SCOTT M. KLARA

DIRECTOR, STRATEGIC CENTER FOR COAL

NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

HEARING ON "BIOMASS FOR THERMAL ENERGY AND ELECTRICITY: A RESEARCH AND DEVELOPMENT PORTFOLIO FOR THE FUTURE"

BEFORE THE COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

U. S. HOUSE OF REPRESENTATIVES

October 21, 2009

Thank you, Mr. Chairman and Members of the Subcommittee. I appreciate this opportunity to provide testimony on the United States Department of Energy's (DOE) Clean Coal Research Program, particularly those activities related to co-feeding biomass materials with coal that reduce the life-cycle carbon intensity of electric power generation and large industrial processes.

Biomass can be introduced to our Nation's energy mix as a feedstock input to thermal energy power plants. In addition, the emissions output of fossil energy power plants can be used to cultivate algae for subsequent energy use. Both applications are effective strategies for reducing the carbon intensity of our Nation's power generation fleet and industrial processes.

Introduction to Clean Coal Research Program

Fossil fuel resources represent a tremendous national asset. Throughout our history, an abundance of fossil fuels in North America has contributed to our Nation's economic prosperity. In Secretary of Energy Steven Chu's October 12, 2009, letter, delivered to Energy Ministers and other attendees of the Carbon Sequestration Leadership Forum in London, he said that: "Coal accounts for 25 percent of the world's energy supply and 40 percent of carbon emissions, and is likely to be a major and growing source of electricity generation for the foreseeable future." Secretary Chu further stated, ". . . I believe we must make it our goal to advance carbon capture and storage technology to the point where widespread, affordable deployment can begin in 8 to 10 years. . . . But finding safe, affordable, broadly deployable methods to capture and store carbon dioxide is clearly among the most important issues scientists have ever been asked to solve."

The Clean Coal Research Program – administered by DOE's Office of Fossil Energy and implemented by the National Energy Technology Laboratory – is designed to remove environmental concerns over the future use of coal by developing a portfolio of innovative clean coal technologies. In partnership with the private sector, efforts are focused on maximizing efficiency and environmental performance, including carbon dioxide (CO_2) capture and storage, while minimizing the costs of these new technologies. In recent years the Clean Coal Research Program has been structured to focus on advanced coal technologies with integrated Carbon Capture and Storage (CCS). The Program is focused on two major strategies:

- Mitigating emissions of greenhouse gases (GHG) from fossil energy systems; and
- Substantially improving the efficiency of fossil energy systems.

Displacing coal fuel with biomass provides an opportunity to reduce GHG emissions from our Nation's power production and industrial facilities.

Background and Potential Importance of Coal-Biomass Systems

A key challenge to enabling the continued widespread use of coal will be our ability to reduce climate warming GHG emissions. Utilizing a coal-biomass feedstock combination complements a carbon capture and storage strategy to reduce GHG. Co-feeding biomass also offers the potential for the Nation to meet its energy and environmental goals, while using domestic energy resources and furthering domestic energy security.

The coal and biomass co-feeding option, when integrated in an advanced energy system like advanced gasification-based technology with CCS, can provide electric power, on a life-cycle basis, with near-zero GHG emissions.

Biomass can be co-fed to existing pulverized coal combustion plants, advanced oxygen-based combustion plants, and advanced gasification-based plants. When combined with pre- or post-combustion carbon capture technologies, co-feeding biomass offers a sound strategy to reduce the carbon intensity of existing and future coal-based energy systems.

Coal-biomass systems could become part of an early compliance strategy, particularly in existing power plants. Further, coal-biomass systems can benefit from the economies of scale offered by large coal-based energy systems. Large biomass-alone power plants are constrained by low biomass energy density, feedstock water content, feedstock collection and preparation, and local/regional feedstock availability. Biomass can be used in economically available quantities as co-feed in large central coal plants, to realize the benefits of economies of scale. Coal can also serve to offset the seasonal and variable nature of the supply of biomass feeds.

CO_2 Perspective of Coal-Biomass Systems

CO_2 reductions associated with using biomass in existing pulverized coal-fired power generation facilities is fairly straightforward. CO_2 reductions from existing plants will be nearly equivalent to the amount of carbon in the biomass feedstock, less the amount of fossil fuel produced CO_2 needed to harvest, prepare, and transport the biomass to be combusted in the boiler. Technology modifications needed to co-feed coal and modest amounts of biomass into existing plants available today and being adopted by industry. For example, First Energy is in the process of converting units 4 and 5 of their Burger Plant in Shadyside, Ohio, to produce up to 312-MW_e firing up to 100 percent biomass.

Gasification-based units, such as Tampa Electric, offer the opportunity to combine biomass offsets of carbon emissions from coal with CCS, resulting in near-zero overall plant carbon emissions. Recent NETL engineering analyses indicate that net-zero life-cycle carbon emissions can be achieved by co-feeding biomass into Integrated Gasification Combined Cycle (IGCC) plants with 90 percent carbon capture and sequestration. The quantity of biomass co-feed needed to reach net-zero emissions varies depending on the type and rank of coal utilized. Limiting issues for both combustion and gasification-based systems include biomass availability and cost, both of which must be overcome by the development of improved technology if we are to dramatically increase the amount of biomass deployed, and the associated carbon benefits in future power production systems.

While biomass feedstocks are generally viewed as having a low-carbon footprint, a careful lifecycle analysis must be performed to fairly characterize their true profile; this is especially true when considering cultivating new biomass crops that are to be dedicated to energy production. For example, some carbon capture processes can make large quantities of affordable fertilizer that could have beneficial effects when reclaiming mined or poor quality land, thus serving as a potential pathway for easing land-use considerations associated with biomass energy crops. The potential also exists for the beneficial reuse of CO_2 recovered from coal-biomass power plants to produce and process algae for subsequent energy use. Such energy systems could be located near the markets they would serve. These two strategies could be useful to enhance overall plant economics by the value added from beneficial reuse approaches, thus helping to support the costs of deployment of the needed CO_2 infrastructure – building CO_2 pipelines and paying for transport and storage.

Global Perspectives and Experience with Coal-Biomass Operations

Considerable experience already exists with a number of biomass to power production facilities that have been constructed and are operating, particularly in Europe. The International Energy Agency's Bioenergy Task 32[1] compiled a database to provide an overview of this experience. It reports "Over the past 5-10 years there has been remarkably rapid progress over in the development of cofiring. Several plants have been retrofitted for demonstration purposes, while another number of new plants are already being designed for involving biomass co-utilization with fossil fuels. . . . Typical power stations where co-firing is applied are in the range from approximately 50 MW_e (a few units are between 5 and 50 MW_e) to 700 MW_e. The majority are equipped with pulverised coal boilers. . . . Tests have been performed with every commercially significant (lignite, subbituminous coal, bituminous coal, and opportunity fuels such as petroleum coke) fuel type, and with every major category of biomass (herbaceous and woody fuel types generated as residues and energy crops)."

[1] http://www.ieabcc.nl/database/cofiring.html.

For IGCC power generation systems, tests have been performed successfully at the Nuon plant in the Netherlands that fed a mixture of 30 percent demolition wood and 70 percent coal by weight to a Shell high-pressure, entrained gasifier. However, only limited data and information are available from these tests. In the United States, Foster Wheeler has been active assessing various aspects of coal-biomass mixtures, with a focus on fuel selection, emissions control, and corrosion issues. Europe is most active in the area of coal-biomass co-firing, and their experience stresses the importance of biomass processing, to avoid slagging and fouling as potential issues to maintaining optimum combustion performance. In addition, there is presently much discussion of indirect CO_2 emissions of biomass from a life-cycle basis that arise from fertilization, harvesting, and transport of the biomass.

United States' Perspectives and Experience with Coal-Biomass

Between 1990 and 2000, research targeted at co-firing coal and biomass within combustion plants was strongly supported by DOE, industry, and academia, all of whom considered co-feeding coal and biomass in combustion power plants to be a technically viable option. Over 40 plants in the United States have co-fired coal and biomass over a period of several years. Operations have ranged from several hours to several years, with five plants operating continuously for testing purposes on either wood or switchgrass, and one plant operating commercially over the past two years on a mixture of coal and wood.

While it is relatively easy to feed small percentages of biomass in co-firing configurations at power plants, care must be taken to specify the type and amount of biomass, and biomass-feed processing requirements that provide optimum carbon reductions with minimal reductions in plant efficiency.

The information base for co-feeding coal and biomass in gasification technology settings in the United States is significantly less than that for combustion. Biomass has been successfully fed in low concentrations at Tampa Electric's IGCC power demonstration in Florida, and biomass co-feeding and preparation tests are currently being conducted at Southern Company's National Carbon Capture Center test center in Wilsonville, Alabama.

Current Office of Fossil Energy Coal-Biomass Activities

Research is being conducted on biomass preparation and pretreatment requirements, feeding coal-biomass mixtures into high-pressure gasifiers at commercial conditions and characterizing the composition of the resultant gas stream to determine impacts on downstream components.

Algae Production as a GHG Reduction Strategy

Biological capture of CO_2 through algae cultivation is another CO_2 reduction strategy that is gaining attention as a possible means to achieve reductions in GHG emissions from fossil-fuel processes. Algae, the fastest growing plants on earth, can double their size as frequently as every two hours, while consuming CO_2. Algae can be grown in regions, such as desert conditions, so as not to compete with farmland and forests; and they do not require fresh water to grow. Algae will grow in brackish water, plant-recycle water, or even in sewage streams, and, when cultivated within closed systems, these waters can be recycled, thereby minimizing further water use.

While it is recognized that the greenhouse gases stored by the algae will ultimately be released to the atmosphere, there is a net carbon offset by more effectively using the carbon contained in the coal. The coal is used to produce power and then again for algae production, hence, a net-carbon offset is realized by an increase in the energy extracted from the coal, compared to that same coal being used for power generation only.

A cost-effective, large-scale production system for growing algae using CO_2 from a power plant has not yet been demonstrated. Using Recovery Act funds, DOE is sponsoring a project with Arizona Public Service to develop and ultimately demonstrate a large-scale algae system coupled with a power plant. The utilization of algae for carbon management is an integral part of the project. The project has already proven the process at a small scale using a one-third acre algae bioreactor, which has been operating for weeks using power plant stack emissions to produce sustained algae growth. Additionally, a prototype algae cultivation system is being evaluated for continuous operation. The project will ultimately assemble a fully integrated energy system for beneficial CO_2 use, including an algae farm of sufficient size to adequately evaluate effectiveness and costs for commercial applications. To complement the engineered system in Arizona, DOE has solicited Small Business Innovation Research proposals to explore novel and efficient concepts for several processing aspects of CO_2 capture for algae growth. The results from these efforts should prove useful to future algae farming applications.

Conclusion

Prior to the current global emphasis on carbon reductions, coal-biomass research, development, and demonstration focused on waste utilization, e.g., demolition wood in the Netherlands and waste wood from the lumber industry in the United States. The major objective of those efforts was to reduce the amount of wastes going to landfills. More recent interests have also facilitated the use of coal-biomass mixtures, e.g., the co-firing of straw with coal at Denmark’s utilities. Now, with carbon reductions at the forefront, there is renewed interest and the possibility of realizing a double benefit to co-firing, particularly for those organizations that have been motivated solely by the benefits of reducing wastes (most of which are biomass-based). Additionally, algae production using CO_2 emissions from fossil fuel power plants is gaining attention as another biologically based option to reduce GHG emissions.

To establish a new and widely deployed industry, based on providing (growing, harvesting, processing) biomass fuel on a regular basis, there are key issues to address – the single most important of which is **how much biomass can sustainably be made available to economically and reliably support a power or industrial facility, and enable that facility to reliably and economically achieve its goal for carbon reduction?** This factor alone (i.e., biomass availability) will, in turn, dictate the scale of the plant or plants in a particular region. Also, experience dictates that the energy crop must not be competitive with the food chain, so land use and crop choices need to be carefully designed and managed. There are technical challenges to adding large quantities of biomass to our Nation's energy systems that must be overcome as well. Preparing the biomass before it is used in the plant, as well as potential slagging, fouling, and corrosion of downstream components and processes, must be addressed for both combustion and gasification systems.