Report of a One-Day Forum

Co-Firing II
Co-firing Coal and Biomass in Utility Boilers

sponsored by

Office of Utility Technologies, U.S. Department of Energy
Northeast Regional Biomass Program
Southeast Regional Biomass Program
Great Lakes Regional Biomass Program

prepared by

Barry Lawson Associates
Old Cemetery Road
Peacham, Vermont 05862

January 1997

On November 19, 1996, a one-day forum on co-firing coal and biomass in utility boilers was held in Cincinnati, Ohio. This by-invitation-only forum was sponsored by the Office of Utility Technologies, U.S. Department of Energy; the Northeast Regional Biomass Program of the Coalition of Northeast Governors; the Southeast Regional Biomass Program; and the Great Lakes Regional Biomass Program. This was the second forum held on this topic, the first being in Philadelphia in 1994.

The purposes of this forum were to:

- Learn developments since 1994 in co-firing coal and biomass successfully;
- Identify issues or challenges remaining to be overcome in co-firing; and
- Develop recommendations and commitments for overcoming these barriers.

The program featured three opening presentations and both large and small group working sessions. Attendees included researchers, industry consultants, policymakers and utility representatives with experience in this field. The meeting was managed by a professional facilitator, Barry R. Lawson of Barry Lawson Associates, who was responsible as well for preparing this report. He was assisted by a number of participants who reviewed the draft report and suggested clarifications and other improvements. Their contributions are appreciated.

Summary of Presentations

After an introduction by Rick Handley of the Northeast Regional Biomass Program, presentations were made by Edward E. Gray, P.E. of the Antares Group (Overview of Co-firing, Lessons Learned); Philip Goldberg of the Federal Energy Technology Center, formerly the Pittsburgh and Morgantown Energy Technology Centers (Testing Combinations of Coal and Biomass); and Karl Hauser of Edward C. Levy Cement Co. and Chair, ASTM Committee on Blended Cements (Standards for Fly-Ash in Concrete).

Overview of Co-firing, Lessons Learned, *Edward E. Gray, P.E.*

Ed Gray of Antares Group explained the reasons why biomass co-firing can be attractive to utilities and discussed typical areas of concern about implementing co-firing. Potential benefits of co-firing with biomass fuels include obtaining a low cost fuel supply; providing an outlet for industrial customer residue products, while reducing SO_2, CO_2, and in some cases NO_x emissions. The various technical concerns of station managers considering the use of biomass fuels include: impacts on boiler operations and environmental controls; increased operating and maintenance costs; possible changes in coal ash marketability; decreased boiler and overall efficiency; capacity derating; required additional fuel storage capacity; dust control; possible increases in slagging and fouling; and increased truck traffic. Experience in previous co-firing applications has provided answers to most of these concerns. In properly selected and planned co-firing applications, the benefits will outweigh the potential negative impacts.

Procuring a dependable fuel supply is the key to success in using biomass fuels. If a reliable long-term supply of biomass fuel is available at a low cost and sufficient for 10 to 15% of the heat input for a single boiler, the opportunity for biomass use in a co-fired plant is good. Plant managers, Gray said, must see direct benefits in terms of lower production costs, a three-year payback on investments , fuel diversity as a benefit to plant operations, and reductions in SO_2, CO_2, and preferably NO_x. Co-firing biomass could assist managers in meeting requirements of the Clean Air Amendments and could provide a positive economic impact on local communities by creating jobs for growing, harvesting, processing, and transporting biomass feedstocks. With respect to emissions, Gray noted that SO_2 reductions are obtainable, but NO_x reductions are presently difficult to predict and very specific to boiler and feedstock characteristics. Net atmospheric CO_2 reductions will result due to CO_2 uptake during the growth of biomass feedstocks and the avoided addition of new atmospheric CO_2 from the burning of fossil fuels. When co-firing with biomass, the percent CO_2 reduction for the power plant is approximately equal to the percent of the total boiler heat input which is obtained from biomass feedstocks.

Gray explained some of the factors affecting capital costs and the benefits that co-firing plants are currently experiencing, and he identified some of the utilities pioneering co-firing (e.g., TVA; Southern Company, including Georgia Power; Savannah Electric; New York State Electric and Gas; Madison Gas and Electric; and others).

Among the lessons learned about co-firing are that cyclone boilers can co-fire moderate percentages of biomass (up to about 10% on a heat basis, or about 20% by mass) with minimal biomass fuel processing; small efficiency decreases, and moderate capital costs ($150 to $210/kW of biomass power). For pulverized coal boilers, biomass co-firing has been done at small percentages (up to 2% on a heat basis, or about 5% by mass) for less than $100/kW using existing fuel processing and handling equipment. Installing separate feed systems for biomass has allowed utilities to co-fire at higher percentages (up to about 15% on a heat basis, or about 30% by mass), but generally requires a higher capital investment ($150 to $400/kW of biomass power). Utilities which have been successful at co-firing have been resourceful in finding their fuel supplies and in minimizing capital investments by making use of used equipment and machinery available in stocks.

During the question period, Gray noted that the Electric Power Research Institute (EPRI) has a spreadsheet that can help utilities decide whether co-firing makes sense. This calculation is relatively simple if the price of biomass relative to coal is cheap. With respect to tax incentives as a factor in co-firing, he said that it depends on whether there are state incentives available. These incentives vary from state to state. Moisture content is not so much a factor affecting price as other options the biomass producer has for selling his product. Transportation cost is an important factor, as it is not included in the price of biomass as it is with coal.

Testing Combinations of Coal and Biomass, *Philip Goldberg*

Philip Goldberg of the Federal Energy Technology Center (FETC) described a variety of research projects currently being funded through FETC regarding biomass as a fuel and more specifically, co-firing. He described the Coordinated DOE Coal/Biomass Co-firing Program as a joint effort among Energy Efficiency, Renewable Energy, and Fossil Energy programs at DOE, and invited the participation of other interested groups.

Goldberg emphasized that there is a large amount of biomass fuel available. He explained some of the research issues surrounding biomass combustion such as the behavior of inorganic materials which are more problematic with agricultural crops than they are with either coals or woody biomass materials. In addition to the combustion research that is ongoing, he identified research and development needs. These include fuel characterization, handling and blending challenges, combustion behavior, ash deposition, corrosion, effects on NO_X, SO_2 and other emissions, toxics of concern in the Clean Air Act Amendments, and use of fly ash.

In response to questions, Goldberg noted that the report from the first phase of FETC-sponsored research should be available in a few weeks and that all results are available to the public. He also mentioned that experiments are being undertaken with fuels that mix wood and non-wood materials (e.g., plywood), and that it has been discovered that properties of biomass may make it more effective under certain conditions than coal or gas in reburning. He also noted that the Danish government requires utilities to burn 25% straw with coal, and that this has provided an opportunity for plant managers to overcome the problems straw presents. The International Energy Agency has recently published a report on the co-firing experience of nations around the world.

Standards for Fly-Ash in Concrete, *Karl Hauser*

Karl Hauser of Edward C. Levy Cement Co. and Chair, ASTM Committee on Blended Cements, described the process of developing ASTM standards with regard to ash content in cement and concrete (and explained the difference between the two -- "cement is to concrete as flour is to bread"). The difficult challenge of getting current standards modified and developing appropriate procedures for specification approvals was highlighted. Accomplishing these entails, at a minimum, proving that ash not only does no harm but has beneficial qualities for cement and/or concrete, and obtaining a sponsor and drafting specifications that can be put before and passed by the appropriate ASTM subcommittee(s), committees and full Society with "no negative persuasive votes." If adopted, then the challenge becomes to persuade people to use the new (superior) product. Mr. Hauser suggested that specifying biomass ash concrete products for in-house projects was the first step to convincing others that the product is a good one.

During the question period, a number of participants tried to identify short-cuts through or around the ASTM adoption process. These included possible redefining of ash or the acceptable chemical constituents of ash, drawing on the experience of other nations, and (the most encouraging) showing that the ash-content material can meet important performance standards rather than material specifications.

An outline of Hauser's presentation appears in the appendix of this report.

During the next session of the forum, the entire group identified the barriers that remain to be overcome to make co-firing a more viable alternative for utilities burning coal. The barriers were then categorized under four headings and a group priority-setting process further refined the list to those barriers the group would address later in the forum.

The group first identified a large list of barriers to co-firing. Each person was then given three votes to identify the three specific barriers that he/she felt were either most important, most challenging, or the ones that the group should concentrate on during the remainder of the forum. The entire list of barriers, by heading, in the order of number of priority votes () given to each, follows. If no number is given, that item received no priority votes. It should be noted that there are interrelationship among some of the items on each list, so a vote for one item could also be interpreted as a vote for another item (e.g., under Technical and Performance Barriers, NO_X increases. . . and Combustion Behavior). No attempt was made to eliminate these relationships before voting occurred.

<u>Economic/Procurement Barriers</u>

- Procurement Specifications (21)
- How One Values Biomass in Relation to Coal (7)
- Controlling Operating and Maintenance Costs (1)
- Insuring Boiler When Shifting Fuel Mix
- Resistance to the Use of Solid Fuels
- Fuel Supply

Technical and Performance Barriers

- Handling, Processing, and Blending Processes (15)
- NO_X Increases Frustrating Biomass Burning (6)
- Slagging and Fouling of Equipment (5)
- Mill Cost as a Function of Moisture Content and Other Factors (4)
- Interaction of Coal/Biomass in Cyclone Boilers (up to 40% biomass) (4)
- Speed of Biomass Burning (2)
- Non-biomass Contaminants (2)
- Combustion Behavior (2)
- ESP Performance (2)
- Site Specificity of the Problem (1)
- Ash and Moisture Content
- Net Heating Value of Fuel
- Effect on Co-firing of Biomass Pulverization
- Need to Study Biomass Intermediaries

Policy, Permitting and Information Exchange Barriers

- U.S. EPA Permitting Issues and Standards (9)
- Restrictive and Incentive Tax Policies for "Closed Loop" Systems (5)
- Government Collaboration in Fostering and Achieving Co-firing (4)
- Inclusion of Co-firing in a National Renewable Energy Portfolio (4)
- Resistance to Solid Fuels and Emphasizing Unique Advantages of Co-firing versus Other Emissions Mitigation Techniques (3)
- Information Exchange (2)
- Ownership Arrangements with Non-utility Co-generators (1)

Fly Ash-Related Barriers

- Marketability of Ash (15)
- Additional or New Markets for Ash (4)
- Fly Ash Components (2)
- Role of Gas Co-firing and Effect on Ash

During the remainder of the forum the participants worked in small groups to address the barriers with the highest number of priority votes. Each participant selected the group with which he/she wished to work. Seven groups were established: Procurement Barriers; Barriers Related to the Value of Biomass versus Coal; Barriers Represented by Handling/Processing and Blending; Barriers Related to NO_X Increases; EPA Permitting Barriers; and two groups on the Barriers Related to the Marketability of Ash.

Each of these groups developed a set of recommendations for overcoming the barrier(s) it focused upon. These recommendations follow.

The following represent the principal recommendations of small groups addressing barriers to wood co-firing with coal at utility plants. They are organized by major area of concern.

Procurement Barriers

The principal recommendations regarding procurement of biomass by utilities were:

- Procurement must be done at the plant level (site specific).
- The specifications of the biomass fuel available in the market must be known to procurement managers.
- Biomass must be given some priority by those dealing with this fuel, including brokers.
- Medium length coal contracts could be used as models for biomass contracts.
- Procurement personnel must first look at their plants' capabilities for burning biomass with coal.
- The plant itself will "define" the merit of alternative fuels and the ratio of biomass to coal mixtures.
- A determination must be made of whether treated and/or untreated biomass material should be used as co-firing fuel.

- ASTM standards for the production of fly-ash should be used to guide fuel selection.

- It is sensible to purchase fuel on the basis of delivered weight.

- So-called "greensealing" (i.e., production consistent with good environmental practices) should be used to get around permitting hurdles.

- Ash residue should not be an issue in wood procurement, but slagging / fouling is.

- Quality control (by the fuel buyer) overshadows other factors.

- Procurement personnel need to understand the markets for competing fuels.

Overcoming Barriers Related to the Value of Biomass Compared to Coal

Four major topics of discussion, viewed as key steps that need to be taken to promote biomass co-firing by emphasizing the benefits (value) relative to exclusive firing with coal were:

- Create a document that addresses all of the potential benefits offered by co-firing biomass. Since the decision to co-fire biomass will not be made unless it is economic for the power producer, this document should discuss methods to quantify each potential benefit in economic terms.

- Educate policy-makers on the benefits of biomass power (using material proposed above).

  [Note: In the near term, the economic viability of biomass may be highly dependent on regulatory incentives. Power producers will not co-fire unless it is economically beneficial to the company. The subgroup felt that biomass is presently under-valued from a policy/regulation perspective. This creates an uneven "playing field" which favors coal. The benefits of biomass co-firing that will likely be on most interest to policy makers are:

  1) co-firing can be used as a CO_2 mitigation (greenhouse gas reduction) strategy,

  2) biomass collection, planting, harvesting, processing and transportation can lead to job creation in rural communities, and

  3) biomass is a renewable resource.

  Policy revisions that would make biomass more economically viable include:

  1) regulations limiting greenhouse gas emissions, and the creation of a market-based trading system which values reduced CO_2 emissions;

  2) tax credits from local governments for power generators who, through the use of biomass co-firing, foster the creation of rural jobs, and

  3) a uniform, nation-wide requirement that the power generation portfolio for utilities include a minimum percentage of generation from renewable resources. A uniform, nation-wide requirement as opposed to requirements which vary from state to state would not favor or unfairly burden utilities based on geography (plant location).]

- Provide recognition to companies that co-fire (similar to the activities of other EPA and DOE voluntary programs such as the Green Lights, Energy Stare, and Climate Challenge Programs). This could create an additional incentive for power producers who commit to co-fire biomass.

- Provide access to resource availability, at the right price, using surveys of existing waste exchange services.

Among the potential benefits identified for biomass co-firing were:

- Cheaper fuel
- SO_2 credits
- CO_2 credits
- Enhanced public relations
- Local economic development
- Tax incentives
- Avoided chemical usage (scrubbers)
- Marketability of resulting ash (potentially a negative impact)

<u>Overcoming Barriers Related to Handling, Processing and Blending Biomass</u>

- Because it has different structural properties, biomass should be processed separately from coal, either on-site or off-site.
- Each plant site is unique and has its own challenges and opportunities.
- Bottom-line dollar savings will drive the whole process of co-firing.
- Expected slag and residual ash are major factors that will determine how

biomass fuel is selected and handled.

Overcoming Barriers Related to Nitrogen Oxides and the Burning of Biomass

- Regarding research, there are a number of needs:
  - Fundamental laboratory studies relating biomass' comparability with coal
  - Separating out the effects of moisture in the biomass
  - After the effects of moisture, analyzing the effects of unburned carbon
- Plans for co-firing mixed fuels can be developed based on other fuel parameters.
- Plant operators must coordinate co-firing within the context of their large-scale boiler operations.
- A model of how to control nitrogen oxides in co-firing should be developed.
- Plant operators should pay special attention to fuel properties, nitrogen reactions, moisture content of fuel, relationship of coal and biomass properties, and exit temperatures of burned fuel.
- The differences among wall-fired, cyclone, and tangentially-fired plants need to be understood.

- Reburn technologies, including the use of natural gas, should be investigated.

- Operators should also be aware of the possibilities of switching to a lower sulphur content fuel as a strategy for achieving emission improvements.

Overcoming Barriers Related to EPA Permitting

- Because of regulatory issues, operators should not mix municipal waste with co-firing fuels.

- Intergovernmental communication must be fostered and CONEG could be a principal source.

- Such communication could lead to enhanced dialogue between trade associations and EPA on the permitting issue.

- A positive image of the use of biomass should be promoted: waste is bad, resource use is good!

- The expansion of EPA's "XL" Program to include co-firing is appropriate. This would include underscoring environmental leadership, demonstrate the environment as the net winner, and lead to a collaborative enforcement forum.

Overcoming Barriers to the Marketing of Ash

The first ash marketing group provided the following recommendations:

- As a starting point, 75% of the existing boilers do not market ash; perhaps this group is the focal point for a dialogue.

- For those who do market ash, they need a more accurate and complete picture of the market and perhaps a study of ash utilization.

- EPRI's Coal Combustion By-products (ash use) manual can be of assistance.

- The American Coal Ash Association (ACAA) should add wood (biomass) to its agenda; the Composting Council may be able to provide information on ash for use as a soil amendment; and ash brokers may be helpful as well.

- ASTM specifications for ash should be pursued, perhaps funded by EPRI, the Department of Energy and the U.S. Department of Agriculture. This involves (a) learning the chemical constituents of biomass ash, (b) seeing how coal-fired ash performs in concrete, and (c) understanding how changes in boiler operation can affect carbon ash.

- The representatives of the various groups represented at this forum (e.g., ACAA) must alert their members who sit on ASTM to help facilitate changes needed in specifications.

- Someone should collect the growing database of ash from New York State Electric and Gas and others with experience in co-firing.

The second ash marketing group provided the following recommendations:

- Existing ash data should be used to determine or learn how ash performs relative to current ASTM standards -- this includes surveying European experiences as well.

- Try to work within ASTM's current C6-18 specifications: first, a standard allowing a small percentage of alternative fuels, and then allowing a larger percentage but tied to a performance standard.

- Consider European regulations regarding use of ash in the concrete industry to see if this provides valuable insight and experience.

- Operators should know that if loose ash is now marketed to a landfill, this could present a liability -- a practice which if halted, could result in potential savings.

- We need to get out the message that biomass is a renewable resource.

At the conclusion of the forum participants identified specific commitments they each could make to helping to overcome the barriers that were the focus of the day's discussion. Several commitments were forthcoming.

- The Federal Energy Technology Center is planning to spend $300 - 400,000 on R&D issues that were identified in the forum. This includes a more substantial co-firing research effort and subsequent dissemination of the results. FETC is also co-sponsoring co-firing demonstrations at several utilities (see EPRI, below).

- Small-scale coal users need to learn a lot more about co-firing and the replicability of others' experiences. It was pointed out that state hospitals in Pennsylvania fear that their grates will burn out with the use of biomass as a fuel. Mike Palko will convene a meeting of Pennsylvania institutions that could consider biomass co-firing. It was noted that wide variations have been observed in the per square foot costs of coal heating in that state.

- Subject to the availability of funds, the United Bio-energy Commercialization Association (UBECA) will sponsor two workshops on co-firing and ash.

- Spreadsheet models to assist plant managers in understanding the use of biomass and the resulting ash are being developed by EPRI and others.

- The University of Pittsburgh is developing three bio-energy projects using stoker boilers supported by the U.S. Forest Service and U.S. DOE. A report on the results of working with recycled pallets at a Pittsburgh brewing company is due in February 1997.

- The ACAA could sponsor a session on co-firing at its upcoming Orlando conference. In addition, perhaps a guidance document on some of these issues might emanate from such a session.

- If small ad hoc groups wish to get together, the Northeast Regional Biomass Program is willing to provide secretarial services. It is also enthusiastic about getting information, including an updated bibliography, disseminated and is currently undertaking some biomass resource assessments.

- Initial funding for a study of carbon sequestration associated with forestry management is available through the Northeast Regional Biomass Program.

- The C. T. Donovan Company will make its information on treated wood characteristics available, to the degree practical.

- The Kentucky Division of Energy will find out what producers of sawmill residue would need to get for a price, or would be willing to pay to have it disposed of.

- EPRI has a current program with FETC that involves large boiler testing at TVA, Madison Gas and Electric, and NYSEG among other plants. They will coordinate their research and the dissemination of results with FETC.

- Fiber Fuel International has a patent on processing wood waste in pulverized coal boilers and will work with others who would like information on this technology.

- The Northeast Regional Biomass Program and other regional programs request suggestions from interested parties on the most useful methods for disseminating information (e.g., identifying experts to serve on panels for trade association meetings or conferences, sponsoring separate workshops, etc.).