Densified Biomass for Co-fired Energy Generation

The UK's leading "green" power utility, Slough Heat & Power Ltd., features state-of-the-art densification equipment for cubing non-recyclable commercial and industrial waste for use in its co-fired energy plant.

By Jim McMahon

The co-firing of biomass and non-recyclable commercial, municipal and industrial waste with coal represents one of the nearest-term and lowest-cost options for carbon dioxide reduction in the electrical power sector. Compared to burning coal by itself, it has proven to be a low-capital investment for utilities, using existing coal-fired plants to burn biomass and non-recyclables that are more environmentally friendly with lowered pollutant emissions. Co-firing has been demonstrated successfully in more than 150 installations worldwide. With its plant numbers continuing to increase, the trend could soon evolve into the preferred and most standard practice for reducing carbon dioxide emissions in power facilities.

Biomass, in the energy production industry, refers to living and recently dead biological material that can be used as fuel. Biomass may also include biodegradable wastes that can be burnt as fuel. It is grown from a number of plants, including Miscanthus, switchgrass, hemp, wheat straw, corn, poplar, willow and sugarcane tops.

Biomass is part of the carbon cycle, where carbon from the atmosphere is converted into biological matter by photosynthesis. On decay or combustion, the carbon goes back into the atmosphere or soil. This happens over a relatively short timescale, and plant matter used as a fuel can be constantly replaced by planting for new growth. Therefore, a reasonably stable level of atmospheric carbon results from its use as a fuel.

Industrial, municipal and commercial non-recyclable (low market value) waste includes paper, cardboard, packaging, industrial fiber materials and wood processing waste. When these carbon-based materials are co-fired with coal, carbon dioxide emissions from coal-fired power stations can be reduced in direct proportion to the quantity of biomass consumed.

Fueling the Growth of Biomass

The main reason utilities are burning biomass and non-recyclable waste is to generate electricity from renewable energy. Biomass and non-recyclables compete with saltwater, hydroelectricity, wind and other forms of renewable energy. For example, one dry ton of biomass will generate approximately one megawatt of electricity. Co-firing with coal reaches a higher temperature and is more efficient, generating about 1.4 megawatts of electricity per ton of biomass.

"The cost per ton of biomass and non-recyclables is still higher than coal, however," says Tom Miles, President of TR Miles Technical Consultants Inc., an engineering firm specializing in power plant co-firing. "The final kilowatt cost is the fuel, what is actually delivered to the boiler. Most biomass is on the order of $70 per ton by the time it is delivered to the burner. That is 7 cents per kilowatt-hour fuel cost. Coal is at roughly 5 cents per kilowatt-hour, and cheaper energy than biomass. Coal prices have been steadily rising, however, gradually closing the gap, which is making co-firing with biomass and non-recyclables more attractive to plants.

"Comparatively, natural gas is more expensive than generating power from coal," Miles explains. "It is about the same cost per kilowatt-hour as biomass. Wind, which at one time was in the vicinity of 3 cents per kilowatt-hour is now in the range of 8 cents per kilowatt-

Warren & Baerg cubers at Fibre Fuels plant in U.K.

hour because many of the ideal sites have now been acquired. All of a sudden, co-firing coal with switchgrass, corn stalks, wood or non-recyclable waste looks pretty interesting to the utilities from an economic point of view.

"Dedicated biomass and non-recyclable waste plants are not the most cost-efficient option," Miles says. "If a utility wants to generate electricity from a renewable resource, it should look at co-burning that resource with coal, in an existing plant, as opposed to building a new plant that generates power entirely from biomass."

The Switch to Biomass

One power facility that has seriously embraced co-firing is Slough Heat & Power Ltd., located in the United Kingdom about 15 miles southeast of London. The power plant is a textbook example of the efficiencies attainable by introducing co-firing biomass and non-recyclable waste into an existing coal-fired facility.

Slough Heat & Power was a dedicated coal-fired power station up until 2001, when it began co-firing coal with biomass and non-recyclable waste. This change was prompted by increases in the price of coal and the desire to burn a sustainable fuel in the facility. The plant decided at the time to move forward toward becoming more of a green power station. Today, Slough Heat & Power is recognized as being the greenest power station in the UK.

Slough Heat & Power supplies electricity, hot water and steam to local businesses, and electricity to local residents. The company is one of the UK's longest-serving and most flexible energy facilities, and a pioneer in renewable energy. The plant is the UK's largest dedicated biomass energy facility with six boilers and six turbines that can operate on a variety of fuels. Wood and fiber fuel are the main fuels but it can also burn natural gas, coal and distillates. Natural gas and coal are now used in small amounts for boiler control.

The facility includes two fluidized bed boilers that drive a 35 megawatt

The Fibre Fuel plant

pass-out steam turbine. These are now fuelled with wood, having been converted from coal in 2001. One multi-fueled vibrating grate boiler drives a 12-megawatt pass-out steam turbine and is also fueled with wood and fiber fuel.

"We burn about 1,000 tons of coal a month, primarily for the chemistry," says John Watson, fuel manager with Slough Heat & Power. "It assists us with corrosion properties. The plant uses about 35,000 tons a month of wood chip fuel, which is both wood and biomass, used for the main part of the power station. We are at the moment about 87 percent green energy.

"Slough Heat & Power uses only clean, uncontaminated wood chips," Watson says. "Much of our wood is from local landscape companies and tree trimmers who perform work on woodlands, forests, parks and roadsides. We purchase chips made from branches, stems and other material which has few, if any, other economic uses.

The plant also sources uncontaminated wood from local sawmills, where chips are a byproduct from sawing timber, according to Watson. "Wood chips are also made from clean pallets, demolition wood, off-cuts etc. and these are delivered to us," he says.

The burning of the biomass and wood chips produces less sulfur and ash, and significantly less carbon dioxide. Most of the plant's ash is recycled and blended into road aggregates, or used as fillers, as opposed to being put into a landfill.

Turning Non-recyclable Waste into Fuel

Slough Heat & Power also operates an onsite subsidiary, Fibre Fuel Ltd., which processes non-recyclable commercial and industrial waste into fuel cubes. Waste material is shredded and densified into small, odorless energy cubes that are then combusted to generate electricity for local businesses and

PHOTO: WARREN & BAERG

Fibre Fuel plant in the U.K.

residents. In essence, waste material is turned into a renewable fuel to generate electricity. These waste materials include mixed papers, magazines, junk mail, coated papers, laminates, adhesive labels, photographic paper, hygiene product rejects and pre-consumer packaging. There is also 15 percent plastic (excluding PVC) in the mix, which is added to improve the caloric content.

The company processes approximately 8,000 tons of waste per month and 260 tons of fuel cubes are produced each day. The fuel cubes are approximately two-thirds the calorific value of coal. Thirteen tons of the energy product produces 12,000 kilowatts of electricity and 20,000 kilowatts of heat.

"We shred all of this waste material to a fraction the size, down to two to three inches," Watson says. "We then run it through high-speed densification equipment to make fuel cubes. In size the cubes are either 1.25 by 1.25 by three inches long, or 2.5 by 1.25 by three inches long. These then go directly to the boilers."

At the heart of Fibre Fuel's cubing is Warren Baerg Manufacturing's state-of-the-art Model 250 cubers, which can produce six to eight tons of cubes per hour per machine, depending on the material and die selection, and can process a wide range of forage and other non-recyclable materials, including biomass, municipal waste or industrial waste. It turns it into a cube and ultimately fuel. The resulting fuel cubes, trademarked Cubed Energy, are 1.25 by one inch square, and break off in lengths of one to three inches, depending on the materials used and the components and adjustments selected. Since the characteristics of the fuel cubes are similar to those of coal or hog fuel, they can be used in most industrial boilers along with their other fuels.

The range of cubing systems the company manufactures can convert

PHOTO: WARREN & BAERG

Recyclable waste to be converted into fuel at Fibre Fuel

many loose, low-density materials into a dense alternative fuel that is economical to transport and efficient to burn. Non-recyclable papers, newsprint, poly coated or waxed cardboard, pre-consumer industrial fiber wastes, wood processing and manufacturing wastes, and post consumer combustible fiber wastes can all be processed through the Model 250 Cubers. Secondary additives, such as paper mill short fibers (sludge), coal fines, and PET coke can be added to form a blended fuel.

"We are currently running six Warren & Baerg cubers, but have the ability to site eight," Watson says. "We don't just feed the raw paper or cardboard directly into the boiler because of two reasons: it needs to be decontaminated, because it is a waste product. It contains undesirables that have to be removed before it can be cubed. Second, because the material cannot go in to the boiler in its raw form, it has to be made to a specific specification of cubing for optimized burning.

"The contaminants are removed with two systems," Watson explains. "First, metals, ceramics, aggregates and glass are removed with an air-knife, which introduces an air flow onto the material, blowing the light material forward and allowing the heavy materials to fall out as a reject. Second, with the ferrous metals we have a whole series of electromagnets. On the non-ferrous metals we have Eddy-Current separators, which work opposite to a magnet, repelling metals like aluminum and brass."

The plant then uses a series of conveyors and screw augers to feed the processed waste into the cubing equipment. Fibre Fuel exercises different options for the fuel once it has been cubed. First, the cubes can be fed directly into the boiler. Second, the cubes can be put into a storage bunker, where 300 tons of cubes can be stored. Third, the cubes can be feed into a truck and transported around site for alternative use or additional storage.

Streamlined Biomass Grinding

"We got interested in grinding our straw for co-firing," Miles says. "We put into place a very unique system built by Warren & Baerg that handles any size bale, even 4 feet by 4 feet by 8 feet long. The equipment takes the bales, automatically removes the twine by running it through a de-stringer, and then grinds it down to a 2-inch vertical size. Then we take it down to about one-quarter-inch size, and blow it 1,500 feet over to a boiler, where it is burned with the coal. It is a very efficient system."

Aside from the automatic de-stringer, this grinder feeds horizontally, which is quite different, allowing large round bales to be processed without delay. The system also has an air-take-away system, greatly reducing dust.

For Slough Heat & Power, converting to co-firing diverts roughly 250,000 tons of carbon dioxide being emitted to the atmosphere annually. Also, 100,000 tons of waste material are kept from being deposited in waste dumps.

The first tests with co-firing wood and coal were conducted in 1979. In the early 1980s, co-firing became popular, then waned. It again gained popularity in the early 1990s and waned. Now, it appears co-firing is back again, and has achieved a new level of popularity with power utilities. Recent technology upgrades for handling biomass and non-recyclable wastes can only add to this momentum, and hopefully will help provide the needed efficiencies to prove co-firing methodology sustainable.

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