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Issue Brief

Biomass Cofiring: A Transition to a Low-Carbon Future

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Global climate change is one of the biggest threats facing the world today. Climate change has the potential to produce widespread and devastating environmental changes, many of which may be difficult to predict and impossible to reverse. The repercussions of these changes will be far-reaching, with particular effects not only on the environment and the economy, but also on human health and welfare.[1]

The primary driver of climate change is the emission of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Of these, carbon dioxide poses the greatest threat. These emissions arise from a number of human activities, including land use change (deforestation) and the burning of fossil fuels. In 2007, the U.S. derived 70 percent of its electric power from fossil fuels and only 9 percent from renewable sources.[2] Coal alone generated 51 percent. Long term climate objectives will ultimately require a transition away from fossil energy to an energy system that is fully renewable. Cofiring is a quick and inexpensive way to replace fossil energy with renewable energy in the electric sector - a potentially valuable tool during this transitional period.

What is biomass cofiring?

Biomass cofiring refers to the simultaneous combustion of a biomass fuel and a base fuel to produce energy, usually electrical power. The most common base fuel is coal. The most common sources of biomass fuel include low-value wood from forestry activities, crop residues, construction debris, municipal waste, storm debris, and dedicated energy crops, such as switchgrass, willow, and hybrid poplar. Most biomass feedstocks must undergo significant processing before they can be utilized for cofiring. The shape, size, and moisture-content of feedstock particles need to be adjusted to meet specifications.

Once the feedstocks are prepared, cofiring is a relatively simple process. A mixture of coal and biomass (typically containing less than 20 percent biomass by energy content) is fed into a modified coal-burning power plant to produce energy. Cofiring systems can be broadly classified as blended delivery systems, in which the two fuels are blended prior to injection, or separate feed systems, in which they are injected into the system separately.[3,4] The former requires less modification to the power plant, although modifications are generally simple for both approaches. Additional modifications to the fuel-handling, processing, and storage systems may be necessary.

COFIRING BENEFITS

Cofiring is a renewable technology

As long as biomass is harvested in accordance with a sustained yield (in which annual harvests do not exceed annual growth), production of energy from that biomass will produce no net carbon emissions above those used in harvesting, processing, and transportation. Although the majority of energy produced in cofiring derives from fossil fuels, the biomass fraction of the total energy load is fully renewable.

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[1] Epstein, P. R. 2005. Climate Change and Human Health. New England Journal of Medicine 14: 1433-1436.
[2] Energy Information Administration. 2007. U.S. Primary Energy Consumption by Source and Sector.
[3] National Renewable Energy Laboratory. May 2004. Federal Technology Alert: Biomass Cofiring in Coal-fired Boilers, DOE/EE-0288. 40 p.
[4] Brem, Gerrit. Biomass Cofiring: Technology, Barriers and Experiences in EU. Presentation to the GCEP Advanced Coal Workshop, March 15-16, 2005, Provo, UT.

Cofiring reduces emissions of greenhouse gases and air pollutants

Using biomass as a supplementary fuel in coal-fired plants reduces total air emissions. Assuming a carbon-neutral biomass resource, CO_2 emissions will decline linearly in proportion to the amount of coal offset by biomass. Most sources of biomass have negligible sulfur concentrations, so sulfur dioxide (SO_2) emissions also decline linearly as the coal fraction is reduced and more biomass is added. Biomass combustion does produce nitrogen oxides (NO_x), so reductions in NO_x emissions during co-firing are less easily quantified. Cofiring wood at 7 percent of total heat input has been shown to reduce NO_x emissions by up to 15 percent compared with a conventional coal-only operation.[5] One of these nitrogen compounds, nitrous oxide (N_2O), is also a greenhouse gas with nearly 300 times the effect of CO_2.

There are several health-related benefits resulting from reduced emissions. A study by the World Health Organization (WHO) in 2005 concluded that climate change was directly responsible for 5 million illnesses across the globe, including 150,000 fatalities.[6] Additionally, SO_2 and NO_x emissions contribute to a number of air quality problems, including the formation of ground level ozone, a major component of urban smog. This ground level ozone poses health risks for asthmatics, children and the elderly. SO_2 and NO_x emissions also contribute to acid deposition, which degrades the water supply, as well as soils and agricultural crops. Reductions in these emissions would therefore decrease many of the health risks directly associated with poor air and water quality.[7]

Cofiring complements sustainable land management

Biomass utilization will benefit forests, agricultural landscapes and other ecosystems. For example, harvesting of excess biomass in fire-prone forests ('hazardous fuels reduction') is commonly done to reduce the frequency and intensity of catastrophic wildfires. These activities are now more important than ever as the cost of fighting wildfires has increased dramatically. Wildfire suppression costs averaged $900 million annually between 2000 and 2006; annual costs exceeded $1 billion in four of those seven years.[8] In the western United States alone, there are 28 million acres of forest currently in need of thinning.[9] Small budgets and lack of a market for small-diameter logs are the main impediments to these necessary treatments; cofiring has the potential to expand markets and make thinning treatments affordable. Thinning and removal of small-diameter, low quality biomass can also be an important component of wildlife habitat management, timber stand improvement, and other forest stewardship activities. On agricultural lands, the cultivation of perennial, low-input crops (such as switchgrass or willow) can conserve soil resources and reduce need for water and nutrients. By adding value to working lands and rural landscapes, demand for biomass resources can help reduce urban sprawl, deforestation, and development of open lands.

Cofiring makes economic sense

Cofiring with biomass offers a cheap and practical means of reducing carbon emissions using existing infrastructure. The capital costs for cofiring are generally low and usually limited to retrofitting boilers with modified delivery systems. Compared to other forms of renewable energy, the up-front investments needed for co-firing in existing boilers are fairly small.[10] These retrofits are often substantially less expensive than the costly overhaul that would otherwise be needed to meet increased emissions standards. For older boilers, especially, cofiring may be the most cost-effective way to reduce emissions.[11] In addition to the low initial investment, the annual fuel costs are often lower in cofired plants

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[5] Hughes, E. E. (No Date). Utility Coal-Biomass Cofiring Tests. [Online] http://www.netl.doe.gov/publications/proceedings/98/98ps/ps4-2.pdf

[6] Eilperin, J. Climate Shift Tied to 150,000 Fatalities. Washington Post 17 November 2005.

[7] Environmental Defense. (No Date). Power Plants, Pollution and Soot: How to Halt the Increasing Threat to Clean, Healthy Air. [Online] http://www.environmentaldefense.org/page.cfm?tagID=78

[8] U.S. Forest Service. April 2003. A Strategic Assessment of Forest Biomass and Fuel Reduction in Western States.

[9] Fong, P. K. and US Department of Agriculture (USDA). January 30, 2007. Statement of the Honorable Phyllis K. Fong, Inspector General, Before the Senate Committee of Energy and Natural Resources.

[10] Nelson, H. T. April 17, 2006. Coal- to-Biomass Cofiring at the Boardman Pulverized Coal Plant.

[11] ibid

(between $60,000 and $100,000 less for an average-sized boiler at a federal facility[12]) than in plants burning pure coal. These annual savings can result in short payback periods on initial investments of less than 10 years and reduce production costs between 0.02 and 0.22 ¢/kWh. As an added incentive, carbon reductions due to cofiring will generate valuable carbon credits in the cap-and-trade carbon market. The Chariton Valley Project, a switchgrass cofiring experiment that took place in 2006 in Iowa, generated 19,600 renewable energy credits over the course of six months.[13] The experiment, which ran for 1,675 hours, produced 19.6 million KWh of electricity and reduced carbon emissions by 50,800 tons compared to burning pure coal. In a future characterized by climate legislation and/or renewable energy mandates, cofiring can reduce carbon emissions while maximizing the revenue potential of sunk investments in existing coal-fired facilities.

In addition to aiding the power generation industry, cofiring would also generate increased demand for sustainable biomass, adding value to unmerchantable byproducts, creating new market opportunities, and supporting rural economies. The use of wastes and residues for energy generation would result in lower costs and reduced environmental impacts associated with waste removal and landfill dumping.

BARRIERS AND PROBLEMS

Costs

Although initial investments for cofiring may be low, they are not zero. Unit costs for retrofitting coal boilers generally range from $50 to $300 per kW (of biomass energy output) depending on boiler type.[14] Total costs vary depending on the type and condition of boiler being modified, as well as the biomass delivery system that is selected, with separate feed systems costing up to four times as much as a blended delivery system.[15] The costs associated with feedstock preparation ultimately depend on the type and condition of biomass being used, the boiler specifications, and the processing equipment available, and is greatly dependent upon the blending ratio, as biomass has a fuel density roughly $1/10^{th}$ that of coal.[16] The cost structure of feedstock is an important consideration, and gives fuel from agricultural residue an advantage over dedicated fuel crops, as residue is produced essentially for free (ignoring transportation and treatment costs) whereas fuel crops are custom grown and sold.[17]

Ash contamination

Many power companies derive additional income from the sale of fly ash, a byproduct of coal combustion and an important additive in cement used in 'green buildings' and other applications. Although fly ash from biomass co-firing is a comparable product,[18] the current ASTM standard (C618) requires that only pure "coal fly ash" be used in cement manufacture.[19] Until this standard is amended, cofiring facilities will be unable to market this product, effectively producing pure, valueless waste.

POTENTIAL FOR THE FUTURE

[12] National Renewable Energy Laboratory. May 2004. Federal Technology Alert: Biomass Cofiring in Coal-fired Boilers, DOE/EE-0288. 40 p.
[13] DOE State Energy Program (SEP). October 2006. Iowa Utility Mixes Switchgrass with Coal in Cofiring Test. [Online] http://www.eere.energy.gov/state_energy_program/project_brief_detail.cfm/pb_id=1057
[14] National Renewable Energy Laboratory. May 1999. Biomass Cofiring: A Renewable Alternative for Utilities and Their Customers, DOE/GO-10099-758. 4 p.
[15] Grabowski, P. March 11, 2004. Biomass Cofiring. A Presentation to the DOE/USDA Technical Advisory Committee.
[16] Baxter, L, and Koppejan, J. Biomass-Coal Co-Combustion: Opportunity for Affordable Renewable Energy.
[17] ibid
[18] Baxter, L. and S. Wang. August 1, 2006. Fly ash and concrete: a study determines whether biomass, or coal co-firing fly ash, can be used in concrete. The Concrete Producer, August 2006 issue.
[19] National Renewable Energy Laboratory. June 2000. Biomass Cofiring: A Renewable Alternative for Utilities, DOE/GO-102000-1055. 2p.

Cofiring carries a great deal of promise as a potential "bridge-technology," as it provides a low-cost, low-risk method of cutting greenhouse gas emissions and reducing overall fossil fuel use. Replacing 5% of the coal used in U.S. power production with biomass would reduce total U.S. emissions by 1.5 percent. Furthermore, cofiring has the potential to reach these reductions within the next 5-10 years. In addition, using biomass feedstocks for cofiring may prove considerably more cost-effective for carbon mitigation than cellulosic ethanol production, as the latter is likely to cost more than $1/gallon produced, comparable to a carbon price of $200/ton or more (making it four times as expensive for carbon mitigation purposes).[20] However, it is important that cofiring serve as a stepping stone to a renewable energy future and not as a means to build new coal facilities or to keep outdated and inefficient power plants in operation. Cofiring holds a great deal of promise and, backed by an effective and responsible policy framework, could prove to be a vital tool in the effort to reduce global carbon emissions at home and abroad.

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[20] ibid