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PERSPECTIVE

CO-FIRING WOOD PELLETS WITH COAL

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As Renewable Portfolio Standards (RPS) deadlines approach, utilities are laboring to add renewable generation. One drawback of most renewable energy sources is that they cannot replace baseload generation due to their intermittency. Additionally, many regions do not have the wind or solar resource to make those technologies reasonable solutions. Biomass, however, is a dispatchable renewable resource, readily available in many areas that lack other renewable resources.

Co-firing biomass in existing coal plants is a straightforward and quickly implemented solution. Specifically, wood pellets are an ideal fuel for this purpose. As a densified, low-moisture, uniform biomass fuel, pellets avoid many challenges associated with raw biomass. Wood pellets have many parameters comparable to coal making them a compatible co-firing fuel.

WOOD PELLET BACKGROUND

Wood pellets are a refined and densified biomass fuel typically manufactured from biomass residues created by wood product manufacturers and environmentally sustainable in-forest harvesting practices. Because of their uniform and compact nature, wood pellets lessen many of the challenges associated with raw biomass, such as the high cost of transportation due to lower bulk densities and handling difficulties based upon non-uniform characteristics.

In addition to being a fuel with a specification, pellets burn very similarly to coal due to their low moisture and friable nature. The chart below details the main physical and chemical properties of wood pellets compared with coal commonly used in Wisconsin.

In general, the properties of coal vary over a much larger range than those of wood pellets. This further highlights the benefit that pellet consistency provides to co-firing. When introducing a new fuel to a system, it is important that fuel operates predictably in order to minimize unforeseen boiler complications.

TECHNOLOGICAL SUMMARY

Co-firing is defined as the combustion of two independent fuels in order to produce energy. There are two main methods to co-fire: direct co-firing, where two fuels are present in the boiler simultaneously, and indirect co-firing, which requires that each fuel be combusted separately and combining the resultant energy streams. Because wood pellets and coal have many technical similarities, pellets are ideal for the less costly method of direct co-firing.

There are several options for direct co-firing based on the

Property	Wood Pellets	Bituminous Coal
Heat Content (MMBTU/ton)	15.8 — 17.0	16.7 — 26.9[3]
Ash Content (% wt.)	0.6 — 2.0	3.3 — 11.7
Moisture Content (% wt.)	<8.0 (typical: 4.0 — 6.0)	2.2 — 15.9
Fines (% wt.)	0.1 — 0.5	10 — 15[4]
Sulfur (% wt.)	0.010 — 0.015	0.7 — 4.0
Nitrogen (% wt.)	0.03	1.5[5]
Mercury (% wt.)	0.16 E-8	2.21 E-8 — 6.91 E-7[6]
Diameter/Length (max)	1/4”/1.4”	Varies
Bulk Density (lb/ft^3)	45	43 — 50

All Coal-Fired Boilers in Wisconsin

Co-firing Rate (Percent by Energy)	1%	2%	3%	5%	10%	15%
Pellets Required (short tons)	280,574	561,148	841,722	1,402,870	2,805,740	4,208,611
Coal Replaced (short tons)	262,240	524,481	786,721	1,311,202	2,622,404	3,933,605
Pellet Plants Required (70KTPY)	5	9	13	21	41	61
Estimated CO_2 Abatement (tons)	725,095	1,450,189	2,175,284	3,625,473	7,250,946	10,876,419
Estimated NO_x Abatement (tons)	2.116	4.232	6.348	10.580	21.160	31.739

type of boiler, each requiring a different means of introducing the co-fired fuel. The first type of direct co-firing involves separate injection, which requires an independent feed and handling system for the secondary fuel. Separate injection co-firing may facilitate high feed rates between 10-15%. Though minimal biomass comparison testing has been done in the U.S., it is anticipated that even higher co-firing rates can be reached with pellets because of their favorable technical parameters. For instance, the 600 MW Amer-9 power plant in the Netherlands is currently powered successfully with 33% wood pellets and 67% coal.

A second, less expensive type of direct co-firing is co-milling, which involves treating the biomass as coal throughout the handling, feeding, and burner systems. Because the biomass is not isolated, co-milling is limited to biomass of a very fine particle size, such as sawdust.

Additionally, co-milling is limited to relatively small co-firing rates of 3% of total energy input for pulverized coal boilers, the most common utility boilers. Larger percentages cause excessive boiler efficiency decreases. Generally with increased percentages of biomass, the heat rate increases, resulting in a less efficient boiler. The main cause of this is latent heat loss from moisture and hydrogen combustion due to the biomass. This can result in higher back end temperatures, which causes increased heat loss. However, this problem occurs mainly with particularly wet biomass and is largely abated with low-moisture wood pellets.

MARKET FOR CO-FIRING IN WISCONSIN

Wisconsin has no coal reserves and must import approximately 26 million tons of coal annually. There are over 30 coal plants in Wisconsin totaling nearly 7,800 MW, including utility and industrial-scale plants. Wisconsin derives 61% of its electric generation from coal , but its major utilities currently generate about 3.09% (We Energies) and 6.19% (WPS) renewably . However, Wisconsin is one of the richest woody biomass-producing states, growing approximately 16 million bone-dry tons annually, 68% more than it harvests. Based on the prevalence of both coal plants and woody biomass, Wisconsin and the Great Lake States have a substantial potential for co-firing.

Each coal-fired boiler in the state is a candidate for co-firing with wood pellets; in fact, the majority of coal plants in Wisconsin utilize pulverized coal boilers, which are the most amenable for co-firing with pellets. As such, there is a sufficient potential market for co-firing in Wisconsin, modeled in the table below, which shows the potential demand for all coal-fired boilers in Wisconsin. The levels of biomass required can be met utilizing sustainable forestry practices.

COSTS & BENEFITS OF CO-FIRING

Modifications are required to coal boiler systems to allow co-firing with pellets; however, they tend not to be technically challenging nor cost-prohibitive.

The first addition required is a separate storage unit for the wood pellets, which is sized depending on delivery frequency and space availability; generally, utilities prefer continuous delivery minimizing on-site storage. This is also because pellets, unlike other forms of biomass, must be stored in an enclosed and dry space. Moisture addition causes pellets to lose their compact, cylindrical shape and alters their physical properties, making handling more difficult.

Additionally, a separate feeding and handling system may be needed dependent on the plant's coal receiving and handling configuration. This system can consist of current technology, such as belt or pneumatic conveying systems.

From there, the pellets may proceed to their own sizing process, similar to the coal pulverizer. Because pellets are less difficult to grind, a separate pulverizer that applies a smaller force is required. Modifications to the boiler itself are not required; this is not the case with many other forms of biomass, specifically high-moisture biomass and agricultural waste, which can often cause excessive fouling due to additives such as fertilizer.

Using wood pellets for co-firing in coal boilers, in addition to making technical sense, would benefit Wisconsin's economy with direct and indirect jobs created by new pellet mills. There are also benefits associated with the property and sales tax that the facilities bring to the state with additional tax revenues generated by harvesting, transportation and O&M wages.

Another benefit to co-firing wood pellets is the long-term stability of fuel cost. Biomass pricing follows a steady pattern similar to that of coal, which is desirable in co-firing because it is likely that any cost increase due to the biomass fuel will be very predictable.

Co-firing with pellets and other types of biomass has generally shown to be cost-effective in comparison with other renewable technologies. The chart below shows the levelized cost of several types of renewable technologies, including co-firing.

Up-front fuel cost is the main concern involving pellet co-firing. On a per megawatt basis, pellets will always be more expensive than raw biomass because of the conversion cost. However, pellets avoid many of the difficulties associated with raw biomass, such as high moisture, inconsistency of product, fuel specifications, excessive storage space, less BTU delivered per truck or railcar, and boiler slagging and fouling, among others. Wood pellets result in fewer and less costly modifications to the system and predictability in operating a coal boiler under co-firing conditions, day in and day out.

In the long run, it is more economical and technologically stable to co-fire with wood pellets than raw biomass.

REGULATORY OUTLOOK

One aspect of co-firing that cannot be ignored is the incentive to do so. Though Wisconsin has an RPS which requires 10% renewable generation by 2015, it applies only to utilities. A fair amount of the coal users in Wisconsin are industrial-grade boilers, which are not constrained by the RPS.

Furthermore, penalties for non-compliance with the RPS are not clearly defined and escape clauses make penalties less enforceable.

In spite of these challenges, co-firing has repeatedly been shown to be the least expensive and most readily adaptable of renewable generation methods.

Some utilities within Wisconsin are already planning ahead and beginning the testing and design phases required to co-fire. As demand for renewable energy increases, it is necessary to be prepared to implement renewable technologies quickly and inexpensively, and starting now places coal users in an ideal position.