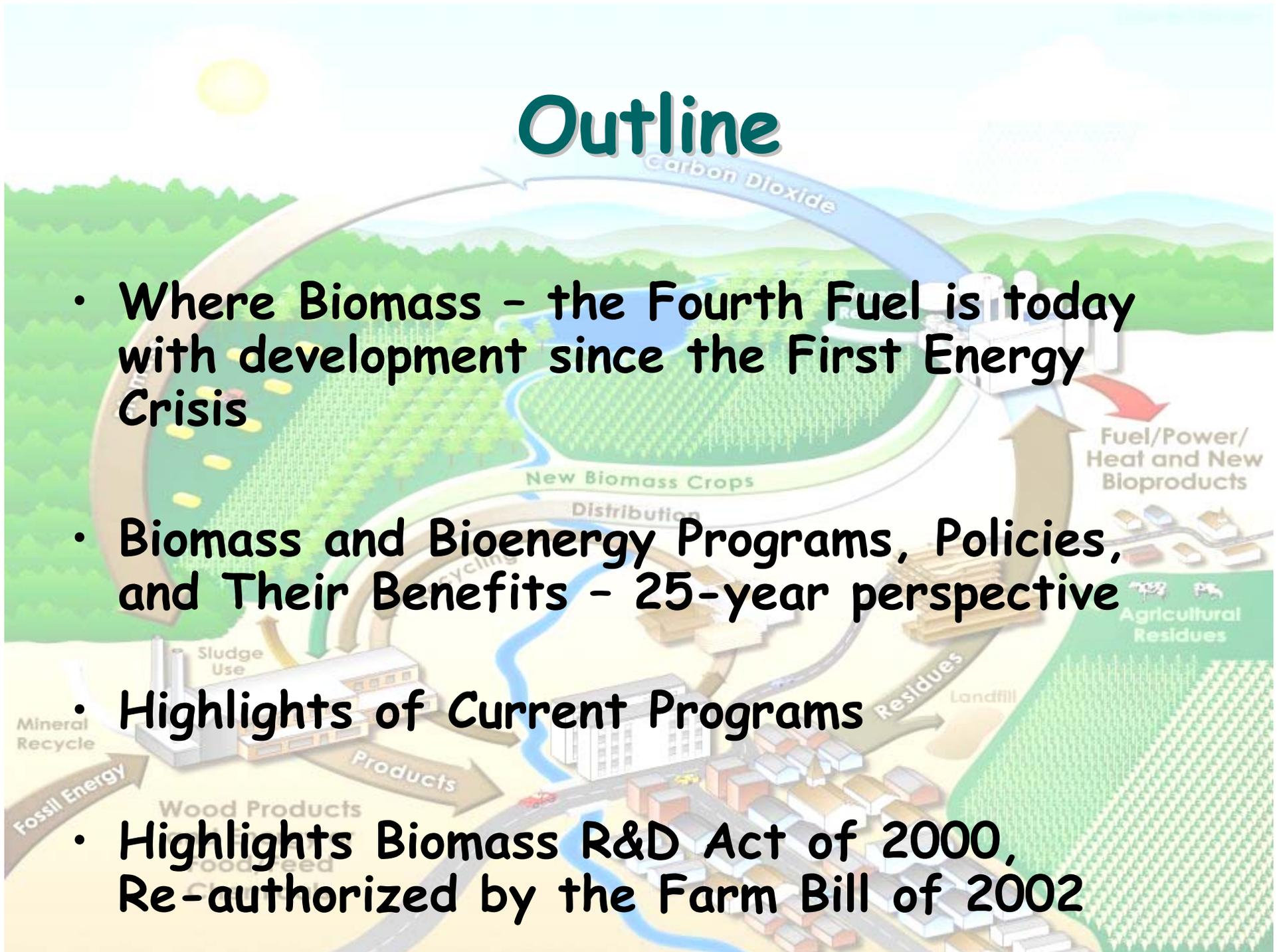
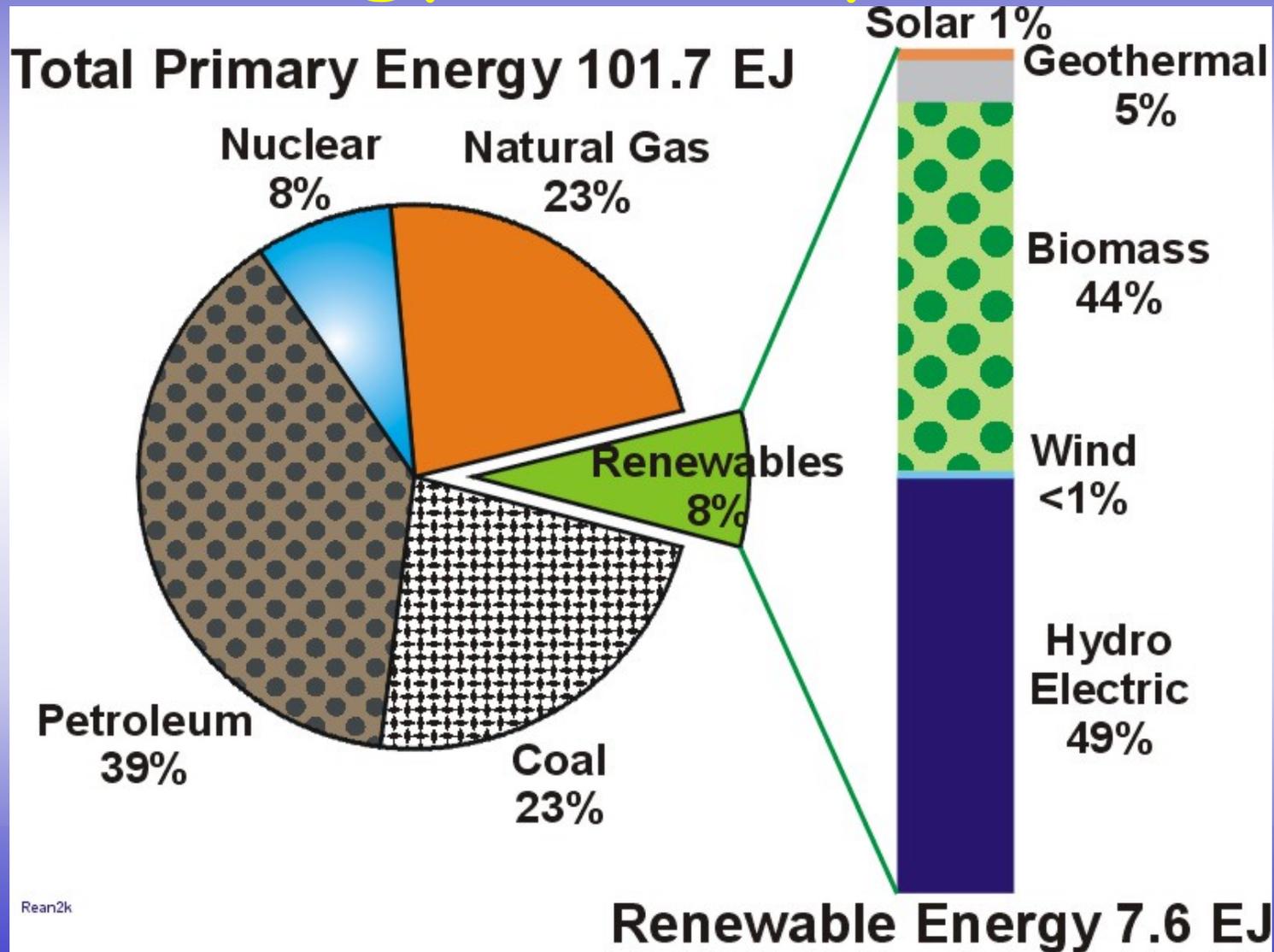


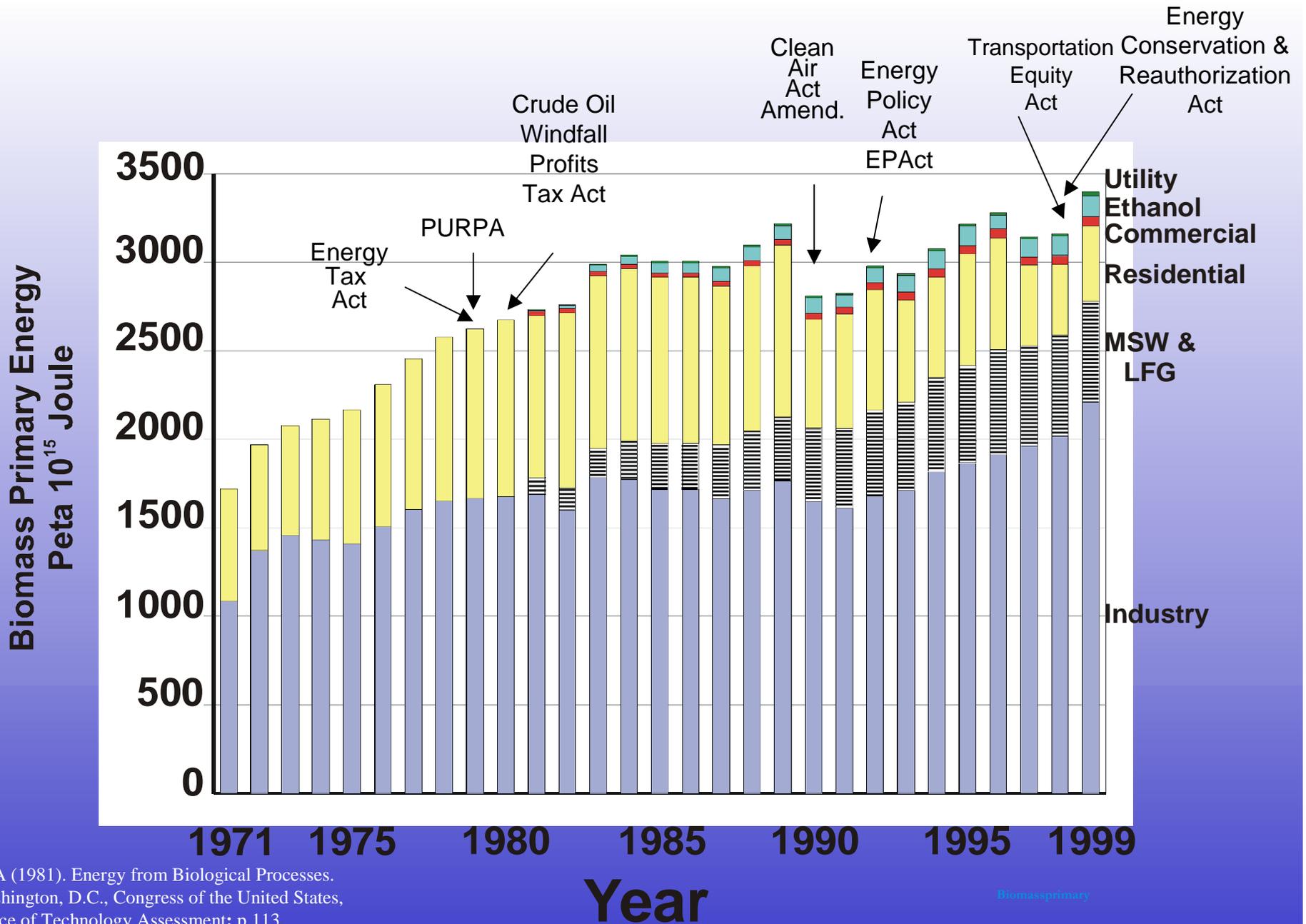
Outline

- Where Biomass - the Fourth Fuel is today with development since the First Energy Crisis
- Biomass and Bioenergy Programs, Policies, and Their Benefits - 25-year perspective
- Highlights of Current Programs
- Highlights Biomass R&D Act of 2000, Re-authorized by the Farm Bill of 2002



US Energy Consumption 2000

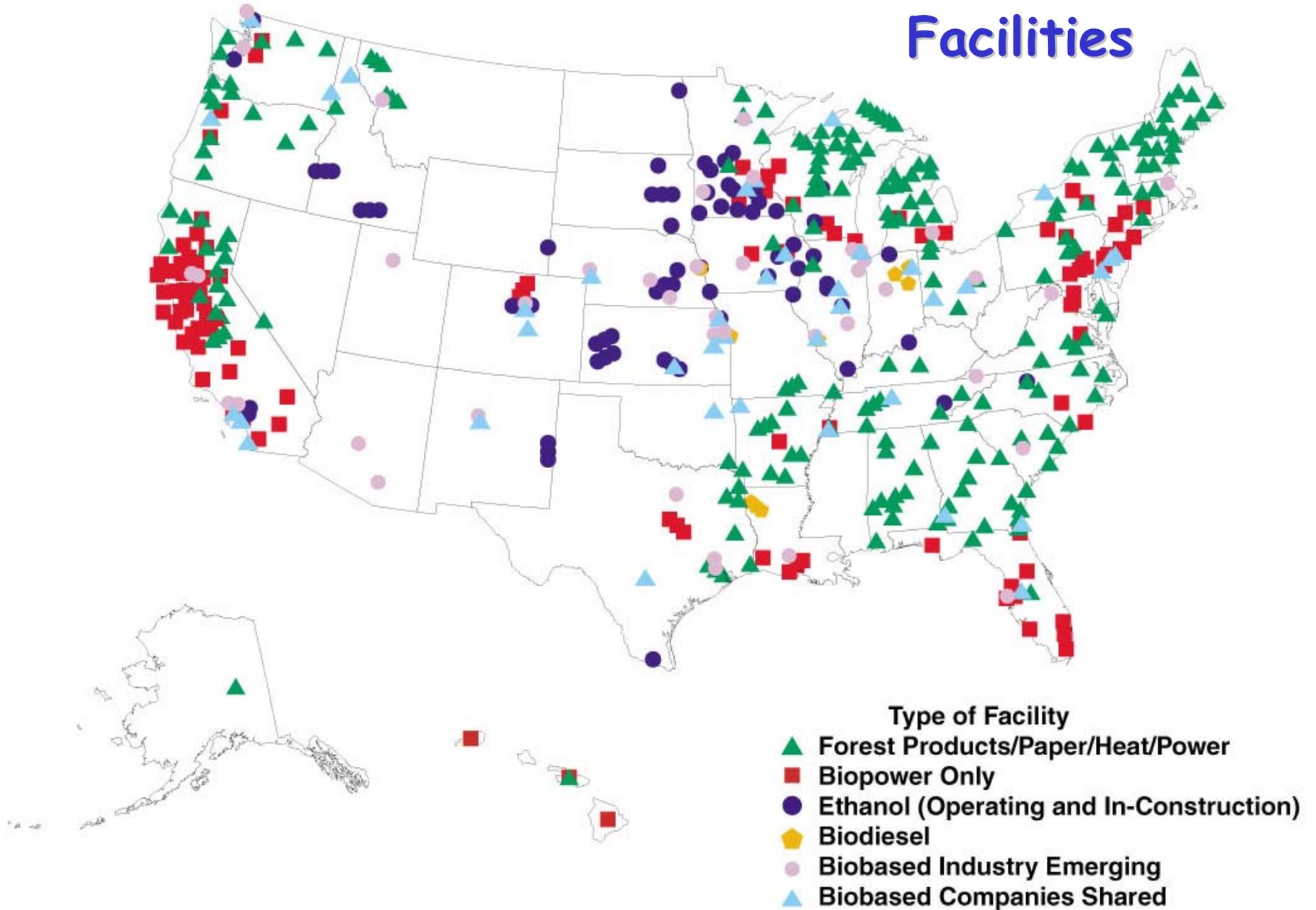




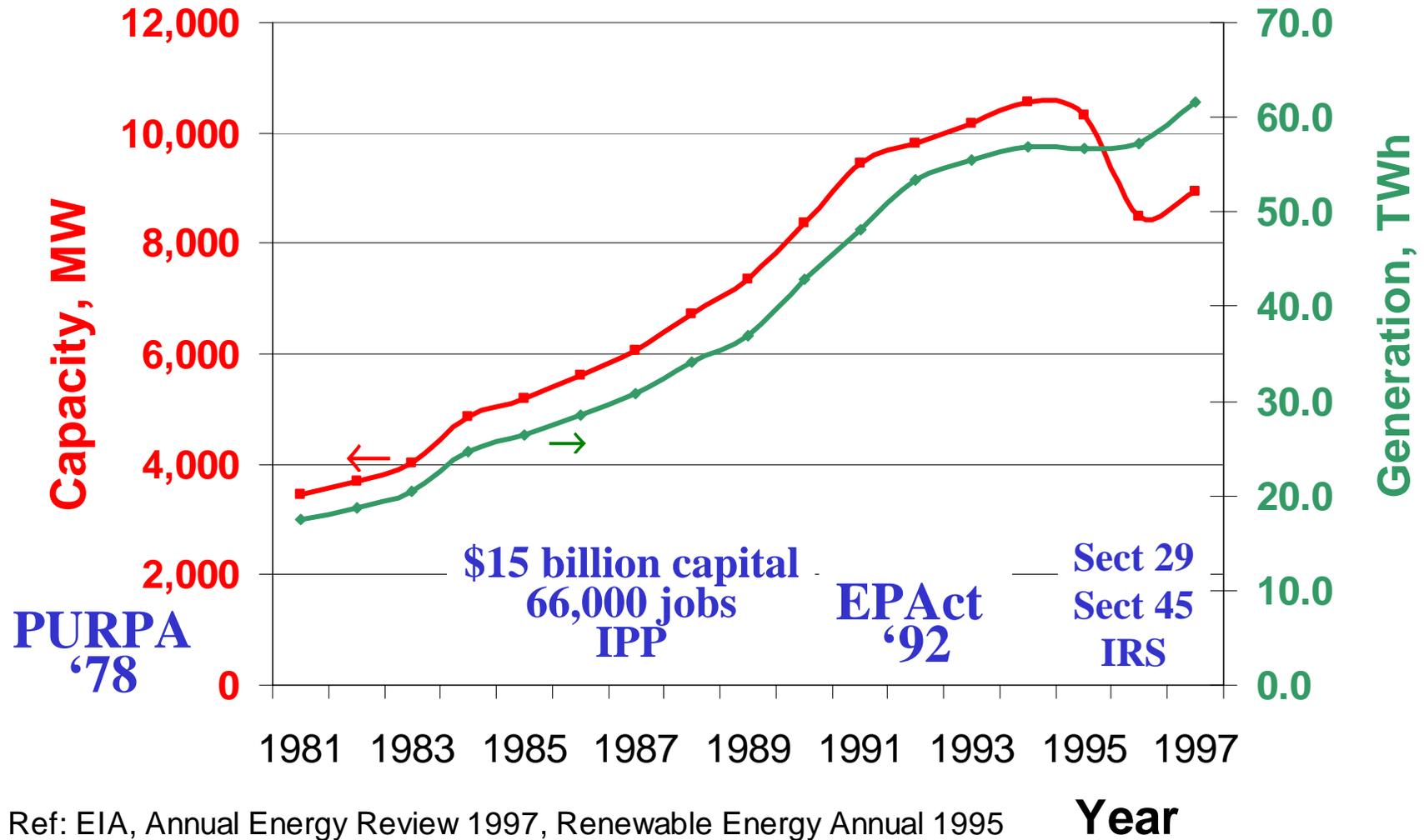
OTA (1981). Energy from Biological Processes.
Washington, D.C., Congress of the United States,
Office of Technology Assessment: p 113.
EIA (2000). Renewable Energy Annual 1999.
DOE/EIA 0603(99) Washington D.C., USA, 117.

1000 Peta Joules = 1 Exa Joule = 0.95 Quads

Examples of Bioenergy and Biobased Products Facilities



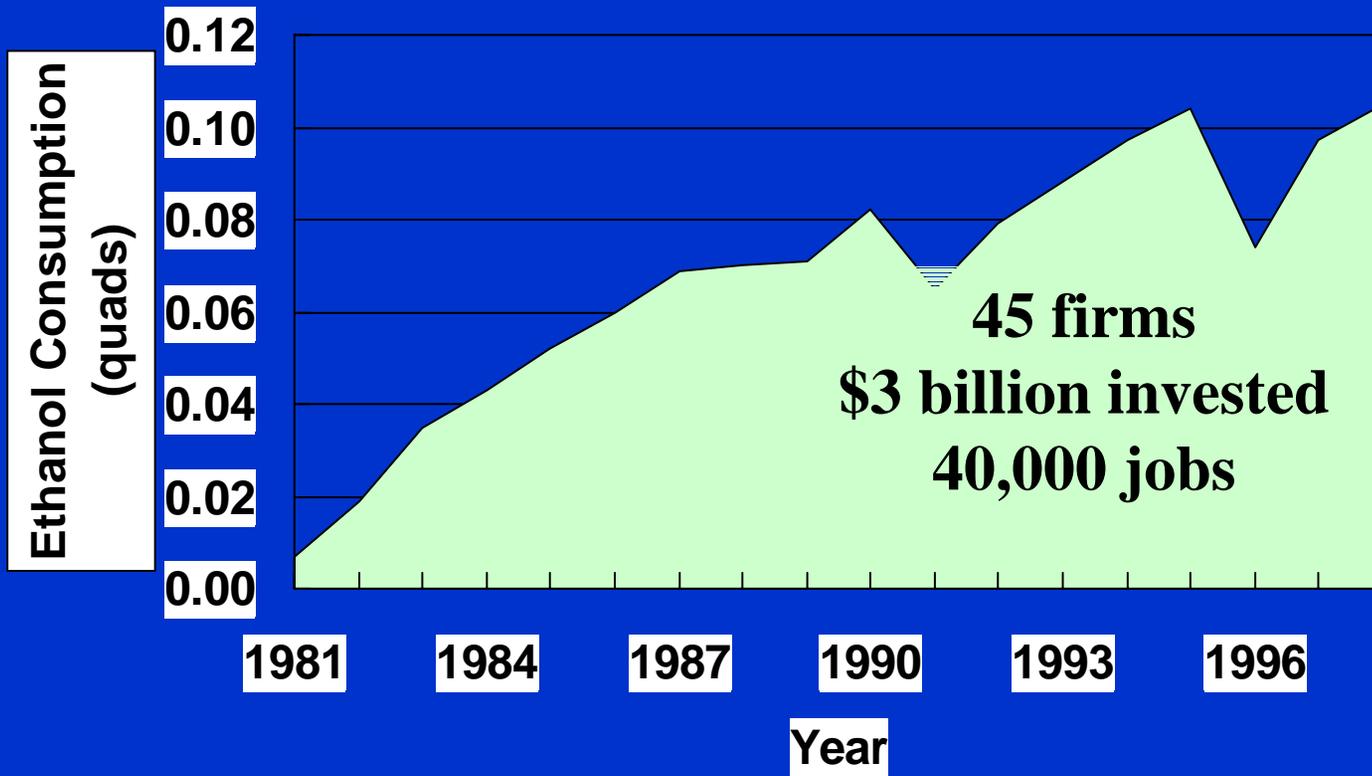
Bioenergy Electricity Generation, 1981 - 1997



Portugal: 39 TWh; UK: 343 TWh; Brazil: 350 TWh



Historical Ethanol Consumption



1.5 billion gallons
or equivalent to 1%
of gasoline
with
ethanol
from cornstarch

~\$750 million/yr
excise tax
exemption '99

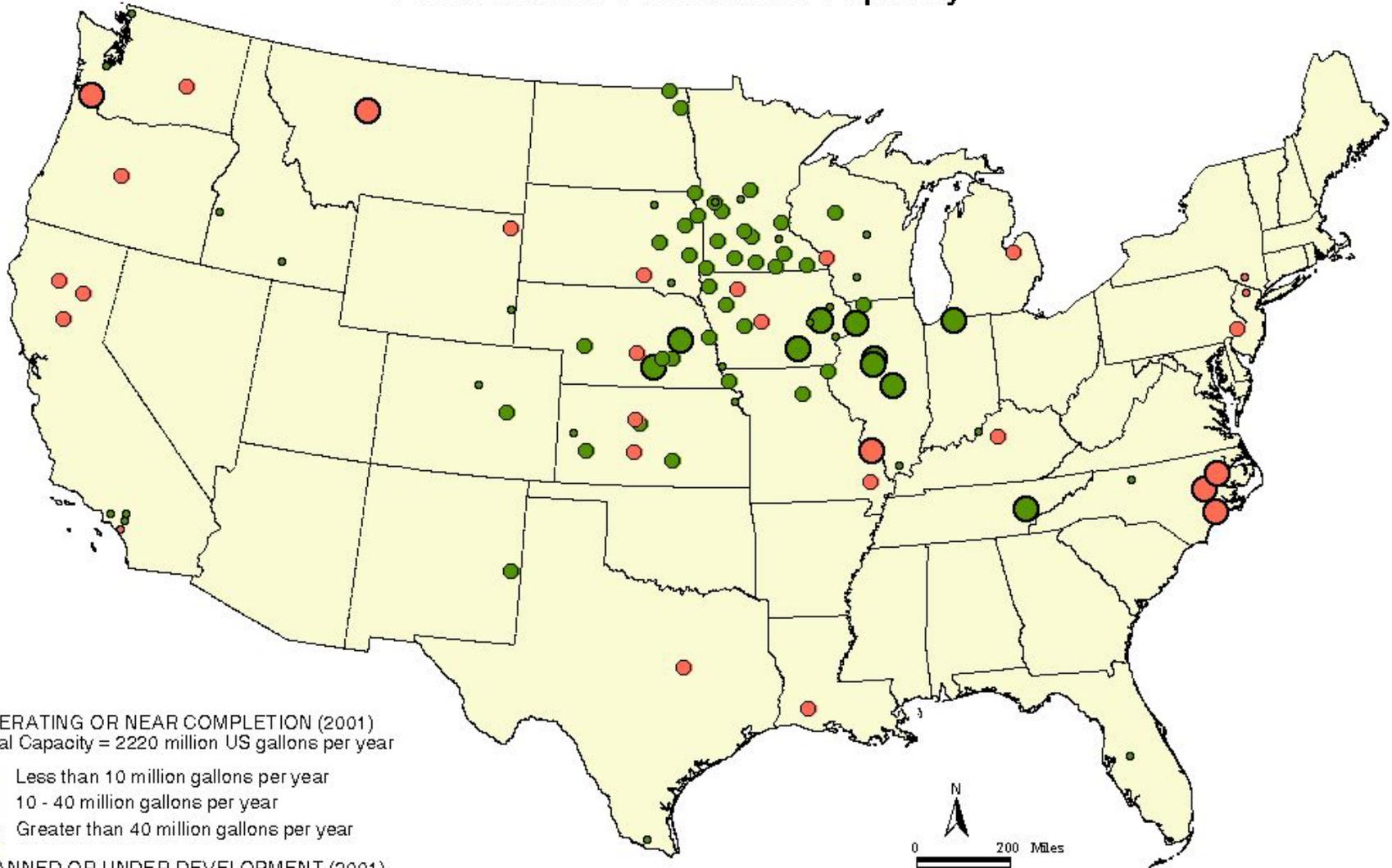
Replace
MTBE?

2000
installed
capacity
about
2.25 billion
gallons

Ref: Energy Information Administration,
<http://www.eia.doe.gov/pub/energy.overview/aer98/txt/aer1003.txt>

Ethanol in
Brazil
2-3 times
U.S. volume

USA Ethanol Production Capacity



OPERATING OR NEAR COMPLETION (2001)
Total Capacity = 2220 million US gallons per year

- Less than 10 million gallons per year
- 10 - 40 million gallons per year
- Greater than 40 million gallons per year

PLANNED OR UNDER DEVELOPMENT (2001)
Total Capacity = 943 million US gallons per year

- Less than 10 million gallons per year
- 10 - 40 million gallons per year
- Greater than 40 million gallons per year

Estimates compiled from various commercial/public sources.
Some geographical locations are approximate.

ORNL Bioenergy Feedstock Development Program
Oak Ridge National Laboratory 10/31/01.

Outcomes of Government Actions

- Primary Energy - doubled in 20 years
- Electricity Production - tripled in 10 years
- Ethanol Fuels Production - increased a factor of 16 in 20 years
- Forest Products Energy Self-sufficiency increased by nearly 50% in 20 years.
- Forest Products/Pulp and Paper Energy Intensity decreased initially and resumed increase in the 1992-1998 period.
- Overall Agriculture/Energy Interactions - **complex** (somewhat negative for soybean and cattle; somewhat positive for poultry)
- Municipal solid waste management --
 - Safe and responsible.
 - Recycling rates **tripled in 30 years.**
 - Primary energy from MSW/landfills increased by a factor of **6 in 20 years.**
- Significant emissions reductions, including carbon, and landfill reduction were achieved.
- Significant economic development including rural.

Summary of Key Bioenergy Federal Subsidies -- 1999

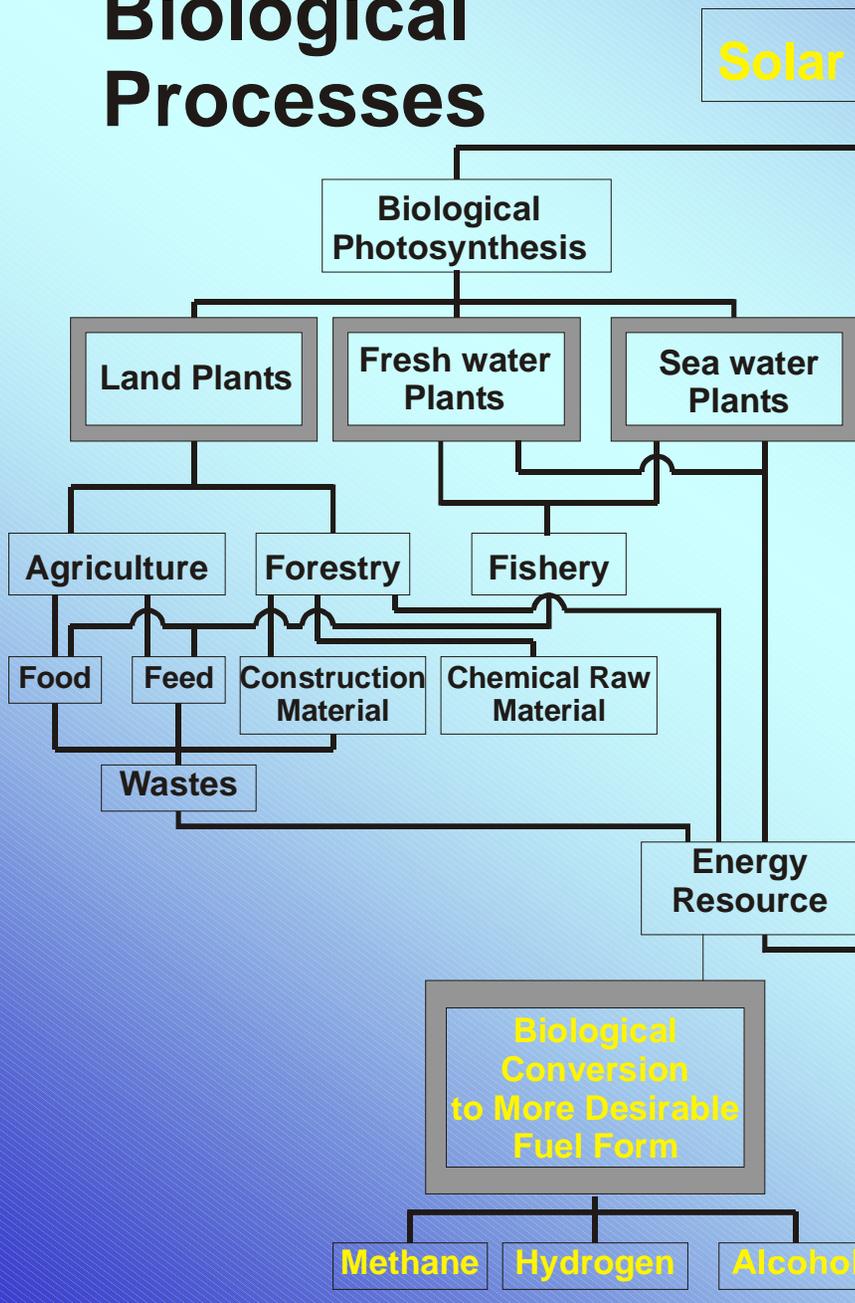
Type	Amount, million 2000 \$	Use/ Uptake by Private Sector*
Renewable Energy Production Incentive (direct expenditure)	\$2.6	Wood residues & landfill gas. Year to year appropriation - considered less effective than others
Internal Revenue Code, Section 29 Tax Credits	\$4.0	Alternative fuel (non- conventional) production credit - effective
Alcohol Fuel Credit	\$15	-- Somewhat effective production credit
Revenue loss estimate for the partial exemption from Excise Tax for Alcohol Fuels	\$680-\$725	Primarily used for ethanol - very effective in driving increased production. This revenue loss is offset by less direct govt payment to farmers due to increased grain consumption

*EIA/SR/01AF/99-03, Federal Financial Interventions and Subsidies in Energy Markets 1999: Energy Transformation and End Use, 2000; Renewable Energy 2000: Issues and Trends, Feb 2001, DOE/EIA -0628 (2000).
GAO/RCED-00-301R Tax Incentives for Petroleum and Ethanol Fuels, 2000

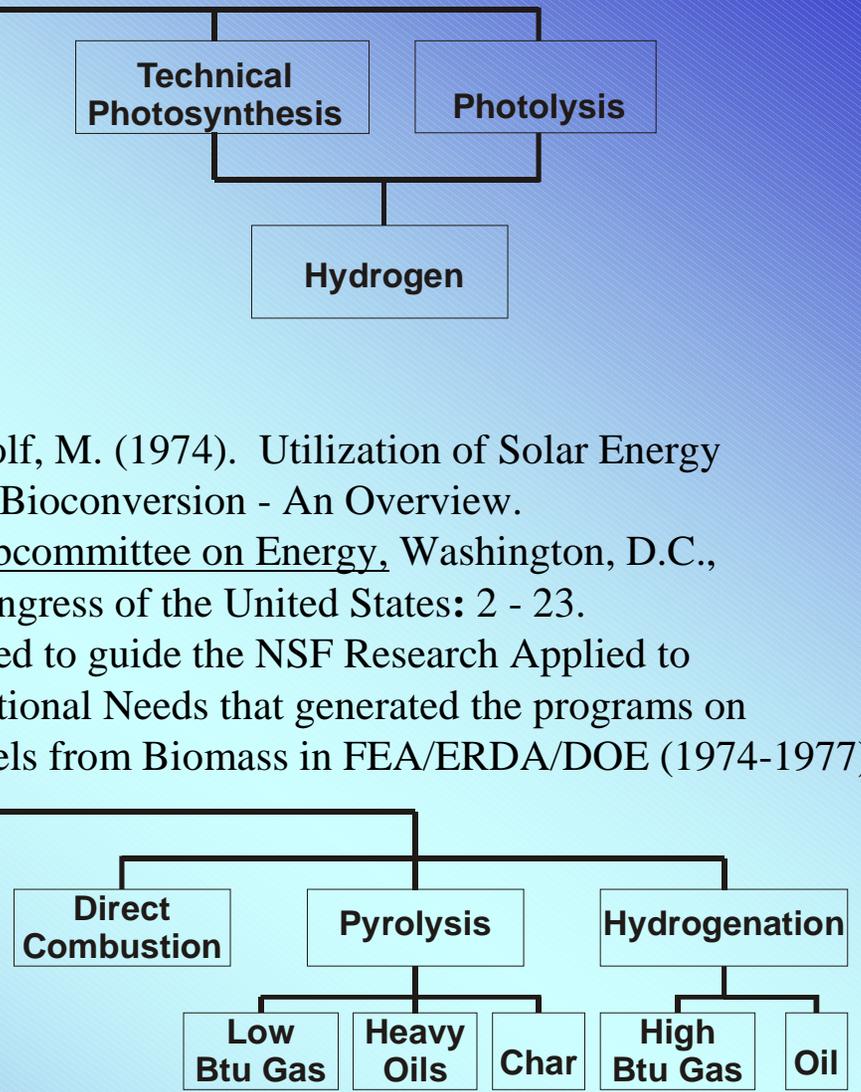
Tax Incentives for Ethanol and Some Major Incentives for Petroleum Fuels

Tax Incentive Expressed as Federal Outlay Equivalents	Summed over Years	Adjusted to 2000\$
Ethanol - Partial exemption from the excise tax for alcohol fuels	1979-2000	\$7.5 to \$11 billion (Treasury or Joint Committee on Taxation calculations). This revenue loss is offset by less direct govt payment to farmers due to increased grain consumption
Income Tax Credits for Alcohol Fuels	1980-2000	\$198-\$478 million (Treasury or Joint Committee on Taxation calculations)
Petroleum industry excess of percentage over cost depletion	1968-2000	\$82 billion
Petroleum industry expensing of exploration and development cost	1968-2000	\$42-\$54 billion (Treasury or Joint Committee on Taxation calculations)
Alternative (non-conventional) Fuel Production Credit	1980-2000	\$8.4-\$10.5 billion (Treasury or Joint Committee on Taxation calculations)

Biological Processes

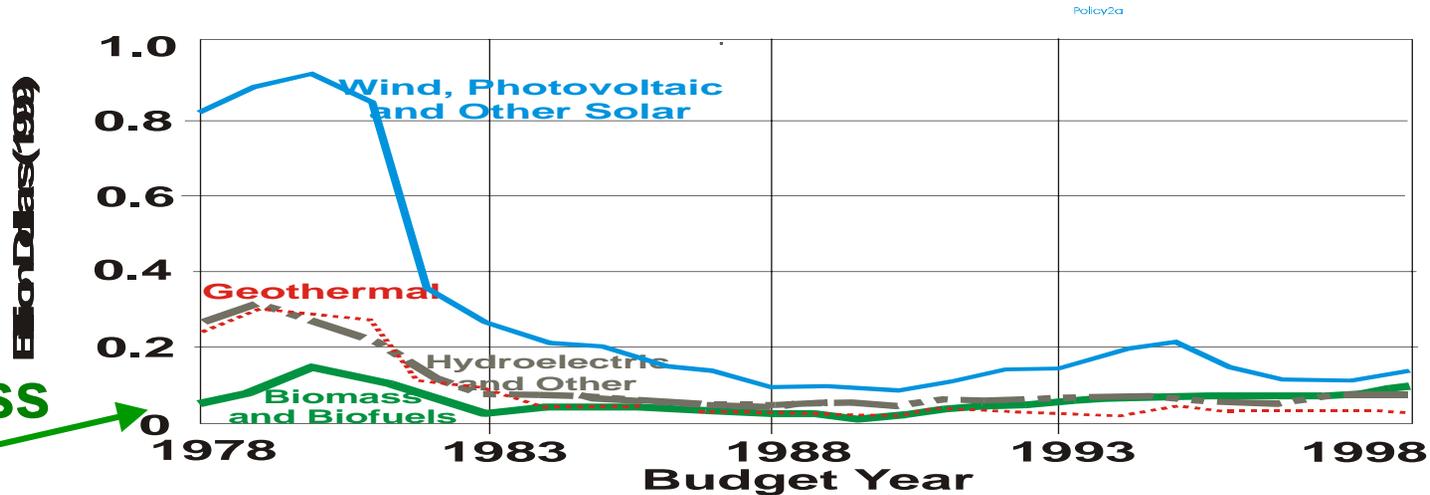
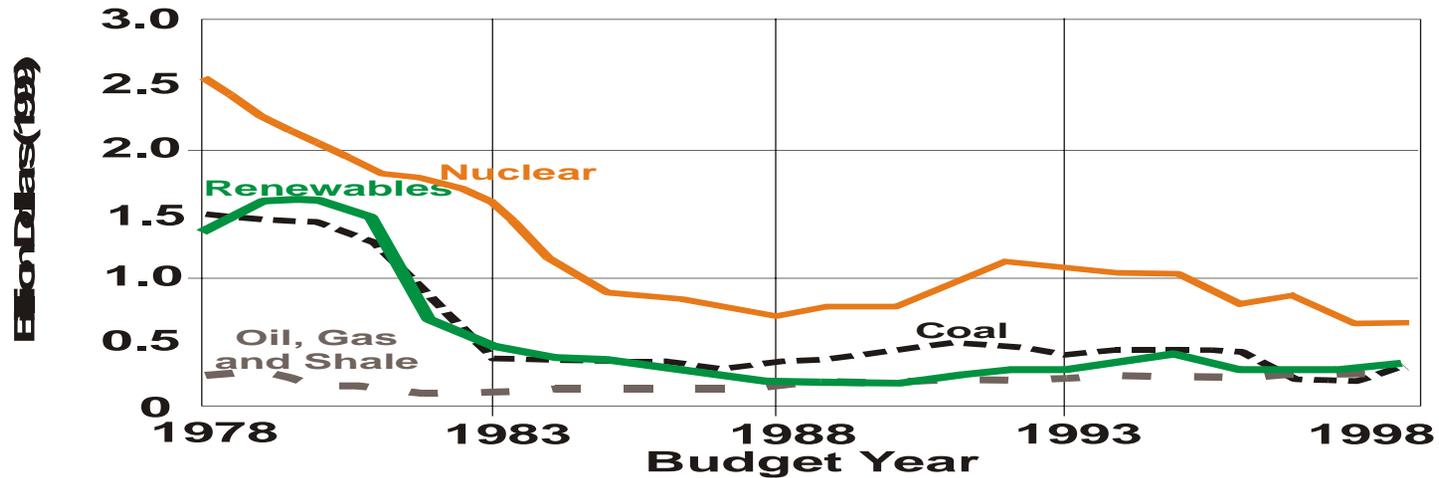


Technical Processes



Wolf, M. (1974). Utilization of Solar Energy by Bioconversion - An Overview. Subcommittee on Energy, Washington, D.C., Congress of the United States: 2 - 23. Used to guide the NSF Research Applied to National Needs that generated the programs on Fuels from Biomass in FEA/ERDA/DOE (1974-1977)

Comparative U.S. DOE R&D Funding for Energy Technologies

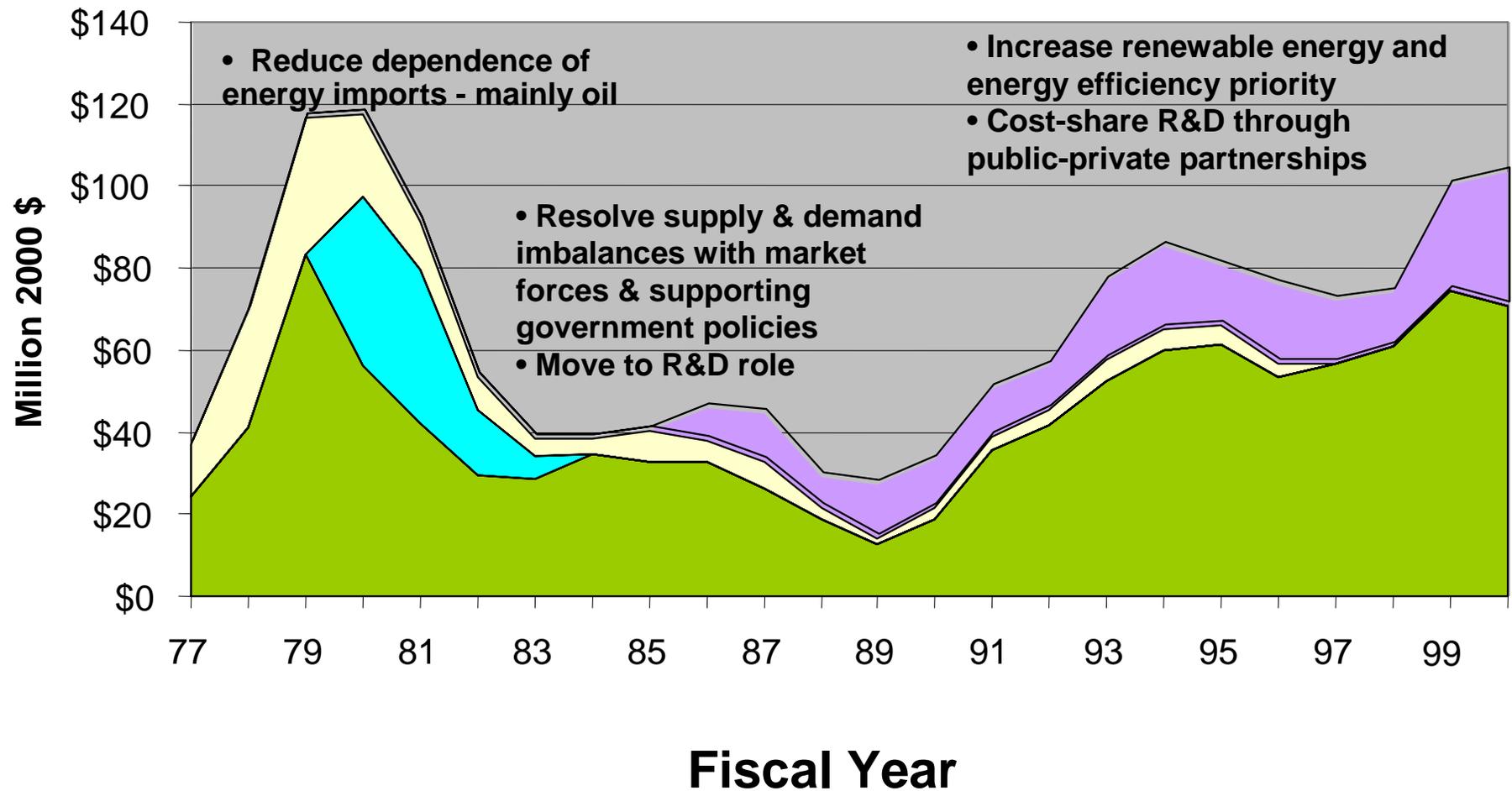


Biomass
12%
RE \$

- Federal Financial Interventions and Subsidies in Energy Markets: Primary Energy. SR/01AF/99-03, 1999.
 - Federal Financial Interventions and Subsidies in Energy Markets 1999: Energy Transformation and End Use. SR/01AF/2000-02, 2000
- Washington D.C., USA, Energy Information Administration

DOE Bioenergy and Biobased Products

Key policies shifted periodically

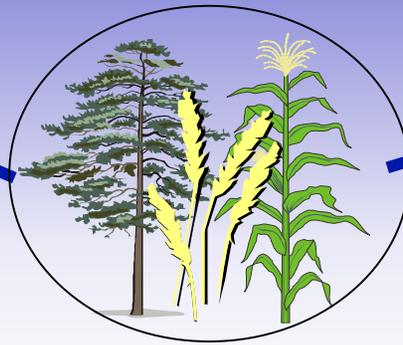


- Biobased Products - includes Forest Products and Agriculture
- Energy from Municipal Waste-EMW
- Alcohol Fuels R&D & Market Development
- Biomass, Biofuels, Biopower, Bioenergy

Biomass: 2000



Chemical
Products
Forest/
Paper
Products



Fuels

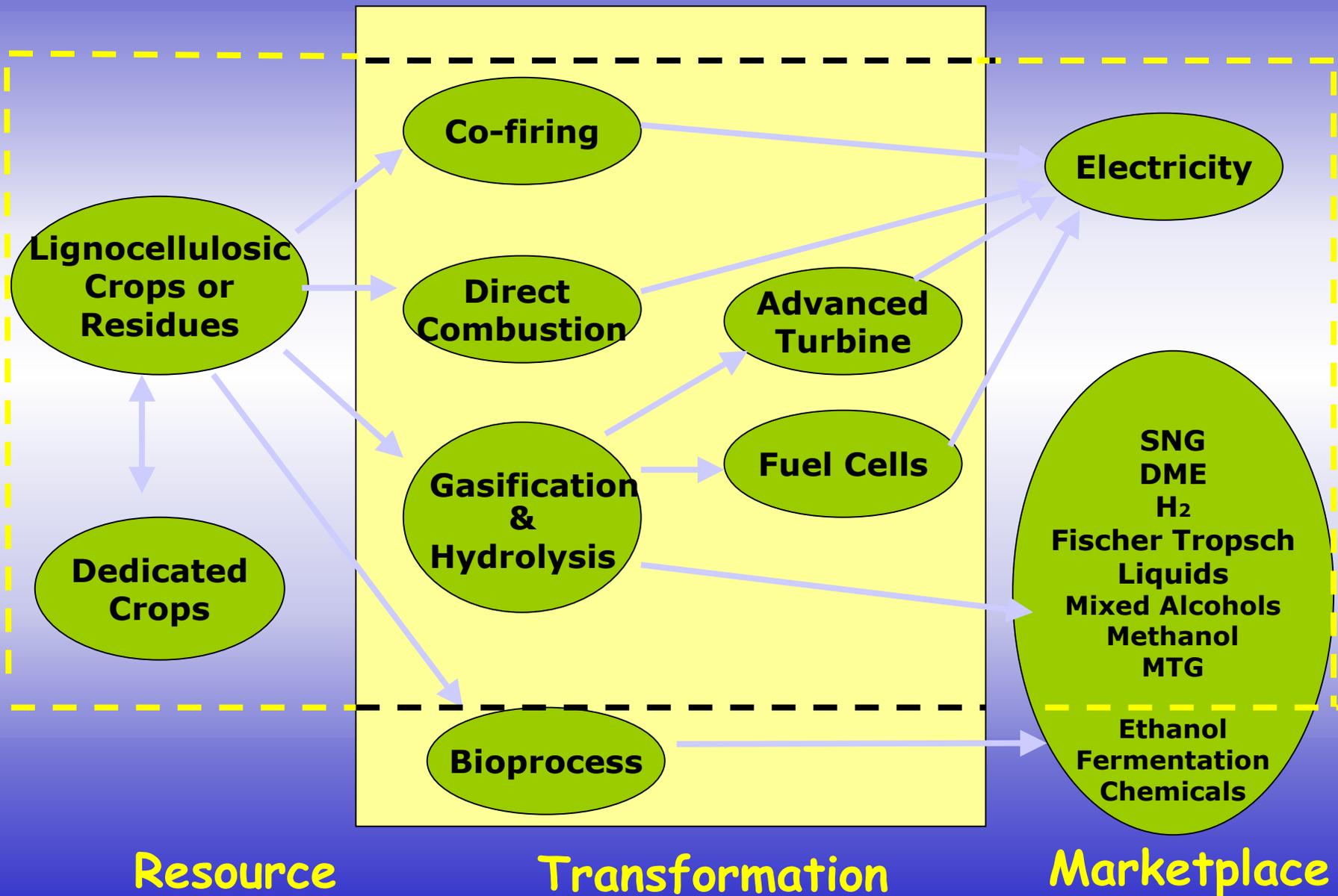
Primarily
Ethanol from
lignocellulosic



Heat, Electricity, Combined Heat and Power

Hydrogen from Renewables a Separate Program

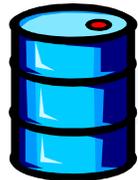
Bioenergy Pathways - 2000



The Potential of Biomass

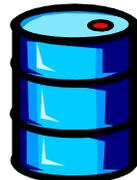
Petroleum transitioned from a single product to a multi-product industry...

Early 1900's



Kerosene

Late 1900's to Mid 2000's



Fuel gas
LPG
Gasoline
Jet fuel

Naptha
Diesel fuel
Lube oil
Coke

Fuel oil
Asphalt
Chemicals

Biomass for Energy/Products – could bridge fossil & renewables industries with multiple complementary products

Early 1900's
and before



Heat

Late 1900's



Heat
Electricity
Ethanol (corn)
Charcoal

Mid 2000's



Chemicals
Plastics
Materials
Ethanol
Biogas
Heat
Electricity
Other fuels
Charcoal

Biomass feedstocks can be selected to optimize the desired output

Past Success: Biomass Feedstocks

1978

• Woody Crop
Research begins

1980

• Species/cultural screening
trials are established

1984

• 22 promising woody
species identified for U.S.

1986

• N.C. region initiates
poplar clonal yield
trials: 7 model species
remain in trials across
U.S.

1988

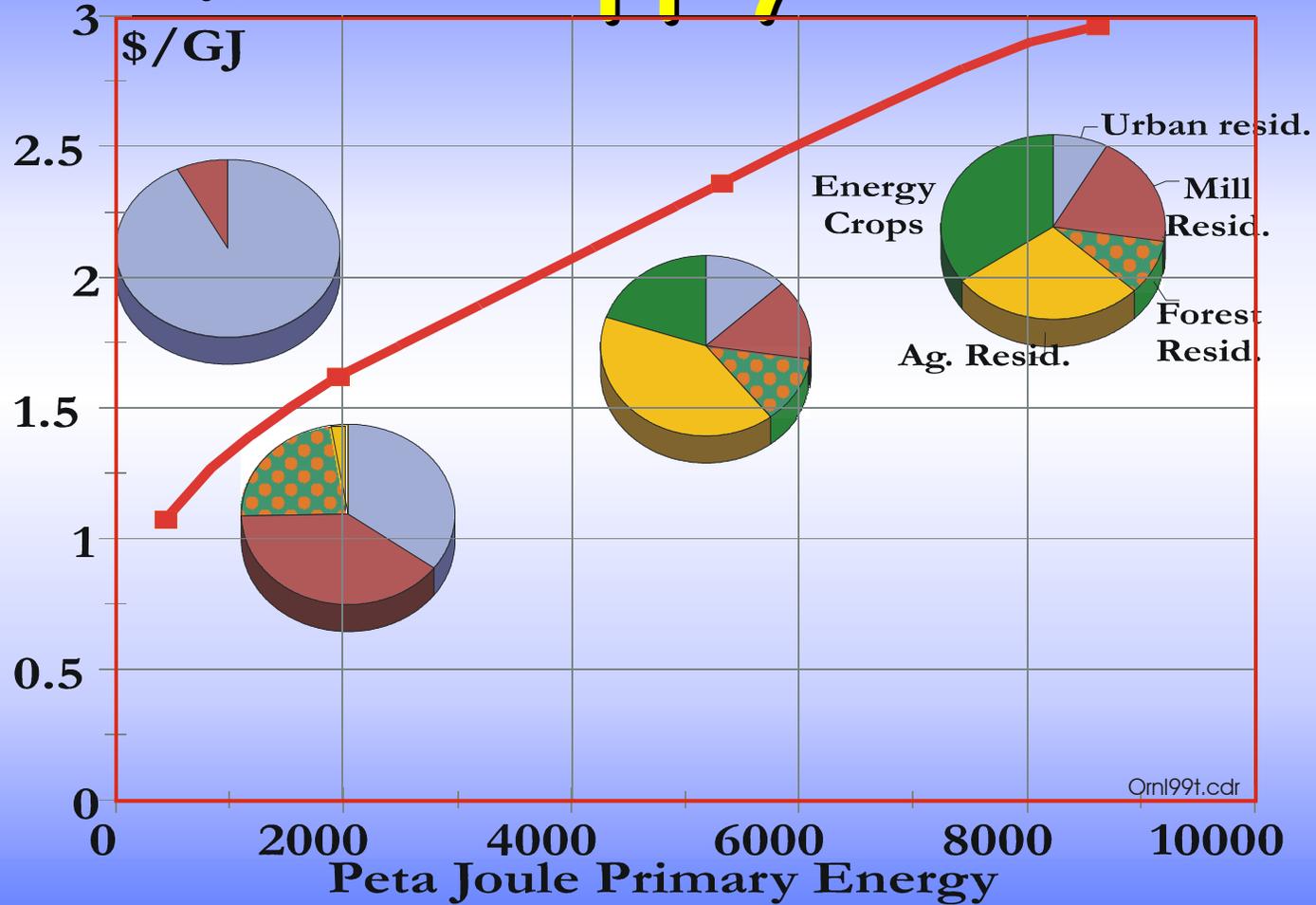
• *Populus* breeding
centers are created

1990

• First commercial harvest
of new poplar clones



Biomass Supply Curve '99



DOE's Current Focus Areas

Office of Energy Efficiency and Renewable Energy
Biomass Program - Doug Kaempf, Acting Director

- **BioPower Focus-** Small Modular Biopower Systems, Gasification (black liquor and biomass)
- **BioFuels Focus-** Cellulosic Ethanol (Bioethanol)
- **BioProducts Focus-** Biorefineries, Integrated R&D, Agriculture

Office of Science

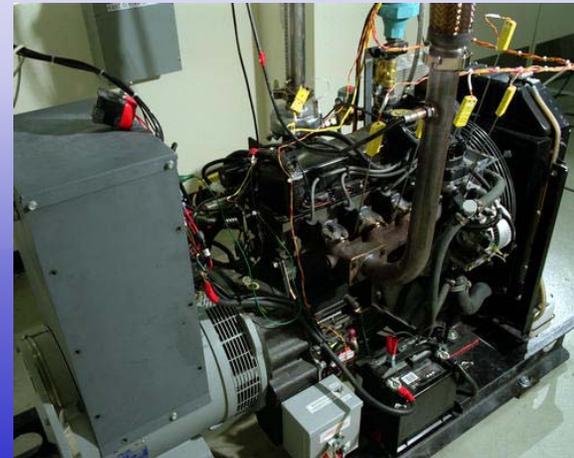
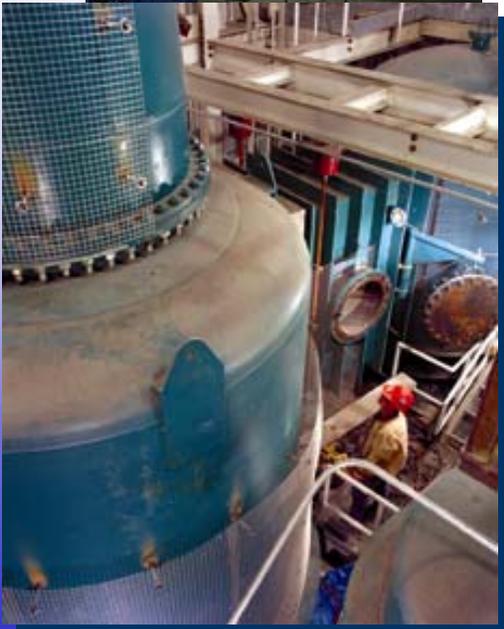
- **DOE- Basic Science-** Biomaterials and Biocatalysis, Extremophilic Organisms, Plant Science, Fermentation Microbiology

DOE Biopower Focus



R&D

- **Gasification (Reach 35–40% efficiencies)**
- **In Field Pre-processing of Feedstocks**
- **Small Modular Biomass (SMB) (5kW–5MW sized systems)**



DOE Small Modular Biopower Systems



1st R&D
Prototype
Island of
Panay,
Phillipines



2nd R&D
Prototype
Hoopa
Indian Tribe
California
with CEC

US DOE and Community Power Corporation

- 5-25 kw gasifier and combustion engine
- Fueled by wood or farm residues
- Heat and electricity for rural areas

Learn more about
partnerships of
DOE's Biomass Power
Program at:

www.eren.doe.gov/biopower

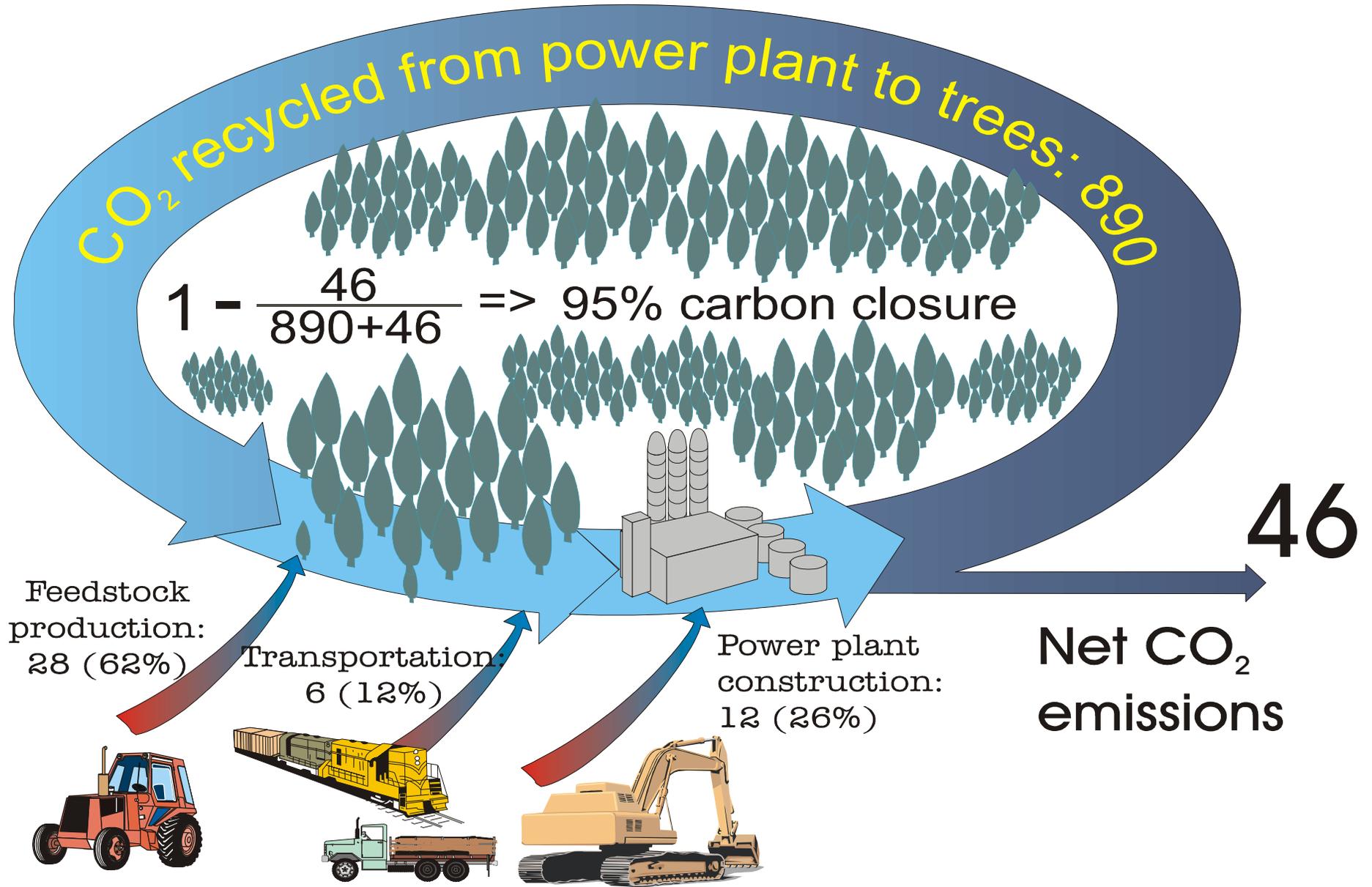
Community Power Corporation Unit Testing at the Hoopa Indian Reservation - DOE/CEC/NREL

- Successful transport of system from Denver to the Hoopa Valley (1600 mi) followed by operation at 12.5 kW within 24 hours.
- Operation of system at 15 kW for 6 hours. This was planned as a 24 hour test.
- Successful operation of engine exhaust gas dryer, wood moisture content of 10-13%, at 15 kW system load.
- Achievement of NO_x levels of 0.1 - 2 ppm at 12.5 kW load using new engine fuel/air throttle valves, and operating at stoichiometric conditions.



Biomass Gasification

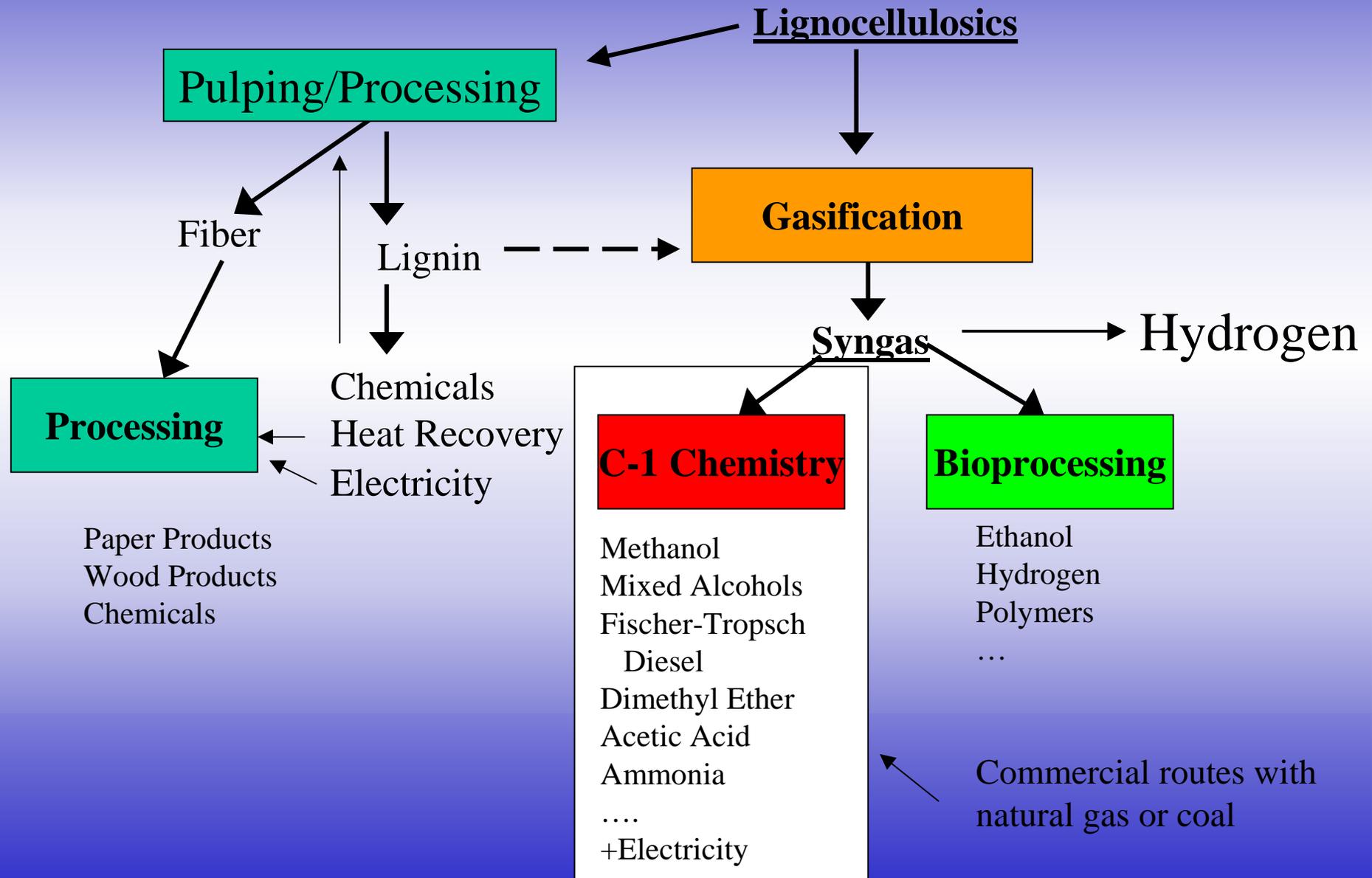




Life Cycle Analysis Biomass Power

- Very near NET ZERO CO₂ at zero soil carbon sequestration (plant/soil/location selection can move to net carbon sequestration)
- Life Cycle System Efficiency = 35%
 - $(E \text{ to grid} - E \text{ consumed by upstream processes}) / E$ in biomass going into power plant
- Net Energy Ratio = 16.3
 - Energy to grid / Fossil fuel energy

Biorefinery for Renewable Feedstocks to Fuels, Chemicals, Power, Fiber

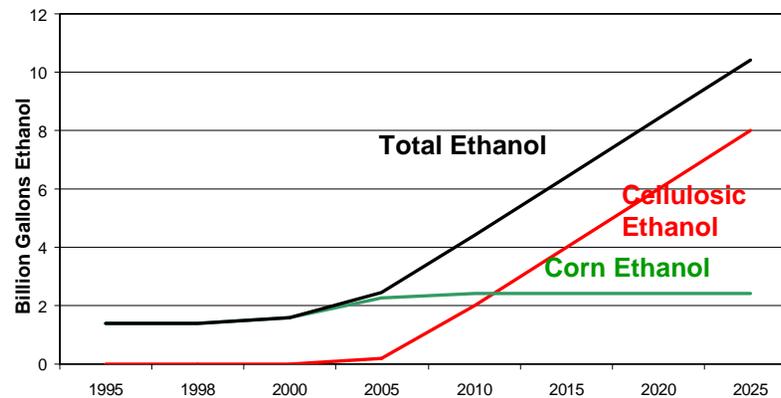


BioFuels Focus



Program Goals

- Ethanol cellulosic production research
 - Production Cost \$1.07/gal by 2010
- Enzyme research
 - Purchase cost < 10 ¢/gal ethanol
- Sugar Platform
 - Production Cost < 6 ¢/lb by 2010



Typical Biomass Composition



Softwoods



Hardwoods

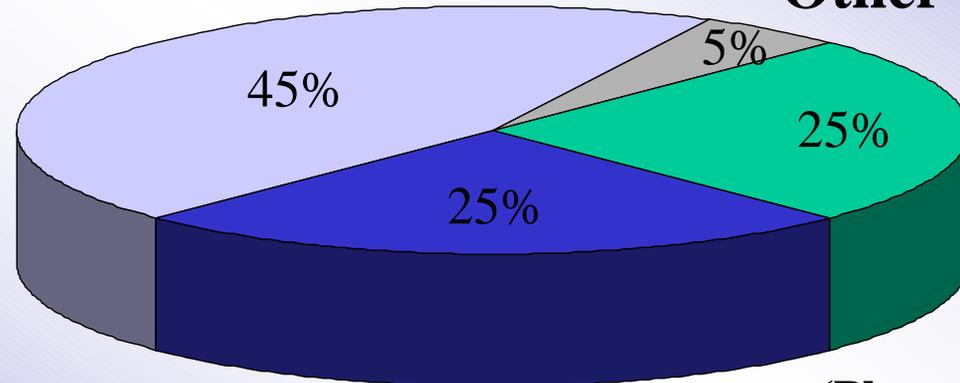


Crop residues



MSW

Cellulose
(Chains of glucose sugar)



Other

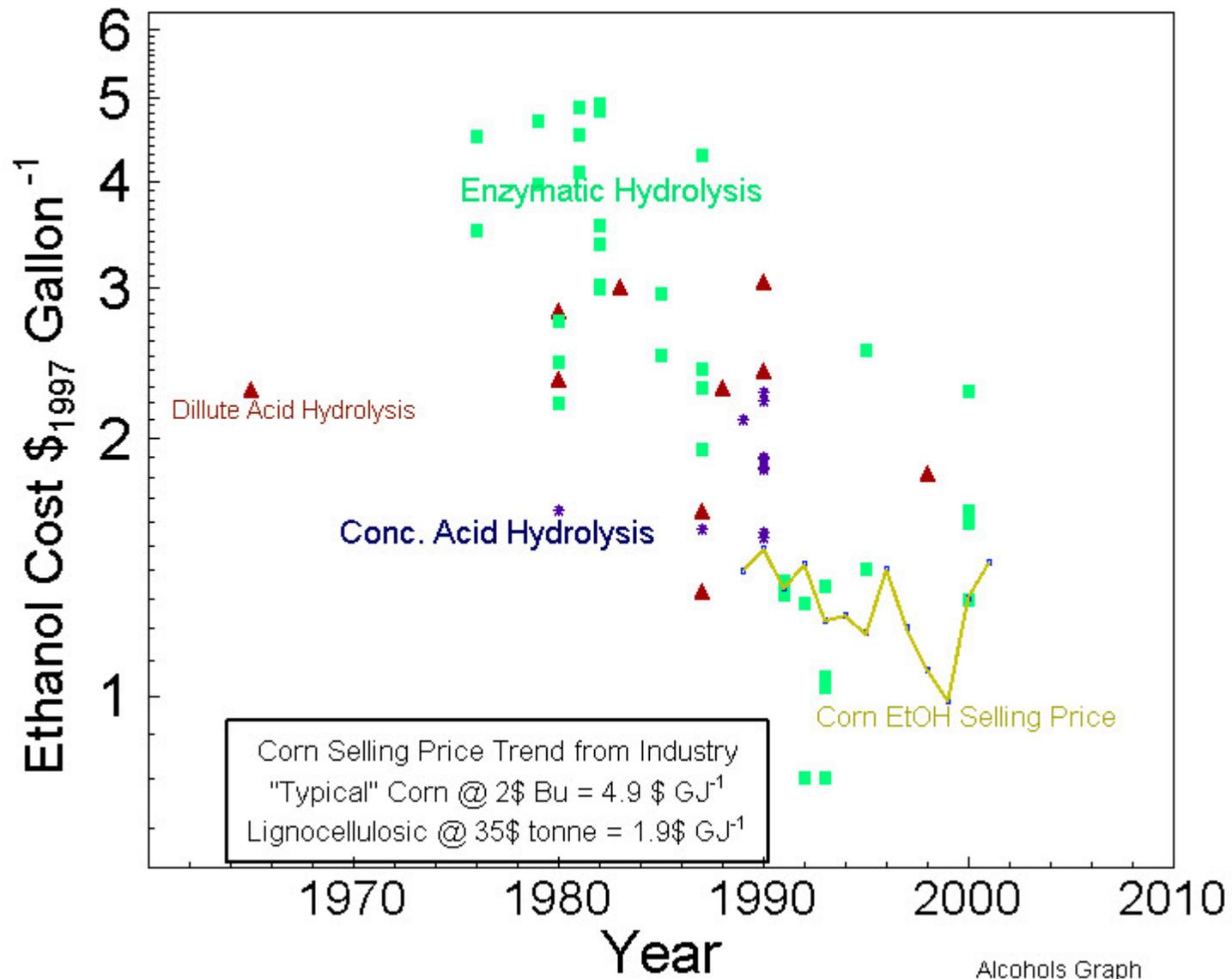
Lignin
(Phenolic Polymer)

Hemicellulose
(Chains of xylose and arabinose in hardwoods;
mannose and xylose in softwoods)

Bioethanol Technology Options

- Two-stage dilute acid
- Concentrated acid
- Dilute acid pretreatment/enzymatic hydrolysis
- Hot water pretreatment/enzymatic hydrolysis
- Gasification/fermentation of syngas
- Gasification/catalytic conversion of syngas
- Other processes:
 - Organosolv
 - Alkaline wet oxidation

Ethanol from Lignocellulosics Trend

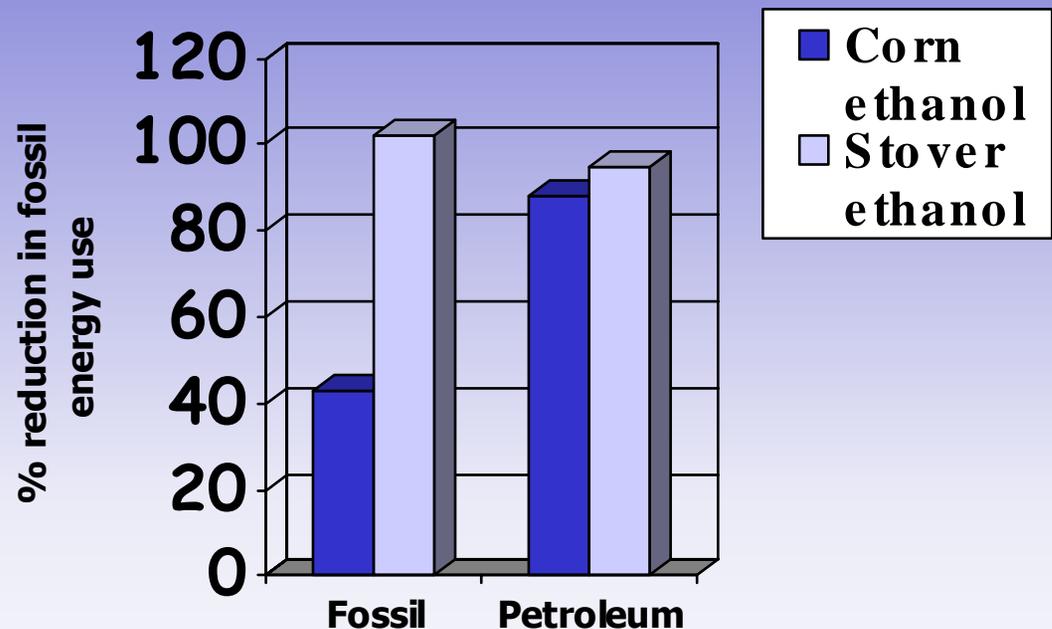


DOE LignoCellulosic Bioethanol Commercialization Projects

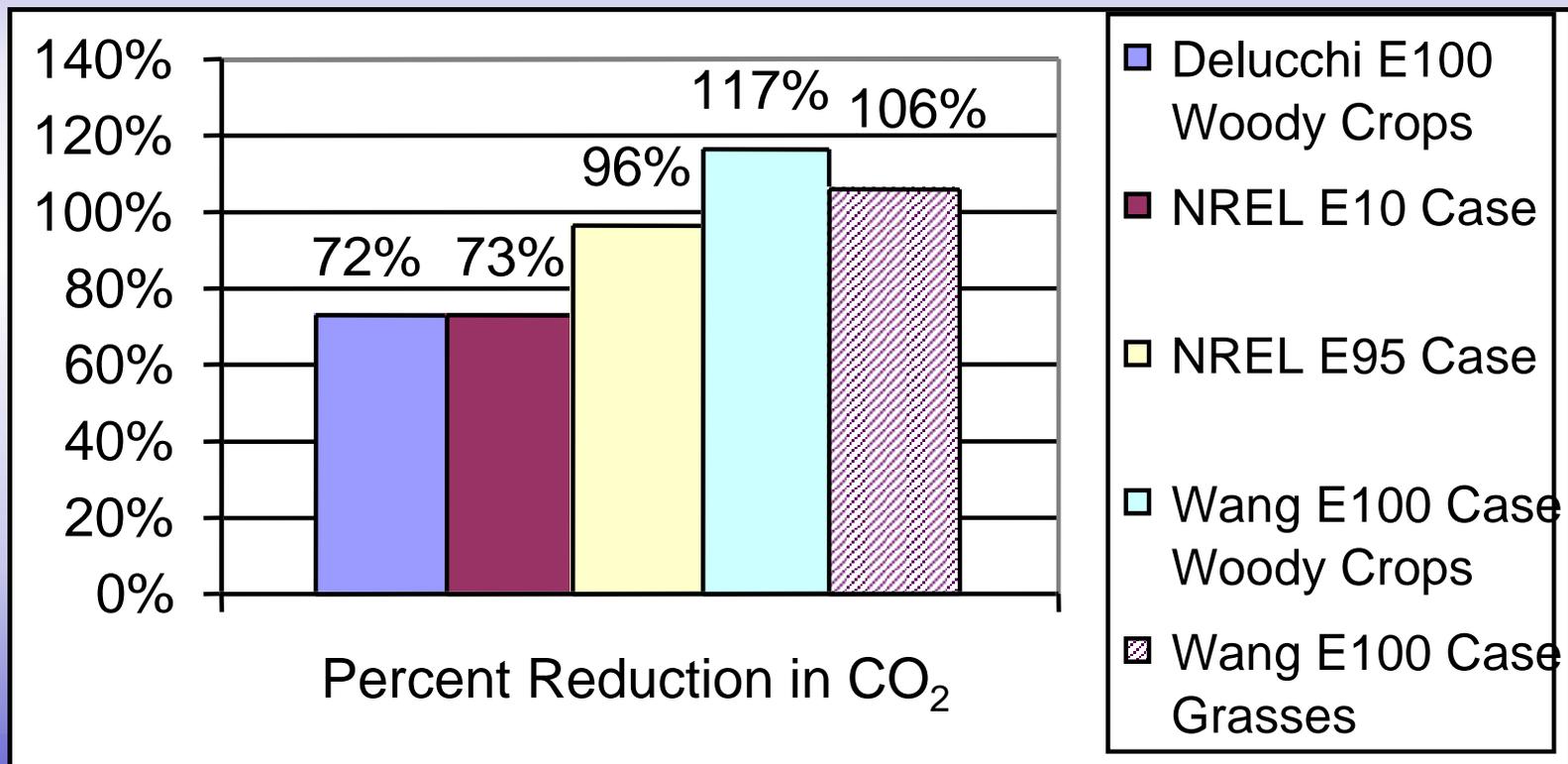
Company Project location	Expected Startup	Technology	Feedstock	Ethanol Million Gallons/Year
BCI Jennings, LA	Pending financing	Two-stage dilute acid	Bagasse	20
Masada Middletown, NY	2003	Concentrated acid	MSW	10
Gridley Gridley, CA	Evaluating approaches	TBD	Rice straw	20
Sealaska Southeast Alaska	Evaluating approaches	TBD	Mill residues	6-8
BCI/Collins Pine Chester, CA	2005?	Enzymatic	Forest thinnings and mill residues	20

Bioethanol's net energy balance per mile driven

- **Corn starch derived**
 - reduces fossil energy use by 43% compared to gasoline
 - Reduces petroleum use by 88%
- **Ag residue-derived ethanol**
 - reduces fossil energy use by 102%
 - Reduces petroleum use by 95%.



Ethanol from energy crops reduces CO₂ emissions

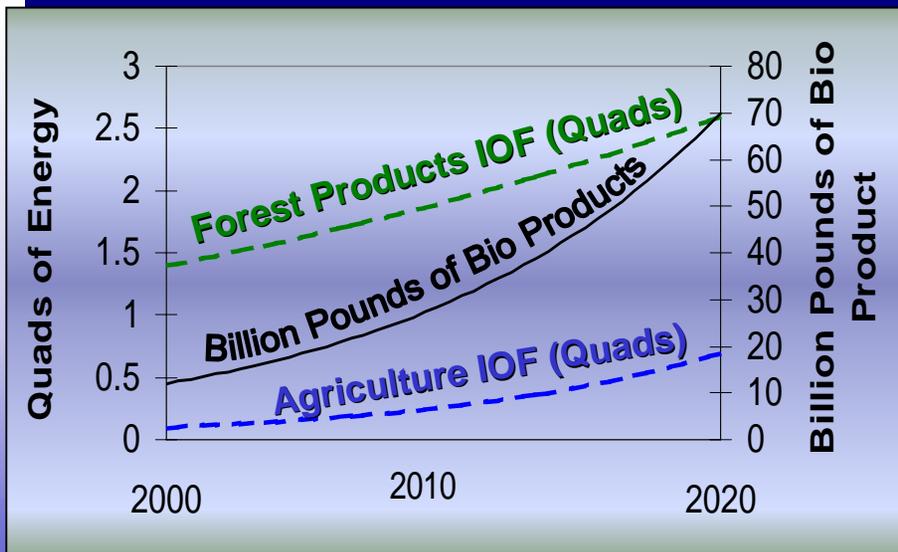


Sucrose/Molasses Current Status

• Brazil's Ethanol Industry

- Ethanol has been used as an automobile fuel since 1975 as both pure ethanol fuel and anhydrous ethanol blended with gasoline. Significant progress in cost reduction over 25 years have occurred for both sugar and ethanol. Ethanol was heavily subsidized initially, however they have now been reduced and in some areas eliminated. Annual production is about 14 billion liters (3.7 billion gallons) or roughly 45 % of gasoline consumption.
- In 2002 ethanol production cost is \$0.68/gallon and gasoline production cost is \$0.80/gallon (oil at \$25/barrel). In energy equivalent terms, ethanol is close to \$1/gallon. Brazil is highly competitive in world sugar markets and generally sets the world floor prices for raw sugar (about 5-5.5 cents/lb).
- 1.5 million jobs have been created (direct and indirect) contributing to lowering the migration to the urban centers.
- Current industry efforts: increase overall energy and cost efficiency, increase co-generation of electricity and heat using bagasse, use of the distributed network of neat ethanol for power production through fuel cells; value added products; cane genome and continued selection of appropriate plants and reduction of environmental impacts.

BioProducts Focus



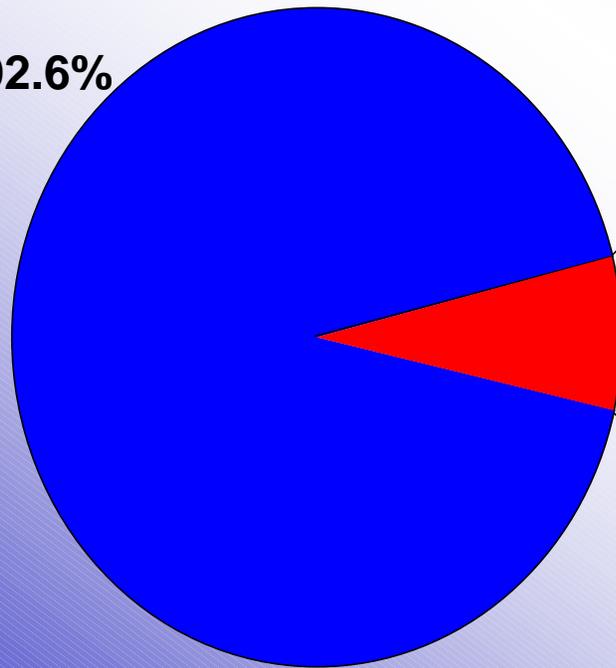
Implementation and Focus

- Multi disciplines, multiple party R&D on Biobased Products
- Black liquor and hog fuel gasification
- New Forest Products Agenda 2020 to include biobased products focus area
- Integration with Biofuels and Biopower through common technology needs and biorefineries
- Education Initiative

Biobased Industrial Products

Wood

92.6%



Other
7.4%

6.6 million tons

Total = 87.5 Million tons

Cellulose
0.6%

Lignin
0.2%

Wood Extractives
1.0%

Vegetable Oils
1.1%

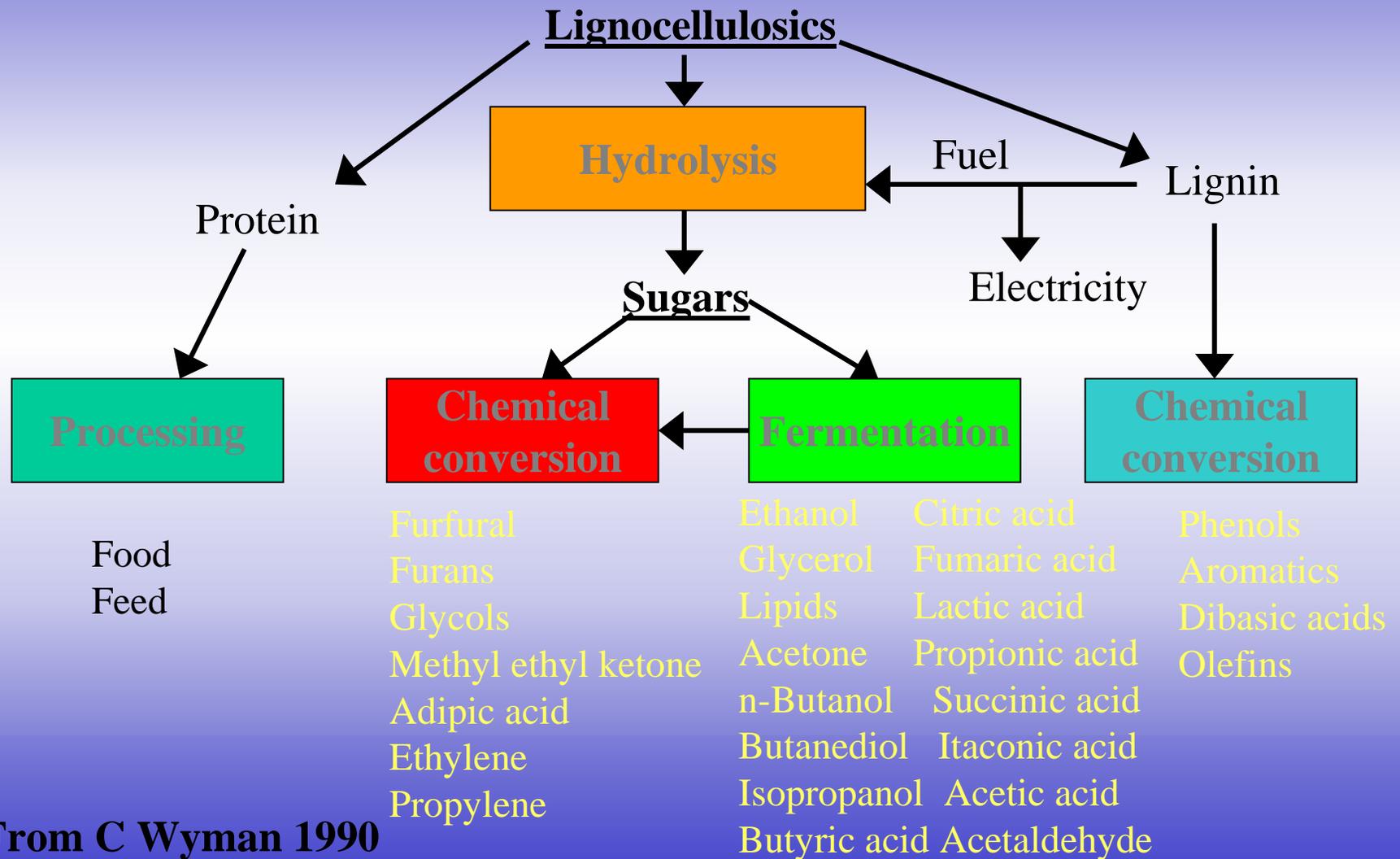
Industrial Starch
3.4%

Natural Rubber
1.1%

Uses

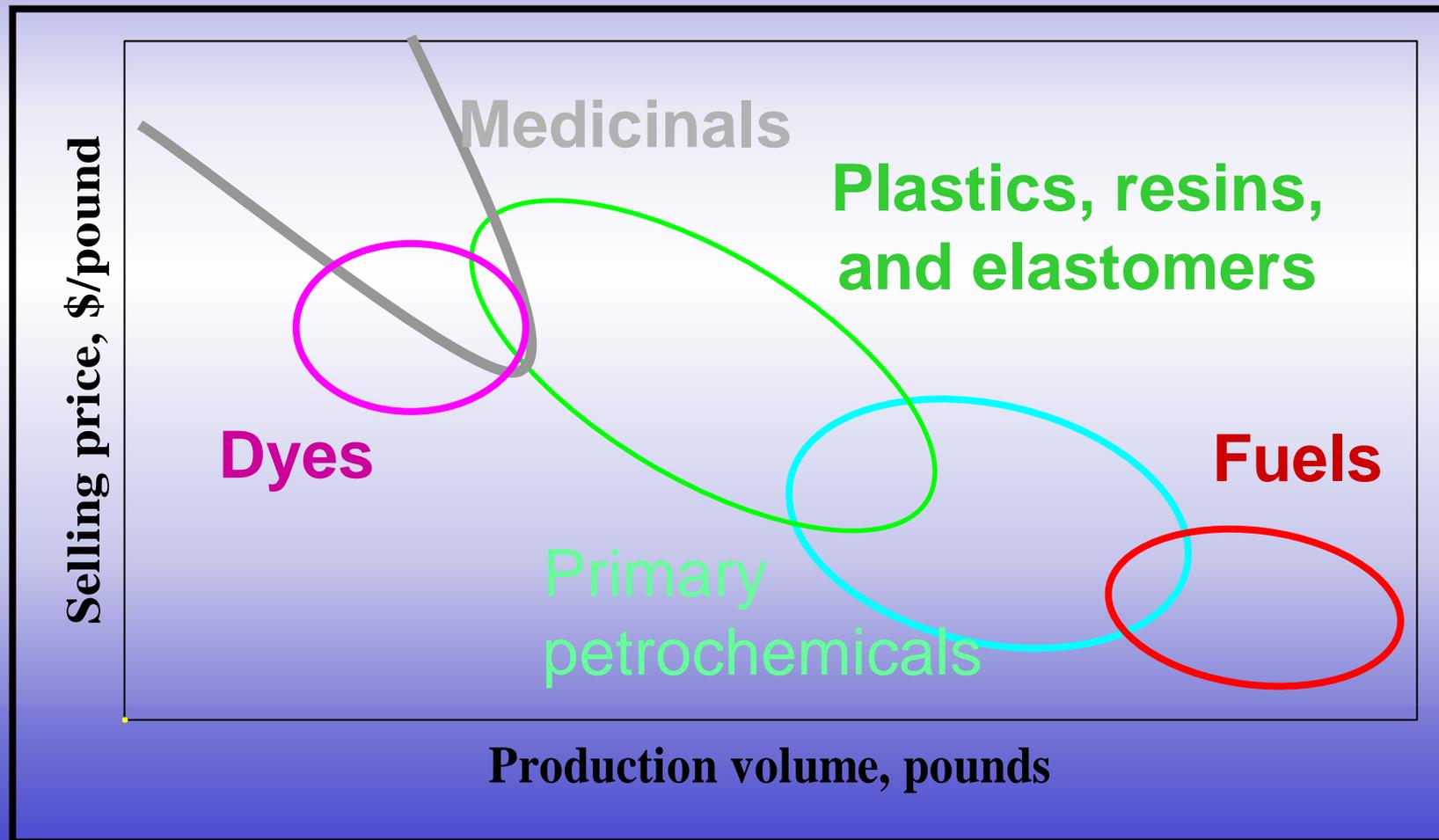
- polymers, textile fibers, fermentation products
- Nonfuel uses: vanillin, adhesives, tanning, dispersants
- Wood chemicals, oils and gums
- Surfactants, ink and paint solvents, resins, adhesives
- Polymer components, adhesives, resins
- Tires, durable and household goods, copolymer resins

Biorefinery for Renewable Feedstocks to Fuels, Chemicals, Power, Food, and Feed



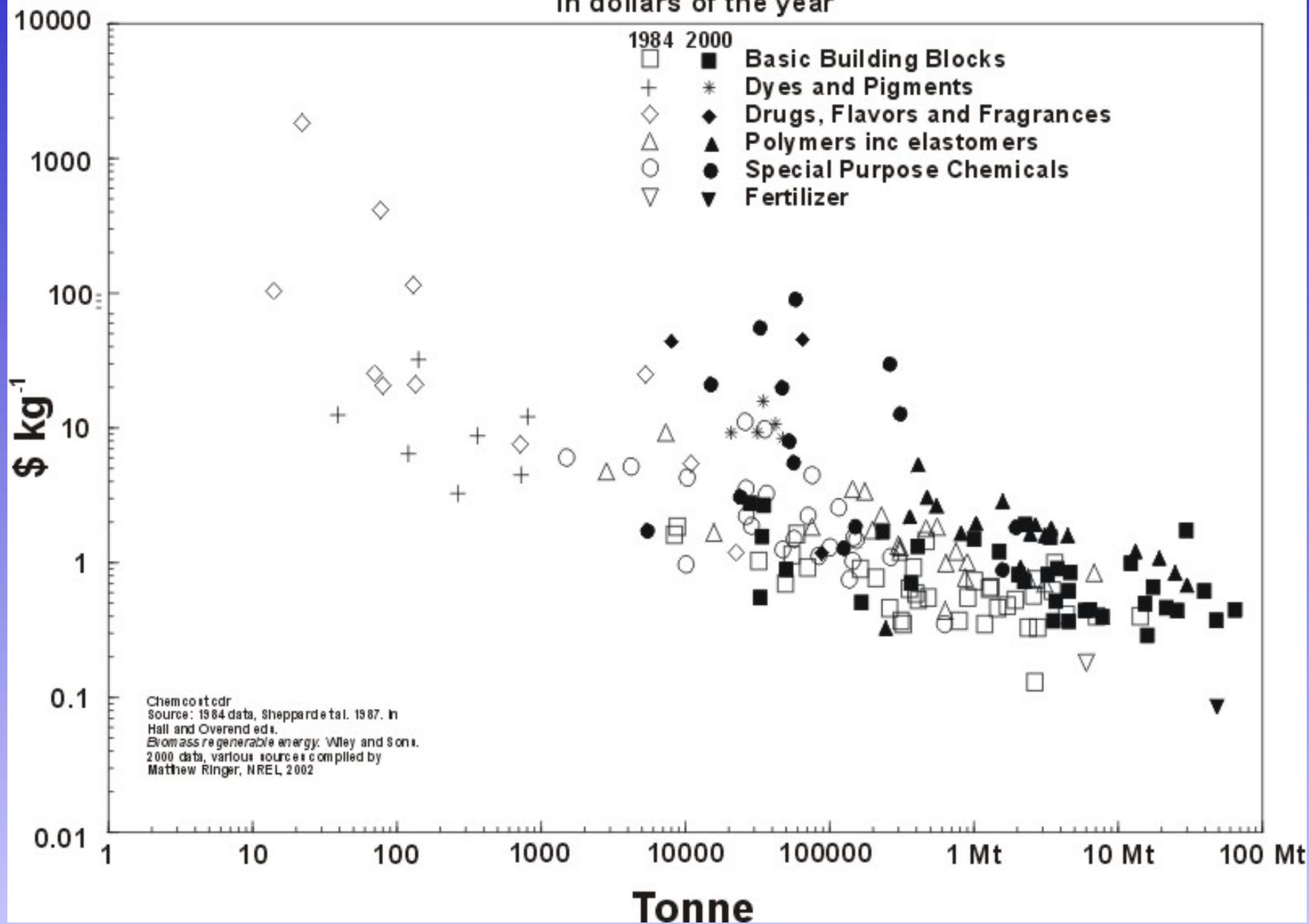
From C Wyman 1990

Low Selling Prices Are Typical for High Volume Products



Representative United States Chemical Prices

in dollars of the year



Examples of DOE Agriculture R&D Projects

Catalytic Upgrading of Glucose



Converts glucose into value-added chemicals (propylene glycol)

Partners: National Corn Growers Assoc., Michigan State University, PNNL

Soy-Based 2-Cycle Engine Oils



Produces biodegradable engine oil from soybeans for recreational marine uses

Partners: Terresolve Technologies, Ltd., United Soybean Board, Smith, Bucklin & Associates, Omni Tech International

Utilization of Corn-Based Polymers

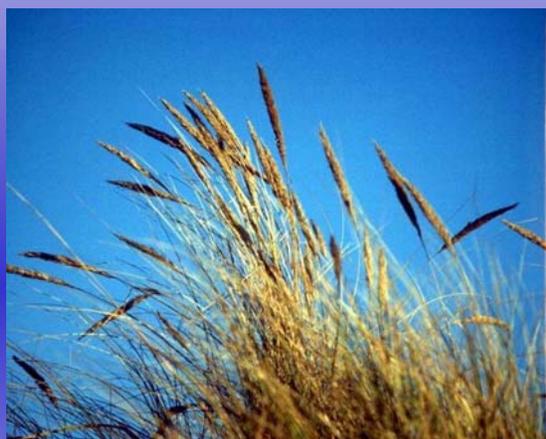


Improves properties of new plastics derived from corn, such as PLA

Partners: Cargill Dow, NREL, Colorado School of Mines

Examples of DOE Agriculture R&D Projects

Products from Wheat Milling



Recovers starch-rich product from mil feed and converts the starch into value added product via catalytic or fermentation process.

Partners: Pendleton Flour Mill, Inc., Mennel Milling Co., PNNL

Membrane Process for Lactate Esters



Advanced fermentation/membrane process converts biomass into lactate esters, for solvents or plastics feedstocks

Partners: NTEC-Versol, Inc, Archer Daniels Midland & ANL

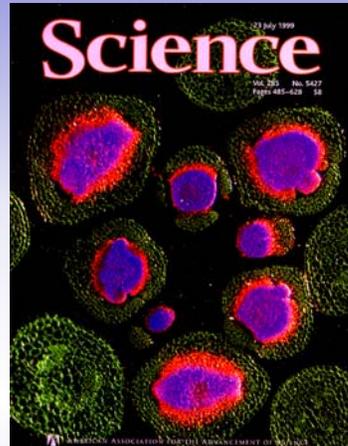
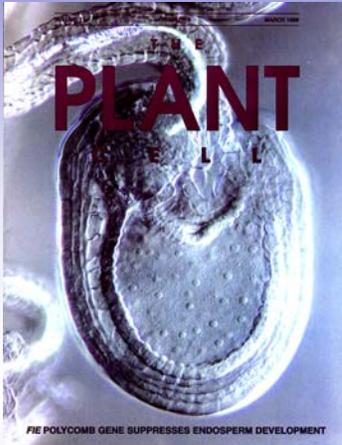
Improved Catalytic Enzymes



Improved catalysts for converting corn to industrial chemicals.

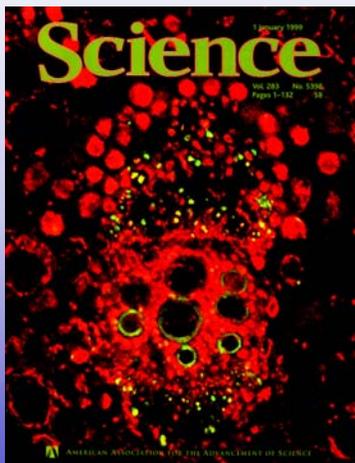
Partners: Altus Biologics, Genencor, Cargill, ORNL

DOE- Basic Science



Office of Science, Energy Biosciences Program

- ❖ Biomaterials and Biocatalysis
- ❖ Extremophilic Organisms
- ❖ Plant Science
- ❖ Fermentation Microbiology





**U.S.
Department of Agriculture**

**Farm & Foreign
Agricultural Service**

*Farm Service Agency
Commodity Credit Corp.*

Rural Development

*Rural Utility Service
Rural Business
Cooperative Service*

**Research,
Education &
Economics**

**Natural Resources
and Environment**

**Office of
Chief
Economist**

**Agricultural
Research
Service**

**Cooperative State
Research, Education,
and Extension Service**

**Forest
Service**

**Natural
Resources
Conservation
Service**

**Office of Energy
Policy and New
Uses
(R. Conway)**

**National Technology
Programs Transfer**

**National
Research
Initiative
Competitive
Grants**

**SBIR
Program**

**Resource
Valuation
& Use**

**Resource
Conservation
& Development
Program**

**#306 - New Uses,
Quality & Marketability
of Plant and Animal Products
#307 - Bioenergy and
Energy Alternatives**

**Hatch Act
McIntire Stennis Act
Formula Grant Programs**

**Forest
Products
Research**

**Vegetation
Management
& Protection
Research**

**National
Association of
Conservation
Districts
Resource
Conservation
and Development
Council
Rural
Conservation
Districts**

Farm Bill

Title VI - Rural Development

- **Value-Added Agricultural**

- Market Development Grants - \$240 million**

Provides \$40 million a year for grants to assist producer owned valued-added businesses.

- **Rural Strategic Investment Program - \$100 million**

Creates regional investment boards that may receive up to \$3 million for economic development.

- **Rural Business Investment Program - \$100 million**

Provides \$280 million in guarantees for rural business investment companies to provide equity investment for businesses.

Farm Bill - Title IX -- Energy

Program	Notes	Cost
CCC Bioenergy Program	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.	\$204 million
Biobased Product Purchasing Preference	Establishes a new program for the purchase of biobased products by Federal agencies.	\$6 million
Biodiesel Fuel Education	Creates a grant program to educate government and private fuel consumers about the benefits of biodiesel fuel use.	\$5 million
Renewable Energy System & Energy Efficiency Improvements	Establishes a loan, loan guarantee & grant program to assist farmers in purchasing renewable energy systems and making energy efficiency improvements.	\$115 million
Biomass Research and Development Act of 2000	Reauthorizes and funds the Biomass Research and Development Act through FY 2007.	\$75 million
		Total: \$405 million

Biomass, Bioenergy, & Biobased Products

**Intersection of civil society
choices & industry investment in these areas**

with Government Policies

- Energy
- Agriculture (Big or Small?)
- Forestry (International Competition)
- Environment
- Regional/Municipal Residue Management
- Chemical Industry Feedstocks (Emerging)
- Economic Development (Rural, Industrial, & Urban)

References

<http://www.bioproducts-bioenergy.gov>

- Biobased Products and Bioenergy Roadmap Presentation from the National Association of Conservation Districts Feb. 3 Meeting, by Doug Kaempf, National Coordination Office Director for DOE
 - BIOMASS R&D TECHNICAL ADVISORY COMMITTEE RECOMMENDATIONS
 - Fostering the Bioeconomic Revolution in Biobased Products and Bioenergy - An Environmental Approach." An Interagency Strategic Plan prepared by the Biomass Research and Development Board
 - Executive Order 13134 - Developing and Promoting Biobased Products and Bioenergy, 1999
 - Agricultural Risk Protection Act of 2000 (P.L.106-224), Title III: The Biomass Research and Development Act of 2000
 - The Biobased Products and Bioenergy Vision and Technology Roadmap
 - National Academy of Sciences report "Biobased Industrial Products: Research and Development Priorities", 2000
 - Proceedings from DOE National Bioenergy Center Strategic Partnership Workshop
- Other Links: Bio Fuels www.ott.doe.gov/biofuels/;
Bio Power www.eren.doe.gov/biopower/main.html;
Science www.science.doe.gov/production/ober/restopic.html
\$20 Million Solicitation (wallace.adcox@mms.gov)