New Energy Awards

Minister of Economy, Trade and Industry Prize

Slashing CO_2 Emissions from Coal-Fired Thermal Power Plants with Carbon-Neutral Fuel

Co-firing with a high-ratio of woody biomass to make the most of existing coal-fired thermal power generation systems

As widely known about retreating ice sheets and rising sea levels, we can waste no time in curbing global warming. Regarding coal-fired thermal power plants, reduction of CO_2 emissions is said to be essential. Accordingly, IHI has carried out a demonstration of a co-firing system for coal and a high-ratio of carbon-neutral woody biomass (up to 50% in calorific value) to significantly cut CO_2 emissions.

1 Logging and collection

2 Transportation

Wood pellet fuel

3 Processing

4 Combustion

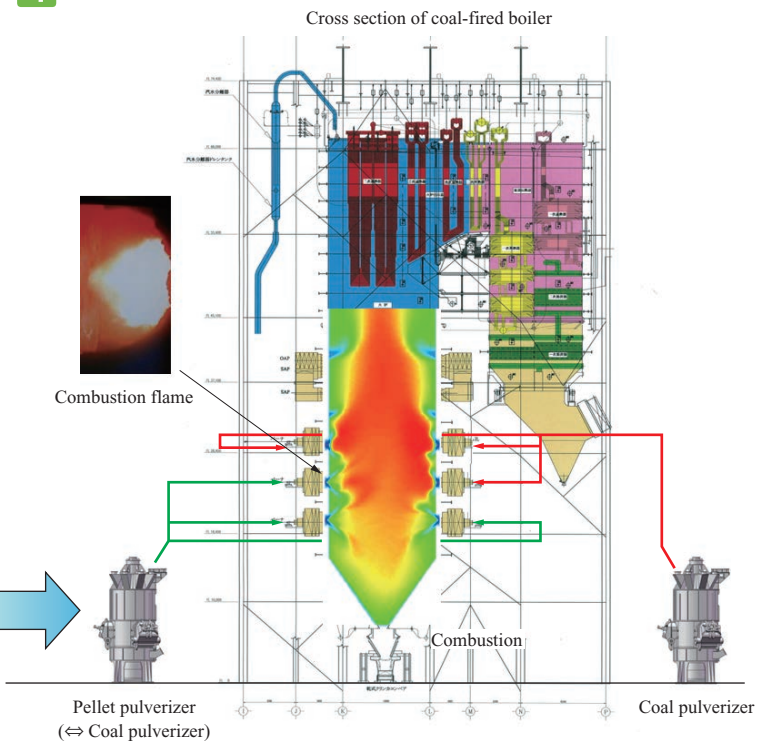


Illustration of the configuration of a high-ratio woody biomass co-firing system

Able to co-firing up to 50% (calorific value)

One day in December 2016, the Boiler Plant Division of the Energy & Plant Operations erupted in cheers when it was announced that their high-ratio woody biomass co-firing system (demonstrated by the division for the first time in Japan) had won a New Energy Award of the Minister of Economy, Trade and Industry Prize offered in fiscal year 2016. The awards recognize pioneering initiatives developing devices that harness new forms of energy outside of fossil fuels (e.g., power generation with biomass, geothermal sources, wind power, thermal utilization of solar energy, snow, and ice), as well as initiatives to introduce and promote such equipment. This prestigious prize in the industrial circle is awarded by the New Energy Foundation, with the patronage of the Ministry of Economy, Trade and Industry.

The new high-ratio woody biomass co-firing system developed by IHI features the co-firing of coal with up to 50% wood pellets (in calorific value) by simply modifying coal pulverizers of conventional coal-fired boilers into pellet pulverizers specialized in woody biomass introducing an improved system. Co-firing has already been attempted, but the ratio was several percent at most to ensure stable power generation using coal-fired boilers. IHI's new system was highly evaluated as the co-firing of a high-ratio of carbon-neutral woody biomass and for its significant reduction in CO_2 emissions. This groundbreaking system and the pellet pulverizer are described below.

Curbing global warming by making effective use of the existing coal-fired thermal power plants

The accidents at nuclear power plants triggered by the Great East Japan Earthquake in 2011 left thermal power generation as the crucial source of base power in Japan. Coal-fired thermal power generation is a particularly important source, accounting for about one-third of the total supply of power. Meanwhile, coal-fired power generation accounts for as much as half of the annual CO_2 emissions for all kinds of power generation, which amounts to roughly 457 million tons (in fiscal year 2014). In other words, coal-fired thermal power generation emits much CO_2, which hardly makes it a desirable source of energy from the viewpoint of preventing global warming.

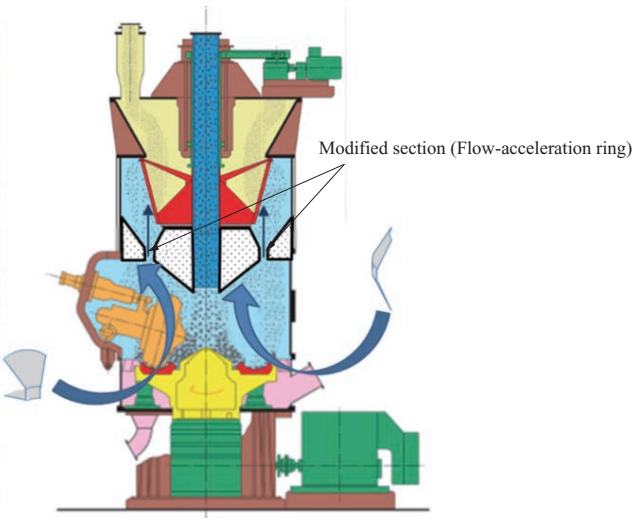
Still, CO_2 emissions from carbon-neutral woody biomass can be excluded from the carbon accounting of any viable co-firing of coal with woody biomass. For this reason, 12 major thermal power plants in Japan employ co-firing woody biomass. Unfortunately, only small reductions in CO_2 emissions could be achieved because, as mentioned earlier, high-ratio co-firing of woody biomass was not possible with conventional technologies.

Supposing that all major power companies operated with 50% co-firing of woody biomass in their coal-fired boilers, CO_2 emission could be slashed by 100 million tons, making a great contribution in the activity for global warming. IHI has been developing the technology to make this happen.

Specialized pulverizer for woody biomass

In major coal-fired thermal power plants, pulverized coal-fired boilers are employed as a mainstream solution. Conventional pulverizer for coal can handle only up to 2-3% woody biomass. To solve this problem, a new method was developed to modify a coal pulverizer into a specialized pulverizer for handling woody biomass for combustion. The preliminary test clarified that even conventional pulverizer works well for biomass of pellet type at least. A challenge was pneumatic transportation of the pulverized biomass. It was hard to blow up the woody biomass particles and blow out from pulverizer. Woody biomass particles tend to remain

Appearance of pulverizer



Cross section of pulverizer

Pellet pulverizer

inside a pulverizer as they are much larger than coal particles. Experiments with some possible solutions found that pulverized biomass can be blown upward by installing a flow-acceleration ring inside a pulverizer to accelerate the flow in a narrow area of airflow. Because this flow-acceleration ring is detachable, a modified pellet pulverizer can be placed back into a conventional coal pulverizer.

Proper combustion was confirmed through tests with an IHI's standard pulverized coal burner, as well as excellent flame stability.

Commonly used woody biomass in Japan includes wood chips made from forest thinnings, wood pellets made from pulverized and dried forest thinnings, and bark. Pellets are the most efficient fuel in terms of transport efficiency and other factors. There are many types of pellets with different characteristics depending on manufacturers. Therefore, the pulverization and combustion by IHI's new system had to be tested for various types of pellets.

Demonstration at a commercial power plant

Once the system had passed preliminary testing, the first-ever demonstration in Japan was carried out at a commercial plant (Kamaishi Works of Nippon Steel & Sumitomo Metal). In this plant, a flow-acceleration ring was installed in one of the four existing coal pulverizers to modify it into a pellet pulverizer. This means that the performance of the pellet pulverizer and operational status of the boiler was tested with the co-firing of biomass at a ratio of 25%. The handling capacity with the modified pulverizer proved to be comparable or superior to that with existing coal pulverizers. Pulverized pellets were able to be ignited with a pulverized coal burner without any problems. In addition, the boiler was found to emit less NO_x, SO_x, and other air pollutants with increasing the ratio of co-fired biomass.

Furthermore, we concluded that co-firing with the ratio over 50% has no problem. In order to conclude, we considered ① the simulation result of verification and evaluation of the distribution of heat absorption in the furnace, as well as ② the impact of ash adhesion to the furnace wall, and ③ the denitration unit.

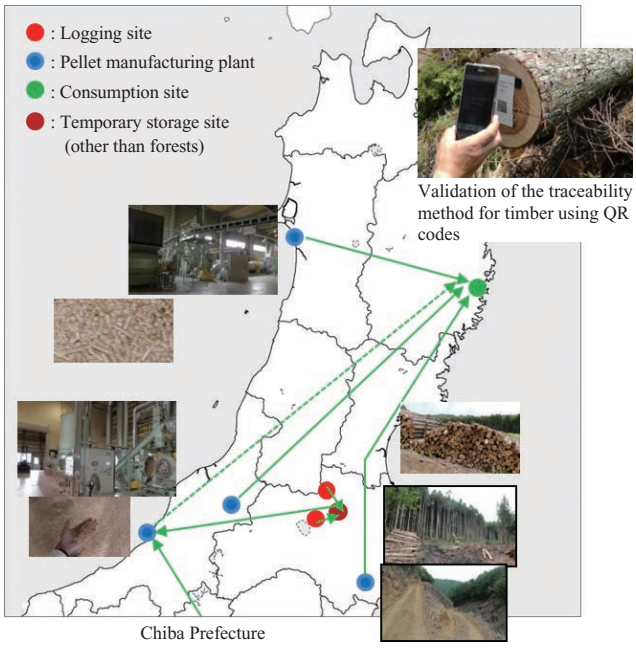
Challenges remain in the revision of the incentive framework, securing access to fuel, and refusal of illegally logged timber

CO_2 emissions can be slashed effectively when major power companies with large-scale boilers introduce the woody biomass co-firing system. For this reason, large boilers with a capacity of over 500 000 kW were chosen as the initial targets for this high-ratio co-firing system.

Still, the shortage of woody biomass is easily predicted if a half of the fuel for conventional coal-fired boilers were replaced to biomass. The wider application of this system significantly depends on stable and constant supply of a large amount of biomass fuel. In the next stage, the development of biomass fuel and secure access to the fuel become important.

There are two major challenges to be addressed. The first one is the industrialization of the potential biomass supply in Japan, where — due to the diminishing labor force — many forests have been left unattended since the planting in the pre-war and post-war period. For our demonstration, woody

149 MW coal-fired thermal power plant
at Kamaishi Works of Nippon Steel & Sumitomo Metal



Validation of the extensive supply of Japanese biomass

biomass was procured in Japan. Wider application of woody biomass can be expected in commercial operations when a well-designed efficient system will be realized by integrating the processes of logging, transport, processing, pelleting, and power generation. In addition to curbing global warming, this brings further benefits in the form of revitalizing domestic industry and developing sustainable energy sources in Japan.

Another concern is the risks of illegal logging when woody biomass is eagerly traded as fuel. A traceability system will be necessary to keep such illegally logged materials at bay.

A system to lead the era of sustainable energy

It is obvious that coal-fired thermal power generation is encountering backlash because of the large amount of CO_2 emission. In the future in Japan, there may be further tightening of regulations against CO_2 emissions. Even in such situation, IHI's high-ratio woody biomass co-firing system will help to switch the fuel to renewable one, making efficient use of the existing facilities. This forward-looking system requiring minimum investment can boost domestic production of woody biomass as a renewable source of energy, and generate demand for this fuel. IHI sets a realistic goal to "halve CO_2 emissions from coal-fired thermal power plants" rather than an unrealistic goal. This project is subsidized by Ministry of the Environment in Japan as the project "Low Carbon Technology Research and Development Program" and the contents on this paper is excerpted from result report of commissioned business from Ministry of the Environment.

The 2016 ceremony of New Energy Awards

Inquiries:
Business Development & Sales Department,
Boilers Business Unit,
Resources, Energy & Environment Business Area,
IHI Corporation
Phone: +81-3-6204-7419
https://www.ihi.co.jp/en/