FY04 Joint Biomass Research and Development Initiative
Projects Selected for Funding

USDA

DOE

FY04 Joint Biomass Research and Development Initiative
Projects Selected for Funding by USDA

Project F5-15

Integrated Size Reduction and Separation to Pre-Fractionate Biomass

Applicant: The University of Tennessee (UT)

Participants: Oak Ridge National Laboratory (ORNL)
First American Scientific Co. (FASC)

Technical Summary (1 page)

Innovative size reduction of biomass reduces energy use, increases ease of bulk handling, increases density, reduces transportation costs, and facilitates efficient separation. One project aim is to develop new shear-dominant size reduction systems, with emphasis on non-rotating machinery with few moving components and large throats to reduce plugging. UT studies indicate shear stresses were ***one-fifth*** tensile stresses to fail individual stems of switchgrass. Tensile failure stress increased two-fold as elapsed time increased from 2 to 386 h. Shear failure was insensitive to elapsed time after harvest. Size reduction metrics include energy per unit mass and particle size, shape, and density. Tasks include categorized listing of grinding units based on functional analyses, power, and grinding performance; systematic measures of biomass shear/tensile properties and failure characteristics; development of two to three innovative concepts as table-top proof-of-concept devices; and development of a new demonstration size reduction unit that most nearly meets performance criteria established early in the project.

Improved physical separation of biomass concentrates higher value components, returns unused plant components to soil, decreases bulk for wet separation processes, decreases drying energy, and improves transportation and use of a voluminous, chemically diverse feedstock. Another project aim is to develop new low-input separation technologies, with emphasis on understanding separating as it relates to particle size, shape, and density. A UT survey showed similar concepts cutting across a range of separating actions. Pneumatic, gravity, and imaging exhibit the greatest potential. Separation metrics include purities of target components and efficiency at defined mass flow rate. Tasks include categorized listing of separating units based on functional relations with separation efficiency, material properties, and equipment factors; implementation of chemical analysis protocols to determine constituents of separated plant parts; advancing biological plant part imaging to identify particle sizes, shapes, and features for correlation with separation effectiveness; developing three to four table-top proof-of-concept devices; and developing a new demonstration separation unit that most nearly meets performance criteria established early in the project.

Integration of size reduction and separation is accomplished through concurrent tasks timed to identify connective functions and biomass properties. The proposed work involves an equipment manufacturer to identify functional, commercial, and performance targets for integrating size reduction and separation. The company develops a business plan from the start, and continues to update it based on their increasing role and stake in the project outcome. The company identifies the end-use format of commercial process control factors, such as mass flow rate, operating settings, and other equipment parameters needed for commercialization. Statistical correlations establish the relations between size reduction and separation equipment variables, biomass input variables, and processed biomass output

conditions. A former federal biomass program manager leads the identification of biomass feedstock for all project testing. High opportunity feedstock like switchgrass, corn stover, forest residues, and at least a tough straw from rice or flax will be prioritized. Demonstrations of the developed system will target biomass processors, converters, and exhibits to maximize the acceptance and tonnage of high opportunity feedstock.

Expected outcomes are innovative, integrated technology to reduce size and separate crop residues and dedicated biomass crops in on-the-go harvesters and stationary units. The systematic approach with university/government research infrastructure and an equipment manufacturer is expected to rapidly lead to a commercialized system and useful understandings for other biomass processing efforts. Expected benefits of an integrated system by 2010 are $1 billion/y savings in physical processing energy and improved wet conversion processes with targeted feedstock streams. Environmental benefits include recycling of non-target plant parts on soil. The project is a critical link between biomass producers and users.

Project F5-17

COVER PAGE
for

FULL APPLICATION

Biomass Research and Development Initiative
DE-PS36-046094002

Project Name: Integrated Feedstock Supply Systems for Corn Stover Biomass

Name of Applicant: Iowa State University

Point of Contact: Thomas L. Richard

Address: Dept of Agricultural & Biosystems Engineering

3222 NSRIC

Ames IA -50011-3120

Phone: 515-294-0465

FAX: 515-294-4250

Email: tlr@iastate.edu

Date Submitted: 3/26/2004

X Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).

Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

_ 1. DOE: Thermochemical Conversion - SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils - Handling and Blending Characteristics
_ 2. DOE: Thermochemical Conversion - Fundamental Breakthrough Research
_ 3. DOE: Biomass - Petroleum Refinery Evaluations
_ 4. DOE: Thermochemical Conversion - Kraft Black Liquor Gasification
X 5. USDA: Feedstock Development and Production
_ 6. USDA: Biobased Products - Environmental and Economic Performance
_ 7. USDA: Biomass Focused Forest Management Training
_ 8. USDA: Incentives

Volume I: Technical Proposal

Integrated Feedstock Supply Systems for Corn Stover Biomass

Technical Summary

This project will address critical needs for corn stover feedstock development through an integrated multidisciplinary approach. The proposed collaboration includes Iowa State University, the University of Wisconsin-Madison, the USDA Dairy Forage Research Center, the USDA Corn Insect and Crop Genetics Research Unit, and the World Resources Institute, with industry partners John Deere and Genencor International. Research teams are focused on plant breeding and crop physiology, harvest and storage technologies, and systems evaluation and integration. The overall goal is to develop productive, efficient, and sustainable strategies for corn stover biomass as a primary feedstock for the bioeconomy of the 21st century, while significantly improving the rural agro-industrial economy.

Corn stover is widely recognized as the most promising high volume, low cost lignocellulosic feedstock on which to base a range of biobased energy, chemical, and material industries for the next several decades. However, several significant challenges must be addressed before this vision can be achieved, including development of cost effective harvest and storage technologies, improved corn varieties, and sustainable production practices. These technologies and practices will only be successful if the system is embedded in a supportive economic and policy context. This project will address these challenges to develop nextgeneration integrated systems for corn stover feedstock supply.

The overall objectives of this project are to:

1) develop innovative harvesting and storage technologies to efficiently and economically move corn stover from the field to the factory gate with physical and chemical properties optimal for the conversion processes;
2) identify genetic varieties of corn with specific properties attractive for biobased industries and initiate a breeding program to enhance those properties; and
3) evaluate and optimize these systems for efficiency, and economic and environmental sustainability.

For harvest and storage, the primary emphasis will be on developing innovative single-pass harvesting and wet storage systems, which have both economic and technical advantages for centralized bioconversion processes. Conventional multi-pass and dry storage systems will be included for comparative purposes, and for their potential in decentralized and thermochemical conversion processes such as gasification. Specific corn breeding targets include lignin and cellulose metabolism for their impacts on fiber quality and hydrolysis characteristics; silica content for its impact on downstream processing and thermochemical conversion; and yield and distribution of corn biomass among stover constituents with respect to densification and conversion characteristics. System integration goals include maximizing the economic viability of processing corn biomass to fuels and chemicals, while increasing overall biomass productivity, efficiency of nutrient and energy use, soil and environmental quality, and rural economic development.

Project F5-22

Imperial Young Farmers & Ranch
SUMMARY
Biomass Opportunity for Imperial, Nebraska Region: What is the Value?

In the next ten years biorefineries are expected to be processing biomass—initially crop residues like straw and stover for the production of fuels and chemicals. Potential processors and others have made great strides in improving the conversion process, but there remains a large amount of uncertainty in the feedstock supply, its cost, reliability and environmental impact of removal. Benefits for changing existing farming practices must be demonstrated to the farmer and the potential processor must be confident that the infrastructure is a secure as the pipeline supplying the Naphtha Cracker, with stable pricing and a suitable Life Cycle Analysis.

We propose to answer these questions, at least for corn stover, mostly using available tools, existing models and analytical procedures. This project's objective is to define the value of sustainable removal of the "excess" feedstock to the farmers and potential processors across the supply chain using innovative methods for corn grain and stover collection, wet storage of stover and rail transport from collection sites to supply a large biorefinery near Imperial NE. The findings can be quickly implemented in the short term and are readily adapted to straw and energy crops as markets for feedstock develop.

A preliminary study initiated by the Imperial Young Farmers and Ranchers and the City of Imperial, NE estimated counties within a 50-mile radius of Imperial, NE have *3.6 M dt/yr excess stover and straw* with no-till, the amount above the surface cover requirements when complying with USDA erosion control guidelines (RUSLE 2 and WEPP). In addition, *rail service improves logistics, lowers transport costs and economically expands the area supply to 6 M dt/yr at $35/dt delivered* to the biorefinery. The *net margin to the farmer will be $17/dt, $35/ac or more*, using one pass harvest (based on silage harvesting cost), wet storage and rail transport from collection centers. This feedstock is equivalent to *500 M gallons ethanol annually*.

The change in cropping practice is estimated to sequester 1 M metric tons soil C/yr. This project will validate these environmental and economic benefits. Additional investment and learning new management methods is required to provide sustainable feedstock in adequate quantities. Will different cropping practices prove beneficial? Will the economics justify these investments? *Improved information is needed* to better enable the farmer and other stakeholders in the area to establish a better basis for decisions to be taken as biorefining opportunities emerge. Such information includes the following:

- Sustainable Removal
- Feedstock Value
- Innovative Collection, Storage and Transporting Systems
- Delivered Cost of the Feedstock
- Life Cycle Modeling of the System
- Feedstock Processing

Most of the resources proposed are used to demonstrate one pass harvest (50%), wet storage and rail transport (25%). The remainder will be employed to validate existing soil quality related models-- RUSLE2, WEPP and Century, and material composition analysis. The results will better identify where extensions are needed for insuring sustainable and economic supply.

Project F6-11

COVER PAGE for FULL APPLICATION

Biomass Research and Development Initiative

DE-PS36-04GO94002

Project Name: Fuel Cell Systems Operating on 100% Bio-Liquid Fuels

Name of Applicant: Technology Management, Inc.

Point of Contact: Mr. Michael A. Petrik
Address: 9718 Lake Shore Blvd.
Cleveland, OH 44143
Phone: 440-995-9500 ext 112
FAX: 440-720-4527
Email: tmi@stratos.net cc: hawkmc@core.com

Date Submitted: March 26, 2004

YES Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

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____	2.	DOE:	Thermochemical Conversion – Fundamental Breakthrough Research
____	3.	DOE:	Biomass – Petroleum Refinery Evaluations
____	4.	DOE:	Thermochemical Conversion – Kraft Black Liquor Gasification
____	5.	USDA:	Feedstock Development and Production
_X_	6.	USDA:	Biobased Products – Environmental and Economic Performance
____	7.	USDA:	Biomass Focused Forest Management Training
____	8.	USDA:	Incentives

Technical Summary

A significant fraction of fuels consumed in the U.S. is from foreign sources, creating a major strategic and economic vulnerability. Shifting America's energy dependence away from imported petroleum sources toward alternative, renewable, domestic agricultural sources could reduce this dependency. Biofuels (especially ethanol and biodiesel) have the potential to decrease the reliance on foreign energy sources. Coupling biofuels with fuel cells for stationary distributed electric power generation would further enhance economic and environmental benefits. *Technology Management Inc. (TMI) proposes to build and operate a modular proof-of-concept solid oxide fuel cell (SOFC) power generation system capable of generating up to 1 kW of biopower from biomass or biofuels. Of specific interest are vegetable oil (e.g., soybean, corn, canola), biodiesel, and ethanol (produced from e.g., corn, sugarcane).* Compared to conventional, engine-based power generation technologies, the proposed fuel cell systems are extremely clean, quiet, and practical at smaller module sizes with the potential to provide *a new revenue stream/co-product for bio-liquids such as vegetable oil and ethanol.*

Liquid biofuels pose more challenges to the fuel cell developer than the fuel of choice – natural gas – primarily in the areas of fluid handling, reforming, and thermal management. An important step is to develop a cost-effective fuel-processing reactor, which provides satisfactory operation over the long-term. Under this program, TMI will modify its' basic steam reforming system for operation on liquid biofuels.

TMI will demonstrate a 1-kW proof-of-concept fuel cell system with potential to be scaled to up to 10-20kW by adding system "modules" in parallel. This size would serve a wide range of off-grid, rural applications (e.g., remote homes/farms, telecommunications, food processing) while producing ultra-low-pollution levels. On-site surplus heat recovery would also be available for cogeneration applications.

This program leverages the current national priority and investment in fuel cell commercialization and provides economic and social benefits for rural enterprises and communities by demonstrating a demand component for renewable biofuels, and modular, distributed SOFC power generation systems that contributes to:

- increased production and use of vegetable oil, biodiesel, and ethanol,
- expanded production of distributed generation electricity in rural areas,
- production of high grade heat for potential agricultural cogeneration applications,
- reduced dependency on fossil fuels,
- increased security through on-site, distributed power generation, and
- lower air and noise pollution.

Project F6-14

COVER PAGE for PRE-APPLICATION *AND* FULL APPLICATION Biomass Research and Development Initiative DE-PS36-04GO94002

Project Name: BioSep: A New Ethanol Recovery Technology For Small-Scale Rural Production of Ethanol from Biomass ___

Name of Applicant: Membrane Technology and Research, Inc. (MTR)

Point of Contact: Anurag Mairal, Ph.D. _____

Address: 1360 Willow Road, Suite 103 _____

Menlo Park, CA 94025-1516 _____

_____

Phone: 650-328-2228 ext. 158 _____

FAX: 650-328-6580 _____

Email: amairal@mtrinc.com _____

Date Submitted: March 25, 2004 _____

___X___ **Applicant is a U.S. entity.**

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).

____1. DOE: Thermochemical Conversion – SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils – Handling and Blending Characteristics
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____3. DOE: Biomass – Petroleum Refinery Evaluations
____4. DOE: Thermochemical Conversion – Kraft Black Liquor Gasification
____5. USDA: Feedstock Development and Production
_x __6. USDA: Biobased Products – Environmental and Economic Performance
____7. USDA: Biomass Focused Forest Management Training
____8. USDA: Incentives

VOLUME I: TECHNICAL PROPOSAL

1. Technical Summary

This project focuses on the development and demonstration of BioSep, a novel membrane-based ethanol recovery technology that allows economical *distributed* production of ethanol from biomass available throughout rural America. In contrast, current ethanol production technology requires a large centralized processing facility because the ethanol recovery step is economically viable only at large capacities (30 million gallons per year or more). The high costs of collecting and transporting distributed biomass to a distant processing plant more than offset the production cost savings associated with a "free" feedstock.

For this project, Membrane Technology and Research, Inc. (MTR) has assembled a broad-based consortium that includes U.S. Environmental Protection Agency (EPA), Integrated Separation Solutions (ISS), Kraft Foods (Kraft), PFM Corporation (PFM), and a large wine producer. The technical approach proposed in this project is to integrate a pervaporation process that uses ethanol-selective membranes with a novel condensation technique called dephlegmation to produce a concentrated aqueous solution of ethanol. Dehydration of this concentrate using a commercial dehydration membrane yields fuel-grade ethanol. The proposed approach has been shown to be technically feasible in bench-scale tests at MTR and EPA over last two years. To confirm the commercial feasibility of the technology, a field demonstration is essential.

To achieve these objectives, we propose a two-year project. In the first year, an existing pervaporation pilot unit will be modified by the addition of a new dephlegmator and a dehydration unit. The unit will be used to evaluate bioethanol recovery from fermentation broths generated from cheese whey, corn stover, grape processing waste, rice hull and other feedstocks. The objective of these tests is to establish the technical feasibility of the process for a wide range of biomass feedstocks, to develop the optimum membranes for field trials, and to solve any mechanical and operating issues involved in technology integration. In the second year, a demonstration unit producing 100,000 gallons of bioethanol per year will be constructed using the optimized membranes, process design, and operating conditions. The unit will be installed and operated at a full-scale cheese-whey-to-ethanol plant to demonstrate the long-term reliability and efficiency of the process. Because the technology performance does not depend on the source of bioethanol, the results of the cheese whey demonstration will be applicable to other biomass feedstocks, including corn stover, rice hull, and grape processing waste. The data obtained from the project will allow the consortium to optimize the process design for commercial implementation.

The proposed technology substantially reduces the cost of small-scale, localized ethanol production in rural communities. For plants with a capacity of 0.5-5 million gal/year, the proposed technology is more energy efficient and has lower capital costs than distillation, the technology of choice for large-scale plants. Our preliminary estimates show that the ethanol production cost is much less than $0.80-1.00 per gallon cost of producing dry-grind ethanol. The modular and skid-mounted nature of the BioSep system makes it easy to install and operate in distant locations. The most important benefit from the proposed technology, therefore, is the economic viability of small-scale (0.5-5 million gal/year) ethanol plants that use a range of biomass feedstocks distributed throughout the rural United States. This will benefit the rural agricultural economy, generating jobs in farming, ethanol production, and distribution. In addition, the ethanol that is produced locally can also be used locally, potentially eliminating the need for an expensive distribution infrastructure. A typical rural community with a 5-million-gal/year bioethanol plant could see an infusion of $10 million into the local economy (assuming an ethanol price of $1/gal and a conservative economic multiplier effect of two).

The biomass-to-ethanol plants are expected to be nearly self-sufficient in energy needed to operate the plant because lignin, a byproduct of the process, can be used to generate heat and steam. This will reduce the dependence on fossil fuel. Because the biomass sequesters carbon by using carbon dioxide, the

conversion of biomass to ethanol and heat energy does not add to greenhouse emissions. The use of ethanol in gasoline also displaces fossil fuels, which leads to a net reduction in greenhouse gas emissions.

Project F6-15

COVER PAGE for

PRE-APPLICATION
AND
FULL APPLICATION

Biomass Research and Development Initiative

DE-PS36-04GO94002

Project Name: Hayfork Biomass Utilization and Value Added Model for Rural Development

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Name of Applicant: The Watershed Research and Training Center

Point of Contact: Lynn Jungwirth, Executive Director

Address: PO Box 356

Hayfork, CA 96041

Phone: 530-628-4206

FAX: 530-628-5100

Email: wrtc@hayfork.net

Date Submitted: 24 March, 2004

__X__ Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
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____	4.	DOE:	Thermochemical Conversion – Kraft Black Liquor Gasification
____	5.	USDA:	Feedstock Development and Production
XX	6.	USDA:	Biobased Products – Environmental and Economic Performance
____	7.	USDA:	Biomass Focused Forest Management Training
____	8.	USDA:	Incentives

Biomass Research and Development Initiative

Project Name: Hayfork Biomass Utilization and Value-Added Model for Rural Development

Technical Topic Area Number 6
Bio-Based Product-Environmental and Economic Performance

Technical Summary

The work:

This project will support the design and early implementation phases of an innovative biomass utilization facility to be located in Hayfork, California. It will include development of stewardship contracts for public lands fuels reduction; a log sort yard; a small log processor, a post and pole operation, a value-added incubator and industrial park and a wood-fired electrical generation plant (10-15MW). The basic approach is to add value in three distinct areas: 1) process currently sub-merchantable material into lumber and poles to increase their value from fuel ($7-$19/ton) to forest product ($40/ton); 2) add value to the electricity generated by the biomass plant by offering seasonally adjusted capacity, increasing in the heavy demand months of July, August, and September, and reducing demand in the shoulder months of April and October 3) add value to the downstream heat and steam from the power plant by selling heat and steam to greenhouses and manufacturers co-located at the facility site.

This consortium of non-profit, private sector, Indian tribe, and local Public Utilities District will solve several technical challenges including: multi-year contracts for supply from public lands, configuration of power sales contracts with seasonally variability, configuration of controls and systems to change generation capacity seasonally, designs and controls to move and control downstream heat/steam for low temperature uses; efficient market strategies for low volumes of softwood and hardwood lumber, and designs for co-location of various value-added manufacturers with a log sort yard.

Participants will develop a finance package based upon the work. A positive package will be presented and financial backing for the project will allow construction to begin within 16 months of project start.

The outcomes:

Currently no single part of this value-added system can stand alone on its own economic merit. Only by combining uses and value-added can the economics work. This model, once it is developed, financed, and built, will provide the infrastructure for forest health and fuels reduction work on public lands. It will also provide desperately needed industrial capacity to help forested rural communities rebuild after years of social and economic degradation caused by the transition from industrial timbering. This model is relatively small scale and can be used in many public land communities.

Project F6-24

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for

PRE-APPLICATION
AND
FULL APPLICATION

Biomass Research and Development Initiative

DE-PS36-046094002

Project Name: Development of a Wood Preservative System from Wood Bio0il Fractions

Name of Applicants: Mississippi State University. Departments of Forest Products. Chemistry and Chemical Enaineerino: National Renewable Energy Laboratory: Chemical Specialties Inc., Renewable Oil Intemational

Point of Contact: Dr. Philip H. Steele
Address: Forest Products Department
100 Blackjack Road
Starkville, MS 39759
Phone: 662-325-8083
FAX: 662-325-8126
Email: psteele@cfr.msstate.edu
Date Submitted: April 2, 2004

X Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic). Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

1. DOE: Thermochemical Conversion - SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils - Handling and Blending Characteristics
2. DOE: Thermochemical Conversion - Fundamental Breakthrough Research
3. DOE: Biomass - Petroleum Refinery Evaluations
4. DOE: Thermochemical Conversion - Kraft Black Liquor Gasification
5. USDA: Feedstock Development and Production

X 6. USDA: Biobased Products - Environmental and Economic Performance

7. USDA: Biomass Focused Forest Management Training
8. USDA: Incentives

Technical Summary

Wood preservation is a large segment of the forest products industry contributing annual sales in excess of $4 billion. Production of a BioOil wood preservative would consume about 8 billion pounds/yr of wood. Thinnings from southern pine stands, the most probable feed stock for BioOil, are likely to be in the 5.0 to 6.9-inch diameter class, which is the minimum size for which survey data is available. The volume of material contained in this diameter class is 11.4 billion cubic feet or more than 350 billion pounds (Smith et al. 2001). This material would be harvested from 570,000 acres of southern pine forests if stocked at average stand volume. If it is assumed that this material is thinned from existing stands at a rate of 20 percent of total stand volume, the total forest acreage required is 2.85 million acres. The energy impact of this technology is greater than 67 trillion Btu/yr.

Durable wood is also an important contributor to sustainable housing. However, recent environmental concerns with the use of chromated copper arsenate (CCA), the wood preservative previously used for approximately 80 percent of the treated wood volume in North America, have resulted in restricting the use of this preservative for commercial application only. Currently, several second-generation copper organic preservative systems are available as alternatives to CCA for residential application, but these treatments are about 3-fold more expensive. Furthermore, these alternatives contain a toxic metal making them vulnerable to future changes in public perception and restrictions on permissible products and end uses. Consequently, there is a need to develop cost-effective environmentally benign organic wood preservative systems for residential applications to minimize environmental concerns.

Our preliminary research indicates limited fungicidal activity for neat BioOil but a very significant synergistic effect was observed when BioOil was combined with low levels of organic or metal biocides (Schultz and Nicholas 2002, Freel and Graham 2002). Our recent research has indicated the potential for development of less expensive preservative systems from addition of antioxidants and water repellents to biocides with resultant synergistic multiplication of fungicidal activity (Schultz and Nicholas 1998, 1999, 2001). It appears that BioOil has inherent antioxidant and/or water repellent properties that result in a similar synergistic increase in biocide efficacy. This indicates that BioOils may have a potential role in the development of new environmentally benign wood preservative formulations. This concept is particularly attractive because BioOil can be derived from low-value wood feed stocks such as pine plantation thinnings, chips, bark or sawdust.

The research and development approach in this proposal is to produce 24 BioOils from pine and hardwood feed stocks at varied pyrolysis temperatures and residence times with both auger feed and fluidized bed pyrolysis reactors. Biocidal efficacy of the initial Bio0ils will be determined by decay testing, antioxidant, water repellency and chemical analyses. The chemical composition profiles for these Bio0ils will be analyzed by both chromatography and spectroscopic methods and multivariate (MVA) pattern recognition techniques. MVA will correlate the complex spectral data with the anti-microbial, antioxidant and dimensional stability properties. The BioOils will be fractionated and further chemically characterized and evaluated as components of wood preservative formulations based on the MVA results. Following identification of the BioOils with highest efficacy, a subset of at least eight BioOils will be selected and evaluated for efficacy in combination with biocides. BioOils polymerization and possible methods for their stabilization will also be evaluated.

This project will develop a novel, technologically advanced approach to develop an environmentally benign wood preservative system with fuel as a by-product. Both the BioOil preservative and fuel will diversify the range of products that can be produced from plentiful timber resources. Finally, it is expected that the new preservative system life-cycle costs will be much lower and carbon sequestration higher than for current systems. Analyses will be performed to substantiate this expectation. This project offers significant energy production and displacement, environmental and economic benefits. In addition to the research and development outlined, this project will initiate work by a team of investigators that integrates expertise from industry, academia and federal laboratories.

Project F7-02

COVER PAGE for FULL APPLICATION

Biomass Research and Development Initiative
DE-PS36-04GO94002

Project Name: Sustainable Forestry for Bioenergy And Bio-based Products

Name of Applicant: Southern Forest Research Partnership, Inc.

Point of Contact: Larry Biles

Address: Warnell School of Forest Resources, Building 4-405
University of Georgia
Athens, GA 30602-2152

Phone: 706-542-3098

FAX: 706-542-3342

Email: lbiles@forestry.uga.edu

Date Submitted: March 25, 2004

YES -- Applicant is a U.S. entity.

The enclosed full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

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____5. USDA: Feedstock Development and Production
____6. USDA: Biobased Products – Environmental and Economic Performance
__**X**_7. USDA: Biomass Focused Forest Management Training
____8. USDA: Incentives

Technical Summary

The southern United States provides sixty percent of the nation's timber supply and by association a very high percentage of the nation's wood waste from timber harvesting and processing. The potential availability of bioenergy and bio-based products in the South is very substantial. We must take advantage of what we already know to rapidly develop knowledge products to inform and train rural community leaders and practitioners involved in growing, harvesting, transporting, and processing biomass and bio-based products.

The **objectives** of this project are to: (1) **Synthesize the available scientific and technical knowledge** on improved systems for sustainably managing, harvesting, processing, and utilizing woody biomass in the southern United States; (2) **Produce a wide variety of information and technology products** from the tried-and-true such as curricula, fact sheets, bulletins, videos, etc. to the new and innovative such as a web-based hypertext encyclopedia of knowledge and web-based structured courses for distance learning; (3) **Craft products into curricula, training events and programs;** (4) **Target marketing, outreach, and program delivery** to southern forest managers and community development practitioners on improved systems for sustainably managing, harvesting, processing, and utilizing woody biomass. This campaign will include special emphasis on historically underserved segments of these communities; and (5) **Provide program evaluation** of the training curriculum products and events through peer reviews, beta-testing and end-user audience evaluation and feedback. Specifically, we will focus our efforts on providing the basic knowledge content for six major training modules:

Module #1: An introduction to biomass use from forestlands in the South
Module #2: Silviculture treatments for enhanced biomass production
Module #3: Harvesting and processing biomass
Module #4: Utilizing biomass for bioenergy, biofuels and bio-based products
Module #5: Socio-economic impacts and community development issues
Module #6: Developing environmentally sustainable biomass production systems for bioenergy and bio-based products

Many southern rural communities in the South still depend heavily on forestry. These communities are often economically and/or socially disadvantaged despite their rich endowment of forest resources. Recent setbacks in pulpwood markets create additional challenges to these communities and illustrate the importance and urgency of diversifying the utilization of the forest resources. Biomass development seems to be a timely and viable option, at least supplementing traditional income from sawtimber and pulpwood. Our programs will initially target those communities that show greatest potential for bioenergy and bio-based product development, including selected economically and socially disadvantaged rural communities in the southern Black Belt.

Finally, this proposal stands to reap huge benefits by taking advantage of the well organized and tightly cooperating forestry research and extension efforts in the South which allows for economies of scale and economies of specialization to make this bioenergy and bio-based products education and training campaign a certain success.

Project F7-03

COVER PAGE for

PRE-APPLICATION
AND
FULL APPLICATION

Biomass Research and Development Initiative

DE-PS36-04GO94002

Project Name: Development of Existing Biomass Resources through Education of Key Supply Bottlenecks

Name of Applicant: Regents of the University of Minnesota

Point of Contact: Mike Demchik

Address: Extension Regional Center, Brainerd
708 Maple Street
Brainerd, MN 56401-3631

Phone: (218) 828-2332

FAX: (218) 828-2424

Email: demch001@umn.edu

Date Submitted: March 26, 2004

__X__ Applicant is a U.S. entity.

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____	4.	DOE:	Thermochemical Conversion – Kraft Black Liquor Gasification
____	5.	USDA:	Feedstock Development and Production
____	6.	USDA:	Biobased Products – Environmental and Economic Performance
_X__	7.	USDA:	Biomass Focused Forest Management Training
____	8.	USDA:	Incentives

Development of Existing Biomass Resources through Education at Key Supply Bottlenecks

Summary

Several biomass burning plants are in various stages of planning across the state. Supplying biomass to these users is a potential market for loggers; however, the supply of wood fiber that is suited to pulpmills, reconstituted products or sawtimber is limited and nearly fully utilized by existing mills. We would need to focus on existing but underutilized resources: logging residues, brushland harvest and materials that currently have no market (cull wood, precommericial thinnings etc.). This focus would allow us to expand economic opportunities with the same resource base. Development of a market for precommercial thinnings and brushland harvest would reduce costs of these valueable management techniques and allow land managers additional opportunities in management (for example management for brushland wildlife, improved forest stand growth etc.). In order to establish this technology, a supply chain and base of buyers is essential. This proposal addresses education that targets key bottlenecks in the supply chain and provides resource-based information to key existing or potential buyers.

Technical Relevance Harvesting and concentrating the biomass from dispersed sources (like logging jobs) in an economically feasible manner is one of the primary bottle-necks to the increased utilization. We propose to develop educational modules based on increasing the economic feasibility of biomass harvest for four client groups: loggers/harvesters; natural resource professionals; landowners; and energy intensive businesses (wood drying kilns, limestone kilns, taconite plants etc). These efforts will be addressed in a sector-specific manner.

Energy Efficiency/Displacement, Rural Economic Development, Environmental Benefits Because commercial wood energy utilization has been increasing annually, it appears that increased availablility of materials could be easily absorbed by the market. As no non-competitive, currently harvested sources of biomass exist in any significant quantity in Minnesota, to develop this industry we need to approach currently unharvested resources in order to develop this industry.

Technical, Management, and Facility Capabilities

This proposal is highly collaborative. The project includes content development or delivery that collaborates with the Minnesota Logger Education Program (who will provide marketing, facilitation and some content for the logger component of the project), the Fond du Lac Tribal and Community College (who will act as a tribal liason, content provider and test facility due to their existing efforts on biomass), the Minnesota Department of Natural Resources (who will provide content to landowners and to the resource managers and knowledge of harvest logistics), WesMin USDA NRCS RC&D (who will provide knowledge of the biomass industry and act as a liason to biomass intensive industries), the University of Minnesota College of Agricultural, Food and Environmental Sciences (who will provide content and integration of this educational project with on-going biomass efforts), College of Natural Resources (who will provide GIS capabilities and resource-based data), Center for Integration of Natural Resources and Agricultural Management (who will act as financial manager and resource archive) and Extension Service (who will be primarily responsible for educational product design, workshop and event coordination and research dissemination).

Project F8-09

Development of Workable Incentive Systems for Biobased Products, Biofuels and Biopower

Solicitation # DE-PS36-04GO94002
Biomass Research and Development Initiative

Program Area 8: Incentives

TECHNICAL PROPOSAL

A proposal to the US Department of Energy

and

the US Department of Agriculture

By

The North Carolina Solar Center
NC State University
Box 7401, Raleigh, NC 27695-7401

Robert McGuffey, Associate Director
bob_mcguffey@ncsu.edu
Fax: 919-515-5778

March 25, 2004

VOLUME I: TECHNICAL PROPOSAL
Technical Summary

This project will develop a series of proposals for incentive systems designed to promote developing markets for biorefineries – entities which take organic feedstocks to produce biomass energy, biofuels, and/or biobased products. Policymakers from many areas of interest, including the fields of energy, agriculture, forestry and land management, have the potential to promote economic development in rural areas from the economically viable development of biorefineries. Environmental regulators and defenders would also see positive gains in water quality, air quality and watershed/wildlife habitat protection from an increase in the number of biorefineries. Because of the myriad of small-scale and mobile technology approaches that make potential projects achievable with the right assistance, local governments and rural communities can participate directly by creating "biomass enterprise zones" with local economic development goals in mind.

Despite these many perks of biorefineries, there are several barriers to market development. The first and foremost of these barriers is cost. Most small-scale biopower technologies are more expensive on a dollars-per-watt basis than conventional sources. This problem is exacerbated by the fact that current energy pricing does not reflect the harm to human health and the environment resulting from fossil-fuel extraction and use, which if accounted for, would make biomass more attractive. Biofuels and biobased products also face cost barriers in the market. Most such technologies lack the economies of scale in production needed to drive down costs and allow competition with conventional alternatives.

Our approach will be to examine models of local, state and national incentives for energy, agriculture and economic development; determine factors that influence their interaction and effectiveness; to identify barriers and gaps and make recommendations to overcome them; then to use this information to create incentive system models to promote biorefinery development; and finally to demonstrate the application of the models through a series of geographically and technologically diverse case studies. We believe the most effective incentives will focus on small-scale technology approaches and will marry the local economic needs and resource strengths of a region with energy and environmental goals, to result in projects with benefits for multiple stakeholders.

The diversity of models and case studies is critical because of the diverse biomass feedstocks and economic situations around the country as well as because of the myriad of technologies encompassed by the biorefineries banner. The case studies will include: (a) a cost/benefit analysis of a targeted incentive system to identify potential economic benefits to a project; (b) an assessment of the direct and indirect economic and environmental impacts of targeted biorefineries to the local community in which a project is based; (c) an examination of extended benefits to the community specific to improvements in public health; forest fire protection; balance of payments issues relating to the avoided purchase of fossil fuels; land sustainability/enhancement; and energy security; and (d) the identification of industries, businesses and communities in the geographic target region for each case study that would have the interest and capabilities of developing biorefineries.

This project will use a comprehensive approach to develop a complete picture of existing and potential incentives and their benefits, including the social and economic benefits derived from the application of each technology. The research will examine the full spectrum of incentives to

ascertain their impact on economic development, environment, energy, labor, agriculture, forestry, and industry and will include how incentives might be adapted or packaged in a complementary manner to create incentive systems most beneficial to biorefinery development.

The Project Team for this effort includes the North Carolina State University (NCSU), a land grant university with strong research, training and extension programs; the New Uses Council (NUC), a nonprofit membership organization dedicated to the development and commercialization of biofuels, biopower and biobased products, and its sister organization, Biobased Manufacturers Association (BMA), representing a broad range of manufacturers making biofuels and biobased products; and the Environmental and Energy Study Institute (EESI), a nonprofit public policy and educational organization. Our team brings together academic institutions, biomass industry groups, and public education organizations, working with state and local governments and their associations, to develop the best possible solutions that promote the biorefinery concept in this country.

Project F8-13

COVER PAGE for
PRE-APPLICATION
AND
FULL APPLICATION
Biomass Research and Development Initiative
DE-PS36-04GO94002

Project Name: Small-Scale, Biomass-Fired Gas Turbine Plants Suitable for Distributed and Mobile Power Generation

Name of Applicant: Electric Power Research Institute (EPRI)

Point of Contact: Roger Bedard

Address: 3412 Hillview Avenue,

Palo Alto, CA 94304

Phone: (650) 855-2131

FAX: (650) 855-2166

Email: rbedard@epri.com

Date Submitted: March 25 2004
Duns Number: 06-251-1126
___X___ Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

____1. DOE: Thermochemical Conversion – SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils – Handling and Blending Characteristics
____2. DOE: Thermochemical Conversion – Fundamental Breakthrough Research
____3. DOE: Biomass – Petroleum Refinery Evaluations
____4. DOE: Thermochemical Conversion – Kraft Black Liquor Gasification
____5. USDA: Feedstock Development and Production
____6. USDA: Biobased Products – Environmental and Economic Performance
____7. USDA: Biomass Focused Forest Management Training
X 8. USDA: Incentives

Technical Summary.

It is considered that the economic benefits of implementing the proposed project will encourage increased usage of biomass resources within the U.S. resulting in substantial improvements in the following areas: -

- Security of energy supply by reducing dependence upon overseas energy sources.
- Environmental quality by reducing fossil fuel use, and in particular reducing carbon dioxide (CO_2) emissions.
- Economic growth by creating employment, especially in rural regions.

For this proposal, EPRI and its industry team proposes to evaluate the economic benefits of using forestry residues, including those arising from the Healthy Forests Initiative, for generating power in small-scale, indirectly-fired, gas-turbine power plants. The forestry residue, shredded to a maximum size of 2 inches, will be fired in a bubbling, atmospheric fluidized-bed combustor (AFBC) and the heat released transferred indirectly to the air from a turbine compressor via tubes within the combustion system. The high-temperature compressed air at around 1,550°F is then expanded through the turbine. This cycle design is known to be more efficient than those based on steam turbines.

Two nominal plant sizes are proposed for evaluation, 2 MW and 15 MW. The nominal 2-MW unit is mobile and transportable to sites where it is uneconomic to extricate the forestry residue and transport it to an existing power plant. The nominal 15-MW unit is intended as a stationary unit operating as a biomass-fired, distributed-generation power plant in areas where forestry residue is readily accessible. When based within a local rural community this unit could also be used for cogeneration with the energy produced being used for heating or, via a lithium bromide chiller, for air conditioning of domestic, commercial, or industrial buildings. Both applications will allow power generators to reduce their emissions of fossil-derived CO_2.

The goal of this proposal is to complete a financial analysis of the proposed indirect-fired cycle and determine the circumstances under which the two plants can operate economically. Preliminary estimates indicate that the cycle offers significant economic benefits over alternative small-scale plant designs, involving steam turbines and moving-grate combustors. Completing this proposed project is expected to confirm these benefits and quantify the commercial risk and in so doing, encourage investors to support commercialization of this biopower technology. Although the process economics are uncertain, it should be noted that the technical risk associated with the cycle is considered low as the development work for the individual components has been completed.

Once such power plants are in operation in rural locations they will create jobs for plant construction and operation, and for collecting and delivering biomass feedstock. The increased income within a community will establish businesses to satisfy increased consumer demand, and increase tax revenues to enhance local services. By establishing a biomass collection and delivery infrastructure, the proposed technology will help establish a dedicated biomass energy crop industry. This will further contribute to rural economic development, job creation, and furnish additional opportunities to make the community energy self-sufficient. Further, these power plant designs have universal appeal and so may be exported for use overseas, thereby creating employment in U.S. manufacturing industries. Potential markets include developing nations who may wish to use indigenous biomass rather than imported fossil fuels.

Energy Products of Idaho (EPI), a leader in biomass-fired AFBC technology, will design the AFBC unit for the two plants proposed and interact with U.S. suppliers of small-scale gas turbines to ensure that the AFBC duty matches that of the turbine. EPI, who have designed mobile AFBC units, will also interact with appropriate heavy equipment movers to determine the maximum size of AFBC plant that can be transported. Once their design is established, EPI will assess the environmental performance of both units, estimate their

capital and operating and maintenance (O&M) costs along with staffing requirements, and prepare a technical report with preliminary design drawings.

EPRI will manage the overall project and interact with the Forest Service and others to determine the cost and availability of forestry residues, and identify criteria for locating the units. EPRI will establish the cost for connecting the generator output to the grid and satisfying all relay protection and safety requirements. EPRI will produce the final project report and disseminate the results to organizations as a precursor to commercialization of the technology.

FY04 Joint Biomass Research and Development Initiative
Projects Selected for Funding by DOE

Proposal F1-01

Biomass Research and Development Initiative

DE-PS36-046094002

Project Name: Trace-Metal Scavenging from Biomass Syngas with Novel high-Temperature Sorbents

Name of Applicant: Southern Research Institute
Point of Contact: Thomas K. Gale
Address: 2000 Ninth Ave South
P.O. Box 35255
Birmingham Alabama 35255-5305

Phone: 205-581-2102
FAX: 205-581-2448
Email: gale@sri.org
Date Submitted: March 25. 2004

X Applicant Is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic). Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

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4. DOE: Thermochemical Conversion - Kraft Black Liquor Gasification
5. USDA: Feedstock Development and Production
6. USDA: Biobased Products - Environmental and Economic Performance
7. USDA: Biomass Focused Forest Management Training
8. USDA: Incentives

TECHNICAL SUMMARY

Project Title

Trace-Metal Scavenging from Biomass Syngas with Novel High-Temperature Sorbents

Solicitation Number and Topic Area

DL-PS3G-O4G09-1002, Topic Area 1 -Thermal Conversion-Syngas cleanup & Conditioning and Pyrolytic Bio-Oils-Handling and Blending Characteristics

Participants

Southern Research Institute (SRI), University of Alabama Birmingham (UAB), Southern Company (SC) including the Power Systems Development Facility (PSDF) staff, and the Gas Technology Institute (GTI).

Summary

The objective of this project is to develop the technology, based on inexpensive *high-temperature sorbents* and novel applications, to condition hot syngas, while preventing the escape of trace metals through the barrier filter. Rather, the trace metals will be reactively captured and ultimately sequestered in a benign form. Application of this technology to full-scale gasifiers will allow Integrated Gasification Combined Cycle (IGCC) systems to operate with relatively high particulate-control device (PCD) temperatures, in order to obtain high cycle efficiency, without fear of damaging the gas-turbine blades with metals that have escaped the PCD. Furthermore, this technology will allow the inexpensive production of very clean bio-syngas streams for subsequent reforming into high-value products. In addition, the *high-temperature sorbents* developed in this work will eliminate toxic metals (e.g., Pb, Cd, As, Se, and Ni) that are poised for regulation.

Slipstream experiments will be performed in the transport biomass gasifier at the Power Systems Development Facility (PSDF) and at the fluidized-bed RENUGAS gasifier at GTI, to establish the effectiveness of sorbents (known to capture trace metals at high temperatures, atmospheric pressure, and oxidizing environments) under pressurized syngas environments. In addition, rates of capture and mechanism-isolation experiments will be performed in a low-temperature slipstream and laboratory drop tube, both with real and simulated bio-syngas (according to need). In the final year of the project, optimized sorbents and mechanisms for trace-metal control will be demonstrated at full-scale in the PSDF, while gasifying wood chips or switchgrass.

The additional mechanisms elucidated will be added to the hot-gas cleanup model currently being developed at SRI and UAB. Ultimately, the hot-syngas cleanup model will be able to completely describe the speciation and cleanup of hot syngas for a wide range of coal types and conditions, including any potential plugging or damage to the barrier filter. The information and model obtained from this project will allow clean IGCC systems and bio-syngas production units to operate more

efficiently, without damaging turbine blades, and while preventing emission of toxic metals into the environment.

Point of Contact
Thomas K. Gale, MS, *PhD*
Senior Scientist
Environment, Energy, and Engineering
Division
Southern Research Institute
Birmingham AL, 35205
Phone: (205) 581-2102
Fax: (205) 581-2448
galeOO.sri.org

Proposal F1-03

COVER PAGE for
PRE-APPLICATION
AND
FULL APPLICATION
Biomass Research and Development Initiative
DE-PS36-04GO94002

Project Name: Biomass Gas Cleanup Using a Therminator

Name of Applicant: Research Triangle Institute
Point of Contact: Dr. Santosh K. Gangwal
Address: 3040 Cornwallis Road
Research Triangle Park
NC, 27709
Phone: (919) 541-8033
FAX: (919) 541-8000
Email: skg@rti.org
Date Submitted: March 26, 2004

___X____ Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

_ X_1. DOE: Thermochemical Conversion – SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils – Handling and Blending Characteristics
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____5. USDA: Feedstock Development and Production
____6. USDA: Biobased Products – Environmental and Economic Performance
____7. USDA: Biomass Focused Forest Management Training
____8. USDA: Incentives

BIOMASS GAS CLEANUP USING A THERMINATOR
TECHNICAL SUMMARY

Research Triangle Institute (RTI) in cooperation with Cratech, Clemson University and Süd-Chemie (SCI) is pleased to submit this cost-shared research proposal to address the Department of Energy's requirements in biomass gasification syngas cleanup. Gasification is the most flexible and energy efficient technology for biomass utilization. Syngas produced by gasification can be converted to electric power, hydrogen, steam and/or a wide variety of fuels/chemicals depending on site requirements. Fluidized-bed biomass gasifiers have the best potential for becoming a large-scale operation and are the gasifiers of choice. The problem, however, is that the
syngas produced by these gasifiers contains tar, ammonia and particles that must be removed before the syngas can be used in an engine, turbine or fuel cell for producing power, or in a catalytic reactor for producing liquid fuels and chemicals. In addition to these contaminants, the gas may contain trace quantities of HCN, halogens (e.g., HCl), alkali metals, and other metals (Hg, As, Pb). Reliable removal of these contaminants, especially tar, from raw syngas produced by a fluidized-bed biomass gasifier still remains the main technical barrier for the successful commercialization and wide-spread application of biomass for power generation and/or fuel/chemical production. Tars, in particular, coat surfaces downstream and gum up the power producing devices. The challenge is to integrate fluidized-bed gasification, gas cleaning, and the power producing device or catalytic fuel synthesis reactor into a package that can economically and effectively exploit biomass for power production, hydrogen generation, or fuel/chemical synthesis.

We propose to develop and demonstrate a novel fluidized-bed reactor system (therminator) to remove tar, ammonia and sulfur from raw biomass syngas from a pressurized fluidized-bed biomass gasifier. Since this system can accept particle-laden syngas, the particle filter can be installed downstream of the therminator block. The key to the development of the therminator is the development of an attrition resistant and active triplefunction catalyst to remove tar, ammonia and sulfur. The project will consist of development and scale-up of the triple function catalyst; design, construction and commissioning of a skid-mounted bench-scale therminator; transport and installation of the therminator at Cratech's pressurized fluidized-bed biomass gasification pilotplant; and slip-stream demonstration of the therminator over three 100-h tests using actual biomass gasification syngas. An engineering evaluation and commercial assessment of the therminator technology will also be carried out. The work will be carried out over 36 months.

RTI has assembled a strong and highly qualified team consisting of a not-for-profit research institution, a university, a small business committed to commercializing the technology, and a large U.S. catalyst manufacturer to meet the challenges of this project. RTI, a leading organization in cleaning coal-derived syngas, possesses significant expertise in design and demonstration of fluidized-bed and transport reactors, and imparting high attrition-resistance to fluidizable catalysts. Clemson University has significant experience with the formulation,
synthesis and testing of catalyst candidates that will be developed. Cratech has over 10 years of process development experience in pressurized fluidized-bed biomass gasification using a variety of biomass fuels. SCI is one of the largest and most reputable catalyst manufactures in the world and has worked in close alliance with RTI to develop and scale-up attrition resistant fluidizable catalysts.

Proposal F2-02

COVER PAGE for PRE-APPLICATION *AND* FULL APPLICATION Biomass Research and Development Initiative DE-PS36-04GO94002

Project Name: _Catalytic Hydrothermal Gasification for Eastman Kingsport Chemical Production Plant

Name of Applicant: ANTARES Group Inc.

Point of Contact:__Edward E. Gray_(Antares)_____

Address: 4351 Garden City Drive, Suite 301 _____

Landover Maryland, 20785_____

Phone: (301) 731-1900_____ _____

FAX: (301) 731-1904_____

Email: egray@antares.org_____ _____

Date Submitted: March 25, 2004_____

___**X**___ **Applicant is a U.S. entity.**

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).

Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

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Handling and Blending Characteristics

__X_2. DOE: Thermochemical Conversion – Fundamental Breakthrough Research

____3. DOE: Biomass – Petroleum Refinery Evaluations

__ _4. DOE: Thermochemical Conversion – Kraft Black Liquor Gasification

____5. USDA: Feedstock Development and Production

____6. USDA: Biobased Products – Environmental and Economic Performance

____7. USDA: Biomass Focused Forest Management Training

____8. USDA: Incentives

TECHNICAL SUMMARY:

Catalytic Hydrothermal Gasification for Eastman Kingsport Chemical Production Plant

Problem: Substantial amounts of biomass are available in high-moisture or slurry waste streams generated by industrial and municipal activity. These include animal manures (especially dairy and swine), pulp mill sludges, food processing sludges, and municipal wastewater sludges. Sixty-million tons a year of waste sludges are generated by the agricultural and wastewater treatment industries alone. The high moisture content of these streams makes them problematic for conventional thermochemical conversion since water removal (either mechanical or thermal drying) puts a significant strain on project economics. The moisture barrier aside, there is substantial industry interest in thermochemical technologies to convert waste streams into added-value products. Eastman's Kingsport, Tennessee plant generates biosludges as a by-product of its process operations. Determining methods of incorporating these streams into the plant's existing methanol production process is a priority for the company. Options under consideration include incorporating the biosludges as feedstock to its coal gasification process or developing a separate gasification unit, designed specifically for the biosludges. The gas developed for either option will benefit from the downstream syngas cleanup and conversion processes Eastman has refined for methanol synthesis at the site for over 20 years.

Solution: Low-Temperature Catalytic Hydrothermal Gasification (LTCHG) offers an attractive solution for the gasification of biomass slurries and sludges. The process is a unique thermocatalytic gasification concept, which converts wet organic residues to medium-Btu gas (methane and carbon dioxide). Specifically, the gasification system is expected to operate with streams containing as little as 5-20 % by weight dry solids (95 to 80% moisture). Conventional gasification systems are generally inoperable with feedstocks containing more than about 50-60 weight % moisture, and generally uneconomical at moisture contents exceeding 30 percent by weight.

Work Plan: The proposed effort includes a series of analysis, research, development, and design efforts targeted at assessing the potential for LTCHG as an alternative for creating added-value products from industrial biosludges like those generated at Eastman's Kingsport plant. This proposal covers two phases of the effort from Process Development Unit (PDU) testing through pilot plant design. The first phase, covered under this proposal, includes an engineering evaluation of the process and process modeling, an economic evaluation and comparison to potential alternatives, and PDU testing using PNNL reactors. This phase will address issues such as biosludge feedstock characterization, catalyst performance, methods for capturing contaminants that would poison the catalyst; assessment of process yields and gas compositional analysis; downstream gas conversion and clean-up requirements; and effluent contaminants and oxygen demand levels.

Project Management and Capabilities: The project team for this effort will include Eastman Chemical, the Antares Group, PNNL, and Galleon Engineering. Eastman Chemical Company (NYSE:EMN) is a global company headquartered in Kingsport, Tennessee. Eastman manufactures and markets more than 1,200 chemicals, fibers and plastics products. Antares will provide chemical engineering support for PDU testing, assist in initial pilot plant development and process integration, and provide economic and business analysis services. Antares has managed a variety of efforts seeking to commercialize new biobased technologies. Key members of their staff have substantial backgrounds in managing the construction and operation of pilot plant facilities. PNNL will

support the effort through a CRADA and is tasked with evaluating and conducting tests at the bench and PDU scale. Galleon engineering is a diversified company involved in the design, manufacture and/or construction of industrial products and processes. They have supported Eastman in the past and are familiar with their operation.

Benefits: Biosludges are produced by municipalities and major segments of U.S. industry including those that produce biobased fuels/products, paper and food. The environmental benefits of converting 60 million tons of biosludges produced annually to clean fuels or synthesis gas for increased chemical production (the case for Eastman) are significant. Broad use of the technology has the potential to treat 58 billion gallons of waste water per year. This technology helps a wide range of industries approach the goal of zero effluent discharges. Realizing the full potential of this technology extends the current biomass resource base for production of alternative fuels, products and chemicals (displacing petroleum-based fuels and chemicals) by 10 percent.

Proposal F2-03

Gas Technology Institute

Engineering New Catalysts for In-Process Elimination of Tars
Non-Confidential Technical Summary

The intent of the proposed project is to develop a new and more efficient methodology for engineering and economically producing optimized catalysts for the reduction or elimination of tars in biomass gasification. Currently, catalysts are prepared by depositing thin layers of catalytically active materials onto rigid, attrition resistant substrates (typically used in a fluidized catalyst bed or a fluidized bed gasifier) or by coating rigid, refractory monoliths (typically used in a self-supporting off-bed tar-cracker). Thus, catalysts are frequently made from two components: an inert, rigid substrate and a thin, catalytically active outer layer. If the outer layer is damaged, catalytic activity is reduced. The advantage of this conventional approach is that relatively large amounts of catalysts that incorporate precious metals can be produced with minimal amounts of these materials.

The approach we propose permits the incorporation of catalytically active materials (e.g. NiO) within an inert, refractory material (e.g. olivine) which is then formed and processed (if necessary) to enhance the availability of catalytic material on all exposed surfaces. The exact methods by which commercial quantities of such mixtures are economically produced and formed into granular or monolithic catalysts are proprietary intellectual property of the Gas Technology Institute and due to patent considerations cannot be publicly disclosed at present. However, when these mixtures are prepared and made into finely divided granules (300 – 600 _m average diameter for use in a fluidized bed) or into self-supporting monoliths, the resulting materials should be indistinguishable (in catalytic function) from catalysts prepared by conventional techniques. Indeed, another potentially fruitful area of investigation in the proposed work involves engineering waste materials of little (or negative) value into catalytically active materials by processing industrial wastes that contain potential catalysts into attrition resistant refractory catalyst substrates and tar-cracking catalysts.

The proposed project is divided into six tasks. In Task 1 (months 1-6), the viability of the proposed approach must be demonstrated. Task 1 concludes with a go/no-go milestone. The benchmark for the milestone is the requirement to produce a material with catalytic tar-cracking activity equal to that of olivine upon which NiO has been grafted (Sci. Tech. Adv. Matl. 3(2002) 271-282). Standard laboratory techniques for assessing catalyst performance that have been utilized by GTI in previous catalyst/sorbent development efforts will be used or improved for use in all developmental testing. Presuming a successful conclusion to Task 1, in Task 2 (months 7-24), catalyst formulations will be optimized to increase performance and reduce preparation cost of an NiOolivine catalyst intended for use in a fluidized bed biomass gasifier to reduce tar formation. Collaborations with our partners (Nextech Materials, Alfred University, and Ohio State University) and with other catalyst suppliers and researchers will confirm and improve the performance of the optimized NiO-olivine catalyst. In Task 3 (months 16-27), a development is proposed where suitable industrial astes are assessed and tested to determine if the methodology used to successfully prepare a catalyst in Task 1 can be extended to this class of materials. Candidates include arc furnace dust - a negative value waste, various slags, and industrial mill scale. The goal of this task is to locate a low or negative cost waste material that can be turned into a valuable catalyst, either by rocessing alone or with the addition of various amounts of conventional catalytic materials. Again, the expertise of our project partners will be of great value in this task. At the conclusion of Task 4 (months 25-35), a techno economic analysis and commercial assessment will be undertaken to compare the costs of producing catalysts by conventional technology with catalysts produced with the methodologies developed in Tasks 1-3 for catalysts made from traditional materials as well as catalysts derived from low or negative value industrial wastes. Task 5 (months 29-33) will conclude with a pilot-scale evaluation of the two most promising catalyst formulations developed in Tasks 2 and 3. This evaluation will be carried

out in GTI's Flex-Fuel facility, a 1 ton/hour RENUGAS™ gasifier. Task 6, covers project management and reporting, an essential component for project success, and is distributed over the 36 months of project activity.

A successful conclusion to the project will result in the development of a new methodology for the economical production of commercial quantities of tar-cracking catalysts that perform as well as or better than present formulations. This technology can then be extended to the design, engineering and economical preparation of new catalysts for the petroleum industry and for Fischer-Tropsch processes.

Proposal F2-08

FULL APPLICATION

Biomass Research and Development Initiative

DE-PS36-046094002

Project Name: "Thermochemical Conversion of Corn Stover"

Name of Applicant: Bioengineering Resources, Inc.

Point of Contact: James L. Gaddy

Address: Bioengineering Resources, Inc.
1650 Emmaus Road
Fayetteville, AR 72701

Phone: 479-521-2745

Fax: 479-521-2749

Email: JLGaddy@aol.com

Date Submitted: March 26, 2004

yes Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic). Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

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_ 8. USDA: Incentives

THERMOCHEMICAL CONVERSION OF CORN STOVER
EXECUTIVE SUMMARY

U.S. farms produce 120 million tons of unused corn stover annually, which could supply two quads of energy. Recent research has led to the successful development of various gasifier designs to convert agricultural residues into useful energy. Some of these units have been commercialized, but few have been economically successful, primarily because the product of gasification, heat, has a low value. This project will investigate the production of higher value liquid fuel, ethanol, and by-product power from corn stover. The stover is gasified and the CO, H2 and C02 in the synthesis gas is fermented into ethanol. A single fermentation product, ethanol, is produced and high theoretical yields (140 gallons per ton) are possible since all biomass components, except the ash, are utilized.

The purpose of this project is to develop and demonstrate at pilot scale an optimal gasification / fermentation process to utilize corn stover. A major emphasis will be placed on the integration of a stover ethanol facility with a conventional grain alcohol plant in the corn belt. The corn plant can utilize waste heat from the stover plant. Other synergies include the use of common ethanol storage and loadout facilities, utilities, waste treatment, maintenance shops, laboratories, roads, fire protection, offices, etc. The economy of these commonalities will be quantified to define an optimal corn / stover plant that can serve as a model for the industry.

The specific tasks in this project include the definition of the best feedstock conditions and gasifier temperatures, as well as enriched oxygen concentration, to maximize gasifier efficiency and throughput; fermentation of the stover syngas to gather data for design scale-up, emissions measurement for permitting and by-product utilization; and the preparation of a detailed design and energy balance for projection of the economics of the combined stover / corn plants. To accomplish these objectives a strong technical team has been assembled: Chippewa Valley Ethanol, Katzen International, Burns and McDonnell and Bioengineering Resources, Inc.

Utilization of the available U.S. corn stover would produce about 1-0 billion gallons of ethanol per year, reducing oil imports by five percent and improving our balance of payments by $350 million per year. Additionally, 400OMW of power would be produced, reducing natural gas imports by 85 billion CF per year. The full exploitation of this technology would create 40,000 direct high-level jobs in rural farm areas and contribute about $10 billion annually to local economies. Perhaps the greatest benefit to the economy is the added income to the farmer from sale of corn stover. Based upon $30 per dry ton, the additional income to the farmer would be $60 per acre, increasing farm income by $3.5 billion annually. Beyond these economic benefits are the improvements to the environment through the use of renewable and clean burning fuels. This technology can lead the nation to energy independence through the use of its agriculture and other residues. The DOE funds will be used to catalyze these developments.

Project F4-03

Advancement of High Temperature Black Liquor Gasification Technology

A collaborative Proposal by:

Weyerhaeuser Company

Chemrec AB

The Institute of Paper Science & Technology at Georgia Tech

Simulent, Inc.

Pacific Simulation, Ltd

Technical Summary

The only high temperature black liquor gasification plant of significant size in the world is operating at Weyerhaeuser's mill in New Bern, North Carolina. This is a high temperature technology supplied by Chemrec™ of Sweden. The unit has been installed to supplement the mill's ability to process spent pulping liquor, thus enabling the production of additional tons of pulp. The unit operates at atmospheric pressure and as a result is very energy inefficient. However, working with the technology supplier the unit can be used as a pilot demonstration of many improvements necessary to advance the technology so that the significant benefits of producing electricity, fuels and/or chemicals from renewable and sustainable raw material while positively impacting the environment can be achieved.

Weyerhaeuser recognizes that the long-term, continuous operation of the New Bern facility presents a unique opportunity to generate improved knowledge of the underlying processes and equipment necessary for high-temperature entrained flow black liquor gasification. This knowledge is relevant to both the air-blown atmospheric technology at New Bern and the future O_2-blown pressurized technology, which will serve as the basis for bio-refinery mills.

In this proposal, Weyerhaeuser proposes to work collaboratively with other researcher's to utilize the New Bern facility to:

- validate the tools (models) and fundamental knowledge generated in other funded and proposed
- utilize the "commercial" operation of the facility to evaluate solutions to long term process issues (e.g. scaling and other process integration issues work by implementing and demonstrating solutions at New Bern)

The atmospheric unit operated by Weyerhaeuser in New Bern, North Carolina represents an unusual opportunity to rapidly advance this technology. By partnering with the technologies developer, Chemrec, the issues that need resolution to achieve the efficiency, through put, reliability and pulp mill integration necessary for the technology to be considered commercially viable can be dealt with relatively quickly and at reasonable cost. The Weyerhaeuser Company, realizing that the technology is not likely to gain commercial success without rapidly addressing these important issues proposes to make their New Bern unit available as a "test bed" to advance the technology to commercial reality. This proposal identifies the scale up and

commercialization issues that the New Bern unit is capable of addressing and lays out a plan, working with others, to achieve the needed results.

Project F4-04

COVER PAGE for
FULL APPLICATION
Biomass Research and Development Initiative
DE-PS36-04GO94002

Project Name: Cost-Benefit Analysis of Gasification for Fuels/Chemicals Production at Kraft Pulp Mills

Name of Applicant: Eric D. Larson
Point of Contact: Kathy Niebo
Address: Office of Research and Project Administration
4 New South Building
Princeton, New Jersey 08544
Phone: (609)258-3110
FAX: (609)258-1159
Email: kathyn@princeton.edu

Date Submitted: March 26, 2004

X Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

____ 1. DOE: Thermochemical Conversion – SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils – Handling and Blending Characteristics
____ 2. DOE: Thermochemical Conversion – Fundamental Breakthrough Research
____ 3. DOE: Biomass – Petroleum Refinery Evaluations
X _ 4. DOE: Thermochemical Conversion – Kraft Black Liquor Gasification
____ 5. USDA: Feedstock Development and Production
____ 6. USDA: Biobased Products – Environmental and Economic Performance
____ 7. USDA: Biomass Focused Forest Management Training
____ 8. USDA: Incentives

Cost-Benefit Analysis of Gasification for Fuels/Chemicals Production at Kraft Pulp Mills

TECHNICAL SUMMARY OF PROPOSAL

The pulp and paper industry is among the largest producers and users of renewable energy in the United States today, consuming an estimated 1.5 Quads of wood-based energy annually. Considerably more wood residuals are potentially available to mills on a sustainable basis. With such renewable energy resources at its disposal, the potential for the pulp and paper industry to catalyze the development of a *biorefining* industry is significant. Creating such an industry has energy savings, energy security, rural development, and environmental implications. These will be quantified in the proposed work via detailed evaluation of prospective production of clean transportation fuels and power at U.S. pulp mills.

The assembled project team has recently completed a major independently-reviewed study in close cooperation with pulp and paper producers, two major electric utilities, and the DOE that examined in considerable detail the prospective energy balances, economics, and regional and national impacts of market penetration of black-liquor gasification combined cycle (BLGCC) for heat and power generation. We are not aware of any such detailed studies that have been undertaken to assess black liquor or biomass-derived fuels and chemicals at pulp-mill based biorefineries in the U.S. The proposed study is intended to help fill this gap. It will inform technology decision makers in the pulp and paper industry and the fuels and electricity industries on the potential value of gasification investments at pulp mills. It will also help inform DOE regarding prospective national costs and benefits of such biorefineries, and highlight R&D needs. The output of the project will include detailed heat/mass balances for case-study mill biorefineries, capital and operating cost estimates, project financials and a national impacts assessment quantifying the energy, environmental and economic development benefits.

The pulp mill biorefinery systems that will be the focus of this proposed work will feature gasification of both black liquor and woody biomass, in order to assess the total potential benefits when additional biomass is collected. As with our recent BLGCC study, we will consider two distinctly different black liquor gasifier designs. We will also consider two distinctly different woody biomass gasifier designs, based on the development status of leading options for this feedstock. Among the many different chemicals and fuels that could be produced at a biorefinery, transportation fuels, for which markets are large, will be the focus of our study. A variety of transportation fuels can be synthesized from CO and H_2. Fischer-Tropsch (F-T) liquids, methanol, DME, hydrogen, and ethanol will all be considered for evaluation as biorefinery products or co-products in the work proposed here.

We will approach the work in two phases. Phase I (representing 25-30% of the overall effort) will lay the groundwork for detailed analysis in Phase II. Unlike in our BLGCC study, where the products were only power and heat, the current analysis could include a much wider variety of products and process configurations. In order to manage the total effort, one important goal of Phase I will be to define and prioritize the detailed process analyses that will be carried out in Phase II. To further motivate the Phase II activities, in Phase I we will also do a thorough literature review and make preliminary (highlevel) estimates of the potential energy/environment impacts of pulp-mill-based bio-refining. We expect these efforts to include extensive consultation with industry experts and DOE.

To the extent possible, our proposed study will be carried out using the framework developed for the BLGCC study. This will help make good use of resources. For the detailed analysis in Phase II, our proposed study will be carried out using the case-study kraft mill defined in our earlier BLGCC study so as to enable consistent comparisons with the earlier work. The project team will work with guidance from a Steering Committee that will include representatives from the pulp and paper industry, the

transportation fuels industry, the electric utility sector, and the Department of Energy. The work will be reviewed by an independent board of experts at key stages. Our recent BLGCC study was well received by industry, government, and academia, providing a strong indication of the quality of the work that can be expected on this project.

Project F4-05

COVER PAGE for
PRE-APPLICATION
AND
FULL APPLICATION
Biomass Research and Development Initiative
DE-PS36-04GO94002

Project Name: Investigation of Pressurized Entrained Flow Kraft Black Liquor Gasification in an Industrially Relevant Environment

Name of Applicant: University of Utah
Point of Contact: Kevin Whitty (technical)
Vincent Bogdanski (administrative)
Address: Office of Sponsored Projects
1471 East Federal Way
Salt Lake City, UT 84102
Phone: 801-585-9388 (tech.) 801-581-3008 (admin)
FAX: 801-585-5607 (tech.) 801-581-3007 (admin)
Email: kevin.whitty@utah.edu (tech.)
vincent.bogdanski@osp.utah.edu (admin)

Date Submitted: April 1, 2004

X Applicant is a U.S. entity.

The enclosed pre-application or full application responds to the following Technical Topic Area (check only one topic).
Note: Detailed descriptions of the Technical Topic Areas can be found in Appendix B.

1. DOE: Thermochemical Conversion – SynGas Cleanup & Conditioning and Pyrolytic Bio-Oils – Handling and Blending Characteristics
2. DOE: Thermochemical Conversion – Fundamental Breakthrough Research
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X 4. DOE: Thermochemical Conversion – Kraft Black Liquor Gasification

5. USDA: Feedstock Development and Production
6. USDA: Biobased Products – Environmental and Economic Performance
7. USDA: Biomass Focused Forest Management Training
8. USDA: Incentives

Investigation of Pressurized Entrained Flow Kraft Black Liquor Gasification in an Industrially Relevant Environment

VOLUME I: TECHNICAL PROPOSAL
TECHNICAL SUMMARY

Kraft black liquor gasification offers a number of advantages over conventional recovery boiler technology in terms of energy efficiency, environmental performance and safety. However, despite more than a dozen efforts in the past 30 years to develop black liquor gasification technology, no system is yet commercially available as a replacement for the recovery boiler. Pressurized, oxygen-blown entrained flow gasification appears to be on the brink of commercialization, but additional research and development in key technical areas is necessary for success.

The University of Utah, Brigham Young University and Simulent, Inc. propose to address several of the research needs that have been identified as critical for successful commercialization of entrained-flow kraft black liquor gasification, and to provide new and relevant data on liquor conversion by gasification. The approach involves combining operation of a special semi-pilot scale pressurized, entrained-flow research gasifier with fundamental lab-scale experiments conducted under controlled conditions. Data on liquor droplet development, conversion behavior and gas and smelt properties will be generated under conditions representative of those in a full-scale gasifier. These data will be used to develop sub-models describing droplet formation, conversion chemistry and physical characteristics of the liquor during conversion. The sub-models will be suitable for incorporation into computational fluid dynamic modeling code, and can be used for development and optimization of commercial systems.

The proposed project comprises five technical tasks. Droplet formation and burner performance will be evaluated through a combination of experimental droplet imaging studies and computational modeling of droplet formation. Physical characteristics of black liquor will be studied throughout the entire range of conversion, from droplet to smelt bead. Chemical transformations of the liquor and development of the syngas will be studied in detail. Transport and radiative properties of the smelt product will be measured, and properties of the syngas resulting from partial oxidation of liquor in a pressurized gasifier will be characterized.

The project team has more than 40 years' experience with thermal conversion of black liquor, and is intimately familiar with high temperature gasification, both atmospheric and pressurized. The experimental and modeling capabilities of the team are very well-suited for this project, and the team has proven experience carrying out projects of this type. The project will greatly advance the understanding of entrained-flow black liquor gasification, and will fill many of the technical gaps that are holding back successful commercialization of the technology.

Project F6-10

New Sustainable Chemistry for Adhesives, Elastomers and Foams
Technical Summary

Rohm and Haas Company will partner with Virginia Polytechnic Institute and State University (Professor Timothy E. Long), Eastman Chemicals (Dale E. O'Dell), the USDA Eastern Regional Research Center (Dr. Thomas A. Foglia) and DOE/USDA to develop novel biobased chemistry. We will pursue a biorefinery approach to produce novel soy-sugar polymers. Our program will develop products which can replace petrochemical-based polyurethane adhesives, elastomers and foams. The estimated total cost is $2.936 million with an industrial cost share of 32%. The drivers for commercial success are manufacturing efficiency for the converting and related industries, worker safety, consumer safety, and price stability from decreased dependence on petroleum-based feedstocks.

The overall U.S. market size for all polyurethane adhesives is estimated to be 92.2 million lbs in 2005 and growing at a 12% per year. The total U.S. market for all adhesive, foam and elastomer applications will approach **5.5 billion lbs by 2005**. A moderate level of success with this technology leads to the replacement of >100 Million lbs of petrochemical-based materials with those derived from biomass. The projected impact of this on the rural economy is estimated to be **$124 million per year in added return to farmers** based on consumption of 50 million lb of soybean oil used. The use of soybean oil in place of petroleum derived chemicals will sequester 138 million pounds of greenhouse gases each year.

We propose using acetoacetates of mono- or disaccharides and other biobased materials such as castor oil, glycerol, isosorbide and crop oil derivatives at levels of 20-50% and acrylate modified crop oils at levels from 20-60% to produce biobased adhesives. Our research on adhesives will then be extended to foams and elastomers. Polyurethane foams and elastomers are closely related technologically to polyurethane adhesives in that all three applications require an excellent balance of elastomeric character and high tensile strength and, not surprisingly, share common raw materials.

Rohm and Haas Company's recent patent-pending work with Carbon Michael chemistry using an improved catalyst technology with petrochemical-based raw materials has demonstrated outstanding promise for commercial adhesive, elastomer and foam applications. This program will develop technologies which will provide a range of advantages over polyurethanes. Specifically, these new products will:

a) Cure faster, thereby reducing working capital and increasing production agility

b) Eliminate the handling of isocyanates in adhesive, foam, and elastomer production

c) Eliminate the handling of isocyanates in production facilities using adhesives

d) Eliminate aromatic amine formation in food packaging

e) Increase price stability due to reduced dependence on petrochemical feedstocks

f) Reduce greenhouse gas emissions

This **biobased, non-isocyanate chemistry** (a.k.a. biobased Carbon Michael chemistry) is an outgrowth of a first generation (petroleum-based) technology platform with great potential to yield a wide variety of polymeric structures and resulting performance properties. Utilization of biobased materials in this new product line will bring tremendous value to the rural community while delivering products which provide exceptional value to our customers. This represents an outstanding example of how green chemistry can simultaneously deliver economic, environmental and social benefits.