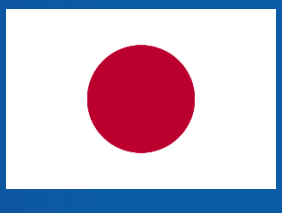
Implementation of bioenergy in Japan - 2021 update

IEA Bioenergy
Technology Collaboration Programme

Country Reports

IEA Bioenergy: 10 2021



This report was prepared from the 2021 IEA World Energy Balances and Renewables Information, combined with data and information provided by the IEA Bioenergy Executive Committee and Task members[1]. Reference is also made to FAOstat as well as data from national statistics. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report for all country reports.

Edited by: Luc Pelkmans, Technical Coordinator IEA Bioenergy

Contributing organizations:

- New and Renewable Energy Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI)
- New Energy Technology Department, New Energy and Industrial Technology Development Organization (NEDO)

HIGHLIGHTS

- Oil products, coal and natural gas are still dominating the Japanese energy system. Renewables make up a modest share of 6% of *total energy supply* in Japan in 2019. The renewable energy share in *final energy consumption* is 8%[2]. Around one third of renewable energy is from biomass.
- After the Fukushima disaster in 2011, nuclear power was phased out and this was compensated by an increase of fossil power (mainly natural gas). In recent years renewable electricity (which was initially mainly hydropower) is growing, particularly solar power, but also some biomass-based electricity. Coal still represents a third of Japanese power production and does not show any substantial decline yet.
- Heat provision and transport fuels in Japan are still largely based on fossil fuels. In terms of transportation biofuels, Japan is putting high focus on Sustainable Aviation Fuels (SAF).
- Japan has important opportunities to further deploy bioenergy, particularly through the replacement of coal by solid biomass in existing assets, the increase of transport biofuels (which

[1] While data for 2020 are starting to become available at national level, it was decided to consider trends up to 2019 for good comparability and benchmarking between the different IEA Bioenergy member countries. Care should also be taken when using 2020 data for analysing trends as these data are distorted by the COVID19 Pandemic.

[2] The difference between the share of renewables in supply and consumption relates to unused heat from power plants (which is counted in energy supply, but not in final consumption).

are still less than 1% of transport biofuels) and the increase of biogas. There are also further opportunities to deploy (renewable) energy from MSW.

- As a current direction, it is necessary to expand the stable supply of biomass fuel and reduce the cost of the power generation business, etc. This is based on the premise of ensuring sustainability by mobilizing various policies in response to issues such as limited biomass resources that can be used for energy, ensuring sustainability, and reducing costs.

COUNTRY PROFILE

Population and land use

Japan is an island country east of the Asian continent. It has a total land area of 365 thousand km² and a population of 126.7 million people. This represents a high population density of 348 persons per km².

Around two thirds of the land area is forest land and 11% is agricultural land, almost exclusively arable land.

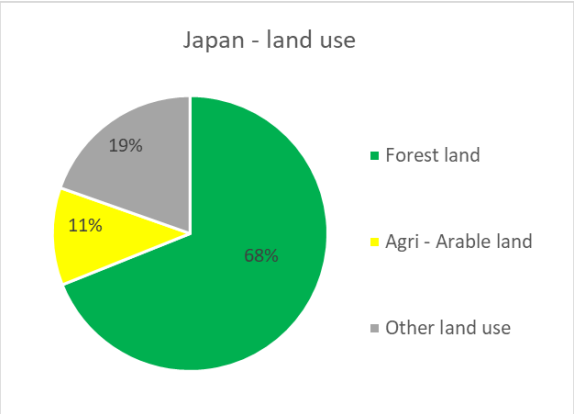


***Figure 1**: Land use in Japan (2018 figures - Source: FAOstat)*

Final energy consumption

Overall final energy consumption in Japan (*also including non-energy use of oil, natural gas, and coal in industry*) equates 2.2 tonnes of oil equivalent (toe) per capita, which is around the average of IEA Bioenergy countries. Transport and residential energy use are fairly low compared to other countries, while energy use in services is somewhat higher.

***Table 1**: Distribution of the final consumption of energy carriers by sector in Japan (2019 figures - Source: IEA (2021) World Energy Balances and Renewables Information)*

Final consumption energy carriers	Toe/capita (2019)	% of total	*Median* (toe/capita)*
Industry (energy use)	0.64	29%	*0.67*
Industry (non-energy use)	0.26	12%	*0.21*
Transport	0.55	25%	*0.69*
Residential	0.33	15%	*0.57*
Commercial & public services	0.39	18%	*0.34*
other	0.03	2%	
Total	2.20		*2.34*

** Median of the 25 member countries of IEA Bioenergy*[3]

[3] Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.

NATIONAL POLICY FRAMEWORK IN JAPAN

TARGETS AND STRATEGIES

On October 26, 2020, Prime Minister Suga Yoshihide declared that Japan aims to reduce GHG emissions to zero, to make Japan a carbon-neutral, decarbonized society by 2050.

The envisaged CO2 emission reductions will be reached with a combination of energy savings, electrification, renewable energy, and negative emissions, as indicated in the following figure.

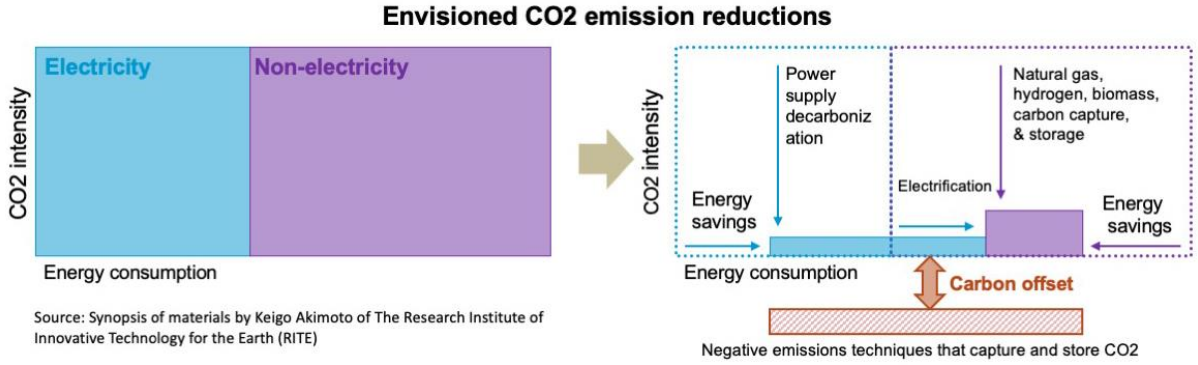


Figure 2: schematic overview of Japan's strategy to reach carbon neutrality by 2050 (source: METI[4]).

Japan aims to reduce Greenhouse Gas emissions by 46% over 2013 levels by 2030 and it aims to have 36 to 38% renewables in the power supply by 2030.

The 6th Strategic Energy Plan has been published on 22 October 2021.

Table 2: renewable energy and climate targets in Japan.

Sector	Share or renewables in gross final consumption per sector	GHG reduction target
Overall target	20% of primary energy supply by 2030	46% reduction by 2030 compared to 2013, carbon neutrality by 2050
Electricity	36 - 38% of total power generation by 2030	

A description of renewable energy and climate policies and measures in Japan is available at the IEA's Policies and Measures Database: https://www.iea.org/policies?country=Japan

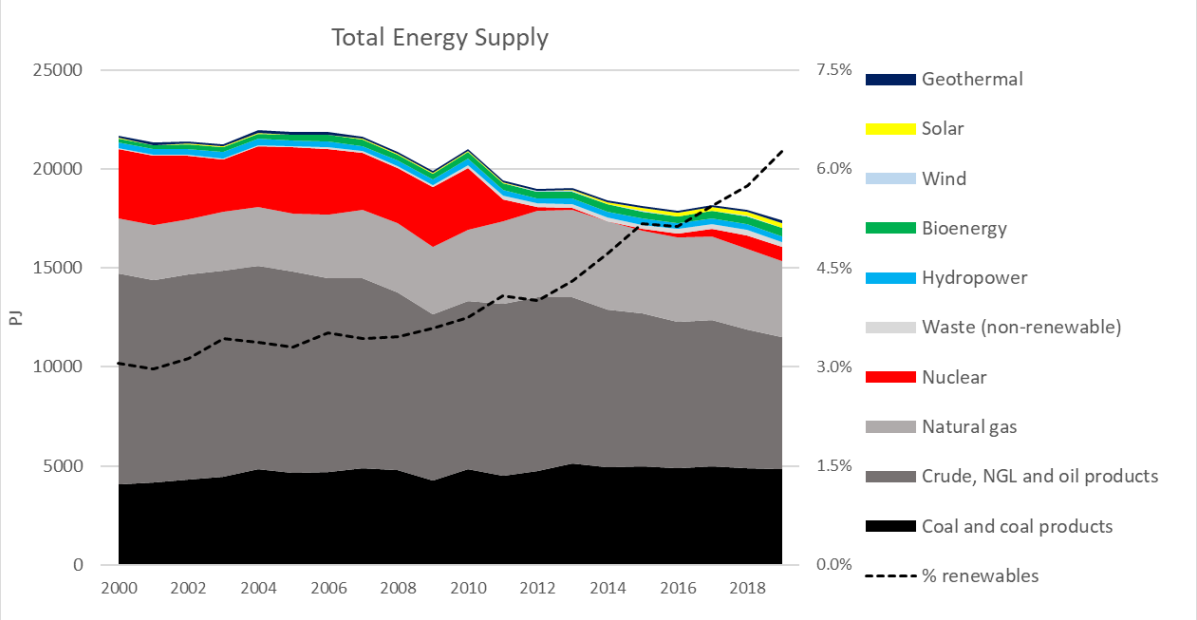
Specific policies related to renewable electricity, renewable heat and transport biofuels will be highlighted in the chapters about the role of bioenergy in different sectors.

4 https://www.meti.go.jp/english/policy/energy_environment/global_warming/roadmap/report/20201111.html

THE CONTRIBUTION OF BIOENERGY IN NATIONAL ENERGY SUPPLY

TOTAL ENERGY SUPPLY

The total energy supply (TES) of Japan in 2019 amounted to 17.4 exajoule (EJ) with fossil fuels (oil, coal, gas) contributing 88%. Oil products (6.7 EJ) are the dominant fuel, representing 38% of total energy supply. Coal represents another 28% (4.8 EJ) and natural gas around 22% (3.9 EJ). Renewable energy sources represent a modest 6.3% of total energy supply, around 40% of it being bioenergy.



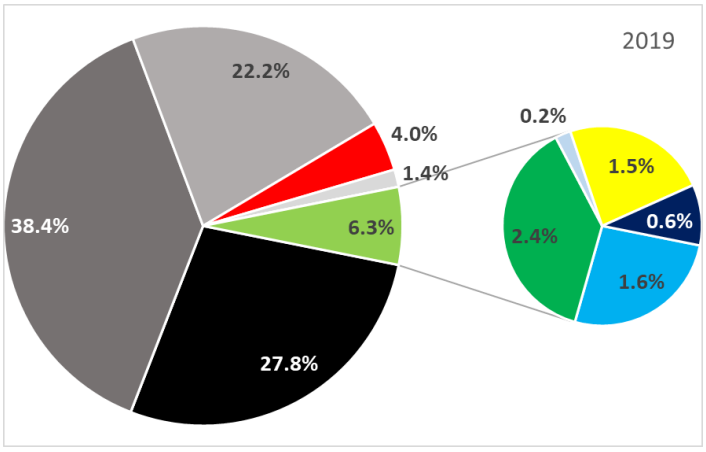


Figure 3: Total energy supply[5] and the contribution of different energy sources in Japan, with distribution in 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Total energy supply in Japan has actually decreased in the past 15 years, coming from 22 EJ in 2005 to 17 EJ currently, representing an average decline of almost 2% per year. The amount of **coal** is very stable around 4.9 EJ, not showing any decline (in contrast with other industrialised countries). **Oil** products are still dominant, but they have come down from 10 EJ in the early 2000s to 7 EJ in recent years. **Nuclear** energy represented 3 EJ or 15% of TES up to 2010 but dropped down to zero after the Fukushima incident in March 2011. There is a slight recovery recently to 4% of TES (0.7 EJ). **Natural gas** saw a steady growth in the 2000s from 2.7 to 3.5 EJ. With the sudden phase out of nuclear

[5] Total energy supply refers to the use of resources. In terms of the role in the energy system this distribution overestimates the role of resources producing electricity with a high share of unused waste heat (like nuclear plants).

energy, it took a step increase up to 4.4 EJ. This is slightly going down again in recent years to a level of 3.9 EJ in 2019.

Renewable energy increased steadily in the past 10 years, albeit at quite modest levels (from 3.5 to 6.3% of TES). Hydropower was fairly stable around 300 PJ, while bioenergy steadily increased from 300 to 400 PJ in the past 10 years. The main increase was in solar energy which increased from 30 to 250 PJ in the same period.

Figure 4 shows the evolution of the several types of bioenergy. Solid biomass represents 90% of bioenergy; the other types of bioenergy (biogas, liquid biofuels, renewable MSW) are much lower.

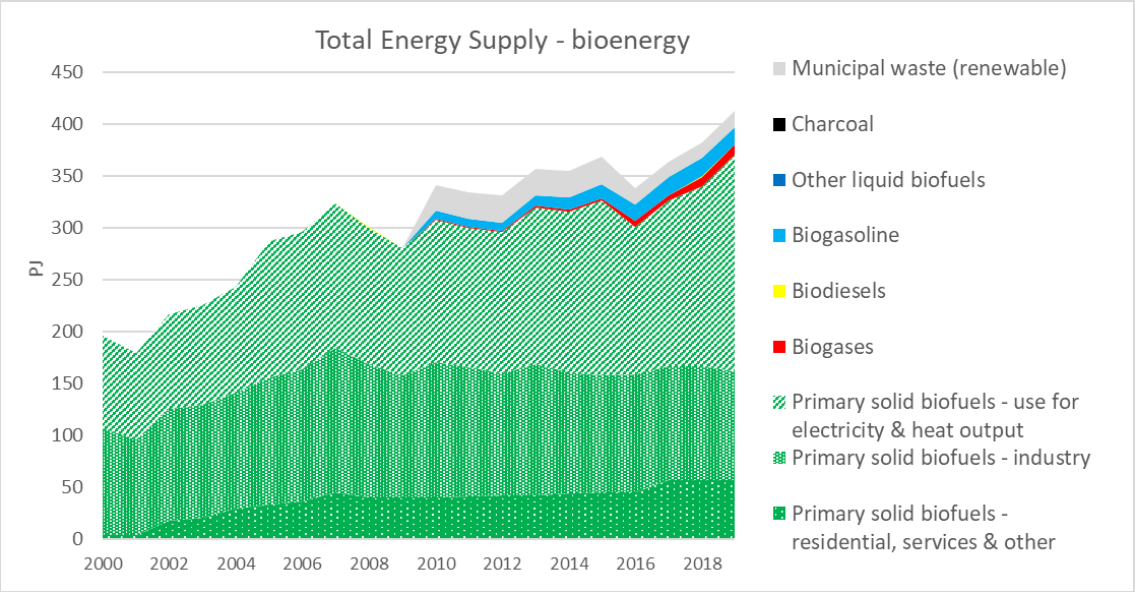


Figure 4: Development of total energy supply from bioenergy in Japan 2000 – 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)

Evolution of the bioenergy carriers:

- Solid biofuels are mostly consumed for electricity production and this application actually presents the main growth of bioenergy recently, using more than 200 PJ of solid biofuels in 2019. The application of solid biomass for energy in industry is fairly stable around 110 PJ. The use of solid biofuels in residential, commercial, and public buildings is much lower (57 PJ).
- Renewable MSW reached a level of 26 PJ in the early 2010s, but this dropped to 15 PJ in recent years.
- Biofuels (particularly bioethanol) were introduced around 2010. Amounts are still quite modest around 17 PJ.
- There is a small amount of biogas (9 PJ) which has been developed in the past 10 years.

Table 3 displays the 2019 total bioenergy supply values on a per capita basis. Compared to the other 24 member countries of IEA Bioenergy (expressed per capita), Japan ranks at the lower end for renewable MSW and liquid biofuels, and very low for solid biofuels and biogas. This implies that major steps can still be taken.

Table 3: Total energy supply per capita in 2019 for different bioenergy carriers

	Supply per capita	*Median IEA Bioenergy members*
Bioenergy	3.3 GJ/cap	*10.6*
Solid biofuels	2.9 GJ/cap	*7.0*
Renewable MSW	0.1 GJ/cap	*0.8*
Biogas	0.1 GJ/cap	*0.7*
Liquid biofuels	0.1 GJ/cap	*1.5*

Source: IEA (2021) World Energy Balances and Renewables Information

Table 4 indicates the amounts of the different bioenergy carriers compared to some relevant reference points, namely the amount of forest in the country (for solid biomass), the amount of generated MSW (for renewable MSW used for energy), the amount of natural gas consumed in the country (for biogas) and the amount of fossil oil products consumed (for liquid biofuels).

Table 4: Comparison of the supply of different bioenergy carriers in 2019 to specific reference points

	Compared to reference points			*Median**
Bioenergy	2.4 %		of total energy supply	*7.2 %*
Solid biofuels	14.9 GJ/ha_forest		compared to the domestic hectares of forest land (excl. protected)	*21.3 GJ/ha_forest*
Renewable MSW	0.36 GJ/ton_MSW		compared to the total generated MSW in the country	*1.4 GJ/ton_MSW*
Biogas	0.002 GJ/GJ_NG		compared to natural gas supply	*0.023 GJ/GJ_NG*
Liquid biofuels	0.003 GJ/GJ_oil		compared to oil products supply	*0.028 GJ/GJ_oil*

Source: energy data from IEA (2021) World Energy Balances and Renewables Information; forest figures from FAOStat; waste figures from World Bank
** Median of the 25 member countries of IEA Bioenergy*[6]

Specific comments in relation to the reference points:

- The amount of solid biofuels compared to the domestic forest area is quite modest (less than 1 ton$_{\text{dry mass}}$ of wood per hectare[7]); moreover, part of this is imported biomass.
- The use of renewable MSW for energy production is on the low side and there are considerable opportunities to develop this further.
- Biogas and liquid biofuels are also low currently, so there is much opportunity to further develop.

[6] Comparative figures of the different IEA Bioenergy member countries are discussed in the central Countries' Report.
[7] Counted with a typical calorific value of wood (dry mass) of 19 GJ/ton$_{\text{dry mass}}$

ROLE OF BIOENERGY IN DIFFERENT SECTORS

OVERVIEW

The overall 2019 share of renewables in **final energy consumption** among electricity, transportation and heat sectors is 8%, with bioenergy making up 2.6% of the energy share (Table 5). Note that these figures are slightly higher than the shares in total energy supply (where unused waste heat, e.g., in fossil power production, is also included).

Table 5: *Role of bioenergy and renewable energy in electricity, transport energy and fuel/heat consumption in 2019*

Sector	Share of bioenergy	Share of renewable energy	Overall consumption
Electricity[8]	2.7%	18.3% *(7.8% hydro)*	1017 TWh (3663 PJ)
Transport energy (final consumption)	0.6%	1.0%	2902 PJ
Overall fuel and heat consumption[9]	3.9%	4.1%	4115 PJ
TOTAL FINAL ENERGY CONSUMPTION	**2.6%**	**8.1%**	**10617 PJ**

Source: IEA (2021) World Energy Balances and Renewables Information

The following paragraphs will consider the evolutions in the different sectors.

ELECTRICITY

Fossil fuels still represent three quarters of Japanese power production. Natural gas is providing 38% (385 TWh) and coal 32% (330 TWh). Up to 2010 nuclear energy represented 25 to 30% of power production (~280 TWh). After the Fukushima disaster this dropped to zero, and only slightly recovered recently up to a level of 6% (65 TWh). The decline of nuclear power in 2011 was mostly compensated by an increase of gas, as well as some oil and coal. In recent years, oil is dropping to very low levels (3.5% of power production) and natural gas decreased slightly to 385 TWh (from its peak of 430 TWh). Coal remains stable around 330 TWh.

[8] Renewable electricity production compared to final consumption. Potential renewable shares of imported electricity are not included.

[9] This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded.
Electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported.

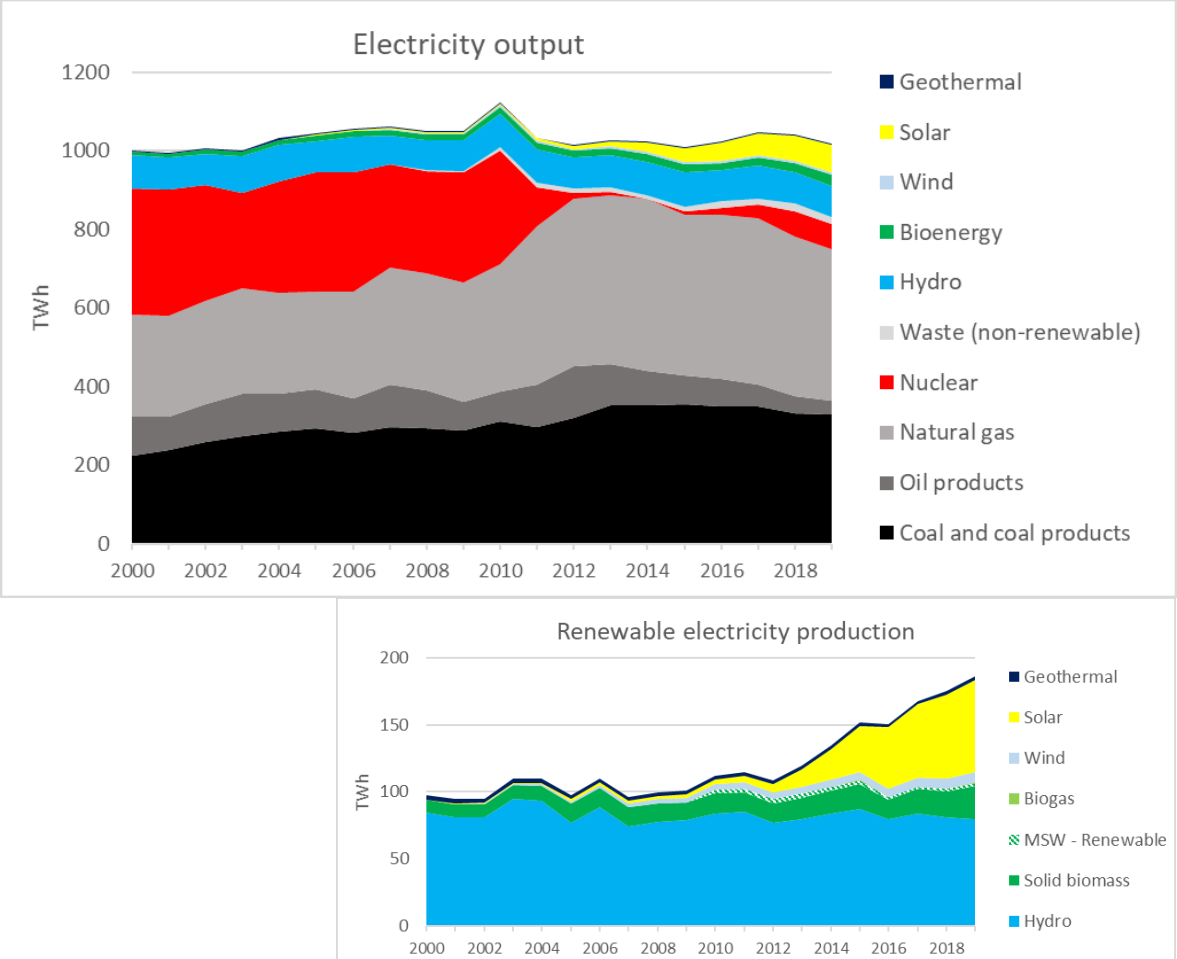


***Figure 5**: Evolution of the electricity mix in Japan 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Renewable electricity was mostly about hydropower, which produced between 75 and 95 TWh in the past decades, representing 8% of power production in Japan. There is a modest, but slightly growing role for biomass-based electricity (currently around 3%). Solar power saw a major increase growing from 3.5 TWh in 2010 up to 70 TWh in 2020, currently representing 7% of power production. Wind power is quite low at 8 TWh (0.8%).

Policy framework

The main relevant policy instruments behind these evolutions are:

- The policies to promote introduction: FIT(FY2012～), FIP<Feed-in Premium>(FY2022～) as provided for in the Act on Renewable Energy Special Measures.
- Various tax reduction measures have been taken, i.e., Energy Reform Tax System (FY1992～FY2011), Green Investment Tax Break (FY2012～).
- Promotion of improvement of utilization rate of non-fossil energy sources of electric power by the Act on Sophisticated Methos of Energy Supply Structures (FY2009-)

HEAT/FUEL

Figure 6 shows the role of different fuels/energy carriers for providing heat in different sectors (industry, residential sector, commercial and public services and other). It also includes heat sold to customers, e.g., through district heating. Fuel use by energy producing industries for transformation and for own use is excluded. Mind that electric heating (direct or through heat pumps) is not included in these figures as this is not separately reported in the IEA database.

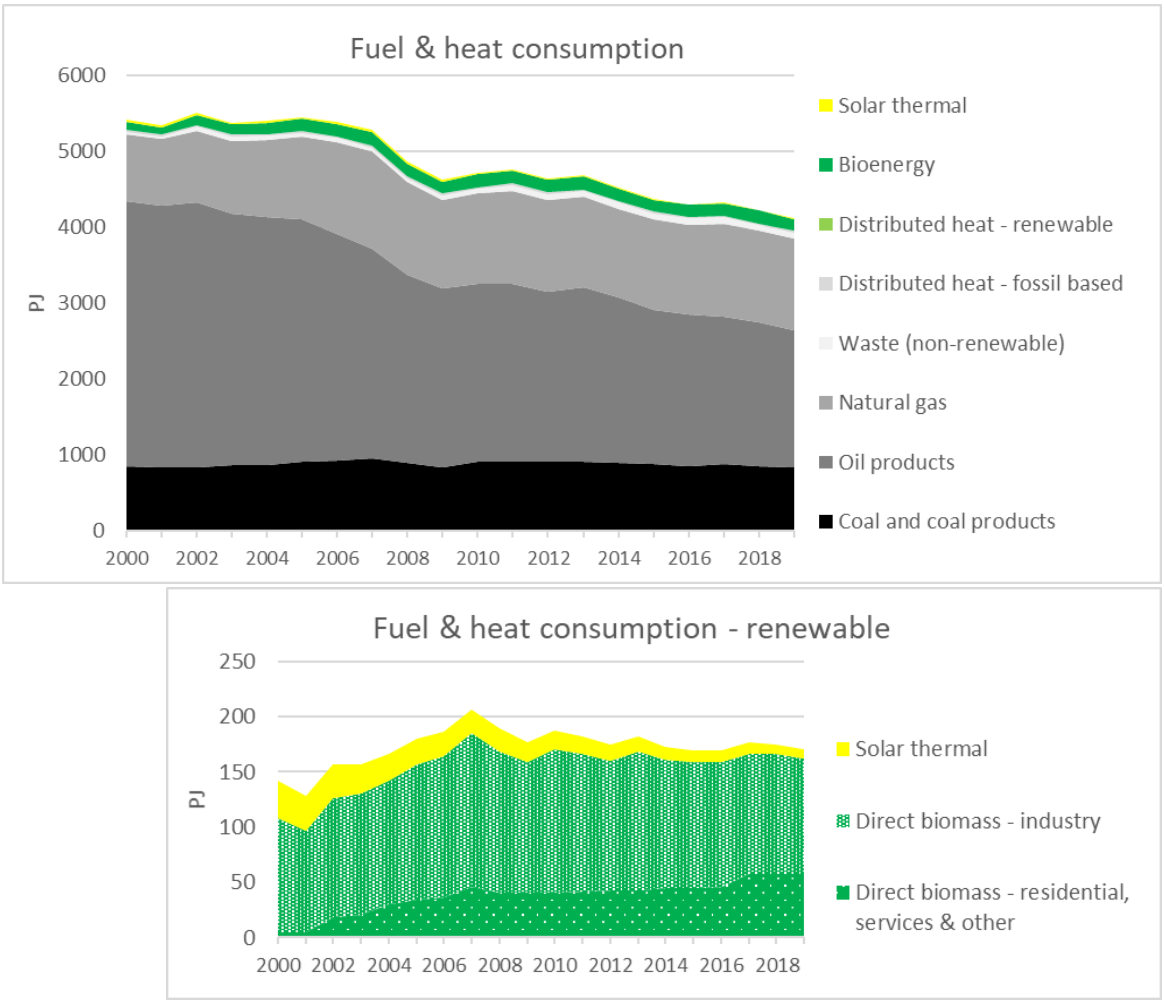


***Figure 6**: Evolution of fuel and heat consumption in Japan 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

The overall consumption of fuels/heat is going down steadily, however, it remains to be largely dominated (for 93%) by fossil fuels, with 44% oil products, 30% natural gas and 20% coal in 2019. Another 2% is from non-renewable waste. The direct use of biomass for heat represents 4% (160 PJ) – this amount has been fairly stable in the past decade. About two thirds is used in industry: the other third in commercial and public buildings. Solar thermal heat represented 0.6% (30 PJ) of overall heat consumption in the early 2000s, but its share has actually dropped significantly in recent years.

Heat sales only represent 0.6% of fuel/heat consumption in Japan and are mostly based on natural gas.

Policy framework

Since renewable energy heat is an important energy source with high regional characteristics, it is important to promote:

- the use of biomass heat using sewage sludge and waste materials,
- the use of biofuels that can partially replace petroleum products - mainly fuels in the transportation sector, and
- heat recovery in waste disposal according to economic economy and regional characteristics.

Regarding renewable energy, heat from solar heat, geothermal heat, snow and ice heat, hot spring heat, river heat, and sewage heat, Japan aims to expand the introduction of renewable energy heat by supporting the introduction of heat supply facilities and supporting efforts to exchange heat in terms of heat in multiple groups of consumers.

TRANSPORT

Figure 7 shows an overview of the energy used in transport in Japan, split up by different fuels/energy carriers.

Overall energy use in transport is steadily going down in Japan, with a 10% reduction compared to 10 years ago. Gasoline is the dominant fuel, representing 55% of transport fuel consumption; diesel represents 33% and other oil-based fuels (mainly jet fuels) 8%.

Biofuels only represent 0.6% of transport energy consumption, with the main focus on bioethanol. Bioethanol was introduced in 2010 a level of 8 PJ – this level has slightly increased to 17 PJ. In 2019 bioethanol represented a share of 1% (by energy) of gasoline consumption. Biodiesel use is much lower at 0.5 PJ.

Electricity represents a share of 2.2% of total transport energy use. This is mostly in rail – there is no reporting of electricity use in road vehicles.

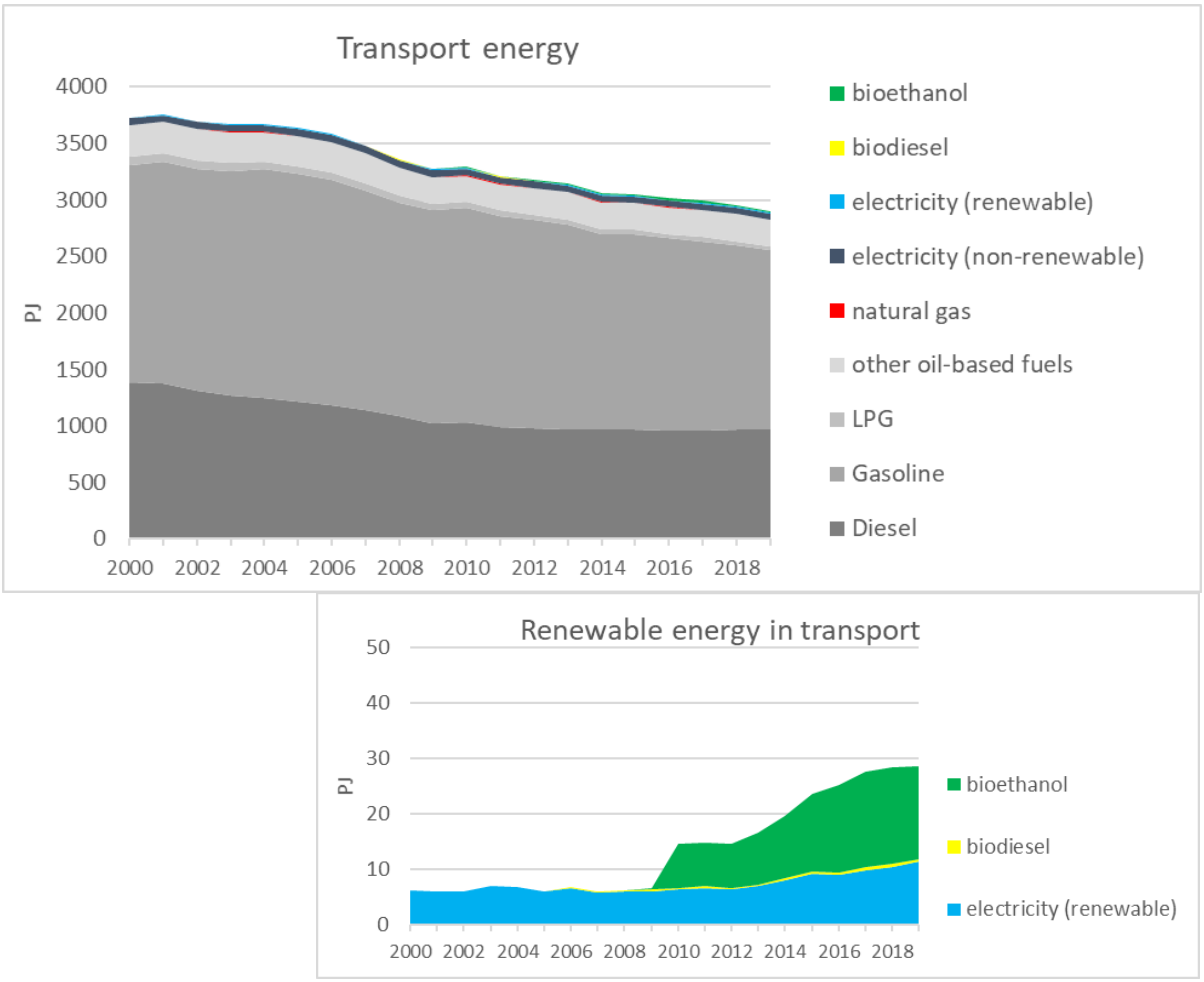


***Figure 7**: Evolution of transport fuels in Japan 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Policy framework

In the past, most passenger vehicle in Japan were gasoline-fuelled, so the market share of diesel fuel for transportation was overwhelmingly small, therefore, domestic demand for biodiesel was also scarce. To expand the use of bioethanol (ETBE) as a means of promoting the introduction of liquid biofuels, Japan has provided subsidies for infrastructure development (FY 2011 to 15) and tax exemption measures so far.

To decarbonize the aviation industry, the UN's International Civil Aviation Organization (ICAO) has set a CO_2 reduction target of 50% by 2050. As the promotion of the introduction of Sustainable Aviation Fuels (SAF) becomes urgent, the demand is expected to increase worldwide. As METI and NEDO believe that it is important to promote environmental measures in the aviation field, in FY 2017, they initiated bio-jet projects working on technological development and demonstration of SAF, which is a liquid biofuel. In addition to these projects, the "Green Growth Strategy" formulated in December 2020 also calls for the mutual cooperation of domestic companies, with the aim of establishing manufacturing technology for SAF that is competitive, the Government will provide support from the fund of JPY 2 trillion.

RESEARCH FOCUS RELATED TO BIOENERGY

・Demonstration project for locally sustainable bioenergy system (FY2014-FY2021)

In order to realize an optimal bioenergy system that makes use of regional characteristics, 35 feasibility studies were implemented from four viewpoints: (1) raw material procurement, (2) energy conversion technology, (3) energy utilization, and (4) overall system. Of these, 7 demonstration projects and one technology development project that were evaluated as having business potential were carried out, and the results have been reflected to the guidelines to facilitate sustainable use to bioenergy in each region.

・Formulation of technology roadmap for microalgae SAF (FY2020-FY2021)

With the aim of contributing to the reduction of GHG emissions in the aviation field in the future by formulating new technology roadmap for microalgae technology centered on SAF production, we are formulating a technology roadmap plan and its proposals by FY2030 through review of the existing research and technology development status, examination of business models leading to practical application, and examination by the working group.

RECENT MAJOR BIOENERGY DEVELOPMENTS

The New Energy and Industrial Technology Development Organization (NEDO) has entrusted the Development of Production Technologies for Bio-Jet Fuels project to Mitsubishi Heavy Industries, Ltd., JERA Co., Inc., Toyo Engineering Corporation, and the Japan Aerospace Exploration Agency (JAXA), who are working to develop production technology for fuel using waste wood as raw material, and IHI Corporation, who is working to develop production technology for fuel made from microalgae. The Bio-Jet Fuel produced by each technology was supplied to JAL & ANA regular flights on 17June 2021 as sustainable aviation fuel (SAF).

This fuel was produced by (1) gasification FT synthesis technology, which synthesizes liquid fuels from syngas derived from gasified solid wood lignocellulose, and (2) hydro refining technology, which refines oil derived from microalgae. Both technologies have been confirmed to be compliant with ASTM D7566, the international standard for SAF.

This will pave the way for carbon neutrality by 2050 and contribute to reducing greenhouse gas emissions in the aviation field.

LINKS TO SOURCES OF INFORMATION

[METI] Japan's Roadmap to "Beyond-Zero" Carbon,
https://www.meti.go.jp/english/policy/energy_environment/global_warming/roadmap/index.html

[METI] Present Status and Promotion Measures for the introduction of Renewable Energy in Japan,
https://www.meti.go.jp/english/policy/energy_environment/renewable/index.html

[METI] Green Growth Strategy Through Achieving Carbon Neutrality in 2050,
https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/index.html

[NEDO] Sustainable Aviation Fuel Produced from Waste Wood and Microalgae Supplied to Regular Flights,
https://www.nedo.go.jp/english/news/AA5en_100437.html

NEDO Channel (YouTube)

- [FY2021] https://www.youtube.com/watch?v=zginf-cj7GI&list=PLZH3AKTCrVsX90YTJbhjfWV-o2t1yLJql&index=2
- [FY2020] https://www.youtube.com/watch?v=MdcK7tRNf-8

(Short Ver.) https://www.youtube.com/watch?v=j-uMdIEJSs4