Wood Biomass Power Generation Target for 2030: Impact on Biomass Fuel Supply in Japan

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1. Introduction

The "Long-Term Energy Supply and Demand Outlook" announced by the Japanese Ministry of Economy, Trade and Industry (hereafter, METI) in 2015 presents the target amount of each energy source for 2030 (hereafter "the 2030 energy mix"), seeking to realise the goals of (1) increasing the energy self-sufficiency rate, (2) reducing generation cost, and (3) reducing the greenhouse gas emissions (GHG) by the equivalent degree to other economically developed countries under UNFCCC.

According to the outlook, of the total assumed power generation for 2030, which is expected to be 1,065 TWh, 3.7 - 4.6% is designated to come from biomass power generation. While the fuel used for biomass power generation is classified into a diverse range of categories, as can be seen in Figure 1, "Timber[1]" occupies the majority, 2,740 - 4,000 MW, of the installed capacity. Therefore, the achievement of the overall biomass power target substantially depends on the deployment of "Timber" facilities. In turn, this issue becomes whether Japan can secure the sufficient biomass fuel to operate these facilities.

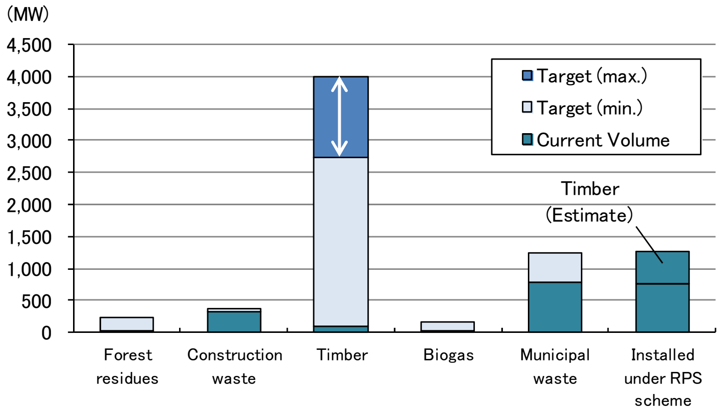

Figure 1. Biomass power generation target for 2030 (installed capacity)
Source: METI, "Long-Term Energy Supply and Demand Outlook".

However, there has been not sufficient number of studies to analyse the biomass

[1] To be accurate, this should be "General timber and agricultural crop residue" in the energy mix 2030. However, since only fractional amount of power is expected coming from "agricultural crop residue", it is renamed as "timber" for simplicity.

target in the 2030 energy mix and its impact on fuel supply. Therefore, this paper highlights the characteristics of biomass power generation within the Japanese energy policy and examines the feasibility of the 2030 target as seen from the viewpoint of the quantity of fuel supply, with a brief discussion on the political options available for Japan at the end.

2. Characteristics of biomass power within the Japanese energy policy

So long as biomass fuel is fed into, biomass power generation can be operated without interruption regardless of weather conditions. Therefore, in the 2030 energy mix, it is considered as a substitute energy source to nuclear power, with the statement of "(it should be) deployed at the maximum taking into account the physical limit of the possible fuel supply." While solar and wind power have the cost condition which is stated as "(it should be deployed) at the maximum in so far that the generation cost can be reduced from the current level," biomass power does not have any cost conditions. This implies biomass power receives high expectations to be grown to meet the 2030 energy mix.

In the rural areas of Japan, biomass power also possesses the characteristic of "power generation that can stimulate the regional economic activities," as stated in the "Strategic Energy Plan" (ANRE, 2014). While biomass power generation requires continuous fuel supply, the effective use of locally available resources is attracting considerable attention as the important benefit of biomass energy since it could satisfy both of the local energy demand and the stimulation of the local economy.

In fact, the "Biomass utilisation promotion plan" approved by the cabinet in September 2016 states that, "Japanese government promotes the maximum deployment of biomass power in harmony with the sound development of the agriculture, forestry and fisheries, restraining the national burden, in order to realise the amount for deployment indicated in the Long-Term Energy Supply and Demand Outlook."

The characteristics of biomass power within the Japanese energy policy can therefore be summarised into two points: (1) the maximum deployment is planned taking into account the physical limit of the fuel supply as a stable energy source, and (2) sufficient amount of domestic fuel supply is expected to satisfy both the local energy demand and the stimulation of local economy.

3. Required energy for wood biomass power generation in 2030

As mentioned in the introduction, this paper focuses on the 2,740 - 4,000 MW expected to be generated from timber in 2030. In addition to this, 504MW of biomass power facilities using timber[2] should be added to the 2,740 - 4,000 MW which were certified under the RPS scheme began in 2003 prior to the implementation of FIT in 2012. Therefore, in total, the deployed amount of power generation facilities using timber in 2030 is calculated as 3,244 - 4,504 MW.

Assuming the capacity factor of biomass power generation is 80% and the latest generation efficiency is 32% (ANRE, 2016), it is estimated that 256 - 355 PJ p.a. of energy input would be required to operate the biomass facilities of 3,244 - 4,504 MW.

4. Comparison to the domestic supply records

Having the estimation of 256 - 355 PJ p.a. of energy input required to meet the 2030 energy mix, the key question here is the amount of domestic fuel supply expected in 2030. Employing the latest 2015 data for wood products supply taken from "Timber Supply and Demand Table" published by the Forestry Agency with the conversion factors from bulk volume of wood to their energy contents following Krajnc (2015), the following estimated values can be obtained.

Table 1. Timber wood supply and estimated energy contents in 2015

		Supply Vol. (Logs, Timber)	Energy (estimate)
Domestic Wood	Fuel	2,946,000 m^3	26 PJ
	Logs	21,580,000 m^3	189 PJ
	Total	24,526,000 m^3	215 PJ
Imported Wood	Fuel	1,156,000 m^3	10 PJ
	Logs, Timber prod.	49,086,000 m^3	430 PJ
	Total	50,242,000 m^3	440 PJ

Source: "Timber Supply and Demand Table" and authors' estimation

Compared to the 2015 domestic wood supply of 215 PJ, it is clearly insufficient to meet the required amount of the energy input of 256 - 355 PJ in 2030. This means that, if the 2015 timber supply level remains constant until 2030, the total amount of the fuel wood supply including both of domestic and imported cannot meet the required volume. In that case, they have to redirect all kinds of wood to power generation to satisfy the request (Fig. 2). In fact, there are much more domestic wood resources in Japan[3], and its timber production could be increased depending on the market prices. However, after the liberalisation of wood imports in 1964, domestic timber lost its price competitiveness, and Japanese forestry business has been in long decline until today. In contrast to the decline, the wood resources existing in Japan have increased

[2] Estimated by authors based on RPS certified facility data.

[3] According to the "FY2014 Annual Report on Forest and Forestry in Japan" by the Forestry Agency, wood resources existing in Japan as of 2012 was 4.9 billion m^3.

approximately 2.5 times in the past 50 years (Ota, 2012), but regardless of the amount of resources, the higher price of domestic timber makes it difficult to increase its domestic supply[4].

In the historical data of the domestic wood supply seen in "Timber Supply and Demand Table" by the Forestry Agency, the highest volume of the domestic wood production was recorded in 1957 at 68 million m^3. This amount is equivalent to 594 PJ of energy when converted to an energy volume using the same method as above. In this case, it is theoretically possible to satisfy the required amount of energy of 256 - 355PJ for the wood biomass power in 2030 (Fig. 2). Although this record was attained once in the past, it is certainly uneasy to rebuild the social systems in the local areas with an enough number of forestry workers well-trained by 2030. Furthermore, in 1957, timber imports were highly regulated, and so the total imported amount was just 4 million m^3.

Given these facts, it seems to be very difficult for Japan to be self-sufficient in solid biomass fuels to meet the 2030 energy mix. Therefore, the country is highly likely to depend on wood fuel imports on a large scale inevitably. The next section will compare the required energy input for wood biomass power in 2030 to the amount of wood fuel traded in the global market.

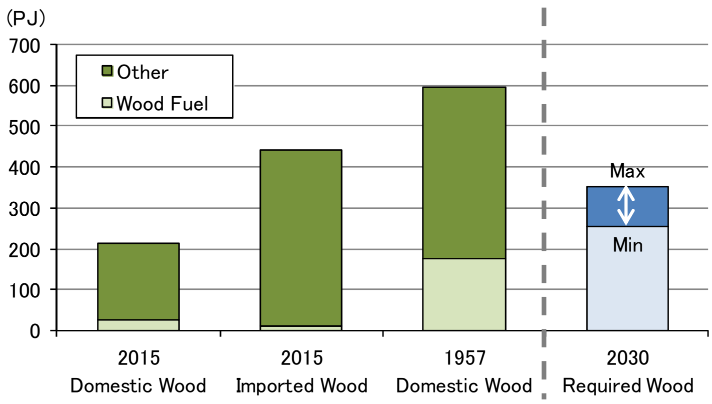

Figure 2. Wood supply in the past and in 2030
Source: Estimation by authors

5. Comparison with the global trade

5.1. Estimation based on the global production

According to the FAO statistics (hereafter, FAOSTAT) in 2015, 1,863 million m^3 of wood was produced for energy, which is approximately half of the total logs

[4] However, due to the recent depreciation of the Japanese Yen and the tougher environmental regulations taken in a number of the wood exporting countries in Asia and pacific regions, the domestic wood products have regained their market competitiveness in recent years.

production. However, the vast majority of this wood is produced for so-called traditional biomass consumed in developing countries which is not appropriate to be included in the global supply available for Japan to import. Thus, in this paper, the amount of wood that is specifically produced in a usable form for power generation is evaluated. This consists of 4 categories: wood chips, wood pellets, wood residue, and palm kernel shells (PKS). The estimated amount of energy that can be supplied from the wood production of these 4 categories is shown in Table 2 below:

Table 2. Global wood biomass energy supply (production basis)

	Production	Density	Calorific Value	Energy (estimated)
Wood chips	24 Million m^3		7.302 GJ/m^3	178 PJ
Wood pellets	27 Million t		18.3 GJ/t	495 PJ
Wood residues	223 Million m^3	0.3 t/m^3	19.25 GJ/t	1,288 PJ
PKS	8 Million t		18.0 GJ/t	143 PJ
			Total	2,104 PJ

Notice: As most of the wood chips are used for other purposes, 10% of production is assumed to be available for energy use.
PKS is estimated from the 2014 "Palm kernel" production.
Numbers may not add up due to rounding.
Source: FAO statistics, Lamers *et al.* (2012), Krajnc (2015).

As shown in the table above, the global wood biomass energy supply in 2015 is 2,104 PJ when estimated based on the wood biomass energy products. As mentioned before, Japan needs 256-355 PJ of woof biomass to meet the 2030 energy mix. If the 2015 level of the global production would be kept until 2030, Japan would require as much as 12 - 17% of the global production (Fig. 3). This is a large proportion to be attributed to a single country in the global market. Moreover, this estimation assumes that all the wood residues are used as energy products, implying that, if estimated more precisely, the percentage of 12 – 17% would further increase.

5.2. Estimation based on the global exports

As the estimation in the previous section is based on the total global production, it naturally includes solid biomass fuels produced for their domestic consumption. Therefore, it can be more appropriate to compare the amount by removing the consumption by the producing countries to meet their domestic demand. To that end, in this section, it is estimated that the wood biomass energy supply being based on the total global exported volume of the same 4 categories as the previous section. This is because that it is assumed that each country exports its surplus of wood after meeting its domestic demand. The results of this estimation are shown in Table 3.

Table 3. Global wood biomass energy supply (exports basis)

	Production	Density	Calorific Value	Energy (estimated)
Wood chips	7 Million m^3		7.302 GJ/m^3	49 PJ
Wood pellets	16 Million t		18.3 GJ/t	296 PJ
Wood residues	10 Million m^3	0.3 t/m^3	19.25 GJ/t	59 PJ
PKS	6 Million t		18.0 GJ/t	117 PJ
			Total	521 PJ

Notice: As most of the wood chips is used for other purposes, 10% of production is assumed to be available for energy use.
PKS is estimated from the 2014 "Palm residues" exports.
Numbers may not add up due to rounding.
Source: FAO statistics, UN Comtrade Database, Lamers *et al.* (2012), Krajnc (2015), *etc.*

As seen in the table, the global wood biomass supply in 2015 in this case is equivalent to 521 PJ. The amount of energy 256 - 355 PJ required by Japan to meet the 2030 energy mix corresponds to as much as 49 – 68% of the 521 PJ (Fig. 3).

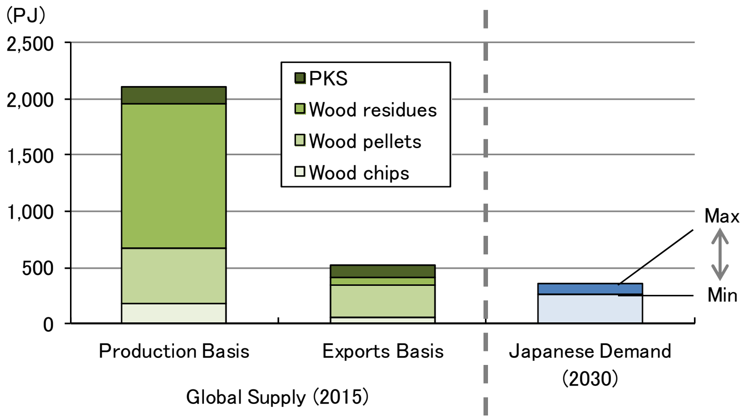

Figure 3. Global wood biomass supply and the amount needed by Japan
Source: FAO statistics, UN Comtrade Database.

5.3. Estimation of future global market and comparison to the Japanese demand

The estimations in the previous sections were based on the production and exports in 2015. However, solid biomass fuel production is recently increasing, driven by the expansion of the global demand. If this trend lasts for long, the balance of wood biomass supply and demand in 2030 would differ from that shown in Figure 3. Therefore, in this section, it is estimated that the global production and exports of wood biomass in 2030 based upon the growing trend in recent years and compare them respectively with the Japanese demand in 2030. The results are shown in Figure 4 (production basis) and Figure 5 (exports basis) below:

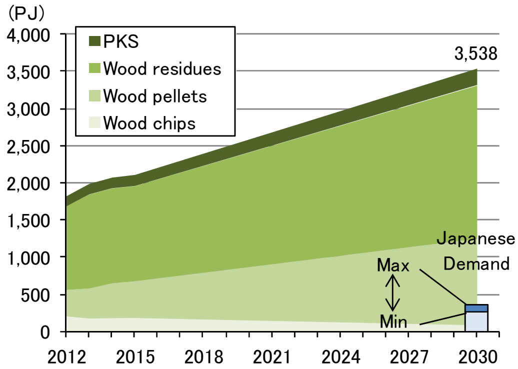

Figure 4. Global production outlook
Source: FAO statistics, UN Comtrade Database.

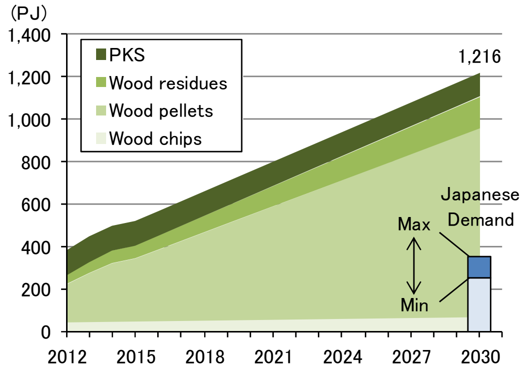

Figure 5. Global exports outlook
Sources: FAO statistics, UN Comtrade Database.

As seen in Figure 4 and 5, both the global production and the exports in 2030 would increase substantially from the 2015 levels. As a result, the proportion of the Japanese demand in 2030 would drop compared to the current level. Nevertheless, Japan would still require 7 - 10% of the total global production and 21 - 29% of the total global exports in 2030. In addition, as many countries implement the mitigation measures under the Paris Agreement, the global demand for wood biomass can be expected to increase, suggesting that Japan is likely to face even more difficulty in securing such a large share in the global market. In any case, it might be necessary for Japan to take international actions to secure and increase the fuel supply sources.

6. Discussion 1: Reconsideration of its position in Japanese energy policy

Keeping in mind the results of the estimations above, this section reconsiders the characteristics of biomass power generation in Japanese energy policy. As mentioned previously, its characteristics in the 2030 energy mix can be summarised into two points, (1) the maximum deployment is planned taking into account the physical limit of the fuel supply as a stable energy source, and (2) sufficient amount of domestic fuel supply is expected to satisfy both the local energy demand and the stimulation of local economy.

As for the first point, securing the stable fuel supply is an essential condition for wood biomass power generation to be a “stable energy source.” However, it is almost impossible to satisfy the Japanese demand in 2030 only by domestic wood, because the demand is much larger not only than current domestic supply but also than that in the golden age of Japanese forestry. If they depend on imports in a large scale, it is at least necessary that the producer countries should continue to increase their exports of solid biomass fuels at the same growth rate as recent years until 2030. Furthermore, even if that condition would be attained, Japan will still require 20 - 30% of the global exports in 2030. Therefore, political measures to secure the enough amount of imports will be required in any cases.

The second point is to "sufficient amount of domestic fuel supply is expected to satisfy both the local energy demand and the stimulation of local economy." Certainly it will be difficult to satisfy the entire demand in 2030 by domestic wood supply, but it may be possible to satisfy a portion of it. In fact, it is practical for Japan to seek the optimal level of domestic supply of wood biomass to bring economic benefits within the quantitative limit and to depend on the imports for the remaining demand. As repeatedly mentioned, the amount of wood biomass that Japan would require in 2030 is so large that it requires such a practical political decision based on the limited capacity of domestic supply.

7. Discussion 2: Economic impact of dependence on imports

Finally, in case that Japan depends on imports for the entire demand for wood biomass in 2030, possible economic impact is considered. To that end, the two factors should be evaluated; first, an increase in imports of wood biomass fuel and, second, a decrease in imports of fossil fuel replaced by the biomass. Accordingly, the net economic effects of these factors is estimated assuming that the 256 - 355 PJ of wood biomass that Japan requires in 2030 should be broken down into the same 4 categories with the same proportion as the global exports in 2015 mentioned in the previous section, and that the thermal power is produced entirely from gas[5] as an alternative fuel to biomass. When the annual power generation of 23 - 32 TWh that would be obtained by the 3,244 - 4,504 MW of wood biomass power plants is covered by gas-fired power plants, the required energy input from gas is estimated as 171 - 237 PJ with 48% power generation efficiency for gas (Hussy *et al.*, 2014) as show in Table 4 below.

Table 4. Required energy input corresponding to the deployment of biomass power generation

(PJ)

3,244 MW Case				4,504 MW Case			
Substitute		Base		Substitute		Base	
Wood chips	24	Natural Gas	171	Wood chips	33	Natural Gas	237
Wood pellets	145			Wood pellets	202		
Wood residues	29			Wood residues	40		
PKS	57			PKS	79		
Total	256	Total	171	Total	355	Total	237

Sources: Estimated by authors

[5] When 3,244 - 4,504 MW of wood biomass power is not deployed, it should be replaced with any other energy resources. However, taking into account of the GHG emission reduction target in 2030 under the Paris Agreement, the alternate resource must be as lower carbon as possible. In this regard, gas is chosen as an alternative fuel to biomass due to its relatively lower emission factor.

The export price in the market of wood biomass per joule can be estimated from the global price data provided by FAO statistics and UN Comtrade Database, and that of gas can be estimated from the Trade Statistics of Japan provided by the Ministry of Finance. Employing these market prices, the amount of energy shown in Table 4 can be converted into the equivalent prices. Then, it is estimated that expenses will increase by 549 - 758 million USD p.a.[6] in case that gas imports are replaced by wood biomass imports.

Table 5: Required fuel expenses corresponding to the deployment of biomass power generation

(Million USD)

3,244 MW Case				4,504 MW Case			
Substitute		Base		Substitute		Base	
Wood chips	193	Natural Gas	1,660	Wood chips	268	Natural Gas	2,305
Wood pellets	1,229			Wood pellets	1,704		
Wood residues	301			Wood residues	417		
PKS	486			PKS	674		
Total	2,209	Total	1,660	計	3,063	Total	2,305

Sources: Estimated by authors

In addition to the import expense, an increase in CO_2 emissions from combustion of gas should be considered. Having the emission factor of gas power plant in Japan which is 424 g-CO_2/kWh (Hussy *et al.*, 2014), by deploying 4,504MW of biomass power generation, it is estimated that Japan can reduce CO_2 emissions by 13.4 million t-CO_2 p.a.. As previously mentioned, fuel cost would increase by 758 million USD in that case to import biomass fuel. A simple calculation of these figures gives 57 USD/t-CO_2 which can be considered as CO_2 emission reduction cost by employment of biomass power. On the other hand, Sano *et al.* (2015) estimates that the marginal abatement cost of GHG emission in Japan to achieve the 2030 target under the Paris Agreement is 380 USD/t-CO_2. Compared to this value to 57 USD/t-CO_2, wood biomass power can be regarded as an appropriate CO_2 reduction option at a lower cost.

8. Conclusion

This paper estimates the demand for wood biomass energy that Japan would require to achieve the 2030 energy mix and conducts a quantitative analysis in comparison between the required energy from wood biomass for Japan in 2030 and the amount of energy which can be obtained from the domestic and the global supply of

[6] This estimation is based on the assumption that the prices of wood biomass in 2015 (that in 2014 for PKS) and gas will remain constant in the future. If Japan increases its imports of wood biomass substantially so that it influences the global wood market, the price can fluctuate over the period. However, the aim of this paper is solely to estimate the possible impact of wood biomass imports, such price fluctuation is excluded from the scope of this paper for simplicity.

wood. As a result, it is clarified that the demand for wood biomass in Japan in 2030 is substantially large amount not only compared to the domestic market in Japan, but also the global market, suggesting that it is not easy to satisfy the demand even if they depend on imports.

The analysis conducted in this paper is just a simple comparison based on the currently available data set, paying less attention to various other factors which should be taken into consideration for more precise analyses. For example, a possible response to the increase in the global demand for wood in the future should be estimated more closely. In addition, it is desired to evaluate the feasibility of the 2030 target of biomass power not only from a viewpoint of wood supply on a quantity, but also from an economic and social viewpoint, which is not well considered in this paper. Possibility of price fluctuation caused by increased demand and changes in the market structure also needs more attention. These issues are left for further research.

References

FAO, "Small-Scale Palm Oil Processing in Africa," FAO Agricultural Services Bulletin 148, 2002.

Hussy, C., Klaassen, E. and Koornneef, J., "International Comparison of Fossil Power Efficiency and CO_2 Intensity – Update 2014," Ecofys, CESNL15173, 2014.

Krajnc, N., *Wood Fuels Handbook*, FAO, Pristina, 2015.

Lamers, P., Marchal, D., Schouwenberg, P., *et al.*, "Global Wood Chip Trade for Energy," IEA Bioenergy Task 40, 2012.

Agency for Natural Resources and Energy, "Trends in Cost of Each Power Source (Small- or Mid-Sized Hydro, Geothermal, Biomass)," Procurement Price Calculation Committee (26th meeting), Document 4, 2016. [in Japanese]

Agency for Natural Resources and Energy, "Trends in Deployment of Renewable Energy Power Sources," Advisory Committee for Natural Resources and Energy, Long-Term Energy Supply and Demand Outlook Sub-Committee (4th meeting), Document 2, 2015. [in Japanese]

Agency for Natural Resources and Energy, "Standard Caloric Volume of Each Energy Source," Appended Table of General Energy Statistics of Japan, 2015. [in Japanese]

Agency for Natural Resources and Energy, "Strategic Energy Plan," 2014. [in Japanese]

Forestry Agency, *Annual Report on Forest and Forestry: FY 2014*, 2015. [in Japanese]

Government of Japan, "Basic Plan for the Promotion of Biomass Utilization," 2016. [in Japanese]

Ministry of Economy, Trade and Industry, "Long-Term Energy Supply and Demand Outlook," 2015. [in Japanese]

Ohta, T., *Forest Saturation – Considering The Transformation of National Land*, NHK Books, NHK Publishing, 2012. [in Japanese]

Sano, F., Akimoto, K., Homma, T., Tokushige, K., "Evaluations on the Japan's Greenhouse Gas Emission Reduction Target for 2030," *Journal of Japan Society of Energy and Resources*, vol.37, no.1, 2016, p.51-60. [in Japanese]

Statistics, database, *etc.*

Food and Agriculture Organization of the United Nations (FAO), FAOSTAT. (http://www.fao.org/faostat/en/)

International Energy Agency (IEA), World Energy Statistics and Balances 2016.

The World Bank, World Bank Open Data. (http://data.worldbank.org)

United Nations (UN), UN Comtrade Database. (https://comtrade.un.org)

Ministry of Agriculture, Forestry and Fisheries, "Timber Supply and Demand Table." [in Japanese] (http://www.maff.go.jp/j/tokei/kouhyou/mokuzai_zyukyu/)

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