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Restructuring Japan's Bioenergy Strategy

Towards Realizing Its True Potential

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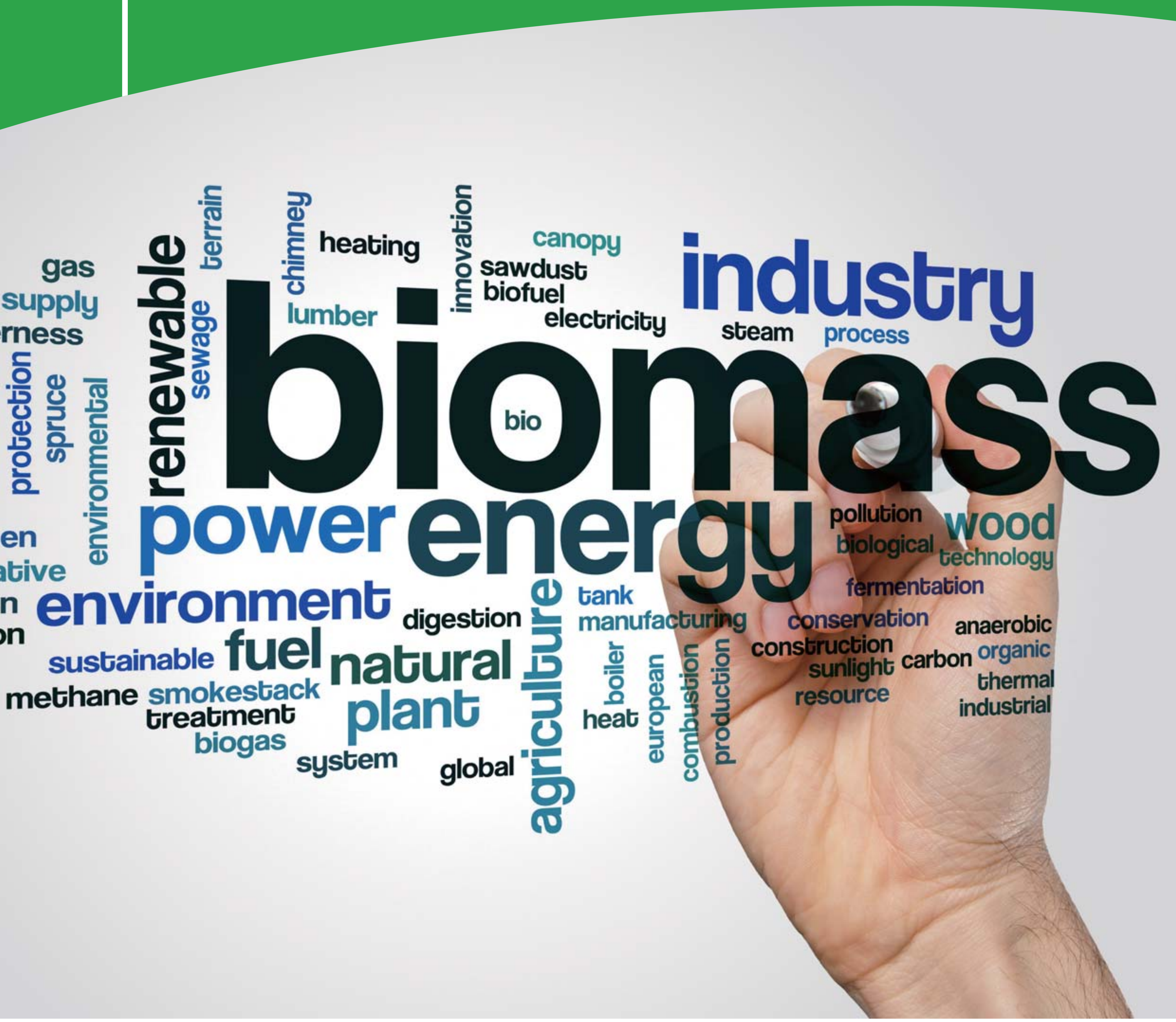

Restructuring Japan's Bioenergy Strategy: Towards Realizing Its True Potential

Author

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About Renewable Energy Institute

Renewable Energy Institute is a non-profit think tank which aims to build a sustainable, rich society based on renewable energy. It was established in August 2011, in the aftermath of the Fukushima Daiichi Nuclear Power Plant accident, by its founder Mr. Son Masayoshi, Chairman & CEO of SoftBank Corp., with his own resources.

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I. Introduction

Bioenergy is the most used renewable energy source in the world (as of 2016).[1] As shown in the IEA's 2°C scenario, it is expected to account for 17% of final energy use in 2060.[2]

Bioenergy has characteristics different from those of solar PV and wind power: it can be stored and transported as a fuel, and often utilized for heating and transport rather than power generation. Using residues from forestry and agriculture for energy purposes provide extra income of these activities and benefit rural communities.

In Japan, bioenergy has a significant potential. It is not fully utilized in terms of quantity or quality. The reason is that bioenergy policies have been developed without understanding the characteristics and suitable roles of bioenergy.

Bioenergy covers several types of fuel and a diverse range of technical conversion methods. An international expert said, "Complexity is poison for policy decision makers, and biomass is complex."[3] Thus, simplification involves risks, and schemes should be carefully designed, taking into consideration the diversity of bioenergy.

This report aims at recommending solutions and indicating future directions for bioenergy policies and markets in Japan. To that end, the report will first overview the basic characteristics of bioenergy, and second, review the experiences of European countries preceding in bioenergy use. Furthermore, the report demonstrates a long-term vision as well as some immediate proposals to revise the bioenergy policies in Japan.

The report primarily deals with heat and electricity, while the transport sector is mentioned only briefly.

[1] REN21 (2017) Renewables 2017 Global Status Report. Bioenergy accounted for 4.9% of final energy consumption even excluding traditional biomass in 2015.

[2] IEA (2017) "Technology Roadmap Delivering Sustainable Bioenergy"

[3] The statement by Dolf Gielen, Director of IRENA Innovation and Technology Centre during EUBCE2016 (the 24th European Biomass Conference and Exhibition) (https://bioenergyinternational.com/opinion-commentary/eubce-2016-killing-biomass-complexity)

II. Current status and issues of Japanese bioenergy market

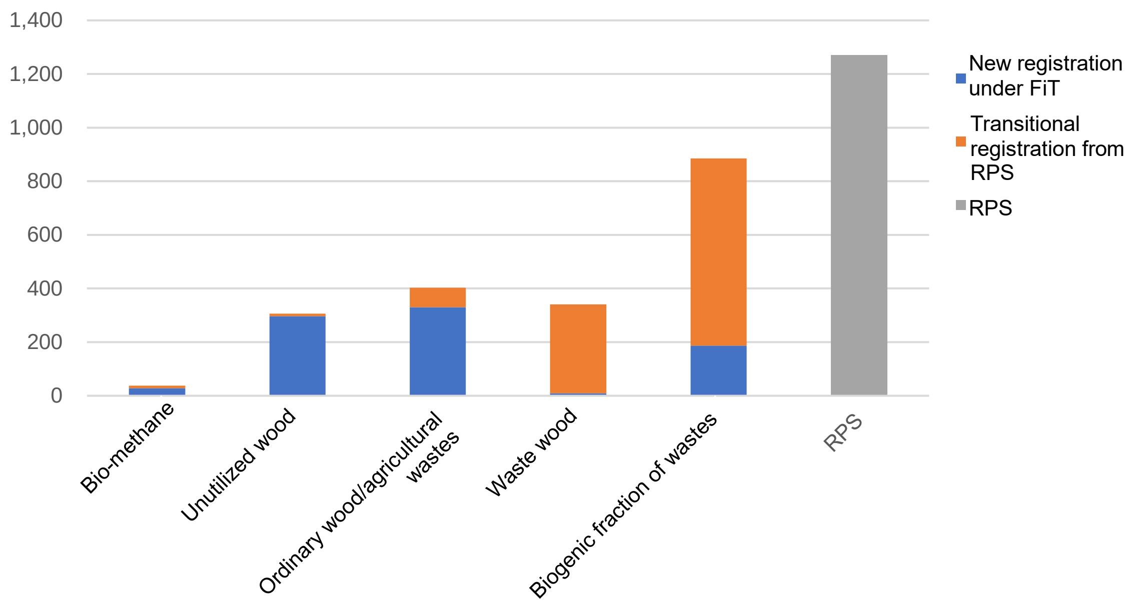
1. Power generation sector: Unbalanced market development

1.1 Domestic wood: Uncertain views after the introduction of FiT

In Japan, woody biomass power generation has been increasing since the introduction of a feed-in tariff (FiT) scheme in 2012. In the time of the Renewables Portfolio Standard (RPS) scheme[4] (from 2003) prior to the FiT, low-priced biogenic fraction of wastes and waste wood were used as main fuels, but the use of forest residues did not progress, due to high costs of collection and delivery. In order to promote the use of forest residues, the FiT scheme has set a new category of unutilized wood and provided preferential purchasing rates. As a result, registered capacity in the unutilized wood category has grown for 5 years after the introduction of FiT. The installed capacity has increased to around 300 MW and the registered capacity to about 500 MW as of March 2017 (Figure 1).

Consequently, the use of forest residues increased from approximately 730,000 tons in 2014 when statistics started to be collected, to 1,920,000 tons in 2016, nearly a factor of three, in only two years. According to Renewable Energy Institute's estimate, woody biomass power generation contributes to jobs (45,000), many of which in rural areas. This is the second largest number following that of solar PV.[5]

Figure 1 Installed capacity under FiT (MW, as of March 2017)



Note: Fuels used by power plants without transition from RPS to FiT are uncertain and do not necessarily correspond to FiT categories.

Source: "Website to Publish Information on the Feed-in Tariff system" by the Agency for Natural Resources and Energy (ANRE)

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[4] Issued in June 2002. The used amount under the transition measure is scheduled to be zero by FY2022. (https://www.rps.go.jp/RPS/new-contents/pdf/h29_34_keika_sochi.pdf)

[5] Capacities in 2016, according to Renewable Energy Institute (2017) "Feed-in Tariff system – Five-year achievements and future challenges"

The power generation cost of domestic wood remains high, but better competitiveness may result from industrial learning and an open power market. Since most power plants today do not utilize heat, profitability improvement through heat sales is an untapped opportunity. An open power market where the value of flexibility is rewarded could further improve the viability of bioelectricity.

Fuel costs are key factor for the competitiveness of bioenergy. According to the cost data reported by the Procurement Price Calculation Committee, the cost of domestic wood generation is still high, “as originally estimated.” Japan is still an underdevelopedmarket and fuel prices have been fluctuating, but little has been seen of a price reduction trend. The accumulation of experience, establishment of markets with sufficient volumes and number of actors to get predictable prices is not yet achieved. To bring down costs investments in special machinery, transport vehicles and development of dedicated companies specializing in the different stages of the supply chain will take time and require a combination of economic policies and investments in research and development.

Figure 2 Changes in fuel costs of bioenergy power generation registered under FiT (yen/GJ)

		FY2015	FY2016	FY2017	Estimated cost
Unutilized wood	2 MW or more	781	958	977	1,200
	Less than 2 MW	−	777	777	900
Ordinary wood		733	644	721	750
Waste wood		263	347	324	200

Note: Fuel costs were reported on a weight (ton) basis through FY2015. As the calculation was changed to a heat (GJ) basis from FY2016, costs are converted into GJ.

Source: “Comments on procurement prices.” in Procurement Price Calculation Committee’s report of each year

1.2 Imported wood: Issues related to sustainability and coal co-firing

In contrast, imported wood (ordinary wood/agricultural wastes) shows a rapid increase in the registered capacity. There are concerns over a shortage of worldwide supply and subsequently expanding use of unsustainable fuel.[6] The situation has become more severe in fiscal year (FY) 2017.

Specifically, the registered capacity reached a large amount of 12.4 GW by the end of March 2017 and exceeded 16 GW by the end of September 2017 (adjusted with respect to the biomass ratio). If all these capacities are to become operational, there is even a possibility that Japan’s installed capacity will rank first internationally, surpassing the current first-place Brazil (14.2 GW), second-place US (12.5 GW) and third-place China. (12.0 GW)[7]

Furthermore, an important issue is to secure procurement of sustainable fuels. Nevertheless, it has become apparent that, in projects using palm oil, the registered capacity is equivalent to about 4.1 GW, accounting for 36% of the total ordinary wood/agricultural wastes. This is a major issue. Palm oil production itself encompasses several sustainability issues, which have been repeatedly pointed out, such as infringement of indigenous people’s rights, forced labor, deforestation, and the loss of

[6] Renewable Energy Institute (2016) “Recommendations for biomass FiT power generation”

[7] REN21 (2017) Renewables 2017 Global Status Report

biodiversity. Palm oil production has another fatal flaw from the standpoint of energy policy, as it is likely to release a greater amount of GHG (greenhouse gas) than fossil fuels in consideration of influences by emission of methane and CO2 through plantation development in lowland swamp forests and indirect cut-down of forest areas through conversion of existing agricultural land[8].

Europe and the US also pay serious attention to sustainability issues of bioenergy fuel and take measures such as setting criteria. Also, in Japan, the sharp increase in registered capacities of ordinary wood and palm oil for FY2017 has made the sustainability-related issues obvious, and the Procurement Price Calculation Committee at its FY2017 meeting has decided to ask third parties to formulate sustainability criteria involving already-operational projects.

Figure 3 Bioenergy power generation capacity registered under the FiT scheme (Adjusted with respect to the biomass ratio, as of the end of March 2017)

Fuel category	Installed capacity (MW)				Registered capacity (MW)
	Non-transition from RPS	Registered under FiT		Total	
		Transition from RPS	New registration under FiT		
Unutilized wood	–	9	297	306	499
Ordinary wood/ agricultural wastes	–	74	330	403	11,466
Waste wood	–	332	9	341	87
Biogenic fraction of wastes other than wood	–	698	187	885	261
Bio-methane	–	10	28	38	103
Total	1,270	1,113	823	3,206	12,417

Note: Palm oil is included in the ordinary wood/agricultural wastes category. It will be classified into a new category, biomass liquid fuel from FY2018.

Source: "Website to Publish Information on the Feed-in Tariff system" by the ANRE

The problem with the current FiT scheme, is that it supports co-firing power generation, including coal-fired power plants that only partially use biofuel[9]. Co-firing using bioenergy fuel has been widely conducted, because it is a good way of creating a market for biomass at the early stage of bioenergy development. Nowadays, the bioenergy co-firing ratio globally tends to be raised for drastic reduction of coal consumption in recent years, with an aim for 100% conversion to bioenergy.

In Japan, FiT project plan registration data published from the autumn 2017 reveal that many existing coal-fired power plants are supported under the FiT scheme (Figure 4). These data include some registrations switched over from the RPS, but there are many power plants assumed to have obtained registrations after the start of the FiT scheme. As shown in Figure 4, in projects with rated output over 200 MW, the bioenergy co-firing ratio remains below 10%.[10]The support scheme should be designed to increase the ratio of co-firing, while any support for bioenergy co-firing in newly built coal-fired power plants should be reconsidered

8 For issues about palm oil power generation, see "Great Risks Involved in Palm Oil Power Generation: Sustainability Standards Are Urgently Needed" by Takanobu Aikawa (2017a)

9 For issues about coal co-firing, see "Biomass co-firing: For the reduction of coal-fired power plants" by Takanobu Aikawa. (2017b)

10 35th Procurement Price Calculation Committee meeting documents. Provided that the biomass co-firing ratio in individual project has not been disclosed.

Figure 4 Coal-fired power plants with bioenergy co-firing registered under FiT

	Company name	Output (MW)
1	Chubu Electric Power Co., Inc.	4,100
2	Electric Power Development Co., Ltd.	2,000
3	TEPCO Fuel & Power, Inc.	2,000
4	Joban Joint Power Co., Ltd.	1,200
5	The Chugoku Electric Power Co., Inc.	1,000
6	The Chugoku Electric Power Co., Inc.	1,000
7	Kansai Electric Power Co., Inc.	900
8	Kansai Electric Power Co., Inc.	900
9	Hokuriku Electric Power Company	700
10	Hokuriku Electric Power Company	700
11	Electric Power Development Co., Ltd.	600
12	Shikoku Electric Power Co., Inc.	500
13	The Chugoku Electric Power Co., Inc.	500
14	The Chugoku Electric Power Co., Inc.	500
15	Electric Power Development Co., Ltd.	500
16	Electric Power Development Co., Ltd.	350
17	Nippon Steel & Sumitomo Metal Corporation	330
18	Joban Joint Power Co., Ltd.	250
19	Electric Power Development Co., Ltd.	250
20	Ube Industries, Ltd.	216

Note: As of the end of November 2017. Power companies ranking in the top 20 in terms of rated output are extracted in order from the top. Since biomass ratios have not been disclosed, the output means rated output only of each coal-fired power plant without considering the biomass ratio.

Source: "Website to Publish Information on the Feed-in Tariff system" by the ANRE

The cost of co-firing power generation is approximately 0.10 USD/kWh at an international level[11] and 12.6–13.2 yen/kWh in Japan.[12] Nevertheless, a high purchasing rate of 24 yen/kWh is applied to the FiT[13] and may deliver excessive profits to power companies.

Phase out of coal-fired power generation should be a priority issue among Japan's climate mitigation measures.[14] To clarify this issue, a roadmap focusing on the utilization of power plants for bioenergy co-firing or conversion should be advanced.

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[11] IRENA (2012) Renewable energy technologies: Cost analysis series volume 1: Biomass for power generation

[12] Power generation cost verification working group (2015) "Report on verification of power generation costs, etc. for Subcommittee on Long-term Energy Supply-demand Outlook"

[13] Kinds of fuels used also have not been disclosed, but most of these co-firing power plants use imported pellets as main fuel and domestic wood chips as only a part of fuel.

[14] Renewable Energy Institute (2018) "RECOMMENDATION Transitioning Energy Policies for a Decarbonized Society"

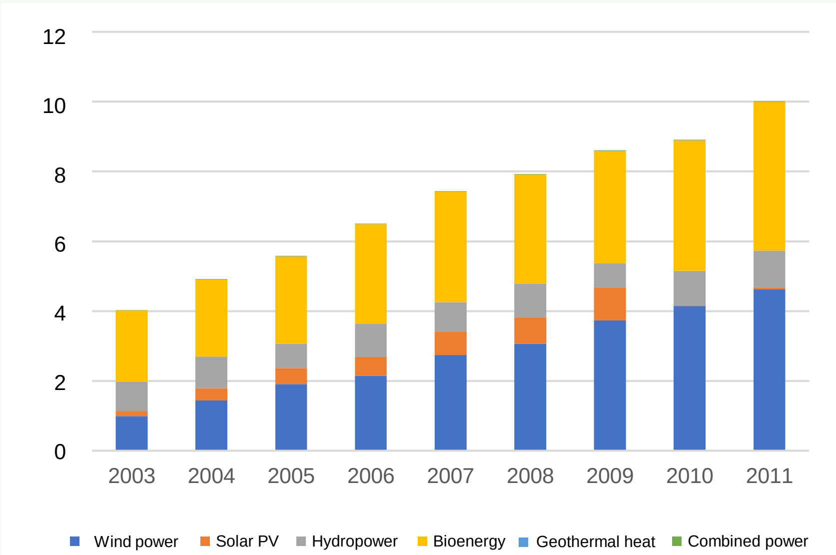
■ **Column:**

Development of bioenergy power generation before the introduction of FiT

Modern bioenergy applications in Japan have been conducted using black liquor and wastes from the pulp and paper industry since the 1950s. Electricity and vapor were used for these applications in manufacturing processes at the paper mills.

After the RPS law was established in 2003 and commercial power business started, many bio-power plants were constructed. However, since the purchasing price of bioenergy power in those days was 7.6 yen/kWh–9.4 yen/kWh[15], cheaper than the current FiT price, most of their fuels were waste wood and biogenic fraction of wastes. Therefore, it can be said that the use of low-quality fuels was promoted at the time. In addition, bioenergy had a competitive edge against other renewable energy and accounted for 40% of purchased electricity at the time of the RPS (Figure 5).

Figure 5 Renewable energy electricity supply under the RPS scheme (TWh)



Source: By Renewable Energy Institute from RPS website

[15] ANRE (2011) "Survey result of trade prices regarding new energy, electricity, etc. under RPS law"

2. Underdevelopment of heat use

Second, notwithstanding the fact that heat use is the most traditional strength of bioenergy, it is hardly developed in Japan except for a very limited range of industrial uses.

Figure 6 compares the bioenergy usage of Japan and Germany. It shows that the industrial sector in Japan uses a considerable amount of heat, mainly in the pulp and paper industry and the wood industry . In other industries, however, heat use is supported as demonstration tests by NEDO projects,[16] but subsequent spread is not yet in sight. It is also shown that heating by bioenergy is considerably conducted in the domestic and commercial/public service sections in Germany, but scarcely in Japan.

For reference, the cumulative total of introduced biomass boilers is fewer than 2,000 units in Japan, while Germany has over 400,000 units for subsidized introduction only. Schemes and policies are strongly required to call for investment in this field.[17]

Figure 6 Differences in bioenergy usage between Japan and Germany (TJ, in 2015)

	Sector	Japan	Germany
Transformation	Power generation	276,103	57,630
	Combined heating and power (CHP)	0	69,654
	Heat supply	0	13,538
Final consumption	Industry	96,748	90,388
	Residential	472	222,600
	Commercial/public service	0	50,066

Note: Comparison extracted from items of Primary solid biofuels. Heat use corresponds to the used amount for a part of CHP, and heat supply in the energy conversion category, and for a part of the industry section and the residential and commercial/public service sections in the final consumption category.

Source: IEA Country Statistics

[16] 56 demonstrations in "Demonstration project for unutilized energy including biomass" by NEDO and 26 demonstrations in "Field test project for local biomass heat use (2006–2010)"

[17] Forest Agency's data for Japan and AEE (2017) Renews Spetial Nr.82/August 2017 Holzenergie in Deutshland for Germany.

III. Issues to be considered upon restructuring strategy

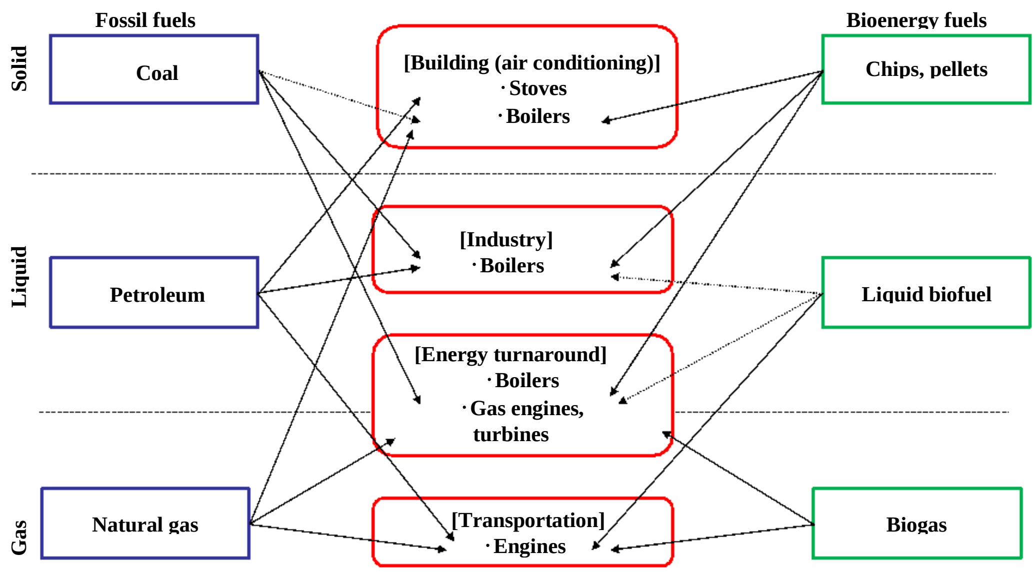
1. Basic characteristics of bioenergy

1.1 Diversity of applications

The first characteristic of bioenergy is that biomass resources can produce diverse types of fuels, in all forms; solid, liquid, and gas. These fuels can be used in all the fields of electricity, heating, and transport. Accordingly, fossil fuels currently used these fields can technically be replaced with bioenergy. Thus, the diversity of applications is the greatest strength of bioenergy, unlike solar PV and wind power mainly used for electricity generation.

However, energy conversion efficiency is not necessarily high in all forms of application. It can be 90% or more for heat, but merely 20-40% for mono-generation of electricity, which improves up to 80-90% if it is combined with heat (CHP). As liquid fuel for transport, it is used in internal-combustion engine. Its efficiency is less than 20%, similar to that of gasoline and diesel. Therefore, possibility of various applications is certain, but it is important to give priority to applications taking advantage of the strengths of bioenergy, sharing different roles with other renewables.

Figure 7 Structure of bioenergy use



Source: By Renewable Energy Institute

1.2 Distribution and the finite nature of resources

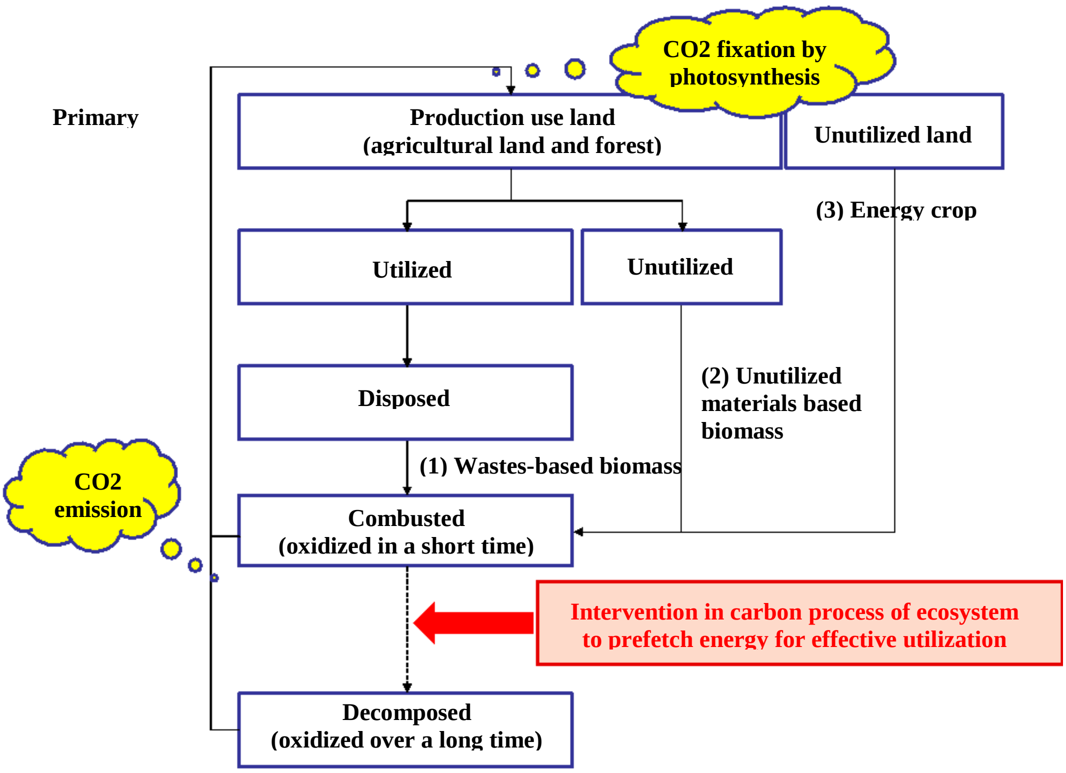
The second characteristic: since bioenergy fuel has lower energy density per unit weight than fossil fuels and because the resources exist over geographically widespread areas, bioenergy fuel cannot be collected intensively from certain areas in the same way as fossil fuels can be. Therefore, unlike fossil fuels, which are relatively easy to scale up, bioenergy systems are rather small-scale decentralized systems.

At the same time, bioenergy use is greatly influenced by the finite nature of resources. Indeed, a trial calculation shows that the use of all biowastes will be able to supply all of primary energy needs all over the world.[18] However, it is not realistic to use all of them in consideration of economic efficiency such as costs of collection and delivery.

Competition for land may occur among ecosystem services other than fuel production, such as food production and ecosystem conservation. Bioenergy requires more land than solar PV and wind power and will reach the upper limit of areas to be used sooner.

For the use of bioenergy, it is important in principle to first consider biomass using unutilized materials such as wastes and then production of energy crop using unutilized land (Figure 8).

Figure 8 Conception for prioritizing bioenergy use



Source: By Renewable Energy Institute

18 Dornburg V, et al. (2010) Bioenergy revisited: Key factors in global potentials of bioenergy. Energy & Environmental Science 3: 258–67.

2. Experiences of bioenergy development in Europe

Next, we outline experiences of bioenergy development in Europe, which leads the world in modern use of bioenergy. Of course, trial and error also happened/took place in Europe. In this section, we summarize how to expand the market in Europe in light of bioenergy characteristics and derive lessons for Japan.

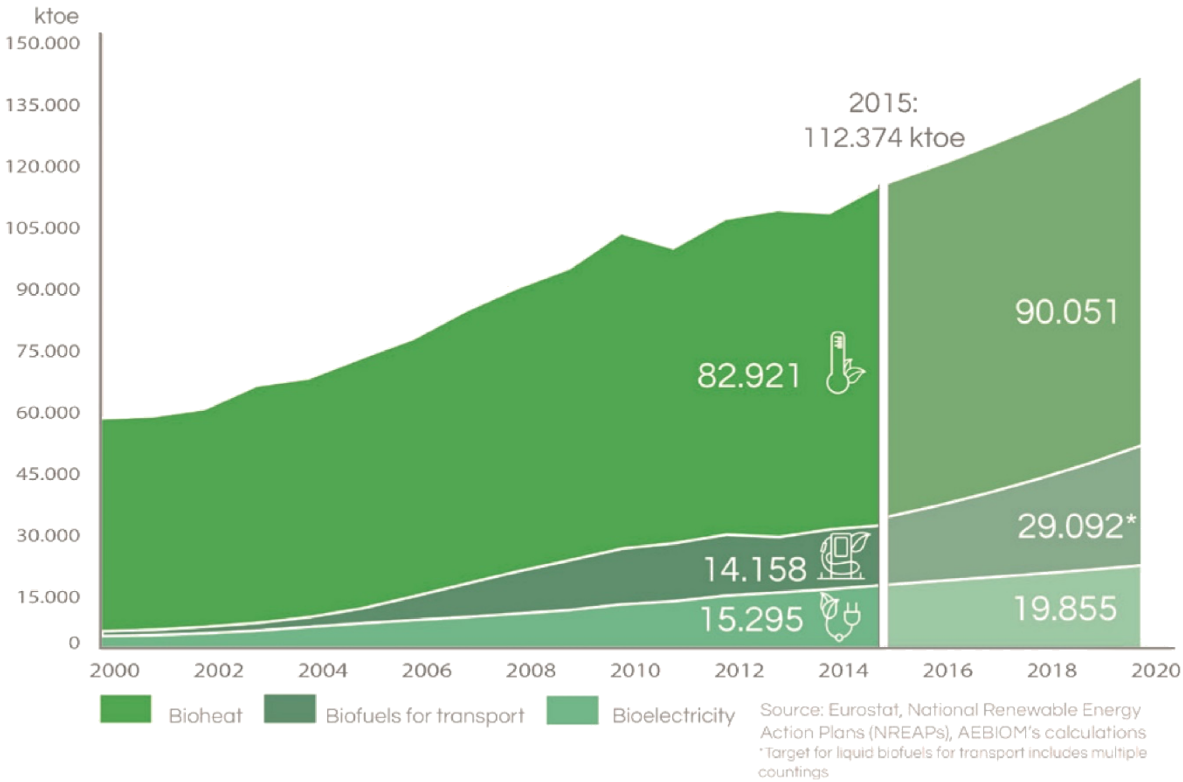
2.1 Utilization taking advantage of characteristics

(1) Development focusing on heat use

The first point is that Europe has achieved development focusing on heat use (Figure 9). Bioenergy is allotted for heating in the residential sector as shown in the breakdown of final consumption of bioenergy (Figure 10). This is a rational result of giving priority on effective resource usages (because the energy conversion efficiency for heat use exceeds 90%).

Bioelectricity use is expected to gradually grow by 2020, but its total amount is less than that of bioheat use. Although liquid fuel is used mainly in the transport sector, an outlook for target achievement for 2020 is uncertain because of competition with food production and sustainability problems.

Figure 9 Development of bioenergy use in the 28 EU member countries



Source: AEBIOM (2017) AEBIOM Statistical Report 2017

Figure 10 Breakdown of final consumption of bioenergy
(in the 28 EU member countries, 2015)

Sector		ktoe	Percentage
Heat	Residential	42,288	38%
	Industry	21,363	19%
	Derived heat*	12,759	11%
	Service	4,422	4%
	Others	2,089	2%
Electricity	CHP	8,829	8%
	Power only	6,466	6%
Transport		14,158	13%
Total		112,374	100%

Note: Eurostat defines heat to be produced in heat supply plants, CHP plants, and power generation plants, excluding heat produced for heat production.

Source: AEBIOM (2017) AEBIOM Statistical Report 2017

(2) Alternative to fossil fuels, and decentralized energy infrastructure

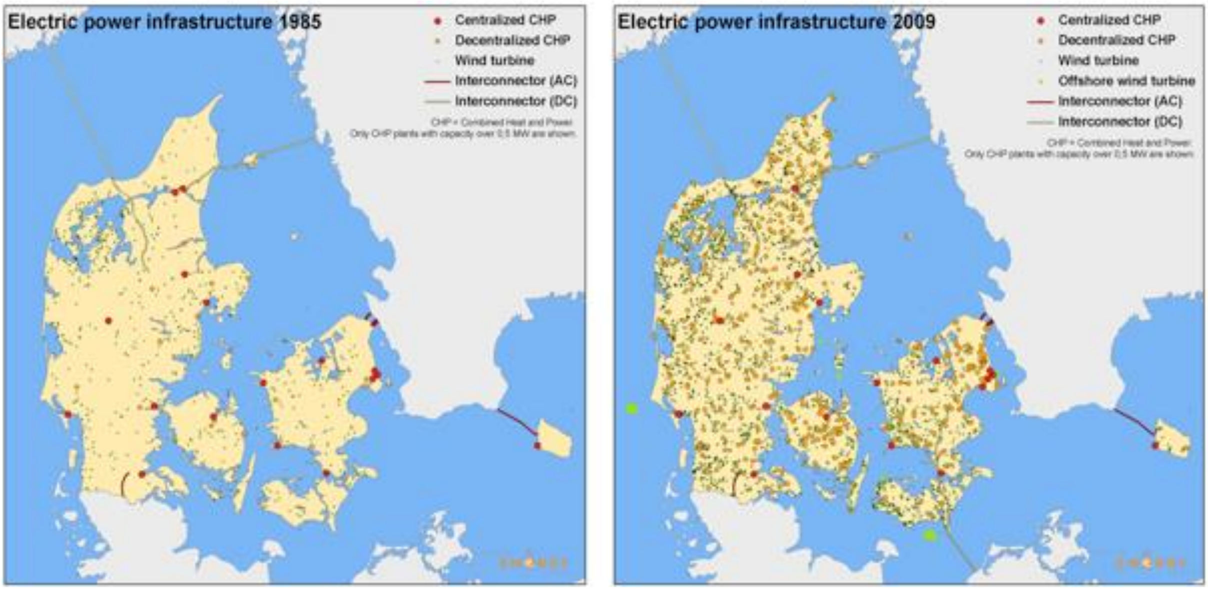
These bioenergy fuels have been mainly used as alternatives to fossil fuels (gas, heavy oil, and kerosene). However, as bioenergy fuels exist over geographically widespread areas than fossil fuels, they are converted into medium- and small-scale decentralized energy systems rather than large-scale energy systems.

This is clearly shown by the Danish case. Denmark has been developing heat and CHP plants using bioenergy as well as wind power generation since the 1980s (Figure 11). At the same time, the rate of fossil fuels such as coal has been reduced in district heating supply plants, and the rate of renewables such as bioenergy has been raised (Figure 12).[19]

With the development of heat storage tanks and heat conduit infrastructure used for heat supply, various heat sources can be used. Especially in recent years, solar PV has been operating large heat pumps using surplus power from wind power generation and playing a balancing role in power systems.

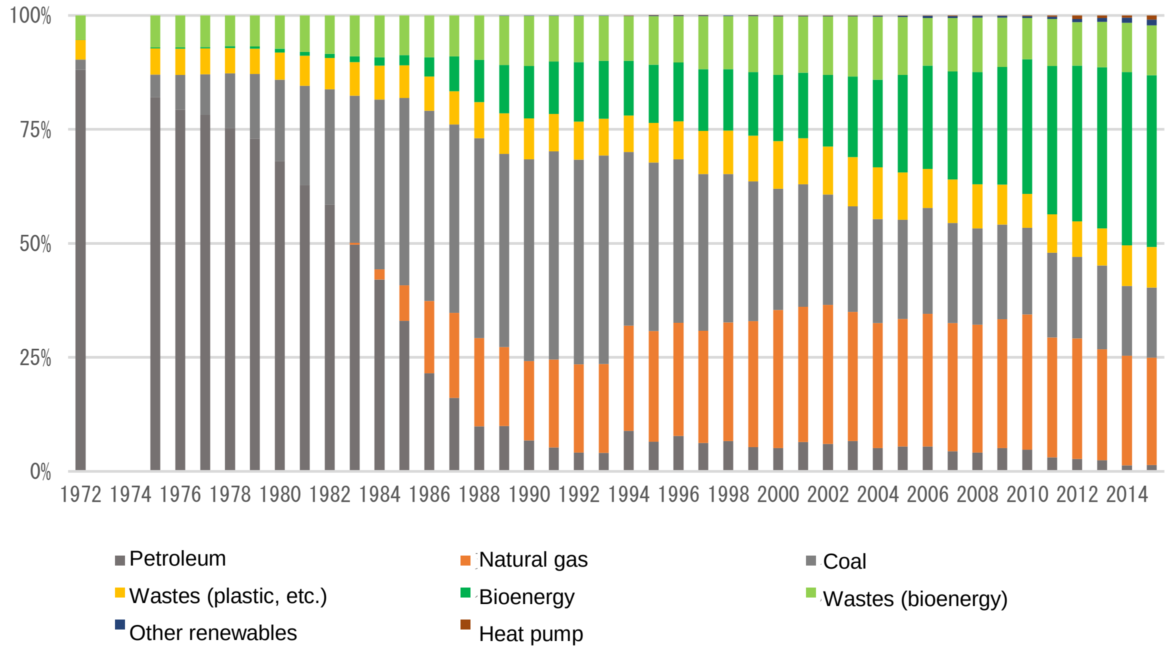
[19] Biogases derived from straw and livestock manures have been used as fuels in Denmark with fewer forests.

Figure 11 Development of decentralized energy system in Denmark



Source: Danish Energy Agency

Figure 12 Changes in fuels used in district heating supply plants in Denmark



Source: Danish Energy Agency (2017) Annual Energy Statistics

2.2 Pursuit of low-cost sustainable fuel procurement

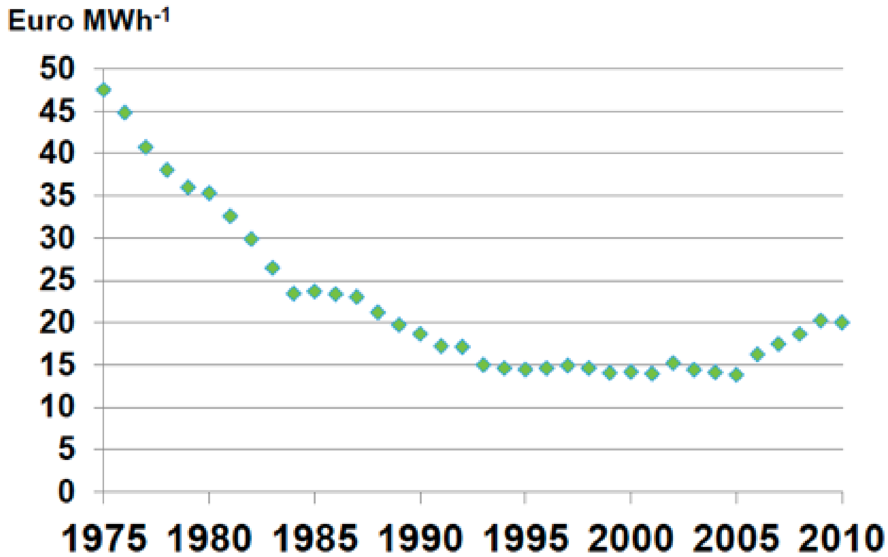
(1) Development from local resources

Bioenergy has been developed utilizing resources such as wastes and byproducts from geographically widespread local areas. Waste incineration facilities have been improved for energy collection in Denmark, the Netherlands since the beginning of the 20th century. For instance, the first district heating supply plant in Copenhagen, the capital of Denmark, utilized waste heat from a waste incineration facility. Biomass contained in wastes was regarded as renewable energy and hereafter has been playing an important role in electricity and heat supply together with the improvement of incineration facilities in Europe.

Woody bioenergy fuel is most frequently used in Europe at present.[20] High costs of collecting and delivering bioenergy fuels including woody fuel have been pointed out as an issue in Japan. In addition, in Europe, low-cost supply was not achieved from the beginning. Specifically, seeing historical changes in prices of woody fuels from Swedish forests, it is shown that supply cost has been reduced with accumulation of experiences in woody fuel use (Figure 13). It can be said that with the reduction in cost, the market has been expanded, enhancing competitiveness with fossil fuels and increasing the number of consumers.

Indeed, Sweden's flat landform is advantageous for low-cost supply in comparison with Japan's mountainous landform. However, even Central European countries with steep landform such as Austria have successfully developed efficient bioenergy supply from forests. Points to make it possible are well-improved road network and the development of bioenergy use integrated with forestry.

Figure 13 Changes in real price of forest-derived woody fuel



Source: Björheden (2012) Challenges of forest energy supply in Sweden

Their aggressive pursuit of usable resources is also a must-see. These countries have been utilizing not only woody fuel from forest but left-over materials generated in various processes using wood, such as lumber residue and waste wood. In addition, survey projects useful for policy making have been conducted, organizing wood material flow.[21]

[20] According to AEBIOM statistics, among bioenergy fuels, 69% is solid biomass, (including agricultural wastes, but mainly woody biomass at present) 12% biogas and 12% liquid biofuel and 7% biomass components contained in wastes.

[21] Mantau, U. (2012): Wood flows in Europe. (EU27) Project report. celle 2012, 24 pp

While searching for diversification of fuels such as agricultural wastes in recent years, comprehensive survey results have been published regarding supply potentials of woody, agricultural, and imported biomass.[22]

(2) Widening areas for fuel procurement and ensuring sustainability

Thus, bioenergy use started using local resources, but has gradually developed to large-scale approaches. For example, the latest district heating supply plant in Stockholm, Sweden, which started operation in 2016, has realized the world's largest level of output, power output of 130 MWe and heat output of 280 MWth, and supplies heat to 200,000 houses.[23]

There have also recently been some cases that biofuel co-firing ratio has been more drastically raised and 100% fuel conversion has been achieved in facilities such as coal-fired power plants requiring a large quantity of fuel including fossil fuels. These movements have not appeared suddenly, but have been developed through the expansion of fuel production and supply chain scale from a local level and their integration.

A pioneering case is Drax power plant in the UK. Drax was UK's largest coal-fired power plant with a power capacity of 3.6 GW, of which 1.8 GW (600 MW × 3) units were nearly 100% converted to biomass fuel. The main fuel is pellets imported from the US and the annual amount reaches 7 million tons.

As seen previously, Ørsted in Denmark has been shifting to local bioenergy fuel such as straw in small- and medium-scale heat supply plants. Based on this experience, the company carefully considered the possibility of sustainable procurement also for large-scale centralized plants and has begun conversion to bioenergy (Figure 14) with an aim to reduce the use amount of coal from 6.2 million tons in 2006 to zero by 2023.

Figure 14 Situation of conversion to bioenergy in coal-fired power plants owned by Ørsted

Power plant name	Power capacity (MWe)	Situation
Asnæs	1,057	Under consideration of conversion to wood chip boilers
Avedøre	810	Under construction using bioenergy as heat source
Kindly	734	Using as peak-cut boiler with petroleum and gas
Studstrup	700	Converted to wood pellets in 2016
Skærbæk	392	Converted from LNG to wood chips in 2017
Esbjerg	378	Under consideration of conversion to bioenergy
H.C. Ørsted	185	Converted from coal to LNG in 1994
Herning	88	Constructed for biomass CHP in 2009
Svanemølle	81	Converted from coal to LNG in 1985

Source: By Renewable Energy Institute from Ørsted website (as of March 2018)

[22] European Commission (2017) Sustainable and optimal use of biomass for energy in the EU beyond 2020. Annexes of the Final Report

[23] Large-scale heat output among Japanese district heat supply plants is approx. 182 MWth in Tokyo Waterfront City plant and approx. 170 MWth in Shinjuku New City plant.

2.3 Appropriate policy design

(1) Incentive setting for market expansion

The expansion of bioenergy use in Europe has resulted from induction by policy. However, incentive schemes in European countries are independently formulated by country. Incentive setting approaches for bioenergy are roughly classified into three types: (i) imposition of greater taxes on fossil fuels, (ii) support for equipment, and (iii) support according to production volume of heat energy.

First, Nordic countries have induced conversion from fossil fuels to bioenergy fuels through imposition of greater taxes on fossil fuels (Figure 15). For instance, Sweden introduced the world's first carbon tax in 1991 to convert fossil fuels to renewables in the heat use sector and succeeded in drastic increase of bioenergy use.[24]

Figure 15 Tax rates on fossil fuels in major European countries and Japan (yen per unit volume)

Country	Industrial fuel oil A (yen/L)	Kerosene (non-commercial) (yen/L)	LNG (residential) (yen/kg)
Denmark	43.9	42.6	55.3
Sweden	42.0	55.6	58.5
Finland	31.7	102.3	34.5
Germany	3.0	0.0	10.5
UK	18.2	0.0	0.0
Japan	0.0	0.0	1.9

Source: Ministry of the Environment (MOE) (2017)

"Introduction of carbon tax, etc. in foreign countries" "Carbon dioxide emissions by fuel"

A representative case of the second type is Germany. The country does not necessarily impose high tax on fossil fuels, but provides support for equipment. Concretely, Germany implements/implemented the Market Stimulation Programme (MAP) subsidization scheme to support boilers and stoves using bioenergy fuels. Moreover, the German Renewable Energies Heat Act enforced in 2009 obligates new buildings to use renewable heat above a certain level, which is an important key to promote the use of bio-heat.[25] Austria also subsidizes 30% of initial cost.

A representative example of the third type is the UK which strongly promoted the introduction of the Renewable Heat Incentive (RHI) scheme. This scheme sets a tariff by technology and provides subsidies according to the produced amount of renewable heat, like FiT for power generation. Bioenergy has rapidly spread with considerably high tariff, 12 pence/kWh for domestic use and 9 pence/kWh for non-domestic use.[26] Then, since the market has been created, the tariff; that is, the cost of heat production, has successfully been reduced (Figure 16).

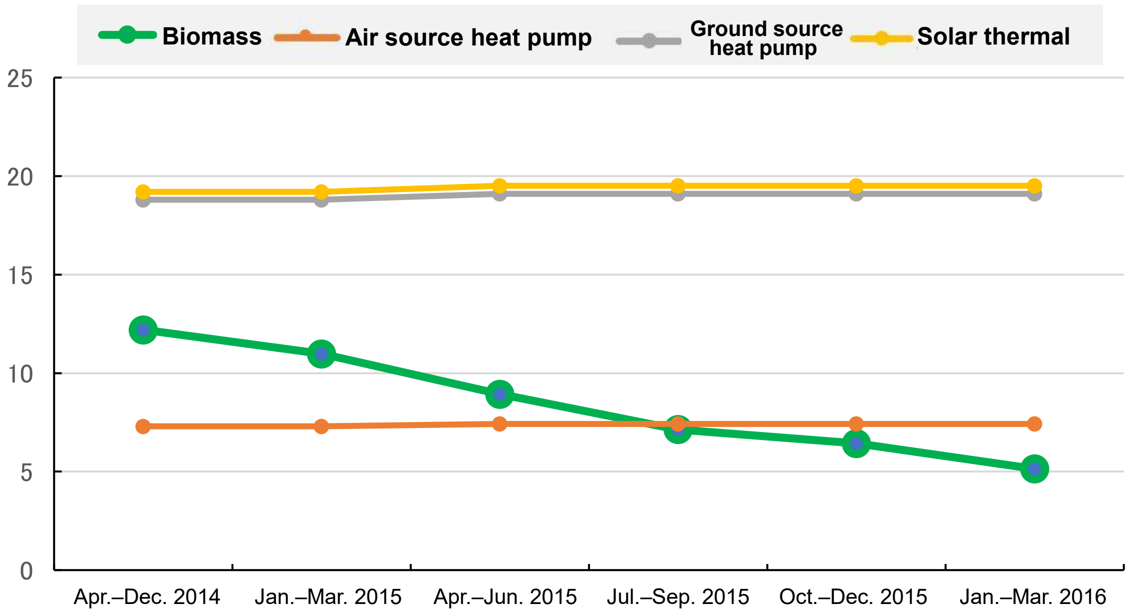
Thus, learning from these European experiences, Japan must also design appropriate incentives for expansion of its bioenergy heat use market, that has not progressed very much yet.

[24] Presentation by Mats Engström "Bioenergy policy in Sweden" (https://www.renewable-ei.org/activities/events/img/20170522/tokyo_MatsEngstrom.pdf)

[25] Germany Renewable Energy Agency (2014) "Biomass Energy in Germany – Present and Future"

[26] Registered capacity as of December 2017 is 58,885 cases for domestic use (no capacity data) and 3,864 MW for non-domestic use.

Figure 16 Changes in RHI tariffs in the UK (for domestic use, pence/kWh)



Source: Ofgem website

On the other hand, for power use, schemes have been carefully designed while reflecting previously-mentioned characteristics of bioenergy.

For instance, Germany consistently limits support for power to less than 20 MW and has started supporting deployment of CHP by granting premiums in 2004. The provision of premiums was discontinued in 2012, but the threshold of total energy efficiency has been set to make CHP practically mandatory.[27] The country has also prepared premiums for innovative power generation technologies such as woody biomass gasification and Organic Ranking Cycle (ORC)[28] to make CHP possible and has been promoting technical innovation. The premium called NawaRo has promoted use of forest residues, as was the case in Japan, but it was provided only for 10 years from 2004 to 2013.

Similarly, Austria has a FiT scheme to give preference to small-scale CHP. Specifically, the FiT scheme covers support only for plants with a capacity of less than 10 MW and total energy efficiency of 60% or more to make CHP practically mandatory.

27 Minoru Kumazaki (2015) Woody Biomass Power Generation under FIT: Comparison between Germany and Japan, Journal of the Japan Institute of Energy 94: 1215–1224

28 Organic Rankine Cycle: Power generation technology using organic liquid with a lower boiling point instead of water and vapor. Since ORC enables power generation from low-temperature heat, it is suitable for waste heat use and CHP.

Figure 17 Changes in incentives for bioenergy EEG in Germany (€cent/kWh)

Incentive Category	Capacity/premium		2000	2004	2009	2012	2014
Basic rate	0.15 MW or less		10.2	11.5	11.7	14.3	13.66
	0.15–0.5 MW		10.2	9.9	9.2	12.3	11.78
	0.5–5 MW		9.2	8.9	8.3	11.0	10.55
	5–20 MW		8.7	8.4	7.8	6.0	5.85
Premium	0.5 MW or less	NawaRo	-	6.0	6.0	6.0	-
		Cogeneration	-	2.0	3.0	-	-
		Innovative technology	-	2.0	2.0	-	-
	0.5–5 MW	NawaRo	-	2.5	2.5	2.5	-
		Cogeneration	-	2.0	3.0	-	-
		Innovative technology	-	2.0	2.0	-	-
	5–20 MW	Cogeneration	-	2.0	3.0	-	-

In contrast, for large-scale power generation, it is noted that support for alternative or transition from coal is limited according to quantity and period (Figure 18). Since a large quantity of bioenergy fuels is needed to substitute for large-scale coal-fired power generation and forest resources are poor in the countries implementing these policies, most fuels are imported. Therefore, the countries have formulated sustainability criteria to conduct risk management. EU countries also established sustainability criteria in 2017 in accordance with the expansion of bioenergy use and plans to apply them from 2021, although they had passed on the formulation on an EU level in 2010.

Figure 18 Policies of main countries with conversion from coal to biomass

	UK	Denmark	The Netherlands
Policy for coal-fired power	Decided to shut down all coal-fired power plants by 2025 (decision in 2016)	(Government) Fossil fuel phase out by 2050 (Ørsted) Decided to stop the use of coal by 2023	Coal power phase out (by parliamentary resolution)
Name of support scheme	FiT-CfD	Carbon tax, energy tax, and subsidies for initial cost	SDE+
Sustainability criteria	Required	Independently adopted by Ørsted	Required
Target for support	Biomass conversion (90% or more)	–	Biomass co-firing (without ratio requirement *1)
Amount to be supported*2	2.5 GW	–	486 MW
Tariff	10.5 pence/kWh (Standard price set by the government)	–	7.0–11.5 €ct/kWh (Standard price in four auctions)
Period of support	15 years	–	8 years

Note 1: The actual co-firing ratio is 10–80% in the Netherlands. The weighted average of co-firing ratio adjusted with respect to installed capacity is equivalent to 31%.

Note 2: The amount to be supported is the generation capacity using biomass fuel. It is equivalent to the capacity adjusted with respect to the biomass ratio in Japan.

Source: John Bingham (2015) The outlook for industrial wood pellets in Europe and Asia, Michael Carbo et al. (2017) Biomass and co-firing: Experience and future perspectives from the Netherlands

(2) Development through local initiatives

Local-level initiatives is effective to promote decentralized renewables including bioenergy. The size of bioenergy projects, like other renewables, is scaling up, such as 100% conversion from coal-fired power generation. It should be noted that local initiatives are often the social support base for such cases.

For instance, Jühnde, Lower Saxony, Germany, which realized a 'bioenergy village' mostly supporting district heat and electricity with bioenergy in the early 2000s, has played a pioneering role in the initial stage of introducting renewable energy[29]. Technologically, a biogas CHP plant supplies electricity first. Using the waste heat and wood chip boiler as an auxiliary heat source, district heat supplying infrastructure, which so far exists only in large cities, has been developed at the village level and enabled rapid conversion to renewable heat instead of conversion of individual home boiler and fuel. This project was promoted mainly by researchers of the University of Göttingen, but the independence of village people is valued in the implementation process and completed facilities are managed by a business cooperative association composed of villagers.

Similar activities in Austria started in the mid-1980s[30] and state government and grass-roots movements played a main role in the spread of these district heat supply systems with an aim for improving farmer's income. Also, in Denmark, local district heat supply plants are mostly of cooperative type.

The promotion of such bioenergy use contributes to the revitalization of regional economies, since local money that had so far been flowing out of the regions as fossil fuel expenditures, can be replaced by payments to the regional farmers and forestry families. Such decentralized bioenergy system brings local independence and is supported by various policies. For example, Germany subsidizes labor costs for climate change managers, create and distribute various planning tools and support the formation of alliances to gather key stakeholders, all of which are important backings to support the expansion of renewables.

[29] Tsunehisa Chiba (2013) "Renewable energy changes the society – German energy revolution by citizens" published by Gendaijinbunsha Co., Ltd.

[30] Shuichi Miura (2013) "District heat supply system with biomass using fuel wood," "Guide to fully utilize woody resources" written and edited by Kumazaki and Sawabe (Rural Culture Association, 2013)

3. Global trends to be expected in the future

Finally, we review global trends that should not be ignored in light of Japan's bioenergy strategy for the future.

3.1 Differences and complementarity with solar PV and wind power

First, in recent years, costs of solar PV and wind power have remarkably been reduced and their installed capacities have sharply increased. On the other hand, bioenergy power cost was relatively low as of 2010, but has not been reduced since then and seems to already have bottomed out (Figure 19).

Figure 19 Changes in renewable power generation costs (2016 USD/kWh)

	2010	2017	Cost reduction rate (%)
Solar PV	0.26	0.10	62.5
Wind (onshore)	0.08	0.07	13.5
Wind (offshore)	0.17	0.14	18.6
Bioenergy	0.07	0.07	0.0

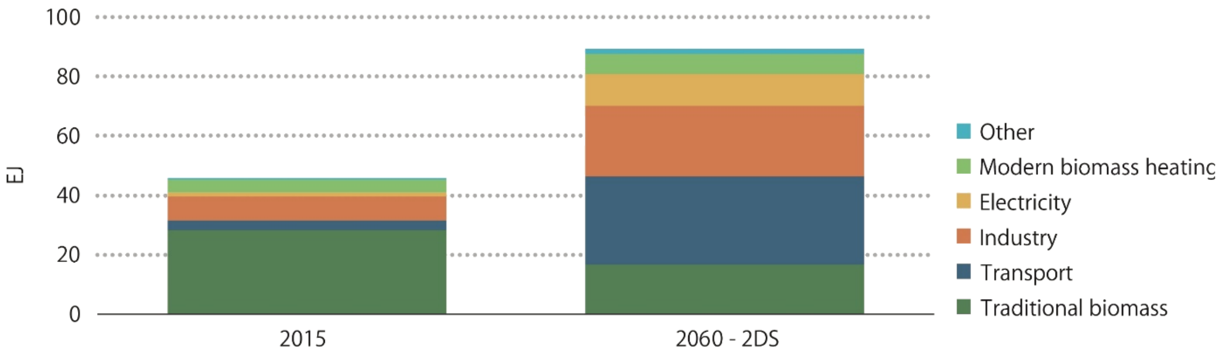
Note: Weighted average value adjusted with respect to installed capacity

Source: IRENA (2017) "Renewable Power Generation Costs in 2017"

Solar PV and wind power are anticipated to continuously lower their costs and be significantly deployed. Accordingly, a concept called "sector coupling" has appeared to positively use surplus power derived from solar PV and wind power in the heat and transport sectors. Specifically, technologies for heat pumps and electric vehicles are expected to be developed and penetrate. There are expectations for bioenergy applications in industrial high-temperature heat use and applications in the transport sector, especially for development and commercialization of biomass-derived jet fuel, making best use of its characteristics. For these reasons, IEA expects bioenergie to greatly increase in the industrial heat and transport sectors as shown in its technology roadmap released in 2017 (Figure 20).

Figure 20 Amount and breakdown of bioenergy in final energy consumption in 2015 and 2060

(2°C scenario)



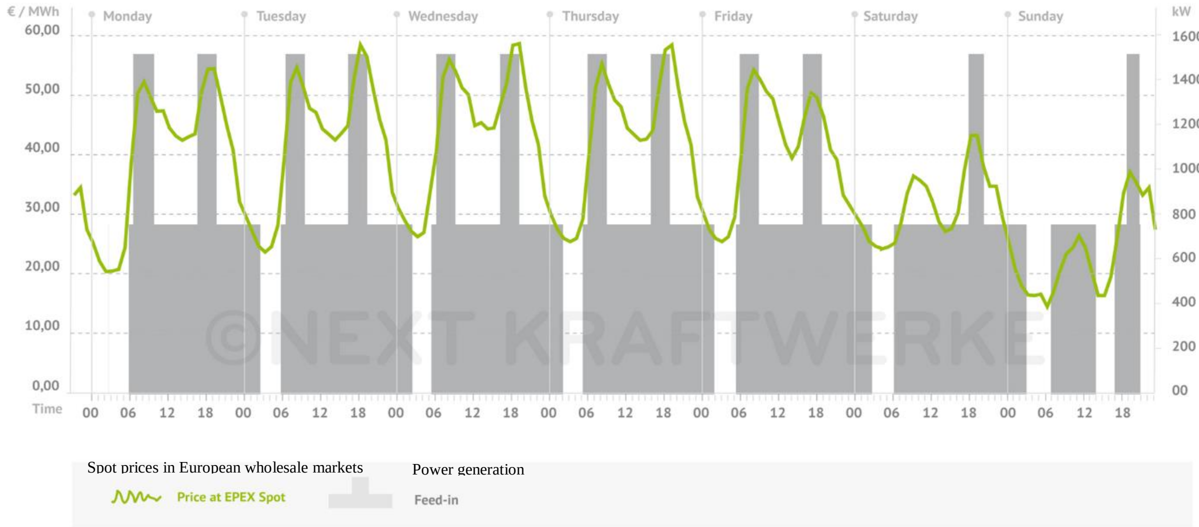
Source: IEA (2017) "Technology Roadmap Delivering Sustainable Bioenergy"

Solar PV and wind power generation are called variable renewable energy (VRE) sources because their output vary depending on weather conditions. To the contrary, operation of bioenergy power generation can be independently adjusted. Flexible output adjustment has come to be required according to power prices that change depending on demand-supply balance.

For instance, a German virtual power plant, Next Karftwerke, provides operation control service according to market prices, concluding contracts with about 1,000 biogas plants out of approx. 4,000 plants throughout Germany (Figure 21).[31] As a result, the equipment utilization rate of the plants is lowered, but electric power can be sold at higher market price and the used amount of fuel can be reduced, thereby contributing to improving revenue.[32]

As a policy, Germany also shifted to a feed-in-premium scheme in 2012 that requires electricity generated to be purchased. In addition, a 130 €/kW bonus as flexibility premium has been provided to biogas plants equipped with an output adjustment function since 2014.[33]

Figure 21 Examples of biogas plants operations based on market prices



Source: Next Kraftwerke

31 https://www.next-kraftwerke.com/

32 Next Karftwerke contracts with biogas plants mainly and with nearly 25 plants using woody biomass. They are CHP plants using steam turbine or ORC with a capacity of 2.8–20 MW.

33 http://www.res-legal.eu/search-by-country/germany/single/s/res-e/t/promotion/aid/subsidy-flexibility-premium/lastp/135/

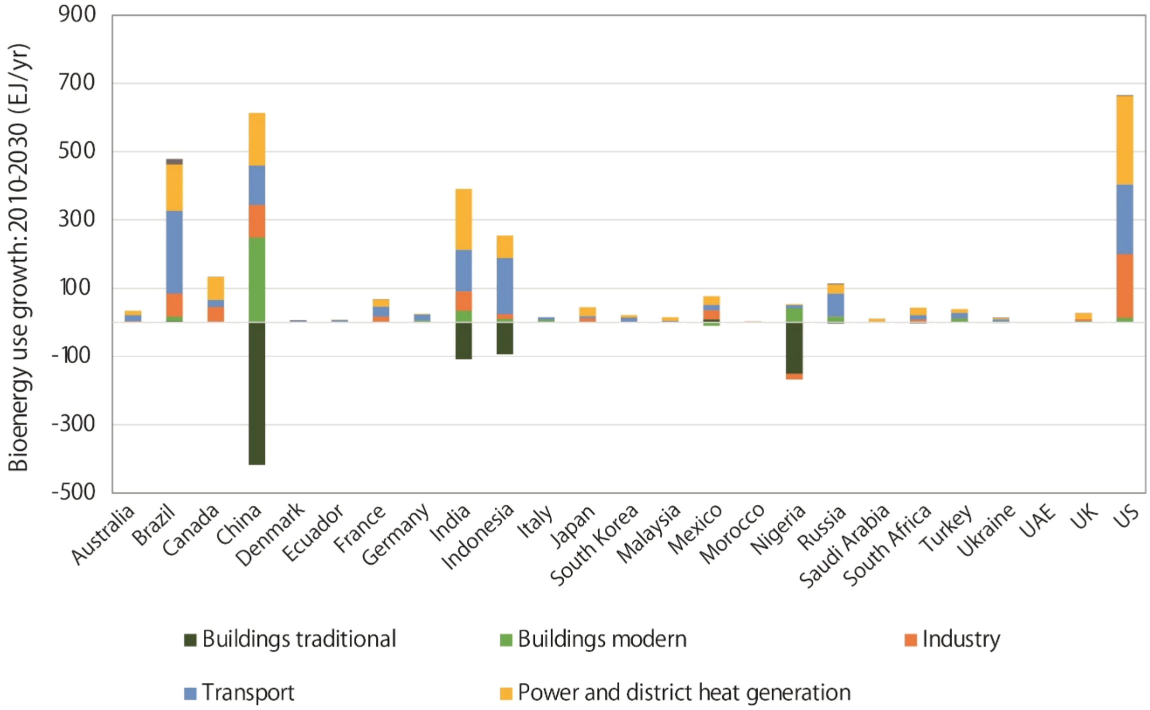
3.2 Worldwide bioenergy use

The second trend is bioenergy use growth throughout the world. In IEA's 2°C scenario, final energy consumption of bioenergy is expected to double from 2015 to 2060 (Figure 20).

A big change in utilization regions is also anticipated. Bioenergy has so far been developed mainly in Europe. Nevertheless, a quantitative increase is expected in the US, Asia, and Africa rather than in Europe. According to IRENA's forecast, a significant increase will occur in Asian countries such as China, India, and Indonesia (Figure 22).

Bioenergy demand and supply is unlikely to be balanced geographically, and trade volume will increase. Therefore, appropriate operation of sustainability criteria will be globally indispensable and the competitive environment for resources will become more severe. Japan will need to develop policies taking into account this situation.

Figure 22 Estimation of annual increase in bioenergy consumption from 2010 to 2030



Note: Estimation for 2030 is based on IRENA's REmap scenario. The decrease is traditional biomass use with low heat use efficiency.

Source: IRENA (2014)

IV. Restructuring Japan's bioenergy strategy

1. Clarification of long-term vision

1.1 Role of bioenergy based on relation to VREs

Seeing global trends, the development of VREs such as solar PV and wind power is remarkable and the energy system is going through a dramatic transformation. Global discussions towards realizing a de-carbonized society using 100% renewables have been launched. Future bioenergy use requires its unique role to be developed towards the realization of a de-carbonized society taking into account VRE development. Nevertheless, a basic understanding about the nature of biofuels, such as the fact that it constantly requires fuel, and being in harmony with agriculture, forestry, and waste handling in the processes of fuel production, collection, and delivery is important.

These issues are exactly the same in Japan. Thus, policies optimizing the potential of bioenergy should also be established in Japan towards the quick realization of a carbon-free and 100% renewable society.

Such thinking is relatively new. Indeed, in this regard Japan's bioenergy policies such as Biomass Use Promotion Basic Plan (September 2016) and Basic Energy Plan (April 2014) have so far been insufficient . The role of bioenergy should be reconsidered to realize a 100% renewable society with an outlook for the development of VREs. For example, in order to make use of bioenergy's potential for flexible power adjustments, good supportive scheme design and technological innovation is necessary.

In the heat use sector, utilization of heat pumps can be considered as a potent measure option. However, it is highly likely that the heat use of renewables such as bioenergy may be more effective in GHG reduction until sufficient development of electric power from renewables such as solar PV and wind power. The use of bioenergy must be actively promoted especially in regions with high applicability of bioenergy use such as industrial high-temperature heat use and demand for heating and hot-water supply in cold districts with lower heat pump efficiency.

1.2 Elaboration of sustainable use potential

As basic information to create a vision for future bioenergy, the potential amount of sustainable bioenergy must be carefully examined. Unutilized and utilized amounts of various biomass resources have been published.[34] Looking at the data, the following improvements are necessary:

First, domestic resources that have certain potentials should be investigated, such as arboricultural arisings from parks and the like, bamboo, and dam driftwood. Since a gradual fuel shortage is likely in the future, all possibilities should be considered. Unutilized wood with a large potential should also be reviewed based on scientific investigations. At least, it is necessary to reflect the difference among frequent non-commercial thinning in the 2000s and forest resources or forestry management.

In addition, overseas resources must be scientifically investigated. As bioenergy use will increase and competition for fuels will become severe in other Asian countries, it is necessary to well review the amount of fuels that can be procured.

[34] As a representative example, Biomass Use Promotion Basic Plan shows the potential amount, the current utilization rate and targeted utilization rate for 2025.

■ Column: Application of liquid biofuel in the transport sector

Application of liquid biofuel in the transport sector is a technology with low barrier for introduction, because of applicable mixture with gasoline and diesel fuel.

The EU and the US set targets for biofuel usages at 10% and 20%, respectively, by 2020 in the late 2000s. However, due to many criticisms against competition with food production, uncertainty of effect on GHG reduction, liquid biofuel is carefully deployed while introducing sustainability criteria.

In Japan, its deployment target is around 3% as a ratio to gasoline by 2020, remaining lower than those of the EU and the US. Looking ahead to mainstreaming of EV using renewables, it will be necessary to consider appropriate use along a time base mainly for jet fuel, which can be only replaced with liquid biofuel. Research and commercialization should be hurried, especially with second-generation biofuels produced from cellulose, and third-generation biofuels produced from algae, that do not compete with food production.

Figure 23 Usage of bioethanol in Japan (crude oil equivalent: 1,000 kL)

	2011	2012	2013	2014	2015	2016	2017
Target for usage	2,100	2,100	2,600	3,200	3,800	4,400	5,000
Actual usage	2,140	2,150	2,550	3,090	4,080	4,410	-

Source: ANRE (2017) The past activities and recent trends related to the introduction of bioethanol

2. Immediate strategy by application field

2.1 Re-examination of FiT scheme in the electric power sector

(1) Prioritize CHP

Re-examination of the FiT scheme is important to redirect appropriate use of bioenergy in the electric power sector.

The first important point is induction to CHP. The importance of CHP has already been pointed out from the viewpoint of high total energy efficiency and efficient fuel use, but its role as a balancing power source would also add to its importance. Therefore, the FiT scheme should be promptly modified so as to accept preferable projects such as CHP-related ones exclusively. Considering that Germany conducted induction to CHP 4 years after the start of EEG, similar flexibility is required for Japan's FiT.

Specifically, one possible approach would be to implement a standard of GHG reduction effectiveness or total energy efficiency, which will make CHP practically mandatory, in conjunction with the introduction of sustainability criteria. Under the FiT scheme, another possible approach could be to grant some premiums to CHP plants, or purchasing prices could be lowered for plants without heat sales, while preparing a subsidy program to help them cover the additional initial cost for making heat available.[35]

■ Column: Efforts for small- and medium-scale CHP in Japan

Gasification and ORC are effective technologies to enable small- and medium-scale CHP. Also, in Japan, these technologies have been adopted for small- and medium-scale CHP, except for large-scale ones in the pulp and paper industry (Figure 24).

As for gasification, technologies and maturity levels vary among different manufacturers, so third-party information in Europe should be collected as reference. It should be noted, however, that some European manufacturers do not provide enough flexibility to serve as balancing power sources.

For paving the way to promote ORC, it is necessary to ease regulations that are leading to high costs, such as regular monitoring.

Figure 24 Cases of CHP using woody biomass in Japan

Name of power plant	Location	Capacity (kWe)	Waste heat supply destination	Fuel used
Rias Forest Biomass Power Plant	Kesennuma City, Miyagi Pref.	800	Hot-water supply to hotels	Wood chips
Volter Japan	Semboku City, Akita Pref.	100	Hot-water supply to footbaths	Wood chips
Ueno-mura Kinoko Center	Ueno-mura, Gunma Pref.	180	Mushroom plant	Wood pellets
Hidatakayama Greenheat LLC	Takayama City, Gifu Pref.	165	Hot-water supply to warm bath facilities	Wood pellets

Source: Wood Utilization Division, Forestry Agency (2017) "Examples of woody biomass heat use and CHP"

35 German CHP Law (KEKG) has a similar system: Electricity derived from CHP plants is purchased under a tariff and subsidies are provided for parts of heat use facilities such as conduits for district heat supply.

Many bioenergy power plants have been built near high-voltage power lines in hilly and mountainous areas, as their priority lies in better grid connections. In order to encourage developers to build bioenergy plants closer to heat consuming areas, it would be effective to guarantee grid connections. In addition, existing non-CHP power plants must be induced as much as possible by granting subsidies to investigation into feasibility of grid connections to surrounding facilities.

(2) Stricter sustainability criteria

Due to a rapid increase in registration of ordinary wood, palm oil, the Procurement Price Calculation Committee at its FY2017 meeting decided to ask third parties for setting sustainability criteria involving already operational projects. Sustainability of fuel will be maintained for the time being using existing certification schemes, such as Forest Stewardship Council (FSC) and Roundtable on Sustainable Palm Oil (RSPO). However, these schemes have been developed for items to be used as raw materials, and do not take into account GHG reduction.

Basically, biofuels, produced appropriately, would be more effective for GHG reduction. However, some types of biofuel, like palm oil, and depending on the way they are produced, may emit a large amount of GHG. The government should make sustainability criteria stricter in phases, based mainly on the verified effect of biofuels for GHG reduction and the standards set out. These measures are expected to form a scheme that promotes CHP, a method which is much more effective for reducing GHG.
In terms of the applicability of sustainability criteria, a flexible approach could be adopted. For instance, they may at first be applicable only to large-scale power plants. Outside Japan, some certification schemes, such as Sustainable Biomass Program (SBP) and Green Gold Lavel (GGL),[36] have been developed solely for biomass, which could possibly be adopted in Japan's FiT scheme effectively.

(3) Settlement of co-firing issues: As a tool for withdrawal from coal-fired power

Japan's FiT scheme approves support for co-firing, without clarifying the outlook for coal-fired power plants. In fact, the FiT continuously covers co-firing of new coal-fired power plants, consequently promoting the increase of coal-fired power generation. Bioenergy can be characteristically used to directly substitute for and reduce fossil fuels. Co-firing of new coal-fired thermal power apparently increases the use of fossil fuels and therefore should be immediately excluded from the FiT.

It is also necessary to review the relationship with classification standards concerning thermal power under the Act on the Rational Use of Energy. Although aiming for power generation efficiency (42.0%) equivalent to ultra-super critical (USC) as total coal-fired thermal power, small-scale thermal power is not uniformly limited and there is a loophole that the new standards can be fulfilled by raising the efficiency with methods such as biomass co-firing and cogeneration.[37] According to "the assessment of the progress of global warming countermeasures in the electric utility industry (electric power review)" announced by the agreement of Minister of the Environment and Minister of Economy, Trade and Industry in March 2018, "Biomass co-firing using coal is not effective enough on actual CO2 reduction, while improving calculated power generation efficiency"; thus, the deficiency of the scheme has become apparent.[38]

In addition, the support for co-firing in existing coal-fired power plants should be immediately reconsidered to adequately place a stepwise measure for phase out from coal-fired thermal power generation.

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[36] Stands for Sustainable Biomass Partnership and Green Gold Label, respectively.

[37] Advisory Committee for Natural Resources and Energy, Committee on Energy Efficiency and Renewable Energy, Energy Efficiency and Conservation Subcommittee, Working Group on Classification Standards concerning Thermal Power (the 4th) Reference materials on February 9, 2016

[38] Record of press conference by Minister Nakagawa (March 23 (Fri.), 2018) http://www.env.go.jp/annai/kaiken/h30/03023.html

2.2 Promotion of heat use

(1) Immediate target setting and sufficient support measures for the deployment of renewables

First, it is necessary to set immediate targets for the deployment of renewable energy and for bioenergy. Indeed, this issue should be discussed together with the improvement of energy efficiency. Renewable heat use is currently promoted by some support programs, but it cannot be said that the target is logically set based on achieving GHG reduction targets for 2030 and 2050.

Moreover, adequate incentives should be designed as a measure for achieving these targets. As mentioned previously, carbon tax is an important tool in Nordic countries. It is shown that also in Germany and the UK with lower tax rates on fossil fuels than in Nordic countries, the deployment of facilities for renewable heat use is promoted in an annual budget from 40 to 100 billion yen (Figure 25). Germany also has a budget called KfW for interest-free or low-interest loans for energy saving improvements such as heat insulation for buildings, which is equivalent to around 100 billion yen per year.[39]

Japan has a budget of more than 60 billion yen as subsidies to support the promotion of investment in energy savings. However, most of the subsidies are for energy saving measures in plants, including shift from oil-fired boilers to gas-fired boilers, but not including much shift to heat sources using renewables such as bioenergy. A budget for energy saving measures regarding construction (ZEB /ZEH-related) also remains at 8,750 million yen. Accordingly, sufficient support measures must be taken for the moment also in Japan, envisaging the implementation of carbon pricing.

Figure 25 Comparison of subsidy programs for the promotion of renewable heat equipment in Germany, UK, and Japan

	Subsidy program name	Annual budget	Outline of subsidy
Germany	MAP (Market Incentive Program)	300 million €	Subsidy for heat supply equipment such as biomass boilers
UK	RHI (Renewable Heat Incentive)	900 million £	Same as above
Japan	Subsidies to support the promotion of investment in energy savings	Approx. 60 billion yen	Subsidies for replacement with energy saving equipment in plants and measures for housing and buildings (introduction and demonstration of Zero Energy Buildings/Houses)

Source: Germany: Hearing to Renewable Energy Agency; UK: DECC (2016) The renewable heat incentive: Budget for FY2018 under a reformed and refocused scheme; Japan: Outline of resource and energy budget (FY2018)

39 The UK has a Green Deal scheme to enable consumers to introduce energy saving equipment without burden by long-term reduction cost recovery of utility expenses via power companies.

(2) Expansion and improvement of intangible support to promote successful cases

The significance of bio-heat use is recognized in Japan, and many technical issues and the high-cost structure have been pointed out.[40] Based on reflection of the past, some cases have succeeded in cost reduction through (i) system design mainly with heat storage tank, (ii) active utilization of small-sized standard boilers, and (iii) revision of construction costs for piping, buildings, silos.[41] It is necessary to analyze these cases in detail and clarify issues for further promotion. As an activity to spread such success cases, Japan Woody Bioenergy Association is holding practical seminars, including on-site investigation, supported by the Forestry Agency.

To accelerate the promotion, roles of municipalities are important. For example, listing main local facilities in demand for heat, municipalities plan shift to biomass boilers in sequence based on results of simple introduction checkup in 5 to 10 years. Local companies will certainly promote learning and investment with an outlook of the market. A framework of support for expenses and personnel by government ministries and agencies will be effective in developing such a locally-led strategy.

■ Column:

Introduction of chip boilers for a golf course in Hokuto City, Yamanashi Prefecture

Sunpark Akeno golf course in Hokuto City, Yamanashi Prefecture, replaced deteriorated boilers for hot water supply and heating with wood chip boilers in 2017.

The small-sized and mass-produced 50 kW chip boiler by Austrian ETA company is capable of higher workability and cost reduction. Wood chips are supplied by Fujihara Forestry undertaking management of the forest surrounding the golf course. Severely damaged by pine tree withering, this area in Yamanashi Pref. plans to preferentially utilize cut-down pine trees for fuel to prevent expansion of the damage.

This case will be a model in various points with benefits from the introduction of the boilers in terms of cost and technology and from ecosystem conservation through the utilization of withered pine trees.

Photography) Left: Renewable Energy Institute; Right: Tokushima Regional Energy

[40] Takanobu Aikawa (2014) “New method necessary for biomass use in Japan” https://synodos.jp/society/7836

[41] Gendai Ringyo (2017) “Realizing cost reduction with regional alliances – Regional strategy for woody biomass utilization for small-scale decentralized hot water supply”

(3) Acceleration of heat use in the industrial sector

Companies remarkably tend to take the initiative in using renewables throughout the world. Also, in Japan, bioenergy activities by companies are attracting attention.

Blazing a trail, Komatsu Ltd. installed a steam boiler system in Awazu Plant (Ishikawa Pref.) using wood chips from thinning in 2015[42]. Ricoh Company, Ltd. also started heat supply for air conditioning using thinned wood chips in the same way in its Gotemba Plant (Shizuoka Pref.).[43] In 2018, the company has also announced its participation in the heat supply project for a resort facility scheduled to be constructed in Taki-cho, Mie Prefecture.[44]

These cases are activities for the hot water supply (air conditioning) field that are relatively easy to approach by means of technology. It is desirable that such so-called big companies have embarked on the use of bioenergy. While companies are globally and competitively increasing bioenergy use and asking suppliers for similar activities, related plants will raise movements of bioenergy conversion in the heat use sector. Industrial heat use is one of the most expected field for bioenergy use, and companies are required to review issues and take measures to develop solutions.

■ Column: Cases of industrial heat use supported by NEDO

NEDO has so far supported industrial heat use through its demonstration project. In the "Demonstration Project for Regional Independent Biomass Energy System" conducted from FY2014, the Organization has been seeking independent business models in consideration of surveys on introduction cases at 138 domestic sites and has adopted 5 demonstration projects via some FS surveys and plans to demonstrate the introduction and operation of plants.

Among them, three projects are for industrial heat use using low-grade fuel wood. Based on achievements by these demonstration projects, industrial bio-heat use is expected to be advanced also in Japan.

Figure 26 Projects for industrial heat use adopted as NEDO's Demonstration Projects

Company	Implementation site	Application	Fuel used
Showa Chemical Industry	Maniwa City, Okayama Pref.	Drying diatomaceous earth materials	Bark, etc.
JFE Environment Service	Kurashiki City, Okayama Pref.	Steam supply to industrial complexes	Low-grade wood fuel such as waste wood
Bamboo Energy	Nankan-machi, Kumamoto Pref.	CHP to bamboo flooring plants	Bamboo

Source: NEDO data

42 http://www.komatsu.co.jp/CompanyInfo/press/2015030911475225059.html

43 https://jp.ricoh.com/info/2016/1206_1.html

44 http://jp.ricoh.com/release/2018/0226_1.html?_ga=2.235141190.639586896.1519692003-689344040.1491376432

2.3 Realizing low-cost sustainable fuel supply

(1) Programmed cost reduction

The usable amount of bioenergy fuel is specified by economic conditions. If any amount of expenses can be spent, the usable amount of biomass will be limitless, but this is clearly unrealistic. Conversely, the lower fuel supply cost, the more biomass can be used. For this reason, cost-cutting measures are very important. In addition, the reduction in fuel supply cost leads to lowering costs of power generation and heat supply and enables acceleration of the market expansion.

To achieve this, first, it will be effective to set a cost target based on the comparison with fossil fuels, cash flow analysis of power generation and heat use works, and expected technical development, while using European cases as benchmarks. For instance, conversion to new fuel supply systems such as chipping in satellite yards is supposed.[45] Thus, ideal situation should be clarified for planned investment.

(2) Ensuring sustainability of domestic forest resources

Considering future demand increase, ensuring sustainability is important also for domestic unutilized wood. Since the current FiT scheme also requests prefectural forest departments to confirm stable fuel procurement at the time of registration, quantitative management is realized to some extent, unlike sky-high registration of imported biomass. However, it is difficult to control tree harvesting amount only under the regulations of the Japanese Forest Act. We cannot deny risks that will cause a shortage of fuels and deterioration of forest resources following a future increase in power plants. Therefore, to secure the sustainability of domestic forest resources, adequate monitoring is important in sites involving forest production.

According to an audit for administrative evaluation by the Ministry of Internal Affairs (MIAC) and Communications, "there have been some cases in which it is difficult to verify the source of woody biomass (unutilized wood, etc. at high purchasing prices)."[46] Adequate measures such as monitoring by third parties are needed also for the management of fuel classification.

(3) Starting consideration of utilizing agricultural wastes, bamboos, etc.

As for solid biomass, the use of woody biomass has mainly been promoted in Europe so far, but the utilization of Miscanthus (a kind of giant pampas grass) and agricultural wastes has been attracting attention in recent years.

In Japan as well, agricultural biomass has a significant potential, and the Ministry of Agriculture, Forestry and Fisheries (MAFF) expects almost the same resource amount as unutilized wood (forest residues). Especially, agricultural wastes such as rice husks and straws have scarcely been utilized and are expected to contribute to the development of bioenergy in rural areas together with bio-methane such as livestock manure.

Bamboo, whose expansion has become a problem especially in western Japan, has been technologically developed and demonstrated for the use as bioenergy fuel in recent years. Among woody biomass, arboricultural arisings from parks and street trees are mostly incinerated as wastes.

Such fuels whose usability has not been systematically examined so far should be clarified for their potentials and investigated in terms of collection, delivery, and combustion technology.

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[45] (General Incorporated Association) Japan Woody Bioenergy Association (2018) "For Supply Expansion of Domestic Wood Fuel"

[46] MIAC (2017) Administrative Evaluation and Supervision of Management and Utilization of Forests: Findings and Recommendations http://www.soumu.go.jp/menu_news/s-news/107317_00005.html

2.4 Contribution to locally-led energy conversion

Hilly and mountainous areas have more abundant biomass resources and higher bioenergy importance than urban areas. In Japan, the development of decentralized energy infrastructure system mainly for heat use is effective in districts requiring regional economic revitalization due to population decline, etc. from a viewpoint of not only energy policy but also regional policy.

In cold hilly and mountainous areas without gas infrastructure, small-scale district heat supply that has been developed in Europe can be an effective measure. It has a big potential contributable to locally-led energy turnaround together with renewables such as solar PV and wind power abundantly found in the regions.

The Ministry of Economy, Trade and Industry (METI) and the MAFF have presented a policy of "regional ecosystem" to promote low-cost energy use leading to regional preservation and revitalization on a relatively small scale.[47] Such energy turnaround has a big effect on the stimulation of regional economy and will be an effective measure for regional revitalization in Japan suffering from population decline and economic contraction.

■ Column: Example of living concentration and district heat supply in cold districts

Small-scale district heat supply using bioenergy has recently been developed in European rural areas. It is very attractive also in Japanese local areas. However, Japan has few experiences in this field and many technical issues.

Mogami-machi, Yamagata Prefecture developed a district heat supply system in a residential area for the promotion of young people settlement in 2017. The system is optimized and efficiently operated by adopting Austrian boilers, an engineering company, and control systems.

Photographed by Japan Woody Bioenergy Association

[47] Report on joint study towards promoting woody biomass use

V. Conclusion

Bioenergy is expected to contribute to the realization of a 100% renewable energy society through its true potential. In view of the need for a great reduction in GHG, biomass-derived renewable materials will be required as substitutes for various petroleum-derived materials also in the materials sector. In addition, biomass-derived materials such as wood are expected to serve as alternatives to iron, concrete, and other materials that need a large amount of energy for production. In this process, a new technology called biorefinery will change the current chemical industry mainly using petroleum-based materials to a completely new industry.

A new economic system using biomass materials instead of fossil fuels in all fields is called "bioeconomy."[48] In the bioeconomy, a large quantity of biomass is needed as materials in addition to energy use. This makes us clearly understand the importance of efficient resource use of bioenergy. In this regard Japan's current bioenergy policy has many flaws, which should be immediately addressed going back to the basics.

In addition, appropriate management of ecosystem in forest and agricultural lands and ideas for waste disposal should be reviewed. This corresponds to the integration of three society visions, low-carbon society, recycling-based society, and living in harmony with nature, that have been expressed by the Ministry of Environment (MOE).[49] As bioenergy-related policy involves not only the MOE but other government ministries and agencies such as the METI and the MAFF, these ministries should work together in closer coordination.

Finally, the promotion of bioenergy use in combination with other renewables contributes to the revitalization of regional economies in Japanese rural areas facing population decline. Careful policy deployment for supporting locally-led activities will also be of great help to advance the energy transition in Japan.

48 https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy

49 Data of the MOE also shows such a direction. e.g. "Integration of Low-carbon Society, Recycling Society and Symbiotic Society" by the MOE in April 2014 (https://www.env.go.jp/council/01chuo/y010-20/mat03-12.pdf)

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Towards Realizing Its True Potential

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