



National Renewable Energy Laboratory

# Technical initiatives linked to policy in the United States

Presentation to IEA Task 39  
Liquid Biofuels

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by

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# The U.S. Energy Picture

- Crude-oil production in the U.S. peaked in 1970, and domestic natural-gas production peaked in 1973.
- Despite various programs over the past three decades, imports account for an ever greater share of the U.S.'s energy.
- Every president starting with Richard Nixon has promised to reduce America's ravenous appetite for oil while investing heavily in new energy sources.
- Mainly for lack of imagination and political will, all have failed.

# U.S. Dependence on Foreign Oil

## Have Oil

Saudi Arabia	26%
Iraq	11%
Kuwait	10%
Iran	9%
UAE	8%
Venezuela	6%
Russia	5%
Mexico	3%
Libya	3%
China	3%
Nigeria	2%
U.S.	2%

## Use Oil

U.S.	26%
Japan	7%
China	6%
Germany	4%
Russia	3%
S. Korea	3%
France	3%
Italy	3%
Mexico	3%
Brazil	3%
Canada	3%
India	3%

**The U.S. uses more than the next 5 highest consuming nations combined.**

Updated August 2002

Source: International Energy Annual 1999 (EIA), Tables 1.2 and 8.1.

# The Office of the Biomass Program

## “Goals and Objectives”

- Energy Security
  - Dramatically reduce or even end dependence on foreign oil
    - Biomass is the only renewable that directly reduces or dependency on liquid transportation fuels
- Economics
  - Spur the creation of a domestic bioindustry
    - The new industrial biorefinery model, with its production of products including fuels and chemicals from biomass, will help enable this domestic industry
- Environment
  - Carbon Neutral Processes
  - Lower GHG emissions
- Part of the EERE answer
  - Biomass to Hydrogen
  - Distributed Energy
  - Industrial Efficiency

# Key Drivers

**Biomass Program responds to executive and congressional directives:**

- Biomass R&D Act of 2000
- Farm Bill 2002, Title IX
- National Energy Policy

**Investment Guidance:**

- DOE Strategic Plan
- EERE Strategic Plan/Priorities
- Advisory Committee Vision, Roadmap, & Recommendations
- Program/Project Evaluations

# Results Driven

- The President's Management Agenda
  - *“Government likes to begin things—to declare grand new programs and causes and national objectives. But good beginnings are not the measure of success. What matters in the end is completion. Performance. Results.”* George W. Bush
- Biomass, like the other EERE programs, must show results for the funds invested
- Formal integration of performance review with budget decisions
- Performance-oriented budgeting and management
- Integrated information systems with cost and performance

# Program Goal Hierarchy



Protect national & economic security by promoting sound energy supplies

Reduce dependence on foreign oil

Create the new domestic bio-industry

Develop new industrial bio-refinery & bio-based economy

2005: Demonstrate integrated process for fuels production

2007: Complete technology development to demonstrate bio-refinery, chemicals & power

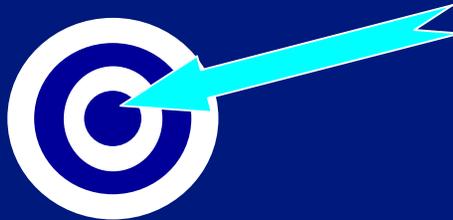
2010: Help U.S. industry to establish the first large-scale bio-refinery

## Target Goals

✓ \$6 per MMBtu syngas

✓ \$0.07 per lb sugars

✓ Industrial viability of four commodity scale products



# Why 2001 – 2002 DOE Emphasis Shifting to Biorefineries?

- Advantages of Biorefinery over Stand-alone Bioethanol Facility
  - Higher revenue from higher value products help offset high capital cost of first plants
  - Producing an array of products will limit downside risk for those financing plant
  - Industrial firms have immediate needs for intermediate product streams if they can compete with existing petroleum-based sources
    - Plastics
    - Polymers
    - Low molecular weight lignins

# New Biorefinery Emphasis (cont.)

- DOE Biorefinery Roadmap – industry input on R&D needs for rapid growth 2000 – 2020
- Biomass R&D Act of 2000
- Industry input to DOE and NREL at series of colloquies and NREL review meetings in 2001 – 2002 (participants included chemical companies, biotechnology firms, enzyme producers, ethanol producers, agricultural processing firms).

They said:

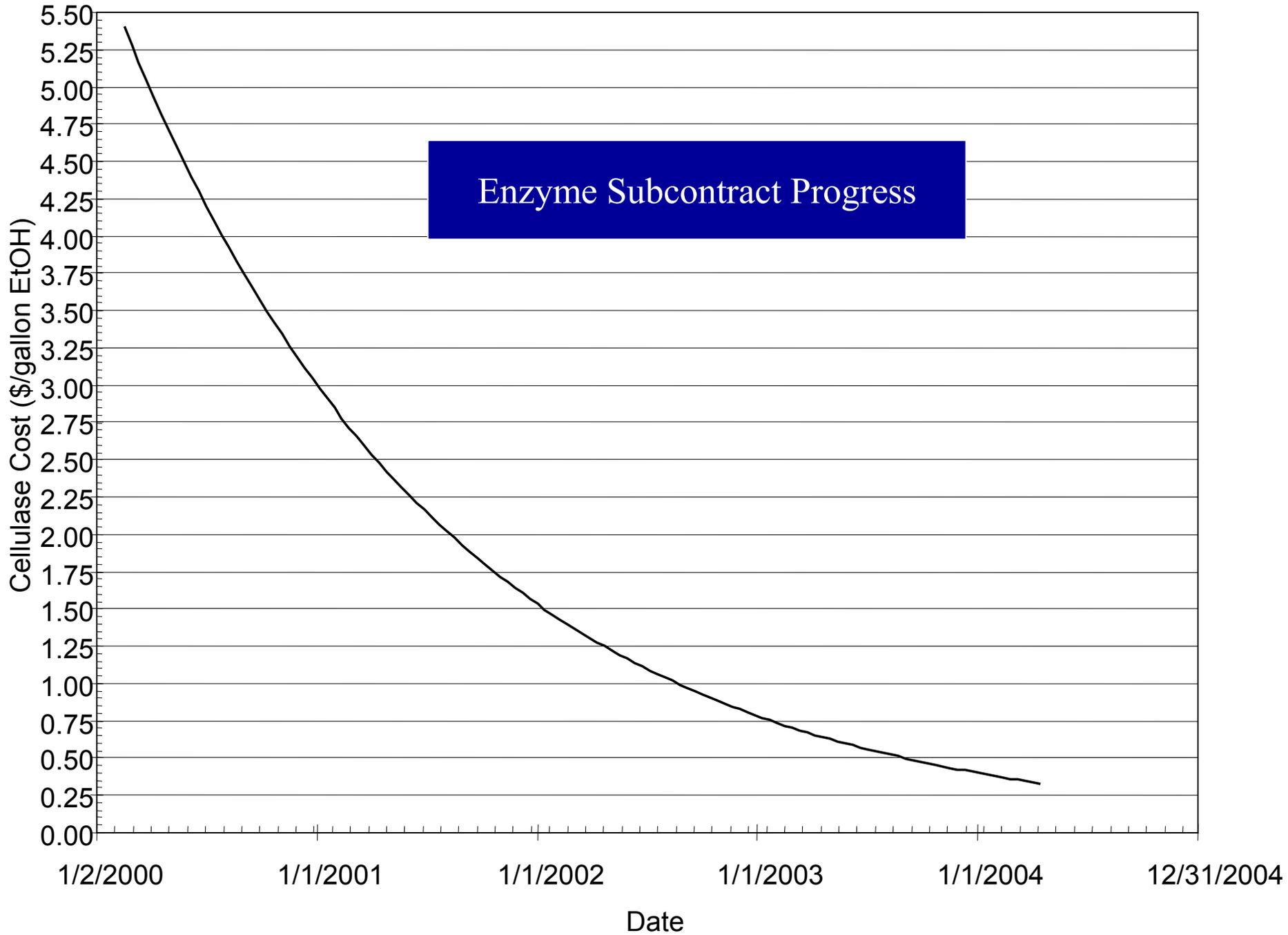
- Bulk commodities like cellulosic ethanol will be produced only after conversion and fermentation technologies are proved in initial pilot and commercial plants
- Higher value products with existing markets like chemicals, fuel additives, and nutraceuticals will attract investment capital
- First plants need to demonstrate stable, continuous processing under industrial conditions for some set of products – then worry about foreign oil displacement, etc.

# 2002 DOE Biomass R&D Solicitation

- Specified industry-led teams leading toward design and construction of pilot plant for producing fuels, chemicals or valuable co-products
- DOE put up total stake of \$80 million -- \$20 million for each of 4 years, starting in FY 2003
- Teams could propose scale of effort, location, and processes to be used
- Required at least 50% industrial cost-share of total project expenses
- Awarded 6 contracts

# New Direction: Enabling the Biorefinery

- Progress at NREL and other R&D labs have brought process efficiency near to target levels
- Focus now on cost reduction and getting the first commercial scale plant(s) financed and built with private sector funds
- Enzyme costs limiting factor, so 2 large contracts let to Genencor & Novozymes to reduce cellulase costs by 10X by 2004
- Increased industrial input on future direction to get needed investment and factory design expertise
- Increasing expectation of close cooperation with USDA on bio-based products, chemicals and feedstocks



# Farm Bill - Title IX -- Energy

Program	Notes	Cost
<b>CCC Bioenergy Program</b>	<b>Provides mandatory funding for the CCC Bioenergy Program, which will enable the Secretary to continue making payments to bioenergy producers who purchase agricultural commodities for the purpose of expanding production of biodiesel and fuel grade ethanol.</b>	<b>\$204 million</b>
<b>Biobased Product Purchasing Preference</b>	<b>Establishes a new program for the purchase of biobased products by Federal agencies.</b>	<b>\$6 million</b>
<b>Biodiesel Fuel Education</b>	<b>Creates a grant program to educate government and private fuel consumers about the benefits of biodiesel fuel use.</b>	<b>\$5 million</b>
<b>Renewable Energy System &amp; Energy Efficiency Improvements</b>	<b>Establishes a loan, loan guarantee &amp; grant program to assist farmers in purchasing renewable energy systems and making energy efficiency improvements.</b>	<b>\$115 million</b>
<b>Biomass Research and Development Act of 2000</b>	<b>Reauthorizes and funds the Biomass Research and Development Act through FY 2007.</b>	<b>\$75 million</b>
		<b>Total: \$405 million</b>

# Implementation Title IX- Section 9006 – 2002

## Farm Bill – Renewable Energy

- USDA selected 113 applications for renewable energy systems and energy efficiency improvement grants in 24 states totaling \$21,207,233.
- Renewable energy systems awarded
  - 35 applications /\$7.4 million to support wind power,
  - 30 applications / \$7 million for anaerobic digesters,
  - 6 applications / \$1.1 million solar and
  - 16 applications / \$3.9 million for ethanol plants/anaerobic digesters, direct combustion and fuel pellet systems.
- Awards were made on a competitive basis for the purchase of renewable energy systems and to make energy improvements (25% govt).
- The grant program is part the overall effort to increase America's energy independence through the development of renewable energy resources as well as improving efficiency of existing systems.

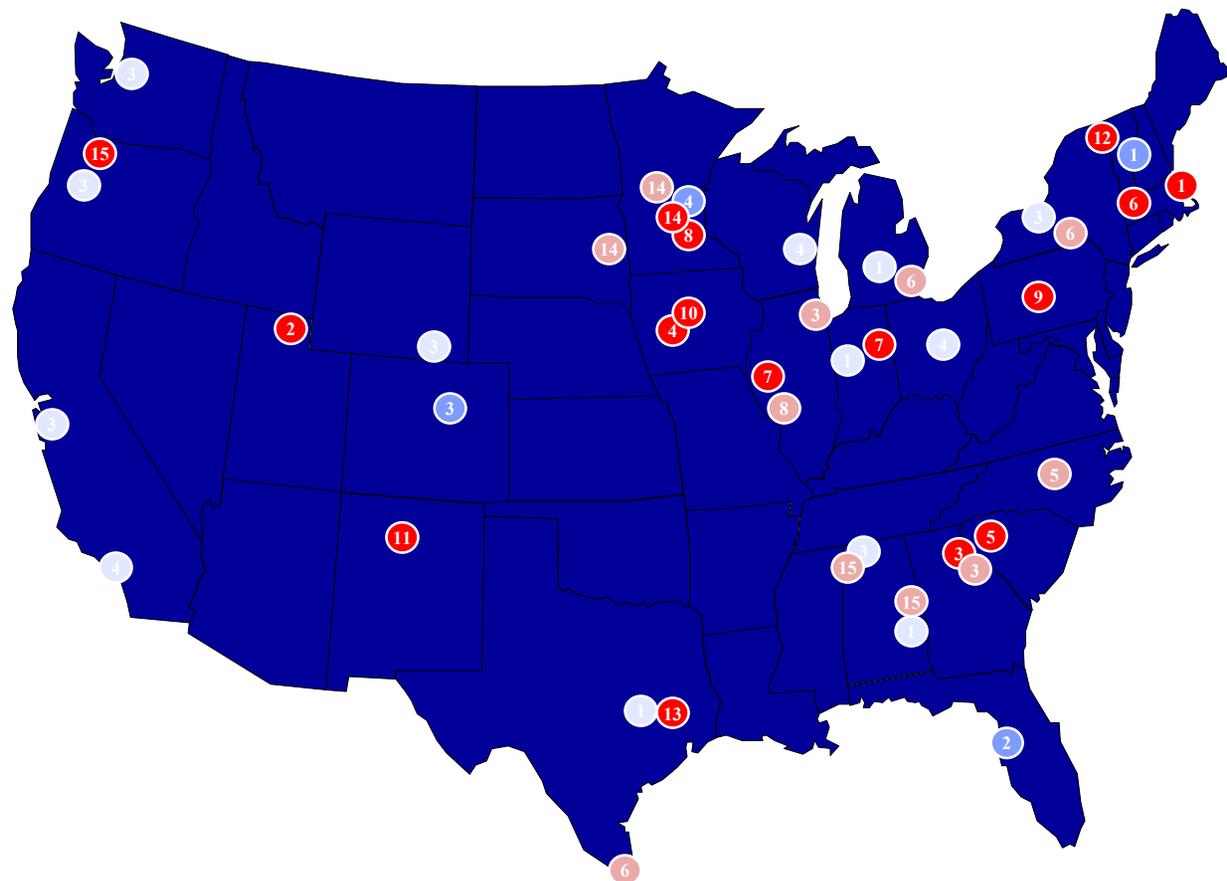
# FY03 USDA-DOE Biomass Solicitation

## DOE's Projects

1. Trustees of Dartmouth (Hanover, NH)
2. University of Florida (Gainesville, FL)
3. Pure Vision Technology, Inc. (Ft. Lupton, CO)
4. Cargill, Inc. (Minneapolis, MN)

## USDA's Projects

1. Metabolix, Inc. (Cambridge, MA)
2. Utah State University (Logan, UT)
3. Earth Resources, Inc (Carnesville, GA)
4. West Central Cooperative (Ralston, IA)
5. Clemson University (Clemson, SC)
6. New Energy Solutions, Inc. (Pittsfield, MA)
7. Archer Daniels Midland Company (Quincy, IL & Decatur, IN)
8. Grain Value, LLC (St. Paul, MN)
9. Pennsylvania State University (University Park, PA)
10. Iowa State University (Ames, IA)
11. Local Energy (Tesuque, NM)
12. Vermont's Alternative Energy Corporation (Williston, VT)
13. Texas Agricultural Experiment Station (College Station, TX)
14. Sebesta, Blomberg, & Associates, Inc. (Roseville, MN)
15. T.R. Miles Technical Consultants, Inc. (Portland, OR)



● DOE Primary Contractor  
● DOE Subcontractor

● USDA Primary Contractor  
● USDA Subcontractor

# Biomass Program

## 1.0 Feedstock Interface

1.1 Emerging Feedstock

1.2 Advanced Feedstock Core R&D

1.3 Feedstock Supply Chain Analysis

## 2.0 Sugar Platform

2.1 Pretreatment

2.2 Enzymes Core R&D

2.3 Sugar Platform Process Integration

2.4 Fundamentals and New Concepts

2.5 Sugar Platform Analysis

## 3.0 Thermochemical Platform

3.1 Feed Process and Handling

3.2 Thermochemical Processing

3.3 Clean-up and Conditioning Core R&D

3.4 Sensors and Controls Core R&D

3.5 Thermochemical Platform

## 4.0 Products

4.1 Fuels

4.2 Chemicals & Materials

4.3 Combined Heat and Power

4.5 Analysis for Products

## 5.0 Integrated Biorefineries

5.1 Sugar Biorefineries

5.2 Thermochemical Biorefineries

5.5 Integrated Biorefinery Analysis

## 6.0 Program Management

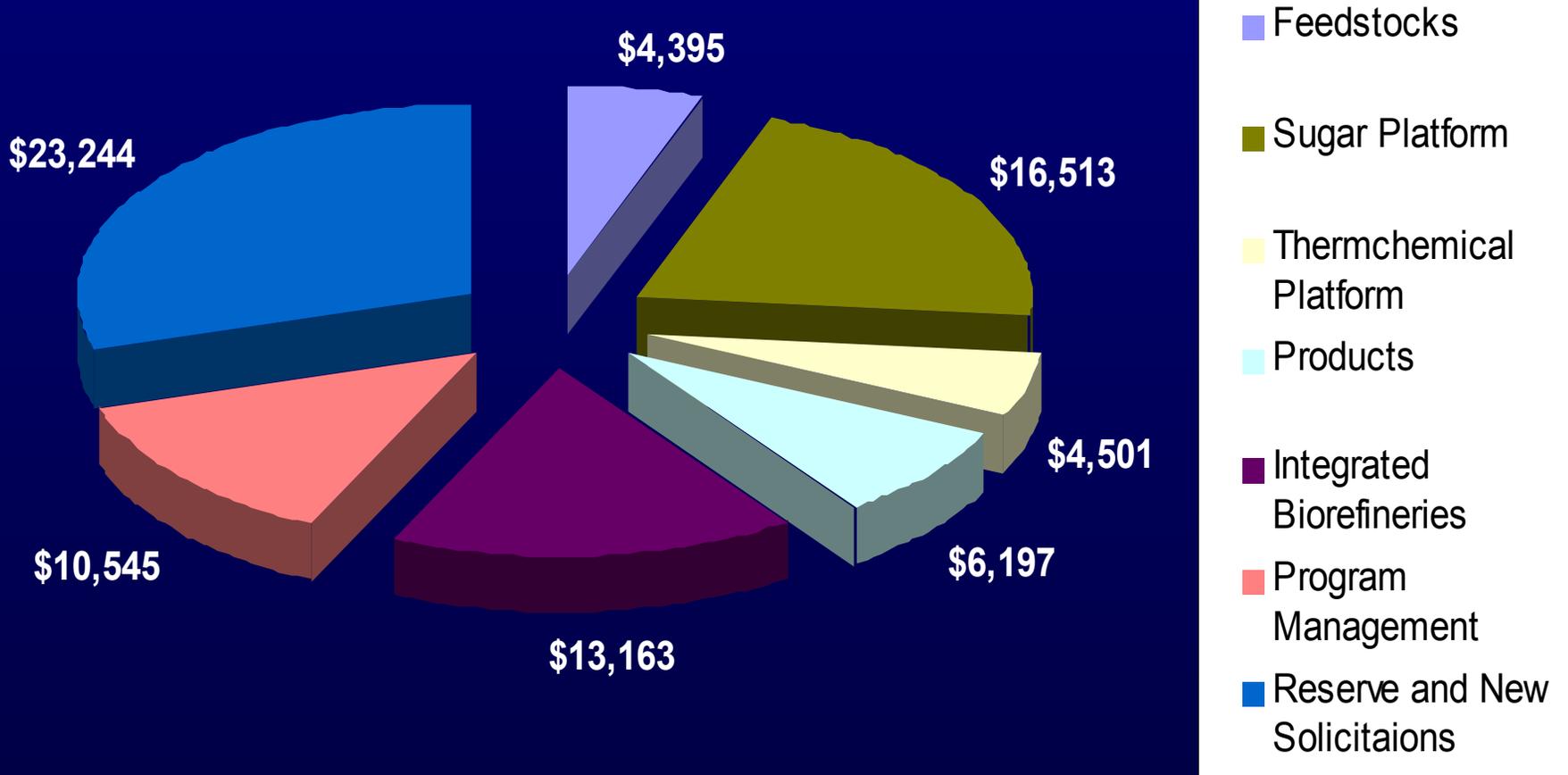
6.1 Management and Integration

6.2 Program Analysis

6.3 Outreach, Education & Partnerships

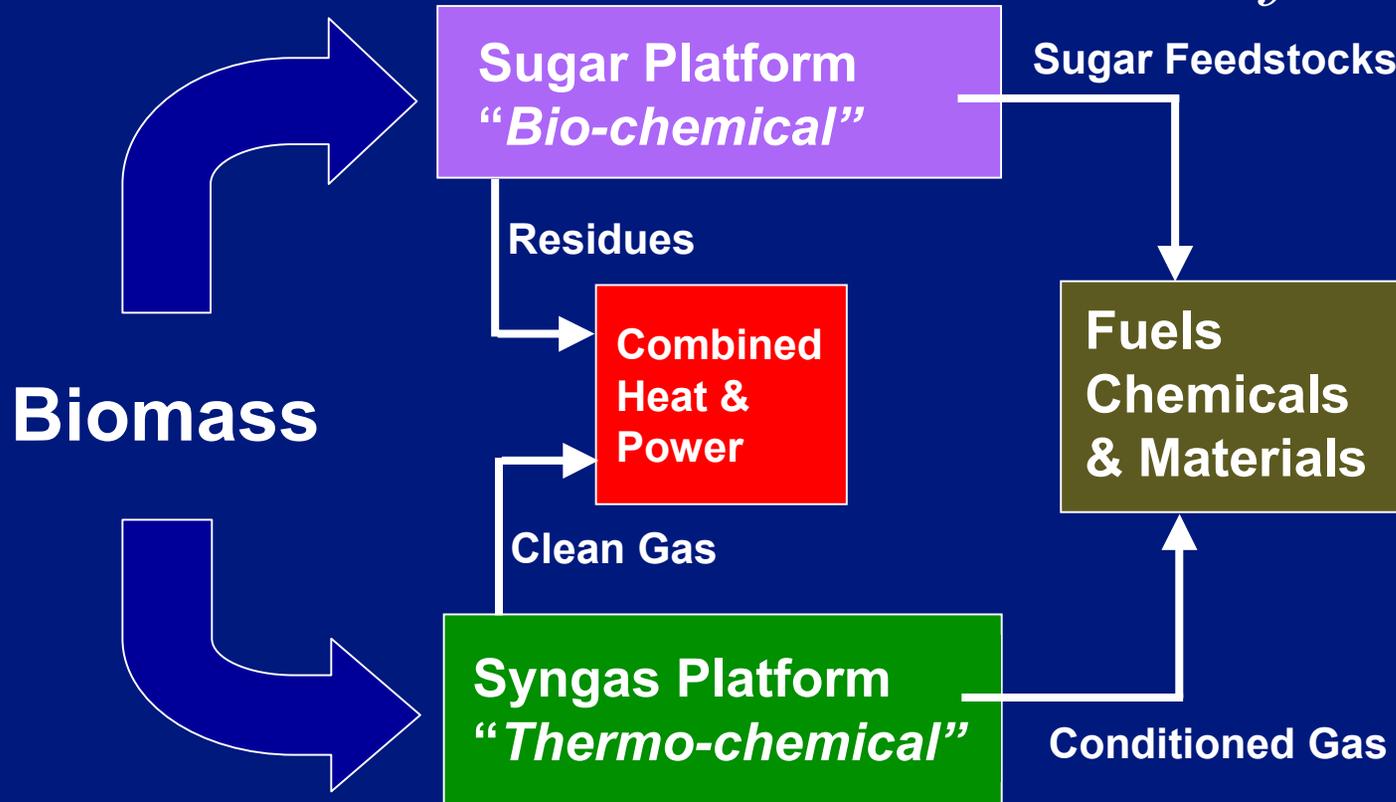
# BP FY04 Budget Components (\$K)

Total Budget Request: \$78.56M



# DOE - Office of the Biomass Program

## *“Core” Biomass Conversion Platforms*



# 2.0 Sugar Platform

## 2.1 *Pretreatment*

### 2.1.1 NBC Pretreatment

Emerging  
Pretreatment Options

2.1.2  
GO CAFI Low pH  
Hydrolysis  
(Dartmouth)

2.1.3  
GO CAFI Integration of  
Leading Pretreatment  
Technologies...  
(Dartmouth)

## 2.2 *Enzymatic Hydrolysis*

### 2.2.1 NBC Enzymatic Hydrolysis

10x Enzyme  
Improvement

25x Enzyme  
Improvement

50x Enzyme  
Improvement

### 2.2.2 NBC Genencor CRADA

## 2.3 *Integration*

### 2.3.1 NBC Sugar Platform Integration

Enzyme Sugar  
Platform

## 2.4 *Fundamentals and New Concepts*

### 2.4.1 NBC Fundamentals and New Concepts

Biomass Structure

Chemical Process  
Fundamentals

Biological Process  
Fundamentals

New Concepts

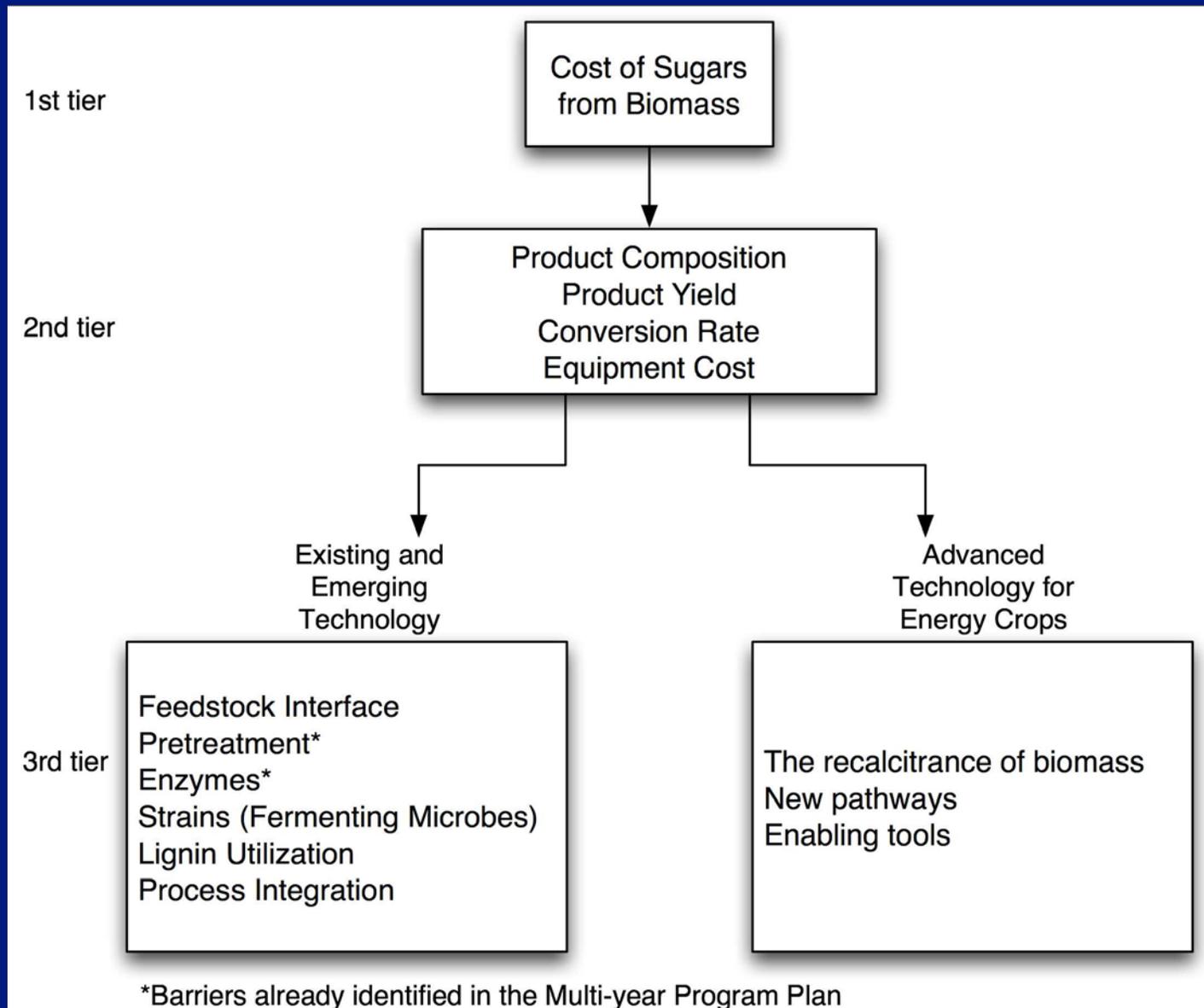
Biomass Surface  
Characterization

2.4.2  
GO Dilute Acid  
Hydrolysis (Auburn)

2.4.3  
GO Complementation of

## 2.5 NBC Sugar Platform Analysis

# Technical Barriers



# What We Need: An Integrated Approach

