



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

biomass program

DOE Biomass Program: A Historical Perspective

National, Fiscal, and Strategic Trends

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Office of the Biomass Program

Presented to

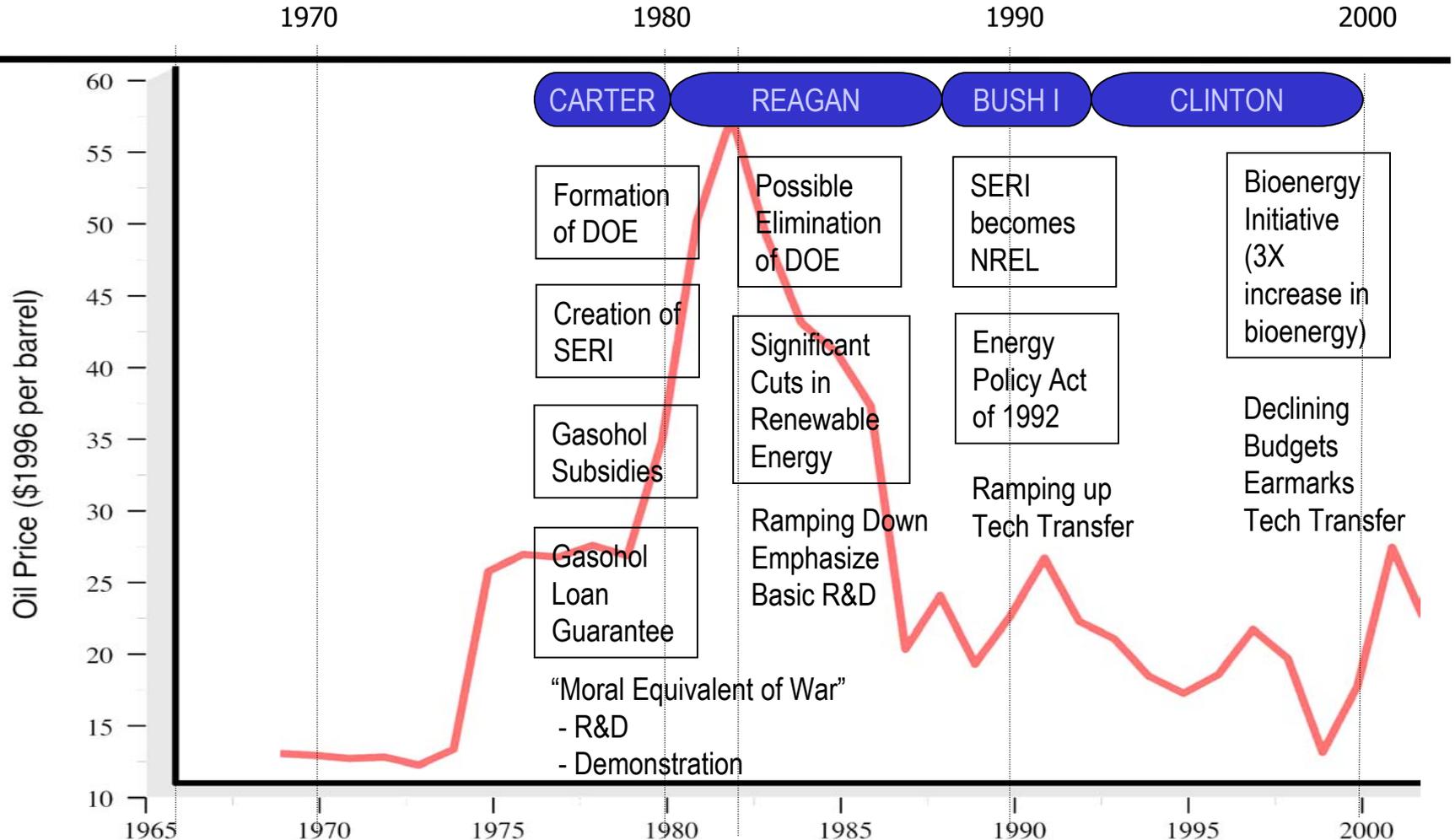
Technical Advisory Committee

March 11, 2004

Washington, D.C.

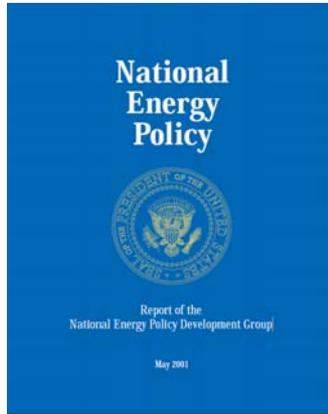


Historical Perspective

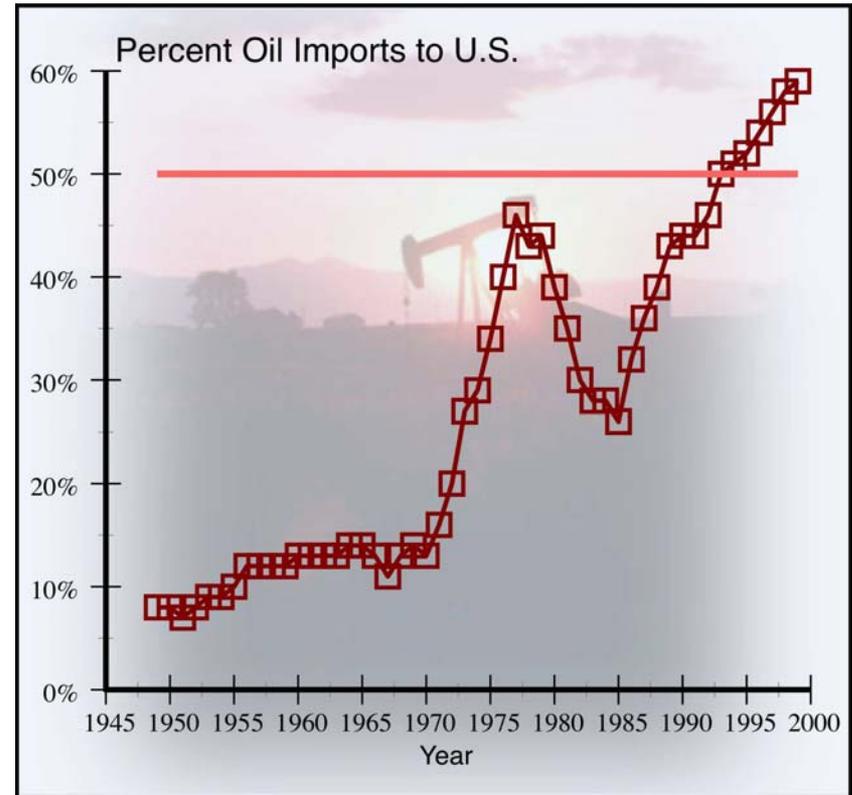




Today

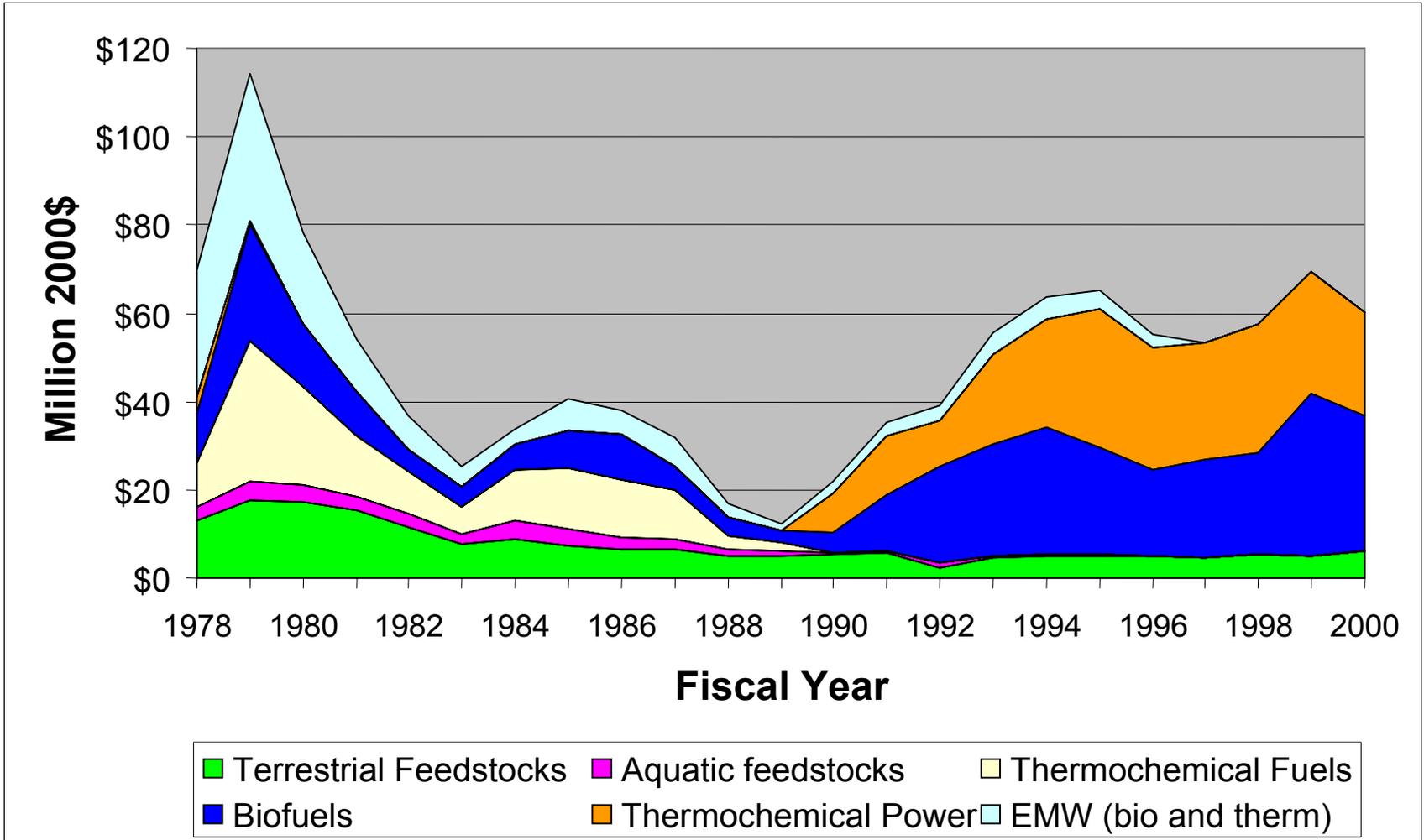


- NEP - Return to an emphasis on national security and petroleum
- Energy Title in Farm Bill
- The hydrogen economy





Biomass Funding History



Funding totals for R&D in selected areas only – From:

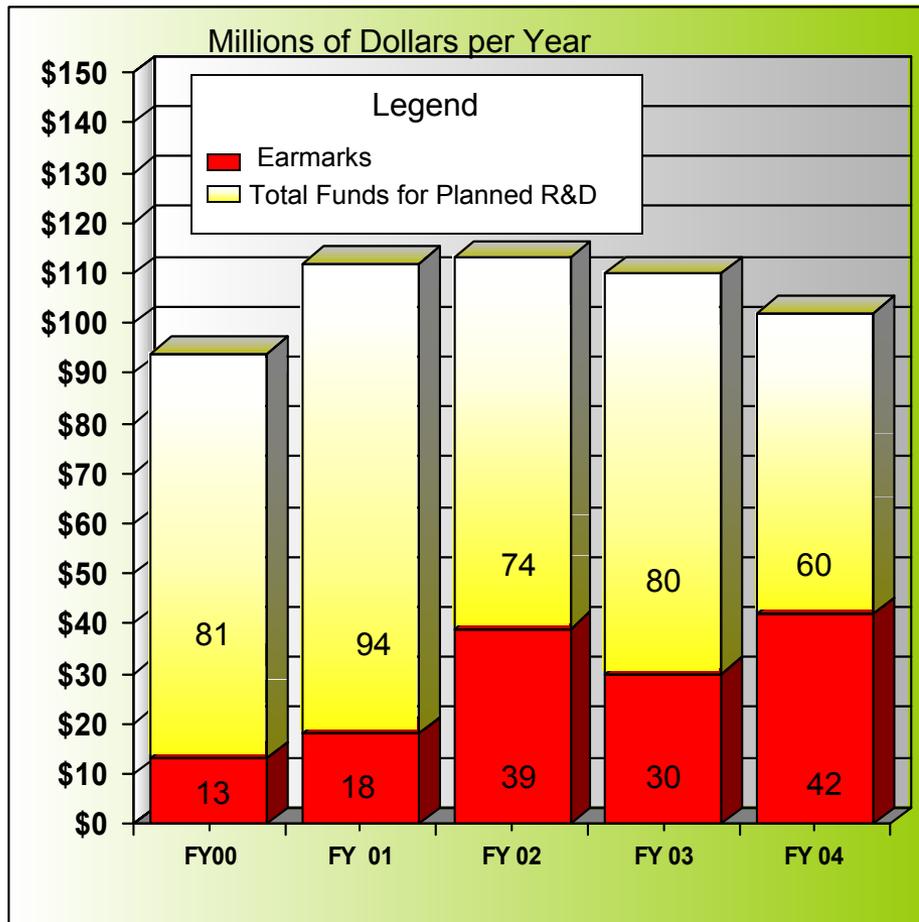
Chum H. L., R. P. Overend (2003). "Biomass and Bioenergy in the United States",

Advances in Solar Energy: an Annual Review. Boulder, CO. USA. ISBN-0-89553-258-1 15 (3): 83-148.



Biomass Funding Today

Earmarks and Total Funding



- **Three-fold increase in earmarks since 2000**
- **Earmarks have grown from 18% to over 40% of the total funding**
- **Real decline in the available funds used in support planned R&D**

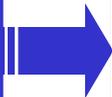


Historical Perspective: 1988-1992

**George H.W. Bush
Administration
Direction**

**Renewable energy as a
matter of national
security**

**The age of technology
transfer and the CRADA**



**Mike Davis
Asst Secretary
Energy Efficiency
Renewable Energy**

Priority on bioconversion R&D

Rapid ramp up of \$ and people

**\$14 million investment in
ethanol pilot plant (AFUF)**

**1ST discussion of USDA
leadership for biomass
feedstocks**

**Reorganization of biomass into
sectors (Power, Transportation,
Industry)**

Amoco CRADA



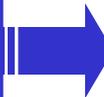
Historical Perspective: 1992-1996

**Clinton I
Administration
Direction**

**Age of budget deficit
reduction**

**Continued priority on
technology transfer**

**Climate Change Action
Plan**



**Christine Ervin
Asst Secretary
Energy Efficiency
Renewable Energy**

**Continued push for near term
demonstrations and build up of
expectations**

- Push for 2000 targets

**Emphasis on environmental drivers
for biomass**

- Kyoto
- Climate Change Action Plan

**Biopower as climate change
strategy**

**Increase in funding for biopower
(thermochemical routes)**

Decline in biofuels funding ('95-'96)

**Microalgae and all thermochemical
fuels research stopped in '96**



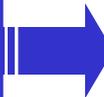
Historical Perspective: 1996-2000

Clinton II Administration Direction

Age of budget deficit
reduction

Executive Order for
Bioenergy Initiative (3x
increase in biomass
use)

Biomass R&D Act of
2000



Dan Reicher
Asst Secretary
Energy Efficiency
Renewable Energy

Continued push for near term
demonstrations and build up of
expectations

Emphasis on “entrepreneurial”
companies to deploy “pioneer
plants” based on niche
feedstocks (BCI, Arkenol and
SWAN Biomass)

Start of escalation of
“Earmarks”

Bridge to Corn Ethanol

Begin shift to the “Sugar
Platform” under Bioenergy
Initiative



Strategic Direction

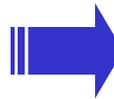
Today

George W. Bush Administration Direction

Return to a focus on
energy as a national
security issue

Energy Title in Farm Bill

The Hydrogen Initiative



David Garman
Asst Secretary
Energy Efficiency
Renewable Energy

Implementation of Biomass R&D

Act of 2000

- FACA
- Biomass R&D board
- Joint USDA/DOE
Bioenergy solicitations

Consolidation of DOE biomass
activities under one program

Importance of H₂

Significant impacts of "Earmarks"

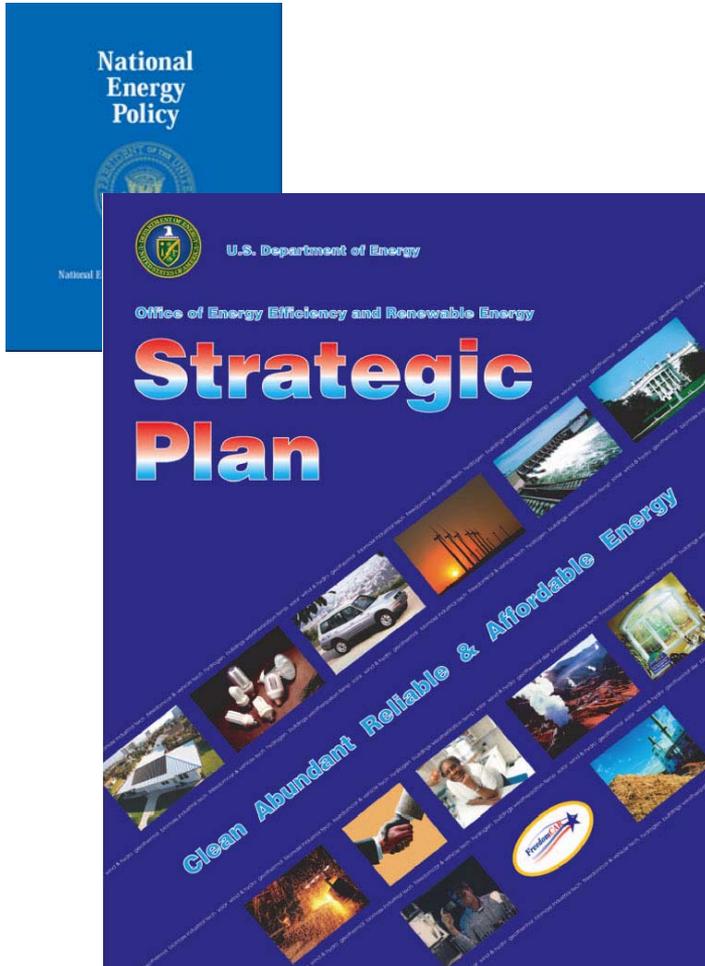
Emphasis on oil displacement and
the creation of the bioindustry



Today

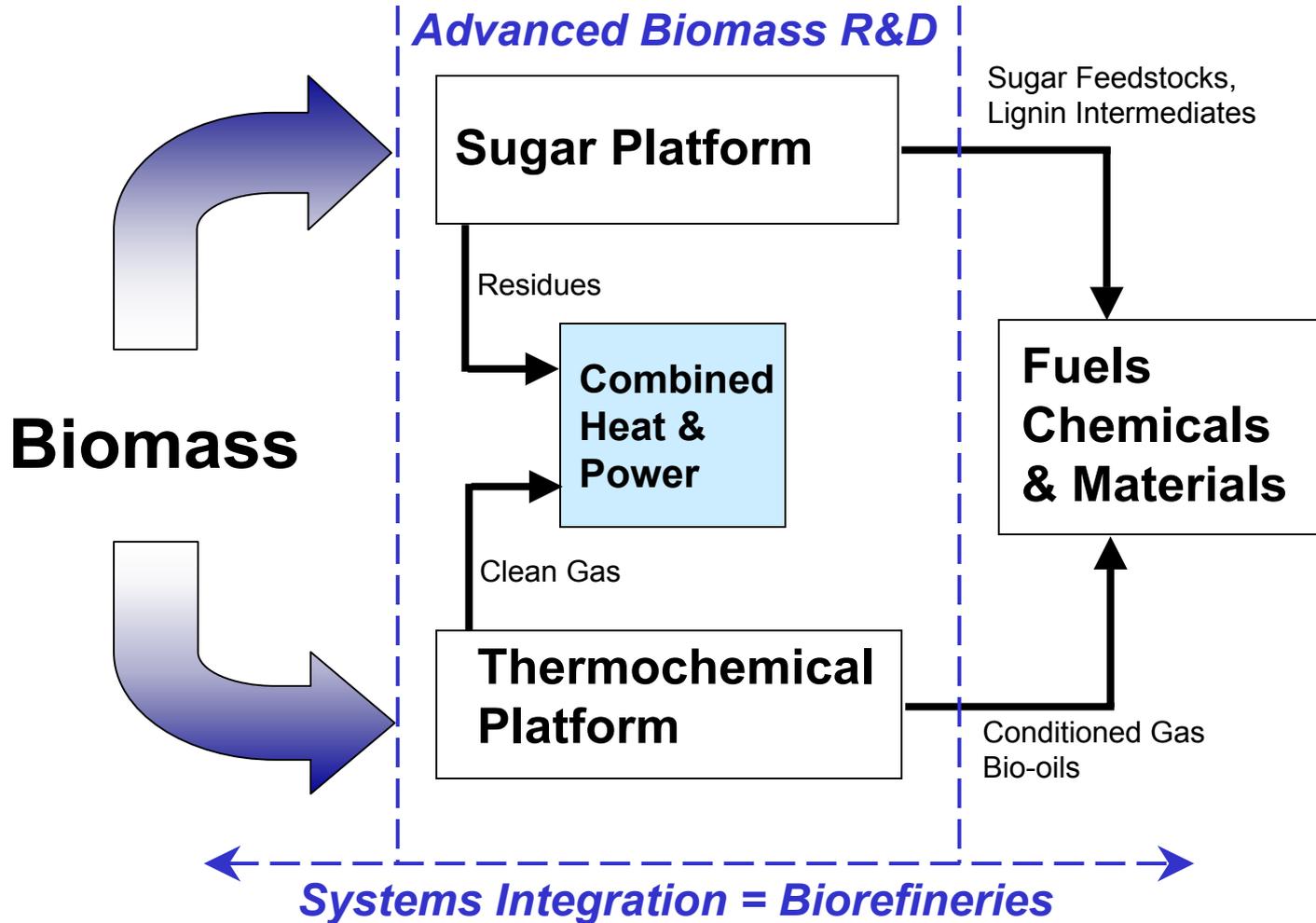
- **EERE Portfolio Priorities**

- **Dramatically reduce or even end dependence on foreign oil**
- Reduce burden of energy prices on the disadvantaged
- Increase the viability and deployment of renewable energy technologies
- Increase the reliability and efficiency of electricity generation, delivery and use
- Increase the efficiency of buildings and appliances
- Increase the efficiency/reduce the energy intensity of industry
- **Create the new domestic bioindustry**
- Lead by example through Government's own actions



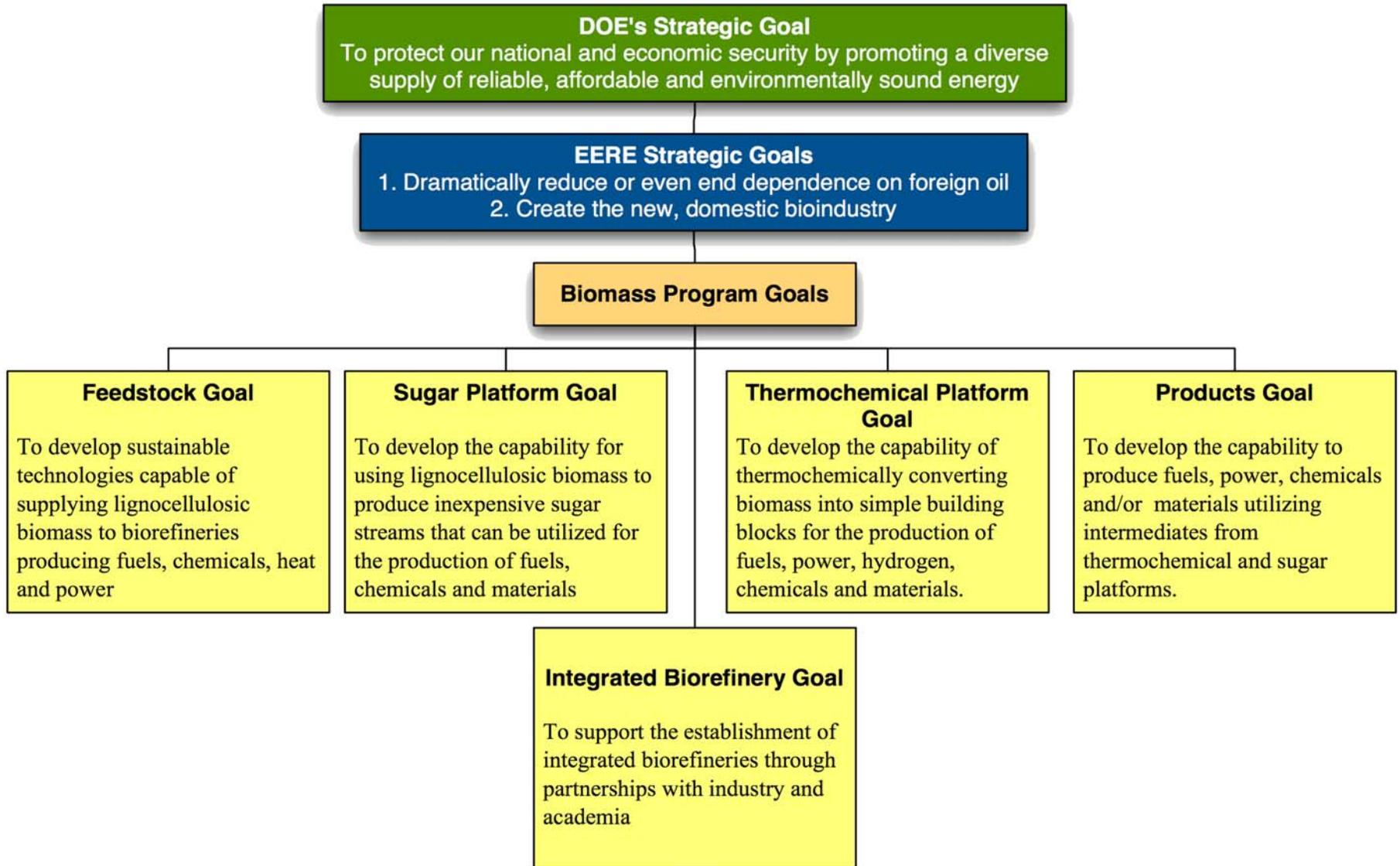


Research Focus



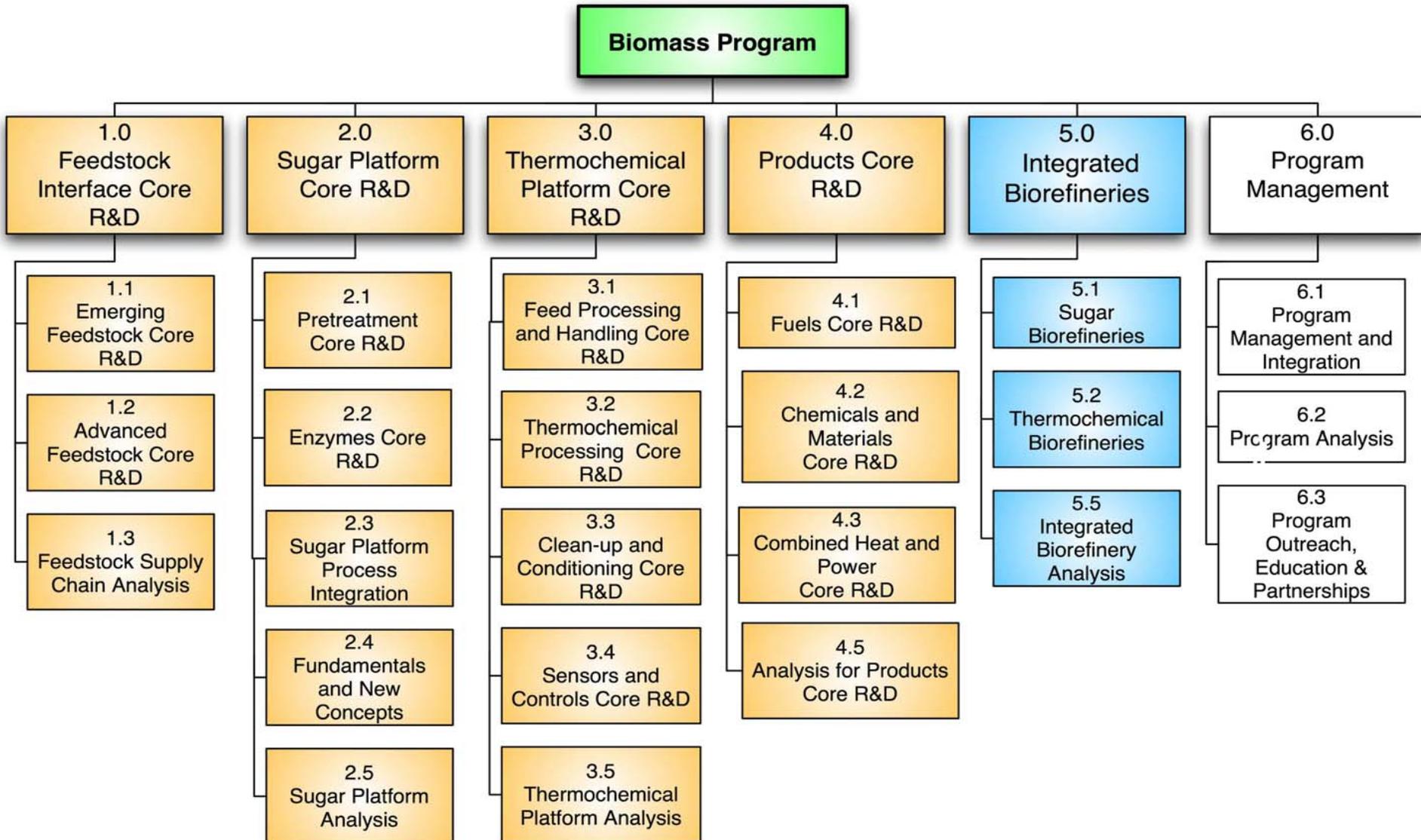


Program Goals





Work Breakdown Structure





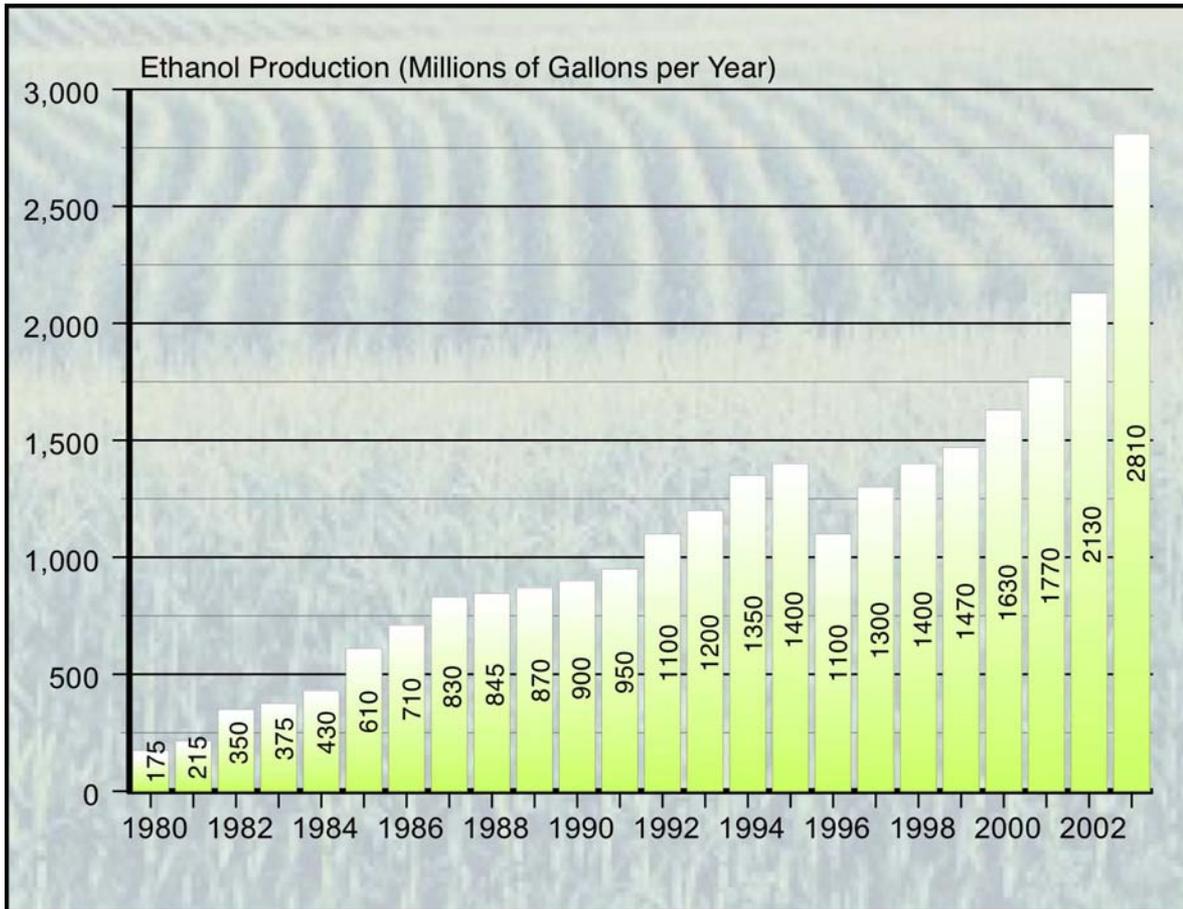
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Ethanol and the Sugar Platform: Past, Present and Future



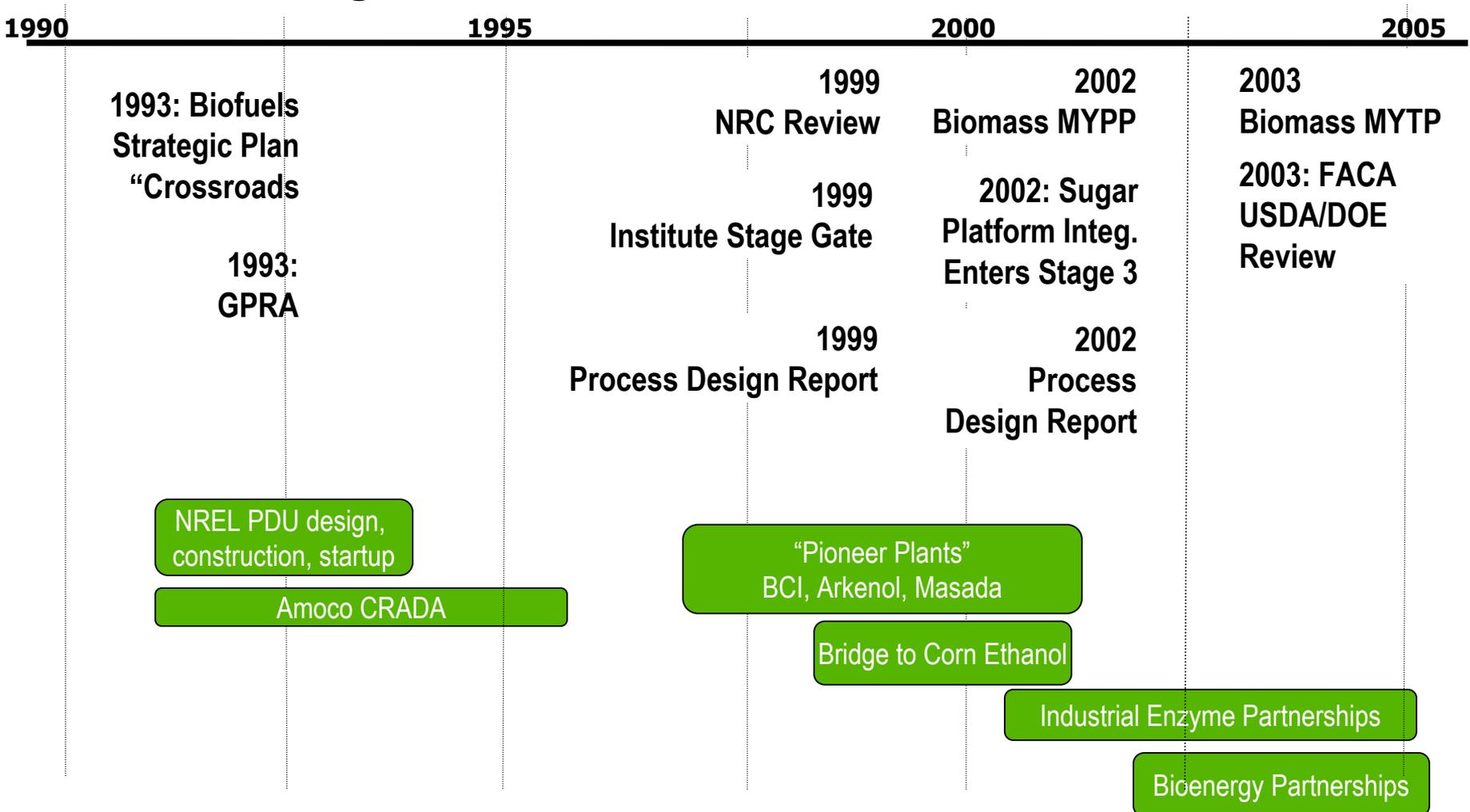
Historical Perspective



Today, fuel ethanol represents a significant success story on which the Biomass Program can build



Planning, Evaluation, and Partnerships





Lessons Learned—1999 NRC Review

- **Redirect the focus from demonstrations to technology fundamentals to reduce inherent cost of fuels**
- **Develop an integrated systems model for biomass development, collection, storage, transport, and processing.**
- **Establish clear criteria for evaluating project performance levels and should include reviewers from academia, industry, and other government programs in its evaluations.**



Lessons Learned—Partnerships

- **Amoco/SWEC/SWAN/Logen CRADA**
- **Pioneer Plant Investments**
 - BCI, Arkenol, Masada, SWAN
- **Bridge to Corn Ethanol**



Lessons Learned—Planning

- **Stage gate management coupled with increasingly robust resource-loaded technical plans**
- **Increased rigor in technoeconomic assessment and stage gate process**
- **Balanced portfolio of projects that reflect both near term and long term objectives**



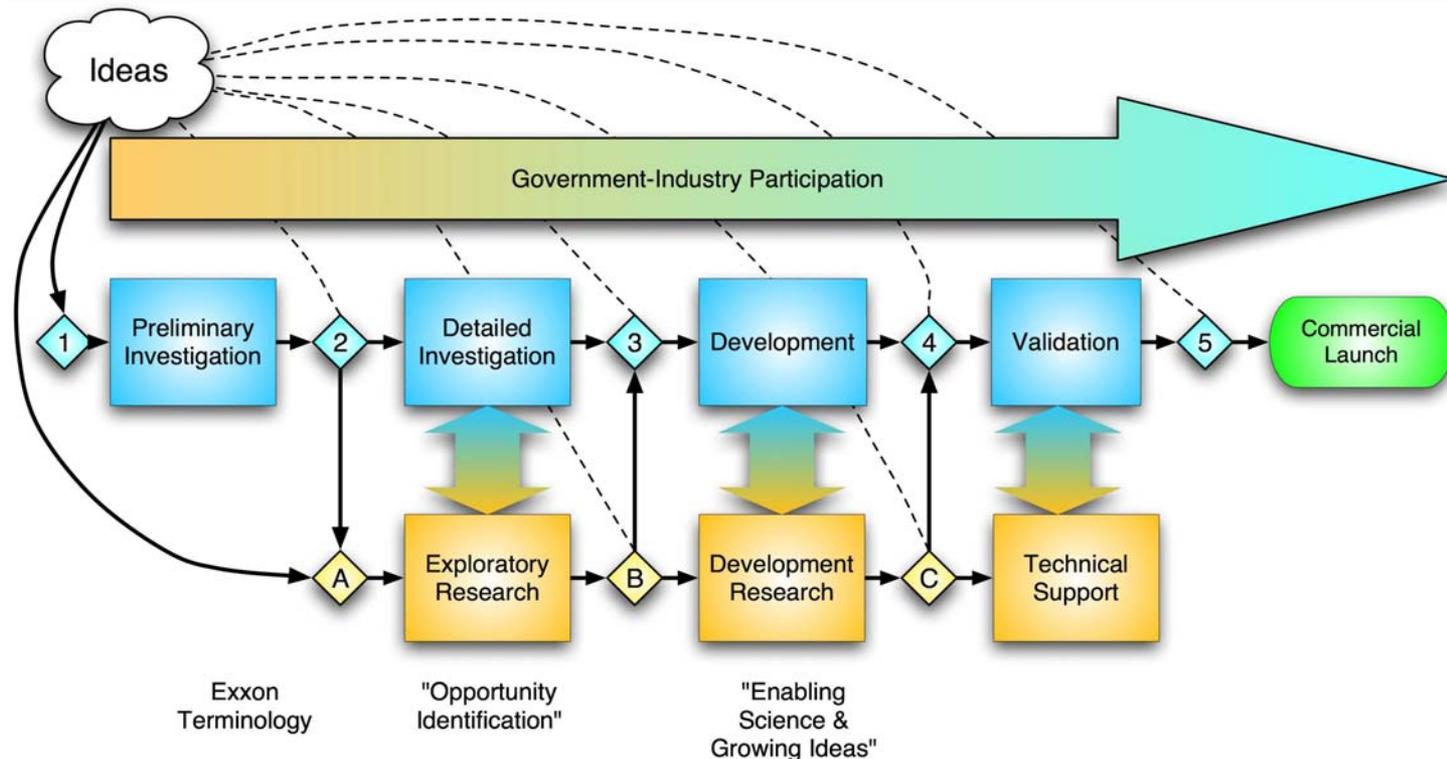
Management Approach

Stage Gate Management

Modified by Biomass Program for early stage, high risk govt-funded technology R&D to insure alignment with industry needs for late stage development and commercialization

Gate Criteria

- ✓ Strategic Fit
- ✓ Market/Customer
- ✓ Technical Feasibility and Risks
- ✓ Competitive Advantage
- ✓ Environmental, Legal, Regulatory
- ✓ Showstoppers
- ✓ Plan to Proceed





Using Stage Gate Management for the Sugar Platform

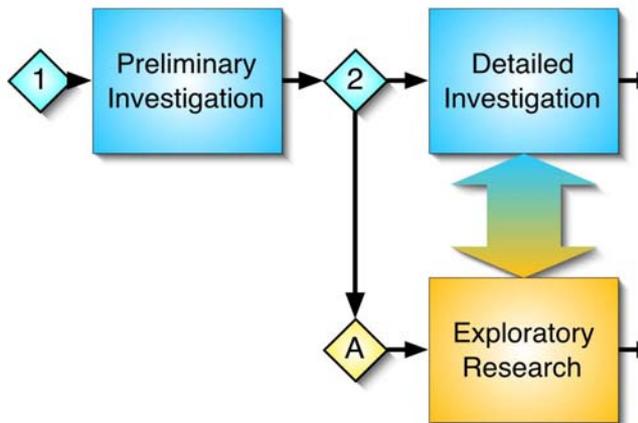


2000: Create stage 1 commercial (blue) line project as place holder for future industry led effort

- Selected corn stover as feedstock
- Focus on stover as new large volume market for enzymes
- Homework (lit reviews) on key technology components



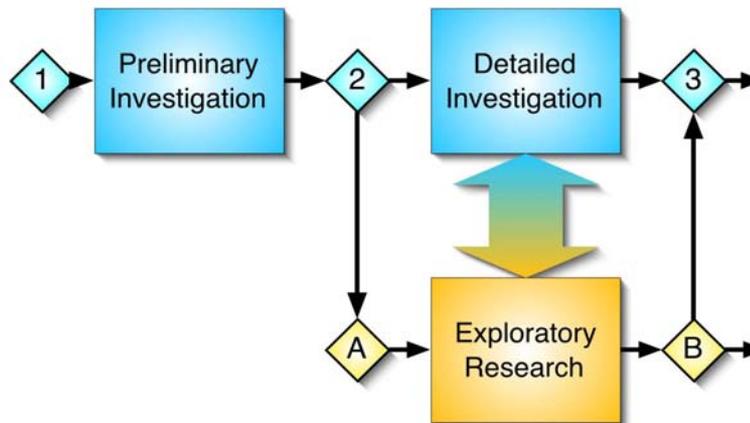
Using Stage Gate Management for the Sugar Platform



- 2001: Pass Gate Review to start Stage 2 work**
- Detailed modeling, technology reviews
 - Some technology “down-selecting”
 - Market characterization



Using Stage Gate Management for the Sugar Platform

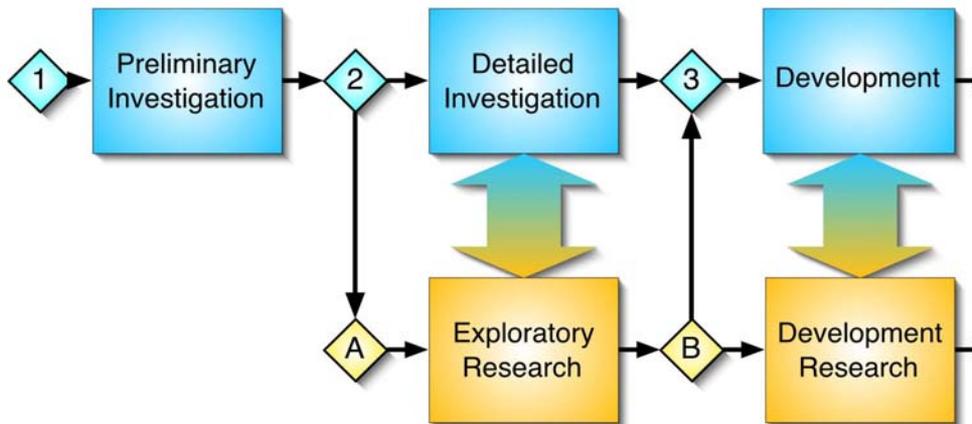


2002: Pass Gate 3 Review to start Stage 3 work.

- Grew stakeholder interest in bioenergy solicitation**



Using Stage Gate Management for the Sugar Platform



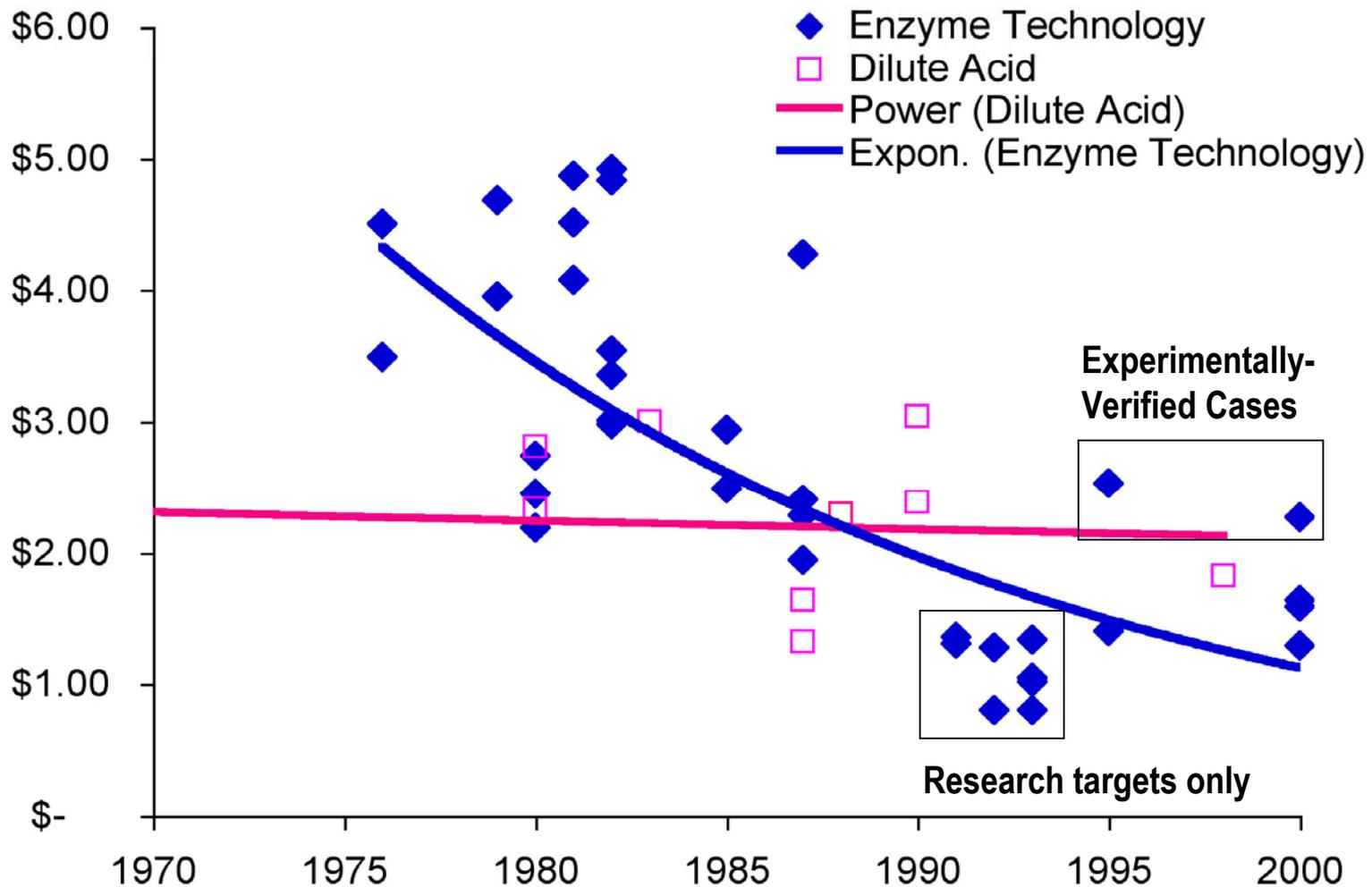
2003: Stage 3 Interim review

- Industry partners from 2002 bioenergy solicitation take over commercial (blue line) development activities
- DOE lab effort transitions from early Stage 3 blue line to orange line core research and development



Ethanol Technology

History—Enzymes vs. Acid





Enzyme Subcontracts

- 1) Improved Production Economics (reduced \$/gm enzyme)**
 - Production Strain Improvements
 - Production Process Improvements
- 2) Improved Cellulase Performance (reduced gm enzyme/gal EtOH)**
 - More Active Enzymes
 - More Digestible Pretreated Substrate

$$\text{Enzyme Cost (\$/gal EtOH)} = (\$/\text{gm enzyme}) \times (\text{gm enzyme/gal EtOH})$$



Enzyme Subcontract Improvements

	Hettenhaus / Glassner Estimate	NREL Model Starting Point	Contract Starting Point	End of Contracts Phase 1
Enzyme Cost (\$/gal EtOH) Current Yield	\$0.68	\$1.03	\$5.00	\$0.40
Enzyme Cost (\$/gal) Near-Theoretical Yield	\$0.44 (\$0.50)	\$0.67	\$3.25	\$0.26
Enzyme Price (\$/kg protein)	\$10.00	\$10.00	\$48.72	\$9.74
Enzyme Loading (kg/g cellulose)	1.4 E-5	2.1 E-5	2.1 E-5	8.6 E-6

H-G Enzyme Loading Lower by 50%



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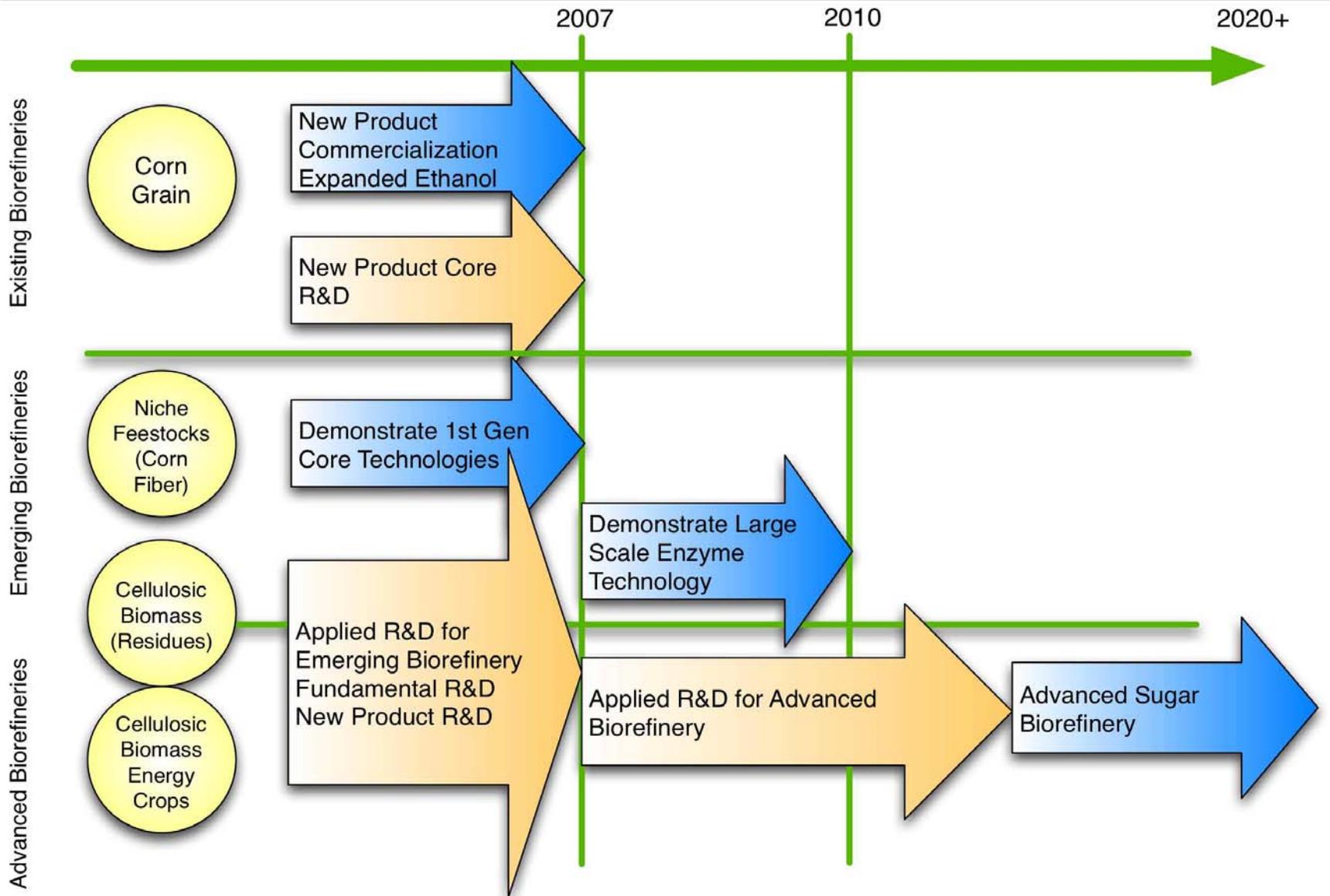
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Production Price Lower by ~5X



The Project Portfolio





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Comments and Questions

