

RIGHT TIME FOR COMMERCIALIZATION

USING MSW AND INDUSTRIAL RESIDUES AS ETHANOL FEEDSTOCKS

ETHANOL, a clean burning fuel, is being converted from waste biomass today. The technology is here; demand for ethanol is increasing dramatically; and the profit model for biomass conversion has vastly improved. The economic and environmental benefits are in place for ethanol production.

Many scientists, engineers and others feel that municipal solid waste (MSW) is an intriguing feedstock for ethanol production. Although we should recognize right away that MSW conversion is still in the pilot plant phase, the technology is ripe for commercialization. In fact, Masada Resources Group plans to break ground on the first MSW-to-ethanol facility in upstate New York in 2002.

Technology for the conversion of MSW into ethanol has been developed by private industry and in partnership with the Department of Energy (DOE) and its national facilities. DOE's National Renewable Energy Laboratory (NREL) and the Tennessee Valley Authority's Public Power Institute have tested and developed technologies both at the laboratory and pilot scale that are ready for real-world application. MSW and other forms of biomass waste are converted to ethanol primarily by converting the cellulose in biomass into sugar, followed by fermentation and distillation.

In blended gasoline, ethanol serves as an oxygenate. The addition of oxygenated fuels to the gasoline pool is federally mandated by the Clean Air Act for many areas of the U.S. to produce cleaner fuels and reduce pollution, particularly carbon monoxide.

Currently, methyl tertiary butyl ether (MTBE) is the most commonly used oxygenate in blended gasoline. Unfortunately, MTBE is a suspect carcinogen that moves quickly through bedrock into underground water supplies where it taints the water and has a distinct odor. MTBE contamination is magnified by its relative stability once it enters the environment — it doesn't biodegrade easily.

MTBE enters the environment from leaking gasoline storage tanks, pipes and



Large-scale TVA facility in Muscle Shoals, Alabama processes biomass feedstocks such as sorted municipal solid waste and agricultural residues into fermentable sugars, which are converted into ethanol.

Technologies, public policies and research support for creating energy efficient fuel from organic residuals are reviewed to show potential impact on the nation's economic development and energy security.

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pumps. Leaks in underground storage tanks (USTs) for petroleum are common — the Environmental Protection Agency estimates that over 400,000 of the country's 743,000 USTs have leaked in the past 15 years. A recent EPA press release says that about 100,000 USTs have yet to meet leak-detection standards. That implies that a lot of MTBE is being released today and finding its way into drinking water.

ALTERNATIVE TO MTBE

As of August 2001, 13 states have passed legislation to ban MTBE. The 107th U.S. Congress has no less than eight bills before it that include a national ban on MTBE in the fuel supply; the concept of phasing out and eliminating MTBE enjoys bipartisan support.

Alternatively, ethanol is an environmentally safer replacement with comparable octane ratings and higher oxygenating content than MTBE. Ethanol-blended fuel has been approved by all major automobile manufacturers, foreign and domestic, for many years. As a result, ethanol has a huge head start over other alternatives to MTBE.

Even if the MTBE ban should stop at 13

To meet the projected increase in demand, ethanol needs to be produced from such renewable feedstocks as industrial waste, MSW and agricultural residues.

states, ethanol demand is projected to skyrocket. The California Energy Commission estimates that in-state demand could be as high as 1.1 billion gallons of ethanol per year if it is used exclusively as a replacement for MTBE beginning in 2003. That amounts to approximately half of the current annual production of all U.S. ethanol plants. BBI International and the Renewable Fuels Association (RFA) estimate current annual production, through August 2001, at just over 2.2 billion gallons per year.

Potential national demand for ethanol is much higher. The RFA estimates that ethanol demand could increase to 3.2 billion gallons annually by 2004. Long-term projections are even greater. According to the Energy Information Administration, it is estimated that 8.2 million barrels of gasoline were consumed on average each day in the U.S. in 2000. This translates into a gasoline usage rate of over 125 billion gallons a year (each barrel is 42 gallons). An overall 10 percent ethanol blend in all gasoline would increase demand to over 12.5 billion gallons of ethanol per year. That would require more than 500 percent growth in ethanol production. With current projected growth rates in ethanol production, meeting demand would require a phase-in over a number of years.

RENEWABLE FEEDSTOCKS FOR ETHANOL PRODUCTION

To meet the increase in demand earlier, ethanol will need to be produced from renewable feedstocks in addition to corn. Research on alternatives to corn has focused on biomass, especially agricultural residue, forest thinning, industrial waste and MSW.

Agricultural residues such as corn stover, sugar cane bagasse and rice hulls

may be the most extensively studied sources of biomass. Unfortunately, converting agricultural residue into ethanol has been challenging from an economic perspective due to collection and transportation issues. It's difficult and expensive to amass enough corn stover, for instance, to produce a high volume of ethanol. Even in areas where significant material exists, the seasonal nature of the agricultural process makes feedstock storage a small but real concern.

In some cases, agricultural residues are already converted into profitable by-products or used to feed or bed livestock, providing market and inertial competition for these raw materials for ethanol production. And, as always, some residue must be left on the ground for environmental and conservation purposes.

As Ron Buckhalt of the U.S. Department of Agriculture (USDA) puts it, "There's a price for taking residue off the soil. We've tested all the numbers and it looks like the economic model will have to change." Buckhalt cochairs the National Biobased Products and Bioenergy Coordination Office, a joint effort between the USDA and the Department of Energy (DOE).

Buckhalt and his cochair, DOE's Doug Kaempf, believe the economic model for creating ethanol from biomass and other feedstock could change with increased demand for ethanol and financial incentives from federal and state governments. If the financial incentive to undertake an ethanol project exists, private developers will find creative ways to the meet demand.

"We need more facilities in place!" says Kaempf. He believes state governments need to be much more proactive in building biomass-to-energy programs. Kaempf suggests states take a simple three-step approach with the support of DOE's Energy Efficiency and Renewable Energy office and representatives of the Office of Fuels Development's Regional Biomass Energy Program. The three steps are:

Identify the possible feedstock in your state; Determine the opportunities for economic growth based on the availability of the feedstock; and Find out how much your state is willing to spend to develop biomass-to-energy production.

PROFITS FOR INVESTORS

Profitability is the key to attract private investment, and it is less frequently in question when considering industrial waste and MSW-to-ethanol conversion than it is with agricultural residue conversion. As feedstock, industrial waste and MSW avoid collection and transportation issues. Industrial waste is generated through manufacturing processes and MSW is collected systematically with established sorting and treatment facilities. Additionally, these potential ethanol sources are not typically seasonal in nature, making their availability and storage less problematic than agricultural residue.

CURRENT FACILITIES CONVERTING INDUSTRY RESIDUALS INTO ETHANOL

MOST industrial by-products that are being used to produce ethanol focus on starch and sugar residuals from food processing or wood product manufacturing. These current facilities include:

Georgia-Pacific Corp. — Paper waste-to-ethanol facility in Bellingham, Washington produces seven million gallons of ethanol per year

Kraft, Inc. — Using cheese whey in its Melrose, Minnesota facility, Kraft produces 2.6 million gallons of ethanol per year

Merrick & Co./Coors Brewing Co. — Facility produces 1.5 million gallons of ethanol per year from brewery waste in Golden, Colorado.

Miller Brewing Co. — Converting

brewery waste, Miller generates 700,000 gallons of ethanol per year in Olympia, Washington.

Parallel Products, Inc. — Company turns beverage waste into 12 million gallons of ethanol per year in Louisville, Kentucky, Bartow, Florida, and Rancho Cucamonga, California.

All totaled, industrial manufacturers generate approximately 31 million gallons of ethanol each year according to the RFA's August 2001 figures. That only represents 1.4 percent of total production (2.2 billion gallons). However, as process industries learn to profit from their waste streams (and as demand/pricing for ethanol increases), ethanol production is anticipated to grow.

To date, however, corn is king in ethanol production — and it will remain that way for the foreseeable future. About 94 percent of U.S. ethanol is produced from corn, according to RFA figures. Of the remaining six percent, most production comes from other grains. A small percent is currently being produced from industrial waste.

The potential for adding industrial waste-to-ethanol facilities is tremendous — current facilities have been successful using a wide array of feedstock. Many of the processes create additional salable by-products, adding to the financial incentives (see sidebar).

REDUCING LANDFILLING BY 75 PERCENT

Converting MSW to ethanol may be the best example of killing two birds with one stone that we can conceive. First, state, county and city government leaders are facing landfill crises across the country — converting MSW into ethanol cuts materials going to landfill by over 75 percent while producing ethanol and other salable products. And secondly, ethanol demand is projected to increase beyond what can be supported by corn alone, especially when considering the lack of available corn in many areas of the country.

One of the appeals of MSW as a feedstock is that it turns the gathering process upside down economically. Tipping fees make ethanol production from MSW more profitable. According to the Web site of industry analyst Chartwell Information Publishers Inc., as of June 2001 tipping fees average over \$36.98 per ton nationwide. Variables such as population, land availability and environmental regulations can produce dramatic variations. Pennsylvania's Department of Energy records show the state's tipping fees ranged from \$16 to \$98 in 1996!

Kay Martin, deputy director of public works for Ventura County, California, is responsible for the county's waste management. As she sees it, MSW-to-ethanol production needs nothing more than a good public relations campaign to drive public and private interest into developing new facilities.

"I'm always surprised to see the look on people's faces when I speak about the conversion of MSW to ethanol," Martin points out. "When people begin to comprehend the ramifications of biomass conversion, they become advocates. We're on the brink of a new industrial revolution. There's a potentially broad spectrum of political support for biomass to ethanol from far right to far left," she continues. "From a macroeconomics or macroenvironmental perspective, it just makes sense."

MIXED POLITICAL SUPPORT

Active political support for biomass-to-ethanol facilities has been mixed. Four states stand out for their support of ethanol producers — Illinois, Iowa, Minnesota and Nebraska. Combined, ethanol producers in the four midwestern states produce just under 1.7 billion gallons of ethanol each year

GROUNDBREAKING SCHEDULED FOR A MSW-TO-ETHANOL PLANT IN MIDDLETOWN, NEW YORK

CONCLUDING development logistics are being arranged by the Masada Resource Group based in Birmingham, Alabama for an MSW-to-ethanol plant in Middletown, New York. The project has been fully permitted by state and federal agencies with groundbreaking scheduled in 2002.

The Recycling and Ethanol Production Facility is permitted to process 230,000 tons of municipal

solid waste and 72,000 dry tons of biosolids annually. The plant is also expected to produce 9.5 million gallons of ethanol per year. The \$100 million dollar-plus facility will create over 350 union construction jobs and 200 permanent jobs, according to Masada, which estimates the project will inject \$38 million each year into the local economy once operations begin in 2003.

according to RFA figures from August 2001. That's over 76 percent of the U.S. total.

In 1991 Nebraska realized that its incentives for ethanol use were benefiting producers in other states. Wanting Nebraska farmers to benefit, the state took action, offering a 20-cent incentive for each gallon of new ethanol produced in Nebraska up to \$5 million per year for five years (\$25 million total) per plant. As a result, in the last ten years over \$1 billion has been invested to increase ethanol production and other by-products in Nebraska alone. Nebraska's ethanol industry produces over 300 million gallons of ethanol each year, up from 15 million gallons in 1991.

Incentive programs have not had as strong an impact in biomass waste-to-ethanol production as they have for grain ethanol because of economics — but that will change in the future. While Nebraska's ethanol production is significant, this large midwestern agricultural state produces less than one-third of the anticipated demand for ethanol of a state like California, and that's at a blend of less than ten percent statewide in the gasoline pool. Cars that use higher percentage blends of ethanol (like flexible fuel E-85 vehicles), ethanol-diesel blends, and the use of ethanol in fuel cell powered vehicles could push ethanol demand even higher.

The federal government has actively supported the growth of the ethanol industry. Legislation supporting the industry has enjoyed bipartisan support. The Departments of Energy and Agriculture have provided unilateral support of the ethanol industry at all levels — federal research laboratories, state and local governments, project developers and agricultural and industrial leaders.

DOE's Office of Fuels Development (OFD), with a \$44 million budget in 2001, leads the way, supporting research to make cellulose-to-ethanol technologies work. "Our research is focused on driving down the cost of biomass conversion," says OFD

"When people begin to comprehend the ramifications of biomass conversion, they become advocates," points out Kay Martin of the Ventura County, California public works agency. "From a macroeconomics or macroenvironmental perspective, it just makes sense."

Director John Ferrell. "We're exploring the possibilities of dedicated agricultural feedstock like fast growing trees and grasses and the logistics of using agricultural residue through Oak Ridge Laboratory." The OFD also supports the advancement of renewable diesels, including ethanol-diesel blends. "Encouraging a national ethanol program is in the best interest of the country," Ferrell says.

DEVELOPING COMMERCIAL PROCESSES THROUGH RESEARCH

The National Renewable Energy Laboratory (NREL), funded by OFD, takes the role of research laboratory. Working on its own and supporting the advancements of private industry, NREL has successfully developed processes that deliver ethanol from diverse feedstocks including forest product waste and agricultural residues.

Another OFD initiative, the Regional Biomass Energy Program, supports development of biomass-to-ethanol production on a state-by-state basis. The Regional Biomass Energy Program sponsors a series of workshops across the country which attract decision-makers in government, agriculture, industry and ethanol production.

Ann Hegnauer manages the program supported by a team of regional directors. "Many government leaders perceive that the (biomass-to-ethanol) technology's in the developmental stage," Hegnauer explains. "We provide a forum where state and regional leaders can explore the possibilities and get their questions answered."

Creating a robust bioenergy industry provides economic opportunity for states, counties, farmers, industry, waste collection and disposal communities.

Tennessee Valley Authority (TVA), a self-funded federal agency, has been involved in ethanol production research at the laboratory and pilot plant levels since the late 1970s. TVA has studied the production of sugars from numerous biomass sources (including starches, wood wastes, agricultural wastes and industrial wastes) as well as the fermentation of these nontraditional sugars. This research was a natural extension for TVA; its initial efforts were focused on development of fertilizer for the agricultural industry. The R&D programs in bioenergy at TVA's Public Power Institute have moved into new areas that can enhance farming economics and provide clean burning, domestically produced fuels.

ACCELERATING MARKET DEMAND

Why has the market been slow to respond to the inevitable demand for ethanol from sources other than grain? Numerous complicating factors such as political uncertainty and project finance issues contribute, but the seeds of new industry have been planted. Now legislative incentives and policies are needed to help this industry grow.

What are the next steps beyond education and developing real financial incentives for commercial development? Several hurdles still remain. Although the technology for biomass conversion is proven and clearly viable, further testing to allow engineering of full-scale facilities and reduce costs is needed.

Engineering and design of a first-of-its-kind facility is no small task and requires significant testing with engineering input to optimize the design and address questions not of technical viability, but of equipment selection, sizing and economic evaluation.

Creating a robust bioenergy industry provides economic opportunity for states, counties, farmers, industry, waste collection and disposal companies, and ethanol plant developers. As an oxygenate in our nation's gasoline, ethanol is good for the environment, economic development and energy security. Waste conversion to ethanol will help "fuel" that development — it just makes sense. ■

RESOURCES

Additional information on bioenergy can be found on the following Web sites:

National Biobased Products and Bioenergy Coordination Office
www.bioproducts-bioenergy.gov

Office of Fuels Development
www.ott.doe.gov/ofd/

Regional Biomass Energy Program
www.ott.doe.gov/rbep/

TVA's Public Power Institute
www.publicpowerinstitute.org
(click on "biomass")

National Renewable Energy Laboratory
www.nrel.gov

Oak Ridge National Laboratory
www.ornl.gov

Environmental Protection Agency's page on MTBE
www.epa.gov/mtbe/

Energy Information Administration
www.eia.doe.gov

Governors' Ethanol Coalition
www.ethanol-gec.org

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