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Bringing biomass to power plants p.42

forced into the mold

[Pressures from inside and outside can force companies to resemble one another—often with disastrous consequences.]

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helping the lights stay on

Cofiring biomass with coal is a relatively inexpensive way to extend U.S. energy resources.

By Daniel Mahr

The environmental path today has become more uncertain than it was only a few years ago. Is carbon dioxide a pollutant? Geologists understand how the world has evolved, and it has nothing to do with the last 100 years. As seen in recent revelations, however, the motives and methods of the most quoted CO_2 control advocates are questionable. There is political pressure to curb CO_2 emissions from fossil fuels; there is political pressure to resist change.

Regardless of where you stand on the issue of global warming, what is certain is that electricity is an integral part of our culture. It's a good barometer of our economy and society's advancements. We are continually inventing new ways to use electricity in automated production, labor saving tools, life saving devices, and as a means to increase our comfort, communicate better, and entertain. It powers mass transit and perhaps soon personal transit—plug-in electric cars, which will ask more from our generating and distribution infrastructure. Will we be ready? We don't think about electricity until there's a power interruption. Then it makes the evening news.

It is equally certain that, however abundant we may believe they are, our fossil fuel resources are finite. Even if they last for the next couple of hundred years, that's a small timeframe considering that the formation of coal, oil, and gas dates back hundreds of millions of years. At some point, we will be judged poorly if the world's energy resources are squandered, because that was just the cheap, easy thing to do.

The power industry is confronting challenges with seemingly conflicting goals—charging affordable rates, providing dependable service, reducing the impact on

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the environment, and at the same time delivering value to stockholders. In the United States, there is also a concern about energy independence—primarily reducing reliance on imported oil.

Different energy conversion technologies have their applications, but no single option does it all. Wind, solar, and hydro options don't need any fuel, but have their limits.

Wind power is best sited where the air currents are, but away from migration pathways and away from neighbors who object to noise and fluttering shadows. It will likely require 100 percent back-up or additional energy storage systems for calm weather, as well as new, longer transmission lines to load centers. There are similar requirements for solar power, just substitute lumens for velocity. It's the delivered cost on your utility bill that counts; the capital cost of the plant itself is only one component.

Hydropower is well established, but probably not widely expandable in the United States. Besides, there are issues over fish migration, land use, the impact of a drought on production, as well as geological concerns for supporting the weight of a new lake and stability concerns for newly saturated perimeter hills.

Large power plants provide the reliability and flexibility that utilities require for baseload, cycling, and on-demand situations.

Following the oil crisis in the 1970s, the country realized that it might not be a good idea to use oil in our central generating stations. It was no longer the low-cost option and it increased our dependency on others. We use gas for power generation, even though household heating and cooking bills have increased and the petrochemical industry has taken a hit.

Nuclear power is being revisited as a means to build large, central generating stations that do not produce CO_2. The distrust of nuclear power is strong in the U.S., and still there is no place to store spent nuclear fuel. A fully constructed nuclear plant on Long Island was never commissioned due to public concerns. That's not a good example of how to keep rates affordable.

No one technology will be the solution to keeping our lights on. There are good reasons why a diversified generating portfolio with a base of large, central generating stations near load centers has evolved. Large, central generating stations provide economies of scale.

Initially, wood and other biomass powered society's early development. As accomplishments in science and engineering began to change our world, coal became the fuel of choice to power the industrial revolution, and that legacy remains. Today approximately 50 percent of the United States' electrical power is generated from coal, which remains a low-cost fuel.

Large sectors of the U.S. economy are tied to coal—mining, rail and waterway transportation, steel, and power. Coal deposits are regionally dispersed, perhaps a reason why those in some cosmopolitan localities might lack an appreciation for how it drives our economy. The U.S. is fortunate to have large coal deposits. We should wisely use this resource.

The role of biomass—wood, stalks, prunings, forest and agricultural residues, and most recently, energy crops—is being reassessed today, as a means to recycle carbon emissions. But it can also be used in conjunction with fossil fuels—particularly by cofiring with coal—as a relatively low-cost means of reducing our consumption of finite fuel resources.

Biomass is produced by photosynthesis. It is stored solar power. Biomass can be substituted for coal, in varying degrees, in existing pulverized coal plants. New, large power plants are being designed to utilize biomass as the primary fuel, most notably in circulating fluidized bed combustion boilers. Biomass is available now and new sources are being developed.

In several ways, biomass can complement the use of coal. This should not be too surprising. Coal is formed by nature from plant matter, with the passing of time, with favorable environmental conditions. Newly mined coal is old biomass.

While biomass-fired plants have been a part of the scene for some time, they are relatively small, 25 to 50 MW, and often address specialized local conditions. In California, they are helping to reduce air pollution by replacing the open field burning of agricultural residue.

Adapting coal-fired units to cofire biomass requires additions and modifications, but compared to starting a new plant from scratch, it's a relatively low-cost, low-risk method to add renewable energy to the plant fleet. In a cofiring application for a pulverized coal plant, biomass can replace 20 percent of the coal being used.

With cofiring, power generation is not dependent upon biomass, so there is a lower risk of technology entry than with other renewable energy options. Biomass can be used when supplies are available. The plant can return to 100 percent coal firing, if needed to keep our lights on.


GWF POWER

Biomass can be assembled from wood scraps (opposite) or agricultural waste. It is used at a 25 MW power plant in California (right).

BÖHRINGER FRIEDRICH

▲ ENEL burns biomass with coal at a plant on Sardinia. Shown are the yard bin and biomass handling and processing systems.

ENERGY ASSOCIATES

▲ A 4,000 MW Drax coal-fired plant in the United Kingdom includes storage silos for biomass pellets.

The European Union expects all member states to supply 20 percent of their energy requirements by 2020 from sustainable forms of energy. Options include wind, landfill gas, and biomass—with small contributions from solar, geothermal, and wave power.

In the United Kingdom, perhaps the largest cofiring project has recently been installed by Drax Power at a 4,000 MW, coal-fired plant in Selby, North Yorkshire. This is the largest coal-fired station in the U.K. and provides enough power to meet 7 percent of the country's electricity needs.

Drax Power began experimenting with a system that blends biomass with coal, using the existing emergency coal reclaim hopper. Based upon the success of that project, Drax Power recently completed an £80 million ($150 million) direct-injection biomass system. Together, the 100 MW blending and the 400 MW direct-injection systems provide 500 MW of biomass generating capacity.

Biomass is also being cofired in circulating fluidized bed boilers. One of the attributes of CFB technology is its ability to use a variety of solid fuels. Very often, a CFB boiler will be using a high-ash, high-sulfur fuel. The low-ash and low-sulfur characteristics of biomass make it a convenient foil to offset the undesirable characteristics of low-quality coal.

ENEL's Sulcis Plant in Portoscuso, on the island of Sardinia, currently has two units, a 240 MW pulverized coal boiler, which has a flue gas desulfurization system, and a new 350 MW, Alstom Power fluidized bed boiler. When the fluidized bed boiler was retrofitted to the plant, two 240 MW pulverized coal-fired boilers were removed. The plant now uses a blend of South African, Colombian, and Sardinian coals.

The Sardinian coal is from a local mine and preparation plant. It has moderate ash content, relatively high sulfur levels, and high moisture content. Biomass is a maximum of 15 percent of the fuel input by heating value. The CFB unit is reducing CO_2 emissions two ways: by using less coal with a more efficient boiler and by cofiring biomass. The use of local coal and local biomass helps Sardinia's economy.

Biomass can be added to an existing coal-fired plant in a repowering program. Public Service of New Hampshire, a subsidiary of Northeast Utilities, replaced an old, inefficient coal-fired unit with a new 50 MW combination biomass- and coal-fired CFB boiler that normally uses 100 percent biomass at the company's Schiller Station. According to Richard Despins, the plant manager, PSNH is pleased with the overall results and the biomass unit is a win-win-win project—for the company's customers, for the regional economy, and for the environment.

For new generation capacity, there are good reasons to consider a CFB boiler. The technology is proven, has been used since the 1980s, and can be used to repower existing coal-fired plants or to serve new greenfield sites.

Drax Power has been investigating the addition of three 300 MW biomass-fired plants in the U.K. One would be located adjacent to its existing 4,000 MW Drax coal-fired plant and another in the Port of Immingham. Sites for the third plant are being evaluated. A variety of biomass products are being investigated including wood chips, wood pellets, miscanthus briquettes, straw pellets, bagasse briquettes, and logs. Much of the fuel will be initially imported while indigenous sources are developed.

FUEL ATTRIBUTES

For engineers designing a biomass-fired power plant, many of the systems and components will be familiar and proven. Biomass fuel procurement decisions, however, have a great impact on a solid fuel power plant's design and its fuel processing, handling, and storage features. A successful application must consider the fuel first and provide the flexibility needed to handle the range of properties and characteristics that will be experienced.

Fuel properties and characteristics are important to boiler and plant design and operation. Different boilers have unique design and fuel requirements. Heating value, percent volatiles, total ash and moisture content, ash constituents, particle size, and energy density are all key parameters to consider.

One of the limitations of biomass is its relatively low energy density. Both the lower mass heating value and low bulk density conspire to require six times the volume of fuel to produce the same energy as bituminous coal. To address this issue, which is significant for large power plants, a biomass pre-treatment industry is developing.

Pelletizing biomass is one pre-treatment option. Pellets are popular with some homeowners who are installing pellet stoves to reduce their high heating bills.

Pellets are formed in a process that dries, mills, conditions with binders, extrudes, and then cools the product. A variety of biomass feedstocks can be used. The pellets are cylindrical, 6 to 8 mm in diameter and 15 to 25 mm long.

Pellets are a convenient biomass product for cofiring in a coal-fired plant. Like grains and other agricultural products that are stored in silos, pellets must be protected from the weather, or they will swell and degrade.

The properties of biomass can be further improved through a thermo-chemical process known as torrefaction. Biomass is heated at a temperature of 250 to 300 °C, in a reducing environment, typically for an hour. During this time, the biomass partly decomposes giving off volatiles. The torrefied biomass char can then be processed into pellets. Torrefaction improves the product's energy density, hydrophobic nature, grindability, uniformity, and durability.

Torrefied pellets can be stored in outdoor stockpiles and handled much like coal. Because of its low ash and sulfur content, torrefied biomass can be marketed as instant clean coal. It has perhaps half of the energy density of coal, which is a big improvement in comparison to untreated biomass products. A couple of manufacturers—Integro Earthfuels in the U.S. and Topell BV in the Netherlands—are moving this technology from the demonstration to the commercial stage.

While nature has provided only so much coal, we will be able to grow and torrefy biomass while recycling carbon dioxide. If we are smart, we will utilize agricultural and forest waste products and develop new energy crop industries, rather than upset the agricultural industry. Energy farms might make resource-poor countries less dependent on oil-rich nations and provide a new export product to uplift their economies.

WHAT'S THE INCENTIVE?

The move to renewable energy technologies requires either economic incentives or government mandates; these technologies would be already used in abundance if that wasn't the case.

Burning biomass can be more expensive than just using coal. There is a capital cost in adding systems for handling and firing biomass at a plant. The cost of biomass fuel and its transportation can be important factors. It is typically more expensive than coal, but at present costs less than oil or gas. The higher moisture content of biomass will result in a higher heat rate for the unit, so more fuel will be required.

ENERGY ASSOCIATES

▶ Pelletizing improves the energy density of biomass and so can reduce transportation cost.

If the objective is to decrease CO_2 emissions from coal, gas, and oil while making electrical energy affordable, industry should be given the responsibility to do it at the lowest cost. That's not, however, how it is being done.

In the U.K., long-term subsidies for biomass are set at only a quarter of the rate for wind power, and then the amount of crops that can be used is capped. That's not an incentive for biomass. It is cheaper just to use coal, and utilities are hard-pressed to justify higher rates to customers and lower returns to shareholders.

In the U.S., open-loop biomass plants (those that use a variety of agricultural, forest, and construction waste products rather than a dedicated energy crop) received only half the subsidy of other renewable sources and this incentive expired in December 2009.

While incentives help us to accept renewable energy, they are not free; incentives only move the cost from our electric bill to our income tax payment—if not today, at some future point, with interest. Washington can shuffle the deck and scramble the chips, but the debate should be about how we can best produce affordable, dependable, and sustainable power.

If we are serious about conserving resources and reducing CO_2, conservation should be a priority from the bottom up. The consumer has control. We know from the rules of supply and demand that consumption is reduced when the price goes up. We saw that gasoline at $4 a gallon makes small and efficient cars popular.

Instead of increasing income or production taxes, the country can use a sales or consumption tax. We'll avoid penalizing the economy while encouraging conservation. It is unclear if special interests, environmental fashions, and political pragmatism trump power economics, consumer knowledge, and taxpayer tolerance.

THE WINNING HAND

We don't have a crystal ball, so the future is a gamble. If we lay our cards on the table, the goals for dependable, economical, and sustainable energy have a number of players. Wind, solar, hydro, gas, nuclear, coal, and emerging technologies all have a place in the game. The unique attributes of biomass should be considered. With all that we know, it's part of the winning hand. ■

Editor's note: This article is adapted from a paper, "Biomass Attributes, Handling, and Processing Issues for Large Power Plants," which was submitted to the ASME 2010 Power Conference, July 13-15. The full text of the paper is available online at www.memagazine.org.