Combustion System Modeling and Design

EXPLORATORY DIRECT ENERGY CONVERSION STUDIES FROM DAIRY SLURRIES

INTRODUCTION
Growing rates of manure produced from large confined animal feeding operations and repeated application of manure on the same parcels of land have increased concerns for the environmental quality of nearby streams and watersheds. Investigators at Texas A&M are exploring and developing small scale, onsite thermo-chemical conversion technologies for agricultural animal wastes. The ultimate goals are to minimize the required capacities of manure storage lagoons and associated land application of solids. Electrical and thermal energy for the farm is a secondary goal. Potential applications of such technologies in the Waco/Bosque River area are also being investigated.

COMPUTATIONAL MODELING AND DESIGN
- Conduct a thorough literature review current biomass combustion systems.
- Develop a computational model of a combustion system using the first and second laws of thermodynamics.
- Determine the allowable moisture and ash contents of manure feedstock for steady and complete combustion.
- Modify combustion models based on fuel properties to optimize efficiency and cost effectiveness.
- Define parameters for future demonstration experiments to show the opportunities of onsite biomass combustion systems.
- Search for applications in the Waco/Bosque River area.

RESULTS AND ANALYSIS
Commercially available solid separators and/or dewatering devices such as auger presses may be used to prepare dairy biomass (DB) solids for combustion. In practice, separated DB solids must be reduced to 70% moisture in order to burn at an acceptable flame temperature of 1200 K in a regenerative combustor design, although for ideal adiabatic systems in which hot flue gases are used to preheat combustion air, the maximum allowable moisture percentage was found to be 79% (assuming low 2% ash separated solids). The low quality steam produced from vaporized wastewater may be used in the thermal processes on the farm or for drying solids before combustion.

FUNDING
US Department of Energy
ECONOMIC MODELING OF CATTLE BIOMASS COMBUSTION SYSTEMS

INTRODUCTION

Although cattle biomass combustion may be good for the environment, it must also prove to be economically responsible. For this task, investigators at Texas A&M are modeling the economics of co-firing, reburning, and gasification technologies for agricultural animal biomass. The analysis includes quantifying both investment costs and operating expenses of producing energy for each process. Current, best estimates of construction costs for transportation, storage, handling and energy-conversion facilities are computed and then amortized with the expected savings from lower fueling costs and possible avoided future carbon taxes throughout the expected life of the facility.

COMPUTATIONAL MODELING

- Obtain economic estimates from literature review, manufacture estimates and government reports.
- Compute capital and O&M costs for biomass combustion as well as other competing technologies such as selective catalytic reduction (SCR) and low NOx burners with air-staging.
- Juxtapose the economic results in a spreadsheet.
- Estimate the net present value/cost and simple payback period of a biomass combustion retrofitted on an existing coal-fired power plant.
- Extend the same economic models to smaller scale on-farm combustion facilities.

RESULTS AND ANALYSIS

The tables and figures shown are results for a 50 MW coal-firing unit using low-ash cattle biomass as a reburn fuel to reduce NOx emissions. The plant has 35% combustion efficiency, 80% capacity factor, and obtains 15% of its heat requirement from the renewable cattle biomass.

An important factor to the success of a cattle biomass retrofit is the distance between the feedlot or dairy and the power plant. Ideally the facilities the fueling savings to be realized. However, these results do not show the possible impacts of future avoided carbon taxes or CO2 sequestering costs.

FUNDING

US Department of Energy