Final Report

Xcel Renewable Development Fund Project (RD-56)

Generating Electricity with Biomass Fuels at Ethanol Plants

Chapter/Task 4 – Fuel Processing Options

This chapter describes requirements and potential methods for processing co-products to a form suitable for combustion. It was primarily prepared by project participants at RMT Inc.

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RD56: Generating Electricity With Biomass Fuels at Ethanol Plants Report for Task 4, "Fuel Processing Options"

Background

Combustion of biomass feed streams evaluated in this project will require fuel processing. Storage, handling, and fuel processing of biomass fuel is discussed in this section. The optimal biomass fuel conditions and characteristics must be matched with the storage requirements, the in-plant transportation and handling requirements, and the selected biomass combustion technology for the individual fuel ethanol plant. An alteration of particle size, viscosity, moisture content, and mixing with materials such as corn stover will affect equipment selection, operating conditions, potential emissions, energy efficiency, and maintenance costs.

The effects of weather must be taken into account when reviewing complete feed systems. In warm weather, biological degradation will be more rapid, especially for the co-products with a higher moisture content. In sub-freezing weather, management of the co-products with a higher moisture content poses additional challenges. Results of the laboratory testing of the feed streams have been used to provide input to these evaluations.

A description of the physical constraints and/or requirements to accommodate the particular biomass fuel component, and a discussion of general capital and operating costs, are presented below, for each combustion option. Although the discussion in this section addresses fuel processing options for each of the selected co-product feed streams, the combustion evaluations performed as part of this project indicate that both the syrup and the DWG contain too much water for practical self-sustaining combustion. Self-sustaining combustion of these two feed streams would require removal of much of the water. In addition, evaluation of the emissions from combustion of the DWG or syrup, described in more detail later in this report, indicates that the high water content exacerbates the potential generation of problematic quantities of nitrogen oxides. Practical combustion of these materials for CHP purposes without removal of much of the water would require blending the syrup or DWG with a large amount of dry biomass material, or adding supplemental fossil fuel, probably coal or natural gas. Such approaches may still be more cost-effective than burning all natural gas, but they do not satisfy one of the primary objectives of this project, the minimization of the combustion of non-coproduct fuels.

Recently, the literature has contained information concerning a new system to efficiently decrease the moisture content of the syrup to 40%-50%, or less. According to the literature, such systems are currently in trials in ethanol plants, and other systems are on order by other ethanol plants. Information regarding where the trial systems are located, and specific engineering or operational information about the systems, have not been made available by the manufacturers.

Anecdotal information indicates that the reduced-moisture syrup will have manageable viscosity as long as the temperature remains at least around 180°F (82° C). Since the temperature of the raw syrup is in this range, and since heat will be conserved if the temperature of the feed material is maintained as high as possible prior to combustion, this constraint is actually a benefit for the energy efficiency of the system. Information is not publicly available regarding the physical characteristics of cooled reduced-moisture syrup, or the effects of cooling, and then reheating, the reduced-moisture syrup. This report therefore doesn't include further descriptions of such systems, or projections of such systems' effectiveness or utility. However, if such systems are effective and cost effective in reducing the moisture content of the syrup to less than 50%, mathematical modeling for this project indicates that stable, self-sustaining combustion of the syrup may be feasible.

Fuel Processing Options for Syrup

Syrup is produced on an ongoing basis by virtually all dry grind fuel ethanol plants. The syrup is produced at an essentially constant rate by any given ethanol plant, and the composition of the syrup is very consistent for that plant. The syrup is stored until it can be processed, usually by adding it to DWG and either selling the mixture in the wet state as DWGS, or after drying to DDGS. Some syrup is sold as-is for mixing with cattle feed at the user's site, but high transportation costs and a short shelf life limit this option to particular situations.

Because of the high moisture content of the syrup, as much of the syrup as possible is sold without drying. Some ethanol plants have considerable storage capacity for syrup to allow scheduling with DWG shipments, or for direct sale, and so to avoid the costs of drying.

Because DWG and DWGS have a short shelf life (days in warm weather and weeks in colder weather), they do not stack well, they require a large area for storage, they may create odors, and they present a housekeeping challenge, ethanol plants ship the DWG and DWGS out as soon as possible, especially in warm weather. Financially, both the DWG and the syrup represent inventory carrying costs to an ethanol plant, so the ethanol plant, again, wants to sell or beneficially utilize the co-products as soon as possible.

Ethanol plants handle the syrup by pumping, and are familiar with maintaining the mechanical systems for syrup management. However, the moisture content of the syrup must be substantially reduced if the syrup combustion is to be stable and self-sustaining (expected to be less than 50% moisture). As described above, the literature has recently contained information concerning a new system to efficiently decrease the moisture content of the syrup to 40%-50%, or less. According to the literature, such systems are currently in trials in ethanol plants, and other systems are on order by other ethanol plants. Information regarding where the trial systems are located, and specific engineering or operational information about the systems, have not been made available by the manufacturers. Anecdotal information indicates that the reduced-moisture syrup will have manageable viscosity as long as the temperature remains at least around 180°F (82° C). Since the temperature of the raw syrup is in this range, and since heat will be conserved if the temperature of the feed material is maintained as high as possible prior to combustion, this constraint is actually a benefit for the energy efficiency of the system. Information is not publicly available regarding the physical characteristics of cooled reduced-moisture syrup, or the effects of cooling, and then reheating, the reduced-moisture syrup. This report therefore doesn't include further descriptions of such systems, or projections of such systems' effectiveness or utility. However, if such systems are effective and cost effective in reducing the moisture content of the syrup to less than 50%, mathematical modeling for this project indicates that stable, self-sustaining combustion of the syrup may be feasible.

For all combustion options, the moisture content of the syrup will need to be substantially reduced prior to combustion. The syrup is used as quickly as possible after production, although a week's or more storage capacity may be present to allow the most cost-effective processing for shipment out of the plant. For most plants, therefore, no additional raw syrup storage capacity would be needed. Storage will need to be provided for the reduced-moisture syrup, unless the moisture reduction is in line with the combustion system. The particulate matter in the syrup is fine, with little settling over the time period during which the syrup is stored. This fine particulate is not expected to unduly interfere with any fuel feeding mechanism. The syrup as produced is hot, and is stored in insulated tanks. Considering the short amount of time anticipated for the syrup to be stored prior to partial drying and burning, excessive cooling is not expected to be a significant challenge.

Depending on the ethanol plant's physical layout, a day tank may be installed for syrup fuel feed. The syrup would go directly from production to moisture removal to the day tank or the combustion unit in the shortest amount of time possible, thereby conserving heat. Only excess syrup, or syrup destined for a use other than combustion, would go to the main syrup storage.

Fuel Processing Options for DWG

The evaluation applied to syrup is equally valid for DWG (with or without the additional of syrup). The material has a short shelf life, does not stack well, requires a large area for storage, may create odors, and is a housekeeping challenge. Ethanol plants ship the DWG out as soon as possible, especially in warm weather. Financially, the DWG represents inventory carrying costs to an ethanol plant, so the ethanol plant, again, wants to sell or otherwise beneficially use the DWG as soon as possible. Like syrup, the moisture content of the DWG is too high for stable, self-sustaining combustion, so moisture reduction will be needed prior to combustion. The literature information concerning the new moisture reduction system for syrup does not include discussion of DWG. If the moisture content of the DWG could be reduced to the same extent as that of the syrup, with a cost-effective technology, both the technical and financial feasibility of using the ethanol plant coproducts for combined heat and power (CHP) would be significantly enhanced.

Unlike syrup, the DWG is not stored in a vessel, but on a concrete slab, under cover in a large unheated shed or building. Storage capacity is usually quite limited, since the DWG is not suitable for long-term storage and since the ethanol plant ships the DWG out as soon as possible. A front-end loader is usually used to move and load the DWG onto trucks. If DWG is to be used as fuel, a system to collect, store, remove excess moisture, and meter the material to the combustion device will be needed. Unless all the DWG is to be used as fuel, the system needs to accommodate both fuel feed and outside sale as animal feed. It should be possible to handle partially dried DWG in a manner similar to the raw DWG, although this should be verified through testing.

The physical characteristics of DWG are not substantially dissimilar from other materials that are routinely handled in industry. These materials range from food products, to concrete, to sewage sludge. For example, Figure FPO1 is a typical refuse-to-energy system. The primary systems for managing the DWG as fuel are applicable to all of the selected combustion technologies capable of burning partially dewatered DWG. Depending on the configuration of the particular ethanol plant, the DWG leaving the centrifuge is either split between a feed tank eventually used for the combustion system and a DWG storage area on a slab (the most efficient configuration) or only to a storage area on a slab, from where the DWG is moved to the combustion preparation system by a front-end loader or by a separate conveyer.

From the storage tank at the combustion system, the feed into the combustion unit depends on the specifics of the unit. For the fluidized bed systems (both combustion and gasification), no further DWG processing (after partial drying) is needed, although, as discussed above, removal of much of the water from the DWG will be necessary for stable self-supporting combustion or gasification in the fluidized bed systems. While injection of the DWG via nozzles into conventional combustion units may be feasible, the high water content of the DWG will preclude self-supporting combustion, and forcing the DWG through nozzles, especially if it is only partially dried, may be problematic. Given these two potentially significant drawbacks to the injection of the DWG through nozzles, this combustion option is not further considered in this project. Drying the DWG creates DDG (or DDGS if the syrup has been added to the wet cake), which is discussed below.

Fuel Processing Options for DDG and DDGS

The handling characteristics of DDG and DDGS, for the purposes of in-plant use as fuel, can be regarded as the same. The syrup content of DDGS may add a certain tendency for agglomeration upon longer term or higher volume storage, but such storage is not anticipated for in-plant use as fuel.

The DDG and DDGS are typically transported by conveyer from the drier to a concrete slab in a large covered building. A front-end loader then moves the material directly onto trucks or into conveyers and elevators for eventual loading into trucks or rail cars. Some interim storage in tanks may be provided.

Pneumatic transport may be feasible for DDG and DDGS; however, pneumatic transport is not typically used in fuel ethanol plants, so a dedicated system would have to be built.

Unlike the DWG, which requires partial drying, no additional processing is needed to feed DDG or DDGS into the fluidized bed systems. Also as with DWG, size reduction may be desired prior to using injection via nozzles into conventional combustion units.

Typical RDF Refuse-To-Energy System

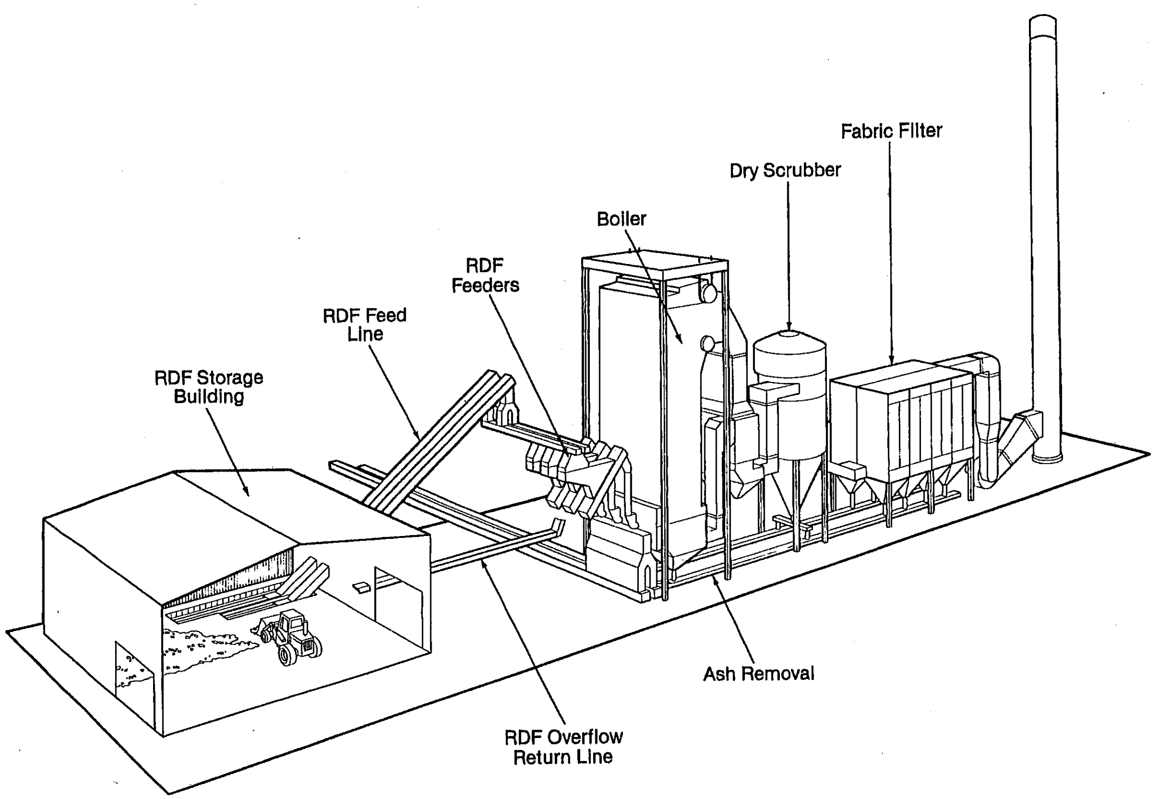

Figure FPO1

Note: Courtesy of the Babcock & Wilcox Company