# A Study of the Challenges in Introducing Power Generation Using Biomass (1)

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## 1. The Current Situation Surrounding Biomass

### 1-1 Types of Biomass

Table 1 lists the sources and types of biomass in Japan. The wide range of sources, including forestry, wood processing, paper manufacturing, building dismantlement and even gardening, reflects the fact that biomass is generated in diverse ways. Among these sources, the paper manufacturing industry generates black liquor used as a source of energy. Most of the biomass is often treated as “by-product” or “waste” and it is incinerated unless a means of using it is consciously developed.

**Table 1 Usable biomass in Japan**

| Source | Type | Posisitioning as Resources |
|---|---|---|
| Building dismantlement | Construction debris | By-products/waste |
| Gardening | Trimmed branches | |
| Paper manufacturing | Black liquor, chip dusts | |
| Wood processing | Bark, sawdust, fraction materials | |
| Deforestation (forest residues) | Branches, leaves, materials shorter than regular length, low quality materials | |
| Improvement cutting and thinning | Wind-fallen trees, diseased trees | |
| Special forest products | Discarded logs for edible fungi | |
| Fuel wood | Pasania, quercus serrata, pine | Energy wood |
| Short rotation forestry | Willow, eucalyptus, poplar, pine | |

Source: Kenichiro Kojima, Clean Energy, March 2002

### 1-2 Latent Volume and Usable Volume of Biomass

Table 2 shows the annual emission and the reused and non-reused volumes of biomass. The annual emission of biomass of all different types is estimated at an approximate total of 70 million $m^3$ nationwide. Of this emission, nearly 27 million $m^3$, or 89%, of biomass is reused as fuels, industrial materials and wood chips. And approximately 43 million $m^3$ or 61% of the total emission appears to be incinerated or discarded as waste or left in forests without being reused.

**Table 2 Emission and reused and non-reused volumes of biomass**

(Thousand cubic meters)

| Type of woody biomass | Fiscal year of survey | Annual emission | Reused | | | Non-reused | |
|---|---|---|---|---|---|---|---|
| | | | As/for | | Reused volume | Incinerated | Left |
| Urban wood waste | 1991 | 21,800 | Fuel | 3500 | 4,400 | 17,400 | - |
| | | | Industrial materials | 900 | | | |
| Residue and waste from lumber mills | 1991 | 15,660 | Wooden chips, etc. | | 14,830 | 830 | - |
| Improvement-cut or thinned wood | 1997 | 4,530 | Lumber, logs, etc. | | 1,930 | - | 2,600 |
| Forest residues | 1997 | 5,690 | | | - | - | 5,690 |
| Unused hardwood | - | 22,500 | Useful forestry production, etc. | | 6,000 | - | 16,500 |
| Total | | 70,180 | | | 27,160 | 18,230 | 24,790 |

Source: Environment Agency materials from the Workshop for Formulating Technical Scenario for Greenhouse Gas Reduction in Biomass Divisions (2000)

**1-3 Characteristics of Biomass**

An overview and the characteristics of biomass are described below on a type-by-type basis.

(1) Urban wood waste

The Environment Agency estimated that urban woody waste, which includes construction debris such as building debris, industrial waste generated in the distribution process and general waste such as disused furniture totaled 21.8 million $m^3$ in fiscal 1991. Approximately 80%, or 17.5 million $m^3$, of this waste is believed to be construction waste. Annual waste emission of 21.8 million $m^3$ includes 3.5 million $m^3$ reused as fuels and 0.9 million $m^3$ used as industrial materials. The remaining 17.4 million $m^3$ is currently incinerated or discarded.

The “Construction By-Products Survey 2000” conducted by the Ministry of Land, Infrastructure and Transport has meanwhile revealed that approximately 85 million metric tons of construction waste is generated per year throughout the nation and that the volume of woody waste emitted from construction reaches a proportion of 6%, or 5 million metric tons, of which 1.9 million is recycled and 2.25 million is reduced. The total reprocessing rate, which includes both the recycled volume and the reduced volume, is 83%, while the remaining volume of 850,000 metric tons is handled at final disposal sites. The usual approach to housing demolition has traditionally been something called “mincemeat demolition” (*minchi kaitai*) in Japanese, in which old buildings are destroyed at once using heavy equipment, without separating materials. However, the Law on Recycling Construction-Related Materials enacted in April 2001 obliges specific construction waste materials, namely concrete, wood and asphalt generated from separate demolition to be recycled into resources. And it has set a target of achieving a wood-recycling ratio of 95% by fiscal 2010. This law is specifically designed to ensure that wood waste will be turned into chips so that they can be recycled into raw materials for woody boards and compost. However, “reduction”[1] effectively means incineration. It is necessary to construct facilities for material separation and for incineration to increase the use of wood waste as fuels.

Affiliates of the surveyed enterprises listed below have already started manufacturing particle boards from building debris.

(2) Residual and wasted materials from lumber sites

It is estimated that lumber sites across the country emit 16 to 17 million metric tons of residual and wasted materials each year. This type of biomass differs from any other type in that lumber sites have already secured a channel to recycle most of it. A major lumber company, which is among the companies surveyed, sends chips emitted from the sawmilling process to paper manufacturers and sells the wood waste as materials for activated charcoal and particle boards or as livestock bedding. A mere 0.4% of waste such as chips and wood waste is used as fuel.

According to a survey conducted by the Japan Housing and Wood Technology Center in fiscal 1991, the residual and wasted wood emitted from the lumber industry amounted to 15.66 million $m^3$ and a large proportion of it, namely 14.83 million $m^3$, was reused as fuels, wood chips and compost. The volume of such waste incinerated or discarded was only 830,000 $m^3$.

Another study carried out by Japan Wood-Products Information & Research Center and the National Wood Chip Industry Association estimates that the lumber industry emitted 17.27 million $m^3$ of residual and wasted wood in fiscal 1997, of which 93%, or approximately 16 million $m^3$, was effectively reused as soil conditioners, compost livestock bedding and other applications. No more than 2.71 million $m^3$ of it was used as fuel.

(3) Improvement-cut or thinned wood and forest residues

The Environment Agency survey in fiscal 1997 estimated that the nationwide emission of

[1] “Reduction”: Wood waste generated from separate demolition of buildings is incinerated to reduce volume when it recycling is expensive, for example because there are no recycling facilities within a certain distance (50 kilometers envisioned in the ministerial ordinance) of the work site.

improvement-cut or thinned wood and forest residues stood at some 10 million $m^3$. The amount of reused material in this category is limited while most of it, specifically 8 million $m^3$, is left in forests without being reused.

Underlying this is the fact that the sales price of thinned wood is 9,000 yen per $m^3$, while thinning costs 12,000 yen per $m^3$. The use is therefore not economically feasible and there is no option but to leave the wood in forests.

A huge amount of improvement-cut or thinned wood and forest residues are unused, but these unused resources are found in forests. Effective use would necessitate first the construction of forest roads, and then cutting and collecting the wood in forests. It is also necessary to consider how to transport the collected the material from forests. In some regions, cutting and transport cannot be done in winter because of snow coverage.

1) Improvement-cut or thinned wood

According to the Environment Agency's review in fiscal 1997, Japan generated 4.53 million $m^3$ of improvement-cut or thinned wood, of which 43% or 1.93 million m3 was used as lumber, round wood and chips. The remaining 2.60 million $m^3$ was left unused in forests. Branches with no commercial value are also discarded in forest when thinned.

2) Forest residues

An Environment Agency study in fiscal 1997 noted that an estimated 5.69 million $m^3$ of forest residues was generated.

(4) Unused hardwood

According to the Environment Agency, hardwood was formerly used for firewood and charcoal and fulfilled the annual demand of some 20 million $m^3$ for firewood and charcoal. Today, however, it is used for limited purposes, such as logs for cultivating shiitake mushroom and wood chips. The annual consumption is merely six million $m^3$ and the remaining hardwood is left as it is without care. The accumulated amount of hardwood biomass is estimated at about 2.5 billion $m^3$ at the moment. Given that it is easy to cut down and convey, the available volume is estimated at approximately 700 million m3 if the area of availability is limited to a zone within 500 meters from forest roads. On the assumption that hardwood trimming is carried out in a thirty-year cycle, the annual supply of biomass is estimated at 22.5 million $m^3$.

## 2. Applications of Biomass Energy

Table 3 shows the results of a survey on actual use of woody biomass energy in the lumber industry conducted by the Forestry Agency in fiscal 1999. The most common application for biomass energy was as a source of thermal energy. There were 174 wood chip boilers in total, of which 157 boilers were in operation in the lumber industry alone. There were 12 examples of power generation using steam generated from wood chip boilers, ten cases of which were within the lumber industry. Outside this business sector, the paper manufacturing industry had two sites that employed this type of power generation. The thermal energy was largely used for drying and hot pressing[2] at 142 sites and for room heating at 37 sites.

**Table 3 Use of biomass energy by business type within the lumber industry in 1999**

| Business type | Site with equipment | Equipment | | | Purpose | | |
|---|---|---|---|---|---|---|---|
| | | Wood chip | Power generators | Other | Drying, hot | Room heating | Power generation |
| | (Mills) | (Units) | (Units) | (Units) | (Mills) | (Mills) | (Mills) |
| Wood processing | 36 | 36 | 1 | 0 | 33 | 7 | 1 |
| Plywood manufacturing | 29 | 32 | 5 | 0 | 28 | 5 | 5 |
| Sawmilling | 27 | 27 | 2 | 2 | 22 | 2 | 2 |
| Laminated wood manuafacturing | 24 | 26 | 0 | 0 | 20 | 5 | 0 |
| Pre-cutting | 8 | 8 | 0 | 1 | 5 | 3 | 0 |
| Lumber drying | 7 | 6 | 0 | 1 | 6 | 2 | 0 |
| Flooring materials | 6 | 6 | 1 | 0 | 6 | 1 | 1 |
| Particle boards | 3 | 3 | 1 | 0 | 3 | 1 | 1 |
| Other | 34 | 30 | 2 | 4 | 19 | 11 | 2 |
| Total | 174 | 174 | 12 | 8 | 142 | 37 | 12 |

Source: Takao Nakajima "Use of Biomass Energy in the Lumber Industry" Mokuzai Sangyo Vol. 55, No. 5, 2000

Note: Those mills operating in more than one type of business are counted based on their main business type.

## 3. A Study on Domestic Uses of Biomass Energy

### 3-1 Summary of the Study

A field study of six companies that undertake relatively large-scale biomass power generation was carried out to examine the use of biomass energy in Japan. Among the six companies surveyed, one was engaged in sawmilling, two dealt with plywood, one with boards, another with laminated wood and the sixth turbine manufacture. Table 4 outlines the study results. The website of the Institute of Energy Economics, Japan has the details of the research findings published as a report.

Unique as it is, an actual case of biomass power generation at a manufacturer of land-use and marine turbines serves as a model that demonstrates power generation equipment.

### 3-2 Background of Introduction of Biomass Power Generation

The study found that the six companies had the following common justifications for their introduction of biomass power generation:

(1) Internal procurement of fuel and internal consumption of energy

In principle, they use biomass emitted from their own sites as fuel and consume the energy generated themselves. Therefore, the scale of the equipment they use for biomass power generation is designed to suit their own energy demands.

(2) Huge demand for energy (electric power and heat)

Whether they manufacture lumber, plywood, boards or laminated wood, all sites consume an enormous amount of motive power and heat (steam) in their production process. As they use both electricity and heat, they originally had energy demand suitable for co-generation. Before adopting biomass power generation, they had mostly depended on a combination of power purchase and heavy oil boilers (for the use of steam).

(3) 24-hour or long-time operation

Their sites themselves are in long-time operation. And the operating duration of energy plants is inevitably long. For example, lumber drying and hot pressing are in operation 24 hours a day and constantly require electric and thermal energy.

(4) Reduction of costs for their energy consumption

Since they naturally had great energy demand, the top priority challenge for the surveyed companies was to cut energy costs, such as the cost of power purchase and of heavy oil. They introduced biomass power generation with the aim of using their own combustible industrial waste as fuel, thereby cutting the contract wattage of purchased power and electric power expenses.

With respect to fuels, there was an example in which materials recycled from building debris, which is part of the woody industrial waste, were on sale at low prices of 1,000 to 4,000 yen per metric ton to reduce the fuel cost itself.

(5) Reduction of cost of disposing of their own industrial waste

By actively using combustible industrial generated themselves, they concurrently cut their industrial waste disposal costs.

## 4. Future Challenges

Based on the survey of the six enterprises, there are some challenges to overcome in the phases of introduction and operation of biomass power generation. These challenges are described below.

### 4-1. Policy Challenges[2.]

(1) As public policy, Japan has no program of giving preferential treatment for the use of biomass energy. There should be a program or financial assistance, such as subsidization, to help private companies introduce power generation using biomass as a recyclable energy source.

(2) When private enterprises introduce biomass power generation, their major objectives lie in the reduction of energy costs and in the use of combustible industrial waste as fuel for cutting waste

[2.] "Hot pressing:" To manufacture laminated plywood by applying adhesives onto multiple thin plates, the plywood is pressed while it is heated with vapor after adhesion to cure it.

disposal costs. Hence, for the purpose of promoting the introduction of biomass power generation as well as biomass energy, it is essential to provide a policy framework or support that leads them to upgrade mere boiler replacement to the introduction of biomass power generation.

(3) Forestry businesses and wood processing companies, which supply biomass as fuel, have never been included in the major coverage of conventional energy policies. A policy approach in terms of both forestry and energy will be key to the advancement of actual supply and use of electric and thermal energy. In this sense, trees in parks, along streets and along rivers will be potential biomass resources. It is important to harmonize different policy measures for boosting the introduction of biomass power generation.

(4) Given the characteristics of districts that supply biomass fuel, municipal authorities must be proactive and either provide assistance for, or take part in, projects such as a scheme for an Energy Center using biomass and a new initiative for regional development centered on the Energy Center.

(5) Many have remarked that forestry operators had no experience in achieving any application for private power generation and that the procedures were extremely complicated. The cultivation of consulting institutions that support tangible procedures for the introduction of biomass power generation and assistance should encourage the introduction.

**4-2 Forestry challenges**

(1) Forestry businesses are unfamiliar with energy. It is necessary to build up an assistance system in the aspect of knowledge, including development of consulting organizations that provide some help in adopting biomass power generation.

(2) It is not economically feasible to use thinned wood as a fuel for biomass power generation. One of the cases surveyed in this study had a loss-making mechanism in which the thinning cost was 12,000 yen/$m^3$ while such wood was priced at 9,000 yen/$m^3$ for sale. Economic viability was barely secured by covering the difference between the thinning cost and the sales price with subsidies (at 4,000 to 5,000 yen/$m^3$). This shows that thinned wood could be a much more expensive fuel than building debris.

Among other issues, thinned wood creates a heavy cost burden in thinning, collection and transport. It is necessary to subsidize thinned wood collection.

(8) The understanding and cooperation of forestry cooperatives and wood industry associations are indispensable for the stable supply of thinned wood as fuel.

**4-3 Challenges in Biomass Power Generation**

(1) Stable procurement of biomass

1) To achieve a stable energy supply, the key challenge is to secure a supply of biomass fuel. What

is important is to develop a system for effective, low-cost and stable collection of bark, waste wood, wood scraps and building debris.

2) A prerequisite for using waste wood generated from sites is to secure a stable supply of auxiliary fuel such as building debris, as the emission of biomass varies depending on the operation of sites.

3) Prone to supply fluctuations, biomass needs storage facilities. But many facilities are outdoor holding type. This poses a problem, because rainfall increases the water content of biomass.

4) Especially in northern areas, large-scale holding facilities are required, since it is difficult to collect and secure biomass in winter because of snow.

(2) Characteristics of biomass

The actual generating performance of the power generation system burning biomass depends very much on the moisture content of the biomass. Moisture contained in biomass removes a huge amount of heat when it is heated and becomes steam. In many cases, fuel biomass is kept outdoors and its moisture content rises with rainfall and snowfall. Some types of lumber are apt to hold water. Among others, cryptomeria has a high water content of about 50% and it is difficult to burn, although a large volume of thinned cryptomeria wood is generated. Consequently, biomass may have to be dried before it is put into combustion furnaces.

There are other problems on handling biomass pointed out as follows.

1) As a solid matter, biomass is more troublesome to handle than are liquid fuels such as heavy oil.

2) Because it contains moisture, biomass poses drawbacks in handling in transit and problems on blockage.

3) Wood biomass often contains many impurities, such as clay, stones and concrete debris, especially if it is generated from “mincemeat demolition,” such as building debris. There must be a separation process when it is converted into fuel.

(3) Preprocessing

1) Because biomass is solid, preprocessing is indispensable before it is put into boilers as fuel. But it requires much more energy for crushing, transport and other tasks than heavy oil does. Moreover, when waste wood is used, an additional cost of preprocessing, such as crushing, is involved, even though the material cost is zero.

2) Since biomass contains moisture, it needs preprocessing such as drying and compressing for use as fuel.

3) Conversion of building debris to fuel may require the approval of a local government.

(4) Biomass power generation

1) The method of generating power using steam turbines, which in turn is generated by burning

biomass as fuel in wood chip boilers, has ample precedent and is likely to find increasing application. That makes it important to assess the power generation scale and the operating duration.

2) It is not easy to install facilities for biomass power generation because equipment such as boilers, turbines and generators is large and that the cost of installation is enormous.

3) Moisture contained in biomass lowers the heat quantity in combustion furnaces. This overshadows the “reliability of power generation.”

4) It is vital to secure stable demand for both heat and electric energy.

**4-4 Other challenges**

(1) At present, the price at which electric power can be sold to electric power companies is so low that reverse power flow from biomass power generation is unlikely. But there will be increasing pressure for growth if there is an institutional measure to support power sales or if the selling price rises to match the biomass power generation cost.

(2) Both forestry businesses and local governments understand the advantage of biomass as power generation fuel in that waste disposal and energy recovery can be made simultaneously, but they have no human resources, or leaders, to plan, negotiate and execute the projects.

(3) To promote this power generation system, it is essential to add facilities to dispose of ash generated by the combustion of biomass.

(4) Taking effect in January 2000, the Law Concerning Special Measures against Dioxins has prohibited the combustion disposal of wood waste and residual and discarded wood using simplified equipment. This may lend impetus to the trend towards central control of biomass for application with power generation and heat supply.

(5) The use of building debris after intermediate treatment (specifically, separated and made into chips) purchased from intermediate industrial waste disposers poses no problem in the context of the Waste Disposal Law. No wood chip boiler has to meet the “technical standards for industrial waste disposal facilities” as it does not constitute waste incineration.

However, if building debris is brought in directly with the collection of the disposal charge, it clearly constitutes an industrial waste disposal business, so that a license is required for collecting and conveying industrial waste or for intermediate treatment. And naturally, wood chip boilers need to meet the technical standards for industrial waste disposal facilities.

(6) In the use of biomass as fuel, stable procurement is the greatest challenge. Operators cannot help but introduce building debris in view of quantitative stability and price. However, it contains anti-termite agents and adhesives and it could be necessary to provide pretreatment to remove hazardous substances in future.

## Conclusion

As discussed, there is a growing need to introduce biomass energy in response to existing social demand for action to address recent global environmental issues and promote the adoption of new forms of energy. By there are numerous problems when it comes to application, and growth in use has yet to gather momentum.

For instance, operators are already conscious of energy recovery from biomass but no more than 10 wood chip boilers out of the existing 157 are used for power generation. The conversion of waste into fuel has great potential but the utilization volume is limited because of cost restrictions. It is also economically difficult to expand the use of improvement-cut or thinned wood and forest residues as fuel.

Given that the Law on Recycling Construction-Related Materials has been put into effect, the use of woody waste as fuel is likely to grow in future. Even so, some supportive measure will have to be taken in the foreseeable future to encourage the introduction of biomass, including energy recovery and the growing use of improvement-cut or thinned wood and forest residues.

<References>

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## Table 4 Survey on biomass power generation

| Company | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Location | Kure, Hiroshima Pref. | Hiroshima, Hiroshima Pref. | Hatsukaichi, Hiroshima Pref. | Katsuyama-cho, Okayama Pref. | Akita, Akita Pref. | Noshiro, Akita Pref. |
| Business | Sawmilling | Manufacturing of pumps and turbines | Plywood and flooring materials | Laminated wood | Plywood and flooring materials | Boards |
| Year of installation | 1997 | 1984 | 1989 | 1998 | 1989 | (2003) |
| Biomass used as material | Scrap wood from mills (waste wood generated from sawmilling) | Building debris / scrap wood | Scrap wood from mills / building debris | Scrap wood from mills | Scrap wood from mills, building debris and thinned wood | Scrap wood from mills, building debris and thinned wood |
| | | Scrap wood: 10 to 20 yen/unit | Debris: 1,000 yen/metric ton | | Debris: 3,000 to 4,000 yen/metric ton | Debris purchase expense unfixed |
| Characteristics of the biomass used as material | Exclusively from its own mills | All biomass is purchased, with no scrap wood generated from the company | - Scrap wood also collected from affiliates<br>- 20 metric tons of debris purchased per day | Exclusively from its own mills | Scraped: debris: thinned = 70:15:15 | 53,160 metric tons per annum for fuels<br>1,200 metric tons per annum for materials |
| Energy recovery | Direct firing in the boiler to generate vapor and power generation with vapor turbines | | | | | |
| Input | 70 metric tons per day | 30 metric tons per day | 70 to 100 metric tons per day | 30 to 40 metric tons per day | 300 cubic meters per day | |
| Steam | 13 metric tons per day | 12 metric tons per day | 29 metric tons per hour | 20 metric tons per hour | 60 metric tons per hour | (24 metric tons per hour) |
| Auxiliary fuel | None | None | None | None | None | None |
| Power output | 660 kW | 2,000 kW | 4,600 kW | 1,950 kW | 4,500 kW | (3,000 kW) |
| Operating duration per day | 24 hours | 9 hours | 15 hours | 13 hours | 24 hours | (24 hours) |
| Electric energy utilization | Covering 14% of the power consumption | Covering 50% of the power consumption | Covering 90% of the power consumption (900,000 kWh per month) | Covering 100% of the daytime power consumption | Covering 78% of the power consumption (2.1 million kWh per month) | Planned to cover 70% of the power consumption |
| Heat energy utilization | All energy used for the drying furnace | Unused | Covering 100% of the demand | Covering 100% of the demand | Covering 100% of the demand | Planned to cover 100% of the demand |
| Energy efficiency | - | Generating efficiency of 15% | Gross thermal efficiency of 33.9% | - | Combined efficiency of 75% | Combined efficiency: 85% (planned)<br>Generating efficiecy: 15% (planned) |

| Company | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Energy cost (power generation unit cost) | Undisclosed | 10.9 yen/kW | 19 yen/kWh | | 6 to 7 yen/kWh | |
| Equipment cost | 170 million yen | 600 million yen | 900 million yen | 1,000 million yen | 1,160 million yen | 1,440 million yen |
| | | | Including cost of construction of the generation system | Including cost of construction of the generation system | Including cost of construction of the generation system | Including cost of construction of the generation system |
| Operating cost | - | - | 13 million yen per month | - | 13 million yen per month | |
| Maintenance cost | - | - | 11 million yen per year | 10 million yen per year | 36 million yen per year | |
| Subsidies | None | From the Nippon Foundation | None | None | From the interest subsidy program of the New Energy Foundation | 990 million yen from national, prefectural and municipal governments |
| Reverse power flow | No | No (though desired) | No | No | No | No (though desired) |
| Benefit | | Reduction of electric power charges | Power purchase: 20 yen/kWh or more | | Power purchase: 9 yen/kWh or more | |
| Energy supply to outsiders | No surplus energy to supply | All vapor is surplus. | No surplus energy to supply | Surplus vapor of six metric tons per hour | No surplus energy to supply | Surplus vapor of four metric tons per hour<br>Hot water of nine metric tons per hour |