Bioenergy lab to join NREL site in Golden

D.P. 31 Oct 2000 1B

By Susan Greene
Denver Post National Writer

Golden will be home to a new federal research lab to convert farm waste, fallen timber and even recyclable paper into fuel and electricity, Energy Secretary Bill Richardson will announce today.

Creation of the National Bioenergy Center follows months of record-high energy prices and political instability in the oil-rich Middle East. It also comes one week before the presidential election in which Vice President Al Gore hopes to snag votes from Green Party challenger Ralph Nader.

Colorado Republicans called the timing of today's announcement "more than coincidental."

"One has to be suspicious, especially because the vice president is so eager for votes from the environmentalists," state party chairman Bob Beauprez said.

An aide to Rep. Mark Udall, D-Boulder — who co-chairs the House Renewable Energy Caucus and has pushed for the research center here — insisted that today's announcement has nothing to do with pres-

Please see ENERGY on 6B

Bioenergy center to join so

ENERGY from Page 1B

idential politics.

"This is a bipartisan effort," Udall spokesman Lawrence Pacheco said. "It's all part of a long-term strategy to have a long-term energy policy in this country."

The bioenergy center will be the third national lab at the Golden-based National Renewable Energy Laboratory, joining the wind energy and solar electricity labs based there.

Some 60 scientists already working at NREL will study how to make ethanol for cars out of agricultural waste such as otherwise unusable corn stalks and rice straw, rather than corn. Researchers also plan to convert farm waste into an electricity-producing

solar, wind labs in Golden

ener-
ased

vork-
w to
agri-
rwise
rice
earch-
farm
ducing

gas, as well as non-petroleum based plastics.

Scientists also are looking to use recylable paper and fallen timber from Colorado forests — a plan that could reduce the risk of wildfires.

Energy Department officials say the center is part of an effort by the Clinton administration to "triple the use" of bioenergy products by 2010. They also tout the research as a way to save the environment from millions of tons of farm waste that otherwise would be dumped or burned.

Despite DOE's optimism about the future of bioenergy, Richardson isn't boosting NREL's $200 million annual budget, or providing funding for new construction or more scientists.

NREL
National Renewable Energy Laboratory

Encouraging the Development of Biorefineries

John L. Jechura, Kelly N. Ibsen,
James D. McMillan

24th Symposium on Biotechnology For Fuels and Chemicals

Gatlinburg, Tennessee, April 28 - May 1, 2002

Source http://www.ott.doe.gov/biofuels/pdfs/p032126.pdf May 25, 2003

TECHNICAL AND ECONOMIC ANALYSIS OF AN ENZYMATIC HYDROLYSIS BASED ETHANOL PLANT

Aspen and wheat straw

Fuels and Chemicals Research and Engineering Division
Solar Energy Research Institute
Golden, CO 80401

151 pages

June 1991

DRAFT

SERI Protected Proprietary Information
~~Do Not Copy~~ released and on web from DOE site NREL

j:pds/3852.pdf

PUREVISION
PUREVISION TECHNOLOGY, INC.

"Pioneering the No-Waste Revolution"

- The Vision
- Technology
- Ecological Resource & Energy Park
- Contacting Pure Vision
- PureVision Technology, Inc.
- PureVision Development Team
- Getting Involved
- News Releases

PureVision Technology, Inc.

info@purevisiontechnology.com

303-857-4530 or 303-322-4665

PUREVISION
PUREVISION TECHNOLOGY, INC.

Company Vision/Mission

Vision/Mission

PureVision Technology, Inc. ("PureVision" or "the Company") was formed in 1992. The Company's mission is to commercialize the conversion of cellulosic biomass (including trees, shrubs, and grasses as well as forest, agricultural, paper, and municipal wastes) into useful industrial products such as energy, fibers, sugars, plastics and other chemicals. PureVision is one of the few companies in the world devoted to perfecting the enzymatic hydrolysis method of converting biomass into fiber and sugars. These sugars can then be converted into bio-based plastics, fuel ethanol, and other chemicals. PureVision has assembled a top-notch pre-commercialization development team including engineering companies, research and testing laboratories, universities and commercial enzyme developers.

Over the years PureVision has made significant progress in developing its novel bio-refinery process as the basis for an emerging industry. The Company is now optimizing its technology at pilot-scale and planning to initiate the commercialization of its biomass-to-resource technology.

Home | PureVision Development Team | Previous Page
The Vision | PureVision Technology, Inc. | Technology
Getting Involved | Eco-Parks | Contacting PureVision

PUREVISION

PUREVISION TECHNOLOGY, INC.

Fort Lupton Press

PureVision and Wyoming's Western Research Institute break ground for bioprocessing facility

Bill Gern, Vice President of Research for the University of Wyoming, and event coordinator Joey Mitchell watch Ed Lehrburger, center, unveil the plaque for the PureVision bioprocessing laboratory at a groundbreaking ceremony on Thursday.

August 7, 2002 - Six years ago, Ed and Carl Lehrburger brought their dream to Fort Lupton, a vision that they could help make the world a better place by converting waste products into energy. They contacted scientists and investors and spent every spare moment trying to turn their idea and their company, PureVision Technology, into a reality. Experiments proved their vision was possible, the company began receiving national attention, and on Thursday, the business and research community of Wyoming gathered to welcome Ed Lehrburger and Fort Lupon-based PureVision to Laramie.

In a ceremony attended by Wyoming politicians, economic officials of Laramie, leaders and staff of Western Research Institute (WRI), University of Wyoming officials, and scientists and executives of PureVision, ground was broken for a new building at the WRI Advanced Technology Center in Laramie that will house PureVision's bioprocessing laboratory.

Ed Lehrburger, president of PureVision, was lauded as a visionary by speakers during the groundbreaking ceremony. "This is the right thing to do, the right time and the right partner to do it with," Dr. William Gern, Vice President of Research for the University of of Wyoming said in his remarks. Calling Lehrburger the "prototypical" type of individual WRI likes to work with, Gern said the partnership with PureVision "gives us a chance to diversify further. This is a big deal for us."

In his address to the group, Lehrburger explained how the technology being developed by PureVision takes waste products - the stover of corn plants, trees too small to be used when a forrest is clear-cut, sugar beet pulp, sawdust and other biological waste, and using bio-refinery techniques, breaks them down. The resulting products are refined into ethanol, biodiesel and chemicals, including polylactic acid, which becomes the basis of plastics. Lehrburger told the audience that biotechnology will enable people to become less dependent on petroleum products, which will, in turn result in a cleaner world. Lehrburger praised the efforts of his chief scientist, Dick Wingerson, whose dedication, he said, has enabled the company to develop its innovative technology.

The groundbreaking was for a 3,000 square foot facility that will provide laboratory space for conducting small-scale experiments

Ed Lehrburger, third from left, president of PureVision Technology, Fort Lupton, is joined by officials from the University of Wyoming, the WRI, City of Laramie, and Wyoming elected officials at a groundbreaking ceremony for Purevision's bioprocessing laboratory at the WRI Advanced Technology Center.

and the development of PureVision's patented biomass fractionation process. A one-ton-per day pilot scale biomass fractionator will provide processing and engineering data for the design of a commercial-scale biorefinery that will produce fuels, chemicals, fibers and plastics from low-value biomass.

The key to the process is reactive fractionation, which provides separation of the lignocellulose found in many sources, including agricultural, lumber and industrial waste, and separates it into hemicellulose, lignin and cellulose fractions. The cellulose can be hydrolyzed, using specific enzymes, into glucose for fermentation to produce ethanol. The lignin can be converted into energy, chemicals and polymers, and the hemicellulose into methane, chemicals and polymers. PureVision's partnership with WRI to develop the bio-refining process is sponsored in part, by a grant from the U. S. Department of Energy.

WRI, a nonprofit entity of the University of Wyoming Research Corporation under the direction of CEO Major General Scott B. Smith, is a technology innovator and business incubator. In its center on the University of Wyoming's main campus and a 22 acre site at the northwest corner of the campus are laboratories and facilities devoted to developing energy efficient technology. Included is the goal of economic feasibility, so products and methods that are developed can compete in the business world. Some of the research at WRI has led to development of asphalt that lasts longer on roads, a method of drying coal so it can be shipped more cheaply and burn more efficiently, the CROW process - contained recovery of oily wastes, the Diesel Dog Soil Test Kit, which, using soil samples can rapidly find fuel contamination on site, the SYNAG process, which converts power plant fly ash into aggregate for building and road construction, and Ready-fill, a flowable fill construction material. In his welcoming address at the groundbreaking ceremony, Smith said the PureVision facility, the first project planned for WRI's bioprocessing laboratory, was the kind of innovative technology the organization was very pleased to support.

www.PureVisionTechnology.com

PUREVISION
PUREVISION TECHNOLOGY, INC.

Getting Involved

Business Opportunities

PureVision is establishing itself as a technology and project developer. With the successful conclusion to its current pilot development and testing program, PureVision plans to begin operating its first bio-refinery during 2003. The PureVision commercialization initiative will include new partnerships with conventional industries that can fulfill key development roles in the implementation of the PureVision agenda, which is nothing short of creating a new bio-based industry. PureVision is establishing strategic alliances with companies who share a common vision, including:

- **Biomass feedstock suppliers** including waste haulers and waste management companies, farmers and farm coops, land managers, and larger commercial and industrial waste generators.
- **End-product markets**, including manufacturers who use fiber, sugars, ethanol, specialty chemicals as feedstocks for producing products.
- **Project developers** including industrial parks and real estate developers, industrial enterprises seeking to expand, and municipalities and governmental agencies undertaking economic development initiatives.
- **Researchers** for collaborative investigations in numerous areas, including feedstock assessments, enzyme enhancement and strain development, process development and environmental, economic and life cycle analyses.
- **Sub-licensees** and technology transfer partners for specific projects, processes and territories.
- **Project financiers**.
- **Electric utilities**.
- **Companies seeking carbon credits** to offset carbon dioxide pollution.

Concurrent with proposing and developing a commercial demonstration project during 2001, PureVision will be completing feasibility, environmental and engineering studies to evaluate and select other commercial bio-refinery projects.

Once the commercial demonstration plant is shown to be an economic and environmental success, PureVision plans to develop additional bio-refineries nationally and around the world. Each plant built may be a separate business entity with financing and contractual relationships tailored to the particulars of each situation. PureVision proposes to license its fiber recovery, biomass-to-ethanol and enzyme production technologies worldwide as a means of securing development rights to projects.

Working in association with affiliated companies, joint venture partners and subcontractors, PureVision will be instrumental in guiding and facilitating the primary functions of developing bio-refineries and undertaking aggressive international commercialization programs.

Investment Opportunities

An equity investment of $2 million over eighteen months is now being sought to lay the groundwork for a pilot scale demonstration of PureVision's biomass-to-resource technology. This money will be spent in two major areas:

1. Building a 1.5 ton per day bio-reactor, integrating the biomass treatment, hydrolysis, economic modeling and other process elements at small-pilot scale to obtain engineering data needed for commercial plant design.
2. Site selection, feasibility analysis, initiating the permitting process to build a commercial bio-refinery, and preliminary engineering costing and design for the first PureVision facility at commercial scale. A detailed Phase II budget projection is not shown here but is available in the complete PureVision Business Plan.

Eighteen months after obtaining its $2 million Phase II financing, PureVision expects to have in hand all prerequisites for securing financing for the first commercial bio-refinery, with the Company continuing in its role as developer. It is at this point that PureVision expects to complete a secondary financing to raise operating capital for use in a multitude of commercial projects.

Services

- **Feedstock Evaluations:** PureVision will proform waste characterization, waste assessments and bench-studies using the PureVision process on specific biomass feedstocks.
- **Economic Feasibility Studies**: PureVision will evaluate the economics of converting a specific waste stream to desired end-products using the PureVision process.
- **Project Development and Co-Development Services** for site-specific projects.

Home	PureVision Development Team	Previous Page
The Vision	PureVision Technology, Inc.	Technology
Getting Involved	Eco-Parks	Contacting PureVision

PUREVISION
PUREVISION TECHNOLOGY, INC.

Strategic Alliances

The PureVision Development Team

PureVision Technology, Inc.
Since 1992, PureVision has been advancing renewable biomass utilization technologies. Along with its strategic partners, PureVision is developing technologies to convert biomass into fiber, sugars, ethanol and energy. The PureVision management structure consists of a seasoned in-house executive team with a President, Vice President, Chief Scientist and a Biotechnology Project Manager. Because of the broad scope of its activities, the PureVision staff makes use of appropriately experienced contractors for program execution, with overall planning and coordination by in-house staff. PureVision's virtual development team brings experience and expertise from people and companies spanning the globe. Well-established alliances are in place with engineering and development firms, universities, consultants, and a commercial enzyme producer. PureVision has assembled an experienced development team to initiate pilot plant operations and complete research, design and engineering tasks for commercial biomass-to-resource plants. These alliances include, but are not limited to:

Hazen Research, Inc. (Hazen)
Hazen was organized in 1961 to provide scale-up and pre-commercialization development services to diverse industries. Hazen professional services include fuels characterization, laboratory and pilot plant testing, engineering and field services. PureVision has contracted with Hazen to complete bench- and pilot-scale testing and to assist in scaling up the cellulosic waste-to-resource technology.

Western Research Institute (WRI)
Western Research Institute, which is partially funded by the U.S. Department of Energy, is a technology development facility serving private clients, industry, and government. Headquartered in Laramie, WY, WRI engages in research, development, demonstration and commercialization of technologies related to energy, environment, and transportation materials. WRI is currently underway with a six-month, pre-pilot testing program involving PureVision's biomass fractionation technology.

Colorado State University (CSU)
Much of PureVision's small-scale conversion of feedstocks to sugars (hydrolysis) and assays will be undertaken at CSU. PureVision will be directing continuing research at CSU to hydrolyze and assay the performance of cellulase enzymes on various cellulosic feedstocks. CSU and PureVision are also working together to figure out ways to economically convert unique feedstocks into sugars.

University of Colorado (CU Boulder)
PureVision has been working with the CU Department of Molecular, Cellular, & Developmental Biology to advance enzyme production systems using transgenetic plants.

Colorado School of Mines (CSM)
PureVision and CSM are collaborating on applying a filtration technique for the fractionalized biomass process streams to perform assays and advanced separation techniques.

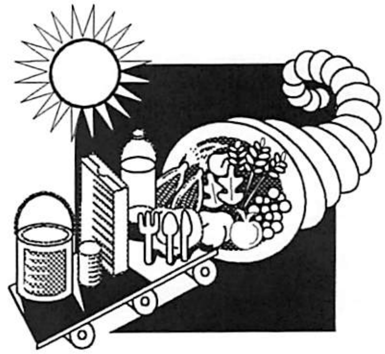
University of Washington
Through its affiliation with the Forestry Products Department, PureVision will be working with the University of Washington to assay cellulosic fibers from diverse biomass feedstocks to determine the best uses for the fibers produced from PureVision's biomass fractionation technology.

Econergy International Corporation (EIC)
EIC is a Boulder, Colorado-based engineering firm specializing in energy efficiency, renewable energy technologies, and greenhouse gas emissions management. EIC is one of the early pioneers in the carbon-offset accounting, certification and trading arena. EIC is working with PureVision to develop markets for carbon offsets derived from bio-refineries.

Colorado Bio-processing Center (The Center)
The Colorado Bioprocessing Center at Colorado State University is a contract research laboratory generating new biotechnology based products and processes. The Colorado Bioprocessing Center and PureVision entered into a Cooperative Agreement in 1999 to verify and scale-up enzyme production processes.

SouthEastern Energy Development, Inc. (SEED)
SEED is in the process of becoming PureVision's first technology licensee. Organized in New York to develop ethanol projects for both clean energy and waste management, SEED has purchased an option from PureVision for the exclusive use of the PureVision technology for the states of North Carolina and South Carolina. SEED is presently raising capital to develop waste-to-ethanol projects using PureVision's technology in the southeast United States.

Home | PureVision Development Team | Previous Page
The Vision | PureVision Technology, Inc. | Technology
Getting Involved | Eco-Parks | Contacting PureVision



Completing Pre-Pilot Tasks to Scale up Biomass Fractionation Pretreatment Apparatus from Batch to Continuous Process

Producing a purified cellulose stream is a critical step to achieving economical conversion of biomass into energy and industrial products

Benefits
PureVision biorefineries will:

- Use agricultural and forest wastes to produce sugars, ethanol, energy and many industrial chemicals
- Offer industry wide saving of 2.3 trillion BTU by 2010
- Minimize fossil fuel inputs by using carbon-neutral processing and producing bio-products

Applications
Biomass conversion has widespread applications and will be beneficial to many industries interested in renewable energy resource management including:

- Agriculture
- Forest products
- Food processors
- Land managers
- Solid waste management
- Specialty chemical manufacturers
- Blenders and marketers of fuel ethanol

A biomass conversion technology has been developed that separates ligno-cellulosic materials into product streams for economical processing into energy and industrial products. PureVision Technology, Inc. has built an operating, bench-scale, biomass-processing apparatus and is currently evaluating the conversion of corn stover into resources. This apparatus has produced a purified cellulose stream with greater than 97% purity. Producing a purified cellulose product is a critical step in achieving economical conversion of biomass into sugars utilizing enzymatic hydrolysis.

A continuous pilot-scale machine will provide the engineering criteria for designing a commercial demonstration biorefinery and will provide the basis for performing formal processing and economic assessments of converting diverse biomass feedstocks into resources at commercial biorefineries. The successful implementation of the PureVision reactive fractionation biomass pretreatment technology would result in the economical processing of biomass into resources, thereby enhancing national productivity and global competitiveness while minimizing adverse environmental impacts.

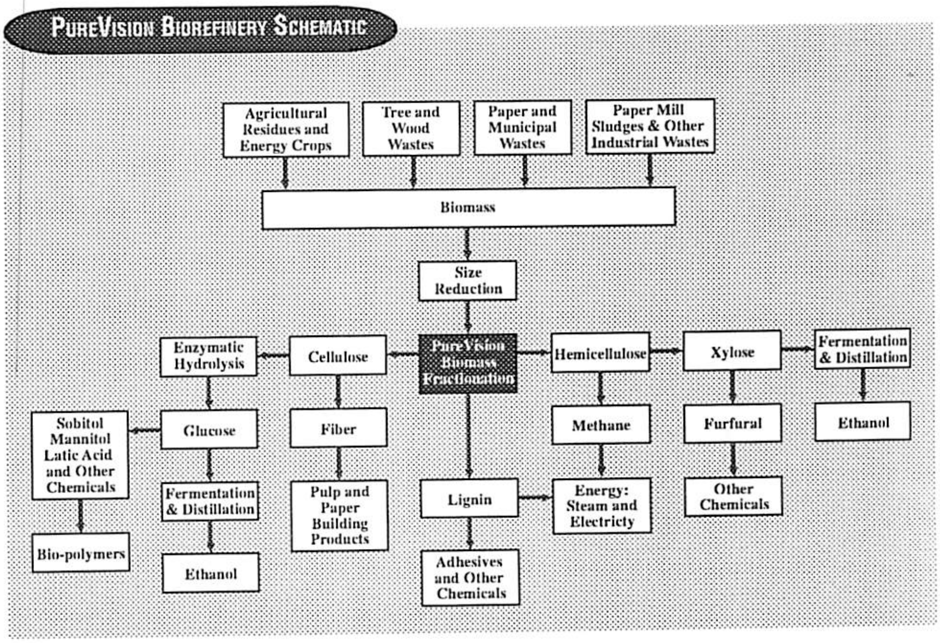


Illustration of the PureVision Biomass process.

Project Description

Goal: The goal of this project is to develop the costing and design criteria to build a one ton per day pretreatment pilot plant. This research is to determine the necessary elements, procedures and costs in retrofitting off-the-shelf plastic extrusion equipment into biomass processing and conversion equipment. PureVision expects to demonstrate the ability to process corn stover into three fractions. The first fraction is a wash liquor stream containing primarily water and hemi-sugars. The second fraction is a wash liquor stream containing primarily water and lignin. The third fraction is a purified cellulose product stream. The continuous process is to be the heart of PureVision's biorefineries of the future.

Progress and Milestones

The following are the main tasks to be performed:

- Operate and collect data on a continuous biomass processing apparatus to process corn stover into three fractions.
- Run samples and collect data on a liquid-separation and purification apparatus from the hemi-sugar-rich wash liquor stream and the lignin-rich wash liquor stream generated from the processing wash stream fractions.
- Perform enzymatic hydrolysis tests and corresponding assays on the purified cellulose product being generated from the biomass process.
- Complete preliminary design and costing for assembling and shaking down the proposed pretreatment pilot plant.

Growing market for bio-fuels and bio-products: Once the cellulose, hemicellulose and the lignin fractions are separated in the PureVision biomass-fractionation process, they become feedstocks for producing sugars, fiber, energy and chemicals. Glucose, xylose and other sugars produced in biorefineries can be manufactured into xylitol, mannitol, furfural, bio-plastics and other industrial chemicals. The market for these fermentation sugars is estimated to be 20 to 50 million tons per year for fuel ethanol production and 100 million tons for production of chemicals and plastics.

A key strategy for utilizing PureVision's technology is to produce fuel ethanol to supplement gasoline. In addition to significant environmental benefits, domestically produced ethanol will reduce the United States dependency on foreign oil. In 2001, approximately 1.8 billion gallons of ethanol representing $2.7 billion in sales was produced from corn in the US. In the PureVision process, corn stover, which includes corn stalks and other corn residues, and other forest and wood wastes can be converted to sugars. The PureVision process can help the U.S. Department of Energy meet its target of producing 10 billion gallons of ethanol per year from all sources of biomass by 2020.

Economics and Commercial Potential

The proposed work will advance commercialization efforts by completing essential equipment evaluations for scaling up an invention currently undergoing testing that, to date, has proven to work only at batch processing. Commercial introduction of this technology is expected by 2005. Annual energy savings by 2010 would be 2.3 trillion Btu from one installation. By 2020 the savings would grow to 41 trillion Btu with 18 biorefineries using the technology.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and to conduct early development. Ideas that have significant energy-savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

For project information, contact:

Ed Lehrburger
PureVision Technology, Inc.
511 N. McKinley Ave.
Ft. Lupton, CO 80621
Phone: (303) 857-4530
Fax: (303) 857-0323
Ed@Purevisiontechnology.com

Home Page:
www.purevisiontechnology.com

For more information about the Inventions and Innovation Program, contact:

Lisa Barnett
Program Manager
Inventions and Innovation Program
Phone: (202) 586-2212
Fax: (202) 586-7114
lisa.barnett@ee.doe.gov

Visit our home page at
www.oit.doe.gov

Office of Weatherization and Intergovernmental Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Avenue SW
Washington, D.C. 20585-0121

September 2002

Oral Presentation 3-04

An Advanced Fractionation Technology for Converting Biomass into Multiple Product Streams

Richard Wingerson, *Ed Lehrburger*, and Carl Lehrburger

PureVision Technology, Inc.
511 N. McKinley
Ft. Lupton, CO 80621

Telephone: (303) 857-4530; Fax: (303) 857-0323; E-mail: info@purevisiontechnology.com

PureVision Technology, Inc. (PureVision) is developing a unique biomass fractionation process for pre-treating biomass prior to enzymatic hydrolysis. The PureVision fractionation process converts lignocellulosic biomass into three distinct fractions: cellulose, hemicellulose and lignin, each with a wide range of uses and by-products including sugars, ethanol, energy and other chemical products. Before scaling up to a continuous-feed pilot, PureVision and Western Research Institute (WRI) are undertaking pre-pilot testing of the biomass fractionation reactor using a washed batch reactor to optimize operating conditions of the PureVision reactive fractionation process. The fractionation reactor, which separates and cleans cellulose from hemicellulose and lignin prior to enzymatic hydrolysis, is the heart of an integrated approach for converting lignocellulosic biomass into useful products in bio-refineries.

This paper describes the bio-refinery and reactive fractionation technology under development by PureVision. The PureVision/WRI pre-pilot program, initiated in September 2001 with co-funding from the U.S. Department of Energy, will be highlighted. Project objectives, technical challenges and milestones are detailed. Results will be presented by PureVision for fractionating and processing corn stover.

Back to main Symposium page

This page was updated 03/26/02

The Potential for Ethanol Production From Alfalfa Fiber Derived From Wet Fractionation

Source http://www.dfrc.wis.edu/Research_Summaries/RS96-18.pdf 25 May 2003

R.G. Koegel and R.J. Straub

Introduction

Wet fractionation of forage crops allows biomass to be produced at very competitive prices due to the high values of the coproducts. The fractionation process consists of expressing juice from fresh herbage. The resulting fibrous fraction is high in cell wall constituents (cellulose, hemicellulose and lignin). It can be immediately field-dried and baled or pelleted if desired to minimize handling, transportation and storage costs. It is suitable for combustion, gasification, or enzymatic hydrolysis and fermentation to ethanol.

The juice fraction typically contains 25 to 30% of the dry matter in the original herbage depending on the severity of processing. It is high in protein and solubles and is almost fiber free. It can be used to produce both food-grade and feed-grade protein concentrates as well as other high-value products. The anticipated market value of the juice products, based on current prices of analogous products, greatly mitigates the production costs of the biomass fraction.

Wet fractionation of green herbage, the separation of fiber and juice, to produce protein concentrates has been researched and developed for more than a half century (Telek and Graham, 1983; Pirie, 1987). The technology and products are well known. For most of this period, however, emphasis was on making a crude, green protein concentrate either for livestock feeding or for supplementing the diets of humans suffering from protein deficiency. While the nutritional value of this product was undisputed, the economics of the process were, at best, marginal. Therefore, it was not, in general, commercialized.

Subsequent developments, however, appear to have greatly improved the potential for profitability:

1. Researchers have identified high-value juice products including soluble protein with good functional properties for human food (Knuckles and Kohler, 1982; Kohler et al., 1983), xanthophyll concentrates for use in the poultry industry (Crombie, 1995) and other products such as plant and animal growth stimulants, cosmetic substances, and pharmaceuticals (Koganov, 1992; Koganov et al., 1988).
2. Biotechnologists at the University of Wisconsin have demonstrated the possibility of adding genes to alfalfa which cause the transgenic alfalfa to produce industrially valuable substances, especially enzymes. Fields of alfalfa could thus become "bioreactors" or "enzyme factories" with the target enzymes recovered from the juice.

To date, transgenic alfalfa cultivars containing manganese dependent lignin peroxidase for biopulping, α-amylase for converting starch to sugar, cellulases for saccharification of ligno-cellulosics, and phytase to allow poultry and swine to utilize otherwise insoluble phosphorus in their grain-based rations, respectively, have been produced.

The use of forage crops, especially perennial legumes as a source of biomass, has a number of other advantages:

1. The need for nitrogen fertilizer, a high energy non-renewable input, is eliminated. Infrequent reestablishment of the crop minimizes the energy requirement for tillage and seed bed preparation.
2. Biomass can be field-dried and pelleted or cubed to minimize transportation, handling, and storage costs.
3. Forage varieties adapted to a wide range of environmental conditions exist, and production practices are established.
4. Machinery and methods for production and harvesting are available.

5. The excellent soil and water conservation characteristics of perennial forage crops are well recognized. This makes their production not only sustainable, but also desirable.

The economics of biomass production via wet fractionation is dependent on both unit prices and per hectare production of the various fractions.

Methods

In the spring of 1995 at Madison Wisconsin, four plots of approximately 42m^2 each were established in an alfalfa field which had been seeded the previous year. The first plot was mowed on May 22 and May 21 in 1995 and 1996, respectively, with successive plots mowed at 8-9 day intervals. This was done to "stage" the area as would be necessary in a large scale operation where it is required to keep harvesting and processing equipment working steadily at near capacity during the entire growing season. Each plot was then harvested at approximately 35-day intervals after its initial harvest for a total of four harvests per plot. The herbage from each plot was weighed and immediately macerated using a double rotor, rotary impact macerator (Koegel and Straub, 1994). Juice was then expressed by running the macerated herbage twice through a 15 cm diameter Rietz screw press. Herbage, juice, and fibrous fraction samples were oven-dried at 105 °C for 24 hours to determine dry matter content.

The following analyses were carried out on the fibrous fraction: (1) neutral detergent fiber (NDF), (2) acid detergent fiber (ADF), (3) acid detergent lignin (ADL), (4) nitrogen, and (5) ash.

The following definitions were used: (1) hemicellulose = NDF - ADF, (2) cellulose = ADF - ADL, (3) lignin = ADL, and (4) protein = 6.25 x nitrogen. Solubles were determined by difference.

Results

Per hectare dry matter yields of herbage and juice for 1995 are 13.5 t/ha and 4.2 t/ha, respectively, for an overall juice:herbage DM ratio of 0.31. In 1996, herbage dry matter yield was 12.9 t/ha and juice DM yield was not measured.

Table 1 gives the composition of the biomass or ligno-cellulosic fraction resulting from wet fractionation of the four harvests of each of the four plots in terms of cellulose, hemicellulose, lignin, protein, ash, and solubles (by difference). These are also converted to per hectare yields based on 9.45 t/ha of fibrous fraction.

Table 2 shows the potential per hectare production of ethanol based on yields of 85% of the stoichiometric. The soluble dry matter, which has not been characterized, was assumed to yield at the same rate as cellulose.

Wyman et al. (1993) give ethanol yields (l/t) of cellulosic biomass as 338 for "reference case" and 497 for "improved technology." Multiplying these yields times the 9.45 t/ha of alfalfa fibrous fraction gives 3194 l/ha and 4697 l/ha, respectively, which bracket the 4200 l/ha shown in Table 2.

Wyman et al. (1993) give approximate compositions of three classes of lignocellulosics: "agricultural residue," "hardwoods" and "herbaceous plants." The ratios of hemicellulose to cellulose for these three groups are approximately 1:1.2, 1:2.2, and 1:1.5, respectively, and the sums of hemicellulose plus cellulose are 70%, 73% and 75% of the total weight, respectively. In the case of the fibrous fraction of alfalfa, the ratio of hemicellulose to cellulose is 1:1.9 and the sum of hemicellulose, cellulose, and solubles is approximately 72% of the total weight. The lignin concentration of the alfalfa, at 7.8% is half or less than that listed for the three groups of cellulosics. Protein at 10-11% is high relative to other cellulosics. It is conjectured that the protein may form highly insoluble complexes during the high temperature pretreatment to hydrolyze the hemicellulose. There may, therefore, be some incentive to remove more of it with the juice by means of rewetting during the pressing process. The ash content at 8.6% is also relatively high. The value of this ash as agricultural fertilizer remains to be determined. The exact content of the solubles likewise has not yet been determined.

Alternately, the fibrous fraction could be field-dried and combusted for production of electrical power. Bomb calorimeter tests have given a higher heating value of approximately 19,000 kJ/kg. At a yield of 9.45 t/ha, this would be approximately 50,000 kWh/ha, or if converted to electricity at an efficiency of 0.3, electrical energy of approximately 15 MWh/ha.

Conclusions

"Staging" of the area to be cut by starting early and spreading the first cutting over approximately 35-days, with repeat cuttings of any area at 35 day intervals, appeared to work well in 1995 and 1996. This strategy could allow harvesting and processing equipment to be used quite steadily, at near capacity, during the entire growing season. On the other hand, it should be recognized that the data presented is for only one set of unreplicated plots for two harvesting seasons. The measured yields are 125%-150% of those frequently reported. Less favorable weather, for example, could reduce yields and delay regrowth.

The high unit values and yields of certain juice products — e.g., soluble food-grade protein concentrates: ≅ 0.6 t/ha, particulate protein-xanthophyll concentrates ≅ 1.6 t/ha, industrially valuable enzymes ≅ 5-25 kg/ha — can make the economics of wet fractionation attractive. The potential high value of the juice products can, in a sense, "subsidize" the ligno-cellulosic fraction making it possible to market it in the neighborhood of $40/t dry matter.

The yield and composition of the fibrous fraction would allow over 4000 liters/ha of ethanol to be produced annually at 0.85 of the stoichiometric conversion. If converted to electrical energy at an efficiency of 0.3, the result would approximate 15 MWh/ha annually.

References

Crombie, L. 1995. Personal communication. Crombie and Assoc., St. Paul, MN.

Knuckles, B. E. and G. O. Kohler. 1982. Functional properties of edible protein concentrates from alfalfa. J. Agric. Food Chem. 30. pp. 748-752.

Koegel, R. G. and R. J. Straub. 1994. Fractionation of alfalfa for food, feed, biomass, and enzymes. ASAE Paper No. 946010. St. Joseph, MI.

Koganov, M. M. 1992. Comprehensive processing of vegetative organs of green plants. MT International, Inc. Dublin, Ohio.

Koganov, M. M., L. V. Shvaiko, N.I. Kuznetzov, L.V. Shaparenko and G. A. Lobach. 1988. The influence of alternating current on alfalfa chloroplast coagulation. Physiology and Biochemistry of Cultural Plants. 20(2):195-200.

Kohler, G. O., R. H. Edwards, and D. de Fremery. 1983. LPC for feeds and foods: The pro-xan process. pp. 508-524. Telek and Graham, eds. Leaf Protein Concentrates. AVI Publ. Co.

Pirie, N. W. 1987. Leaf protein and its byproducts in human and animal nutrition. Cambridge University Press.

Telek, L. and H. D. Graham (ed.). 1983. *Leaf Protein Concentrates.* AVI Publ. Co., 844 pp.

Wyman, C. E., R. L. Bain, N. D. Hinman, and D. J. Sevens. 1993. *Ethanol and Methanol from Cellulosic Biomass.* Chapter 21 in Renewable Energy. Johansson et al., ed. Island Press. Washington D.C.

Table 1. Composition (%) of the fibrous fraction obtained from maceration and juice expression of alfalfa (4 plots x 4 cuttings per plot).

	Cellulose	Hemicellulose	Lignin	Protein	Ash	Solubles (by difference)
Mean	33.05	17.48	7.77	10.94	9.28	21.48
Std. Dev.	4.40	3.44	1.67	1.75	2.00	3.91
Max.	43.38	24.40	12.97	15.56	16.38	28.32
Min.	24.04	12.52	4.83	8.13	6.81	14.51
n = 16 x 2 reps						
t/ha*	3.12	1.65	0.74	1.03	0.81	2.09

*Based on annual herbage yield of 13.5 t/ha and fibrous fraction = 0.7 x herbage = 9.45 t/ha.

Table 2. Potential ethanol production from alfalfa "fiber."

Material	t/ha	Stoichiometric Ratio	Efficiency	Ethanol yield (t/ha)
Cellulose	3.12	.568	.85	1.51
Hemicellulose	1.65	.581	.85	0.81
Solubles	2.09	.568	.85	1.01
		(assumed)	Total	3.37 t/ha = 4266 liters

Short-Rotation Woody Crops Program
at
State University of New York
College of Environmental Science & Forestry

Biomass Power for Rural Development Technical Report:

SOIL SUSTAINABILITY AND PRODUCTIVITY IN SHORT ROTATION INTENSIVE CULTURE

Interim Program Report

Prepared for the United States Department of Energy
Under Cooperative Agreement No. DE-FC36-96GO10132

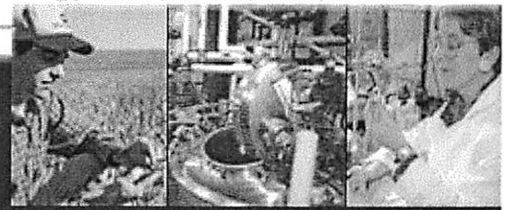
Submitted to:
Edward Neuhauser, Project Manager
Niagra Mohawk Power Corporation
Syracuse, New York

by:
F. Ulzen-Appiah, R.D. Briggs, C.A. Nowak, T.A. Volk, L.P. Abrahamson, and E.H. White

March 2000

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable.

Biofuels For Sustainable Transportation



for researchers | for policymakers | for students | basics

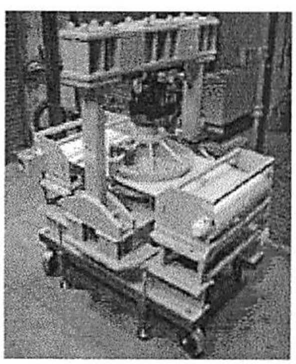
about the program | research & technology | biofuels issues | information center | partnering with biofuels

search the site GO

Related Resources:
- Biofuels Documents
- EREN Topics
- Subscribe to *Biofuels News*
- FAQs

What's New?

Biorefinery Project Awards
The DOE Biomass Program has awarded about $75 million to six major cost-share agreements for integrated biomass research and development. Broin and Associates, Cargill, Cargill Dow LLC, Dupont, High Plains Corporation, and the National Corn Growers Association head the multiple-organization teams for the six projects. More



The U.S. Department of Energy (DOE) National Biofuels Program seeks to cost-effectively produce ethanol and other fuels and chemicals from biomass resources such as agricultural and forestry residues or fast-growing trees and grasses. This requires efficient technology to extract and use the sugars in cellulose and hemicellulose—the fibrous bulk of plant material. Developing this technology is the primary focus of the Biofuels Program and of this Web site.

Biofuels such as ethanol made from starch and biodiesel made from vegetable oil already clean our air, support rural economies, and improve our energy independence and balance of trade. We hope you will also find this Web site a useful portal to current biofuels use and to other biofuels-related DOE programs.

DOE | EERE | Biomass Program
Related Links | Security and Privacy Notices | Webmaster

Last updated: 12/17/02

Cofiring

Cofiring biomass with coal represents one of the nearest term and lowest cost options for CO_2 reduction in the electrical power sector. However, there are a number of critical issues associated with cofiring that require careful consideration. These issues were identified in part by a workshop that included utilities and others involved or potentially involved in cofiring. The following pages summarize some of the progress we have made to date on these issues. The major subtopics are indicated in the list to the left, with most subtopics including further links to more details. These subtopics include the formulation of a series of guidelines for cofiring biomass with coal.

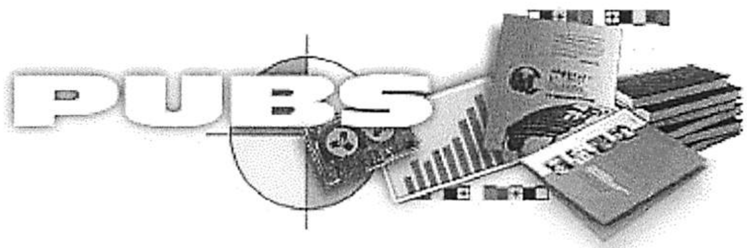
Cofiring

- Ultimate Analyses
- Web Settings for Active Server Pages
- Black Liquor
- Carbon Dioxide Sources
- Coal
- Corrosion Summary
- Experiments
- Probe
- Available Biomass
- Comparitive
- Heating Value
- Corrosion Issue
- Burnout Experimental Highlight
- Continuous Gas Analysis
- Energy Laboratory Home Page
- Inorganic Properties
- Algorithms
- Ash Deposition
- Integrated Biomass Boiler Models
- Chemical Fractionation
- Diagnostics
- FTIR
- Summary of Guidelines
- Deposition Conclusions
- Deposition Experimental Highlight
- Deposition Issues
- Carbon Burnout
- Combustion Properties
- Corrosion
- Ultimate Analysis
- Contaminated Fuels
- Metals
- Proximate Analysis
- Pyrometer
- Ash Chemistry
- Deposition By Reaction
- Emissivity
- Emissivity
- Integrated PC Boiler Models
- Ash Management
- Biomass
- Major Contributors
- Motivation
- Particle Characteristics
- Kyoto Goals
- Ash Fusion Temperatures
- Mission Statement
- Publications
- Tunable Diode Laser

Sponsors: Department of Energy: Biomass Power Program: National Energy Technology Laboratory

National Renewable Energy Laboratory

PUBLICATIONS DATABASE



Help

Search

New e-Pubs

Welcome to NREL's Publications Database. This database contains references to documents written and/or edited by staff and subcontractors of NREL.

Covering subjects related to sustainable energy technologies from 1977 to the present, our bibliographic database includes NREL technical reports, fact sheets, brochures, videos, books, journal articles, conference papers, patents, and exhibits.

Subscribe to NEON

NREL's Electronic Outreach Network

Selected publications are available in full text online and can be located by searching the database or the DOE Information Bridge at www.osti.gov/bridge/. If the publication you want is not yet online, documents are available, unless otherwise noted, in limited quantities from the NREL Document Distribution Service: (303) 275-4363; fax: (303) 275-4053, email: document_distribution@nrel.gov

HOME | Disclaimer | Questions or comments: Publications Webmaster | Security & Privacy

Western Research Institute

Home | Technology Areas | Products | Services | Contacts | Working With WRI | About WRI | Links | T-WY Corp

Links

Alternative Fuels
Power Energy Fuels, Inc.
Power Generating, Inc.
SRT Group, Inc.
PureVision Technology, Inc.

Ash Related Sites
Foster Wheeler Energy International
Electric Power Research Institute
Montana-Dakota Utilities (MDU)
North Dakota Industrial Commission

Asphalt Related Sites:
ATS RheoSystems
Chevron
Citgo
Dongré Laboratory Services, Inc
INSTRON
The International Center for Aggregates Research (ICAR)
Martin Marietta Materials
Moore & Munger
National Asphalt Pavement Association
National Center for Asphalt Technology at Auburn University
Nevada Department of Transportation
Nichols Consulting Engineers
North Carolina State University
Paar Physica
Pennsylvania Transportation Institute
Petersen Asphalt Conference
Q-Panel Lab Products
Shell
Sunoco
Texas Transportation Institute at Texas A&M University
Transportation Research Board
Turner-Fairbank Highway Research Center
University of Wyoming Civil Engineering
US Department of Transportation, Federal Highway Administration
Vulcan Materials Company

Associations
American Association of State Highway Transportation Officials (AASHTO)
The American Coal Ash Association
The Air & Waste Management Association (A&WMA)
The American Chemical Society
The American Society for Testing & Materials

Energy Related Sites
Montana-Dakota Utilities – MDU Resources
National Petroleum Technology Office
North Dakota Industrial Commission
Public Service Co. of Colorado
Xcel Energy

Emergency Response – or Clients/Partners
AristaTek – PEAC
Department of Energy National Nuclear Security Administration, Nevada Test Site

Environmental Related Sites
Gas Research Institute
En Chem
Montana Department of Environmental Quality
North Dakota Department of Health
United States Environmental Protection Agency

Please sign our guestbook

CONTAC
If you wou
WRI link t
contact:
morena@

Government Sites
Energy Information Administration
Turner-Fairbank Highway Research Center
US Department of Energy home page
US Department of Energy, Office of Fossil Energy
US Department of Energy, Office of Fossil Energy - National Energy Technology Laboratory
US Department of Energy, Office of Power Technologies
United States Environmental Protection Agency
US Department of Transportation, Federal Highway Administration

Oil companies
Amoco
Chevron

Power Generation/Research
Electric Power Research Institute

Wyoming
Laramie Chamber of Commerce
Laramie Economic Development Corporation
The Blue Sky Group, Inc.
The University of Wyoming
Wyoming Business Council
Wyoming Technology Transfer Center

Wyoming State Government
State of Wyoming
Wyoming Department of Environmental Quality
Wyoming Department of Transportation

TOP

Western Research Institute | 1-307-721-2011 | 365 North 9th Street | Laramie, WY | 82072-3380
TERMS OF USE | © 2001 WESTERN RESEARCH INSTITUTE | SITE MAP

Last Modified /content/links/index.shtml: Jun 2

Full Fuel Cycle Analysis
of Biomass to Ethanol:
Wastewater Treatment
System Performance

By
CH2M HILL

December 10, 1991

67 pages

Submitted to
National Renewable Energy Laboratory

CH2M HILL Protected Information

Technical and Economic Evaluation Wood to Ethanol Process

A report prepared for Solar Energy Research Institute

August 1990

68 pages

DOI site N.R.E.L.
3pdf5/3951.pdf

has reviewer notes
esp. on gathering wood chips
p10
p24 vent steam an env. issue

CHEM SYSTEMS

Chem Systems Inc.
303 South Broadway
Tarrytown, New York 10591
Telephone: (914) 631-2828 Telex: 221844 Facsimile (914) 631-8851

Bioethanol Technology Process Engineering and Analysis

Process engineering and analysis of bioethanol technologies is carried out to support research, development and demonstration projects to convert cellulosic biomass to ethanol. Activities include developing conceptual process designs, conducting technical and economic evaluations, evaluating research and developmental results, identifying areas for future research and development, and supporting engineering designs for demonstration plants. This ongoing effort combines the resources of federal, institutional and private groups to help streamline the bioethanol research effort.

Current Research

A new design report details the design basis and economic parameters for the enzymatic hydrolysis process. The report: "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis For Corn Stover" provides a complete updated design basis for the enzyme based process using corn stover as the feedstock with a detailed discussion of all design assumptions and economic evaluation parameters including equipment size and costs and projections of ethanol production costs for the year 2010. This report is the second design report from NREL, the first report, published in 1999, utilized hardwood feedstock.

Alternately, the "Lignocellulosic Biomass to Ethanol Process Design and Economics Utilizing Two-Stage Dilute Acid Hydrolysis" report will contain a complete design basis for the two-stage dilute acid hydrolysis process with a detailed discussion of all design assumptions and economic evaluation parameters including equipment size and costs and projections of ethanol production costs. Publication is expected in 2003.

In an effort to improve the process design and strengthen the information it is based on, the process engineering group is always working with a collection of engineering firms, other federal agencies and operating companies. These collaborations provide valuable insight for creating a sound process based on industry standards and engineering principles.

(Click on the title for downloading options)

The Harris Group investigated equipment for corn stover handling, pretreatment reactors, and solid/liquid separations to improve understanding of these operations in ethanol production from biomass.

Phase I of a joint USDA/NREL project exploring the costs of producing ethanol from corn starch and corn stover has been completed and the results published: Determining the Cost of Producing Ethanol From Corn Starch and Lignocellulosic Feedstocks. Phase II will explore the synergies of the two processes and is slated for 2002.

Back to top

Recent Publications, Reports and Presentations

(Click on the title for report downloading options)

These reports summarize recently completed work aimed at developing better process designs and costing information for bioethanol. There are several downloading options available to make the report size more manageable and let you target the information you are looking for.

- Building a Bridge to the Corn Ethanol Industry (2000) Six engineering companies teamed with corn ethanol producers and research institutions to explore the synergy between the corn and cellulosic ethanol processes.

- Lignocellulosic Biomass to Ethanol Process Design and Economics, Utilizing Co-Current Dilute Acid Prehydrolysis and Enzymatic Hydrolysis, Current and Futuristic Scenarios(1999) Complete design basis for the enzyme based process using chipped hardwood feedstock with a detailed discussion of all design assumptions and economic evaluation parameters. Equipment size and costs, and projections of ethanol production costs out to the year 2015. NREL.

- Energy Analysis of Biomass-to-Ethanol Processes (1999) Options for burning the waste lignin from the biomass to ethanol process and supplying steam and electricity. Reaction Engineering International.

- Wastewater Treatment Options for the Biomass-To-Ethanol Process (1998) Options for waste water treatment in the biomass to ethanol process. Merrick & Company.

- Development of an ASPEN PLUS Physical Property Database for Biofuels Components (1996) Physical properties for components specific to the biomass to ethanol process that are not included in the ASPEN Plus databases. NREL.

- Rapid Evaluation of Research Proposals Using ASPEN Plus (2000) Anoutline of the methods and tools used for rapid analysis of research proposals. NREL.

Back to top

Older Publications and Reports

(Click on the title for report downloading options)

- A Manual for the Economic Evaluation and Energy Efficiency and Renewable Energy Technologies (1995) The basis of many of the economic evaluation parameters used in the current study. NREL.

- Biomass to Ethanol Process Evaluation (1994) NREL Final Subcontract Report, Chem Systems, Tarrytown, NY.

- Full Fuel Cycle Analysis of Biomass to Ethanol: Wastewater Treatment System Performance (1991) The design and cost of waste water treatment facilities for a biomass to ethanol process. Superseded by the 1999 Merrick report. CH2MHill.

- Technical and Economic Analysis of an Enzymatic Hydrolysis Based Ethanol Plant - Draft (1991) by D. Schell, C. Riley, P. Bergeron, and P. Walter, Solar Energy Research Institute, Golden, CO, SERI Report TP-232-4295. This is a complete economic evaluation of the enzymatic process using a spreadsheet model. This model was considered state-of-the-art in 1991.

- Biomass-to-Ethanol Total Energy Cycle Analysis (1991) NREL Subcontract Report, Radian Corporation

- Technical and Economic Evaluation: Wood to Ethanol Process (1990) SERI Subcontract Report, Chem Systems, Tarrytown, NY.

- Economic Feasibility Study of an Acid Hydrolysis-Based Ethanol Plant (1987) NREL subcontract ZX-3-03096-2 Final Report, Badger Engineers, Inc., Cambridge, MA.

Back to top

General Interest Publications and Reports

(Click on the title for report downloading options)

- Fluidized Bed Combustion and Gasification: A Guide for Biomass Waste Users (1994) Southeastern Regional

Biomass Energy Program, FBI, Inc. and Tennessee Valley Authority.

- Report on Biomass Drying Technology (1998) A review of drying equipment suitable for boiler fuel. NREL.
- Characterization and Anaerobic Digestion Analysis of Ethanol Process Samples (1998) Samples of pseudo waste water generated in NREL's miniplant were analyzed for COD to help support the waste water treatment process design. Pinnacle Biotechnologies.

For additional publications and reports search the Biofuels Document Database

Back to top

For More Information
Contact:
Kelly Ibsen (kelly_ibsen@nrel.gov)
Process Engineering and Analysis Team Leader
NREL Biofuels Program

Back to top

Last updated: 03/03/03

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy

Biofuels
For Sustainable Transportation

Softwood Conversion Technology

Lumber manufacturing, timber harvesting, and thinning of forests to prevent wildfires generate a large quantity of softwood residues that makes an attractive feedstock for fuel ethanol production. The quantity of softwood residues is not as large as some agricultural residue quantities, such as for corn stover; however, softwood residues are an important near-term biomass feedstock because there is a need for environmentally sound and cost-effective methods for disposing of these residues. For the past 3 years, softwood research activities at NREL have focussed on investigating the feasibility of converting softwood forest thinnings to ethanol using two-stage dilute sulfuric acid hydrolysis technology.

Current Research
Recent Publications, Reports, and Presentations
For More Information

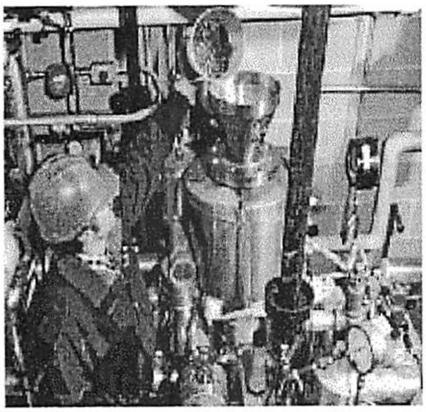
Current Research

Biofuels researchers recently completed bench-scale experiments confirming the technical feasibility of converting softwood forest thinnings to ethanol using two-stage dilute acid hydrolysis.

- Dilute sulfuric acid hydrolysis
- Sulfur dioxide-steam explosion pretreatment
- Sugars recovery from first-stage hydrolysates
- Ethanol fermentation
- Rapid analysis of biomass materials
- Coproducts
- Process modeling and evaluation

Dilute sulfuric acid hydrolysis

Single-stage and two-stage dilute sulfuric acid hydrolysis of California softwood forest thinnings (whole tree chips) were carried out using a 4-L batch steam digester at NREL. After two-stage dilute acid hydrolysis, the hemicellulosic sugar yield was 85%-90% and the glucose yield was 55%-60%. The residual cellulose can be further hydrolyzed to glucose by cellulase enzyme. With enzyme addition, the total sugar yields increased to 75% for single-stage dilute acid pretreatment and 82% for two-stage pretreatment. Preliminary hydrolysis experiments with Alaska mixed softwood sawdust were also completed. Hemicellulose sugar yield was in the 88%-94%



NREL 4-L steam digester

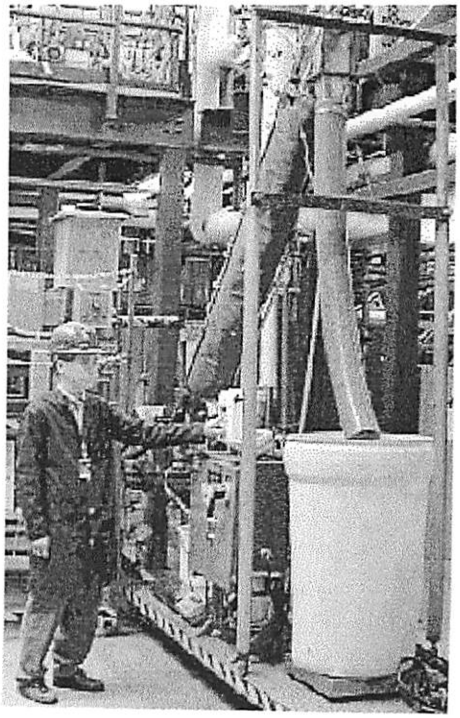
Dilute-acid pretreated softwood

Back to Current Research

Sulfur dioxide-steam explosion pretreatment
The objective of this project was to maximize ethanol yield from softwood hemicellulose using SO_2-catalyzed steam explosion. The work was carried out under an NREL subcontract by researchers at the University of British Columbia. The pretreatment experiments were conducted using a 2-L steam explosion reactor. Feedstocks included California whole-tree softwood forest thinnings (with needles and bark), whole-tree mixed wood (with bark but no needles), and mixed wood (no bark or needles). Under optimized pretreatment conditions, 92% recovery of original hemicellulose sugars in hydrolysate liquor was achieved. The resulting soluble hemicellulose sugars consisted of 61% monomers and 39% oligomers. Though the three feedstocks responded similarly in terms of hemicellulose sugar yields, hydrolysates from whole-tree forest thinning feedstock had poorer fermentability.

Back to Current Research

Sugars recovery from first-stage hydrolysates
For two-stage dilute acid hydrolysis process, it is important to achieve high (>95%) soluble sugar recovery from the first-stage hydrolysate while minimizing the amount of wash water required. High water usage would dilute the sugar stream and increase the cost of ethanol recovery. After surveying available commercial leaching equipment, a continuous countercurrent screw extractor was installed in the NREL Process Development Unit. The extractor was successfully tested using

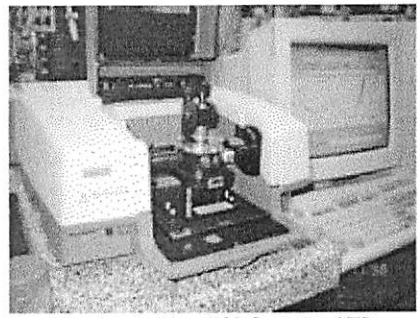


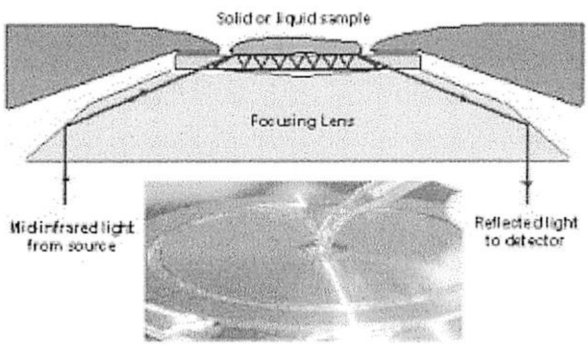
first-stage pretreated forest thinnings. Mathematical models are being developed to predict the performance of the NREL screw extractor and other countercurrent washers being tested by vendors.

Countercurrent screw extractor
(4-inch diameter x 9 ft long)

Back to Current Research

Rapid analysis of biomass materials
Fourier transform infrared (FTIR) methods were successfully developed to rapidly determine the chemical composition of hydrolysate liquors, ethanol fermentation broth, and washed pretreated solids. The FTIR results were correlated with results obtained by wet chemical and high performance liquid chromatography (HPLC). Once a database of correlated FTIR and HPLC results is established, the FTIR method can cost-effectively replace HPLC for routine chemical analysis. Most importantly, the FTIR methods are invaluable for on-line process monitoring and control in commercial plant operation.


Nicolet Avitar 360® FTIR-ATR measuring cellulose



Diamond-Composite Attenuated Total Reflectance (ATR) Cell

Back to Current Research

Ethanol fermentation
A *Saccharomyces cerevisiae* yeast was adapted to the inhibitors (extractives and degradation products of lignin and carbohydrates) in the softwood hydrolysates. The mutant yeast gives >90% ethanol yield from all available hexose in hydrolysate liquor obtained from whole-tree forest thinnings without detoxification requirements and minimal nutrient addition. In the future a recombinant xylose fermenting yeast will be tested.

Back to Current Research

Coproducts
Under an NREL subcontract, Kemestrie, Inc. (Sherbrooke, QC, Canada) developed preliminary methods for recovering and characterizing extractives from softwood forest thinnings.

Some of the extractives may be toxic to ethanol fermenting organisms and removing them may improve ethanol production. High-value chemicals (e.g., antioxidants) have been identified in extractives isolated from whole-tree softwood forest thinnings. The potential market value of these compounds (not considering the cost of purification) may be considerably higher than the value of ethanol that can be derived from the cellulose and hemicellulose. Thus, coproducts from extractives may improve the overall process economics for the conversion of softwood residues to ethanol.

The Biofuels Program is currently assisting Collins Pine Co. (Chester, CA) and BCI (Dedham, MA) in monitoring research in characterization and market analysis of potential coproducts from softwood extractives under subcontract with Enerkem Technologies (Sherbrooke, QC, Canada). NREL is also analyzing combustion characteristics of lignin residues obtained from softwood-to-ethanol conversion processes under evaluation for the Collins Pine/BCI project.

Back to Current Research

Process modeling and evaluation

A conceptual plant design based on the two-stage dilute acid hydrolysis was developed using the Aspen Plus™ process simulator. The design package includes process flow diagrams, material and energy balances, an equipment list, and an estimate of capital and operating costs. Models for stand-alone and for collocation with current biomass power plants were compared. The models assisting industrial partners in identifying areas requiring further research and development and in evaluating the economic feasibility of potential demonstration projects.

Based on the NREL process design and ASPEN Plus simulation models for a 2,000 dry metric ton/day softwood-to-ethanol plant using two-stage dilute sulfuric acid hydrolysis technology, Merrick & Company (Aurora, CO) developed a conceptual design for an 800 dry metric ton/day plant for a site near Martell, CA. Two scenarios were investigated: a stand-alone plant and a plant colocated with a biomass power plant. A feasibility study was also conducted for a 275 dry metric ton/day plant for converting softwood residues to ethanol in Southeast Alaska. Colocating an ethanol plant with an existing biomass power plant offers significant cost advantages.

Back to top

Recent Publications, Reports, and Presentations

Dilute sulfuric acid hydrolysis

- Nguyen, Q.A.; Tucker, Boynton, B.L.; Keller, F.A.; Schell. D.J. (1998). "Dilute Acid Pretreatment of Softwoods." *Applied Biochemistry and Biotechnology* (70:72); pp. 77-87.

- Nguyen, Q.A.; Tucker, M.P.; Keller, F.A.; Eddy, F.P. (2000). "Two-Stage Dilute-Acid Pretreatment of

Softwoods." *Applied Biochemistry and Biotechnology* (84:86); pp. 561-576

- Nguyen, Q.A.; Tucker, M.P.; Keller, F.A.; Beaty, D.A.; Connors, K.M.; Eddy, F.P. (1999). "Dilute Acid Hydrolysis of Softwoods." *Applied Biochemistry and Biotechnology* (77:79); pp. 133-142.
- Schell, D; Nguyen, Q.; Tucker, M.; Boynton, B. (1998). "Pretreatment of Softwood by Acid-Catalyzed Steam Explosion Followed by Alkali Extraction." *Applied Biochemistry and Biotechnology* (70:72); pp. 17-24.

Sugars recovery from first-stage hydrolysates

- Kim, K.H.; Tucker, M.P.; Keller, F.A.; Aden, A.; Nguyen, Q.A. (2000). "Continuous Countercurrent Extraction of Hemicellulose from Pretreated Wood Residues." Poster presented at the 22nd Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, TN., May 7-10, 2000.

Ethanol fermentation

- Keller, F.A.; Bates, D.; Ruiz, R.; Nguyen, Q. (1998). "Yeast Adaptation on Softwood Prehydrolysate." *Applied Biochemistry and Biotechnology* (70:72); pp. 137-148.
- Keller, F.A., Tucker, M.P., Eddy, F.P., Nguyen, Q.A. (2000). "High Yield Fermentation of Softwood Hydrolysate by Adapted Yeast followed by HPLC and FTIR Sample Analysis." Poster presented at the 22nd Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, TN., May 7-10, 2000.

Rapid analysis of biomass materials

- Tucker, M.P.; Mitri, R.K.; Eddy, F.P.; Nguyen, Q.A.; Gedvilas, L.M.; Webb, J.D. (2000). "Fourier Transform Infrared Quantification of Sugars in Pretreated Biomass Liquors." *Applied Biochemistry and Biotechnology* (84:86); pp. 39-49.
- Tucker, M.P.; Nguyen, Q.A.; Eddy, F.P.; Kadam, K.L.; Gedvilas, L.M.; Webb, J.D. (2000). "Fourier Transform Infrared Quantitative Analysis of Sugars and Lignin in Pretreated Softwood Solid Residues." Poster presented at the 22nd Symposium on Biotechnology for Fuels and Chemicals, Gatlinburg, TN., May 7-10, 2000.

Process modeling and evaluation

- Nguyen, Q.A.; Keller, F.A.; Tucker, M.P.; Lombard, C.K.; Jenkins, B.M.; Yomogida, D.E.; Tiangco, V.M. (1999). "Bioconversion of Mixed Solids Waste to Ethanol." *Applied Biochemistry and Biotechnology* (77:79); pp. 455-472.

the Enzymatic Hydrolysis of Dilute-Acid Pretreated Douglas Fir." *Applied Biochemistry and Biotechnology* (77:79); pp. 67-81

For additional publications and reports search the Biofuels Document Database.

Back to top

For More Information
Contact:

Quang Nguyen
Collaborative Industrial Process Development Team Leader
NREL Biofuels Program

Back to top

DOE | EERE | Related Links | Questions/Comments | Home

Last updated: 03/03/03

The official home of Ethanol Producers and Consumers 2003 Conference

13th Annual Montana Ethanol Conference "Under The Big Sky Greening"

Tentative Agenda

13th Annual Montana Ethanol Conference "Under the Big Sky Greening" June 11, 12 , 13 at Big Sky Resort, located south of Bozeman.

(Pre-arrange for Free Transportation from the Bozeman airport by calling Kathy Jackson at 405-225- 3194) Bozeman airport is serviced by United, Northwest, Delta, Horizon & Big Sky.

This conference is being held in conjunction with Yellowstone National Park and Headwaters Recycling. General Sessions will be held all three mornings, and will then break into three concurrent tracks. One track will feature Ethanol/biodiesel issues, one track will feature recycle issues and the other will focus on composting. Registration Form - Please fill out this form completely. If you must cancel, your registration fee will be refunded minus a $20 processing fee until May 16, 2003.

After May 16th, only $65 will be refunded. You may also register on the web at: http://www.peakstoprairies.org/greening.

You may also print out a registration form here:

Until May 16, 2003, conference registration is $125. AFTER May 16, 2003, registration is $175 and includes: · Conference and Technical Sessions · Three breakfasts (Wed., Thurs., Fri.) · Two lunches (Wed., Thurs.)
· Get Acquainted Reception (Tues.) · Banquet and Entertainment (Wed.) · Trade Show
· Bus tour of West Yellowstone and Yellowstone Park
Guests may accompany conference registrants to meals, golf tourney, Yellowstone tour, banquet and reception only if pre-arranged. Fees will be charged on a per event, per person basis.

Registration Fee - # ___ attending X $125 __________
after 5/16 add $50/person One day only Registration - # ___ X $75 __________
(circle one) Weds. Thurs. Fri. Golf Tournament - # ___ X $100 ________________ Guest Meals:
Tues. Reception - # ___ X $20
Weds. Breakfast - # ___ X $15
Weds. Lunch - # ___ X $20
Weds. Banquet - # ___ X $40
Thurs. Breakfast - # ___ X $15
Thurs. Lunch - # ___ X $20
Fri. Breakfast - # ___ X $15

TOTAL ENCLOSED

or credit card payment: ___ Visa ___ MasterCard
Credit Card # __________________ Exp. Date ______
Signature ____________________________
_________ Attending tour of W. Yellowstone and park
_________ Attending Yellowstone-Clean Cities Meeting

Biofuels Market Barriers Study

On 10 May, the Government announced a $5 million study to address market barriers to the increased use of biofuels in transport. The study is being managed by Environment Australia and is part of the Government's broader strategy to increase production of bio-fuels to 350 million litres/pa by 2010.

The study will have two main parts.

- The first will involve vehicle testing and a technical assessment of the use of 20% ethanol:80% petrol blends (E20). This will be conducted over two years and will provide information on the suitability of E20 blends for use in the current vehicle fleet. The vehicle testing is expected to be completed during the second half of 2004.
- The second part of the study is a detailed examination of current and potential future market barriers to the take-up of biofuels. This covers both bio-diesel and bio-ethanol and will cover a wide range of issues related to the economics of production and sale; consumer concerns and acceptance; production, blending and distribution infrastructure requirements; legal and tax constraints; availability of inputs for production and blending; import competition etc. The aim of the study is to improve current understanding of the factors inhibiting the take-up of biofuels and to develop recommendations on the most suitable mechanism/s to address these barriers. It will include an examination of a possible biofuels mandate, a comprehensive voluntary inter-industry agreement, and a range of other potential biofuels initiatives. The study will be informed by research, stakeholder consultation and an interdepartmental government committee. The final report on the study will be presented to the Government in December 2002.

The biofuels market barriers study is necessary to complement incentives aimed at increasing biofuels production, by providing a framework for the expansion of market demand for these fuels. The study will enable the Government to develop a biofuels strategy that will provide more stability in the industry with a view to ensuring a long term place for biofuels within the Australian fuel market.

Terms of reference for the biofuels market barriers study

For more information on the study, please email fuel.quality@ea.gov.au or contact:

Director
Clean Fuels and Vehicles
Environment Australia
GPO Box 787
CANBERRA ACT 2600

Other Environment Australia Biofuels Activities

- Literature Review on the Impacts of a 20% Ethanol Gasoline Fuel Blend
- Setting an ethanol limit in petrol
- Establishing a fuel standard for biodiesel

Biofuels Assistance Programs

BBI

PO Box 159
5015 Cty Rd 12
Cotopaxi, CO 81223
(719) 942-4353
Fax: (719) 942-4358

International Convention on

Biofuels-Driving India's Future

7-9 November, Hotel Taj Palace, New Delhi

Accommodations

Topics

Who Should Attend

Sponsors

Registration

Information:
Angela Graf
303-526-5655

Additional Information
(CII Website)

Summary information will be posted soon.

The first-ever International Convention on Biofuels will be held November 7-9, 2002, in New Delhi, India. International experts will share their experience on biofuels to facilitate the development of a long-term strategy for the use and production of ethanol and renewable diesel in India. Pilot programs are already underway to support ethanol production and use in India. There is also great interest by the auto industry and government to utilize ethanol-diesel and biodiesel for reducing air pollution and promoting economic development.

The program agenda is available for download:

- **MS Word .DOC**
- **Adobe .PDF**

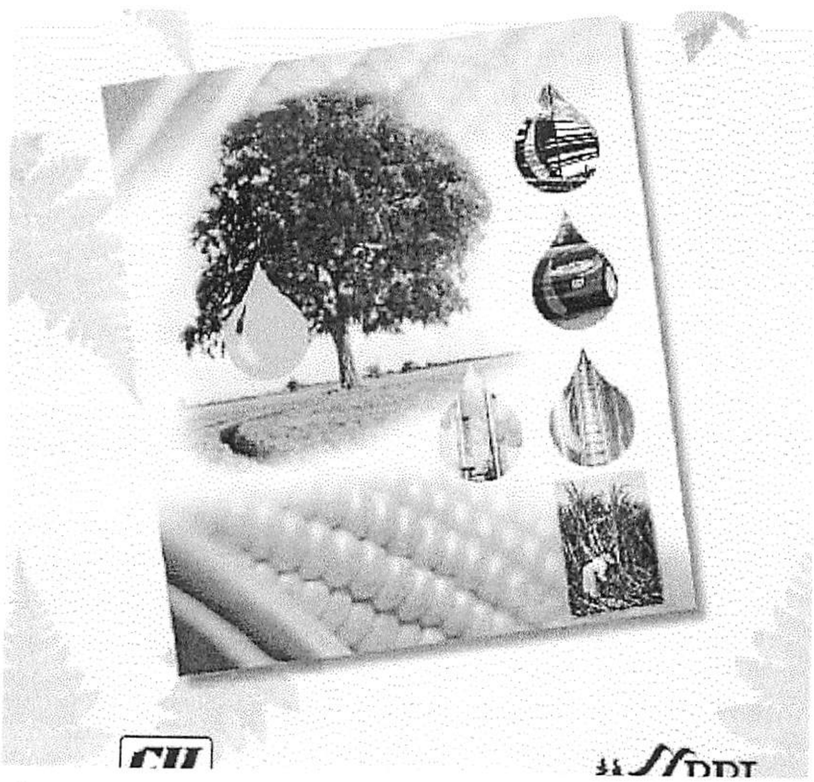
Conference Presenters

BBI

CII

Principal Sponsor:

PRAJ



NREL

[x] Office of Energy Efficiency and Renewable Energy

[x] Biofuels for Sustainable Transportation

[x] Photos of researcher examining ionic liquid, PIX #10030; Harvesting corn stover, PIX #10467; Digital drawing of enzyme, PIX #05014.

Softwood Conversion Technol

Lumber manufacturing, timber harvesting, and thinning of forest quantity of softwood residues that makes an attractive feedstock softwood residues is not as large as some agricultural residue qua softwood residues are an important near-term biomass feedstock sound and cost-effective methods for disposing of these residues. activities at NREL have focussed on investigating the feasibility ethanol using two-stage dilute sulfuric acid hydrolysis technolog

Current Research

Biofuels researchers recently completed bench-scale experiments converting softwood forest thinnings to ethanol using two-stage (

- Dilute sulfuric acid hydrolysis
- Sulfur dioxide-steam explosion pretreatment
- Sugars recovery from first-stage hydrolysates
- Ethanol fermentation
- Rapid analysis of biomass materials
- Coproducts
- Process modeling and evaluation

Dilute sulfuric acid hydrolysis
Single-stage and two-stage dilute sulfuric acid hydrolysis of Cali chips) were carried out using a 4-L batch steam digester at NREI hemicellulosic sugar yield was 85%-90% and the glucose yield v further hydrolyzed to glucose by cellulase enzyme. With enzyme 75% for single-stage dilute acid pretreatment and 82% for two-st

From: Ralph (Butch) Clark <reclarkIII@pcrs.net>
To: Carol F Kwiatkowski <ckwiatkowski@fs.fed.us>
Date: Monday, June 02, 2003 8:48 AM
Subject: Reply: refs. to biomass to ethanol articles

Carol,

Thanks for sending back the materials. Glad they might be useful.

The source for the three technical articles is the web site of DOE's National Renewable Energy Laboratory and within it the Biofuels Program.

The web site address is:
http://www.ott.doe.gov/biofuels/process_engineering.html and
the listed Team Leader for the site is Kelly Ibsen at kelly_ibsen@nrel.gov
.

The site offers downloadable current, recent, and older reports related to engineering and economic analysis. The report covers I brought to the meeting were from the older collection. They offered some good suggestions of what external considerations could be involved with a project. I have full copies of the three reports, if you encounter difficulties. Hope you have a fast connection - I don't - and downloading took a while.

Butch

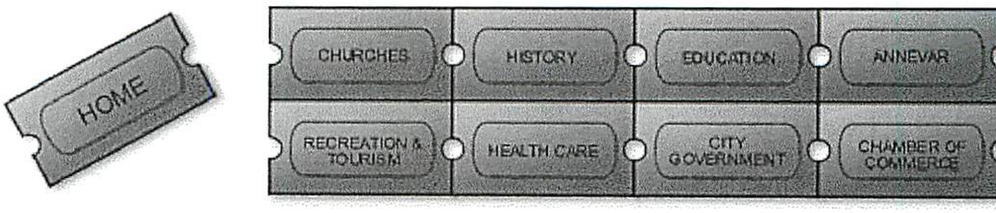
From: Carol F Kwiatkowski <ckwiatkowski@fs.fed.us>
To: reclarkIII@pcrs.net <reclarkIII@pcrs.net>
Date: Friday, May 30, 2003 3:56 PM
Subject: biomass to ethanol articles

Butch,
Thanks for all the information on ethanol related processes. I have been reading through them and doing some searches myself. I haven't been able to find the three technical articles that you provided cover pages for (Technical and Economic Analysis of an Enzymatic Hydrolysis Based Ethanol Plant; Technical and Economic Evaluation Wood to Ethanol Process; and Full Fuel Cycle Analysis of Biomass to Ethanol: Wastewater Treatment System Performance).Can you provide any more information on the web sites that you found them on? Oh - by the way, I sent your materials back to you on Wednesday so you should have them shortly. Thanks.

Carol

Carol F. Kwiatkowski
Painted Sky RC&D
USDA Forest Service
2250 Highway 50
Delta, CO 81416-2485
970-874-6614

Ravenna Proposed Ethanol Plant Questions & Answers



Since the May 20, 2002, Ravenna City Council meeting several questions concerning the Nordic biofuels LLC ethanol production facility have been raised. We have attempted to address each question or issue completely given the information that is currently available to us. Certainly, there will be an on-going dialog as it relates to this important economic development project so we will continue to address issues as they are identified.

Over the coming days and weeks we hope to have additional information available to the community and to also schedule more public meetings where everyone has a chance to learn more about the project. Please feel free to contact us at The Development Council or the Ravenna Economic Development Corporation for more information.

Please submit any additional questions at the following link: Proposed Ethanol Plant Questions Form. These questions and answers will be posted as they are received and answered.

Process:

NEW!

Various concerns have been raised about the inpact upon Ravenna as the construction process begins this Spring:

Over the course of the one year construction period, there will likely be hundreds of people involved in that process, but they will not all be on-site at the same time. A good number of the construction workers may actually come from the Buffalo County area as sub-contractors or temporary laborers. Consequently, many will be commuting to the work site from nearby homes. Others who relocate temporarily specifically for this project may seek motels or rental housing in Ravenna or surrounding communities like Kearney or Gibbon. Others may actually take up permanent residence in Ravenna. The increased activity related to construction of the plant should present welcome opportunities to existing businesses and local entrepreneurs but should not cause unmanageable stress to the community.

What if there was a backlog of wet distiller's grain. Will there be storage facilities for it?

The plant will have equipment available to dry the wet material for shipment to other, more distant markets. With this capability the plant will be able to adjust its output to market demand.

Is Nordic biofuels of Nebraska, LLC a legal entity in the State of Nebraska?

After this question was raised earlier in the process, Nordic biofuels representatives discovered that their first filings had been done incorrectly. The papers have been refiled and Nordic biofuels will operate as a legal nebraska entity.

Incentive Type: Net Metering Rules
Eligible Technologies: Photovoltaics, Wind, Biogas, Solar
Applicable Sectors: Commercial, Industrial, Residential
Limit on System Size: 1 MW (1,000 kW)
Limit on Overall Enrollment: One half of one percent of a utility's peak demand
Treatment of Net Excess: Granted to utility annually
Utilities Involved: IOUs; Municipal utilities are allowed to permit either net-metering or co-metering
Date Enacted: 1/1/96; amended 1998, 2000, 2001, 2002
Website: http://www.energy.ca.gov/greengrid/net_metering.html
Authority 1: AB 58 in 9/02
Authority 2: California Public Utility Code 2827, as amended, including AB 29X in 4/01

Summary:

California's net metering law requires that all California investor-owned electric utilities allow net metering for all customer classes for systems up to 1,000 kW (1 MW). Municipal utilities are allowed to permit either net-metering or co-metering. The Los Angeles Department of Water and Power, the largest municipal utility in the nation, is exempt from the net metering rules. Eligible systems include solar or wind turbine electrical generating facilities, or a hybrid system of both. Also, AB 2228, signed by the Governor in September 2002, provides that biogas electrical customer-generated facilities up to 1 MW are eligible for net metering until January 1, 2006, under a pilot program. The pilot program limits biogas digester generation load to 5 MW per energy service provider service territory and also provides for retail cost recovery.

The 2002 net metering amendments (AB 58), signed by the governor in September 2002, provide the following: (a) extend the system size limit to 1 MW; (b) limit the total amount of net metering to one half of one percent of a utility's peak demand; (c) exempt net metering from "exit fees" or "departing load fees"; (d) prohibit inter-class cost shifting that results from net metering; (e) allow municipal utilities to permit either net-metering or co-metering, which credits customers for generation on a "time-of-use" basis for the generation value of their production; (f) require the California Energy Commission to establish a separate rebate for pubic sector affordable housing projects of up to 75% of total installed costs for these projects; (g) establish that the Treasurer should consider net metering and co-metering projects as sustainable building methods or distributed energy technologies for purposes of evaluating low-income housing projects; (h) grandfather in projects permitted prior to December 31, 2002 and completed before September 30, 2003; and (I) permit wind energy projects up to 50 kW to net meter and requires wind energy projects from 50 kW up to 1 MW to utilize "wind energy co-metering" which provides for time-of-use pricing and credits.

Customers are billed annually. Any net excess generation at the end of each 12-month period is granted to the utility. Customers subject to time-of-use rates are entitled to deliver electricity back to the system for the same time-of-use (including real-time) price that they pay for power purchases. Any new or additional demand charge, standby charge, customer charge, minimum monthly charge, interconnection charge, or other charge that would increase an eligible customer-generator's costs beyond those of other customers in the rate class to which the eligible customer-generator would otherwise be assigned is not allowed.

The 2001 amendments to the original law, enacted in 1995): (a) extended eligibility to all customer classes; (b) extended the system size limit to

1,000kW (1MW); and (c) eliminated the overall "cap" of 0.1% of each utility's peak demand apply through the end of 2002 only.

California's original net metering law, enacted in 1995, required that all California's electric utilities (regulated and unregulated) allow net metering for residential customers with solar electric power systems under 10 kW with a capacity cap of 0.1% of each utility's 1996 peak demand. Customers were paid the utility's avoided cost for all net excess generation.

Contact:

Les Nelson
California Solar Energy Industries Association
Southern California Office
30012 Aventura, Suite A
Rancho Santa Margarita, CA 92688
Phone: (949) 713-3500
Fax: (949) 709-8044
E-Mail: lnelson@westernrenewables.com
Web site: http://www.calseia.org/

Colorado

Aspen Electric/Holy Cross Electric - Net Metering

Last DSIRE Review: 09/25/2002

Incentive Type: Net Metering Rules
Eligible Technologies: Photovoltaics
Applicable Sectors: Commercial, Industrial, Residential
Limit on Overall Enrollment: 50 kW
Treatment of Net Excess: Customers receive full retail credit
Utilities Involved: Aspen Electric, Holy Cross Electric

Summary:

Aspen Electric's and Holy Cross Electric's net metering policies allow customers to get full retail credit (7¢/kWh) for any net excess generation supplied to the grid. The two utilities have agreed to net meter the first 50 kilowatts of PV in their service territories.

In addition, customers of Aspen Electric and Holy Cross Electric who install solar photovoltaic systems can now receive up to $4,000 in "solar production incentives." This program "Sun Power Pioneers" is sponsored by the Community Office for Resource Efficiency (CORE), in partnership with the City of Aspen and Holy Cross Energy.

Sun Power Pioneers will earn 25 cents per kilowatt-hour for all the power their systems produce for four years.

Contact:

Randy Udall
Community Office for Resource Efficiency (CORE)
P.O Box 9707
Aspen, CO 81612
Phone: (970) 544-9808
Fax: (970) 963-5691
E-Mail: core@aspencore.org
Web site: http://www.aspencore.org

Fort Collins Utilities - Net Metering Rules

Last DSIRE Review: 09/24/2002

Incentive Type: Net Metering Rules
Eligible Technologies: Photovoltaics
Applicable Sectors: Commercial, Industrial, Residential
Limit on System Size: 3 kW
Limit on Overall Enrollment: None
Treatment of Net Excess: Purchased at avoided cost on a monthly basis
Interconnection Stds. for Net Metering? Yes

Summary:

Fort Collins Utilities allows net metering for systems 3 kW and below. All electric rate classes are eligible. Residential Rate R requires approval from the director. Net excess generation is purchased at avoided cost on a monthly basis. Interconnection applications are required for approval of the system. To receive a copy of the Interconnection Guidelines, contact Fort Collins Utilities.

Contact:

Gary Schroeder
Fort Collins Utilities
700 Wood Street
Fort Collins, CO 80521
Phone: (970) 221-6395
E-Mail: gschroeder@fcgov.com
Web site: http://www.fcgov.com/lightandpower/

Gunnison County Electric - Net Metering

Last DSIRE Review: 12/16/2002

Incentive Type: Net Metering Rules
Eligible Technologies: Photovoltaics, Wind
Applicable Sectors: Commercial, Residential
Limit on System Size: 10 kW
Limit on Overall Enrollment: First 50 customers
Treatment of Net Excess: Purchased by utility at retail rate
Interconnection Stds. for Net Metering? Yes
Effective Date: 2000
Expiration Date: 2004
Website: http://www.gcea.coop/consumerserv/netmetering.cfm

Summary:

Gunnison County Electric Association's (GCEA) net metering pilot program began in 2000. The program is scheduled to end in 2004, but it may be extended beyond this date. Currently the program has one participant.

The program is available to the first 50 customers who install eligible photovoltaic or wind systems of 10 kW or less. GCEA reimburses customers for net excess generation at the retail rate, currently $0.7001 per kWh . GCEA does not install systems for customers, but does offer a low-interest loan of up to $25,000 for approved photovoltaic and wind systems. Visit the program Web site to download the net metering application and compliance form.

Contact:

Mark Daily
Gunnison County Electric Association, Inc.
37250 Hwy. 50
P.O. Box 180
Gunnison,, CO 81230
Phone: (970) 641-3520
Fax: (970) 641-5302
E-Mail: gcea@gcea.coop
Web site: http://www.gcea.coop

Connecticut

Net Metering

Last DSIRE Review: 08/14/2002

Incentive Type: Net Metering Rules
Eligible Technologies: Solar Thermal Electric, Photovoltaics, Landfill Gas, Wind, Biomass, Hydro, Fuel Cells
Applicable Sectors: Residential, includes 2-4 multifamily units
Limit on System Size: Fossil technologies: 50 kW; Renewable technologies: 100 kW
Limit on Overall Enrollment: None
Treatment of Net Excess: Purchased by utility at spot market energy rate
Utilities Involved: Investor-owned Utilities Only
Date Enacted: 1/1/90
Effective Date: 1/1/2000
Expiration Date: none
Authority 1: CGS 16-243h; CT Legislature, Public Act 98-28

Summary:

In 1998, the Connecticut Legislature, as part of its Electric Restructuring Public Act 98-28, requires all investor-owned utilities to provide net metering to residential customers who own solar, wind, hydro, biogas, fuel cell, or sustainable biomass electrical generators. No capacity limits were set.

Net excess generation is purchased at the spot market energy rate, which is essentially avoided cost. Electric suppliers must make required interconnections, install the necessary metering equipment, and give a credit for any electricity generated by a residential customer. Net metered customers are charged, however, for the competitive transition assessment and the systems benefits charge based on the amount of energy consumed by the customer from the facilities of the electric distribution company without netting any electricity produced by the customer.

In 1990, Connecticut's Department of Public Utility Control established net metering with Ruling 159. Under this ruling, utilities were required to purchase net excess generation from qualifying facilities up to 50 kW in capacity for systems using non-renewable energy and 10 kW for renewable energy systems.

Contact:

Mark Quinlan
Connecticut Department of Public Utility Control

Pilot Project: Converting Biomass Synthesis Gas to Alcohol Fuels Using Advanced Catalytic Processing

Painted Sky Resource Conservation and Development Council

In Close Cooperation With
Power Energy Fuels, Inc.
And
Western Research Institute

May, 2003

Solicitation Number:
USDA-GRANTS-031803-001

Table of Contents

List of Figures

Executive Summary

Power Energy Fuels, Inc. (PEFI) of Lakewood, Colorado, is the sole licensee of a patented catalytic process to make a mixed alcohol fuel from synthesis gas produced from any carbonaceous source. Earlier developmental testing at Dow Chemical Company, and Brookhaven National Laboratories, showed that the process produces predominately straight-chain terminal $C_1 - C_6$ alcohols. The data also showed that by manipulating the composition of the catalyst and processing conditions, the ratio of ethanol and higher alcohols to methanol produced can be controlled within a wide range. To facilitate commercialization, the technology needs verification at the pilot and demonstration scale.

A three-year, pilot-scale development and testing program is proposed to prepare the technology for commercialization using various feedstocks. A 500 gal/day pilot plant has been designed and is being constructed by PEFI for installation at Western Research Institute's (WRI's) Advanced Technology Center in Laramie, Wyoming, but it has not been completed due to funding shortfalls. Additional funding will allow completion of the plant along with debugging and shake down of the plant using pipeline natural gas. Catalyst and plant performance data will be compiled with natural gas as the initial reference feed. In years 2-3, the plant will be upgraded to include gasification and gas conditioning facilities and operated with synthesis gas produced from various feedstocks. Catalyst and plant performance data will be compiled and reported for each of the various feedstocks for purposes of proving the commercial viability of the process.

The proposed project is a significant opportunity to prove that any number of waste or non-waste carbon sources can be turned into an economical and profitable alcohol fuel, that is of a renewable nature, to serve America's appetite for energy. This new technology can contribute to the solution of a number of regional and global environmental problems while, at the same time, creating jobs in rural communities. Some of the benefits include: the ability to convert municipal solid waste, animal and crop waste, stranded natural gas wells, and forest residue (wood waste) into a renewable energy product; improved auto emissions and air quality through the use of this product as a clean-burning fuel additive; and reduced dependence on non-renewable fuel sources. It is particularly significant that ***a waste material*** can play such an important role in the reduction of air pollution.

Painted Sky Resource Conservation and Development Council has been involved with Federal and State Land Management agencies extensively and with fire planning and fuels reduction activities on public and private lands in west-central Colorado. These activities have shown that there is a need to find markets for significant volumes of waste wood from forests, which public lands agencies and private land owners are interested in supplying. Add to that the need of many municipalities to reduce municipal solid waste and of farmers to reduce huge volumes of agricultural wastes, the result is that there is no shortage of available carbon fiber for feedstock. This application, submitted by Painted Sky RC&D, in collaboration with PEFI and WRI, is the next step in determining whether the economics of this plan are sound and in making this unique opportunity a reality.

Statement of Work

Power Energy Fuels, Inc (PEFI), of Lakewood, Colorado, has developed a technology to convert synthesis gas from any carbonaceous source into mixed alcohols. PEFI has received patents on the catalyst process and have filed for additional patents and claims. PEFI expects to file additional applications. The trade name, Ecalene ™ has been registered to PEFI nationally. Earlier developmental testing at Dow Chemical Company and Brookhaven National Laboratories (BNL) has shown that the process produces C_1 – C_6 alcohols that are predominantly straight-chain. The data also show that by manipulating the composition of the catalyst and processing conditions, the ratio of ethanol to higher alcohols produced can be controlled within a wide range. The process is an outgrowth of a long-term development project in Fischer-Tropsch (FT) chemistry, although the new technology is not FT. On the basis of previous work, the data also indicate that the yield can be nearly two times that of the conventional FT synthesis. The principal use foreseen for the alcohol mixtures is as a high-powered, clean-burning fuel, 85% Ecalene (E85), and as a high-octane (124) blending stock (10% or higher) for gasoline and diesel. The availability of the co-product, higher alcohols, offers chemical producers and refiners an attractive way to use synthesis gas, particularly from isolated natural gas sources. Similarly, synthesis gas from various waste materials, such as biomass from municipal solid waste, coal, and wood waste can become chemical feedstocks.

The PEFI process offers several advantages over conventional FT synthesis. Sulfur poisoning of the catalyst is a major problem in a number of other processes and usually requires a reduction in the sulfur levels in the synthesis gas before it can be admitted to the reactor. The catalyst formulation for the PEFI process is sulfur tolerant and hence such a conditioning step is not required. The process also offers higher conversion rates at relatively low pressures and temperatures. Extensive testing of the catalyst has shown no significant deterioration of activity or change in selectivity for the alcohols. Furthermore, unlike conventional FT catalysts, this particular catalyst is not prone to carbon buildup. This reduced coking tendency permits the use of synthesis gases with varied hydrogen to carbon monoxide ratios.

Objectives

The overall goal of the project is to verify and further define the catalyst performance, operating conditions, and yields of various alcohols in the PEFI process. Specific objectives for the project are:

1. Complete the construction of an instrumented and flexible 500 gal/day pilot plant, based on extensive (previously completed) bench-scale modeling and testing.

2. Perform equipment shakedown, process optimization tests and plant modifications as warranted.

3. Characterize various feedstock process emissions and effluents for permitting requirements.

4. Perform steady-state "production" runs to promote commercialization of the product.

5. Produce quarterly and annual progress reports.

Tasks involved in meeting the objectives stated above are described here.

Objective 1: Complete the construction of an instrumented and flexible 500 gal/day pilot plant, based on extensive (previously completed) bench-scale modeling and testing.

Design of the pilot plant was based on eight bench-scale reactors of different scale and configuration. Each bench scale reactor was designed, fabricated and operated at WRI's Advanced Technology Center. Initial experiments were conducted with dry catalyst in a fixed bed configuration. Later experiments were conducted with the reactor in slurry configuration. Figure 1 shows a simplified flow diagram of the bench-scale system. Figure 2 shows a photograph of the system with a fixed-catalyst-bed reactor.

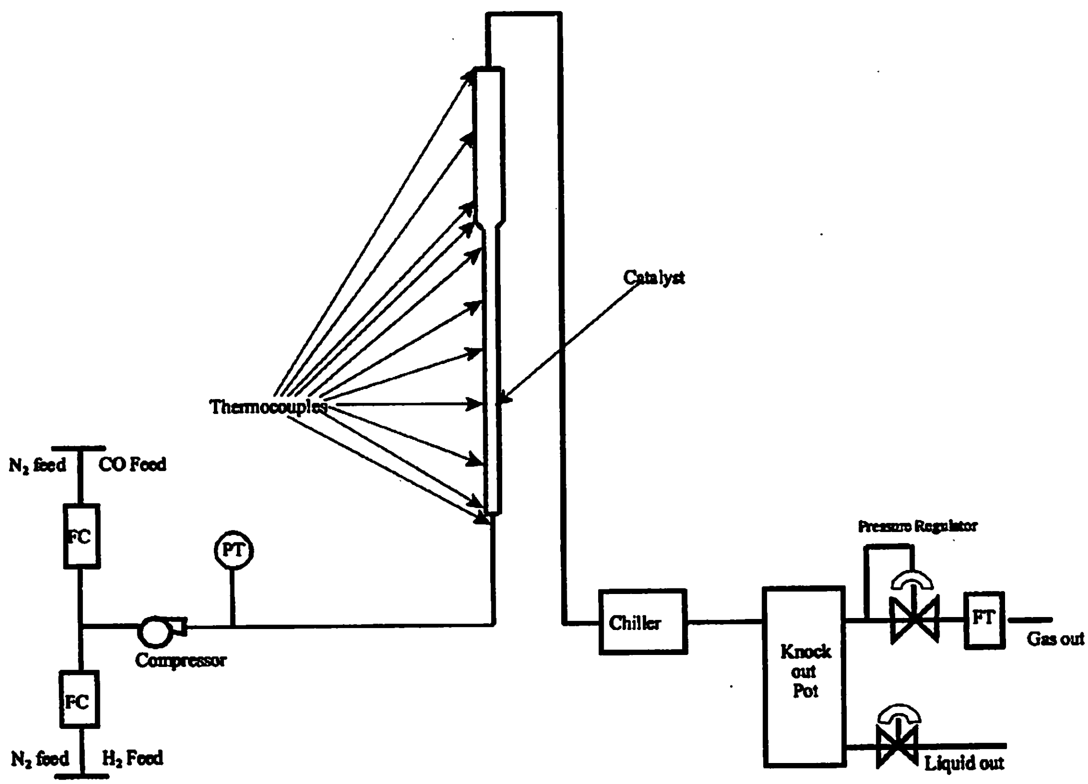


Figure 1. Flow Diagram for Bench-Scale Reactor System

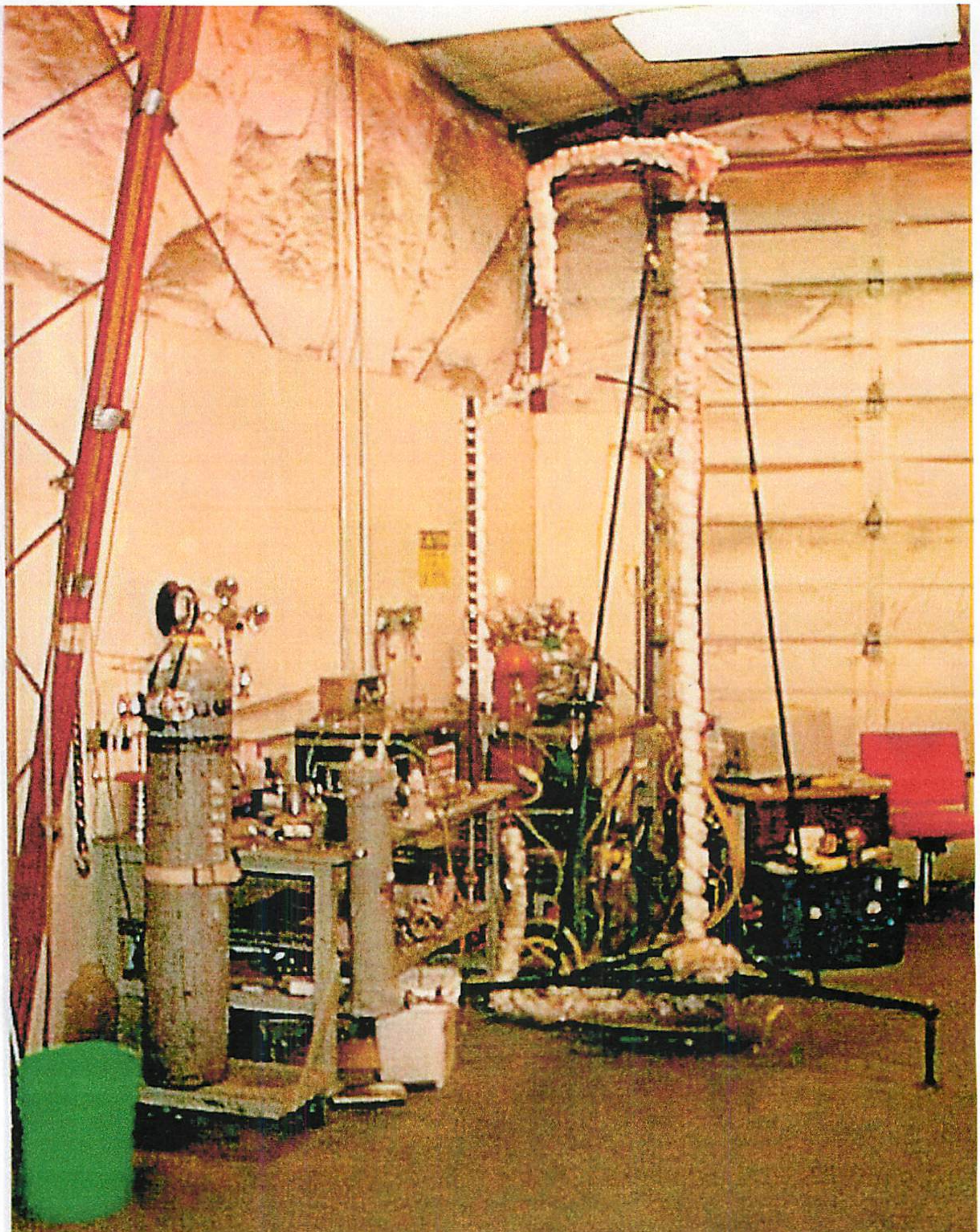


Figure 2. Photograph of Bench-Scale Reactor System

Results from experiments conducted with the reactor in a fixed, catalyst bed configuration were presented at the American Chemical Society National Meeting in Chicago, IL, August, 2001, and at the American Institute of Chemical Engineers National

Meeting in Reno, NV, Nov., 2001. Results from the experiments conducted to date have duplicated or exceeded published literature, with space-time yields of alcohols up to 500 grams per hour per kilogram of catalyst (see Figure 3) and CO^2-free selectivities up to 90%. The composition of the alcohols in the product has been shown to vary greatly depending on the operating conditions and the feed composition. Figure 4 shows the product composition from a series of fixed-bed experiments. The variables adjusted during the experiments included total flow rate, H^2 to CO ratio, temperature and pressure. For most of that series of experiments, the dominant alcohol in the product was methanol. Operation of the reactor in slurry configuration allows additional control of the composition of the products. Figure 5 shows the composition of the product for recent slurry reactor experiments. The dominant product is now ethanol.

A significant issue has been consistently encountered concerning temperature control for fixed-bed experiments. Figure 6 shows several temperature readings on the reactor on an early experiment. The exothermic reactions produced several hotspots and near runaway conditions. Since the catalyst tends to produce undesirable hydrocarbon side products at high temperatures, effective temperature control is critical. To combat this issue for the subsequent tests, the catalyst was mixed with increasing amounts of glass helixes, or beads, effectively lowering the spatial concentration of the catalyst, i.e. less catalyst per unit volume. This approach would likely have limited success as the scale of the reactor is increased, and would allow undetected hotspots in larger reactors. One solution used for this issue in FT reactors is to operate in a slurry configuration. Figure 7 shows a temperature profile during a preliminary experiment in slurry configuration. Temperature control is greatly improved in this configuration.

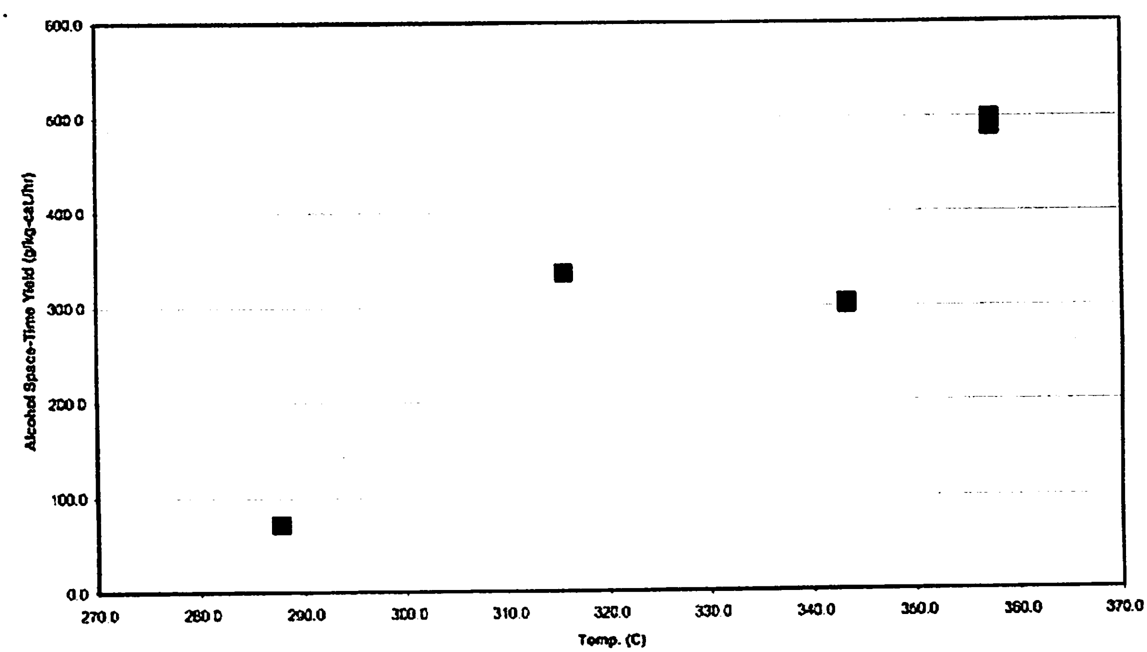


Figure 3. Alcohol Space-Time Yields as a Function of Temperature

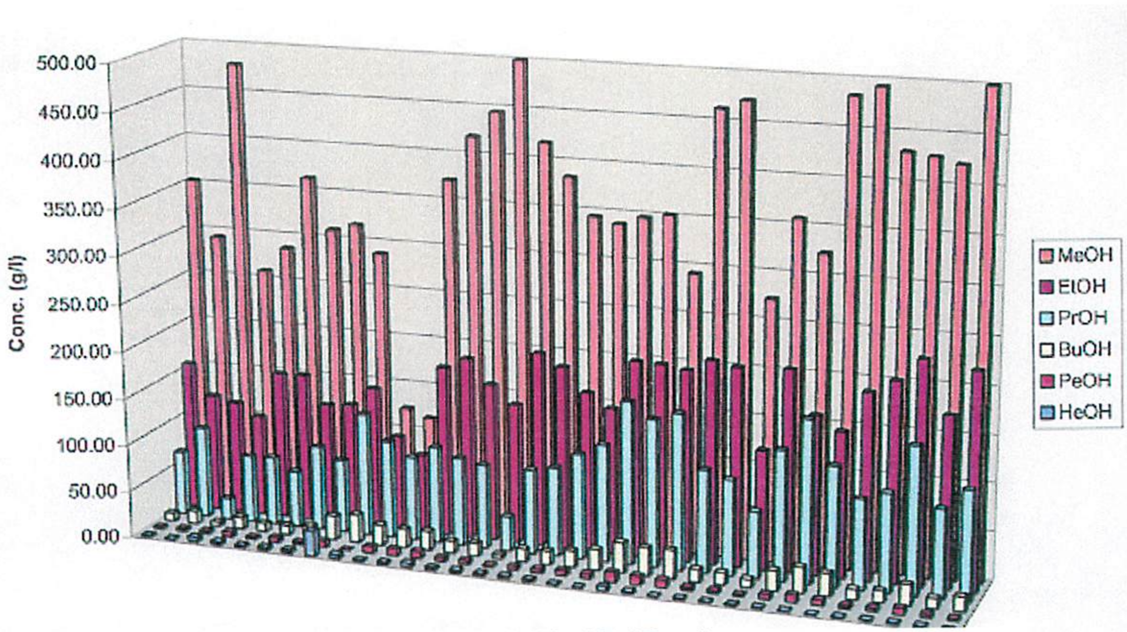


Figure 4. Distrubution of Alcohols in Product for Fixed-Bed Experiments

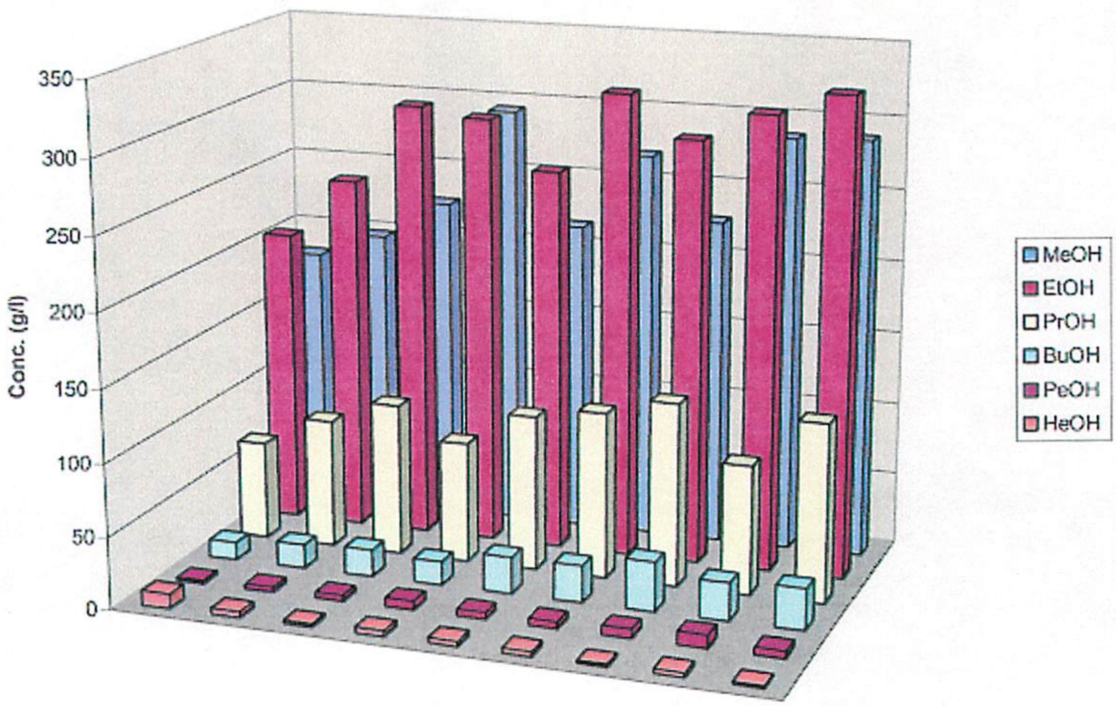


Figure 5. Distribution of Alcohols in Product for Slurry Reactor Experiments

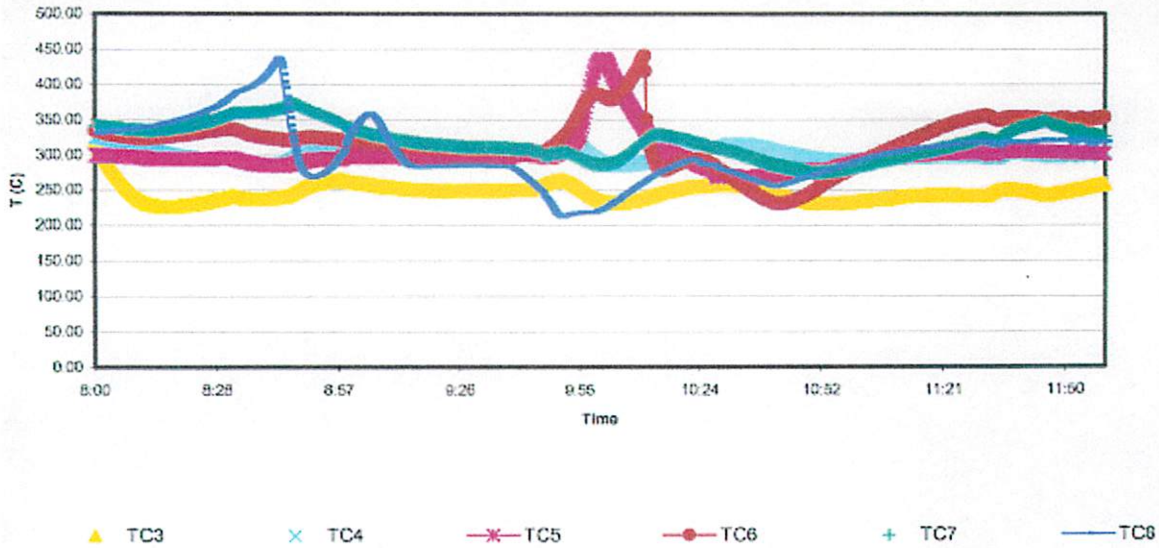


Figure 6. Thermocouple (TC) Readings during Fixed-Bed Experiment

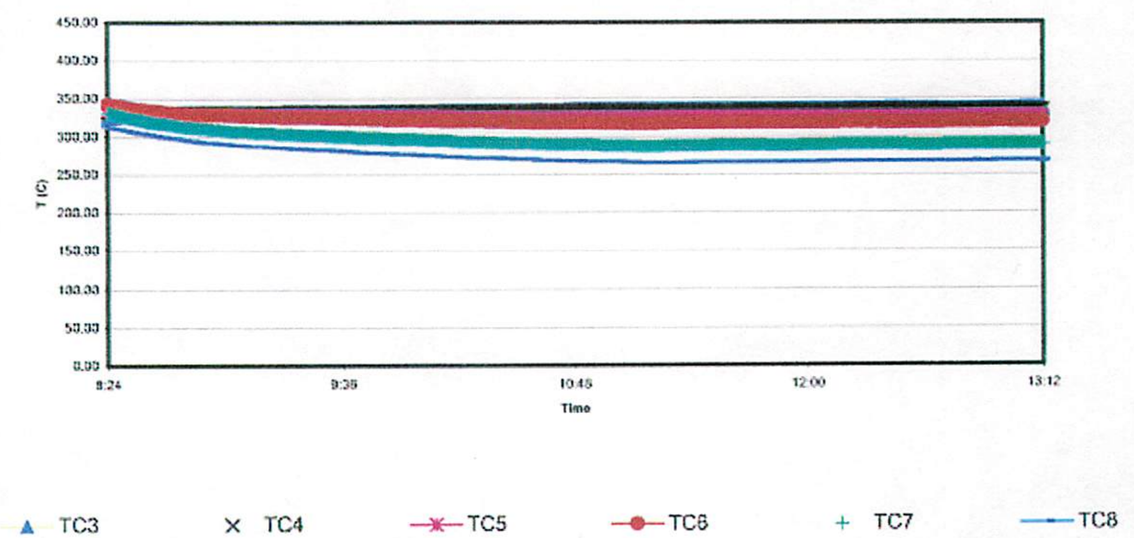


Figure 7. Thermocouple (TC) Readings during Preliminary Slurry Reactor Experiment

Based on the results of these bench-scale experiments, as well as process modeling/simulations to facilitate design and component sizing, the 500 gal/day pilot plant was designed in collaboration with BNL and FABPRO, an equipment fabricator in Denver, CO. The base design of the plant is for use with natural gas as the reference feedstock. However, future plant operations will require synthesis gas derived from several other sources. Therefore, all vessel and component designs were made flexible and readily configurable. Similarly, process control strategies and instrumentation schemes were developed to be flexible and readily configurable.

Construction of the pilot plant is currently 80% complete. Component fabrication is being managed and directed by PEFI in Denver, Colorado. Off-the-shelf components are procured and delivered directly to PEFI. PEFI is responsible for developing PC-based plant/process controls. Currently, the skids, partial oxidation reactor and the alcohol reactor have been fabricated. Most of the instrumentation has been received and the control room and control system are complete. The plant will be assembled in Denver and shipped to WRI's Advanced Technology Center in Laramie. PEFI will arrange for the production of required amounts of its proprietary catalyst for the plant startup. Figure 8 shows the main reactor skid for the pilot plant.

Figure 8. Pilot-Plant Reactor Skid

Objective 2: Perform equipment shakedown, process optimization tests and plant modifications as warranted.

Following the installation of the plant at WRI, a plant shakedown will be undertaken to verify the performance of the components and controls. Sufficient time is allotted for this process so that modifications and upgrades can be made on an as-needed basis.

Objective 3: Characterize various feedstock process emissions and effluents for permitting requirements.

Following completion of Objective 2, steady-state plant operations will commence on natural gas. Several continuous tests, up to 48 hours long, will be conducted at different temperatures, pressures, and space velocities to determine optimum processing conditions. Limited tests up to 100 hours are planned as well. Various feedstock process streams will be sampled and analyzed. Similarly, process emissions and effluents will be periodically monitored to facilitate future plant permitting. Mass and energy balances from the analyses of the samples will be developed for the tests.

Objective 4: Perform steady-state "production" runs to promote commercialization of the product.

Once the plant has been sufficiently tested and modified, it will be operated to produce sufficient quantities of product for evaluation by prospective gasoline blending marketers. The plant will also be operated on an as-needed basis for demonstration of the technology to potential commercial partners and investors.

Objective 5: Produce quarterly and annual progress reports that will be made commonly available.

Appropriate quarterly and final project reports will be prepared by WRI for Painted Sky RC&D, the applicant entity, who will be responsible for submitting them to the appropriate funding officer. WRI's reporting obligations do not include a requirement to disclose information that is considered by WRI or PEFI to be confidential. WRI's program managers are ultimately responsible, in cooperation with PEFI, for the content of their reporting and the actions taken to ensure that confidential information is not included in any reports. However, Painted Sky RC&D, as the applicant entity, is responsible for ensuring that relevant information that results from this publicly funded research project is made commonly available. Should confidential information be needed for project review, the information will be provided under separate cover in sealed envelopes with the pages containing sensitive information marked "PEFI CONFIDENTIAL". This confidential information will not be made commonly available.

Projected benefits

Ecalene™ production is a sustainable technology that can contribute to the solution of a number of regional and global environmental problems while, at the same time, create jobs in rural communities. Examples include the ability to convert municipal solid waste, sewage waste, animal and crop waste, and industrial waste into a renewable energy product; the ability to utilize gas in stranded natural gas wells; improved auto emissions and air quality; the ability to convert forest residue (wood waste) into a useful commercial product; and reduced dependence on non-renewable fuel sources. These typical waste products can be converted to useable energy products that are beneficial to farmers, industry and the rural economy.

America produces more municipal solid waste than any other nation. Not only are some landfills running out of room and are closing, but they also pose the threat of toxicity to ground water resources and the production of methane gases. Current tests estimate that a ton of typical municipal solid waste can be converted to approximately 100 gallons or more of Ecalene™.

Dairy, hog, and horse farms have the problem of disposal of the water used to wash the manure from their barns. Most farms pump this liquid into large lagoons; the result is air and ground water pollution. Some farmers are pumping this liquid into anaerobic digesters that convert it to methane gas. Power Energy System™ can convert the methane gas produced in anaerobic digesters into Ecalene™ profitably, while providing usable waste heat for other farm operations. As well, the animal manures can be put through the patented catalytic system to produce Ecalene™ fuels that can be used for many purposes on the farm.

This same solution can be applied to food processing waste. Many Industrial plants produce small amounts of carbon monoxide and hydrogen (1 to 10 MMSCF) that is now being flared. The Power Energy System™ can solve this problem by producing Ecalene™ and creating a positive cash flow from a waste product.

The most widespread beneficial environmental impact of using alternative fuels are related to air quality. The direct effect is lower motor vehicle emissions due to the use of Ecalene™ as a substitute petroleum fuel by mixing 10% Ecalene™ by volume in motor vehicle fuels. Alternative fuels such as Ecalene™ will replace MTBE as a motor vehicle fuel additive in metropolitan airsheds of the United States as required by the EPA to meet atmospheric acidity levels for sulfur dioxide. This will become a huge market for alternative fuel products such as Ecalene™. Additionally, compared to gasoline vehicles with advanced emission controls, alternative fuel vehicles of the future emit lower levels of reactive hydrocarbons and other pollutants. These vehicles can burn the higher, cleaner burning alcohols such as Ecalene™.

Another important opportunity is to provide the US Forest Service and public land management agencies the technology to convert forest residue (wood waste) into useful commercial products. Recent devastating and costly wild fires are forcing the agencies to take preventative action by thinning large areas of the forests in the 190 million acres of public lands nationwide considered to be at high risk for fire. In addition, communities located near these forests have lost huge numbers of jobs in the downturn of the timber and public lands industries in the last 25 to 35 years. The PEFI technology provides an excellent "fit" because of its unique ability to convert waste wood into clean commercial fuels on a very large scale while creating a significant number of jobs in local, rural communities. See Appendix A-letter from Director, Cooperative and International Forestry Larry Roybal to Power Energy Fuels President, Gene Jackson, July 17, 2002.

PEFI has foreseen the need to develop at least two differing sizes of alcohol fuels plants. The larger of which could be located centrally where significant sources of carbon material is located. An example would be in a farming valley. In other cases there would be the need to have a portable, skid mounted alcohol fuels processor that could be moved around for site specific processing. Examples include a processor moved to a stranded natural gas well site or a municipal waste landfill site. Processed alcohols then would be trucked to market from the location.

Statement of Capabilities of Participating Entities and Their Key Personnel

Each of the organizations involved in this collaborative endeavor has capabilities that strengthen this renewable energy research grant application. The organizations are listed along with their strengths, capabilities and key personnel..

Painted Sky Resource Conservation and Development Council

Painted Sky, a private, non-profit, rural conservation organization, is concerned with natural resources and economic development for a six-county area in West-Central Colorado. Painted Sky RC&D brings the strength of a diverse, dedicated, eleven member board, a strong, organized staff to handle and manage the project, and an accounting system to handle and manage federal and state grants, their management and reporting. Painted Sky has been successful at developing a number of natural resource related programs and has obtained a broad cross section of grants several of which pertain closely to finding markets for waste wood from thinning programs. One of our identified goals is to develop renewable energy, hence our involvement with PEFI, Western Research Institute, and a number Federal agencies.

Rick Isom-Painted Sky RC&D Coordinator

Mr. Isom conducted undergraduate work in Civil Engineering and received his BA from the University of Nevada Las Vegas in Political Science, with a Minor in Business Administration. He received his MA from the University of Colorado in Urban and Regional Planning/Community Development, with a Minor in Business Administration. Mr. Isom has 25 years of experience in community development activities, including project development, facilitation, collaboration and multi-level funding development. This includes over $20,000,000 in project value that has been developed in the last 10 years. He also has a background in mechanical and civil engineering design and seven years of private business experience.

Carol Hughes-Finance Manager

Ms. Hughes received her education in accounting through the ICS/ Dealer Management program at General Motors Education. She has 30 Years experience in accounting and small business management. As Painted Sky RC&D Finance Manager for the past 3 years, she has conducted grant administration of over $600,000. She has also been an Accounting & Small Business Consulting Business Owner for 10 Years. Prior to working for Painted Sky, she worked for 10 years at General Motors Auto Dealerships. As their Accounting Office Manager, she managed $5,000,000 in Flooring Line of Credit and handled Cash Flow, A/R, A/P, Payroll and Financials. As their Finance Manager, she contracted over $2,000,000 annually.

Carol Kwiatkowski-Program Assistant

Ms. Kwiatkowski received her BA in Psychology from the College of William and Mary, Williamsburg,VA and her Ph.D. in Cognitive Psychology from the University of Denver, Denver, CO. She has 13 years of experience in data analysis, statistics, grant writing and academic publications and 5 years experience in grant-supported program management. She recently joined Painted Sky RC&D as a Program Assistant.

Power Energy Fuels, Inc

Power Energy Fuels, Inc. (PEFI) is located in the Denver, Colorado metropolitan area. PEFI was formed for the purpose of commercializing the Power Energy System™, whereby any carbonaceous source, ranging from natural gas to farm and municipal solid waste, may be converted into a high-grade alcohol product trademarked Ecalene™. PEFI's corporate mission is to improve and perfect this innovative, patented technology. PEFI has invested several million dollars of its own money to prove, through the use of public, non-partisan research laboratories, that the technology is viable and is suitable for commercial purposes in the renewable energy field. This technology will not only benefit the environment but also produce a clean burning motor fuel from renewable sources.

Gene R. Jackson-President, CEO, and Chairman of the Board

Mr. Jackson has pursued a varied and successful career, from agriculture, education and science to the forefront of the sustainable energy industry. His impressive knowledge and expertise in the production of alcohol fuel result from more than twenty years participating as a scientist, engineer and entrepreneur in the production of alternative fuels. Mr. Jackson assisted in the development of a pilot plant for one of the first American companies to employ a gas-to-liquids technology for the conversion of sulfur-free natural gas into clean-burning diesel. Mr. Jackson recognized the need for a sulfur-tolerant catalyst which could convert synthesis gas from all carbonaceous materials directly into mixed alcohols, transforming waste into pollution-free motor fuels. The culmination of Mr. Jackson's 20 years of work was highlighted by the issuance of a catalyst process patent in June of 2001. Under Mr. Jackson's direction, working with a number of highly regarded scientists and engineers, the viability of the technology has been confirmed, bringing the process to the point of commercialization. He will continue to lead Power Energy Fuels, Inc. in the rapid growth that is promised by the world's long-term need for a clean environment and energy independence.

Kenneth P. Bottoms-Corporate Organization and Operations

Mr. Bottoms has enjoyed a successful career in the domestic and international resource industries, serving with private and publicly traded companies for more than 30 years. After receiving his BS and Master of Science Degrees from the University of Michigan, he worked as geologist, manager and executive with corporations ranging in size from the largest to start-up publicly traded companies. As president of Stampede Oils, which he founded, he is credited with the discovery of two major gas fields in the Canadian Rockies containing more than 4 trillion cubic feet of recoverable reserves. Mr. Bottoms has worked in China, Ukraine, and Poland with International Methane Company Ltd. of Denver, CO, and in Pakistan with the Canadian International Development

Agency. Mr. Bottoms joined Power Energy Fuels, Inc. in November 2000 and directly participates in management, project evaluation, and corporate planning.

Ronald E. Wilson-Sales and Marketing

Mr. Wilson attended Metropolitan State College, in Denver, CO, in Sales and Marketing. He served in the U.S. Marine Corps for 6 years, including a tour of duty in Vietnam. From 1970 to 1989 he held several positions including National Accounts Manager, District Manager and Brand Development Manager for Murray Distributing Co. in Denver, CO. From 1989 to 1991 he served as General Manager of Sheya Brothers Specialty Beverage Co. where he re-organized the sales department and managed the growth of Sheya Brothers, increasing sales of this start-up company from $2 million to $14 million in 3 years. From 1991 to 1993, Mr. Wilson managed new brands and packaged the introduction of Snapple, Mistic and Evian. He was responsible for key accounts that represented sixty five percent of total company business. From 1993 to 1996, Mr. Wilson served as Division Manager of non-alcoholic beverages for Western Murray Distributing Co. and re-organized the sales department that eventually resulted in an increase in sales of forty seven percent. From 1996 to 1997 he was employed at Full Service Beverage Co. as Director of Sales to oversee all departments including warehouse, delivery and sales. Mr. Wilson joined Power Energy Fuels, Inc. in 1997.

Roberto E. Valles-Financial Planning and Control

Mr. Valles is a graduate of the ITESM in Monterrey, Mexico, with a BS Degree in Business Administration and a major in Accounting. Mr. Valles moved to the United States in 1984 and started out in Public Accounting with a local firm in El Paso, TX. He later joined KPMG Peat Marwick LLC where he had extensive exposure to Off-Shore Manufacturing operations with U.S. and Japanese companies. He became independent in 1988. After seven years in Public Accounting, he accepted a position as controller with a Colorado hotel owner and operator company. He was directly involved in the reorganization of the company that led to the acquisition of two more properties. Mr. Valles assumed the position of Executive Vice President with this company in 1994 and became a resourceful and team-oriented executive in the hospitality industry with proven leadership skills that led the company to a strong financial performance in a very competitive market. Mr. Valles has been involved with Power Energy Fuels, Inc. since July 2000, assisting also in the preparation of the Master Business Plan to develop Mexico and Latin America markets. Mr. Valles is fluent in Spanish.

William B. Michel, Jr. PE-Project Management

Mr. Michel graduated from New Mexico State University in Las Cruces, NM with a BS Degree in Mechanical Engineering. Mr. Michel has extensive experience in engineering, production support, and management. Mr. Michel spent 26 years with the Operating Contractor for the U.S. Department of Energy at the Rocky Flats Plant in Jefferson County, Colorado. During this time, Mr. Michel held different positions in engineering and production support including Facility Project Management, Pre-production Planning and Analysis, Budget and Plans, Industrial Engineering, Assembly Engineering, and Manufacturing Design. Other positions in the management field held by Mr. Michel include Cost Estimating, Facilities Engineering and Construction, Facilities Project Management, and Maintenance, Technical Support. Mr. Michel also owned and operated a successful retail business for seventeen years. Mr. Michel is a registered Professional Engineer in the State of Colorado.

Western Research Institute

Western Research Institute was established in 1924 as a Petroleum Experiment Station to study the characteristics of high-sulfur crude oil in Wyoming. Asphalt research began in 1964 and in 1977 the Laramie Energy Technology Center (LETC) was established as the lead for U.S. Department of Energy (DOE) oil shale and underground coal gasification programs. In 1983, LETC was de-Federalized and the Western Research Institute was established in a Cooperative Agreement with DOE.

Today, WRI is a leading research, technology development and contract services organization in the energy and highway materials industries, serving private clients, industry, and government. WRI engages in research, development, demonstration and commercialization of technologies related to energy, environment, and transportation materials, with the goal of finding ways to boost energy production and efficiency while safeguarding natural systems. In the energy sector of WRI, the focus is on developing and demonstrating technologies that address energy production and generation and the production of clean, efficient fuels. WRI is working on a host of projects that reflect the commitment to the idea that energy use and environmental responsibility go hand in hand. Among the many products and services offered by WRI are environmental cleanup; standards development for the American Society for Testing & Materials; oil production, refining and upgrading; developing products from coal combustion by-products; bio-refining technology for fuel, fiber and energy; hydrogen-based electricity storage; and a biomass-fired gas turbine. The 22-acre Advanced Technology Center at WRI is used for bench-scale and pilot-scale work of all kinds.

WRI is located in Laramie, Wyoming. Laramie is a small, western city of 27,000 and is home to a growing technology sector comprising software development, web-based training, technical support, and environmental and energy technologies, including WRI's diverse programs. WRI is located on the southwest corner of the University of Wyoming campus and is much enriched by the relationship with the university. Research collaboration and student internships are two examples. Also, the university is a source of highly educated employees, while WRI provides opportunities for many UW graduates to work in their chosen field in their chosen state.

Michael L. Hauck, Ph.D. Chief Technology Officer

Dr. Hauck has his B.S in Geology and his Ph.D in Geophysics and Engineering. Prior to joining the Institute he was employed with the Royal Dutch / Shell Group where he was director of Shell Exploration and Production Company's Collaborative Virtual Environment. As Chief Technology Officer for WRI, he leads the technical staff focusing on technology transfer and commercialization. Dr. Hauck's longer focus is on staff development, technical strategy and new commercial technology directions for WRI. New commercial successes of Dr. Hauck include two Industry Innovation Awards, first licensing of the TaBoRR skid mounted refinery and the Institute's first municipal contract.

Dr. Vijay K. Sethi, Program Manager, Energy Production and Generation Business Unit

Dr. Sethi has his MS in Physics and his Ph.D Metallurgy and Materials Science. Dr. Sethi has enjoyed a distinguished 35 year career as a research scientist and for the past 11 years, in management capacities with WRI. The Business Unit he heads develops and demonstrates technologies that address clean and efficient energy and fuels production and environmental processes related to energy and fuels production. Dr. Sethi is also responsible for managing WRI's Cooperative Agreement with the US Department of Energy, and in this capacity acts as liaison on all technical, contractual and budgetary matters.

Andrew J. Lucero, Lead Engineer

Dr. Lucero, Ph. D., Chemical Engineering, is currently directing the efforts to assist Power Energy Fuels Inc. in developing their proprietary technology to convert carbonaceous feedstocks into mixed alcohols. Dr. Lucero developed in-depth understanding of the catalytic reactor system and prepared bench scale experimental plants to identify optimum operating conditions. He also directed experiments, evaluated data and confirmed that space-time yields of alcohols exceed all available literature data. Prior to joining WRI, Dr. Lucero spent 8 years with Oak Ridge National Laboratory, where he excelled in a wide range of research functions. He gained valuable experience in catalytic alcohol synthesis, evaporation, precipitation, clarification and ion exchange. Dr. Lucero headed a team which earned a Significant Event Award and an Operations and Support Award for planning and conducting successful experiments to identify optimum vapor temperature, to evaluate system performance with material and energy balances, and to identify operating parameter changes that dramatically improved distillate purity.

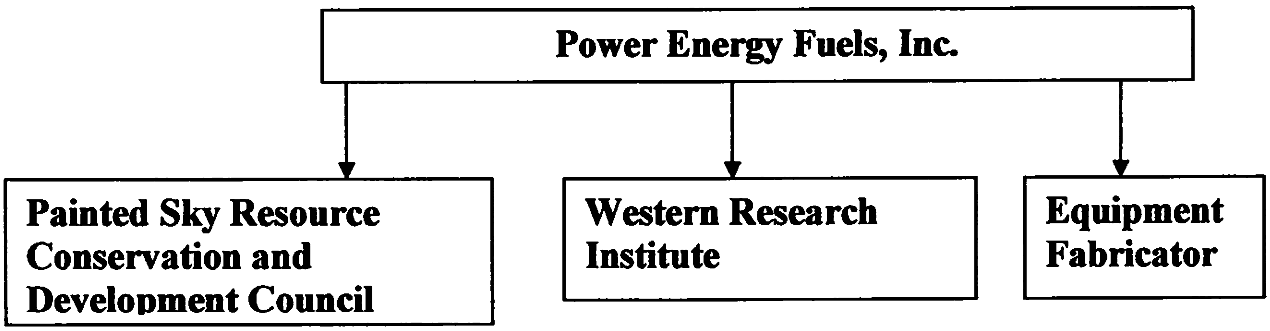
Brookhaven National Laboratory

The Department of Energy's Brookhaven National Laboratory (BNL) conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies. Brookhaven also builds and operates major facilities available to university, industrial, and government scientists. The laboratory supports thousands of research projects annually making results available to scientists, researchers, engineers, academia and citizens. The lab is involved in partnerships, collaborations with other agencies, businesses and communities throughout the United States and the world. BNL conducted a substantial portion of the research prior to this proposal, however, they will not be involved in research funded through this application.

Lines of Authority

Painted Sky RC&D is the grant applicant and will be responsible for the financial and reporting accountability for the project. It must be emphasized, however, that this is a collaborative project. Without each of the participating collaborative partners, this project would not go forward. The idea and the drive to bring the technology to market originated with Power Energy Fuels, Inc., who has the overall lead in this project. Western Research Institute and Brookhaven National Laboratory are where the ideas have been proven to have merit and were given the best means and design to become a commercial reality. Painted Sky RC&D, in addition to managing the financial accounting and reporting, will assist in the future with setting up and building one or more local commercial plants.

Project Management Flow Chart



Collaboration

Painted Sky RC&D is involved in over 30 local projects in a six-county area in West-Central Colorado. In virtually all those projects we work collaboratively with a team of local individuals who usually represent a local task force of persons in municipal, county, state and federal government, private business and non-profit entities who have come together work on an issue of concern. Frequently, Painted Sky will become the fiscal agent for a project because of its non-profit, 501C(3) status and its experienced accounting staff.

Painted Sky RC&D is assisting PEFI in developing and writing this proposal in order to get this promising technology to market in hopes that they will eventually build an alcohol fuels plant in West-Central Colorado. Painted Sky is involved closely with Federal Land management agencies in this area. The agencies have a serious concern about forest health, in that the forests are overgrown due to 100 years of fire suppression and are in need of forest thinning, which directly leads to a need to develop markets for the wood. A project such as being proposed by PEFI to produce alcohol from carbonaceous sources fits perfectly with the need of the federal agencies to find markets for wood. We are in a unique position to facilitate in developing the resources to build such a plant pending the positive outcome of the commercialization tests of the pilot plant. Local economic development organizations, municipalities, counties and regional economic development organizations are eager to help, as well

PEFI has long established working relationships with the research, development and fabrication entities involved in this project through the past several years of collaborating on earlier phases of this research. During the final construction phase, close interactions between WRI, PEFI and the fabricators will continue to be needed in order to get the pilot plant to the exact specifications that are needed.

Ability to commercialize results

PEFI has chosen to prove the commercial potential of the carbon to alcohol fuels process through the use of third-party research laboratories, i.e., Brookhaven National Laboratory in New York State and Western Research Institute in Laramie, Wyoming. The approach adds credibility to the results that indicate that the catalyst driven system developed by PEFI, resulting in Ecalene™ higher alcohol fuels, has commercial potential. The commercial potential exists in the greater efficiency of this process. That is, the same amount of alcohol can be produced in half the time. In addition, the process is not plagued with the difficulties of sulfur and carbon buildup as other processes are. The other processes are forced to pre-treat the feedstocks to remove the sulfur and carbon before alcohol can be produced. The overall result is that PEFI's processing system is more economical and potentially very profitable for industry.

Upon completion and testing of a 500 gallon per day plant, PEFI and WRI will present to industry the results of studies of various feedstocks at this pilot plant. Also, industry will be able to come and witness the pilot plant in operation using various feedstocks. The plant itself will be operating upon energy that has been taken from the feedstock. The pilot plant will be an outstanding model in order to show industry that the patented process is better than others created in the past.

Other related government contracts, grants and cooperative agreements

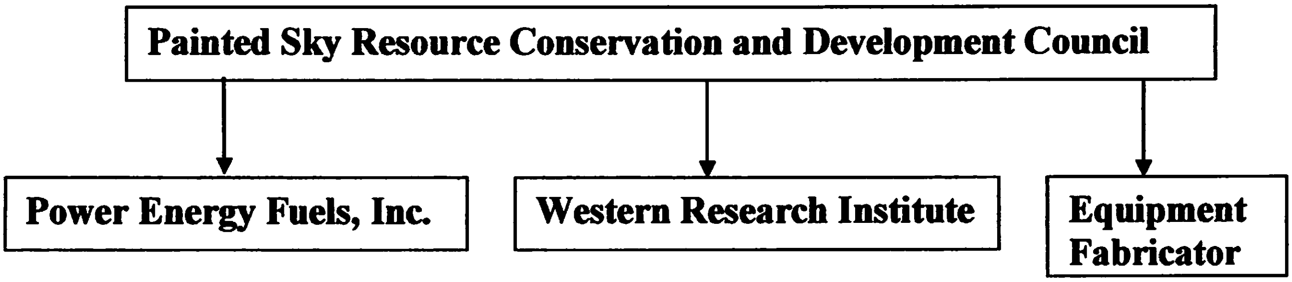
Painted Sky RC&D currently has a fire planning project where we work to assist thinning of hazardous woody fuels from around homes in subdivisions and work to find markets for the wood materials. We also have assisted in developing manufacturing opportunities for small diameter wood material. One such effort was an edge-glue project where a company glues small boards into large boards to make cabinet doors and facings. Another small company saws small logs into fencing materials for backyards. Each of these projects were funded through Federal grants that Painted Sky received directly and administered to local private companies. Each of them involved an economic analysis in order to prove the project was a good investment for the private companies.

WRI currently has two major federal contracts. One is a contract with the Federal Highway Administration to apply asphalt chemistry to specifications for better highway performance. The other is a Cooperative Agreement with the DOE wherein WRI and DOE work jointly with industry to support the needs of the coal and power industries. The Cooperative Agreement consists of a Base Program for internal basic research, and a Jointly Sponsored Research Program to share 50/50 in the cost of research and development of technologies for the energy industry. The Cooperative Agreement appropriation for FY 2002 was $3.9 million.

Cost proposal

The following is a diagram of the financial relationships as related to disbursement of funds requested in this proposal.

Financial Relationships for Disbursement of Funds



Painted Sky RC&D is the grant applicant and, as such, will administer the funds and be responsible for reporting on the progress of the project. Painted Sky has collaborative and technical agreements with: Power Energy Fuels, Inc., which is the project management agency and pilot plant owner; Western Research Institute, which provides the location for the plant and is responsible for all research and testing of the PEFI process; and a Denver-based equipment fabricator which will work cooperatively to design and build the remaining parts of the pilot plant to be shipped to WRI.

To date, PEFI has supplied substantial investment, totaling over 2 million dollars, in the building of the pilot plant as well as in prior research related to this patented process. Painted Sky has also invested substantial time and energy collaborating on this proposal. In addition, both entities are prepared to invest matching resources toward the continuance of this important program. This information is depicted in detail in the table below and in the required budgetary forms. Specific budget categories of this funding request are reported in the table.

Budget Table and Narrative for Painted Sky RC&D Application (USDA-GRANTS-031803-001)

Pilot Plant stats:	
Started:	July 2000
Capacity:	500 - 700 gal/day
Purpose:	Demonstrate Ecalene™ production commercially

Scope of work and cost breakdown:	ACTUAL COST TO DATE (5/2003)	ESTIMATED COST TO COMPLETE	BUDGET CATEGORY
Fabrication and Assembly:			
- Vessels, structural, piping, labor	275,804	440,000	Construction
Instrumentation	167,484	50,000	Equipment
Western Research Institute (Testing)	358,930	600,000	Contractual
Compression	40,000	-	Equipment
Electrical & Instrumentation housing	20,118	15,000	Equipment
Oxygen plant	-	90,000	Equipment
Engineering and CAD Drawings	-	30,000	Contractual
Boilers	-	-	
Turbine Accessories	-	-	
Biomass Storage	-	-	
Steam Reformer	-	-	
Slurry Reactor	-	-	
Contingency	-	-	
Sub-total	862,336	1,225,000	**Match**
R & D (JSRP DE-FC26-98FT40323)	845,000	-	
Catalyst	16,000	550,000	Equipment
Project Management (PEFI)	277,558	125,000	475,000
General & Administration (PEFI)	185,039		Contractual
Grant Administration(Painted Sky RC&D)		100,000	5,000
Total	2,185,933	2,000,000	480,000

Power Energy Fuels Inc. Our Product

Environmental Solutions

Auto Emmisions | Air Quality | Dairy and Hog Farm Waste | Solid Waste

Our technology is committed to changing the future! The Power Energy Fuels mission statement is to globally produce the highest quality, clean burning alternative fuel. Ecalene™ has worldwide need and our vision is to become the foremost high-tech company in the environmental and alternative fuel industries.

Beginning in 2002, the Clean Alternative Fuel Program requires motor fuel sold in the U.S. to contain an increasing percentage of renewable fuel, such as ethanol. The use of ethanol/Ecalene™ will result in improved air quality, effectively addressing the threat of increased air pollution in our nation's most polluted cities.

The U.S. Senate Environmental and Public Works Committee approved legislation (S. 2962), which bans the use of MTBE by 2004, virtually tripling the demand for ethanol over the next ten years. The legislation has been amended to require the Environmental Protection Agency to evaluate air quality requirements and also provides the EPA with authority to regulate on the basis of those studies to preserve the emissions benefits of Re-Formulated Gasoline (RFG). The amendment also caps the level of aromatics used

Corn dominates the current ethanol market as the primary feedstock. Our technology and process break these boundaries by solving existing environmental waste problems while making a clean alternative fuel. Municipal solid waste, dairy and hog manure, landfill gas, stranded natural gas, construction and demolition debris, coal fines, wood waste - all these feedstocks can be converted into Ecalene™, an ethanol of unprecedented quality, a truly clean burning alternative fuel.

MTBE has been widely used as a fuel additive, however due to ground water pollution this product is being phased out. The demand for MTBE is over 10 billion gallons annually and ethanol/Ecalene™, will be the product of choice to replace the use of MTBE.

A growing number of States in the country have joined to mandate clean alternative fuels to control air pollution. At the present time, it is estimated that 60% of all gasoline sold has 10% ethanol added to reduce air pollution in the Denver area alone. This "10% blend" represents an already huge market for our product: Ecalene™. The passage of the bill that bans the use of MTBE will only increase the demand for a superior blending alternative.

There is no other known catalytic process available in the world, which is capable of converting carbonaceous sources into higher, mixed alcohols at the conversion rate achieved by the Power Energy System™.

Ecalene™ is registered with the United States Environmental Protection Agency as a fuel additive.

Ecalene™ and Automobile Emissions

The successful implementation of the Clean Alternative Fuel Program will intensify the need for clean fuels. Ecalene™ is the most promising clean fuel for today and the future.

Ecalene™ and Air Quality

The most widespread environmental impacts of the alternative fuels implementation program are related to air quality. Of course, the direct effects are beneficial; lower motor vehicle emissions due to the use of ethanol as a substitute petroleum fuel. In addition to reducing atmospheric acidity levels, compliance will also be achieved with the national air quality standard for sulfur dioxide.

Compared to gasoline vehicles with advanced emission controls, alternative fuel vehicles emit lower levels of reactive hydrocarbons and other pollutants as well. These lower vehicle emissions would be particularly helpful in urban areas, which continue to have serious air quality difficulties.

Ecalene™ and Dairy and Hog Farms

Dairy and hog farms have similar problems, disposal of the water used to wash the manure from their barns. Most farms pump this liquid into large lagoons. The result is foul air and ground water pollution. Some farmers are pumping this liquid into anaerobic digesters that convert it to methane gas. The methane gas is normally used to produce electricity, and while this solves the air and ground water pollution problems, it isn't very profitable.

The Power Energy System™ can convert the methane gas produced in anaerobic digesters into Ecalene™, a very profitable and marketable motor fuel. The solution provided by the Power Energy System™ also provides usable waste heat for farm requirements.

This same solution can be applied to food processing waste.

Ecalene™ and Municipal Solid Waste (Garbage)

America produces more garbage than any other nation, and disposing of it is an immense problem. Not only are some landfills running out of room, but they also pose the threat of toxicity.

The Environmental Protection Agency estimates that, on average, each individual produces 4.4 pounds of garbage a day. The cost of handling garbage is the fourth biggest item after education, police, and fire protection in many city budgets. But where does each of our 4.4 pounds per day go? Some is recycled, some is incinerated; but the majority of it is laid to rest in more than 2300 U.S. landfills in operation today. And that is where the problem starts. Landfills produce leachate, runoff that contaminates ground water, and incinerators, no matter how sophisticated, produce air pollutants.

The Power Energy System™ technology is capable of converting virtually all-carbonaceous materials found in municipal solid waste to Ecalene™, the superior, clean burning ethanol.

Power Energy Fuels, Inc.
6595 W. 14th Ave
Suite 203
Lakewood, Co. 80214

tele (303) 205-1991
fax (303) 205-1990

Staff@PowerEnergy.com

Copyright © 2002 Power Energy Fuels, Inc.

Power Energy Fuels Inc. Investor Relations

Home
About Us
Our Technology
Our Product
Deploy Targets
Investor Relations
Contact Us
Newsletter
Search

Power Energy Fuels, Inc.
6595 W. 14th Ave
Suite 203
Lakewood, Co. 80214

tele (303) 205-1991
fax (303) 205-1990

Staff@PowerEnergy.com

Revenue Strategy and Projection

Sales will be generated through the transportable skid-mounted plants. Industry interest in Stranded system sales is developing quickly. As well as, the conversion of methane gas from landfills and the digestive processes of dairy and hog manure.

Revenue

The Company's revenue stream will be generated from the following sources:

- Plant licensing.
- Production royalties will become a significant revenue stream within three to five years.
- New plant sales.
- Operating plants owned by Power Energy Fuels, Inc.
- Joint Venture Partnerships.

Research will continue to further enhance the technology and to develop new and related technologies.

Copyright © 2002 Power Energy Fuels, Inc.

Power Energy Fuels Inc. Deployment Targets

Industry Analysis

There is no other known catalytic process available which is capable of converting carbonaceous sources into higher, mixed alcohols. No other process is transportable, or exhibits the efficiency, profitability and flexibility offered by the Power Energy System™.

The Company expects the market for Ecalene™to expand into many applications. The product can be used in blended gasoline as E85 or E10, straight fuel (E100), higher-octane aviation fuel, bio-diesel, fuel for fuel cells and other significant markets. Ethanol, hence Ecalene™, is the product of choice to replace MTBE. The market to replace MTBE is estimated at ten billion gallons annually. Current ethanol product amounts to approximately 25% of this demand.

American and foreign automobile manufacturers are expanding the number of flex-fuel models available. Flex-fuel vechiles can operate on either gasoline or alternative fuels without modifications. The U.S. Government is expected to continue tax incentives for the purchase of these flex-fuel vehicles (FFV's). As more retail stations have pumps dedicated to E85 and E100, the market is expected to increase dramatically.

Copyright © 2002 Power Energy Fuels, Inc.

Power Energy Fuels, Inc.
6595 W. 14th Ave
Suite 203
Lakewood, Co. 80214

tele (303) 205-1991
fax (303) 205-1990

Staff@PowerEnergy.com

Power Energy Fuels Grant Application: Executive Summary

Power Energy Fuels, Inc. (PEFI) of Lakewood, Colorado, is the sole licensee of a patented catalytic process to make a mixed alcohol fuel from synthesis gas produced from any carbonaceous source. Earlier developmental testing at Dow Chemical Company, and Brookhaven National Laboratories, showed that the process produces predominately straight-chain terminal $C_1 - C_6$ alcohols. The data also showed that by manipulating the composition of the catalyst and processing conditions, the ratio of ethanol and higher alcohols to methanol produced can be controlled within a wide range. To facilitate commercialization, the technology needs verification at the pilot and demonstration scale.

A three-year, pilot-scale development and testing program is proposed to prepare the technology for commercialization using various feedstocks. A 500 gal/day pilot plant has been designed and is being constructed by PEFI for installation at Western Research Institute's (WRI's) Advanced Technology Center in Laramie, Wyoming, but it has not been completed due to funding shortfalls. Additional funding will allow completion of the plant along with debugging and shake down of the plant using pipeline natural gas. Catalyst and plant performance data will be compiled with natural gas as the initial reference feed. In years 2-3, the plant will be upgraded to include gasification and gas conditioning facilities and operated with synthesis gas produced from various feedstocks. Catalyst and plant performance data will be compiled and reported for each of the various feedstocks for purposes of proving the commercial viability of the process.

The proposed project is a significant opportunity to prove that any number of waste or non-waste carbon sources can be turned into an economical and profitable alcohol fuel, that is of a renewable nature, to serve America's appetite for energy. This new technology can contribute to the solution of a number of regional and global environmental problems while, at the same time, creating jobs in rural communities. Some of the benefits include: the ability to convert municipal solid waste, animal and crop waste, stranded natural gas wells, and forest residue (wood waste) into a renewable energy product; improved auto emissions and air quality through the use of this product as a clean-burning fuel additive; and reduced dependence on non-renewable fuel sources. It is particularly significant that *a waste material* can play such an important role in the reduction of air pollution.

Painted Sky Resource Conservation and Development Council has been involved with Federal and State Land Management agencies extensively and with fire planning and fuels reduction activities on public and private lands in west-central Colorado. These activities have shown that there is a need to find markets for significant volumes of waste wood from forests, which public lands agencies and private land owners are interested in supplying. Add to that the need of many municipalities to reduce municipal solid waste and of farmers to reduce huge volumes of agricultural wastes, the result is that there is no shortage of available carbon fiber for feedstock. This application, submitted by Painted Sky RC&D, in collaboration with PEFI and WRI, is the next step in determining whether the economics of this plan are sound and in making this unique opportunity a reality.

Biomass combustion power generation technologies

Broek, R. van den, A. Faaij, A. van Wijk, 1995, *Biomass combustion power generation technologies*, Study performed within the framework of the extended JOULE-IIA programme of CEC DGXII, project "Energy from biomass: an assessment of two promising systems for energy production", Department of Science, Technology and Society, Utrecht University, Utrecht (Report no. 95029).

Other relevant reports: 95100, 96092

Summary

At present power generation from biomass is mostly done by means of direct combustion. This report aims at making an inventory of the state of the art of biomass combustion technologies and to compare efficiencies, investment costs and emissions. The study focuses at power plants larger than 10 MWe.

This study is a background report within the Joule II+ project "Energy from biomass : an assessment of two promising systems for energy production". The objective of this overall Joule project is to provide support for the design and operation of biomass energy conversion units based on existing plans in the Netherlands and Ireland. In the Netherlands these plans are to construct a 30 MWe biomass gasifier with a combined cycle, fuelled by biomass residues and organic waste material. In Ireland the plans are to assess the feasibility to substitute peat with biomass in the form of short rotation coppice for energy production.

This general report on biomass combustion is meant as a support for a more specific study on retrofit options of Irish peat plants in order to enable biomass firing.

The inventory which has been undertaken consists of a general boiler technology description on the basis of qualitative criteria and a comparison of most recently built and planned power plants on the basis of quantitative criteria.

Important methodological considerations have been made on the field of recalculating CHP output to single power output, calculations on overall-electric, boiler and turbine efficiencies and the conversion of different monetary data into one common basis. Final comparison of efficiencies has been done on the basis of lower heating values, which is the most fair basis to do so.

If biomass as a fuel is compared with different kinds of fossil fuels, the most important differences can be found in the variability of fuel characteristics, higher moisture contents and low nitrogen and sulphur contents of biomass fuels. The moisture content of biomass has a large influence on the combustion process and on the resulting efficiencies. NOx formation in biomass combustion can be kept low, partly because of low nitrogen contents in most biomass fuels and partly with the help of control techniques like combustion at low temperatures and staged combustion.

Qualitative analysis

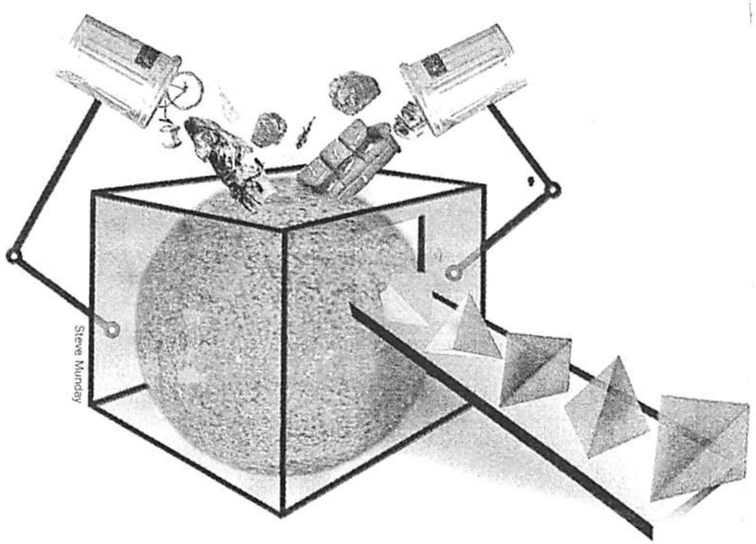
A qualitative analysis has been made of existing boiler technologies to combust biomass. Boiler technologies which have been dealt with are : pile burners, stoker fired boilers, suspension fired boilers and fluidized bed boilers.

THE WALL STREET JOURNAL. Feb 17/05

Drying Up Waste Stream With Power of the Sun

'Plasma Torch' Turns Trash To Fuel, Building Products; But Is It Cost-Competitive?

BY JIM CARLTON



A new kind of space race is gaining velocity: harnessing a power akin to the stars' to zap away garbage and free up room in landfills.

One of the leaders in the field is **Westinghouse Plasma** Corp., a Madison, Pa., company that has developed a machine whose "plasma torch" blasts into oblivion practically anything fed through its chute.

The plasma machines being sold by Westinghouse and others disintegrate waste with a stream of plasma, or ionized gas, that reaches as much as 30,000 degrees Fahrenheit, three times as hot as the surface of the sun. The process reduces the waste to gases—mostly hydrogen and carbon monoxide, piped away for reuse as fuel—and a glass-like material that is used in construction.

Westinghouse Plasma, a descendant of the former Westinghouse Electric Corp., says it has deployed 16 plasma machines in the past six years to help dispose of municipal waste in Japan, where there is almost no room for landfills and incineration has contributed to an air-pollution problem. Other companies have sold plasma technology in Europe, as well as Japan. Now, with landfill space at a premium in many places in the U.S. and concerns growing about incinerator pollution, the technology is drawing increased interest from American waste managers.

"If this works on an industrial scale the way it is supposed to, this has the potential to change all the waste rules," says Jeff Voorhis, an engineer at the Texas Commission on Environmental Quality, which is reviewing a plan for at least two plasma machines to be operated in the Houston area.

Westinghouse is also teaming with **Geoplasma** LLC, Atlanta, and the Georgia Institute of Technology to pitch a plasma-waste system for Honolulu, which is exploring alternatives as it runs out of landfill space. Westinghouse Plasma designs and makes the plasma torch reactor; Geoplasma designs the technology that collects the waste gas and combusts it to generate electricity.

First used in the late 1800s by metal makers for such purposes as melting iron, "plasma arc" technology—in which gas is ionized with an electric arc to form a plasma torch—was later used for such applications as making fuel and testing spacecraft.

Other companies now using the torch to melt everything from hazardous materials to household garbage include **Retech Systems** LLC, a former unit of Lockheed Martin Corp., and **Startech Environmental** Corp. Retech, of Ukiah, Calif., said it has supplied six commercial versions of its Plasma Arc Centrifugal Treatment machines to customers in Switzerland, France and Germany, among other places. Startech, a small publicly traded company based in Wilton, Conn., said it has sold one of its Plasma Converter Systems for $3 million to a commercial customer in Japan, and that it has signed contracts to deliver more in such places as Poland. All of the contracts are contingent on customers getting financing, however.

The 14-year-old Startech is currently unprofitable, posting a loss of $2.6 million on $1.7 million in sales in the fiscal year ended Oct. 31. Startech is trying to stay focused on its technology while its largest investor, NorthShore Asset Management, is subject to a Securities and Exchange Commission probe. The SEC is investigating whether millions of dollars was stolen from a hedge fund bought by NorthShore, a Chicago investment firm. A lawyer for NorthShore has said he didn't believe there had been any misuse of funds by his client, and added that the

Please Turn to Page B5, Column 1

Plasma Torches Turn Garbage Into Gasses, Building Products

Continued From Page B4

firm is cooperating fully with the SEC. NorthShore bought a 20% stake in Startech, now valued at about $11 million, about two years ago, and NorthShore representatives occupy two of the five board seats.

Startech Chief Executive Joe Longo says, "We don't get involved in the affairs of our shareholders."

Plasma technology isn't without issues. Some environmentalists, for example, say the plasma machines are indirect polluters, requiring great quantities of electricity that often comes from fossil-fuel power plants. Industry proponents say that using the waste gas as fuel can actually generate more electricity than the plasma-arc technology uses.

The process does produce dangerous gases, says John Hankinson Jr., an environmental consultant in St. Augustine, Fla. These have to be safely contained within the machine, he says. "You want to manage the gases properly, that's critical," says Mr. Hankinson, who also was the Environmental Protection Agency's regional administrator in Atlanta. He notes that the process also has its limits. It isn't the answer to radioactive waste, for example—it can significantly reduce the volume, but it doesn't make them safe.

Finally, the technology often is more expensive than the older methods it replaces. Municipal dumps in the U.S., for instance, spend on average $30 a ton to dispose of waste, says Shyam Dighe, chief executive of Westinghouse Plasma. With plasma machines selling for as much as $20 million, zapping away garbage runs $50 to $80 a ton, he says. Startech officials say that cost comes down when the value of recycled waste fuel is factored in.

In the U.S., the plasma makers hope to find more market opportunities—especially for hazardous waste, which industry officials say is less expensive to dispose of with plasma than with other methods.

New York City officials, meanwhile, say they are looking at plasma machines made by Startech and others to reduce the 24,000 tons of daily trash the city now has to truck to distant states such as Virginia. The trucking has been going on since New York closed its last landfill in 2001. According to Carmen Cognetta Jr., a lawyer for the city, that has raised the cost of garbage disposal to as much as $80 a ton.

COO - CD D:
file - New folder
~~alternative~~
altenergia
231696.pdf

HEMP BIOMASS for ENERGY

By Tim Castleman

© Copyright 2001, all rights reserved
Version RV2

Table of Contents

Executive Summary

This report evaluates the use of Industrial Hemp (Cannabis Sativa) as a feedstock in the production of energy.

Included in this report are:

- An explanation of what biomass is.
- The potential of biomass for various applications.
- The economics of using hemp as a source of biomass
- The Fuel and Fiber Company approach to using hemp as a source of biomass

Biomass is any plant or tree matter in large quantity. It is used in a variety of ways as a feedstock for numerous industrial processes now. These include food processing, papermaking, electricity generation, building materials and pharmaceuticals to name a few.

The knowledge base regarding these production systems and their feedstocks is large and sophisticated with stakeholders at every level of our society. Industrial hemp suffers from 60 years of banning and is not routinely considered at all among upper level planners and policymakers. Technologists can only wonder about the potentials of it. Therefore, hard data is elusive and frequently colored by emotive expressions of idealism, from both sides of the controversy.

It is technically feasible to produce energy from hemp. The challenges are in the areas of economics and politics.

- To produce biodiesel using hempseed oil is estimated to cost $3.66 or more per gallon in the most optimistic scenario.
- Anaerobic digestion would produce methane, which can be converted to methanol. These are both highly toxic and corrosive which presents problems to existing energy distribution and consumption, but is highly suitable for some applications.
- Hemp biomass can also be converted under high heat (Gasification, Pyyrolysis, Destructive Distallation) into "bio-oils" and synthetic gas using any of several commercially available systems.
- Hemp is rich in cellulose and has less lignin than wood. Technology under development would convert this cellulose into sugars to be fermented into ethanol. Ethanol is a non-toxic organic used to oxygenate gasoline and has a ready market nationwide. Current costs to convert cellulose are estimated at $1.37 gallon,

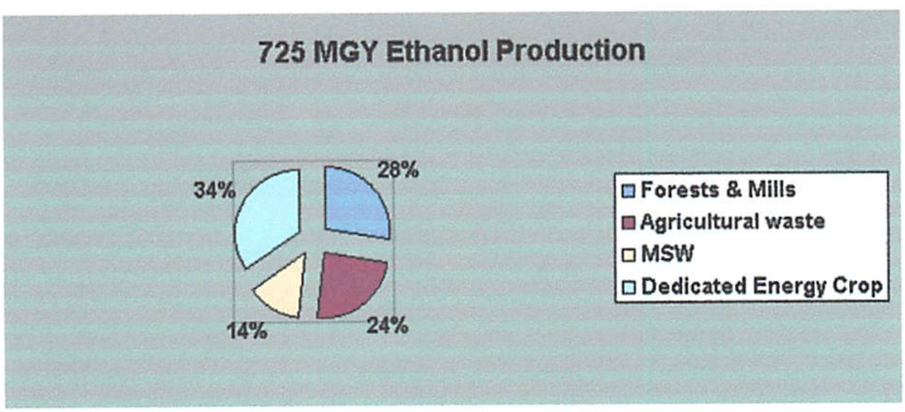
Hemp Cellulose for Ethanol

Another approach will involve conversion of cellulose to ethanol, which can be done in several ways including gasification, acid hydrolysis and a technology utilizing engineered enzymes to convert cellulose to glucose, which is then fermented to make alcohol. Still another approach using enzymes will convert cellulose directly to alcohol, which leads to substantial process cost savings.

Current costs associated with these conversion processes are about $1.37 per gallon of fuel produced, plus the cost of the feedstock. Of this $1.37, enzyme costs are about $0.50 per gallon; current research efforts are directed toward reduction of this amount to $0.05 per gallon. There is a Federal tax credit of $0.54 per gallon and a number of other various incentives available. Conversion rates range from a low of 25-30 gallons per ton of biomass to 100 gallons per ton using the latest technology.

In 1998 the total California gasoline demand was 14 billion gallons. When ethanol is used to replace MTBE as an oxygenate, this will create California demand in excess of 700 million gallons per year. MTBE is to be phased out of use by 2003 according to State law.

In this case we can consider biomass production from a much broader perspective. Sources of feedstock under consideration for these processes are:



Call the Pandas: Bamboo Engulfs Defenseless Yards

* * *

Relentless Spread Foils Poison, Pickax, 'Dozer; The Polyethylene Cure

WSJ 24Mar08/A1

By Matthew Rose

Randy Bothwell, a police detective in Chester, Pa., considered and rejected a number of ways to rid his yard of bamboo: salt, an exorcism, shooting it with his service revolver. When he asked for advice at a local garden center, he says, they "laughed hysterically."

So Mr. Bothwell whacked the stand with a machete. It grew back. He bought a pickax and tried digging up the roots, a process that traced a 30-foot arc across his once-pristine lawn. One month and two broken shovels later, he rented a Bobcat minibulldozer and a big metal trash bin, acquired 14 gallons of poison and bought 24 cubic yards of dirt to

Please turn to page A16

Bamboo

Continued from Page One

fill the resulting hole. Total approximate cost: $1,500.

One year later, a single shoot appeared. "It gave me ... the final salute." Mr. Bothwell says. "I was like, 'Mother of God.'"

Bamboo is environmentally friendly, grows fast and forms a nifty screen that walls off the neighbors. It's also eating suburban America.

Bamboo spreads relentlessly, like kudzu and Japanese honeysuckle, two other species that drive gardeners to distraction. Its roots are like steel cable, and neighbors sometimes battle over the consequences. A 2002 lawsuit, which complained that the plants were threatening a pool and a retaining wall, summarized one part of the problem: "Bamboo is not indigenous to Long Island, New York."

"The client thought it was evil," says lawyer Steve Lester of Garden City, N.Y., who represented the plaintiff.

Brent Langdon, a software engineer in Sterling, Va., spent two years trying to clear 200 square feet of bamboo lodged in the hard Virginia clay at a home he had bought. He used a pickax to soften the roots and applied potent Roundup herbicide.

After one exhausting weekend, Mr. Langdon decided to cut it all down and rented a large commercial chipper to dispose of the remains. The bamboo jammed the machine. It "wrapped itself around the coils," he recalls. He had to rent a trailer to haul the debris to the dump instead.

There are two popular types of bamboo that grow in the U.S., known as running bamboo and clumping bamboo. Running bamboo, not surprisingly, is the problem. Depending on the species, it can grow up to 80 feet high and 7 to 8 inches in diameter. Bamboo roots tunnel far from the plant and spawn new shoots, often dozens of feet from the original stand.

Not only does bamboo grow fast, it's virtually indestructible. Bamboo growers claim the plant was the first to re-emerge after the atomic bombing of Hiroshima. William Aley, an import specialist at the Agriculture Department's Animal and Plant Health Inspection Service, says he can't say whether the story is true, but confirms that "depending on how deep the heat flash was at a bomb blast, the shoots are formidable enough to survive having the above-surface portions destroyed."

Bamboo, which is most commonly found in East and Southeast Asia, became popular in the U.S. in the 1970s when homeowners began planting it. More recently, scenes of gracefully wafting bamboo in the 2000 movie "Crouching Tiger, Hidden Dragon" did wonders for that particular species, says Brad Salmon, president of the American Bamboo Society. Besides being beautiful, say bamboo advocates, the plant, as a source of material for flooring and some other building materials, is an environmentally appealing alternative to cutting hardwood forests.

So even as some people struggle to get rid of bamboo, others are out there planting more of it. Mr. Salmon, for instance, runs a business called Needmore Bamboo Co. in Nashville, Ind.

Plastic Moat

In Seattle, James Clever, owner of Bamboo Gardener, both spreads bamboo and experiments with ways to keep it from spreading too far. He recommends encasing the planting area with high-density polyethylene sheeting, sunk 2½ feet into the ground.

He started offering polyethylene with a thickness of 40 mil, a unit of measurement equal to 1/1000th of an inch. But the bamboo "pierces it like a spear," Mr. Clever says. He found a plastics manufacturer that would go to 60 mil, but even that was "compromised by black bamboo." Now, he recommends using only polyethylene of 80 mil, about 1/12 of an inch thick.

Mr. Clever loves bamboo. If it spreads too much, "the problem is not bamboo, the problem is a human error" in installing and siting a stand of it, he says. "That's how I keep busy: lots of people out there screwing it up and getting it wrong."

There's little agreement on the best way to eradicate bamboo when it gets out of hand. Natural remedies such as pouring on salt or undiluted vinegar are generally scoffed at. Many experts suggest cutting bamboo to the ground, adding weed killer and then mowing regularly to keep new shoots under control.

Erik Christiansen, a doctoral candidate in history at the University of Maryland, used bamboo canes he hacked out of his garden in Greenbelt, Md., to build a com-

THE WALL STREET JOURNAL.

Engulfs Defenseless Yards

post bin and a couple of trellises. As far as getting rid of it is concerned, he says, "to me the only thing that works is you cut it down, it grows back, you cut it down, it grows back, you cut it down, it grows back. And hopefully it doesn't grow back after the third time."

Bamboozled

In Kensington, Md., Scott Robinson, owner of a business that makes sports novelties, hired a landscaper to dig a trench in front of his bamboo grove. It stretches 50 feet across the back of his yard. His landscaper lined the trench with the kind of metal flashing more commonly used for roofing.

The bamboo roots, however, disappeared below the barrier. They sprinted sideways into a neighbor's yard, then doubled back onto Mr. Robinson's. "Literally, short of using a backhoe to dig up the backyard, I don't have a solution," he sighs. "We could keep a herd of pandas."

Francis Gouin, a professor emeritus in ornamental horticulture at the University of Maryland, who decades ago experimented with the tropical defoliant Agent Orange, has developed what he says is an eradication strategy that really works, involving the application of doses of weed killer at precise times. Mr. Gouin has simpler advice, though: "Don't plant bamboo."

Matthew Rose

It's environmentally friendly, but **bamboo is eating** suburban America.