

CIBO Fluid Bed XX Conference
May 21 - 23, 2007
Lexington, KY

I. Optimizing Circulating Fluid Beds (CFBs) - Roger Leimbach, Metso Power and Automation

Roger reviewed the primary characteristics of fluidized beds and CFBs in particular. As air is introduced to a bed of solids, the pressure drop increases until the particles begin to lift. At this point, the particles rearrange themselves resulting in a slight reduction in pressure drop. This is the minimum fluidizing velocity. Below the minimum fluidizing velocity, the system acts like a stoker fired unit. As the air flow is increased, the added air forms bubbles of air in the bed, resulting in a bed that has the properties of a fluid. This is the bubbling bed regime. A well defined bed is still maintained. As the air flow is increased further, the particles can be lifted out of the bed, but at the "slip velocity" rather than air velocity. This is the operating range of the CFB. Once the air velocity reaches the terminal velocity of the particles, the particles are carried out of the bed and the system becomes a transport reactor typical of pulverized coal firing.

Fluid beds can burn a wide variety of fuels, provided that the handling systems and ash systems are designed to handle the materials. These units have increased in size since commercialization in the 1980s. The largest unit under construction is the Lagisza unit in Poland at 460 Mwe. This FW unit is also the first supercritical CFB. Several units are in operation at the 300 MW level. China is investing even larger size units for anthracite and other low volatile fuels.

Challenges for this technology include disturbances, multiple fuels/mixtures, load demand, and mismatches between supply and demand. There are many variables, but only a few opportunities for control. Essentially, the fuel feed, combustion air, air distribution, and limestone feed are the primary control variables. In order to compute and control the true heat release, feeder speed is not particularly reliable. Fuel variability is substantial, even from the same fuel source. It is desirable to "totalize" the heat release from all sources and maintain the proper fuel air ratio over the entire load range. It is also desirable to maximize sulfur capture and minimize NO_x formation. There is also a coordination requirement with the steam turbine.

A conventional control system would utilize steam pressure as the master for fuel flow (i.e. connected to feeder speed) with air flow trim based upon oxygen sensors in the stack. The air is further split to primary and secondary air flows. This is the basis for control design. In order to optimize the operation, better control systems are needed. An advanced control system would require a "fuel compensator" strategy. This compensator makes use of a system heat balance and an oxygen consumption calculation in order to estimate the true heat release. The heat balance is relatively slow, but very accurate. The oxygen consumption calculation (wet basis) is very fast, but less accurate. By combining the two calculations, a good estimate of the true heat release can be obtained. This

approach is particularly useful when burning mixtures of biofuels. The moisture contents and heating values of these fuels are quite variable, putting exceptional demands on the control systems. In Scandinavia, there was a substantial shift from oil and coal to renewable fuels (wood, wood waste, forest residue, etc.). A combustion optimizer is used to provide the optimum bed temperature so that maximum sulfur capture and minimal NOx formation can be obtained. Turndown requirements also impact temperature control. With biofuels, the concentration of active alkalis is higher, resulting in lower ash fusion temperatures. Loss of bed temperature control could result in a high enough temperature to start melting the bed. SNCR effectiveness is also dependent upon temperature. There is a lot of process data available, as well as operator experience and know how. Fuzzy logic is used to model the plant operation to provide performance predictions with regard to bed temperature, emissions, and performance. The fuzzy logic controller will hold the temperature closer to the set point and will modify the set point over the load range. The benefits are reduced limestone usage, reduced fuel cost, and reduced NOx emissions. CO and O2 levels are also reduced.

II. Equipment Suppliers' Forum - Facilitator, Bob Bibb, B&A Inc.

One of the issues is the permit process which typically starts before the owner has selected the equipment or the engineer, but needs to start the process. The Federal Land Managers are now actively looking at every solid fuel power plant seeking a permit. Their strategy is to take the lowest emission rate in any permit anywhere in the country, regardless of fuel, equipment, and site location. In many cases, the FLM asked why the plant can't get the fuel that the other plant was meeting. The Dept. of Interior and Dept. of Agriculture have been driving this approach. Even if the plant is not in a Class I area, the DOI and DOA will send the information to the Sierra Club and other environmental groups to fight the project. Cost is not a valid concern for these groups. The negotiation is on "what's the best you can do?" It is nearly impossible to permit a small solid fuel plant. Turndown issues, start up, shut down, and upset conditions all have specific problems which need to be identified. Limits can be defined as lb/MMBTU or lb/hour or both. Interactions amongst the various species are also a problem. The lowest NOx may come at the expense higher CO. Higher SO2 may come at the expense of higher NOx (increased calcium). Pet coke or waste anthracite has lower NOx than lignite. Lignite has lower CO. One coal company is attempting to supply "compliance coal" for Industrial Boiler MACT for existing units (.04 - .06 ppm mercury and 0.01 - 0.03 ppm Cl).

For owners, starting early and identifying the fuel early would help with some of the questions that come up during the permit process. The flip side is that if a fuel is specified, the manufacturer and the engineer will hold to that analysis for the guarantees and price. A fuel spec that doesn't make sense will just be "no bid". For existing units, there have been a lot of requests for a wide variety of "biomass" to be co-fired in units. The fuel contaminants are the issue. The same fuel (rice hulls, for example) can have very different ash constituents depending upon the type of soil and type of fertilizer that was used. Alkalis and chlorides are serious contaminants. Most manufacturers have limits for these contaminants and will average the concentrations from the coal and the biomass to set the limit for how much of a particular biomass can be used.

In the way of operational problems, tubular air heaters are starting to reach the end of their useful lives. Many units have had to replace the air heaters with attendant improvements in performance. The age old question of minimizing cold end corrosion in tubular air heaters continues. Tramp material is still an issue for ash handling equipment. Pneumatic ash systems are energy intensive. Mechanical systems are somewhat less reliable, but can be made to work and are less energy intensive. Limestone preparation for size needs a preparation plant rather than just a crusher to meet the particle size spec. Tramp material and oversize is one problem, while too many fines is also a problem. Customers now seem to have a better appreciation of the importance of particle size. With the utilization of add on SO₂ control for higher SO₂ capture, there can be some optimization between the boiler and the back end. Efforts are underway to reduce the amount of limestone required, which in turn helps to reduce NO_x and improve efficiency. With regard to mercury, measurement issues are a big problem. Getting a material balance on mercury is virtually impossible at the moment, partly due to variability and partly due to measurement issues.

With regard to annual limits and potential to emit, it was suggested that the annual potential to emit should be estimated at 5% more than anticipated to account for future equipment modifications or improvements in availability or fuel variability. Another issue comes from fuel switches. In the case of pet coke, there is often a spike in SO₂ emissions when pet coke is first added. Regulators are starting to look at this issue.

Although availability has been improving, steam valves have been a problem. Duplication of small items of instrumentation are being suggested in order to minimize down time over small ticket items.

Suppliers are also stretched at this point. Staffing is very lean due to years of low demand. Suppliers are being very selective about which projects they will entertain. Suppliers that are busy are tending toward larger projects as well. The CO₂ issue is driving biomass use. A high "tax" on CO₂ could drive the market away from solid fuels.

III. 2006 FBC Owners' Survey Results - Jack Fuller, West Virginia University

This year a new format was used for the survey. There were 13 plants responding, of which one was a BFB. Slightly more than half were less than 40Mw. The smaller plants had net plant heat rates over 13,400 BTU/Kwhr. The larger units were about 12,200 BTU/Kwhr. Auxiliary power consumption was high for most of these plants. Over 2/3 of the units had beneficial uses for both fly ash and bottom ash. Over 80% are responding to Boiler MACT requirements for mercury. Plant availability has fallen off in the last 2 years to 88%. Interestingly, availability on units whose primary fuel was coal had a lower availability than the plants using waste fuels. However, there were fewer numbers of units with coal as the primary fuel.

Units placed in operation after 1990 generally showed a somewhat higher availability than those placed in operation before 1990. All data was greater than 80%. Of the outage hours, about 30% were forced outage hours. The older units had about 40% of the outage

hours as forced outage hours. Of the forced outage hours, about 70% of these hours come from auxiliary systems. A little more than 30% was due to the boiler. The older plants have a lower percentage of outage hours due to the boiler. The top contributor to forced outages continues to be tube leaks. In 2006, tube leaks were responsible for over 45% of the forced outage hours. The total hours for tube leaks were about the same. The overall forced outage hours had decreased.

IV. Owners' Forum Panel - Harvie Beavers, Pete Kline, and Dan Graham

As the CFBs have become mainstream, tube leaks now dominate the forced outage problems of the boilers. The refractory interface problems have been mostly resolved. For pad welding, the final grinding to smooth out the weld is critical. They pointed out that they used a mock up of 3 tubes showing the grooves from ash erosion, the pad weld, and the pad weld made smooth with the tube as a training technique. All pad welds need to be inspected prior to start up. It was recommended that time needs to be taken to identify the flow areas that lead to excessive wear. One of the panelist pointed out the CIBO network provides an excellent source of experience and information that can be tapped to help avoid some of the problems that others have experienced. They noted that there is a gap in experienced maintenance personnel (as is true for many of the skills in the power industry). One issue that was specific to biomass units was "back pass blasting" for cleaning. There were not enough people present with this experience.

V. Suppliers' Forum Panel - Bob Bibb, Bill Campbell, Scott Darling, Charles Wagner

Bill Campbell noted that permitting has taken on a more serious problem in that the Federal Land Manager is now driving the process. The FLM is pushing the limits on all projects. There is a strong need for information on what can be done and what can't be done and why. BACT requires demonstrated technology. However, the regulators are looking at permits rather than built plants. Further, the approach is to pick and choose. The lowest CO on one plant would be added to the lowest SO₂ on another plant and the particulate on a third unit. All three of these will be put against the request for permit on a new unit. Charles Wagner pointed out that tubular air heaters are reaching the end of their useful lives. A number of units have replaced air heaters in recent years.

Scott Darling elaborated on the permit and guarantee issue. Many of the requests for levels are below the experience level, particularly for new fuels or combination of fuels. In the case where a permit is agreed upon, but the fuel and/or manufacturer has not been selected puts the owner at a lot of risk.

Charles pointed out that the bank's engineer will not recommend such a project. There are also issues with measuring low levels. The EPA, the FLMs, and the environmentalists are driving for the absolute lowest emissions, assuming that somehow the manufacturers, the owners, and the operators will make it work. Load conditions often run afoul of a "lbs/MMBTU" limit as the efficiency is usually lower at low loads leading to more lbs/MMBTU emissions. It is a good idea to schedule an appeal into the permit

process.

On the choice of CFB or BFB, the smaller sizes (less than 500 kpph) and biomass fuels tend to favor BFBs. Coal and mixtures tend to favor CFBs as well as larger sizes. The lower limit on CFBs is around 100 kpph. Knowing the fuel and having justification on that fuel as a requirement can bring about a more rational discussion. Up front work is required well before the permit application process is started.

VI. Energy and Environmental Issues Impacting Boilers - Ann Curnow, Bill Campbell, Bob Fraser, and Mike King

Ann Curnow of Sebesta Blomberg & Associates, Inc. pointed out that start up, shut down, and upset conditions cannot be exempted from a Title I permit. The BACT Clearinghouse shows 6 or 7 entries for 2006 for permit requests covering NO_x, SO₂, particulates, CO, and VOCs. There were a few entries for mercury, lead, sulfuric acid mist, ammonia slip, and a few others. Portions of Boiler MACT have been remanded. There are some NSPS revisions and fine particulates will require new SIPs from a number of states. In one case study a small entity wanted to use a bubbling bed to burn tires using SNCR, spray dryer scrubber, and a baghouse. This plant would have been one of the cleanest plants in the state. A permit was actually issued, but the plant was defeated through public pressure at the local level. The University of Minnesota has accepted a very low level HCl level in their permit. It remains to be seen if they can operate at that level. The University of Iowa also has a CFB. The mercury in their coal tested high. They are specifying a mercury level in their coal spec.

Bob Fraser of ENSR International reported on material handling issues with regard to emissions. Particulate emissions also come from other parts of the plants. Dust can be point source or fugitive emissions which are also regulated. These might include coal piles, handling systems, bin filters, etc. Coal fired plants are typically "major" PM emission sources and subject to NSR/PSD considerations. For new units, BACT and Dispersion Modeling apply. For non-attainment areas, LAER would apply, which could lead to closed or covered coal piles. There are also Title V compliance monitoring and reporting. There are general opacity prohibitions in most states. With the recent interest in firing biomass, there could be permit issues with handling systems for biomass. The operating permit typically does not include biomass. This could trigger NSR. There are NSPS regulations that apply to coal prep plants and mineral processing plants (limestone prep plant). For a hypothetical plant, there were 24 sources of fugitive and point source dust. For a 1000 MW plant, the total of these estimated emissions was 72 tpy. The significant level for PSD analysis is 15 tpy. AP-42 has emission factors for a variety of applications. Actual data is preferable, but not always available. Engineering judgement is often required to apply these factors and calculations.

Mike King of Black & Veatch Corporation reported on some of the market issues. Capital spending is increasing for power and environmental equipment with attendant price and supply pressures. There about 80 Gw of announced power projects, of which perhaps half are "qualified". There are currently nearly 20 projects under construction. Cost

increases have been experienced on most projects. There has been significant escalation in commodity prices. Shop space is limited. Experienced personnel are in short supply. A major peak in demand is currently forecast for 2011 - 2012. Lead times are increasing as world wide demand increases. For the longer term, there is a need to address labor availability, including increasing the number of trained craft personnel and increasing the number of engineers in the industry. The CO2 issue is also a factor. B&V prepared a scenario analysis with a variety of approaches to mitigate CO2 without capture and sequestration (nuclear, combined cycle, wind, etc.). A CO2 price ranging from \$5/ton of CO2 to \$35/ton of CO2 was evaluated.

VII. CCB Placement at SMCRA Mines - Gary Merritt, Inter-Power/AhlCon Partners, L.P.

Gary noted that we had invited Kimery Vories of the Office of Surface Mining to make this presentation, but a NOPR on mine placement of ash has been issued and his presence was required. Gary gave the presentation in his place. The National Academy of Science did a major study on CCB mine placement. Their report noted that there are a number of regulations already in place for mine placement. Pennsylvania is the leading state in this area. The report indicates that a national set of standards is needed. The EPA and the Dept. of Interior need to come to agreement on which activities fall within whose jurisdiction.

The Office of Surface Mining proposes that all CCB placement activities should come under SMCRA permitting and performance requirements. There have been CCB placements under SMCRA for over 30 years. OSM has issued and advanced notice of proposed rule making. The comment period has been extended to June 13, 2007. The goal is to put forth a rule by the end of the year with finalization in 2008. Under Title IV, there is an abandoned mine lands requirement. The OSM has been responding to the NAS report (rather than EPA). The OSM has generally been supportive of beneficial use of CCBs. A major concern is that with the turnover in Congress and the next presidential election, there could be a change in approach (where EPA decides to take action). This might mean a complete review of what was already done.

VIII. Manufacturer's Panel - Scott Darling, Phil McKenzie, Rick Cashatt

Scott Darling of ALSTOM Power, Inc. reported on market drivers and trends in CFBs. Fuel flexibility and biomass have been important issues for CFBs. Fuel flexibility has always been a key factor for CFBs. The ability to use niche fuels that are low in cost and problematic for other solid fuel technologies have provided CFB with cost advantages. Biomass has recently been more active due to the CO2 consideration. In looking at one fuel characteristic (FC/VM), a spectrum of plants in operation from the lowest ratio to the highest, shows a wide range for CFB, a more narrow range for PC, and a considerably more restricted range for IGCC. The extremes of this parameter are lower cost fuels, while the center (where traditional coals reside) is more expensive.

Biomass impacts include higher gas flow, alkalis in the ash, and potentially erosive ash. There is also some potential for chlorides, depending upon how the biomass was moved from where it grew to where it will be consumed. CFBs can be designed for 100% biomass. CFBs can be designed for fuel mixtures. For existing units that were not designed for biomass, up to 10% biomass can be substituted with minimal impact. Above 10% some impacts can be expected.

Phil McKenzie of The Babcock & Wilcox Company reported on some of the biomass projects that have been recently proposed. One facility was looking at burning all biomass on site, as well as buying in biomass. An existing boiler at an abandoned plant was converted to a bubbling bed and moved to a pulp and paper plant. The plant went on line in December, 2006. March was reported to be the most profitable month in the plant's history, mostly due to fuel savings. Another plant is being driven by Renewable Energy Credits. The value of credits along with the power purchase agreement made this project economical. It will start up by the end of the year.

Rick Cashatt of Metso Power (formerly Kvaerner) is part of a major technology company headquartered in Finland. The 4 divisions include Metso Paper, Metso Minerals, Metso Automation, and Metso Ventures. Gotaverken, Keeler DorrOliver, Tampella, and Kvaerner boiler technology have all been purchased. The largest unit is a 250 MW multifuel unit in Finland, with peat as the main fuel. This year there will be about 4500 Mw of CFBs with about 3500 Mw in the 300 Mw class range.

In response to a question about air heaters, the manufacturers are using regenerative air heaters (Ljungstrom) on larger units (>150 Mw) and modular tubular air heaters on smaller units. The modular tubular air heaters allow for a replacement of the cold end module without replacing the entire air heater. For biomass units, it is possible to use economizer surface for exit gas temperature reductions. Another issue is the availability of substantial amounts of biomass.

IX. Limestone Sorbant Consideration for FBC Systems - Howard Fitzgerald, Chemical Lime Company

Howard reviewed the acid gas reactions from combustion. Hydrated lime can react with many of the acid gases. Wet scrubbers can remove SO₂ up to the 98+% level. These scrubbers are generally not effective for SO₃, HCl, and Hf. These gases tend to pass through the scrubber. Dry scrubbers utilize lime rather than limestone along with a baghouse. The more reactive lime along with the added contact of the gas with the filter cake on the bags makes these units more effective for SO₃, HCl and Hf. LIMB systems (Limestone injection multi burner) can be used for more modest sulfur removal. Moist duct injection can also be used for 90 - 95% SO₂ removal, as well as SO₃, HCl, and Hf. Limestone production in the US is a major industry and is used in a number of industries including cement, FGD, CFB, aggregates, and fillers.

With the increase in FGD requirements, limestone use in this segment will nearly triple with an additional 35 million tons required in the next 5 years. For FBC units, the size criteria is relatively tight (roughly between 30 and 200 mesh). Some considerations for FBC include matching the limestone to the fuel, multiple sources, and onsite processing vs purchased material. If the limestone is too expensive for the fuel in question, spray dryers and/or duct injection can be used to get the final SO₂ requirement.

X. Multi Pollutant Reduction in CFB Systems - Dave Judy, MobotecUSA

Mobotec deploys rotating overfire air (ROFA) in CFB units to provide lateral mixing in order to improve combustion efficiency, reduce emissions, and reduce particulates. The ROFA system can be used to reduce the gas temperature in order to optimize SO₂ capture. More uniform distribution of oxygen and other constituents helps improve CO burnout. At the Colver unit, the flyash CaO was reduced by 16%, the bottom ash CaO was reduced by 17%, and the LOI went from 14% to 9%. At Cedar Springs (bark fired), the LOI went from 28% to 8%. Bark utilization was increased.

XI. Boiler MACT Dust Emissions Control for a FB Cogen Facility - Earl Parker, Auburn Systems, LLC

Vast amounts of data are collected at plants under requirements from various environmental agencies. Performance monitoring, data analysis, and reporting are all required. Reliable monitoring technology combined with appropriate data analysis and reporting software can help. Field management needs to be tied in with operations management and business management. These internal plant networks need to communicate with one another.

The Black River Cogen units at Fort Drum, NY had an expiring Title V permit. The new permit would require rapid response maintenance in order to minimize any time out of compliance due to any problems. The Auburn system for dust control looks at individual bag compartment data to identify any potential tears or punctures in the bags. The software then pulled together information on the fan amps to provide a full monitoring system to bring all of the information in one place. Any data averaging for compliance purposes can be calculated continuously. The system can send e-mail messages for severe alarms to appropriate individuals. The system works continuously in the background. Alarm data can be tallied so that data can be sorted, subtotaled, or segregated as required.

XII. Bubbling Bed vs. Stoker Firing - John DeFusco, The Babcock & Wilcox Company

There are a number of market drivers for renewables including federal tax credits, renewable portfolio standards, displacement of higher cost fuels, and voluntary "green"

programs. Biomass can provide dispatchable power, provided it is available. For smaller units, this is usually the case. Availability had been high with such units. Biomass is considered to be CO₂ neutral. The stoker has been the industrial workhorse over the years. For dry fuels such as wood or wood waste, straw, stover, animal wastes, and coal, stokers can be used. However, bubbling beds can also handle many of these fuels. A study was undertaken to look at bubbling beds and stokers. CFBs were not considered as no coal was to be fired.

Typical differences from the 2 types are higher unburned carbon for stokers, higher excess air for stokers, ESPs for stokers vs, baghouses for BFBs, lower fan horsepower for stokers, higher uncontrolled emissions for stokers, and SCR capability for BFBs with “clean fuels”. For the boiler proper, the surfaces and air heater are similar for both types. The BFB has a greater requirement for fans, including a flue gas recirculation fan. Bed burners are needed for startup. A sand system will be needed to provide adequate bed material. The stoker requires a cinder re-injection system and a mechanical collector ahead of the ESP. The capital cost comparison came out with a BFB having a slightly lower cost than the stoker. On the O&M side, the horsepower requirement is higher for BFB, but the carbon loss and oxygen level provides an efficiency gain. Without the re-injection system and the mechanical collector, the O&M cost was less than the stoker. In all evaluations, the fuel was virgin wood waste at \$25/ton.

XIII. Matching Ash Systems to CFB Boilers and Fuels - Bob Walsh and Gary Mooney, ALSTOM Power, Inc.

Conveying options include mechanical systems and pneumatic systems. For fly ash, pneumatic systems are recommended. For other system, a combination of mechanical and pneumatic system can be used. Besides bed ash and fly ash, there is economizer and air heater ash. These hoppers pick up the 5% of heavier particles that drop out in the hoppers. These hoppers need to be accounted for.

The temperature of delivery is important to the selection of equipment. Continuous production of ash equates to continuous removal of ash. Head room is another issue. Often the delivery point is only a few feet off the ground. Drag conveyors can handle a low head room, high temperature ash. This can then connect to a bed ash storage tank. This tank can connect to either a pressure or vacuum system. For mechanical systems, a catenary idler is used to allow the drag chain to adjust for temperature. A sliding bearing system is used to account for temperature changes in the bearing systems.

Bed ash, economizer ash, and air heater ash should be removed continuously. The pneumatic systems include vacuum, pressure, and combination systems. The combination system is a good retrofitable system. A swing gate valve for ash inlet valves is more reliable, particularly with the high calcium levels in the ash. Large access ports are helpful in maintaining ready access for either clean out or maintenance. Equalizing valves are similar to the inlet valves. The vacuum system can tolerate the lower head room. In many cases, the vacuum suction can't be maintained.

Pressure systems can provide enough air pickup through the use of blowers. Airlocks are needed to get the ash into a pressurized system. Tungsten carbide seats and gates are desired to avoid leakage or puffing. The combination system can allow for the low head systems along with the higher temperatures and still move the ash longer distances with the pressure system.

XIV. Repower Coal Fired FBC for Liquid Fuel Production - Don Bonk, DOE

Don pointed out that DOE can work with Industrial companies through Cooperative Research and Development Agreements (CRADAs). DOE NETL implements research, development, and demonstration. Gasification can produce synthesis gas which can be used for either power generation or chemical production. Fluid bed gasifiers generally had lower carbon conversion than the entrained gasifiers. A hybrid system could be used for retrofit at an existing site. A CFB could be used to replace the existing boiler. A fluid bed gasifier could be added which will produce a syngas and a solid fuel for the CFB. A combined cycle can be added to double the output of the plant. FBC owners can have an advantage. Much of the infrastructure is already in place. The fluid bed know how is already in place. Thus, the addition of fluid gasifier can allow for an easier modification. If the fuel is biomass, the plant becomes a little greener. Any char goes over to the CFB boiler. The syngas can then be used for power production or chemical combustion. With the rising prices of liquid fuels, the potential for liquids production should not be overlooked.

The transportation needs indicate that light duty trucks requiring diesel fuels. Fischer-Tropsch synthesis produces a diesel based feedstock that is suitable for refineries. The process does release a lot of heat which can be utilized. There is a wax byproduct which needs to be hydrotreated to make more liquid fuel. The Energy Policy Act of 2005 has sections that provide funds for using IL coal, waste coals, liquid fuels, and alternate fuels. Tax credits are proposed under legislation before Congress this year. The US Air Force is very interested in liquid fuels. Cooperative Research and Development Agreements are available from DOE NETL.

XV. Fuel Transportation and Delivery Concerns - Vanta Coda, Consultant

The permitting problem is even more difficult for fuel production and transportation. Drilling and mining operations are not welcome in most communities. Manufacturing operations are much more spread out over the country, making it more difficult to transport fuel to plants. With plant permits and construction taking on the order of 4 years, the transportation industry will not be able to make any commitment due to the volatility in their own fuel prices.

New solid fuel units are forecast to be 80% coal or coal waste fired. Rail delivery to small size plants is problematical. The rail industry is basically interested in working "unit trains" (100 cars or more) transporting coal to large utility boilers. Plant Scherer in Georgia

consumes 3 unit trains/day of PRB coal. Small volumes will pay a penalty in high rates for rail shipment. Barge facilities can be very helpful. The inland waterways are still a major thoroughfare for market traffic. Siting a plant that can take advantage of this water highway can have an advantage. Trucking has been relied upon for local delivery.

Locating close to the fuel supply helps to reduce transportation costs. Some companies have lined up docks, terminals, and trucking operations to set up a network that can move goods around the country. A barge lot is 1500 tons. This translates into 15 rail cars or 58 trucks. The fuel cost to run these barges, rail cars, and trucks varies by orders of magnitude. Railroads have been charging 15 - 18% surcharge on top of regular rates for escalating fuel prices. Barges have experienced more competitive pressure. Improved technology has allowed better tracking and placement of barges. Surcharges are running at the 25% level. The trucking industry drove the major changes in the rail industry. However, trucking firms are experiencing cost inflation in fuel cost, tires, and truck drivers. A substantial number of smaller trucking operations went bankrupt in the last year. Gasoline prices are increasing. Last year's national average was \$2.85/gal and was forecast to be \$2.95/gal. Recently, it has been \$3.12/gal. Peak driving season is still coming.

XVI. Fuel & Ash Storage and Handling – Mathew Norgard, Steve Engstrom and Simon Shipp, Stock Equipment Company

Stock Equipment specializes in material handling systems. Bulk movement of material within a plant is crucial to reliable operation. The material properties are critical to the design and selection of equipment. These include bulk density, moisture, particle size distribution, maximum size, material characteristics, and variability. At the delivery point, weather protection, volumes, foreign material, delivery method, downstream needs, and convey system preferences all need to be considered. For railcar unloading, it is desirable to standardize the unloading system. Rail cars are typically of standard size. A covered system is provided. For truck unloading, a simple hopper system is recommended. Alternatively, an above ground system can be designed with a ramp for the truck. This system is not recommended for systems that require high truck volumes (25 trucks/hr). Biomass and alternate fuels tend to experience wide variability. An apron conveyor is recommended for such fuels. Wood chips are variable by nature and contain contaminants from their processing. Material is often pushed (using hydraulic rams) onto conveyor belts for delivery to further processing. Coal is often outside. Stackers and reclaimers are used to handle and move coal to manage the pile. Covered storage has become more standard in Europe. Advances in storage techniques have helped reduced the size of the covered facility. Storage silos normally provide local storage near to the plant operation. Process conveyors are needed to bring the fuel to the feed system. For PRB coal, consideration to premature combustion (fires) is important and leads to a different conveyor system. Belt conveyors can be constructed for up to 4 miles. Trippers and chain conveyors can be used to distribute material across a silo or a bunker.

Steve Engstrom reported on the feed systems from the active bins into the boilers. Rectangular inlets are now standardized from mass flow bins. The ratio comes from soil

mechanics. A ratio of 3:1 is required for good flow. Gravimetric feeders are typically used for metering fuel flow. Mass flow bins are desirable. This translates into having a hopper that provides for a near constant downward velocity in the hopper bottom leading to a rectangular spout. Funnel flow bunkers are particular bad for fuels with a propensity for spontaneous combustion. Typically the fuel bunker is one column bay away from the boiler wall (about 15 - 20 ft). A weigh belt feeder can be used to meter the coal and transport it from the hopper bottom to the final chute into the boiler. There are a variety of modifications that can be done to the feeder to accommodate biomass or PRB coal. Common difficulties include bunkers with different fuels, differential system pressures, flow rate changes, system purging, and emergency discharge. Predicting the differential system pressure has been a problem as the actual pressure within the combustor at the point of the fuel introduction is often unknown. Rear wall feed arrangements require transport to the rear wall from the fuel bins, in addition to the actual feeder. Considerations include effective distribution to multiple openings, pressure requirements, clean environment, simple to maintain, and operational reliability. The flow from the gravimetric feeder is very steady. The typical feed system would require this flow to be divided in thirds. The conveyor has two variable control points and an "always open" end. There is a need to assure that there is no fuel left anywhere on the conveyor. Twin blade slide gates are used to control the flows from the two apertures.

Simon noted that they agreed with all of the information presented by Alstom in the ash handling presentation. Stock provides mechanical systems for ash handling. Chemical composition and moisture content are two key considerations in the design of conveyors. Hygroscopic materials need to consider sources of moisture that can cause problems with the material. This consideration might negate the advantages of a vacuum system that could add moisture from the air.

XVII. Real World Experience with Biomass and Renewable Fuels - Harvie Beavers, Colmac Clarion, Inc.

Biomass activity is heaviest in California, with a handful of states that have a few plants each. Current activity is being driven by tax incentives and greenhouse gas concerns. Biomass is considered to be CO₂ neutral. The MECCA plant in California has averaged 94% availability since 1991. The target fuel has 7500 BTU/lb with less than 30% moisture and less than 10% ash. The original plan was to burn a lot of agricultural waste. The availability of such material has not kept up. Other sources include wood, wood waste, waste companies, and some demolition waste. Higher quality wood is being diverted from the fuel stream to other markets. Wood waste is an issue because of a variety of contaminants coming from plastics, metals, etc.

Current problems include the regulatory agencies that require grinding operations to minimize fugitive dust with water sprays adding to the moisture content. Past problems include dry fines extraction, improved wood hog system, storage and conveying, ash conveying, limestone feed system, SNCR, refractory, and controls. The finishing superheaters experience corrosion due to the biomass. Material upgrades have given

better than 6 year life expectancy on the superheater. Inconel 625 overlay is used in some sections. The fuel bins went to ceramic lining to resist corrosion. Screw feeders were used to feed the biomass. Thicker shafts with welded flights have been substituted to avoid shaft breakage.

XVIII. Plant Tour Overview - Richard Kieda, East Kentucky Power Coop

Richard is the operations manager at Spurlock Station. This station is the largest in the East Kentucky system. There are 2 pulverized coal units and the Alstom CFB unit. A second Alstom CFB is under construction. SNCR is used for NO_x control. The 3 cyclones are divided to one FBHE for finishing SH, one FBHE for finishing RH, and one directly back to the furnace. This boiler is equipped with a "just in time" limestone feed system. The ash goes to a fluid bed ash cooler to reduce the ash temperature prior to the ash handling system. A Ljungstrom tri sector air heater with special seals for the high differentials across the CFB cools the flue gas. A flash dryer absorber (FDA) provides additional SO₂ removal to meet regulations. The FDA drops the flue gas temperature to 145 F. Unit 4 is under construction. Headers, ductwork, piping, and drum are already hung. This will give an opportunity to look inside many of the components. The plant construction took 30 months. The guaranteed output was 293 Mw. The unit is capable of over 300 Mw.