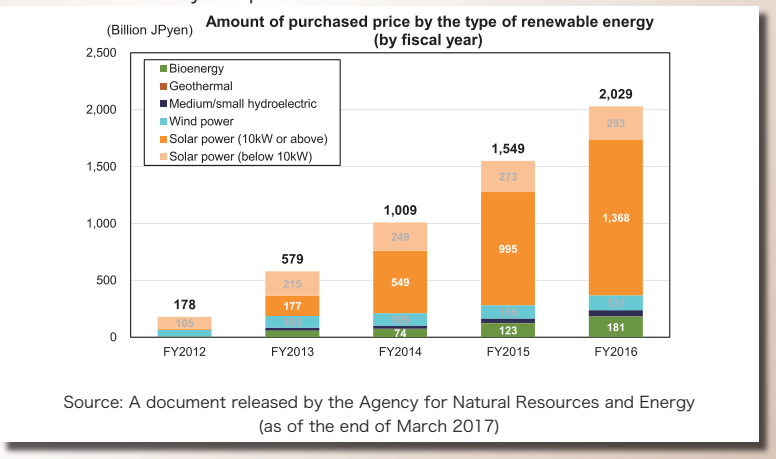
The introduced capacity of renewable energy indicated in the previous section(newly certified amount) is 35.4 million kW, and about 2% came from biomass power generation. However, the accumulated electric power purchased at the purchase price (procurement price) set in the FIT scheme reached about 152.5 billion kWh (including the amount purchased from the equipment that was conventionally controlled under RPS law and currently controlled under the FIT scheme) of which biomass power generation accounts for approximately 13%. This is achieved because biomass power generation is not affected by weather and ensures high generating efficiency (long actual operating time).



Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

④Changes of purchase price by type of renewable energy

Although it has already been 4 years since the feed-in tariff scheme was introduced, in fiscal 2016, the amount of renewable energy purchased under the scheme reached 2 trillion yen. Of that, electric power generated by biomass power generation accounted for approximately 9% of the entire figure (fiscal 2016). The reason for the small figure compared with the produced amount was the high proportion of power generation using fuel categories, which were purchased at relatively low prices.



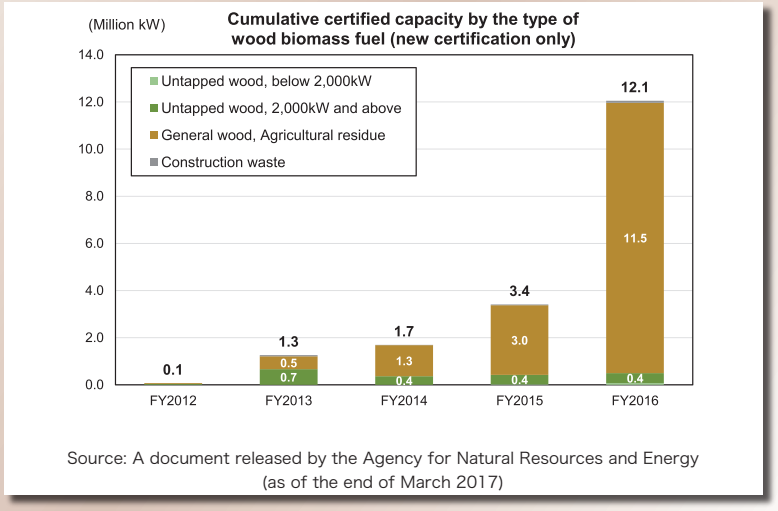
Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

3.3 Wood Biomass Energy

3.3.1 Introduction of Wood Biomass Energy

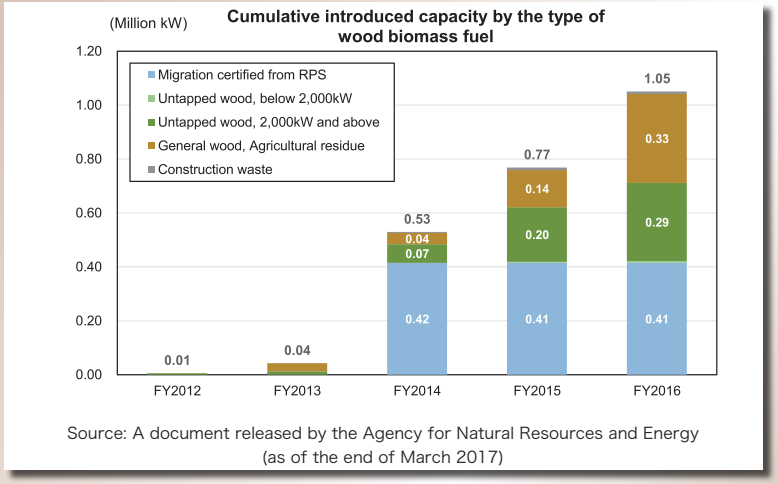
①Certified equipment capacity for wood biomass energy

There are 491 power plants certified as wood biomass power generation equipment (as of the end of March 2017) with around 12 million kW of certified power generation capacity. Approximately 84% of the certification and 95% of the certified capacity are occupied by power generation using general wood, agricultural residue, etc.



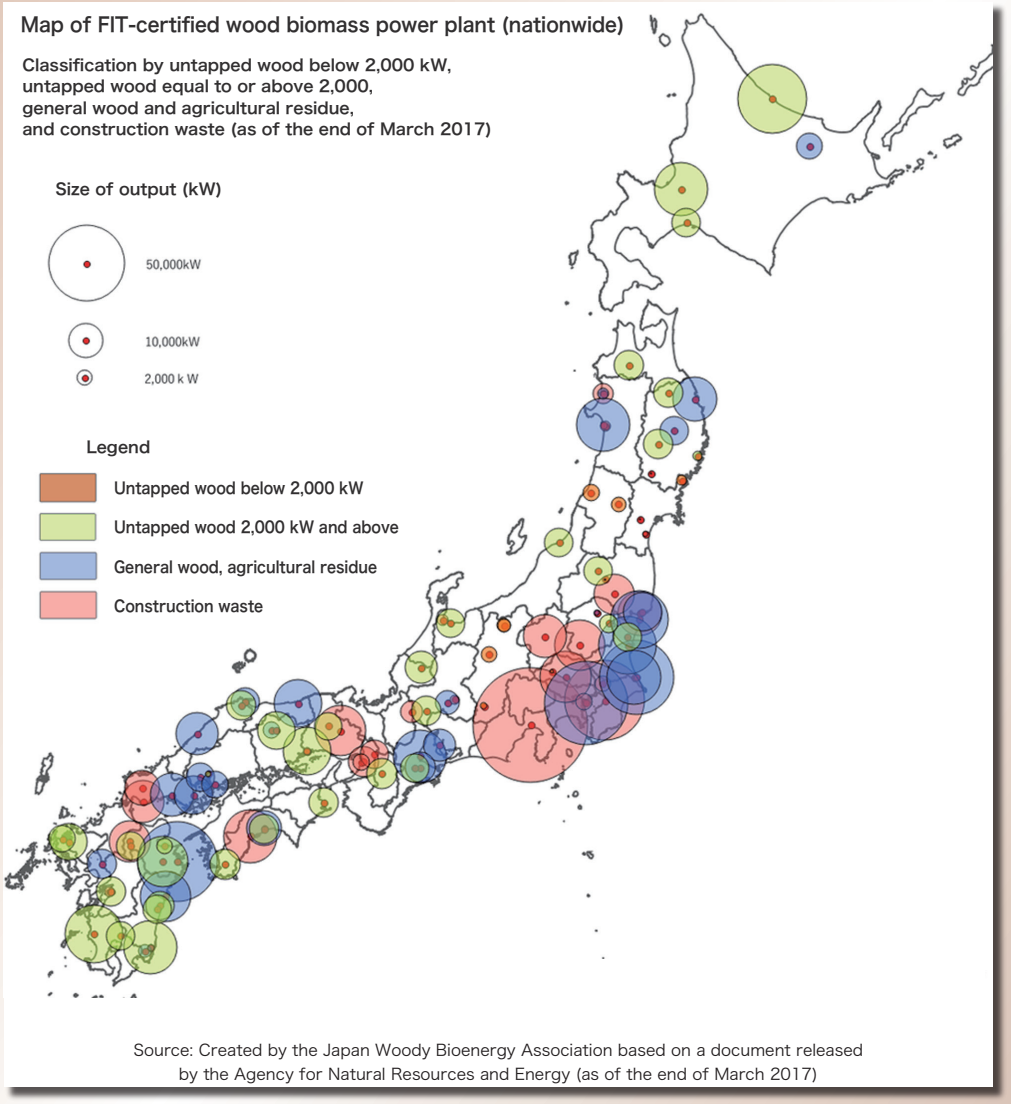
Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

②Introduced capacity for equipment using wood biomass energy (new + migrated)



Source: A document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

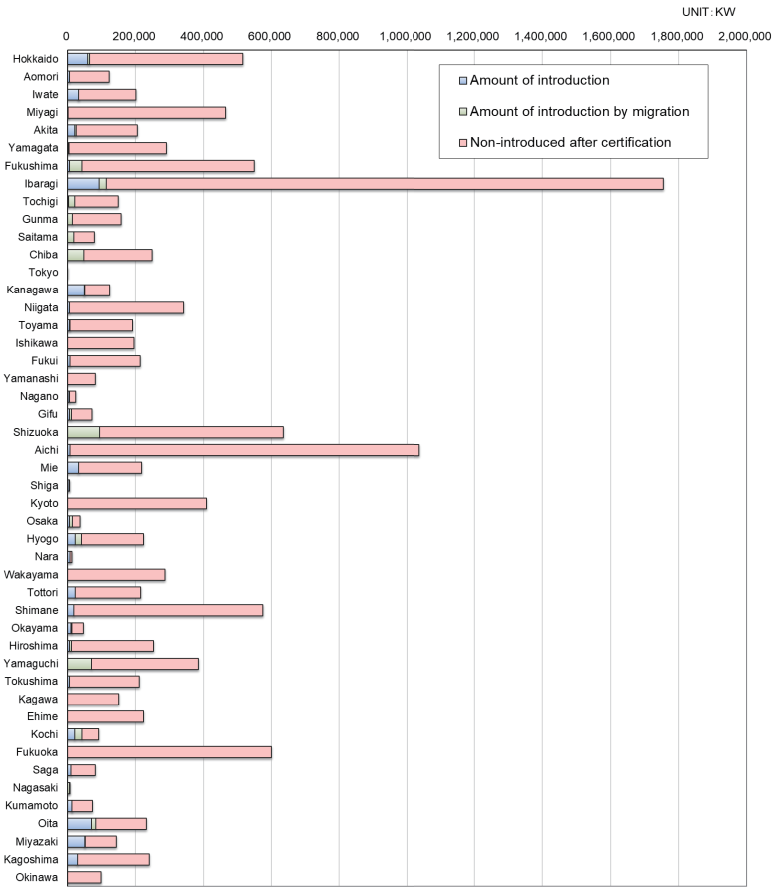
③Introduction map of wood biomass power plant in the FIT scheme



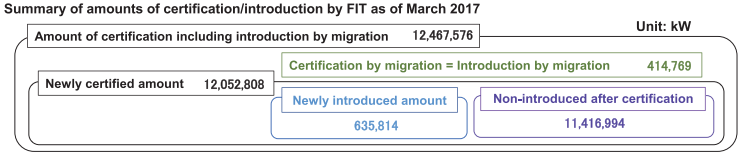
Source: Created by the Japan Woody Bioenergy Association based on a document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

④Certification/introduction status of wood biomass power plants by prefecture

Data by prefecture



Summary of amounts of certification/introduction by FIT as of March 2017

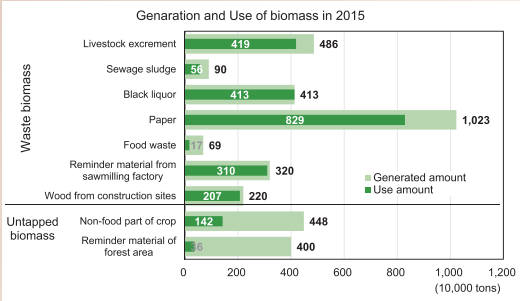


Source: Created by the Japan Woody Bioenergy Association based on a document released by the Agency for Natural Resources and Energy (as of the end of March 2017)

3.3.2 Generation and Use Quantity of Wood Biomass

①Generation and use of various types of biomass

Biomass generation (potential quantity) is decreasing over the medium-and-long term thanks to efforts for suppressing the generation of waste biomass. While the amount used in fiscal 2015 (carbon equivalent)was about 24 million tons, we aim to increase it to 26 million tons in 2025. Taking the existing use in to consideration, we set individual goals by biomass type for promoting multi-staged use to create economic value as well as for promoting thermal use to ensure high energy efficiency.

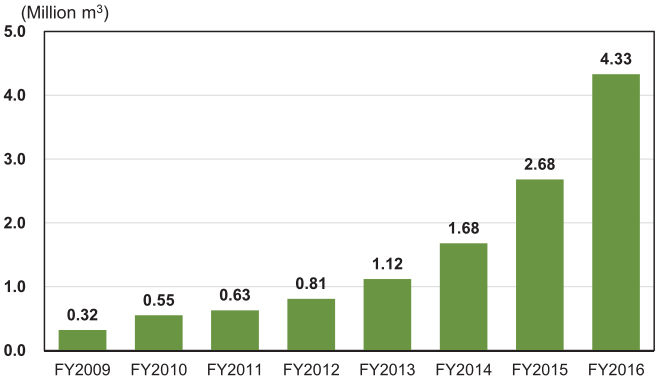


	FY2010	FY2015	FY2025
Generation of biomass	Approx. 35 Mt	Approx. 34 Mt	Approx. 32 Mt (estimate)
Use of biomass (carbon equivalent)	Approx. 23 Mt	Approx. 24 Mt	Approx. 26 Mt (target)
Type of biomass	Use rate	Use rate	Use rate
Livestock excrement	Approx. 65.7%	87%	Approx. 90%
Sewage sludge		63%	Approx. 85%
Black liquor		100%	100%
Paper		81%	Approx. 85%
Food waste		24%	Approx. 40%
Reminder material from sawmilling factory		97%	Approx. 97%
Wood from construction sites		94%	Approx. 95%
Non-food part of crop		32%	Approx. 45%
Reminder material of forest area		9%	30% or above

Source: “Circumstances Concerning Utilization of Biomass” created by the Ministry of Agriculture, Forestry and Fisheries (April 2017)

②Use amount of untapped wood biomass in power generation

The amount of untapped materials, such as lumber from thinning and remainder materials of forest areas, is increasing each year since the introduction of the feed-in tariffs scheme. In fiscal 2015 and 2016, it increased by about 60% compared to the previous year.



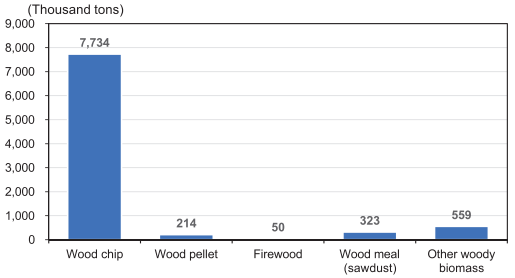
Note: These values are obtained by converting the amount of lumbers from thinning and remainder materials of forest areas used for wood chips and wood pellets into tree volume by using a conversion rate (2.2 m²/t for wood chip).

Source: According to the survey of the Wood Utilization Division of Forestry Agency for data of 2014 and earlier. Data in 2015 and 2016 is based on the “Survey of Wood Biomass Use Trends” and “Statistics of Production of Forest Products for Special Use” created by the Forestry Agency.

③Use amount of wood biomass by type and origin

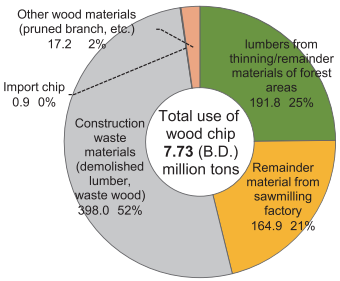
Of the total use of wood biomass by type in fiscal 2016, “wood chips” accounted for approximately 87%, “wood meal (sawdust)” accounted for approximately 3%, “wood pellets” accounted for approximately 2%, “firewood” accounted for about approximately 0.5%, all of which occupied approximately 93% of the total figure. The use amount of wood chips included in the figure consisted of construction waste (approx. 52%), lumber from thinning/remainder materials of forest areas (approx. 25%), and remainder material from sawmilling factories (approx. 21%).

Use amount of wood biomass by type



* The unit of wood chip is bone-dry ton and that of other materials is 10,000 tons.

Use amount of wood chip by origin

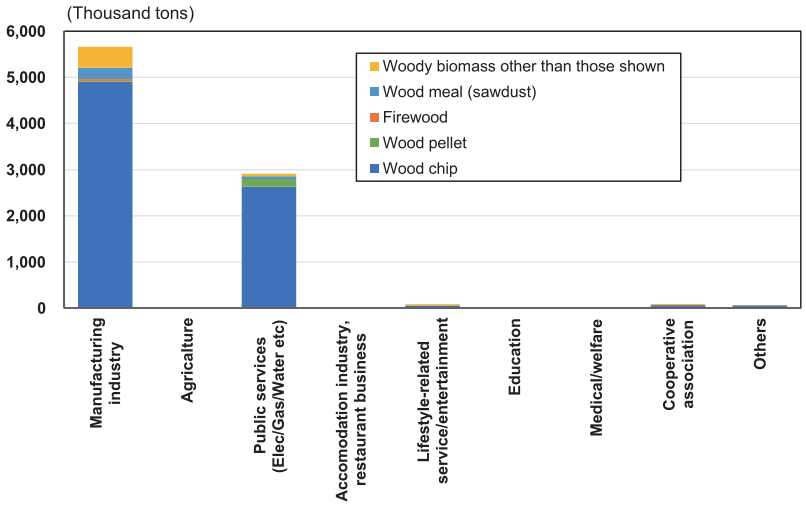


* The unit of wood chip is bone-dry ton and that of other materials is 10,000 tons.

Source: FY 2016 “Survey of Wood Biomass Use Trends by the Forestry Agency

④Use amount of wood biomass by industry type

By industry, “Manufacturing industry” has the largest share, approx. 64%, followed by “Electricity/gas/heat supply/water industry,” which accounts for approx. 34%. Approximately 98% of the entire figure is occupied by these two industries.

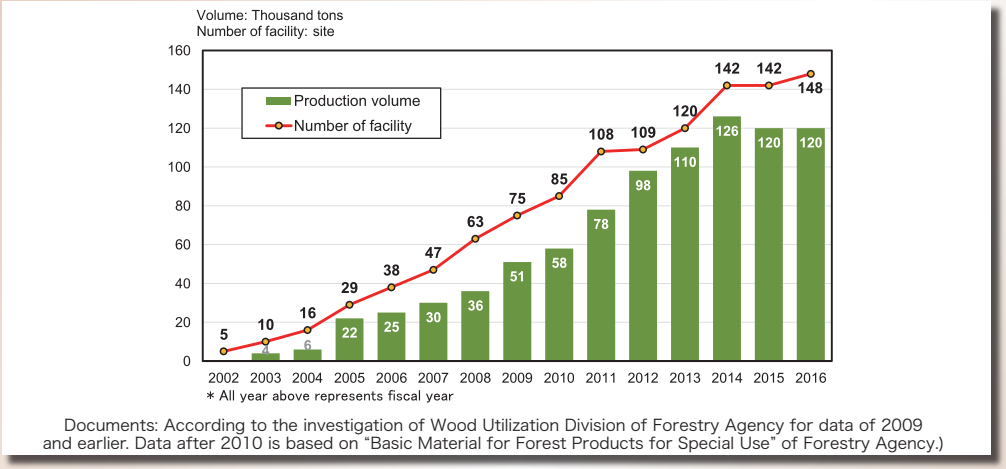


* The unit of wood chip is bone-dry ton and that of other materials is 10,000 tons.

Source: FY 2016 “Survey of Wood Biomass Use Trends by the Forestry Agency

⑤Changes in the number of wood pellet manufacturing facilities and domestic production volume

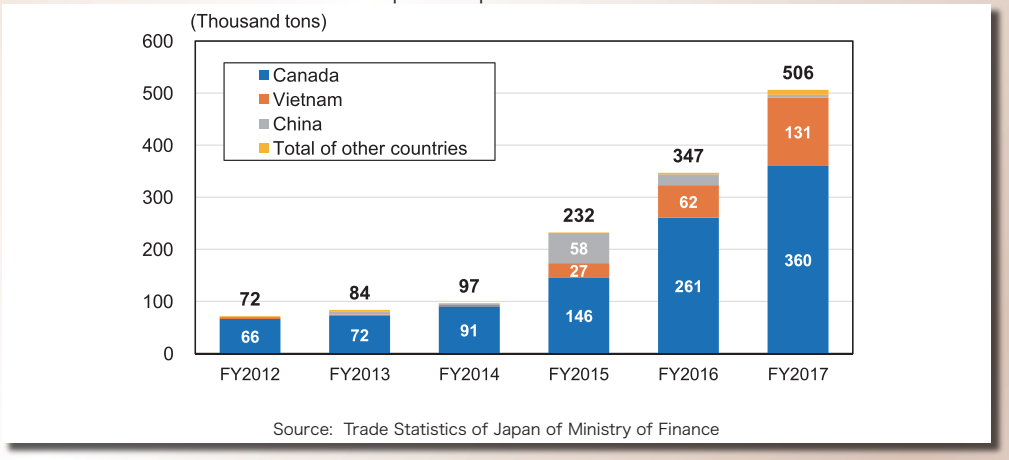
Wood pellet fuels are made from compacted sawdust. It has a consistent shape, high energy density, low moisture and other benefits including the easiness of transfer and storage. The domestic production volume of wood pellets was 120,000 tons (in fiscal 2016), and there has been no remarkable changes in the past three years. The number of wood pellet manufacturing facilities is about 140 to 150, of that small-sized pellet factories with an annual production volume 100 to 1000 tons account for about 60%.



Documents: According to the investigation of Wood Utilization Division of Forestry Agency for data of 2009 and earlier. Data after 2010 is based on "Basic Material for Forest Products for Special Use" of Forestry Agency.)

⑥Changes of import quantity of wood pellet

As mentioned above, the domestic production volume and the number of facilities have not increased in recent years. However, as part of the measures against global warming, co-combustion of wood pellets in coal fired power plants is becoming popular, and wood pellets are exclusively used for imported wood pellets. In fiscal 2015, the import quantity increased more than two times the previous year, which has further grown by one and half times from then on. Most of the imports depend on Canada and Vietnam.

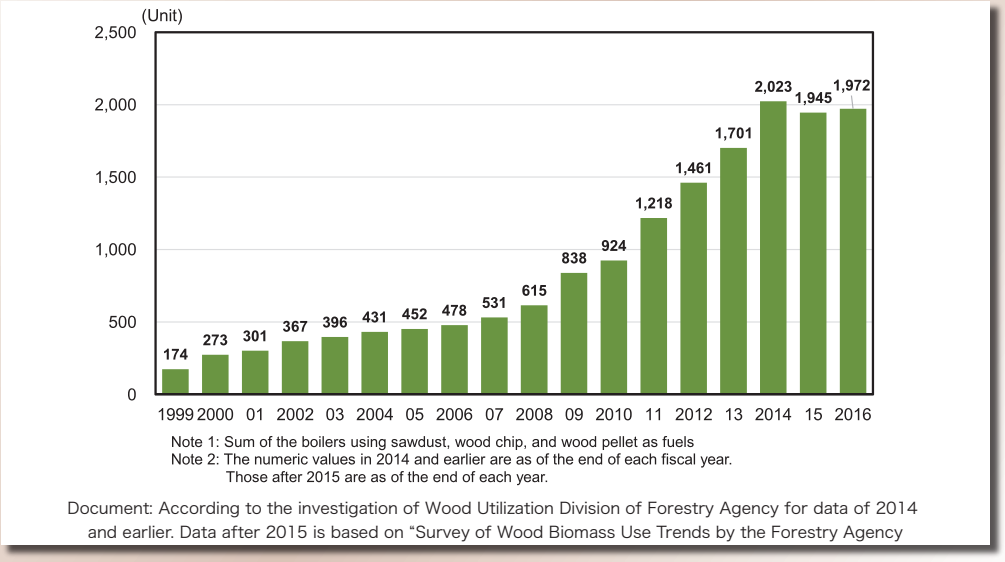


Source: Trade Statistics of Japan of Ministry of Finance

3.3.3 Utilization of Heat from Wood Biomass

①Number of boilers using wood resources

About 2000 boilers using wood biomass are currently installed mainly in the manufacturing and agriculture industries, however the figure has remained steady since fiscal 2014.

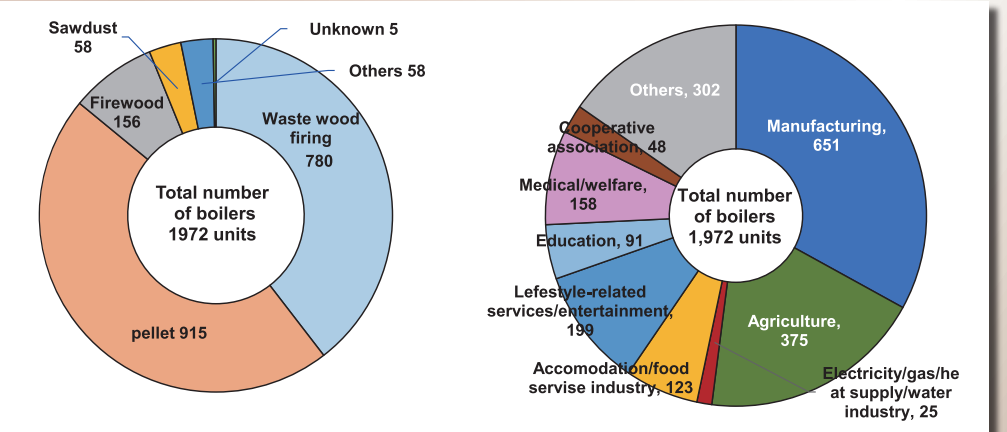


Note 1: Sum of the boilers using sawdust, wood chip, and wood pellet as fuels
Note 2: The numeric values in 2014 and earlier are as of the end of each fiscal year. Those after 2015 are as of the end of each year.

Document: According to the investigation of Wood Utilization Division of Forestry Agency for data of 2014 and earlier. Data after 2015 is based on "Survey of Wood Biomass Use Trends by the Forestry Agency

②Classification of boilers using wood resources by fuel and industry type

Of the total number of boilers using wood resources by type of fuel in fiscal 2016, waste wood firing (780 units) and wood pellets (915) accounted for more than 80% of the entire figure. Also, by type of industry that introduced the boilers, while the manufacturing and agricultural industries accounted for more than half the entire figure, recently they have also begun to be introduced in public facilities and spa facilities.

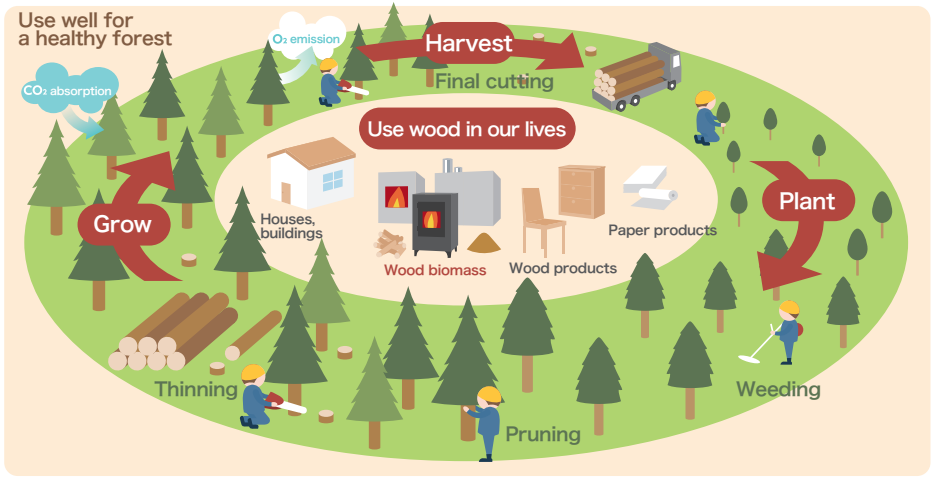


Source: FY 2016 "Survey of Wood Biomass Use Trends" by the Forestry Agency

4 Domestic Forest Resources

①CO_2 circulation through utilization of wood resources

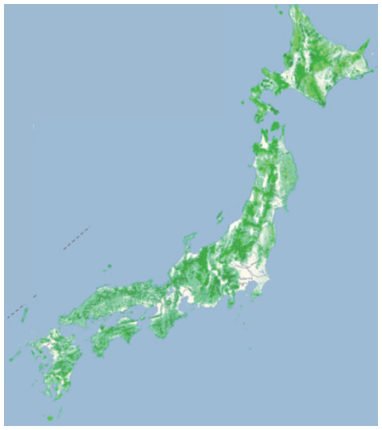
The utilization of wood resources not only leads to the creation of a comfortable living environment and revitalization of the regional economy, but it also contributes to prevention of global warming through CO_2 absorption by woods. In particular, by using domestic wood materials, we can maintain a cycle of plant -> grow -> use -> plant to continually make the best use of the multidimensional functions of forests, while distributing profits to mountain owners for regional revitalization.



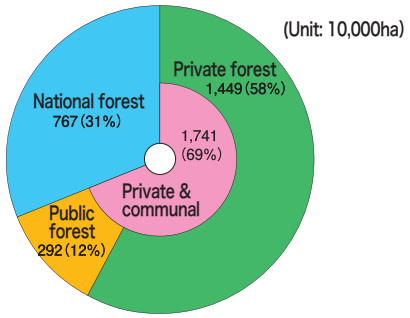
Source: "For those who considering power generation and thermal use using wood biomass – Introduction Guidebook - " issued by the Japan Woody Bioenergy Association

②Forestry map of Japan

Japan is one of the countries well known for abundant forest areas with two-thirds of its territory covered by forests. The forest area of Japan is about 25 million ha (of which 10 million ha is occupied by planted forests), which is bigger than the main island (23.1 million ha). The proportion of national forests and privately owned forests is 3:7.



Source: Released version of forest cloud (NTT Space Information, Inc.)



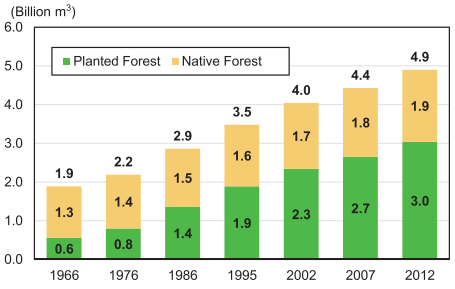
Note: The values in the graph are as of 31 March 2012.

Source: Trend of Forest and Forestry in Japan" (Annual Report on Forest and Forestry in Japan Fiscal Year 2016)

③Forest resources in Japan

The cumulative amount of forest, which represents forest resources, is as much as about 4.9 billion m^3, more than twice the figure 30 years ago. It is still increasing by about 100 million m^3 each year.

Changes of cumulative amount of forest



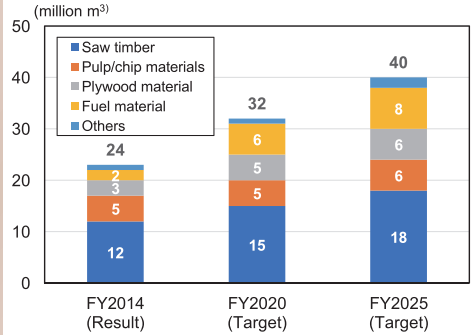
Note 1: The values shown in the table are as of March 31 of each year.
Note 2: In 2007 and 2012, yield tables were reviewed in some prefectures to improve accuracy, therefore, the values are not completely comparable with those in other years.
Material: "Current Situations of Forest Resources" created by the Forestry Agency

Source: "Trends of Forest and Forestry (May 2016 Annual Report on Forest and Forestry in Japan Fiscal Year 2016)

④Goals in using forest products

The amounts of wood to be used in 2020 and 2025 by usage are determined for the realization of the smooth circulation of forest practices and the sustainable and healthy development of forestry.

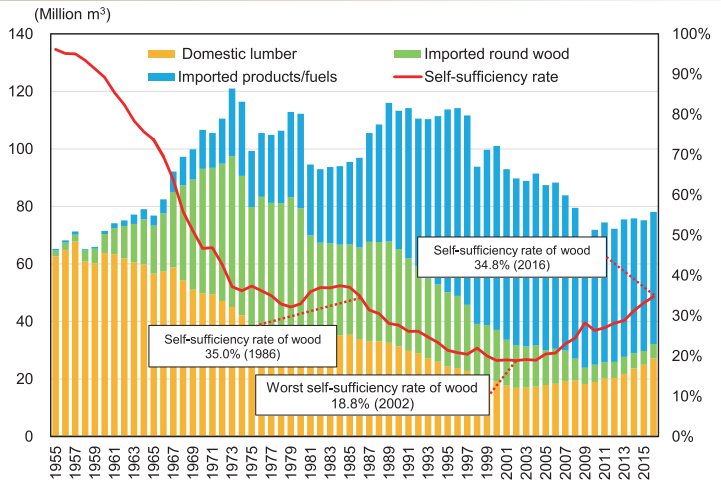
Result and target for the amount of wood used



Source: "Basic Plan of Forest and Forestry" (2016) created by the Forestry Agency

④Changes of the demand for wood and self-sufficiency rate

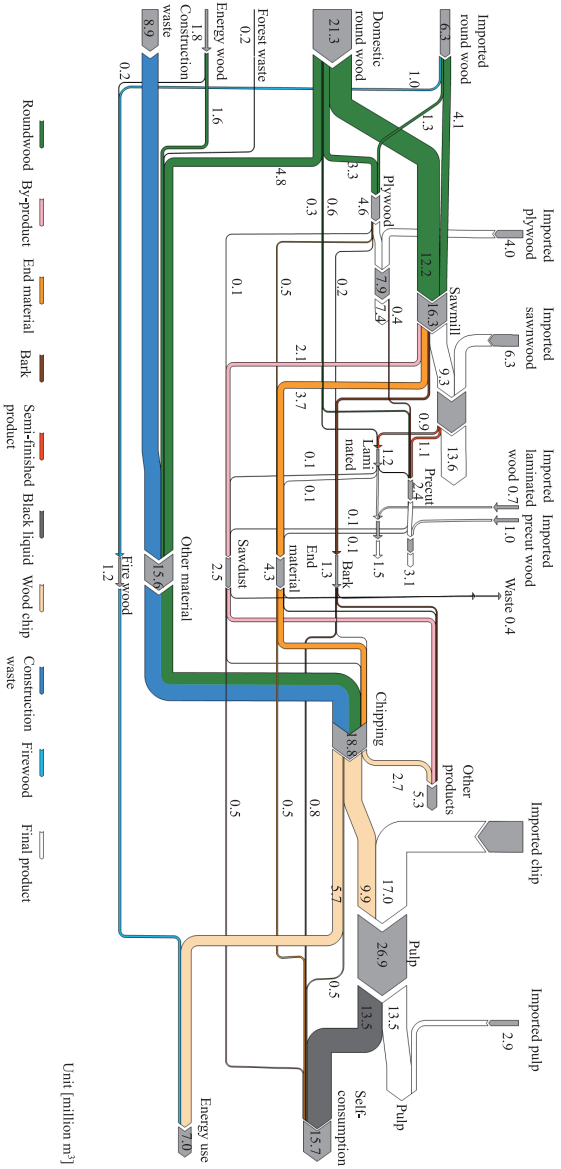
Looking at the changes in Japan, wood demand continually increased during the period of high economic growth, reaching a record high of 121.02 million m^3 (round wood equivalent) in 1973. After that, the demand kept on fluctuating because of the impact of the first and second oil shocks, and although it continued on a downward trend due to the recession after the collapse of the bubble economy, the demand has recovered in recent years. Moreover, the self-sufficiency rate of wood, which also marked the worst 18.8% in 2002, recovered to 34.8% in 2015.



Source: 2016 Wood Demand Table created by the Forestry Agency

⑤Woodflow chart for Japan

Dr. Furubayashi and his team at Tohoku University are conducting research on the quantification of the cycle of raw wood materials through final use and visualizing it along with the use of wood biomass energy.



Source: Wood Flow Chart for Japan: Material and Energy Utilization, Journal of Japan Institute of Energy (2017)
Takaaki Furubayashi and his team, Graduate School of Engineering, Tohoku University

Conversion Table

Conversion table of volume and weight of wood

	Volume (round wood equivalent) (m^3)	Wet weight of raw wood for chip (tons)	Chip capacity (apparent capacity) (m^3)	Bone dry weight (BDt)	Pulp yield (tons)
Softwood chip	1.0	0.8	3.0	0.5	0.2
	1.3	1.0	2.4	0.4	0.2
	0.3	0.2	1.0	0.1	0.1
	2.2	1.8	6.6	1.0	0.5
	4.8	3.8	14.4	2.2	1.0
Hardwood chip	1.0	1.3	3.0	0.6	0.3
	0.8	1.0	2.4	0.5	0.2
	0.3	0.4	1.0	0.2	0.1
	1.7	2.1	5.1	1.0	0.5
	3.7	4.6	11.1	2.2	1.0

(Note) The conversion rate used for transactions is different depending on the region, tree species, section, and quality.
Wet weight of raw wood used for chip is different by tree species and moisture content.

Source: Conversion between round wood and bone-dry weight: Wood Demand Table created by the Forestry Agency,
Conversion between apparent capacity and round wood capacity: Wood Chips (1987) created by Japan Wood Chip Industrial Association,
Conversion between bone-dry weight and pulp yield: Wood Industry Handbook edited by Forest Research and Management Organization,
Conversion between round wood and wet weight of raw wood for chip: administrative documents created by the Forestry Agency (results of interview in the industry)

About water content and moisture content

Water content % at wet base (w.b.)	Ratio of water weight to the weight including water (raw wood) Water content % (w.b.) = (Weight before drying [kg] – Total bone-dry weight [kg]) / Weight before drying [kg]
Moisture content % at dry base (d.b.)	Ratio of water weight to the weight including completely dried Moisture content % (d.b.) = (Weight before drying [kg] – Total bone-dry weight [kg]) / Total bone-dry weight [kg]

Source: Operational Text Concerning Introduction/Operation of Wood Biomass Boiler, created by Forest Realize Co. Ltd. and other organizations.

Unit conversion table of water content by type of fuel and energy content(Softwood)

Water content (%)	0	5	10	15	20	25	30	35	40	45	50	55	60
kWh/ton	5,200	4,910	4,610	4,320	4,020	3,730	3,440	3,140	2,850	2,550	2,260	1,970	1,670
kWh/round wood m^3	1,971	1,957	1,942	1,925	1,906	1,885	1,860	1,832	1,799	1,760	1,713	1,656	1,584
kWh/firewood m^3	1,380	1,370	1,360	1,348	1,334	1,319	1,302	1,282	1,259	1,232	1,199	1,159	1,109
kWh/chip m^3	788	783	777	770	763	754	744	733	720	704	685	662	634
Bulk density (ton/chip m^3)	0.15	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.25	0.28	0.30	0.34	0.38

Source: Created by Bioenergy Research & Investment Inc. based on a document issued by the LWF (The Bavarian State Institute of Forestry, Germany)

Conversion table of energy unit

		MJ	kWh	Mcal
1MJ	=	1	0.278	0.239
1kWh	=	3.60	1	0.860
1Mcal	=	4.187	1.162	1