U.S. Department of Energy's 2005 Biomass R&D Activities

Accomplishments Towards the *Roadmap for Bioenergy and Biobased Products in the United States*

October 3-4, 2005

Prepared for the
Federal Technical Advisory Committee

Created under the
Biomass R&D Act of 2000

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Data Sources: The Department of Energy's Annual Operating Plan Fiscal Year 2005 for the Office of Energy Efficiency and Renewable Energy's Office of the Biomass Program; and The Department of Energy's Golden Field Office data bases.

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I. INTRODUCTION

This report is part of an annual review of U.S. Department of Energy and the U.S. Department of Agriculture biomass R&D as it relates to the *Roadmap for Bioenergy and Biobased Products in the United States*. The purpose of this report is to provide the Biomass R&D Technical Advisory Committee with an overview of DOE R&D investments and progress as they relate to the Committee's *Roadmap* objectives. It will support Committee development of recommendations to the Secretaries of Energy and Agriculture on the direction of biomass related R&D. A separate report describes USDA Biomass R&D activities as they relate to the *Roadmap*.

This is the third year in which DOE's biomass R&D portfolio analysis has been provided to the Committee. This year, a new field, "Accomplishments towards Roadmap Objectives" was included in the report in an attempt to better address the relationship of ongoing R&D to the Committee's direction on strategic areas for biomass.

The original document containing the Committee's agreed upon format has been updated and will be submitted as Attachment A in this report. This document was updated using the DOE's OBP Annual Operating Plan for 2005, the Multi Year Program Plan, Golden Field Office data bases, and Executive Summaries of OBP joule Milestone reports.

This report is organized by Roadmap category:

- Feedstocks Production,
- Processing and Conversion,
- Products Uses and Distribution, and
- Public Policy Measures to Support Biomass.

Each category included Roadmap objectives and reports progress towards those objectives by DOE Technical Platforms, specifically:

- Technical goals,
- R&D challenges,
- Projects, and
- Accomplishments towards Roadmap objectives.

This is not a mapping of program investments along program budget or platform areas. Earmarked projects are also included in this report, which are not competitively awarded by the DOE and do not necessarily reflect the Biomass Program's technical and strategic goals. Many projects included in this report crosscut across Roadmap objectives but have been categorized according to their primary, not secondary objectives.

Among the crosscutting activities are DOE Program Management tasks which relate to all of the Committee's Roadmap objectives. Staff located at DOE/HQ, the National Energy Technology Laboratory, the National Renewable Energy Laboratory, and Golden Field Office support the management of the program, provide technical and engineering support for demonstration projects, and assist in the development of technical R&D.

Summary Table: U.S. Department of Energy's Research and Development Activities as They Relate to The Biomass Initiative's *Roadmap*

Roadmap Objective	DOE		
	2003	2004	2005
II. Feedstock Production	**$6,176**	**$7,230**	**$4,148**
II.A. Biotechnology and Plant Physiology	**$648**	**$1,194**	**$1,132**
Objective One - Plant biochemistry and Enzymes	*$481*	*$1,194*	*$1,132*
Objective Two - Chemical/biological Pathways	*$167*	*$0*	*$0*
II.B. Agronomic Practices	**$3,130**	**$3,534**	**$846**
Objective Three - Agronomic Practices for Sustainability	*$3,130*	*$3,534*	*$846*
II.C. Feedstock Handling	**$2,398**	**$2,502**	**$2,170**
Objective Four - Collecting and Storing Feedstocks	*$2,398*	*$2,502*	*$2,170*
III. Processing and Conversion	**$60,926**	**$64,198**	**$53,955**
III.A. Thermo-chemical Conversion Pathways	**$15,466**	**$26,804**	**$21,076**
Objective One - Thermochemical Conversion	*$15,466*	*$26,804*	*$21,076*
III.B. Bio-conversion	**$15,567**	**$22,284**	**$16,852**
Objective Two - Bioconversion Processes/Technologies	*$15,567*	*$22,284*	*$16,852*
III.C. Biorefinery Integration	**$29,893**	**$15,110**	**$16,027**
Objective Three - Biorefineries	*$29,893*	*$15,110*	*$16,027*
IV. Product Uses and Distribution	**$5,557**	**$9,476**	**$6,823**
IV.A. End-Products and Distribution Systems	**$5,557**	**$9,476**	**$6,823**
Objective One - New Markets and Distribution	*$4,966*	*$3,606*	*$4,518*
Objective Two - High Value Products	*$591*	*$2,381*	*$1,762*
Objective Three - Distribution Systems and Rural Development	*$0*	*$3,489*	*$543*
V. Public Policy Measures to Support Biomass Development	**$5,768**	**$6,139**	**$16,777**
Objective One - Commercialization of Biobased Technologies	*$1,935*	*$2,946*	*$5,952*
Objective Two - Institution and Policy Changes	*$0*	*$0*	*$0*
Objective Three - Environmentally Sound/Sustainable Biomass	*$3,833*	*$3,193*	*$5,946*
Objective Four - Rural Economic Development	*$0*	*$0*	*$4,879*
TOTAL FUNDING	**$78,427**	**$87,043**	**$81,703**

FY2003 and FY2004 do not include all Earmarked projects. DOE Funding Sources: OBP FY05 AOP, FY05 Spend Plan, GFO Earmarked Projects, Biomass R&D Portfolio 2004. Earmarked projects are not competitively awarded by DOE and do not necessarily reflect the Biomass Program's technical and strategic goals.

II. Feedstock Production

The Department of Energy's Biomass Program has indicated that the success of the biorefinery is critically dependent on having a large supply of low cost, high quality lignocellulosic biomass. The primary mission of the feedstock interface area is to work closely with the sugars and syngas conversion platforms to conduct the necessary R&D to meet their feedstock needs. Meeting the long-term needs of the biorefinery in a sustainable manner will require fundamental changes in our agricultural system and feedstock infrastructure system. Current technologies and agricultural practices are inadequate to meet this goal. New technologies and methods must be developed. The feedstock interface area will focus on developing the new technology and methods necessary in the feedstocks infrastructure area to produce one billion tons of cellulosic feedstock per year in a sustainable manner at $35/ton or less.

Highlights - Significant Recent Accomplishments

- Feedstock Supply Chain Analysis – An analysis of the value of crop residues in several U.S. regions was recently completed. This and additional data will be incorporated into a milestone report on grower payments that is scheduled to be completed in the September October timeframe. An updated estimate of forest residue resource for U.S counties was also completed and was incorporated into the billion ton vision analysis.

- Native Grass Utilization Project: Fuel Feedstocks - Spring-harvested switchgrass and big bluestem has been analyzed for ash and potassium and pyrolyzed in the Ensyn reactor system. As expected, the over-wintered grass had much lower ash and potassium content. Previous research at NREL found that potassium catalyzes pyrolysis and pyrolysis oil cracking reactions. Initial results from the Ensyn pyrolysis tests show increased yield of anhydro-sugars and hydroxyacetaldehyde in the pyrolysis oils.

- A DOE study (Roadmap for Agricultural Biomass Feedstock Supply in the United States) has identified the strategic goals, performance targets, and major technical barriers 3-6 associated with production, harvesting and collection, storage, preprocessing, transportation, and systems integration for feedstock core R&D.

- Successful proof-of-concept demonstration of a single-pass harvesting system.

- Preferential deconstruction of biomass tissue is demonstrated, showing the potential for targeted fractionation of biomass for increased equipment efficiencies and throughputs.

- A joint DOE and USDA study (Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply)

has identified the potential for 1.3 billion tons of biomass that could be sustainably processed annually in the U.S.

- Baseline feedstock assembly scenarios have been analyzed with the Integrated Biomass Supply Analysis and Logistics (IBSAL) model showing the potential to achieve the $35/ton cost target for dry biomass (less than 15% moisture) systems.

- Sophisticated engineering simulation tools have demonstrated unprecedented integration of advanced computational models and experimental data sets creating a unique tool for analyzing and optimizing complex engineering systems.

II.A. Biotechnology and Plant Physiology

Objective One - Improve the technical understanding of plant biochemistry and enzymes and develop the ability to engineer enzymes within desired crops.

II.A.1 Sugars Platform

Technical Goals: The main focus of this subtask is to develop a clear understanding of the extent of compositional variation in corn stover and identify possible major causes of that variability.

Barriers: The barriers addressed under this objective are product yield, conversion rates enzymes process integration, recalcitrance of biomass, enabling tools and cost of sugars from biomass.

WBS #, Title, Major R&D Performer:
2.3.1.1 Feedstock Variability, NREL

II.A.2. Earmarks

Technical Goals: DOE/OBP has received various earmarks that relate to this objective. The goals to be addressed under this Roadmap objective are to support hybrid poplar research in the North Central regions of the United States and to continue to develop hybrid poplars as a viable fiber and energy crop. Furthermore technical goals will focus on developing a clear understanding of that variability; the research will generate information on the novel soybean germplasm with enhanced oil qualities for use in biodiesel blends.

Barriers: The main barriers are pest resistance and possess characteristics such as ease of propagation, as well as pentose utilization – product yield.

WBS #, Title, Major R&D Performer:
1.2.2 Hybrid Poplar Research Project - North Central Forest Experiment Station (NCFES);
4.1.1.3 Research in Nebraska on Improved Soybean Oil for Biodiesel Fuel - University of Nebraska, Lincoln
7.05.1.GO85011 Alternative Fuel Source Study;

II.A. Biotechnology and Plant Physiology

Objective Two - Develop the chemical and chemical/biological pathways necessary to improve the energy density and chemical characteristics of delivered feedstocks.

II.A.1. Products Platform

Technical Goals: The plant science work will focus on exploring the stress response and stress proteins for solvent tolerance. With some of the new tools, this research will develop a genomic library-based identification of genes imparting a tolerant phenotype. The production work involves transcriptional analysis of 4 solvent tolerant strains may identify commonly differentially expressed genes that might impart solvent tolerance.

Barriers: Barriers addressed in the Products Platform are the availability of a sustainable feedstock, and development of genetic tools to modify the feedstock crop.

WBS #, Title, Major R&D Performer:
4.2.1.3 Genomic and Genetic Approaches to Solvent Tolerance

II.B. Agronomic Practices

Objective Three - Optimize agronomic practices for sustainable biomass feedstock production

II.B.1. Feedstock Interface

Technical Goals: DOE/OBP goals related to this Roadmap objective are to provide data and analyses on current and future feedstock supplies. These data are largely in the form of supply schedules (i.e., quantities and costs) and supporting information, such as analysis of specific factor cost components that comprise total delivered feedstock costs.

Barriers: Feedstock supply uncertainty and demonstrating an integrated feedstock supply system that reduces the overall delivered costs of biomass feedstocks.

WBS #, Title, Major R&D Performer:
1.3.1 Supply Forecast and Analysis - ORNL

II.B.2. Program Management

Technical Goals: The objectives of these projects are to provide support between DOE/HQ and NETL, NREL, and Golden Field Office, to support in the management of the program, provide technical and engineering support for demonstration projects, assisting in the development of technical R&D and to continue to achieve technical goals.

Barriers: No information is available to describe the progress on program management. For more information on barriers see page 23 in this document.

WBS #, Title, Major R&D Performer:
6.1.3.4 Lab support of HQ (INEEL)

II.B.3. Earmarks

Technical Goals: DOE has received various earmarks that relate to this Roadmap objective. They include researching the technical and economical feasibility and environmental implications of developing a cellulosic ethanol industry moving west from Minnesota into North and South Dakota evaluating the potential of producing switchgrass on commercial agricultural land and to utilize that switchgrass as an energy feedstock; and development of markets for energy crops in southern Iowa.

Barriers: Overcoming challenges of low prioritization of biomass amongst stakeholders and diversity of perspectives; Resource availability and sustainability, feasibility/costs of the projects.

WBS #, Title, Major R&D Performer:
1.2.1 Native Flora Utilization Project - Fuel Feedstocks - Great Plains Institute for Sustainable Development;
1.2.4 Biomass Power for Rural Development Project - Chariton Valley RC&D
1.2.5 Switchgrass Demonstration Project - University of Tennessee;

II.C. Feedstock Handling

Objective Four - Optimize logistics for collecting, storing and combining multiple feedstocks that can be applied for diverse applications in an environmentally sound manner.

II.C.1. Feedstock Interface

Technical Goals: The goals addressed under this Roadmap objective are to produce high quality, low cost biomass feedstocks in a sustainable manner reducing the cost of handling and stable storage of biomass. These were identified in the Feedstock Colloquies as critical elements to sustainably maximize the amount of cellulosic feedstocks available to contribute to the OBP targets of 1B tons of biomass at $35/ton. These projects will help achieve those goals. They are also designed to help develop commercially viable technologies needed to use crop residues as an inexpensive source of fermentable sugars; to evaluate and define equipment and infrastructure options that will reduce the cost of delivered biomass from the present baseline baling system of $53/dry ton to the cost goal of $35/dry ton.

Barriers: The barriers addressed under this objective are equipment limitations, sustainability, feedstock costs; feedstock characterization and monitoring, effects of storage, infrastructure requirements, and sustainability, inadequate information on quantities, costs, and location, costs of crop residues, plant science, crop production, and biomass processing.

WBS #, Title, Major R&D Performer:
1.1.1.1 Harvesting, Collection and Preprocessing - INEEL;
1.1.1.2 Biomass Bulk Processing and Storage Task - INEEL;
1.1.3 Multicomponent Harvesting Equipment for Inexpensive Sugars from Crop Residue Project - Iowa State University;
1.3.2. Supply System Logistics - ORNL

III. Processing and Conversion

Thermochemical Platform: Overview
The Thermochemical Platform (TC Element) develops technology to thermochemically convert biomass into intermediate products that can then be used as intermediates for fuels and chemical synthesis. The processing technologies can be categorized as gasification, pyrolysis, or hydrothermal processing. Intermediate products include clean syngas (a mixture of primarily hydrogen and carbon monoxide), bio-oil (pyrolysis or hydrothermal), and gases rich in methane or hydrogen. These intermediate products can then be upgraded to products such as gasoline, diesel, alcohols, ethers, synthetic natural gas, or high-purity hydrogen, or may be used directly for heat and electric power generation. The conversion and clean-up technologies developed within this TC Element are closely coordinated with the Products and the Integrated Biorefineries Element so that technologies from those efforts are effectively integrated to convert the TC intermediates into fungible fuels and/or chemicals.

Highlights - Significant Recent Accomplishments:
Completed a technical and economic evaluation of integrated biomass to fuel systems to validate the sugar cost of $0.13 per pound and syngas cost of $6.13 per million Btu.

The Joule Target of $6.13 per million Btu syngas was met using the techniques and level of analysis that was available at the time that the Joule Milestone was written[1]. This value is the cost of clean, reformed syngas, not raw syngas. The syngas cost target was obtained using a simple Stage 1 spreadsheet containing a basic material and energy balance and cost estimate. In order to determine the syngas cost, the Stage 1 spreadsheet developed for hydrogen production was used as the starting point. The process design uses the indirectly-heated Battelle Columbus Laboratory (BCL) gasifier followed by gas cleanup and conditioning, steam reforming, shift conversion, and hydrogen purification. The costs for the process steps downstream of syngas reforming were removed and the hydrogen yields were replaced with syngas yields. Currently, more detailed analysis and cost estimating is under way to improve the accuracy in determining syngas production costs as well as the variation relative to various integrated fuel synthesis processes. These efforts will continue and analyses will be updated annually with new information as it becomes available.

- The technology for feeding and handling wood and some agricultural residues has been developed by industry.
- The Program is currently assessing the need for additional technology capable to handling slurries and other residue streams that might come from a biorefinery.
- Gasification technology applicable for spent pulping liquors produced by the Pulp and paper industry has been developed. Two commercial-scale “spent pulping liquor” gasifiers are operating in the United States.
- Industrial partners are evaluating innovative gasification technology for several different biomass feedstocks.

- Industrial partners and national laboratories are developing and demonstrating technology for cleanup (removal of tars and other impurities) of biomass derived syngas.
- Options for removal of sulfur from syngas to levels suitable for production of liquid fuels have been identified.
- A recent report illustrates the potential for producing a number of products from biomass syngas.

Sugars/Biochemical Platform: Overview

This platform is a major program structural element focused largely on fractionating the lignocellulosic matrix of biomass into its component parts. Five of the seven pathways contain a component of pretreatment and fractionation. In the case of corn and wet mill pathways, commercial and economic operations already exist although some improvements are still possible. This platform or program element has the most impact on the pathways involved in Agricultural Residues, Energy Crops and to some extent Pulp and Paper Mill Improvements. It is in these areas that the potential for producing biofuels on very large scales becomes possible. However, until the technology to "crack biomass" as readily and economically as we can "crack crude oil" is available, the vision of the program cannot be fully realized in producing 30% of the nation's transportation fuel needs. This difficulty or recalcitrance of biomass to being fractionated into its component parts is one of the major barriers to the use of biomass for fuels, products, and energy. Hence, this program element evaluates routes to obtaining molecular sugars and lignin to be used as intermediates for conversion into fuels, chemicals, materials or heat/power. Production of such commodity products falls under the Products Core R&D and Integrated Biorefinery elements of the program's work breakdown structure.

Highlights - Significant Recent Accomplishments

This Joule Target of 13¢ per pound for intermediate sugars has been met by the 2005 Post Enzyme-Subcontract Case[ii]. This case has the most current Minimum Sugars Selling Price (MSSP) and is based upon a process design and associated models for converting corn stover to sugars for ultimate conversion to ethanol. The enzyme cost contributions and performance are based upon public statements from Genencor and Novozymes. A MSSP of 12¢ per lb was calculated (associated with this is a current Minimum Ethanol Selling Price (MESP) of $2.26 per gal ethanol).

- Improved cellulose digestibility has been demonstrated with pretreated and hot washed woody biomass (poplar) as well as a better understanding of the differential reactivity of the anatomical fractions of corn stover during dilute acid pretreatment.

- Two major enzyme-producing companies and a national laboratory, Genencor International, Novozymes, and the National Renewable Energy Laboratory provided 20-30-fold reductions in the projected cost of using cellulases for commodity biomass conversion applications. This accomplishment received a R&D 100 award in 2004.

- The structural complexity and compositional variability of biomass has been shown to greatly affect the efficiencies of feedstock assembly/preprocessing systems and pretreatment (i.e., biomass format and quality does matter).

- The integration of biomass preprocessing into feedstock assembly operations has been demonstrated to improve assembly system efficiencies (i.e., enabling bulk handling) and impact pretreatment.

- Rapid analysis methods have been developed for corn stover and pretreated corn stover solids that facilitate improved processing and control options.

- Demonstration of clean-up weak acid hydrolysate and possibly eliminate over-liming and materials toxic to fermentation with a fractal-based ion exchange process. These reduced size fractal based chromatography systems are now being commercialized.

Integrated Biorefineries Platform:
Significant achievements to date include:

- Conduct a 50,000 sheet plywood and composite board production run using adhesives derived from biomass instead of wholly from petrochemicals, work started with Louisiana Pacific but completed by Weyerhaeuser.

- Development and demonstration of a new front-end pretreatment operation for a dry mill by Broin that increases the ethanol yield and produces more valuable, high protein animal feed.

- A pilot plant demonstration by Archer Daniels Midland and the National Corn Growers Association at NREL to scale up bench results to define operating parameters involved in integrating processes into existing corn wet mills.

- The deliverable for a task was met related to the pretreatment conditions combined with enzyme hydrolysis of the cellulose in that at least 80% of the cellulose, hemicellulose, and starch in the corn bran was recovered as monomeric sugars with an overall carbohydrate closure of 85%-115.

- Cargill confirmed the production of 3-HP from glucose via the alanine pathway by employing Codexis's Round 5 Enzyme 2 variant, in conjunction with the other 3 enzymes in the pathway.

- The increased yield goal from fermenting the residual starch was met economically.

III.A. Thermo-chemical Conversion Pathways

Objective One - Develop cost-effective, environmentally sound thermochemical conversion technologies to convert biomass feedstocks into useful electric power, heat and potential fuels and products.

III.A.1. Thermochemical Platform

Goals: DOE/OBP goals related to this Roadmap objective are to develop a basic understanding of chemical and catalytic pathways that will lead to pyrolysis products with improved characteristics; to study the flow and heat transfer properties of the heat exchanger geometry; to make critical advances in the understanding of high-temperature, pressurized gasification of black liquor; validate the tools (models) and fundamental knowledge; to reduce the estimated cost for production of a cleaned and reformed biomass-derived synthesis gas produced from a mature gasification plant, from $6.48 per million Btu ($6.14 per GJ) in 2003 to $5.28 per million Btu ($5.01 per GJ) by 2010.

Barriers: The barriers addressed under this objective are product quality. This includes addressing containment; maximizing gasification; addressing tar formation & conversion and gas composition; removal and avoidance of toxins; reducing capital & operating costs; and removal of trace metals that can harm turbines and pollute the environment.

WBS #, Title, Major R&D Performer:
3.2.1.2 Biomass Fundamentals Task - NREL
3.2.2.2.1 Catalytically and Chemically Modified Pyrolysis Project (Chemical Modification Task & Catalytic Modification Task) - NREL, PNNL;
3.2.3.1.1 Modeling of the Big Island Heat Exchanger and Gasifier Project - NREL; 3.2.3.1.2 Optimization of High-Temperature Black Liquor Gasifiers Project - SNL; 3.2.3.1.3 Advancement of High Temperature BLG Tech - Weyerhaeuser;
3.2.3.1.4 Investigation of Pressurized Entrained Flow Draft BLG - University of Utah; 3.2.3.2.1 Materials Evaluation for Black Liquor and Biomass Gasifiers Project - ORNL; 3.2.3.2.2 Materials Evaluation - Pulsed Black Liquor Reformer - ORNL;
3.2.3.2.3 Refractory for Black Liquor Gasifiers Project - UMR - University of Missouri-Rolla;
3.2.3.3.1 Causticizing for Black Liquor Gasifiers Project - Institute of Paper Science and Technology (now Georgia Institute of Technology);
3.2.3.3.2 Direct Causticization for Black Liquor Gasifiers Project - University of Maine; 3.2.3.4.1 Fuel Chemistry and Bed Performance in a Black Liquor Steam Reformer Project - University of Utah – Department of Chemical Engineering;
3.2.3.4.2 Cost-Benefit Analysis of Gasification of Fuels/Chemicals Production at Kraft Pulp Mills - Princeton University;

3.2.4.2 Thermochemical Conversion of Corn Stover - Bioengineering Resources, Inc.; 3.2.4.3 Catalytic Hydrothermal Gasification for Eastman Kingsport Chemical - PNNL, Antares Group, Inc;
3.2.4.4 Evaluation of Membrane Systems for Gasifiers (Summary of Tasks 1-3) - NREL, PNNL, NETC;
3.2.4.5 Evaluation of Membrane Systems for Gasifiers (Summary of Tasks 1 & 2, PNNL and NREL) - PNNL, NREL;
3.3.1 Clean-up & Conditioning Project (Summary of Tasks 1 & 2) - NREL;
3.3.1.4 Evaluation of RVS-1 Sorbent for Removal of Sulfur from Black Liquor Gasification Project - NREL;
3.3.2.1 Biomass Gas Cleanup Using a Therminator - Research Triangle Institute;
3.3.2.2 Trace-Metal Scavenging from Biomass Syngas with Novel High Temperature Sorbents - Southern Research Institute;
3.3.2.3 Engineering New Catalysts for In-Process Elimination of Tars - Gas Technology Institute;
3.5.0 Thermochemical Platform Analysis Project - NREL

III.A.2. Products Platform

Goals: The objective of this project is to upgrade biomass pyrolysis oils to fuels and chemical products in a cost-effective manner.

Barriers: The major barrier for the Products Platform in this Roadmap Objective is the difficulty to upgrade biomass Pyrolysis oils.

WBS #, Title, Major R&D Performer:
4.2.2.2 Pyrolysis Oil Upgrading Project - Pacific Northwest National Lab

III.A.3. Products Platform

Goals: The objectives of these projects are to have commercial scale demonstrations designed to prove the viability of black liquor reformer technology in the forest products industry.

Barriers: The major barrier for the Products Platform in this Roadmap Objective is the difficulty to upgrade biomass Pyrolysis oils. For more information on barriers see page 18 in this document.

WBS #, Title, Major R&D Performer:
5.2.1.1 Demonstration of Black Liquor Gasification at Big Island Project - Georgia-Pacific Corporation;
5.2.2.10 SEER - expenses for facilities that produce fuels from an agriculture & animal waster - Society for Energy and Environmental Research (“SEER”)

III.A.4. Earmarks

Goals: The goals addressed under this roadmap objective are to integrate and evaluate syngas cleanup and treatment technologies for synthesis gas produced by biomass gasification; to provide research results on the feasibility of small modular biopower systems to convert biomass to cooling, heating and power; assess the technical and economic viability of using modular biopower for micro-CHP applications. Additionally they are to reduce requirements for #2 fuel oil from 215,000 gallons per year to approximately 5%-7% of that requirement.

Barriers: The barriers addressed under this objective are to address peak power costs of ~$19/kWhr and reducing the need for #2 fuel oil. Furthermore sustainability of feedstocks, resource availability, the size of the processing area; and outreach, education partnerships on the state & local level are important challenges to overcome.

WBS #, Title, Major R&D Performer:
3.2.1.4.2 Biomass Gasification Research Center Project (new GTI) - Gas Technology Institute;
4.2.3.3 Maine Forest Bioproducts R&D - Maine Technology Institute;
4.5.2 Regional Biomass Program - Council of Great Lakes Governors (CGLG) - Council of Great Lakes Governors, CGLG
5.2.1.3 Modular Biopower Micro-cooling, Heating and Power System, Mount Wachusett Community College - Mount Wachusett Community College;
5.2.1.4 Biomass/Cogeneration Project at North Country Hospital - North Country Hospital;
5.2.1.5 North Central Texas Dairly Waste Control Pilot Project - Brazos River Authority; 5.2.1.6 On-Farm Small Scale Waste Energy Demonstration Project - Farm Power; 7.03.4.GO13049 Phillips Biomass CHP Facility;
7.04.5.GO14268 Energy Supply - Production of Fuel from Agricultural and Animal Waste; 7.05.1.GO85001 Alaska Wood Biomass Project;
7.05.3.GO85006 Biomass-Derived Syngas Utilization for Fuels and Chemicals;
7.05.4.GO85008 SUNY- Morrisville Anaerobic Digester Project;
7.05.4.GO85009 Small Scale Biomass System (BioMax);
7.05.4.GO85010 Research on Anaerobic Digestion;
7.05.5.GO85003 Texas A&M Renewable Energy from Animal Waste Project;
7.05.5.GO85013 Kentucky Rural Energy Supply Program

III.B. Bio-conversion

Objective Two - Develop economically viable and environmentally sound bioconversion processes/technologies for commercial application of a range of biobased fuels and products.

III.B.1. Sugar Platform

Goals: The goals addressed under this roadmap objective are to reduce the cost of biomass pretreatment and increasing the enzymatic digestibility of residual cellulose and hemicellulose in pretreated biomass and to focus on benchmarking integration process performance.

Barriers: The barriers addressed under this objective are product yield, conversion rates enzymes process integration, recalcitrance of biomass, enabling tools and cost of sugars from biomass.

WBS #, Title, Major R&D Performer:
2.1.1 Pretreatment and Enzymatic Hydrolysis – NREL;
2.1.3 Integration of Leading Biomass Pretreatment Technologies with Enzymatic Digestion and Hydrolyzate Fermentation Project (CAFI 2) - Trustees of Dartmouth College;
2.3.1 Sugar Processing Integration – NREL;
2.4.1 Targeted Conversion – NREL;
2.5.0 Sugar Platform Analysis Project - NREL

III.B.2. Products Platform

Goals: The objectives of the Products Platform are to develop novel and improve existing catalysts for the fermentation of sugars.

Barriers: The barriers addressed under this objective are the ability to utilize pentose and maintain a high product yield; the cost of aerobic fermentation; the limits of improving catalyst selectivity; heterogeneous catalysts; and barriers to reduce separation costs. The projects will also address barriers to economical organic acid production, sustainable feedstock availability, and the development of genetic tools to modify the feedstock crop.

WBS #, Title, Major R&D Performer:
4.1.1.2 Engineering Thermotolerant Biocatalysts for Biomass Conversion to Products Project University of Florida - IFAS;
4.1.1.5 New Yeast Fundamentals - Utilization of C5 sugars for Ethanol - NREL;
4.1.2.1 Catalyst Development - Iowa State;
4.2.1.1 Engineering of E.coli Sugar-Utilization Regulatory Systems for the Consumption of Plant Biomass Sugars - Iowa State University;

4.2.1.2 Development of Yeast for the Fermentation of Agricultural Feedstocks to Chemicals Project - Cargill Dow Polymers;
4.2.1.4 Fungal Genetics - Pacific Northwest National Laboratory;
4.2.3.4 Development of Improved Chemicals and Plastics from Oilseeds Project - Dow Chemical
4.2.3.5 Platform Chemicals from an Oilseed Biorefinery Project - Cargill, Inc.;
4.2.4.2 Separations, ANL - Argonne National Laboratory;

III.B.3. Program Management

Goals: This project will focus on providing programmatic and technical support to the office of biomass program.

Barriers: See page 24 in the Biomass R&D Portfolio: Program Management Barriers

WBS #, Title, Major R&D Performer:
6.1.3.3 Lab Support of HQ (PNNL)

III.B.4. Earmarks

Goals: OBP earmarks related to this Roadmap objective are to demonstrate and quantify the process operability, robustness, and efficiency of corn fiber conversion at higher solids loadings and process-relevant scale; and to maximize ethanol production in viscous fermentations while minimizing power consumption by the reactor. An additional goal is to focus on States' interest in the development of an integrated forest products refinery (IFPR).

Barriers: The barriers addressed under this objective are the variable composition of lignocellulosic-derived sugars may create hydrodynamic excursions deleterious to the fermentation process. The ability to employ high concentrations of sugars or hydrolysates can lower capital costs particularly for fermenting lignocellulosic hydrolysates.

WBS #, Title, Major R&D Performer:
2.1.4 Ethanol Production from Biomass Large Scale Facility Design Project - University of Louisville Research Foundation, Inc.;
4.1.3.2 Center for Catalysis at Iowa State University;
4.2.1.4 Fungal Genetics - PNNL;
4.2.3.2 Biobased Development of Sustainable Biobased Products and Bioenergy at Purdue University in Cooperation with the Midwest Consortium for Sustainable Biobased Products and Bioenergy - Purdue University;
7.02.5.GO12001 Biomass to Fuels and Chemicals: Building a Bridge to the Corn Ethanol Industry;

7.05.5.GO85007 Sugar-Based Ethanol Biorefinery: Ethanol, Succinic Acid and Byproduct Production

III.C. Biorefinery Integration Platform

Objective Three- Advance the development of biorefineries that 1) efficiently separate biomass raw materials into individual components, and 2) convert these components into marketable products, including biofuels, biopower, and conventional new bioproducts.

III.C.1. Sugar Platform

Goals: The goals addressed under this roadmap objective are to develop simpler, less-expensive filtration and separation equipment for use in biomass processing plants; and to develop novel, cost effective separation methodologies to facilitate viable production of building blocks and chemicals in the current and future biorefinery industry.

Barriers: The barriers addressed under this objective are separation systems high capital cost and poor efficiency.

WBS #, Title, Major R&D Performer:
2.4.4 Industrial Membrane Filtration & Short Bed Fractal Separating System - Amalgamated Research, Inc., INEEL, NREL;
2.4.5 Separation Methodologies - INEEL, NREL, Argonne

III.C.2. Products Platform

Goals: The goals addressed under this roadmap objective are to employ a biorefinery approach to produce novel sugar and crop oil feedstocks and polymers derived from the feedstocks; to develop commercial-scale processes for organic acid ester production; to provide ongoing analytical support for the impact of products on the biorefinery; to build market for biofuels and biobased products; to increase electricity production from biomass; and to develop novel catalysts for the conversion of sugar alcohols to produce polyols.

Barriers: The barriers addressed under this objective are fermentation: cost-effectiveness of conversion systems and to develop novel catalysts to convert sugars to polyols.

WBS #, Title, Major R&D Performer:
4.2.2.1 Advanced Catalyst Development for Polyols Production Project
4.2.2.4 New Sustainable Chemistry for Adhesives, Elastomers and Foams - Rohm and Haas Company;
4.2.3.6 Biomass Biorefinery for Production of Polymers and Fuel Project - Metabolix, Inc.;
4.4.2 Product Opportunities - Analysis for Products - Pacific Northwest National Laboratory;

4.4.1 Biorefinery Integration - Analysis for Products - NREL, PNNL

III.C.3. Integrated Biorefineries

Goals: OBP is addressing multiple goals related to this Roadmap objective. These include: to economically derive high-value chemicals and oils from lower value corn fiber and to research and develop dry mill “Biorefinery” process(es) which will improve the economics of existing ethanol dry mills. Additional goals are to improve the quality of products and reduce the cost of biorefinery processes.

Barriers: The barriers addressed under this objective are the possibility of gel forming in the heat exchanger and trapping particles which could lead to plugging; the scale-up of the thermochemical hydrolysis, secondary acid hydrolysis and liquid/solid separation. Furthermore, additional barriers towards fermentation of xylose will be determined, and technical issues on animal feed (ruminants and companion animals), enzyme cocktail, optimum hydrolysis condition will be addressed.

WBS #, Title, Major R&D Performer:
5.1.1.1 Separation of Corn Fiber and Conversion to Fuels and Chemicals: Phase II, Pilot-Scale Operation Project - NCGA
5.1.1.1.2 Separation of Corn Fiber and Conversion to Fuels and Chemicals: Phase II, Pilot-Scale Operation Project - PNNL
5.1.1.2 A Second Generation Dry Mill Biorefinery Project
5.1.1.4 A New Biorefinery Platform Intermediate Project
5.1.1.4.2 A New Biorefinery Platform Intermediate - PNNL
5.1.2.1 Advanced Biorefining of Distiller's Grain and Corn Stover Blends: Pre-Commercialization of a Biomass-Derived Process Technology Project
5.1.2.2 Integrated Corn-based Biorefinery Project
5.1.2.3 MBI Biorefinery
5.1.2.4 Making Industrial Bio-Refining Happen! Project
5.1.2.6 Collection, Commercial Processing, and Utilization of Corn Stover Project
5.1.2.8 Demonstration of the PureVision Biorefinery Project
5.2.1.1 Demonstration of Black Liquor Gasification at Big Island Project
5.3.1 Integrated Biorefinery Analysis Task - NREL

III.C.4. Earmarks

Goals: The goals of OBP earmarks related to this Roadmap objective are to demonstrate a new and more economical process technology for the fractionation of biomass, achieve the enzymatic conversion of its cellulose component to sugar, and achieve the economic separation and utilization of other biomass components from wash streams.

Barriers: The barriers addressed under this objective are feasibility of biomass gasifiers and process validation; resource availability and feedstock technologies, systems integration for the biorefinery; high capital cost and poor efficiency of separation systems.

WBS #, Title, Major R&D Performer:
5.1.1.3 Corn Dry Mill to Ethanol Plant, Jasper County, IN Project
5.1.2.7 EERC Center for Biomass Utilization 2003 Project
5.1.2.9 Improved biorefinery for the production of EtOH, chemicals, animal feed, and biomaterials from sugar cane , LSU
5.2.2.2 Mississippi Ethanol Gasification Project
5.2.2.3 Commercial Demonstration of Thermodepolymerization (TDP) Technology - Nevada Plant Project
5.2.2.5 Agricultural Mixed Waste Biorefinery - Colorado Project
5.2.2.6 Southeast Alaska Ethanol Project
5.2.2.7 City of Gridley Biofuels Project
5.2.2.8 AgraPure MS Biomass Biomass Project - Fibrowatt Project
7.05.5.GO85004 Generating Process and Economic Data for Preliminary Design of PureVision Biorefineries;
7.05.5.GO85012 Biorefinery and Hydrogen Fuel Cell Research

IV. Product Uses and Distribution

Products Platform: Overview

The Products Platform Element envisions the use of all biomass components (i.e. cellulose, hemicellulose, and lignin) as building blocks for conversion of raw material feedstocks to useful “products”. The term “products” is often synonymous with chemicals and materials, but also encompasses fuels and heat and power. The potential building blocks considered in the Products Platform Element are derived from the outputs of the Biochemical and Thermochemical Platforms, along with outputs from the existing biomass industry. The basic building blocks from the grain based biomass, oleochemistry industries, and forest products industry include C5 and C6 sugars, lignin, oil, and protein. Building blocks from the Thermochemical Platform include synthesis-gas and pyrolysis oils from the existing forest products industry.

Highlights - Significant Accomplishments

- Successfully demonstrated technical and economic feasibility of a soy-based marine lubricant which went to commercialization.

- Metabolix’s Natural Plastics win presidential green chemistry challenge award.

- A patent was filed resulting from yeast development work for new strains with multisugar fermenting capabilities.

- Two patents filed for separative bioreactor wafers and applications.

- Top Ten Study for Lignin (in process), Top Ten Study for Sugars/Syngas completed in 2004.

IV.A. Objective One

Objective One - Advance the understanding of biomass applications to expand existing markets, create new markets, and improve distribution for environmentally sound bioenergy and biobased products.

IV.A.1. Program Management Platform

Technical Goals: To promote multidisciplinary education and training programs for graduate students in the area of bioprocess engineering and biobased industrial products; and to educate chemists, chemical engineers and materials scientists in the fields of genetic engineering, microbiology, biochemical engineering, and biobased materials by offering a selection of classes designed to broaden their traditional expertise.

Barriers: The barriers addressed under this objective are outreach, education, partnerships; and university curriculum development.

WBS #, Title, Major R&D Performer:
6.3.2.1.1 Multi-disciplinary Graduate Training Program for Biobased Industrial Products - MSU
6.3.2.1.3 Multidisciplinary Graduate Education in Bioprocess Engineering - Georgia
6.3.2.1.4 Multidisciplinary Graduate Curriculum in Support of the Biobased Products Industry – CO School of Mines
6.3.2.1.7 Establishment of Graduate Certificate Program in Biobased Industrial Products
6.3.2.1.8 Multidisciplinary Education and Training in Biobased Products Graduate Major in Bioresource Engineering
6.3.2.3 Biomass Research Initiative for Student Advancement (BRISA) Task

IV.A.2. Earmarks

Technical Goals: The goals addressed under this roadmap objective are to facilitate the increased use of bioenergy and biobased products in accordance with state and regional goals that support DOE's plans and strategies; investigate specific performance issues of biobased industrial lubricants; to develop economically and environmentally sound technologies to promote efficient biopower or bioenergy, transportation biofuels, and bioproducts such as marketable chemicals and hydrogen; and install a heating system that uses wood chips for fuel to heat an elementary school in Nevada

Barriers: The barriers addressed under this objective are cost and funding barriers to implementing new technologies and improving outreach and education to those who can affect biomass technology implementation.

WBS #, Title, Major R&D Performer:
4.1.2.5 Biodiesel Demonstration in School Buses - Missouri Soybean Association;
4.3.2.1 Heat and Power Biomass Project - The Green Institute
4.3.2.3 White Pine City NV Public School Heating Project - White Pine County School District, NV
4.5.3 Regional Biomass Program - Southern States Energy Board (SSEB) - Southern States Energy Board;
4.5.4 Regional Biomass Program - Western Governors Association (WGA) - Western Governors' Association;
4.6.2 National Agricultural-Based Industrial Lubricants Center Project - University of Northern Iowa (UNI) Agriculture Based Industrial Lubricants (ABIL) Research Program; 5.1.2.7 EERC Center for Biomass Utilization 2003 Project - University of North Dakota; 7.05.0.GO13072 National Center on Energy Management and Building Technologies 7.05.5.GO85041 Research Extension, and Educational Programs on Bio-based Energy Technologies and Products

IV.A. Objective Two

Objective Two - Identify and develop high value products from biomass feedstocks.

IV.A.1. Earmarks

Technical Goals: The goals addressed under this roadmap objective are to demonstrate the use of a renewable (BioDiesel) fueled diesel generator equipped with state-of-the-art emissions control technology utilizing various blends of BioDiesel and conventional diesel (2% BioDiesel/98% conventional diesel, 5% BioDiesel/95% conventional diesel, 20% BioDiesel/80% conventional diesel, 50% BioDiesel/50% conventional diesel, and 100% BioDiesel).

Barriers: The barriers addressed under this objective are the ability to synthesize a pure stream ethyl lactate through reactive distillation and address the market and economic feasibility of biodiesel. They will also address issues associated with outreach and education.

WBS #, Title, Major R&D Performer:
4.2.4.1 Reactive distillation for esterification of bio-based organic acids - NCGA;
4.3.2.4 McMinneville Biodiesel Project - McMinnville Electric System;
4.5.1 Regional Biomass Program - Council of Northeastern Governors (CONEG);
7.05.3.GO85015 Pressurized Oxidative Recovery of Energy from Biomass;
7.05.4.GO85017 Vermont BioFuels Initiative

IV.A. Objective Three

Objective Three - Identify and develop distribution systems, and locate processing and conversion facilities in proximity to biomass resources, to maximize rural development and minimize negative environmental impacts.

IV.A.1. Earmarks

Technical Goals: The goals of OBP earmarks related to this Roadmap objective are to conduct research on diesel engine wear and emissions to further the commercialization of E-diesel fuel as a cleaner-burning substitute for conventional diesel fuel; to support commercialization and entrepreneurship of agricultural research into alternative industrial use products; to reduce environmental impacts; to decrease U.S. reliance on imported oil by producing oil from renewable waste, improve the ambient air quality using technology compared to other less desirable alternative waste disposal methods (rendering and landfilling), provide a "green" alternative to food processing organic waste disposal, and eliminate the waste liability incurred by converting these materials into energy and salable product streams.

Barriers: The barriers addressed under this objective are to increase access to developmental and growth capital within a rural area and to specialized facilities and equipment to support client companies.

WBS #, Title, Major R&D Performer:
4.1.2.3 E-Diesel research by NCGA - National Corn Growers Association;
4.1.2.4 Development and Optimization of Novel Biodiesel Production Techniques, Mississippi State - Mississippi State University
4.2.3.1 Biobased Products by the New Uses Information and Entrepreneur Development Center, Belvidere, IL - Growth Dimensions, Inc;
4.6.1 Eastern NV Landscape Coalition for Biomass Restoration - Eastern NV Landscape 5.2.2.4 Agricultural Mixed Waste Biorefinery using the Thermodepolymerization (TDP) Technology - Alabama Plant Project - Gas Technology Institute
Coalition;
7.04.4.BB044800 Oxydiesel Demonstration in California and Nevada FY 2004 Earmark;
7.04.4.GO14240 Missouri Soybean Association Biodiesel Demonstration;
7.04.4.GO14250 Agricultural Bio-Fueled Generation of Electricity and Development of DurFeable and Efficient NOx Reduction;
7.05.4.GO85019 Recycling for Energy Conservation Project

V. Public Policy Measures to Support Biomass Development

Overview of Public Policy and Program Management
Public Policy falls under the Program Management activities of the Biomass Program. Program Management is the responsibility of EERE/OBP HQ and includes program oversight; development, review and approval of program plans; program & technology goals development; hosting of biennial peer reviews; cultivation of interagency relations; program budget development, execution, and defense; portfolio gap identification; strategic planning; partnership development; communications and outreach; and interface with laboratory relationship managers to provide priorities and obtain programmatic laboratory feedback. There are five major program areas within HQ program management which align with the technology R&D elements. There are also three support functions, including Systems Integration, Program Analysis, and Communications and Outreach.

Highlights - Significant Accomplishments
OBP does not fund work in the area of Policy analysis or development. However OBP does fund market analysis and supports various outreach and education activities that contribute to Roadmap objectives in this area. This section describes DOE/OBP activities in these areas as well as overall management activities. Significant accomplishments include:

- Strategic Analysis – Estimate of Biomass Cost Targets for NEMS and MARKAL - A set of cost and yield curves with respect to time were generated for use in the cost/benefit analysis of the OBP's investments in corn mills and lignocellulosic conversion. There were three sets of curves generated: costs from existing mills with a "do nothing" philosophy, existing mills with the addition of bound starch and fiber conversion, existing mills with the addition of lignocellulosic co-processing, and the contribution of co-products as a means to reduce the cost of ethanol production. Draft versions of the results have been discussed and the final versions are nearly complete. (WBS 6.2.2)

- Systems Integration – Provided significant support to the Sugars, Thermochemical and Biodiesel reviews; and to the drafting of the OBP MYPP. Helped develop new templates for the FY06 AOP and FY06 Quarterly Reports with GFO personnel that will improve accountability and ease of program information storage and management. (WBS 6.1.4)

- Graduate Education Programs. (Michigan State University, ID14005; University of Georgia, ID14007; Colorado School of Mines, ID14008; Kansas State University, ID14126; Iowa State University, ID14127). GO has been working with the PIs to get these projects completed based on requests from OBP.

- Biorefinery Workshop - OBP and the European Directorate for General Research partnered together to sponsor the First International Biorefinery Workshop held in Washington, DC 2005. This workshop brought together industry, government, and academia to develop partnerships and well as promote the biorefinery and exchange ideas and information on how to improve the biorefinery.

- Conducted Stage Gate review meetings for OBP R&D in each of the Technical Platform areas.

- Ethanol Outreach - OBP's office of communication has continued to educate the public on the net energy benefits of ethanol through its website and promoting studies and materials. Additional communication campaigns are planned.

V.A. Objective One

Objective One - Promote the commercialization of successfully demonstrated environmentally sound biobased technologies

V.A.1. Earmarks

Technical Goals and Barriers: Although earmarked projects have been identified under this Roadmap category, there is a lack of information available to identify goals, accomplishments towards roadmap objectives, and technical barriers. Earmarked projects are not competitively awarded by DOE and do not necessarily reflect the Biomass Program's technical and strategic goals.

WBS #, Title, Major R&D Performer:

4.1.3.1 Energy from Biomass Research and Technology Transfer Program Project;

7.05.4.GO85002 Mississippi Technology Alternative Energy Enterprise Program

V.B. Objective Two

Objective Two - Outline the institutional and policy changes needed to remove the barriers to economically sound development of sustainable biomass systems

V.B.1. Program Management

Program Management Technical Goals: Program Management technical goals addressed under the Roadmap category: Public Policy Measures to Support Biomass Development are crosscutting through all four objectives in this category. Overall technical and programmatic goals are to provide support between DOE/HQ and NETL, NREL, and Golden Field Office, to support in the management of the program, provide technical and engineering support for demonstration projects, assisting in the development of technical R&D and to continue to achieve technical goals; This program-level engineering and analysis team performs crosscutting and strategic analysis that benefits multiple Biomass projects and external collaborators, and provides direction and focus to the overall research program by evaluating the technical, economic, and environmental aspects of biomass utilization via integrated pathways; to nurture and enable public-private partnerships that are the cornerstone of the ongoing DOE research and development implementation strategy; to encourage federal sites to purchase bio-based products where appropriate.

Program Management Barriers: Program management barriers under the Roadmap Category: Public Policy Measures to Support Biomass Development are crosscutting through all four objectives in this category. The overall barriers addressed under this category are a lack of data for low temperature steam reforming projects to support the above analyses; Integration and cost of biomass processes; Lack of consensus on impact or direction for biomass; State & Local Partnerships; Integration and cost of biomass processes; Lack of consensus on impact or direction for biomass; Technical and economic feasibility of new technologies, identification of new areas of R&D emphasis; Cost effective and sustainable feedstock system by 2015 Establishing markets for bioproducts. Establishing markets for bioproducts; State & Local Partnerships; Lack of data for low temperature steam reforming projects to support the above analyses; Integration and cost of biomass processes; lack of consensus on impact or direction for biomass

WBS #, Title, Major R&D Performer:
6.1.1.1.3 Golden Support Contract;
6.1.1.1.4 NETL Support Contracts;
6.1.2 National Laboratory Integration;
6.1.2.1 Management (NREL);
6.1.2.3 Partnership Development (NREL);
6.2.2 Strategic Analysis;
6.3.1.2 Buy Bio Initiative Task

V.B.2. Earmarks

Earmarks Technical Goals and Barriers: Although earmarked projects have been identified under this Roadmap category, there is a lack of information available to identify goals, accomplishments towards roadmap objectives, and technical barriers. Earmarked projects are not competitively awarded by DOE and do not necessarily reflect the Biomass Program's technical and strategic goals.

WBS #, Title, Major R&D Performer:
7.04.4.GO14260 Restoration of Gleason Creek Watershed;
7.05.4.9999999 Undetermined- Regional Biomass Energy Program (04 EARMARK)

V.C. Objective Three

Objective Three - Ensure that the biomass technologies developed are environmentally sound and move the country in the direction of sustainable biomass systems.

Earmarks Technical Goals and Barriers: Although no projects have been identified under this Roadmap category, there is a lack of information available to identify goals, accomplishments towards roadmap objectives, and technical barriers. Some projects identified are crosscutting through the objectives in the Public Policy Measures to Support Biomass Development category.

WBS #, Title, Major R&D Performer: No projects were specifically identified. Some projects identified are crosscutting through the objectives in the category.

V.D. Objective Four

Objective Four - Enhance opportunities for rural economic development.

Earmarks Technical Goals and Barriers: Although earmarked projects have been identified under this Roadmap category, there is a lack of information available to identify goals, accomplishments towards roadmap objectives, and technical barriers. Earmarked projects are not competitively awarded by DOE and do not necessarily reflect the Biomass Program's technical and strategic goals.

WBS #, Title, Major R&D Performer:
7.05.4.9999999 Undetermined- Regional Biomass Energy Program (04 EARMARK);
7.05.4.GO85005 National Biofuel Energy Laboratory
7.05.4.GO85050 Regional Biomass Program;
7.05.4.NT99999 National Conference of State Legislators - Regional Biomass Energy Program (04 EARMARK);
7.05.4.R110953 Vermont Biomass Energy Center, Burlington, VT (04 EARMARK)/ FY 2005 $0.5M less general reduction,$496K.;
7.05.4.SRO9999 Seattle- Western RO - Regional Biomass Energy Program (05EARMARK);
7.05.5.GO85014 Research Extension, and Educational Programs on Bio-based Energy Technologies and Products;
7.05.5.GO85016 Livingston Parish Alternative Fuel Plant Construction

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[i] Spath, P. "Progression of Syngas Cost Targets." NREL Technical Memo. August 31, 2005. http://devafdc.nrel.gov/bcfcdoc/9325.pdf

[ii] Jechura, J. "Sugar Platform Post Enzyme-Subcontract Case." NREL Technical Memo. http://devafdc.nrel.gov/bcfcdoc/9382.pdf

ATTACHMENT A -

U.S. Department of Energy's Research and Development Activities as They Relate to the Biomass Initiative's *Roadmap*

Roadmap Main Category Sub-Category & Focus	**II. Feedstock Production**					
	A. Biotechnology and Plant Physiology					
	Objective One - Improve the technical understanding of plant biochemistry and enzymes and develop the ability to engineer enzymes within desired crops					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds $1,000**	
Sugar Platform	The main focus of this subtask is to develop a clear understanding of the extent of compositional variation in corn stover and identify possible major causes of that variability.	This work address specific barriers related to feedstocks and process integration.	See page 9 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	2.3.1.1 Feedstock Variability, NREL	**FY2003**	**$0**
					FY2004	**$703**
					FY2005	**$636**
Earmarks	DOE/OBP has received various earmarks that relate to this objective. The goals to be addressed under this Roadmap objective are to support hybrid poplar research in the North Central regions of the United States and to continue to develop hybrid poplars as a viable fiber and energy crop. Furthermore technical goals will focus on developing a clear understanding of that variability; the research will generate information on the novel soybean germplasm with enhanced oil qualities for use in biodiesel blends.	The main barriers are pest resistance and possess characteristics such as ease of propagation, as well as pentose utilization – product yield.	There is no information available to identify accomplishments towards Roadmap Objectives	1.2.2 Hybrid Poplar Research Project - North Central Forest Experiment Station (NCFES); 4.1.1.3 Research in Nebraska on Improved Soybean Oil for Biodiesel Fuel - University of Nebraska, Lincoln; 7.05.1.GO85011 Alternative Fuel Source Study	**FY2003**	**$481**
					FY2004	**$491**
					FY2005	**$496**
Roadmap Main Category Sub-Category & Focus	**II. Feedstock Production**					
	A. Biotechnology and Plant Physiology					
	Objective Two - Develop the chemical and chemical/biological pathways necessary to improve the energy density and chemical characteristics of delivered feedstocks.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Products	Exploring the stress response and stress proteins for solvent tolerance; Genomic library-based identification of genes imparting a tolerant phenotype; Transcriptional analysis of 4 solvent tolerant strains may identify commonly differentially expressed genes that might impart solvent tolerance.	Sustainable Feedstock Availability, Developing genetic tools to modify the feedstock crop	See page 18 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	4.2.1.3 Genomic and Genetic Approaches to Solvent Tolerance - Northwestern University	**FY2003**	**$167**
					FY2004	**$0**
					FY2005	**$0**

U.S. Department of Energy's Research and Development Activities as They Relate to The Biomass Initiative's *Roadmap*

Roadmap Main Category Sub-Category & Focus	**II. Feedstock Production**					
	B. Agronomic Practices					
	Objective Three - Optimize agronomic practices for sustainable biomass feedstock production					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Feedstock Interface	DOE/OBP goals related to this Roadmap objective are to provide data and analyses on current and future feedstock supplies. These data are largely in the form of supply schedules (i.e., quantities and costs) and supporting information, such as analysis of specific factor cost components that comprise total delivered feedstock costs.	Feedstock supply uncertainty and demonstrating an integrated feedstock supply system that reduces the overall delivered costs of biomass feedstocks	See page 3 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	1.3.1 Supply Forecast and Analysis - ORNL	**FY2003**	**$547**
					FY2004	**$52**
					FY2005	**$150**
Program Management	The objectives of these projects are to provide support between DOE/HQ and NETL, NREL, and Golden Field Office, to support in the management of the program, provide technical and engineering support for demonstration projects, assisting in the development of technical R&D and to continue to achieve technical goals.	See page 24 in the Biomass R&D Portfolio: Program Management Barriers	See page 23 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	6.1.3.4 Lab support of HQ (INEEL)	**FY2003**	**$0**
					FY2004	**$0**
					FY2005	**$200**
Earmarks	DOE has received various earmarks that relate to this Roadmap objective. They include researching the technical and economical feasibility and environmental implications of developing a cellulosic ethanol industry moving west from Minnesota into North and South Dakota evaluating the potential of producing switchgrass on commercial agricultural land and to utilize that switchgrass as an energy feedstock; and development of markets for energy crops in southern Iowa.	Overcoming challenges of low prioritization of biomass amongst stakeholders and diversity of perspectives; Resource availability and sustainability, feasibility/costs of the projects.	There is no information available to identify accomplishments towards Roadmap Objectives	1.2.1 Native Flora Utilization Project - Fuel Feedstocks - Great Plains Institute for Sustainable Development; 1.2.4 Biomass Power for Rural Development Project - Chariton Valley RC&D; 1.2.5 Switchgrass Demonstration Project - University of Tennessee	**FY2003**	**$2,583**
					FY2004	**$3,482**
					FY2005	**$496**

U.S. Department of Energy's Research and Development Activities as They Relate to The Biomass Initiative's *Roadmap*

Roadmap Main Category Sub-Category & Focus	**II. Feedstock Production**					
	C. Feedstock Handling					
	Objective Four - Optimize logistics for collecting, storing and combining multiple feedstocks that can be applied for diverse applications in an environmentally sounds manner					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Feedstock Interface	The goals addressed under this Roadmap objective are to produce high quality, low cost biomass feedstocks in a sustainable manner reducing the cost of handling and stable storage of biomass were identified in the Feedstock Colloquies as critical elements to sustainably maximize the amount of cellulosic feedstocks available to contribute to the OBP targets of 1B tons of biomass at $35/ton. These projects will help achieve thos goals. They are also designed to help to develop commercially viable technologies needed to use crop residues as an inexpensive source of fermentable sugars; to evaluate and define equipment and infrastructure options that will reduce the cost of delivered biomass from the present baseline baling system of $53/dry ton to the cost goal of $35/dry ton.	The barriers addressed under this objective are equipment limitations, sustainability, feedstock costs; feedstock characterization and monitoring, effects of storage, infrastructure requirements, and sustainability, inadequate information on quantities, costs, and location, costs of crop residues, plant science, crop production, and biomass processing.	See page 3 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	1.1.1.1 Harvesting, Collection and Preprocessing - INEEL; 1.1.1.2 Biomass Bulk Processing and Storage Task - INEEL; 1.1.3 Multicomponent Harvesting Equipment for Inexpensive Sugars from Crop Residue Project - Iowa State University; 1.3.2 Supply System Logistics - ORNL	**FY2003**	**$2,398**
					FY2004	**$2,502**
					FY2005	**$2,170**

ATTACHMENT A

Roadmap Main Category Sub-Category & Focus	**III. Processing and Conversion** *A. Thermo-chemical Conversion Pathways* Objective One - Develop cost-effective, environmentally sound thermochemical conversion technologies to convert biomass feedstocks into useful electric power, heat and potential fuels and products.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Thermochemical Platform	See page 11 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 11 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 8 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	3.2.1 Biomass Gasification - NREL/PNL; 3.2.2 Pyrolysis and Other Thermal Processing to Oils - NETL; 3.2.3 Black Liquor Gasification - GFO; 3.2.4 Innovative Gasification Project - NREL; 3.3.1 Clean-Up and Conditioning Project - NREL; 3.3.2 Clean-Up and Conditioning Industrial Partners - GFO ; 3.5.0 National Lab Thermochem Platform Analysis - NREL	**FY2003** **FY2004** **FY2005**	**$4,970** **$6,169** **$8,817**
Products	The objective of this project is to upgrade biomass pyrolysis oils to fuels and chemical products in a cost-effective manner	Pyrolysis	See page 12 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	4.2.2.2 Pyrolysis Oil Upgrading Project - Pacific Northwest National Lab	**FY2003** **FY2004** **FY2005**	**$400** **$675** **$700**
Integrated Biorefineries	The project is a five-year commercial scale demonstration designed to prove the viability of black liquor reformer technology in the forest products industry.	See page 18 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 18 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	5.2.1.1 Demonstration of Black Liquor Gasification at Big Island Project - Georgia-Pacific Corporation; 5.2.2.10 SEER - expenses for facilities that produce fuels from ag & animal waster - Society for Energy and Environmental Research ("SEER");	**FY2003** **FY2004** **FY2005**	**$8,408** **$15,743** **$0**
Earmarks	The goals addressed under this roadmap objective are to integrate and evaluate syngas cleanup and treatment technologies for synthesis gas produced by from biomass gasification; to provide research results on the feasibility of small modular biopower systems to convert biomass to cooling, heating and power; assess the technical and economic viability of using modular biopower for micro-CHP applications. Additionally to reduce requirements for #2 fuel oil from 215,000 gallons per year to approximately 5%-7% of that requirement.	The barriers addressed under this objective are to address peak power costs of ~$19/kWhr and reducing the need for #2 fuel oil. Furthermore sustainability of feedstocks, resource availability, the size of the processing area; and outreach, education partnerships on the state & local level may be difficult.	There is no information available to identify accomplishments towards Roadmap Objectives	3.2.1.4.2 Biomass Gasification Research Center Project (new GTI); 4.2.3.3 Maine Forest Bioproducts R&D; 4.5.2 Regional Biomass Program - Council of Great Lakes Governors (CGLG); 5.2.1.3 Modular Biopower Micro-cooling, Heating and Power System, Mount Wachusett Community College; 5.2.1.4 Biomass/Cogeneration Project at North Country Hospital; 5.2.1.5 North Central Texas Dairly Waste Control Pilot Project; 5.2.1.6 On-Farm Small Scale Waste Energy Demonstration Project; 7.03.4 GO13049 Phillips Biomass CHP Facility; 7.04.5 GO14268 Energy Supply - Production of Fuel from Agricultural and Animal Waste; 7.05.1 GO85001 Alaska Wood Biomass Project; 7.05.3 GO85006 Biomass-Derived Syngas Utilization for Fuels and Chemicals; 7.05.4 GO85008 SUNY-Morrisville Anaerobic Digester Project; 7.05.4 GO85009 Small Scale Biomass System (BioMax); 7.05.4 GO85010 Research on Anaerobic Digestion; 7.05.5 GO85003 Texas A&M Renewable Energy from Animal Waste Project; 7.05.5 GO85013 Kentucky Rural Energy Supply Program	**FY2003** **FY2004** **FY2005**	**$1,688** **$4,217** **$11,559**

Roadmap Main Category Sub-Category & Focus	**III. Processing and Conversion** *B. Bio-converersion* Objective Two - Develop economically viable and environmentally sound bioconversion processes/technologies for commercial application of a range of biobased fuels and products					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Sugar Platform	The goals addressed under this roadmap objective are to reduce the cost of biomass pretreatment and increasing the enzymatic digestibility of residual cellulose and hemicellulose in pretreated biomass and to focus on benchmarking integration process performance.	The barriers addressed under this objective are product yield, conversion rates enzymes process integration, recalcitrance of biomass, enabling tools and cost of sugars from biomass.	See page 9 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	2.1.1 Pretreatment and Enzymatic Hydrolysis – NREL; 2.1.3 Integration of Leading Biomass Pretreatment Technologies with Enzymatic Digestion and Hydrolyzate Fermentation Project (CAFI 2) - Trustees of Dartmouth College; 2.3.1 Sugar Processing Integration – NREL; 2.4.1 Targeted Conversion – NREL; 2.5.0 Sugar Platform Analysis Project - NREL	**FY2003**	**$13,212**
					FY2004	**$12,656**
					FY2005	**$9,717**
Products	The objectives of the Products Platform are to develop novel and improve existing catalysts for the fermentation of sugars.	The barriers addressed under this objective are pentose utilization and product yield; "Low Cost Aerobic Fermentation"; improved catalyst selectivity; improved heterogeneous catalysts; and barriers to reduce separation costs. The projects will also address barriers to economical organic acid production, sustainable feedstock availability, and the development of genetic tools to modify the feedstock crop.	See page 18 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	4.1.1.2 Engineering Thermotolerant Biocatalysts for Biomass Conversion to Products Project University of Florida - IFAS; 4.1.1.5 New Yeast Fundamentals - Utilization of C5 sugars for Ethanol - NREL; 4.1.2.1 Catalyst Development - Iowa State; 4.2.1.1 Engineering of E.coli Sugar-Utilization Regulatory Systems for the Consumption of Plant Biomass Sugars - Iowa State University; 4.2.1.2 Development of Yeast for the Fermentation of Agricultural Feedstocks to Chemicals Project - Cargill Dow Polymers; 4.2.3.4 Development of Improved Chemicals and Plastics from Oilseeds Project - Dow Chemical; 4.2.3.5 Platform Chemicals from an Oilseed Biorefinery Project - Cargill, Inc.; 4.2.4.2 Separations, ANL - Argonne National Laboratory;	**FY2003**	**$2,355**
					FY2004	**$6,162**
					FY2005	**$2,155**
Program Management	This project will focus on providing programmatic and technical support to the office of biomass program.	See page 24 in the Biomass R&D Portfolio: Program Management Barriers	See page 23 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	6.1.3.3 Lab Support of HQ (PNNL)	**FY2003**	**$0**
					FY2004	**$350**
					FY2005	**$500**
Earmarks	OBP earmarks related to this Roadmap objective are to demonstrate and quantify the process operability, robustness, and efficiency of corn fiber conversion at higher solids loadings and process-relevant scale; and to maximize ethanol production in viscous fermentations while minimizing power consumption by the reactor. An additional goal is to focus on States' interest in the development of an integrated forest products refinery (IFPR).	The barriers addressed under this objective are the possibility of gel forming in the heat exchanger and trapping particles which could lead to plugging; variable composition of lignocellulosic-derived sugars that may create hydrodynamic excursions deleterious to the fermentation process; the ability to employ high concentrations of sugars or hydrolysates can lower capital costs particularly for fermenting lignocellulosic hydrolysates.	There is no information available to identify accomplishments towards Roadmap Objectives	2.1.4 Ethanol Production from Biomass Large Scale Facility Design Project - University of Louisville Research Foundation, Inc.; 4.1.3.2 Center for Catalysis at Iowa State University; 4.2.1.4 Fungal Genetics - PNNL; 4.2.3.2 Biobased Development of Sustainable Biobased Products and Bioenergy at Purdue University in Cooperation with the Midwest Consortium for Sustainable Biobased Products and Bioenergy - Purdue University; 7.02.5.GO12001 Biomass to Fuels and Chemicals: Building a Bridge to the Corn Ethanol Industry; 7.05.5.GO85007 Sugar-Based Ethanol Biorefinery: Ethanol, Succinic Acid and Byproduct Production	**FY2003**	**$0**
					FY2004	**$3,116**
					FY2005	**$4,480**

Roadmap Main Category Sub-Category & Focus	**III. Processing and Conversion** *C. Biorefinery Integration* Objective Three- Advance the development of biorefineries that 1) efficiently separate biomass raw materials into individual components, and 2) convert these components into marketable products, including biofuels, biopower, and conventional new bioproducts.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Sugar Platform	The purpose of this project was to develop simpler, less-expensive filtration and separation equipment for use in biomass processing plants. The overarching objectives of FY05 efforts are development of novel, cost effective separation methodologies to facilitate viable production of building blocks and chemicals in the current and future biorefinery industry.	Separation systems high capital cost and poor efficiency;	See page 18 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	2.4.4 Industrial Membrane Filtration & Short Bed Fractal Separating System - Amalgamated Research, Inc., INEEL, NREL; 2.4.5 Separation Methodologies - INEEL, NREL, Argonne	**FY2003**	**$646**
					FY2004	**$102**
					FY2005	**$53**
Products	See page 20 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 20 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 20 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	4.2.2.1 Advanced Catalyst Development for Polyols Production Project; 4.2.2.4 New Sustainable Chemistry for Adhesives, Elastomers and Foams - Rohm and Haas Company; 4.2.3.6 Biomass Biorefinery for Production of Polymers and Fuel Project - Metabolix, Inc.; 4.4.2 Product Opportunities - Analysis for Products - Pacific Northwest National Laborator; 4.4.1 Biorefinery Integration - Analysis for Products - NREL, PNNL	**FY2003**	**$2,257**
					FY2004	**$3,250**
					FY2005	**$2,625**
Integrated Biorefineries	See page 10 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 10 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	See page 10 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	5.1.1 Existing Sugar Biorefineries - PNNL; 5.1.2 Emerging Sugar Biorefineries - PNNL; 5.3.1 Integrated Biorefinery Analysis Task - NREL	**FY2003**	**$14,951**
					FY2004	**$11,758**
					FY2005	**$13,114**
Earmarks	The goals of OBP earmarks related to this Roadmap objective are to demonstrate a new and more economical process technology for the fractionation of biomass, achieve the enzymatic conversion of its cellulose component to sugar, and achieve the economic separation and utilization of other biomass components from wash streams.	The barriers addressed under this objective are feasibility of biomass gasifiers and process validation; resource availability and feedstock technologies, systems integration for biorefinery; separation systems high capital cost and poor efficiency.	There is no information available to identify accomplishments towards Roadmap Objectives	5.1.1.3 Corn Dry Mill to Ethanol Plant, Jasper County, IN Project; 5.1.2.7 EERC Center for Biomass Utilization 2003 Project; 5.1.2.9 Improved biorefinery for the production of EtOH, chemicals, animal feed, and biomaterials from sugar cane; 5.2.2.2 Mississippi Ethanol Gasification Project; 5.2.2.3 Commercial Demonstration of Thermodepolymerization (TDP) Technology - Nevada Plant Project; 5.2.2.5 Agricultural Mixed Waste Biorefinery - Colorado Project; 5.2.2.6 Southeast Alaska Ethanol Project; 5.2.2.7 City of Gridley Biofuels Project; 5.2.2.8 AgraPure MS Biomass Biomass Project - Fibrowatt Project; 7.05.5.GO85004 Generating Process and Economic Data for Preliminary Design of PureVision Biorefineries; 7.05.5.GO85012 Biorefinery and Hydrogen Fuel Cell Research;	**FY2003**	**$12,039**
					FY2004	**$0**
					FY2005	**$235**

Roadmap Main Category Sub-Category & Focus	**IV. Product Uses and Distribution** *A. End-Products and Distribution Systems* Objective One - Advance the understanding of biomass applications to expand existing markets, create new markets, and improve distribution for enviromentally sound bioenergy and biobased products.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Program Management	To promote multidisciplinary education and training programs for graduate students in the area of bioprocess engineering and biobased industrial products; and to educate chemists, chemical engineers and materials scientists in the fields of genetic engineering, microbiology, biochemical engineering, and biobased materials by offering a selection of classes designed to broaden their traditional expertise.	The barriers addressed under this objective are outreach, education, partnerships; and university curriculum development.	See page 23 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	6.3.2.1.1 Multi-disciplinary Graduate Training Program for Biobased Industrial Products - MSU; 6.3.2.1.3 Multidisciplinary Graduate Education in Bioprocess Engineering - Georgia; 6.3.2.1.4 Multidisciplinary Graduate Curriculum in Support of the Biobased Products Industry – CO School of Mines; 6.3.2.1.7 Establishment of Graduate Certificate Program in Biobased Industrial Products; 6.3.2.1.8 Multidisciplinary Education and Training in Biobased Products Graduate Major in Bioresource Engineering; 6.3.2.3 Biomass Research Initiative for Student Advancement (BRISA) Task	**FY2003**	**$261**
					FY2004	**$663**
					FY2005	**$60**
Earmarks	The goals addressed under this roadmap objective are to facilitate the increased use of bioenergy and biobased products in accordance with state and regional goals that support DOE's plans and strategies; investigate specific performance issues of biobased industrial lubricants; to develop economically and environmentally sound technologies to promote efficient biopower or bioenergy, transportation biofuels, and bioproducts such as marketable chemicals and hydrogen; and install a heating system that uses wood chips for fuel to heat an elementary school in Nevada.	The barriers addressed under this objective arecost and funding barriers to implementing new technologies and improving outreach and education to those who can affect biomass technology implementation; Platform Outputs, biorefineries, new product development.	There is no information available to identify accomplishments towards Roadmap Objectives	4.1.2.5 Biodiesel Demonstration in School Buses; 4.3.2.1 Heat and Power Biomass Project; 4.3.2.3 White Pine City NV Public School Heating Project - White Pine County School District, NV; 4.5.3 Regional Biomass Program - Southern States Energy Board (SSEB) - Southern States Energy Board; 4.5.4 Regional Biomass Program - Western Governors Association (WGA) - Western Governors' Association; 4.6.2 National Agricultural-Based Industrial Lubricants Center Project - University of Northern Iowa (UNI) Agriculture Based Industrial Lubricants (ABIL) Research Program; 5.1.2.7 EERC Center for Biomass Utilization 2003 Project - University of North Dakota; 7.05.0.GO13072 National Center on Energy Management and Building Technologies; 7.05.5.GO85041 Research Extension, and Educational Programs on Bio-based Energy Technologies and Products.	**FY2003**	**$4,705**
					FY2004	**$2,943**
					FY2005	**$4,458**

Roadmap Main Category Sub-Category & Focus	**IV. Product Uses and Distribution**					
	A. End-Products and Distribution Systems					
	Objective Two - Identify and develop high value products from biomass feedstocks.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Earmarks	The goals addressed under this roadmap objective are to demonstrate the use of a renewable (BioDiesel) fueled diesel generator equipped with state-of-the-art emissions control technology utilizing various blends of BioDiesel and conventional diesel (2% BioDiesel/98% conventional diesel, 5% BioDiesel/95% conventional diesel, 20% BioDiesel/80% conventional diesel, 50% BioDiesel/50% conventional diesel, and 100% BioDiesel).	The barriers addressed under this objective are the ability to synthesize a pure stream ethyl lactate through reactive distillation and address the market and economic feasibility of biodiesel. They will also address issues associated with outreach and education.	There is no information available to identify accomplishments towards Roadmap Objectives	4.2.4.1 Reactive distillation for esterification of bio-based organic acids, NCGA; 4.3.2.4 McMinneville Biodiesel Project; 4.5.1 Regional Biomass Program - Council of Northeastern Governors (CONEG); 7.05.3.GO85015 Pressurized Oxidative Recovery of Energy from Biomass; 7.05.4.GO85017 Vermont BioFuels Initiative	**FY2003**	**$591**
					FY2004	**$2,381**
					FY2005	**$1,762**

ATTACHMENT A

Roadmap Main Category Sub-Category & Focus	**IV. Product Uses and Distribution** *A. End-Products and Distribution Systems* Objective Three - Identify and develop distribution systems, and locate processing and conversion facilitites in proximity to biomass resources, to maximize rural development and minimize negative environmental impacts.					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Earmarks	The goals of OBP earmarks related to this Roadmap objective are to conduct research on diesel engine wear and emissions to further the commercialization of E-diesel fuel as a cleaner-burning substitute for conventional diesel fuel; to support commercialization and entrepreneurship of agricultural research into alternative industrial use products; to reduce environmental impacts; to decrease the U.S. reliance on imported oil by producing oil from renewable waste, improve the ambient air quality using technology compared to other less desirable alternative waste disposal methods (rendering and landfilling), provide a “green” alternative to food processing organic waste disposal, and eliminate the waste liability incurred by converting these materials into energy and salable product streams.	The barriers addressed under this objective are increase access to developmental and growth capital within a rural area and to specialized facilities and equipment to support client companies. Additional barriers are the prototype development and market barriers for projects as well as the weather and process validation.	There is no information available to identify accomplishments towards Roadmap Objectives	4.1.2.3 E-Diesel research by NCGA; 4.1.2.4 Development and Optimization of Novel Biodiesel Production Techniques, Mississippi State; 4.2.3.1 Biobased Products by the New Uses Information and Entrepreneur Development Center, Belvidere, IL; 4.6.1 Eastern NV Landscape Coalition for Biomass Restoration; 5.2.2.4 Agricultural Mixed Waste Biorefinery using the Thermodepolymerization (TDP) Technology - Alabama Plant Project; 7.04.4.BB044800 Oxydiesel Demonstration in California and Nevada FY 2004 Earmark (FY 2005 CONGRESSIONALLY DIRECTED PRIOR YEAR UNCOSTED REDUCTION); 7.04.4.GO14240 Missouri Soybean Association Biodiesel Demonstration; 7.04.4.GO14250 Agricultural Bio-Fueled Generation of Electricity and Development of DurFeable and Efficient NOx Reduction; 7.05.4.GO85019 Recycling for Energy Conservation Project	**FY2003** **FY2004** **FY2005**	**$0** **$3,489** **$543**

Roadmap Main Category Sub-	**V. Public Policy Measures to Support Biomass Development**					
	Objective One - Promote the commercialization of successfully demonstrated environmentally sound biobased technologies					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Earmarks	The goals addressed under this roadmap objective are to facilitate the increased use of bioenergy and biobased products in accordance with state and regional goals that support DOE's plans and strategies; investigate specific performance issues of biobased industrial lubricants; to develop economically and environmentally sound technologies to promote efficient biopower or bioenergy, transportation biofuels, and bioproducts such as marketable chemicals and hydrogen; and install a heating system that uses wood chips for fuel to heat an elementary school in Nevada.	Environmental Assessment, Equity and debt financing, Power Purchase Contract, Air permitting	There is no information available to identify accomplishments towards Roadmap Objectives	4.1.3.1 Energy from Biomass Research and Technology Transfer Program Project; 7.05.4.GO85002 Mississippi Technology Alternative Energy Enterprise Program	**FY2003**	**$1,935**
					FY2004	**$2,946**
					FY2005	**$5,952**

Roadmap Main Category Sub-	**V. Public Policy Measures to Support Biomass Development**					
	Objective Two - Outline the institutional and policy changes needed to remove the barriers to economically sound development of sustainable biomass systems					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
N/A	Although no projects have been identified under this Roadmap category, there is a lack of information available to identify goals, accomplishments towards roadmap objectives, and technical barriers. Some projects identified are crosscutting through the objectives in the Public Policy Measures to Support Biomass Development category.				**FY2003**	**$0**
					FY2004	**$0**
					FY2005	**$0**

Roadmap Main Category Sub-	**V. Public Policy Measures to Support Biomass Development** Objective Three - Ensure that the biomass technologies developed are environmentally sound and move the country in the direction of sustainable biomass systems					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Program Management	The objectives are to provide continuity to the coordination of the Black Liquor Gasification Program between DOE/HQ and NETL, to support NETL in the management of the program, provide technical and engineering support for the demonstration projects, assisting in the development of an Environmental Assessment (EA) or other NEPA documents as needed, to assist NETL in coordinating the review of proposals received in response to the Black Liquor Gasification R&D Solicitation and Lab Call, and provide support to the Black Liquor Gasification Cost/Benefit Analysis	Lack of data for low temperature steam reforming projects to support the above analyses; Integration and cost of biomass processes; Lack of consensus on impact or direction for biomass; State & Local Partnerships	See page 23 in the Biomass R&D Portfolio: Accomplishments Towards Roadmap Objectives	6.1.1.1.3 Golden Support Contract; 6.1.1.1.4 NETL Support Contracts; 6.1.2 National Laboratory Integration; 6.1.2.1 Management (NREL); 6.1.2.3 Partnership Development (NREL); 6.2.2 Strategic Analysis; 6.3.1.2 Buy Bio Initiative Task	**FY2003**	**$3,833**
					FY2004	**$3,193**
					FY2005	**$5,698**
Earmarks	No information is available to describe the technical goals of these earmarks.	No information is available to describe the R&D challenges of these earmarks.	There is no information available to identify accomplishments towards Roadmap Objectives	7.04.4.GO14260 Restoration of Gleason Creek Watershed	**FY2003**	**$0**
					FY2004	**$0**
					FY2005	**$248**
Roadmap Main Category Sub-	**V. Public Policy Measures to Support Biomass Development** Objective Four - Enhance opportunities for rural economic development					
U.S. Department of Energy - By OBP Work Breakdown Structure Area	**Technical Goals**	**R&D Challenges**	**Accomplishments towards achieving Roadmap Objectives**	**WBS #, Project Titles, Major R&D Performers**	**Federal Funds**	
Earmarks	No information is available to describe the technical goals of these earmarks.	No information is available to describe the R&D challenges of these earmarks.	There is no information available to identify accomplishments towards Roadmap Objectives	7.05.4.9999999 Undetermined- Regional Biomass Energy Program (04 EARMARK); 7.05.4.GO85005 National Biofuel Energy Laboratory 7.05.4.GO85050 Regional Biomass Program; 7.05.4.NT99999 National Conference of State Legislators - Regional Biomass Energy Program (04 EARMARK); 7.05.4.R110953 Vermont Biomass Energy Center, Burlington, VT (04 EARMARK)/ FY 2005 $0.5M less general reduction,$496K.; 7.05.4.SRO9999 Seattle- Western RO - Regional Biomass Energy Program (05EARMARK); 7.05.5.GO85014 Research Extension, and Educational Programs on Bio-based Energy Technologies and Products; 7.05.5.GO85016 Livingston Parish Alternative Fuel Plant Construction	**FY2003**	**$0**
					FY2004	**$0**
					FY2005	**$4,879**