Gasification Based Biomass Co-Firing
Phase I

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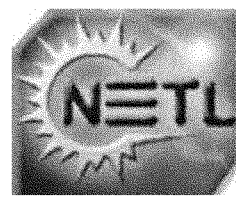

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ABSTRACT

Biomass gasification offers a practical way to use this widespread fuel source for co-firing traditional large utility boilers. The gasification process converts biomass into a low Btu producer gas that can be used as a supplemental fuel in an existing utility boiler. This strategy of co-firing is compatible with variety of conventional boilers including natural gas and oil fired boilers, pulverized coal fired conventional and cyclone boilers. Gasification has the potential to address all problems associated with the other types of co-firing with minimum modifications to the existing boiler systems. Gasification can also utilize biomass sources that have been previously unsuitable due to size or processing requirements, facilitating a wider selection of biomass as fuel and providing opportunity in reduction of carbon dioxide emissions to the atmosphere through the commercialization of this technology.

Nexant Inc., with its team member, Primenergy LLC., and utility partners Western Kentucky Energy Corp. (WKE), and TXU Energy Services, with guidance from Dr. Philip Goldberg of NETL, has undertaken the engineering and economic evaluation of the biomass gasification and co-firing technology under the Department of Energy's Biomass Co-firing program. US DOE's Biomass Program within the office of Energy Efficiency and Renewable Energy sponsored and co-funded this project under a cost share cooperative agreement DOE DE-FC26-00NT40898. This study evaluated two plants: WKE's Reid Plant and TXU Energy's Monticello Plant for technical and economical feasibility. These plants were selected for their proximity to large supply of poultry litter in the area.

The Reid plant is located in Henderson County in southwest Kentucky, with a large poultry processing facility nearby. Within a fifty-mile radius of the Reid plant, there are large-scale poultry farms that generate over 75,000 tons/year of poultry litter. The local poultry farmers are actively seeking environmentally more benign alternatives to the current use of the litter as landfill or as a farm spread as fertilizer.

The Monticello plant is located in Titus County, TX near the town of Pittsburg, TX, where again a large poultry processor and poultry farmers in the area generate over 110,000 tons/year of poultry litter. Disposal of this litter in the area is also concern.

This project offers a model opportunity to demonstrate the feasibility of biomass co-firing and at the same time eliminate poultry litter disposal problems for the area's poultry farmers.

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EXECUTIVE SUMMARY

Integration of poultry litter gasification with conventional PC fired power plant

The purpose of this federally co-funded project is to demonstrate the technical and economical feasibility of biomass gasification and co-firing in an existing pulverized coal fired utility boilers. The primary focus is to use poultry litter as a fuel for the gasification process. However, any other biomass-based fuel that meets the sizing requirements and can be easily transported to the stand-alone gasifier is suitable for this application. Specific objectives of this project are:

- To support commercialization of a biomass co-firing technology that utilizes biomass, agricultural waste and/or farm animal wastes in an environmentally benign, technically practical, and economical application
- To evaluate the technical and economic impact of gasification based co-firing on the existing class of fossil fuel fired boilers currently within proximity of animal waste and agricultural biomass resources of reliable consistency and delivery rates needed for economic operation
- To determine possible modifications, if any, required in either the proposed gasification or boiler technology, for effective utilization of the biomass sources available
- To evaluate these factors specifically for the two plants selected: Reid Plant operated by Western Kentucky Energy Corp., and Monticello Plant operated by TXU Energy
- To develop cost and schedule estimates for implementation at these sites
- To implement such a facility at these sites, provided that the technical and economical evaluations of this study indicate that a useful demonstration of the proposed biomass gasification and co-firing is technically feasible and economically viable

Fuel Supply

The Reid plant is located adjacent to a large poultry processing plant in southwestern Kentucky with over 500 poultry farmers within a 50-mile radius of the plant and estimated litter supply of over 75,000 tons per year.

Monticello plant is located in northeastern Texas with similar large poultry processing plant and estimated litter supply of over 110,000 tons per year. Samples of litter form the both of these areas were analyzed and were comparable to litter analysis found in literature.

Primenergy has analyzed poultry litter samples from various sources, and have estimated an average heating value of the as received litter to be about 10,460 kJ/kg (4,500 Btu/lb) and 14,420 kJ/kg (6,200 Btu/lb) on dry basis, making litter as an acceptable biomass fuel source.

Existing Utility Boilers

Reid Plant Boiler: The existing Reid Plant boiler is a Riley Stoker forced draft, pulverized coal (PC) fired boiler built in 1964. The boiler is rated at 313,000 kg (690,000 lbs) of steam/hr at 90.6 Bars and 513ºC (1300 psig and 955ºF) at the super heater outlet. Primary fuel for the boiler is compliance coal from the local Kentucky coalmines. The boiler was recently converted to a dual fuel system that gives boiler capability of switching to natural gas firing during the NOx mitigation season from May to October.

Monticello Boiler: The unit 1 boiler at the Monticello plant is a Combustion Engineering tangentially fired reheat boiler. The boiler is rated at 1,450,000 kg (3,200,000 lbs) of steam/hr at 248 bars and 814ºC (3600 psig, 1005ºF) at the super heater outlet. The reheat flow is 1,270,000 kg (2,800,000 lbs) of steam/hr at 814ºC and 38 bars (1005ºF and 550 psig). The boiler fuel is 60% Texas lignite from the nearby mine and 40% low sulfur Powder River Basin (PRB) coal from Wyoming.

Proposed Gasifier

The proposed gasifier is a Primenergy KC-18 system consisting of fuel receiving and storage system, fuel feed system, gasifier(s), hot gas filtration system and a two stage after burner combustion system. A single KC-18 will handle 7.6 t/h (8.4 tons/hr) of poultry litter. The KC Reactor/Gasifier is a sub atmospheric pressure, fixed bed, air blown, updraft gasifier. The project evaluated a single KC-18 gasifier for the Reid plant application and twin KC-18 gasifier system for the Monticello plant.

In each gasifier, fuel is introduced by a water-cooled screw conveyor that discharges into the drying and heating zone of the gasifier. The gasification process is controlled by the proportioned injection of gasification and combustion air in a manner that supports efficient gasification. Residence time in the gasifier is varied by a control system that is adjusted to achieve the desired gasification temperature and minimize carbon content of the ash discharged from the gasifier. The use of mechanical bed agitation, precise gasification air control and zoning produces a clean, combustible gas with heating value of between 3,170-5,220 kJ/M^3 (85 to 140 Btu/cu. ft.). In order to minimize impact of the external gasifier on the existing boiler operation, the gases are filtered through hot ceramic filters to remove particulates and other contaminants.

Ash from the poultry litter gasification retains phosphorous and potassium present in the litter while the fuel bound nitrogen is lost with the gasification products. The ash has potential value as P&K fertilizer. The project has investigated potential application and market for the gasifer ash.

Boiler Gasifier Integration

The low Btu gas from the gasifier (producer gas) is at 840ºC (1550ºF) and has a calorific value of about 4,100 kJ/M^3 (110 Btu/std. cu. ft.) The gas is burned in a two-stage combustor, which raises the temperature of the gas to about 1275ºC (2330ºF). The gas can be fed into any existing boiler at a suitable location as additional or supplemental heat input. For the Reid and Monticello plant, the cleaned hot gases can be fed above the existing coal burners, allowing the reduction of the coal, the primary fossil fuel fired into the boiler.

It is estimated that for the Reid case, about 8~10% of heat input can be provided from the gasifier gases, which can allow Reid operators to reduce proportionate amount of coal to the boiler. Similarly, for the Monticello plant ~1% of the heat input into the boiler can be provided with the twin gasifier system.

Conclusions

Due to low sulfur content in the poultry litter, and two-stage combustion process, the gasifier is expected to reduce the SO_2 and NOx emission from the boiler. With the hot gas filtration system, clean producer gas can be fed into the existing boiler, thus reducing particulate loading on the gas filtration system such as electrostatic precipitator (ESP) or bag house filters of the existing boiler.

Poultry litter is a renewable energy resource. Any fossil fuel fired boilers can proportionately reduce their fossil fuel consumption by gasification based co-firing and can claim a reduction in greenhouse gas emissions (CO_2) from their boiler. The process is technically feasible. Project was able to get concurrence from respective boiler vendors on feasibility of installing additional gas burners on the boiler to fire producer gas from the gasifier. The size and locations of these burners are boiler dependent.

Although, this approach is technically feasible, current economic conditions, and low fuel prices for the coal, primary boiler fuel in the cases examined, did not provide economic incentives for the two utilities (WKE and TXU) to proceed with the demonstration phase of this work. A demonstration phase can provide an opportunity for actual construction of gasifiers at the sites selected and demonstration of the technical feasibility and economic evaluation of gasification based cofiring concept.