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—for the realization of a sustainable use of bioenergy

December 2016

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26 December 2016　(Japanese original published on 25 November 2016)

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Introduction

Bioenergy[1] covers various types of fuel and a diverse range of technical applications, among which woody biomass holds an important position. In Europe and other countries, woody biomass is basically used to generate heat, and when used to generate electricity, combined heat and power (CHP) technology, or co-generation, is applied to make the most of the waste heat for better total energy efficiency.

Large-scale power plants generate a great amount of waste heat, but such heat, when delivered over a long distance, cools down and lose much of its energy, and it is sometimes difficult to secure a large enough demand with heat in their neighborhood. Because of these difficulties, governments around the world, with few exceptions, avoid offering support for large-scale biomass power plants and provide supports to biomass conversion or co-firing, only when they intend to phase out existing coal-fired power plants.

However, Japan has a Feed-in Tariff (FiT) scheme that covers power generation only. It is not designed to induce suppliers to adopt CHP. Under the scheme, the same FiT rate is applied to both smaller and large-scale power plants, including those operating with co-firing of coal. This has resulted in the construction of large-scale biomass power plants designed only for greater efficiency in electricity generation, with the rapid growth of approved capacities. That places great strain on the supply-demand balance both for domestic and imported woody biomass, and the fuel price is expected to remain at a high level.

The current scheme leaves CHP in an economically difficult position in market environments where a growing supply of solar and other low-cost renewables are driving down the electricity price. Efforts to develop efficient bioenergy generation operating on CHP in Japan may be hindered by the limited supply of fuel, which existing users buy up.

[1] In this report, "bioenergy" is used according to the international classification as a general term for organic resources of biological origin. Primarily, bioenergy found in a solid state is known as biomass, while that in a gas form is classified as biogas.

Another serious problem lies in imported woody biomass, as Japan has no scheme in order to ensure its sustainability.

In the light of what has been described above, this report compares the current situation in Japan and the experiences of European countries, which are moving ahead of us in woody biomass use, to make clear challenges we must address, and offers recommendations for a better FiT scheme and related measures in order to realize sustainable use of bioenergy in Japan.

Background

1. A rapid increase in approved capacities, and concerns over fuel shortages

1.1 A rapid increase in approved capacities of woody biomass power generation

Bioenergy that the FiT scheme covers are classified into three large groups: woody biomass (which includes agricultural residues), waste, and biogas (biomethane). Of these, woody biomass has shown a rapid growth in approved capacities. Woody biomass is further classified into the two categories of, "unutilized wood," which includes timber from forest thinning and forest residues, and "ordinary wood and agricultural residues ("ordinary wood")", which includes imported biomass fuel. The two categories of woody biomass came into full use for power generation after the introduction of FiT. With growth in the approved capacities of plants that operate on it, problems with the scheme are now coming to the surface.

Since the introduction of FiT scheme in July 2012, a number of plans for "unutilized wood" generation were announced; as of July 2016, the approved capacities almost reached double the amount stated in the "Long-term Energy Supply and Demand Outlook," released by Ministry of Economy, Trade and Industry of Japan, METI, in July 2015 (Figure 1). The move was followed by a recent large increase in the capacities of "ordinary wood" generation. Its approved capacities, standing at 1.3GW as of March 2015, have grown beyond 3GW as of July 2016, and became larger than the lowest estimate stated in the Long-term Energy Supply and Demand Outlook.

A larger-scale bioenergy power plant generally operates with a higher electric efficiency, and therefore a smaller cost. At present, however, Japan's FiT scheme fails to set different purchasing rates for plants of different sizes, except for those running on unutilized wood with a capacity smaller than 2MW. In fact, it also covers the portion of power generated by extremely large-scale co-firing plants using coal that is deemed to be produced using biomass fuel. These arrangements have resulted in increases of large-scale power plants designed in anticipation of large supplies of fuel, including imported woody biomass. In consequence, the average capacity of "unutilized wood" plants stands at around 8MW, while their "ordinary wood" counterparts have a capacity of around 28MW on average.

Figure 1 Approved capacities of woody biomass power generation (MW)

Categories for FiT	March 2015	March 2016	July 2016	Long-term Energy Supply and Demand Outlook
Unutilized wood	36	420	436	240
Ordinary wood	1,322	2,954	3,220	2,740-4,000

Note: For co-firing plants, biomass ratios are considered, and capacities approved after transitions from RPS to FiT are included.

Source: FIT page, METI/ANRE website

1.2 Concerns over fuel shortages

Such a rapid expansion of capacities planned for woody biomass power generation has given rise to concerns over shortages of fuel, for both domestic and imported woody biomass. However, with no aggregated data of how much fuel of which type is, and will be, consumed by approved biomass power plants, arguments are difficult to develop in quantitative terms[2]. Under the assumption that all the biomass power plants approved by July 2016 will come into operation, then the amount of fuel needed can be estimated as follows (Figure 2).

The estimate shows that the ‘unutilized wood’ category alone will consume a total of 5.56 million tons, or 8.55 million cubic meters, of domestic woodchip in 2030[3]. Meanwhile, the Basic Plan for Forest and Forestry, a decision made by the Cabinet in July 2016, refers to a supply of 8 million cubic meters of fuel wood in 2025. In other words, the demand from ‘unutilized wood’ power plants approved by July 2016 should exceed the estimated supply stated in the Basic Plan, and taking into consideration heating boilers and other equipment used for purposes other than power generation, more severe fuel shortages are expected.

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2 For obtaining approval for FiT, power plants file plans of which type of fuel they will consume in what amount though no aggregated data is made publicly available.

3 Calculated with a specific gravity of 0.65.

Figure 2 Estimated fuel consumptions of biomass power plants

Categories for FiT	Capacities approved by July 2016 (MW)	Main fuel assumed	Estimated fuel consumption (million tons)
Unutilized wood	436	Domestic chips	5.56
Ordinary wood	3,320	Imported pellets	31.97

Note: Lower Heating Value (LHV) for pellets and chips are assumed to be 3.978MWh/t and 2.340MWh/t, respectively. The electric efficiency is set at 25%, with a load factor of 87%.

On the other hand, ordinary wood fuel is expected to come mainly as imported pellets. Power producers see great promise in palm kernel shells (PKS), a low-cost byproduct of palm oil. However, swayed by the production of palm oil, the main product, annual exports of PKS to Japan seem to stay within the range of 1 million to 3 million tons[4]. The sustainability of PKS use must also be constantly reviewed as palm oil production is blamed for forest destruction that it allegedly causes.

Suppose instead, that wood pellets are used as the sole fuel, then demand will go beyond 30 million tons in 2030 (Figure 2). How large an impact this increased demand would have is easily imaginable given the fact that global production of wood pellets in 2014 stood at 24 million tons, with a projected growth up to 47 million tons by 2020[5].

On a global basis, bioenergy still holds some room for growth as woody biomass alone has an estimated potential of 7.8 billion tons[6]. However, any rapid increase in demand is quite likely to drive up the price, which is feared would hinder procurement at practical prices. In June 2016, Japan enacted the Act on Promotion of Distribution and Use of Legally Logged Wood Products as a measure to prevent illegal timber and wood from being imported. The Government, which is still preparing a Ministerial Ordinance that should set out the details of the Act, has yet to make clear whether it will apply to imported biomass fuel, failing to sweep away concerns that any timber illegally felled in a manner that could cause destruction of the forests may be imported as fuel.

4 "Survey Report on Sustainable Biomass Power Generation (commissioned by the Ministry of Economy, Trade and Industry)", Mitsubishi UFJ Research and Consulting, 2016 (Japanese version only)
5 Hawkins Wright (2015) Global Wood Pellet Market Outlook
6 World Bioenergy Association (2015) Global Biomass Potential Towards 2035

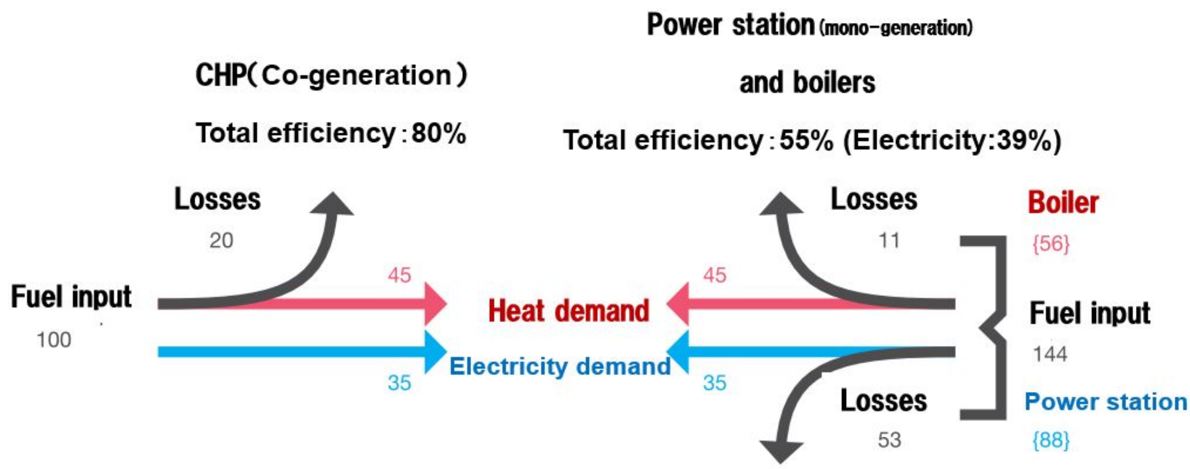
1.3 Underdevelopment of CHP

Another serious problem with the current FiT scheme is the lack of incentives for CHP in its design. Accordingly, few of the power plants which have been put into operation so far have been designed to put the heat to any use[7].

Plants designed only to generate electricity operate at an electric efficiency of 20 to 40% while CHP plants demonstrate a total efficiency of some 80% (Figure 3). From a business viewpoint, the profitability will improve if the plants can sell heat. In other words, because they are failing to make efficient use of heat, they keep on operating depending on high purchasing rates, a problem that the current form of FiT is faced with.

The reason behind the fact that the FiT schemes has ended up this way lies in the fundamental problem that Japan has no integrated policy for heat use. Among the prospective uses of waste heat on a significant scale may be district heat supply. In fact, since the enactment of the Heat Supply Business Act in 1972, some districts have developed district-heating networks, but only on a limited scale, and they have made little progress in the shift from fossil fuel to biomass. The current FiT scheme is intended to apply solely to electricity production, a comprehensive heat policy, which should include demand-side measures, must be developed together with a system design to help the two initiatives work organically.

Figure 3 Efficiency of CHP
(Compared with power generation and heat supply as separate operations)



7 Some power plants, such as Green Power Generation Oita (Hita City, Oita Pref.), and Taki Bio Power (Taki Town, Mie Pref.), have started working to use waste heat.

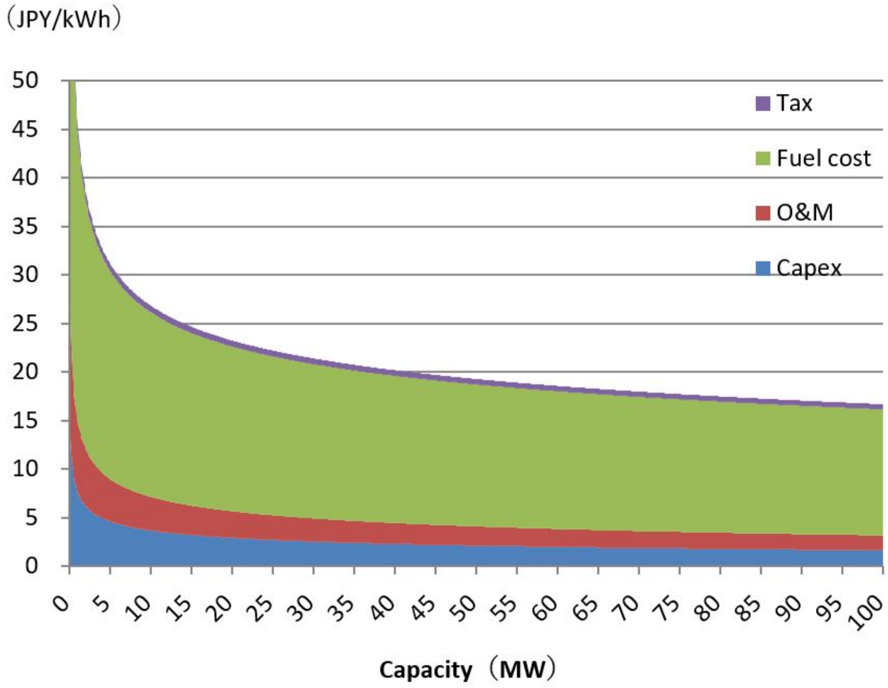
Source: "District Heating Manual for London", Mayor of London (2013); adapted by Renewable Energy Institute

2. How should bioenergy power generation be structured?

2.1 Preconditions: Different sized bioenergy power plants should have different cost structures associated with them.

Bioenergy generation is different from other types of renewables, it needs fuel costs. Indeed, generation on a larger scale costs less, but it should be noted that the fuel expenses, as a variable cost, always account for a certain portion of the generation cost (Figure 4). Solar PV and wind power operate with no fuel to be paid for, and once their facilities and equipment are fully depreciated, they are expected to run as extremely cheap energy sources. In contrast, bioenergy power plants must continue paying for fuel, although CHP and low-quality biomass recycled from waste, if exploited to their full extent, help them reduce cost. As described previously though, the FiT scheme which Japan currently has in place generates a great deal of demand for bioenergy fuel, especially woody biomass, a structure which sustains the imbalance between supply and demand, leaving the fuel price unlikely to go down[8].

Figure 4 Cost structure of bioenergy power generation



Source: Mitsubishi UFJ Research and Consulting (2016)

8 Of course, the learning effect should help reduce fuel supply cost, but as long as sellers maintain the upper hand in the market, the fuel price, and therefore the fuel cost, is expected to remain high.

2.2 Basics of bioenergy strategies developed by advanced countries in Europe

In Europe, which is forging ahead with the use of renewable energy, countries have developed bioenergy not for generating electricity but basically for utilizing heat. For fuel, in principle they use waste timber and other low-quality resources that they can obtain domestically. Having closely linked bioenergy with their globally competitive forestry and forest industry, they successfully make use of the energy while saving resources.

In addition, biomass is basically used to produce power together with heat, or for CHP (Figure 5)[9]. CHP technology allows a plant to exploit almost 80% of the energy which biomass fuel contains, and the production of heat which it can sell, helps absorb some of the cost of generating electricity, a business advantage. Germany modified its FiT scheme in 2004 to allow some markup on the purchasing rate of power produced by CHP plants, before making the CHP technology mandatory for biomass power plants. In Austria, the FiT scheme only offers support to plants with a total efficiency of 60% or more as a policy to encourage CHP.

With two products to sell, electricity and heat, CHP plants can operate as a "power source with great flexibility." Even after a great deal of solar, wind, and other types of variable renewable power sources have been installed, they can still operate flexibly, generating more electricity when its price is higher, then producing more heat when power becomes cheaper[10]. In technical terms, heat, produced in the form of hot water, can be stored in thermal energy storage tanks. District heating networks, developed all over Europe, are replacing fossil fuel with biomass and other types of renewable energy as their heat source, a move that is drawing attention to the function they can serve as huge heat storage tanks for CHP plants. Work on innovation is also underway mainly in Europe to develop smaller CHP equipment with the greater flexibility needed to deal with the demand for heat in smaller-sized facilities (single-family houses, for instance) with no connection to any district heating network.

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9 In Germany, some bioenergy power plants generate solely electricity, but they came into operation in the early days of the FiT scheme. They use inexpensive fuel, such as construction debris, which allows their business to continue. For more details, see, for instance, Hisashi Kajiyama, 2013, "The Current State of Woody Biomass Use and Challenges to Address: Comparison between Japan and Germany, Focusing on Their FiT Schemes" (Japanese version only)

10 Yo Yasuda, 2014, "Japan Is Unaware of the Potential of Wind Power Generation" (Japanese version only)

Figure 5 Power generated in major European countries by CHP plants with woody biomass (TWh)

	Germany	Austria	Sweden	Finland
Mono-generation	5.333	1.129	0.000	1.227
CHP	6.535	2.308	9.077	9.927
Subtotal (electricity)	11.868	3.437	9.077	11.154

Source: EurObserv'ER (2016), Solid Biomass Barometer

2.3 Position of large-scale power generation

As shown above, European countries have basically applied CHP when introducing bioenergy. They have also introduced policies to restrict large-scale bioenergy power plants as they have difficulty in making full use of the heat they produce. Among countries that have adopted FiT, Germany and Austria exclude those with a capacity of 20MW and 10MW or more, respectively, from the scheme.

Indeed, some countries in Europe, such as the United Kingdom and the Netherlands, offer a minimum level of support to large-scale plants that includes co-firing plants operating with coal, only when they assume that coal-fired power generation should be phased out in the end[11]. The UK government has decided to shut down all coal-fired power plants by 2026, and in September 2016, the Dutch parliament approved a target for the reduction of CO2 emissions, which assumes that all coal-fired power plants should be closed[12]. Accordingly, support is only provided to plants operating on a higher co-firing rate, of several tens percent[13]. Some of them, such as Drax, a power plant in the UK, have succeeded in 100% full conversion[14].

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[11] For the latest trends worldwide, see Renewable Energy Institute (2016) "Coal Business and Policy Trends -What Japanese investors should know after the Paris Agreement-".

[12] https://www.theguardian.com/environment/2016/sep/23/dutch-parliament-votes-to-close-down-countrys-coal-industry

[13] Three of the five coal-fired power plants located in the Netherlands, operate on a co-firing basis, at ratios of 30%, 50%, and 80%.

[14] Teruyuki Ohno & Romain Zissler (2014) "The UK targets for 30% renewable energy for 2020, even with policies to maintain nuclear power" (Japanese version only) https://www.renewable-ei.org/column/column_20141113.php

In contrast, Japan does not have a policy to withdraw from coal-fired power generation. A series of plans for new coal-fired plants has been announced, an extraordinary deviation from the global trend. What must be avoided is the consequence that biomass co-firing under current FiT is used merely as a pretense of efforts to reduce the burden on the environment, with no actual progress toward the original target of phasing out coal-fired power generation.

The United Kingdom and the Netherlands, being poor in forestry resources, rely mainly on imported biomass like Japan. European countries, which are examining the life cycle assessments (LCA) and risk analyses of various supply chains to understand their actual realities[15], have set standards for the sustainability of bioenergy. Japan would also be required to take a similar course (Figure 6).

Figure 6 Sustainability criteria of the United Kingdom and the Netherlands: Overview

	United Kingdom	Netherlands
Adopted in	2013	2015
Apply to	All power plants with a capacity of 1 MW or more	Coal-firing and large-scale heat production
Sustainability of land use	Legal and sustainable forest management	Certification required for forest biomass
Upper limit of GHG emissions per production (gCO_2/ MJ electricity)	• 66.7 (2014–20) • 55.6 (2020-25) • 50.0 (2025-30)	56

Note: In the UK, upper limits of GHG emissions per production are set against the target of the Department for Business, Energy & Industrial Strategy, and a more severe reduction ratio is applied every five years. The Netherlands requires a reduction equivalent to 70% of the criteria set by the EU.

Source: By Renewable Energy Institute from various materials

15 European Commission (2010) Report from the commission to the council and the European parliament on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling

Recommendations for Japan's FiT scheme

Based on the state of bioenergy power generation introduced so far in Japan, and the policies of European countries for bioenergy use, as described above, we offer the following recommendations for amending the current FiT scheme and related policies.

1. Introduce a new FiT category for large-scale bioenergy plants with a lower purchasing rate

First, in order to avoid further strain on the supply-demand balance of woody biomass as a fuel, some measures should be introduced to restrict any new plans for large-scale. This is also the natural conclusion of the principle under which FiT rates are set as larger-scale plants produce power at a lower cost. Such measures also help prevent large-scale producers from holding a fuel monopoly, and preserve the prospects for CHP and heat use, which should serve as the base.

Specifically, at its FY2016 meeting, the Procurement Price Calculation Committee should set up a new category for large-scale plants for both "unutilized wood" and "ordinary wood" categories, e.g. those with a capacity of 20MW or more, and apply lower purchasing rates to them.

2. Reform the support mechanism for co-firing on the assumption that coal-fired power plants should be phased out

Second, before discussing co-firing using coal, Japan should present a roadmap of closing coal-fired power plants. Only then, based on that roadmap, Japan should again consider what support should be offered in what way, including whether any support should be offered for co-firing in the first place. Any aid should only be provided for existing power plants with some conditions set for the co-firing ratio, for instance, as a transitional measure before phasing out coal.

3. Conduct risk analyses regarding sustainability

Third, fuel supply chains, now being created, should be classified into several categories, whether they are located inside or outside Japan, to analyze the risks they each may have regarding sustainability. In order to secure the transparency of discussions that will be held when setting the appropriate level of regulations, the sustainability of land use in forests and the effect on reduction of GHG emissions should be examined to understand the actual state of both items.

4. Work to increase and promote CHP projects

Fourth, efforts must be made to increase and promote CHP (waste heat use) projects. For that purpose, case studies and analyses should be conducted while working to add to new projects as these endeavors will be significant and constructive when considering what will be needed 20 years later, when the FiT scheme is terminated. In addition, studies on the introduction of a comprehensive heat policy should get started as soon as possible.

Addendum: On the Category of "Unutilized Wood"

Under the FiT scheme, the category of "unutilized wood" has been established with the intention of promoting the domestic forest industry. The fuel price was originally estimated to be ¥12,000 per ton, due to the expensive domestic forestry. However, the cost data presented in 2015 at least showed "unutilized wood" fuel was traded at ¥7,800 per ton, suggesting that the expected effect had not been produced (Figure 7). Also, the fuel price for “unutilized wood” was only a little higher than that of "ordinary wood", ¥7,118 per ton.

The data was obtained when only a limited number of woody biomass plants had come into operation, with little strain placed on the supply-demand balance. A final conclusion should be formed after the latest data is released, but if such tendency continues, it would suggest that setting up the "unutilized wood" category was not effective.

In the first place, the category was established to accommodate the structural high-cost of the forest industry; timber from forest thinning is abandoned as it cannot be carried out of a forest due to underdeveloped infrastructure, such as forest road network. This means that any aid investment in the forestry would have a greater effect when its use is limited to projects that should help lower the marginal cost for production of timber and for transport of fuel out of the forests, or infrastructure development, under a framework independent of any FiT scheme. Here, the issue is dealt with merely as an addendum due to the limited amount of data available at the moment. Once more of the actual conditions are recognized, the current scheme may need reconsidering.

Figure 7 Fuel prices by category (2015 actual data)

	Cost data reported	Originally estimated prices
Unutilized wood	¥7,809/t (28 reports)	¥12,000/t
Ordinary wood	¥7,118/t (37 reports)	¥7,500/t

Source: 20th Procurement Price Calculation Committee meeting documents