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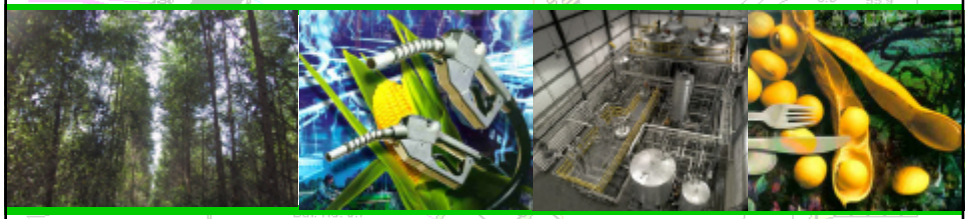
Commercializing Biorefineries
The Path Forward



Bioenergy ExCo 59 Workshop

Golden, CO

Lawrence J. Russo, Jr.
Office of the Biomass Program
Energy Efficiency and Renewable Energy

April 25, 2007

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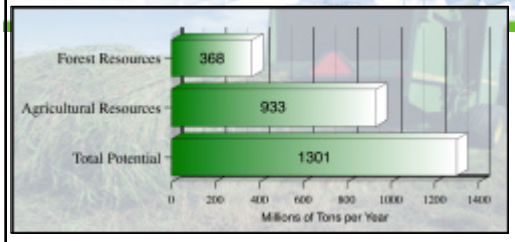
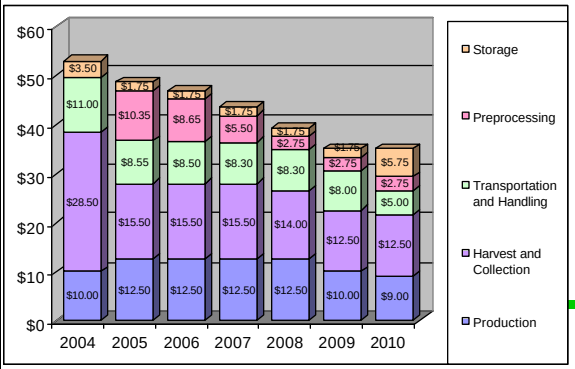
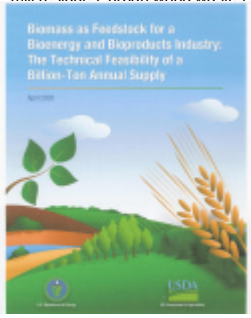
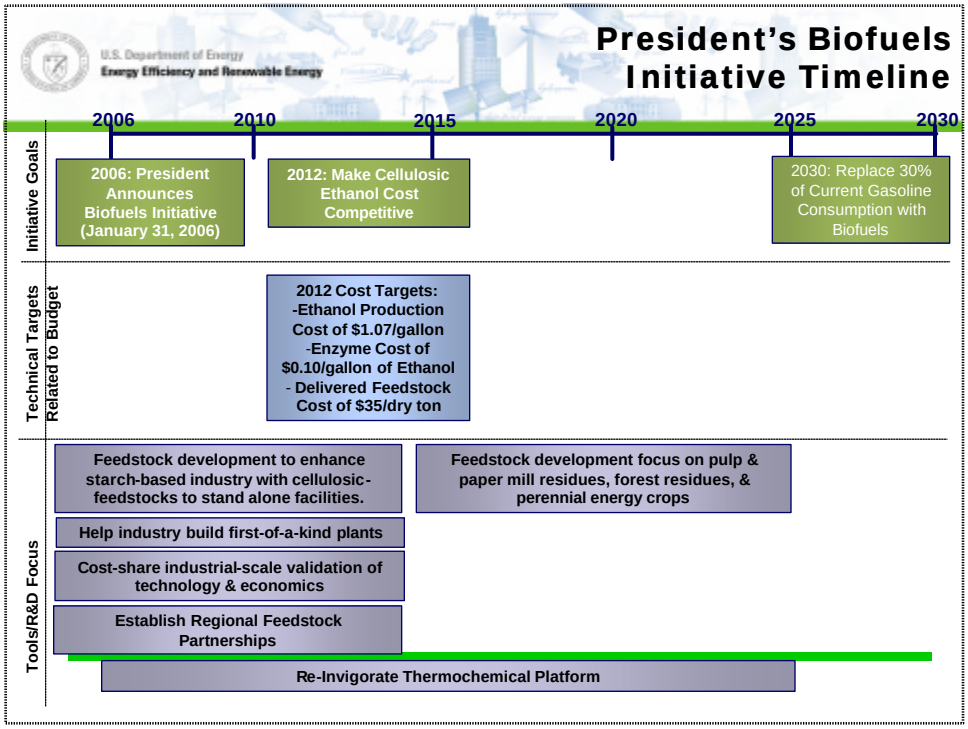
Conversion of Available Feedstocks



- "Billion Ton" study indicates that enough biomass is potentially available to displace > 30% of current U.S. petroleum consumption
- But it requires variety of biomass types
  - Agricultural lands
    - Corn stover, wheat straw, soybean residue, manure, switchgrass, poplar/willow energy crops, etc.
  - Forest lands
    - Forest thinnings, fuelwoods, logging residues, wood processing and paper mill residues, urban wood wastes, etc.



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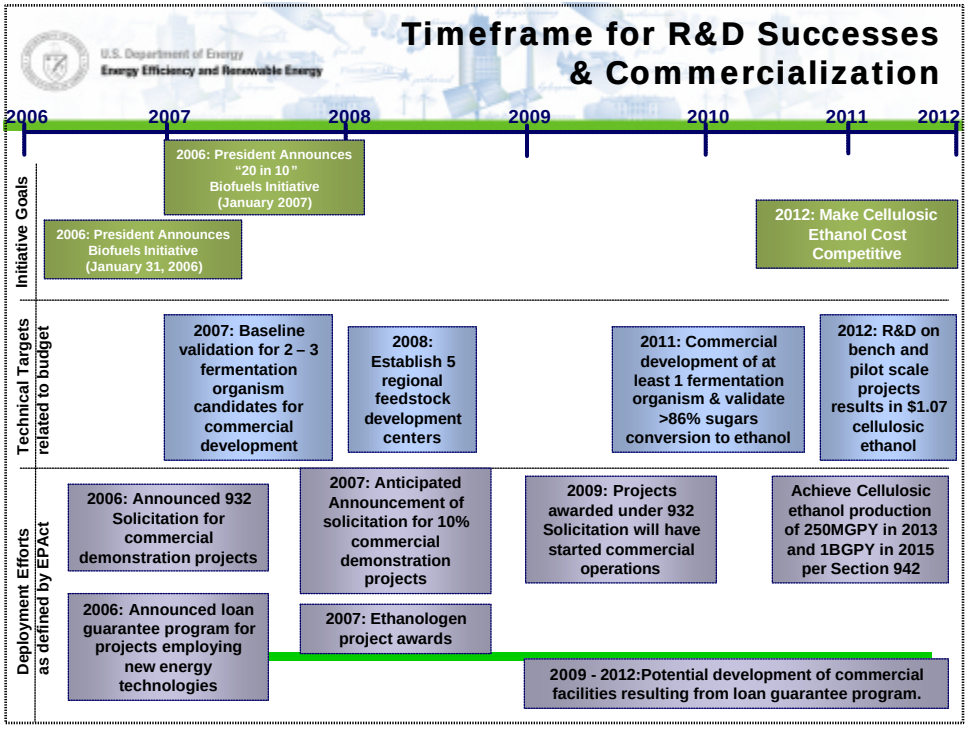
President's Biofuels Initiative Timeline
2006
2010
2015
2020
2025
2030
Initiative Goals
2006: President Announces Biofuels Initiative (January 31, 2006)
2012: Make Cellulosic Ethanol Cost Competitive
2030: Replace 30% of Current Gasoline Consumption with Biofuels
Technical Targets Related to Budget
2012 Cost Targets:
-Ethanol Production Cost of $1.07/gallon
-Enzyme Cost of $0.10/gallon of Ethanol
- Delivered Feedstock Cost of $35/dry ton
Tools/R&D Focus
Feedstock development to enhance starch-based industry with cellulosic-feedstocks to stand alone facilities.
Feedstock development focus on pulp & paper mill residues, forest residues, & perennial energy crops
Help industry build first-of-a-kind plants
Cost-share industrial-scale validation of technology & economics
Establish Regional Feedstock Partnerships
Re-Invigorate Thermochemical Platform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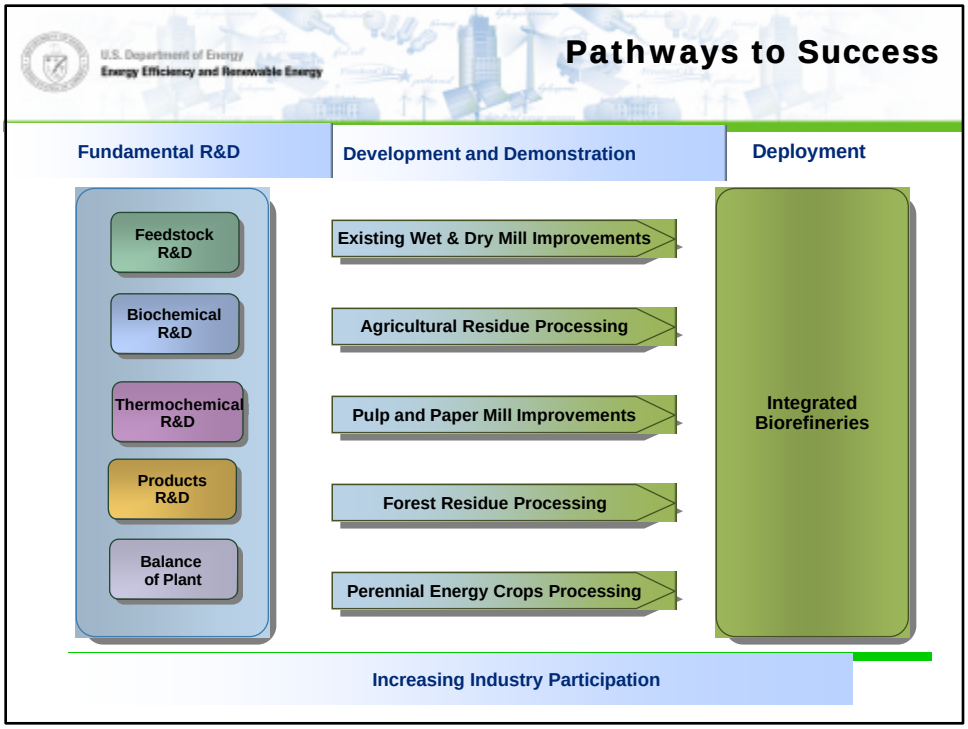
Timeframe for R&D Successes & Commercialization
2006
2007
2008
2009
2010
2011
2012
Initiative Goals
2006: President Announces "20 in 10" Biofuels Initiative (January 2007)
2006: President Announces Biofuels Initiative (January 31, 2006)
2012: Make Cellulosic Ethanol Cost Competitive
Technical Targets related to budget
2007: Baseline validation for 2 – 3 fermentation organism candidates for commercial development
2008: Establish 5 regional feedstock development centers
2011: Commercial development of at least 1 fermentation organism & validate >86% sugars conversion to ethanol
2012: R&D on bench and pilot scale projects results in $1.07 cellulosic ethanol
Deployment Efforts as defined by EPAct
2006: Announced 932 Solicitation for commercial demonstration projects
2007: Anticipated Announcement of solicitation for 10% commercial demonstration projects
2009: Projects awarded under 932 Solicitation will have started commercial operations
Achieve Cellulosic ethanol production of 250MGPY in 2013 and 1BGPY in 2015 per Section 942
2006: Announced loan guarantee program for projects employing new energy technologies
2007: Ethanologen project awards
2009 - 2012:Potential development of commercial facilities resulting from loan guarantee program.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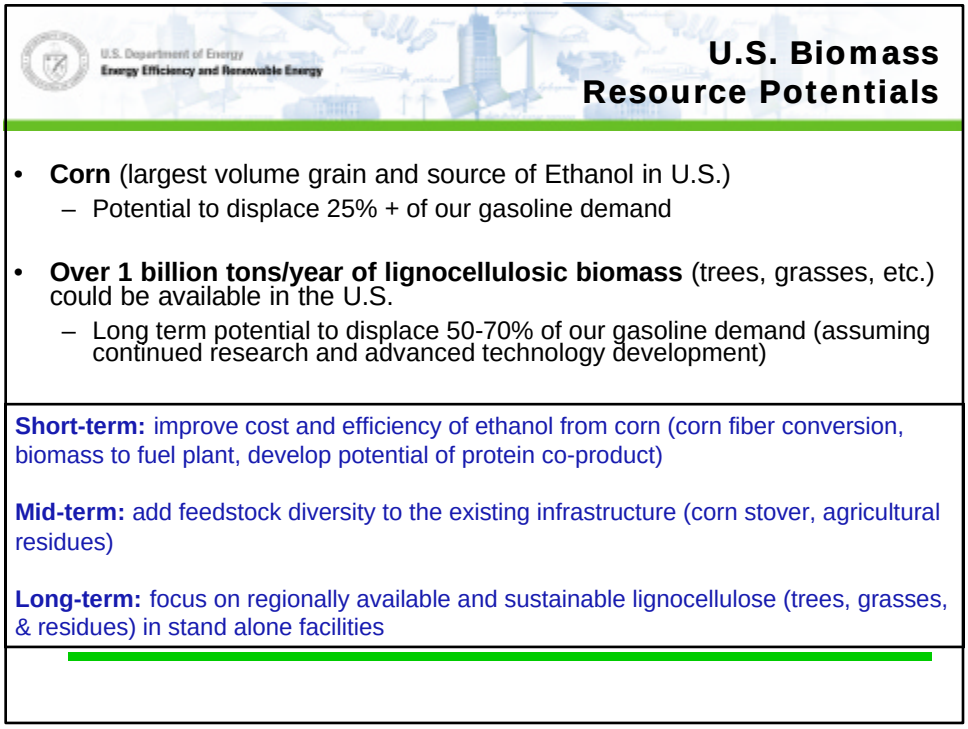
Pathways to Success
Fundamental R&D
Development and Demonstration
Deployment
Feedstock R&D
Biochemical R&D
Thermochemical R&D
Products R&D
Balance of Plant
Existing Wet & Dry Mill Improvements
Agricultural Residue Processing
Pulp and Paper Mill Improvements
Forest Residue Processing
Perennial Energy Crops Processing
Integrated Biorefineries
Increasing Industry Participation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U.S. Biomass Resource Potentials
• Corn (largest volume grain and source of Ethanol in U.S.)
– Potential to displace 25% + of our gasoline demand
• Over 1 billion tons/year of lignocellulosic biomass (trees, grasses, etc.) could be available in the U.S.
– Long term potential to displace 50-70% of our gasoline demand (assuming continued research and advanced technology development)
Short-term: improve cost and efficiency of ethanol from corn (corn fiber conversion, biomass to fuel plant, develop potential of protein co-product)
Mid-term: add feedstock diversity to the existing infrastructure (corn stover, agricultural residues)
Long-term: focus on regionally available and sustainable lignocellulose (trees, grasses, & residues) in stand alone facilities

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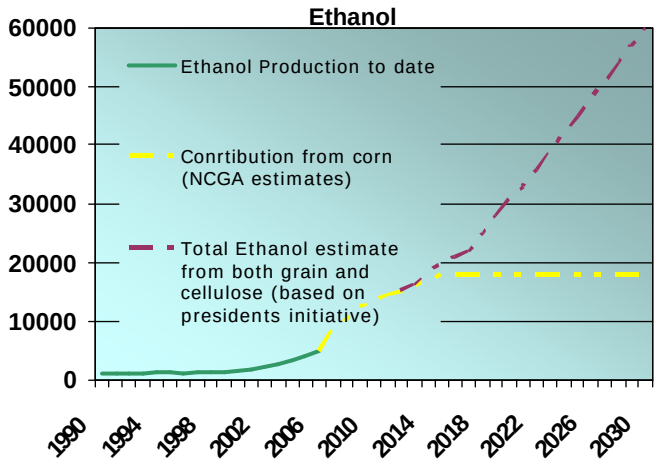
U.S. Biofuels Production
(Million Gallons/Year)



Sources:
RFA Ethanol Industry Outlook 2006
National Biodiesel Board Estimated Biodiesel Production
EERE Alternative Fuels Data Center:
NCGA
Presidential Biofuels Initiative

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Biofuels Sources

Today (2006)

- Grain Crops (Corn)

~5 billion gallons

2030

- Grain Crops (Corn, Milo, Barley, Wheat, etc.)
- Corn Fiber
- Switchgrass
- Corn Stover
- Agricultural Residues
- Forestry Residues

~15 - 20 billion gallons

~45+ billion gallons

~60 billion gallons

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Commercialization Risks

Corn to Ethanol – technology is commercial – issues revolve around market risk

- The RFS will be met well before 2012 timeframe and the MTBE replacement market is close to saturation.
- Petroleum industry may attempt to control ethanol deployment through market price once RFS is met, lowering ethanol prices and curtailing deployment.
- **What do we do with the protein?**

Cellulose to Ethanol

- **Technology Risk**
  - Many technologies need continued technical development, before ready for deployment
  - Concern that venture capital may flow to unproven technologies
  - Funding needed in all stages of technology to lower risks
- **Financial Risks**
  - Loan Guarantees may help, but will they result in sustainability
  - Competition from corn-to-ethanol limits funding opportunities
- **Policy incentives**
  - Need to support energy crop development
  - Need to be separate from corn to ethanol if market is to grow in near to mid-term
  - 1B gallon mandate by 2015 (RFS) for cellulosic ethanol needs to be accelerated and expanded
- **Project Failure Risk**
  - "Gold Rush Mentality" – VC funds, IPO's, Equity funds, and Federal Loan Guarantees tend to push projects to commercialization without proper due diligence leading to unsuccessful pioneer plant launches.
  - Technology failures) will result in a rapid pull-back of available commercialization capital
- **General**
  - Risk of technology deployment or industry and institutional investment if crude oil prices drop for an extended period
  - Risk of consumer perceived failure due to the lack of a well coordinated, rational plan for FFV, Fueling station and transportation infrastructure deployment
  - Competition for engineering, construction and material resources may increase plant costs and limit the rate of deployment – Big Dig Phenomenon

Its all about developing and maintaining critical mass

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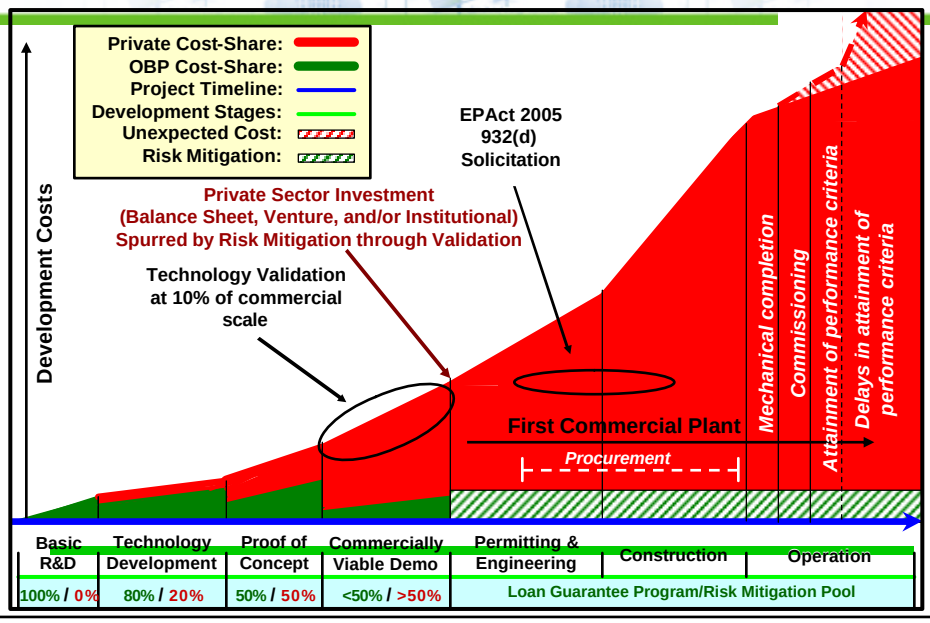
Deployment Barriers and Solutions



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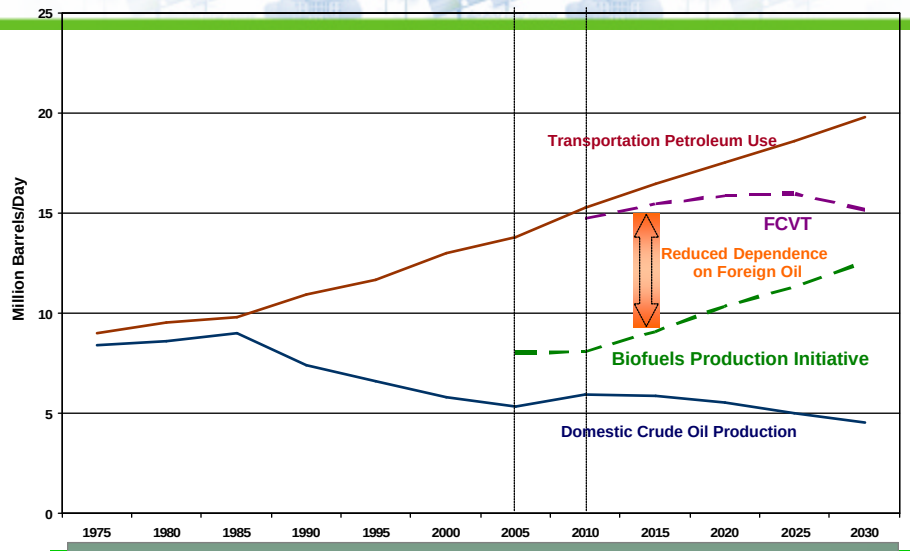
Biofuels Production and Vehicle Efficiency



The combination of increased vehicle efficiency and biofuels production will result in reduced dependence on foreign oil imports.

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A Balanced Approach