FUTURE PERSPECTIVES: BIOMASS CO-FIRING IN COAL-FIRED POWER GENERATION ATTRACTING DOMESTIC ATTENTION

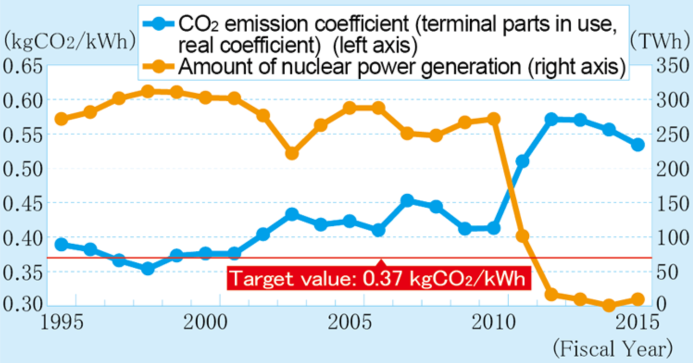
Hiroshi Uno
Yusuke Kikuchi
Technology & Innovation Studies Div.

In recent years, coal/woody co-firing (hereafter referred to as “biomass co-firing”) in coal-fired power generation has been attracting attention in Japan. So far, it has been mainly implemented for small amounts of co-firing in large-scaled coal-fired power generation. However in the future, as in the case of Chubu Electric Power Co., Inc.’s Taketoyo thermal power plant, efforts for raising the co-firing ratio in large-scaled coal-fired power generation mainly by major electric companies are expected to increase, aimed at achieving CO_2 emission reduction targets and improving proceeds from Feed-in Tariffs (FIT). This report discusses the current situation and the future prospects regarding biomass co-firing in coal-fired power generation.

BACKDROP: EXPECTATION FOR ROLES PLAYED BY BIOMASS CO-FIRING

First of all, the necessity of CO_2 emission reduction can be pointed out as one of the factors behind the growing attention being paid to biomass co-firing of large-scaled coal-fired power generation in Japan. Although President Trump announced on June 1, 2017 the United States' withdrawal from the Paris Agreement on climate change, this withdrawal drew criticisms from heads of states, which demonstrates that the global momentum for maintaining the Paris Agreement has not changed. The power industry set a goal of 0.37kg CO_2/kW (at end terminal parts in consumption[1]), nationwide CO_2 emission coefficient (amount of CO_2 emissions per amount of generated electricity) by fiscal 2030, in compliance with the “Energy Sector’s Action Plan for Low-Carbon Society.” However, under the current situation, restart of nuclear power generation has not fully proceeded and the nation’s dependency on thermal power generation, which emits CO_2, is still high. As a result, the CO_2 emission coefficient remains high (Figure 1). Because CO_2 emission trading cannot be fully utilized in these current situations, the prospect of a restart of nuclear power generation remains uncertain. On the other hand, in the field of solar and wind power generation, their cost has been reduced and is also expected to be reduced further in the future. However, there still remain issues for popularizing solar and wind power generation into large scale, such as responding to insufficiency of grid capacity, discrepancies between supply and demand in the whole area, and responding to the erratic output of solar and wind power generation. Also, Carbon dioxide Capture and Storage[2] (CCS) has still many hurdles to overcome for commercial development and, therefore, at the present stage, has a low level of practical application. This means that possible alternatives for achieving CO_2 emission reduction are limited in these circumstances. In particular, the uncertain prospects for restarting

Figure 1. CO_2 Emission Coefficient and Change in Nuclear Power Generation



Note: CO_2 emission coefficient up to fiscal 2014 indicates the value of 10 companies in former General Electricity Utility. As for fiscal 2015, it indicates the value of member companies in the Electric Power Council for a Low Carbon Society. CO_2 emission coefficient for each fiscal year described here is real emission coefficient, however is not the emission coefficient after adjustment, such as the adjustment with Kyoto mechanism credit.

Source: Created by MGSSI based on data from the Ministry of the Environment, the Federation of Electric Power Companies of Japan, the Electric Power Council for a Low Carbon Society.

nuclear power generation results in increasing the need for coal-fired power generation, which provides the same baseload electricity source as nuclear power generation. This increase runs counter to the moves toward CO_2 emission reduction. For electric power suppliers who have to make every effort, biomass co-firing plays a vital role as a project which those suppliers can undertake first.

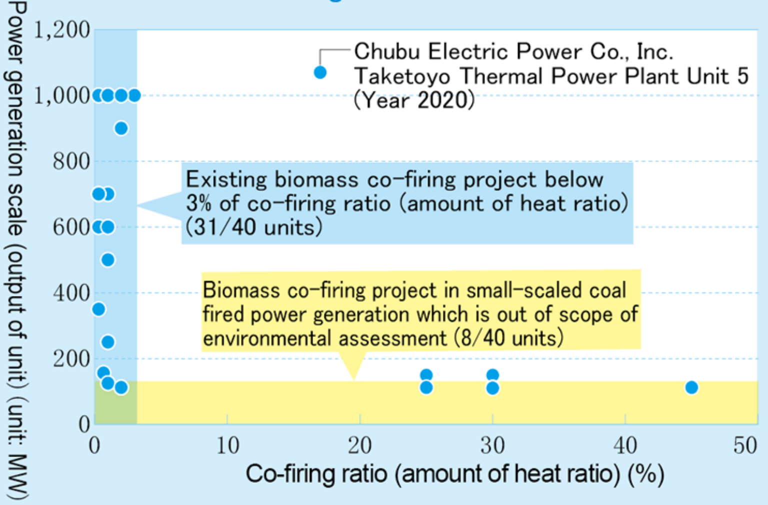
On top of that, for achieving CO_2 emission reduction electric power suppliers are regulated by the Energy Saving Act and retail businesses are regulated by Sophisticated Methods of Energy Supply Structures (Sophisticated Methods). The Energy Saving Act prescribes achievement of the two standards of efficiency. One is set for each new plant, and the other is set for each business unit, which covers all facilities including new one. If biomass co-firing is utilized, the value of efficiency as a result of the calculation, subtracting the input energy amount of biomass from the total input energy amount, becomes available. Consequently, as the co-firing ratio is raised higher, the calculated efficiency increases, which results in contributing to achievement of the standard. Sophisticated Methods prescribes achievement of a 44% non-fossil electricity source[3] ratio by fiscal 2030. Without expectations of a sufficient supply of a non-fossil electricity source, biomass co-firing projects are expected also from retailers as the supply source of non-fossil value[4].

Profitability is also an important point to consider. The Ministry of Economy, Trade and Industry is implementing power system reform and strengthening competition in the field of power generation. Therefore, power generation businesses with low competitive power plants are expected to have lowering profitability. If biomass co-firing is implemented in such power plants under the FIT scheme, the amount of co-firing will be purchased for 20 years at a fixed price (e.g. 21 JPY+Tax/kWh since October 2017 in the case of general woody biomass project of 20MW or more[5]). For electric power suppliers, biomass co-firing is positioned as the business which can earn stable money by utilizing their own company's large-scaled coal-fired power generation.

TECHNOLOGY TO SUPPORT HIGH RATIO OF CO-FIRING IN LARGE-SCALED COAL-FIRED POWER GENERATION

Large-scaled coal-fired power generation in Japan has been adopting pulverized coal fired boilers[6] and up to around 3% only (amount of heat ratio) has been said to be available for biomass co-firing due to limitations on the coal grinding capabilities[7] of coal pulverizers (blue part of Figure 2) and others. Recently, the technology, which surpasses previous limitations, has emerged. For example, IHI additionally built a dedicated coal pulverizer and burner in the 149MW pulverized coal fired power plant and achieved a 25% co-firing ratio (amount of heat ratio). In terms of raw materials, the development of black pellets, which are pellets made to resemble coal properties by torrefaction (producing semi-carbonized biomass fuel by roasting biomass) etc. is progressing. The most outstanding feature of black pellets is that they can be input directly into the existing coal-fired power generation.

Figure 2. Trend in Domestic Biomass co-firing Project from the View Point of Power Generation Scale and the Co-Firing



Note: This graph shows output volume for a total of 40 units specified through researching implemented biomass co-firing projects or planned units. Units with identical output volume and co-firing ratio are indicated at the same plot. Therefore, the number of plots does not equal to that of units specified this time.

Source: Created by MGSSI based on data from each company

More specifically, black pellets do not require remodeling of the existing facility (Table 1). In the 2010s, development of such technology has started mainly in Europe and the U.S., and Arbaflame, New Biomass Energy, Airex Energy, Nippon Paper Industries, etc. are progressing its process development and the construction of commercial facilities. Co-firing biomass at high ratios is implemented intensely in the projects of less than 112.5MW (yellow part of Figure 2), which is out of scope of the environmental assessment specified in the Environmental Impact Assessment Act. Some projects intend to make co-firing biomass at high ratios in the same pulverized coal fired boiler as in large-scaled coal-fired power generation[8]. Therefore, adopting these new technologies is surmised to be under consideration. Considering the above mentioned needs, as in the case of Chubu Electric Power Co., Inc.'s Taketoyo thermal power plant, it is likely that moves to promote making co-firing biomass operate at high ratios also in coal-fired power generation will emerge in the future.

Table 1. Comparison of White Pellet and Black Pellet

Type	White Pellet 	Black Pellet 
Overview	Pulverized chips are molded to a cylindrical shape.	Raw materials are exploded by steam or roasted to lower moisture content.
Moisture content	Below 10%	Around 1-3%
Amount of heating (low level)	16.0MJ/kg or more	20.0MJ/kg or more
Price (rough standard/FOB)	130-150 USD/Ton	180-200 USD/Ton
Merit	・ There are precedents mainly in Europe as for large-scaled project of co-firing biomass at high ratios and single fuel combustion project. ・ Procurement of raw materials is easier than black pellet.	・ This pellet does not require power plant to be converted. ・ High-calorific fuels therefore, have high transport efficiency.
Demerit	・ Efforts to raise co-firing ratio in the existing power plant require remodeling of existing facilities, which increases their costs and generates opportunity loss caused by the shutdown of operation.	・ Compared with white pellet, unit fuel cost is high. ・ Issues remain on bulk procurement due to less experiences.

Source: Created by MGSSI based on data from Ministry of Economy, Trade and Industry, etc. Photos taken by author

FUTURE IMAGE OF BIOMASS CO-FIRING POWER GENERATION

For the time being, there are high expectations of biomass co-firing power generation in Japan. Going one step further, we would also like to comment on its medium- and long-term feasibility. Biomass power generation is another kind of renewable energy just like solar or wind power generation. While solar or wind power generation do not incur fuel costs, fuel costs in the woody biomass power generation accounts for around 70% of total power generation cost (including the facility cost). This is the huge difference between them. This high fuel cost is currently covered with FIT. However, when the term of the FIT scheme terminates, its profitability will be reduced and it is highly likely that it will be difficult to maintain the woody biomass power generation because it does not have cost competitiveness compared with other electricity sources. In addition, under the current system, biomass co-firing or single fuel combustion is considered to be a target for output control ahead of long term and fixed electricity sources (nuclear power generation, hydroelectric power, hydroelectric power generation, geothermal power generation, etc.) or solar and wind power generation[9]. This means that the output control risk for biomass co-firing or single fuel combustion will be growing, when restart of nuclear power generation is promoted and the power generation volume of solar and wind power generation is increased in the future.

Table 2. Future Image of CO_2 Reduction Target and Electric Power System in 2030 and 2050

	Year 2030	Year 2050
CO_2 reduction target	▲26% (compared to fiscal year 2013)	▲80%
Current condition of electricity system	・Good balance between fossil fuel power sources and non-fossil fuel power sources	・Low carbon power sources will account for 90 % or more. (according to the long-term vision for low carbon by Ministry of the Environment) ・Massive introduction of solar power generation and wind power generation
Issues of electricity system	・How to realize S (Safety) + 3E (Energy Security, Economic Efficiency, Environment)	・How to maintain stable system (securement of adjustment capabilities)
Value of electricity	Amount of power(kWh) ・The electric power, which meets demand or needs stably, will be valued.	From amount of power(kWh) to adjustment capabilities(kW) ・Increase of power sources such as solar power generation and wind power generation which require no fuel costs (zero marginal costs) will allow the value of amount of power (kWh) to decline. ・The value of adjustment capabilities(kW) to cover instability of solar power generation and wind power generation will rise.

Source: Created by MGSSI

Table 2 indicates the projected CO_2 emission reduction and power system in 2030 and 2050. In the world of 2050, the electricity sources such as solar and wind power generation, whose output fluctuates depending on weather regardless of demand, will be prevalent massively. As a total power system, it will become difficult to maintain the balance between supply and demand. Consequently, it is likely that new value will be generated in adjustment capabilities to maintain the balance between supply and demand (i.e. the capability to increase or decrease the output of electrical generators in accordance with the status of supply and demand). It is easy for biomass power generation to adjust its output unlike solar and wind power generation. Moreover, the technological development towards improvement of operational flexibility, such as reduced start-up times, enhancement of load change ratios, and reduction of minimum loads, would be required in order to further improve value as adjustment capabilities. In the future, it is likely that promotion of cost reductions in hydrogen and storage batteries will make them compete with biomass power generation in terms of low-carbon adjustment capabilities. As mentioned in the long-term low-carbon vision of the Ministry of the Environment, in the case that low-carbon power sources[10] account for 90% or more of the total generated electric power amount is realized without using CCS, it will become difficult to continue biomass co-firing and application of single fuel combustion will need to be considered. If CCS can be used in Japan, biomass co-firing alone can be a low-carbon power source. However, if combined with single fuel combustion, there is a likelihood that it can become a negative emission electricity source[11] with the significant effect of CO_2 emission reduction. However, to leverage this kind of electricity source, a CO_2 emission reduction effect, system to evaluate low-carbon adjustment capabilities, and establishment of a market are needed.

CONCLUSION

In Japan, biomass co-firing in large-scaled coal-fired power generation, for the time being, will be powerfully positioned as a CO_2 emission reduction policy, stable power supply and source of profits, and will continue to increase its presence. However, it is likely that biomass co-firing will run into harsh conditions in the medium- to long-term because of environmental changes, such as strengthening CO_2 emission regulations, termination of FIT, and the mass introduction of highly competitive solar and wind power sources. As a countermeasure, focusing on new value as low-carbon adjustment capabilities, the design of a market system to evaluate the value of this as an electricity source would need to be considered as well as making efforts to develop the technology to promote single fuel combustion and operational flexibility. Emerging countries are burdened with massive large-scaled coal-fired power generation. Therefore, the technological development and system design in the process from making the ratio of co-firing high to making single fuel combustion in large-scaled coal-fired power generation would be considered to be needed for those countries' countermeasures for CO_2 emission reduction in the future.

1. The result value of dividing the amount of CO_2 emissions from all power plants by the amount of electricity consumption.

2. The technology to separate CO_2 from gas emissions of power generation facilities, collect and store CO_2 in the ground.

3. Non-fossil fuel electricity source corresponds to renewable energy power generation and nuclear power generation.

4. When FIT is applied, value of renewables is not vested in its producers. As for the FIT electricity in which supply agreement has been concluded since 2017 April, general electricity transmission/distribution businesses are obliged to purchase the relevant electricity. Environmental value is separated from the company, and is attributable to the coordinating organization for cost burden purposes. The relevant electricity is assumed to be bought and sold in the non-fossil value trading market which is planned to be established within fiscal 2017.

5. Sawdust and shavings, imported lumber, palm tree shells, rice husks, rice straw, etc.

6. The method of pulverizing coal into a fine powder with a coal pulverizer and burning it as a gas.
7. Compared with coal, woody biomass is difficult to pulverize because it is high in fiber. Stable burning cannot be maintained when inputting a large amount of woody biomass into boilers.

8. In small-scale projects of high co-firing ratios or single fuel combustion projects, fuels are not required to be pulverized into a fine powder and therefore fluidized bed boilers, where combustion of woody biomass is easier, are used in many cases.

9. For regional biomass resources, there exists preferential treatment for exemption from the scope of output control.

10. The long term low-carbon vision of the Ministry of the Environment defines low-carbon power sources as renewable energy, thermal power generation provided with CCS, and nuclear power generation.

11. Biomass absorbs CO_2 while it is growing. Therefore, the capture and storage of CO_2, which is emitted during the combustion of biomass, means removal of CO_2 from the air. This results in producing an assessment that the amount of CO_2 emissions is negative. Its corresponding technology is called "negative emissions technology."