Study of Biomass Fired Utility Plants

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Listening to news reports, one would believe that wind and solar are the most prevalent forms of renewable energy. Yet when compared with either of these other types, published data from the Energy Information Agency makes clear that biomass and hydroelectric generation each made a far larger renewable energy contribution in 2001.

Some touted developing technologies for biomass processing and combustion are in theoretical or prototype stage today. Among these are co-firing with coal, gasification, and conversion to bio-synthetic transportation fuels. Most people do not realize what potential forest generated biomass, wood, offers to help meet that need now. This paper discusses existing systems by example, touching on reliability and whether they meet economic and environmental expectations. It ends by asking a question: could what we already know how to do help solve today's energy problems and meet other needs of society?

Electrical Energy on the Grid

The first example is Tractebel Power's Northumberland Cogeneration Facility. Fueled by wood chips, Northumberland co-generates 16.2 megawatts of electricity and enough process steam to commercially preserve more than 50,000 tons of food goods annually. Northumberland is one of seven similar facilities owned by Tractebel Power, Inc. as part of its power generating station portfolio listing more than 30 facilities. U.S operations are based in Houston and are part of the Suez group of companies. Fuels include natural gas, lignite, anthracite waste coal, bituminous, wood, and landfill gas. Capacities reach in excess of 500 MW. Some produce only electricity. Others supply only industrial process steam, some others, like Northumberland, are cogenerators.

Commercial power generation began in 1989 at Northumberland, located north of Harrisburg in central Pennsylvania. Private developers undertook the project after the oil shortages of 1970s and early 80s in response to the recognized need for energy self sufficiency. Funding was private and did not involve grants or public bond issues.

The facility site occupies approximately ten acres. Power production from wood requires hardware, space, and staff to receive, process, store, and feed to the boiler approximately 200,000 tons of fuel wood per year. That combustion also creates some ash, which has a cost in hardware and staff time. These facts are trade-offs, necessary to achieve the real values of renewability, local sourcing (employment), and environmental sustainability.

Tractebel Power Northumberland Cogeneration,Facility

Fuel handling system

Fuel consists of wood chips delivered by truck, purchased by weight. It is unloaded using a hydraulically lifted platform manufactured by Phelps. This device lifts truck and trailer to a steep angle, allowing the fuelwood payload to slide into a receiving hopper. Steel conveyor chains move the wood into a Williams "disk screen" classifier. This sizing operation

Unloading wood chip fuel

accepts particles of the correct size and rejects oversized pieces. Accepted fuel drops onto a stacking Kohlberg conveyor fitted with a Eriez magnet to remove tramp steel, and is ultimately placed on a peaked inventory pile. Northumberland can store 28 days, or 17,000 tons of fuel.

Inventoried fuel moves into the plant beginning with a Laidig under-pile reclaimer. This is an auger with toothed flights, oriented radially in a circular concrete-lined pit under piled wood. Chips are drawn toward an opening at the pit bottom center, falling through the opening, onto a series of conveyors.

After passing through a second sizing screen and magnet set, fuel is moved by bucket-elevator into a pre-combustion storage bin above the furnace called the "metering-bin". Rates of fuel transfer from the metering bin to the furnace, and from inventory into the metering bin are computer controlled with manual over-ride capability.

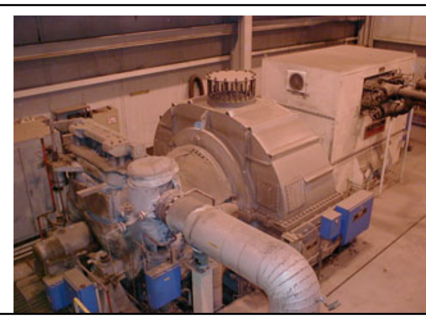
Normal daily deliveries are 840 tons, or 42 loads each with an average processing time of fifteen minutes. This rate of inflow covers normal use at the rate of 25 tons per hour or 600 tons per day.

Boiler, Turbine, and Generator Set

Wood enters the boiler by means of computer-controlled augers in the metering bin floor. After sliding down sloping entry chutes, the fuel stream is pushed toward the back of the furnace by pre-heated overfire air. Sawdust and other small light particles burn in suspension, but most chips drop onto a traveling grate floor. Separate fans push two air streams, forced draft and overfire air into the furnace to encourage drying and uniform combustion. The rates are damper adjusted, and held to just negative pressure by a third fan, drawing air from the fire box. Situated outside the plant, this unit is called the induced draft fan.

The Zurn furnace generates 161,000 lbs steam/hr. Steam formed in the water-walls and other tubes is collected in the steam drum, after which a bank of superheating tubes dries the steam to improve its quality by increasing temperature. Steam reaches the turbine at a pressure of 1,150 psig.

The, prime mover is IMO DeLaval's model MJ multi-stage impulse type multiple extraction condensing turbine with 19 fans in five stages. It is direct connected to the generator, an Alsthom enclosed water cooled two pole revolving field synchronous unit with a rotational speed of 3,600 rpm. Generation occurs at 13,800 volts, stepped up to 69 kv for transmission to the electricity customer PPL Electric Utilities.



DeLaval turbine and Alsthom

Steam is extracted from the 4th turbine stage for delivery to the steam host customer, Furman Foods, Inc. Once conditioned and piped over a quarter mile, it reaches the cannery at 125 psig. A second host, Tuckahoe Fire Department, seasonally receives space heating steam.

Controls

DCS links on each sub-system are merged through a Fisher Provox console in the control room. This allows the plant to operate with one roving equipment operator and one shift supervisor overnight and weekends. The full complement of staff at Northumberland is 21.

Emissions Containment and Monitoring

Sulfur is insignificant as a wood fuel constituent; as a result, monitoring of SO_x emissions is not required. Entrained nitrogen is generally low except with some engineered woods having higher percentages of urea-formaldehyde glues. Northumberland uses a continuous emissions monitoring system to constantly extract and analyze stack gas samples, creating a computerized record of criteria pollutants NO_x, and CO. Particulate emissions, as opacity, are measured and recorded. Limits are established under a Title V permit administered by Pennsylvania's DEP, at .25 lbs/mmbtu for each criteria pollutant. Particulate is limited to 0.1 lbs/mmbtu.

The facility does not employ special combustion systems to manage NO_x. Particulate emissions are controlled by a combination of mechanical separators for the larger particles and an electrostatic precipitator to remove fine particulate normally comprising the "smoky haze" many people connect with wood heat.

The "mechanical" and "esp" ash streams are combined in an open-flighted auger where sufficient water is added to quench the glowing embers and control dust. This "flyash" stream is moved by trailer to a separate storage building, from which it is loaded onto the delivery trucks for ash markets. Typical flyash production is approximately 2% by weight, or 6,000 wet tons per year. Flyash is considered a byproduct with markets.

A second type of ash, heavy, slag-like chunks mixed with sandy non-combustible particles which reach the end of in-furnace grate travel is called bottom ash. Reaching the end of grate flat travel, it falls down a level onto a closed chain conveyor for removal from the building. The quantity is small, averaging 2000 tons per year. Bottom ash is also considered a byproduct with markets.

Fuel Character and Sources

Fuel consists of chips from logging and sawmill operations, trees removed during land development, salvaged/recycled pallets, crating, yard waste and storm debris. Two others are among the best future fuel markets. Timber stand improvement projects will help forest health as small diameter low quality stems are pruned out of growing forests. Danger fuels, are brushy and woody material from the urban-wildland interface zones. These are at woods-city edges, where homes are being placed into forests at serious risk to people and property.

Benefits to community, forest health, and society of this cross-disciplinary interaction are seldom discussed. More dialog is needed between foresters and energy specialists. There are limits to sustainability, but to this point the country is no where reaching them.

Costs and Reliability

Wood fuel has over time been in the range of $2.00/mmbtu. That number changes with diesel fuel as a function of delivery distance and forest operations. Reliability is also good, with a capacity factor of greater than 98% since commercial operation began.

Schools, Public Buildings

In 1987 the Mountain View Board of Education, a small district in rural northeastern Pennsylvania, needed to build a consolidated elementary school. They were approached by the local Pennsylvania Energy Center, a state energy office project promoting efficiency and self reliance, with the suggestion that they use wood as the principal energy source. The suggestion included piping hot water across the road to an existing high school building and using the oil fired system in that building as the back-up.   To decide, the Mountain View board eventually traveled to Wisconsin where they observed first hand four operating wood fired boilers serving schools and other buildings managed by three Boards of Education at Rice Lake, Barron, and Hayward. At the time, the Wisconsin projects had been operational for approximately five years.

Mountain View Elementary School, Kingsley, PA

Mountain View installed a wood chip boiler system in 1988. The entire wood heat system including fuel storage, is inside and is similar in character to the school building. Delivery is by live floor tractor-trailer into a live-floor storage bunker holding enough fuel for three winter days of operation.

Wood chip movement is driven by hydraulic slides, augers, and conveyors. The combustor is of step grate design of Scandanavian origin with adaptations by the contractor, Sylva Energy Systems. The boiler is a conventional water-tube design manufactured by Bethlehem Boiler.

Controls are electronic, programmable by the school maintenance staff. In 2003 the district successfully implemented a controls upgrade. Ash production is described by staff as minimal, with the ash product being used on site as a soil amendment.

Fuel use and Sourcing:

Mountain View uses an average of 1,200 tons of wood chips per heating season. They have been purchased from local forest products producers from in-woods chipping, and local sawmills. According to the business manager in office at that time, during the winter of 2000, #2 fuel oil to heat the two school buildings would have cost $90,000. The fuel wood chips did cost them approximately $30,000.

During recent communication with the business managers at Rice Lake schools, Barron Area school district, and Mountain View school district, all stated that their use of wood heat has been successful and is expected to continue into the future.