Biomass Cogeneration Demonstration Plant at Central MN Ethanol Coop

Cecil T. Massie PE, Amit Shukla
Sebesta Blomberg & Associates, Inc.
2381 Rosegate
Roseville, MN 55113
cmassie@sebesta.com

Prepared for presentation at AICHE 2004 Conference Session T4008
Unpublished

Abstract

Confronted with a need to achieve environmental compliance on VOC emissions, Central MN Ethanol Coop chose a novel approach while securing a long-term stable energy supply at prices below current natural gas prices. Sebesta Blomberg & Associates, Inc. of Roseville, Minnesota has developed a combined gasification, thermal oxidation and co-generation plant based on locally available wood waste. This project will eliminate the use of natural gas in the production of ethanol in the plant while the co-gen plant reduces electrical imports by nearly 600 kilowatts.

Using an updraft gasification plant to produce high temperature synthesis gas, the process will then blend VOC laden dryer exhaust gas into the synthesis gas. Following a short residence time, the purified gas will be fed to a heat recovery steam generator where high pressure steam will be produced. The steam is then directed to a back-pressure turbine where nearly 1000 kilowatts will be generated.

The plant will have higher overall thermal efficiency while achieving substantial reductions in emissions, eliminate the use of fossil fuel and make ethanol a truly renewable fuel.

Keywords
Biomass, gasification, ethanol, VOC, thermal oxidizer, cogeneration, energy balance

Introduction

Dry mill ethanol plants have become a major source of transportation fuel with production in excess of 3 billion gallons annually and expectations for production to reach 5 billion gallons annually in the near future. From the beginning of the fuel ethanol movement, arguments have raged over the overall energy balance on ethanol production with critics arguing that it takes more energy to plant, harvest and process the corn to ethanol than the fuel value produced.

In recent years, a further challenge to the industry has emerged as it was learned that VOC (volatile organic carbon) emissions from dryers processing the distillers grain co-product were far in excess of permit limits. In Minnesota, where the EPA and Minnesota Pollution Control Agency, have taken the most aggressive action, most plants have entered into consent decrees to construct thermal oxidizers to reduce the emissions. For some plants, the prospect of additional processing costs and essentially unproductive capital investment has been unattractive and they have sought alternate means to achieve compliance.

Ethanol plants are very dependent on a supply of natural gas. Most were constructed when natural gas hovered around $2 per million Btu and natural gas consumption is routinely in the range of 45,000 Btu per gallon of ethanol. In recent times, however, concerns about natural gas supply and increased demand from power plants has pushed the price of natural gas dramatically higher.

It was against the backdrop of these market and regulatory forces that Central MN Ethanol Coop sought a solution to their long-term energy needs.

Project Description

Central MN Ethanol Coop (CMEC) is located in Little Falls, Minnesota approximately 110 miles northwest of the Minneapolis-St Paul metro area. Geographically the plant sits at the northern fringe of the corn producing region and within a few miles of the beginning of the great northern forests of Minnesota. The plant is a more or less conventional dry mill plant producing 20.5 million gallons of ethanol per year.

When confronted with the three pronged challenge outlined in the introduction, the management determined to seek a unified solution that would bring the plant into compliance, reduce operating costs and secure the long-term energy needs of the plant.

For the solution, CMEC turned to Sebesta Blomberg & Associates in Roseville, Minnesota, a suburb of the Twin Cities. Sebesta Blomberg is a full service engineering firm with primary offices in Roseville, Chicago, Boston and Washington D.C. The firm has of late developed a track record in the area of renewable fuels and in particular the application of biomass gasification to ethanol production.

The first requirement for a biomass energy plant is a reliable source of biomass at a predictable price. While Sebesta Blomberg had done extensive development work on the use of corn stalks for energy production, it was determined that the plant was situated too far north to reliably harvest corn stalks before the first snow. Dependence on this fuel source would leave the plant with a precarious energy supply and corn stalks were ruled out.

The solution emerged when it was determined that local saw mills, logging operations and paper mills produced an ample supply of wood waste and sawdust suitable for gasification. A partnering agreement was established by which producers committed to supply the nearly 100,000 tons per year of wood waste required under long-term supply agreements. The key limiting consideration is that the moisture content of the fuel cannot exceed 30%.

These agreements are doubly beneficial. CMEC is assured of a continuous supply of needed fuel at a predictable price. By this stroke the uncertainties of natural gas pricing was taken out of the business risk. At the same time, local logging operations and sawmills have gained a dependable market for their co-product which was often disposed of in large piles. Overall the predicted economic impact in the local economy is expected to exceed $3 million annually. Given the stimulus to support industries and retail, the overall impact may exceed $10 million.

For the combustion and thermal oxidation technology to execute the project, the team turned to Primenergy LLC of Tulsa, Oklahoma. Primenergy has a proven track record in biomass gasification with nearly 20 gasifiers operating around the world. Building on previous test work with Sebesta Blomberg on corn stalks, the team was able to tackle the energy needs of the plant.

Gasification is the process for converting a solid fuel to a fuel gas. An early incarnation of this technology was used to produce “town gas” typically from coal before natural gas gained widespread acceptance. During gasification, biomass is heated in the presence of a limited amount of air to achieve a partial oxidation of the solid fuel. Ideally the fuel gas produced is comprised of carbon monoxide, hydrogen and non-reactive components of air. Heating values will typically be in the range of 300 to 400 Btu per SCF.

The Primenergy gasifier is in the class of updraft, air fed gasification units. The gasification plate is a large perforated refractory bed on which a fuel supply 1 to 2 inches deep is slowly fed from the center to the outer edge. Combustion air enters the gasification chamber through the perforations in the bed at a rate sufficient to gasify the fuel with minimal conversion to carbon dioxide. The gasification chamber operates at about 1600F and the synthesis gas is drawn from the gasification chamber into the mixing chamber via an induction fan at the end of system.

Dryer exhaust is laden with moisture, fine particles and VOCs. When this exhaust gas is mixed with the synthesis gas from the gasifier, the oxygen in the dryer exhaust fuels the complete combustion of the synthesis gas. The temperature of the gas is elevated even further by this combustion to a temperature in excess of 2000F. All that remains to achieve VOC destruction is to wait for 0.5 to 1.0 seconds to decompose the VOCs to carbon dioxide and water. This is achieved in the transfer pipe from the gasifier to the heat recovery steam generator.

The heat recovery steam generator (HRSG) extracts energy from the exhaust stream to produce 600 psig steam. A small portion of the hot gas is also directed back to the dryer to provide the dryer heat. High pressure steam is directed to a back pressure steam turbine/generator to produce nearly 1000 kilowatts of electricity. Since the gasification process will consume only 400 kilowatts, the net electrical demand of the plant will drop by nearly 600 kilowatts.

Emissions from the plant via the HRSG exhaust will contain only very low levels of residual pollutants. This achieves the first objective of environmental compliance. Owing to the overall improved efficiency of the combined heat and power system, there is an additional benefit at the utility plant as 35% efficient generation is replaced with a system showing over 60% overall thermal efficiency.

The project is expected to cost about $14 million and has a simple payback of 3 to 5 years. With natural gas prices rising and expected to go even higher, the payback period continues to decline and may, in the end, be as little as 2 to 3 years. The Department of Energy and Department of Agriculture have awarded this project a $2 million grant to facilitate the financing and construction of the plant.

And what of the overall energy balance? Recognizing that some numbers are simply estimates our best guess is that the overall energy output as ethanol is now twice the inputs. By this method, ethanol has become a truly renewable fuel and as world energy markets become higher priced and less reliable this project will demonstrate how America's agricultural and forestry sectors can contribute to both our energy and economic security.

Acknowledgement

Work leading to the development of this project has been supported by the U.S. Department of Energy and the U.S. Department of Agriculture. Substantial support has been provided by the Minnesota Department of Commerce and the Xcel Energy funded Renewable Development Fund. Authors acknowledge the ongoing encouragement and support of Central MN Ethanol Coop in encouraging and developing this project.