



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

Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

U.S. DOE Biomass Program

NP213 (307) BIOENERGY
Planning and Coordination Meeting
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John Ferrell
Office of Biomass Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy



2012 – 2015:

- Grain Ethanol ~12+ billion gal.
- Cellulosic Ethanol 167-860 million gal.

2030:

- Grain Ethanol ~12-18* billion gal.
- Cellulosic Ethanol ~40-50 billion gal.

* NCGA estimates

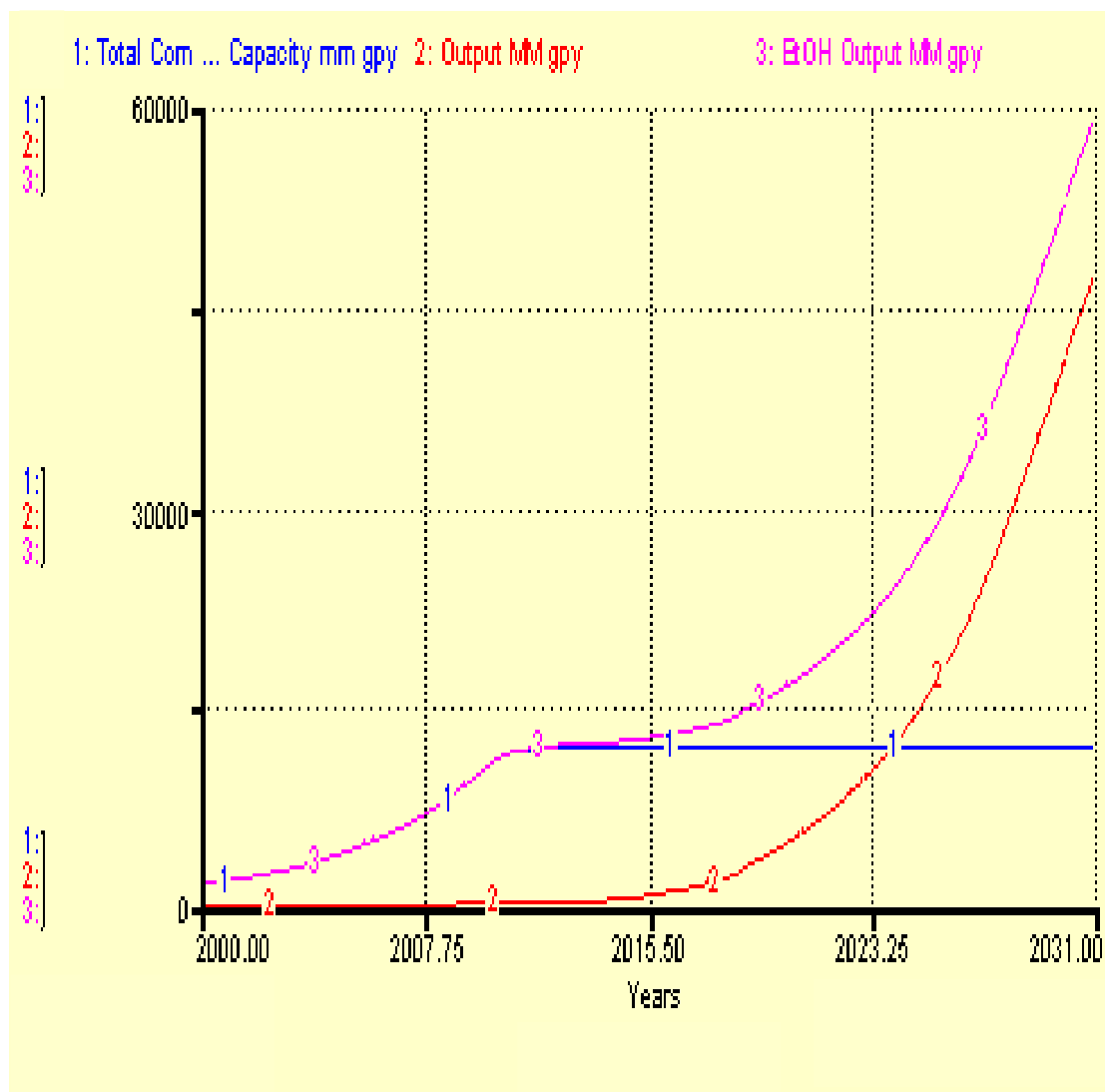


Chart representing ethanol volumes predicted from the high oil case using the transition model for the 30x30 report.
Date:11/22/06, contact – Bob Wooley.



What the Initiative Provides for Biofuels

- Investigate the conversion of a much broader number of possible feedstocks
- Develop regional feedstocks partnerships to identify local opportunities for feedstock production and ethanol production
- Reestablish the thermo-chemical conversion technology as a second possible pathway to success
- Fermentation organism development solicitation
- Accelerated research on all major hurdles to \$1.07 gallon production cost in an established industry
- Enable the 1st U.S. commercial scale cellulosic ethanol production facility (EPAct, Section 932)
- Enable larger scale demo's of a variety of feedstocks and conversion technologies.



Hurdles to Overcome

Overall Needs

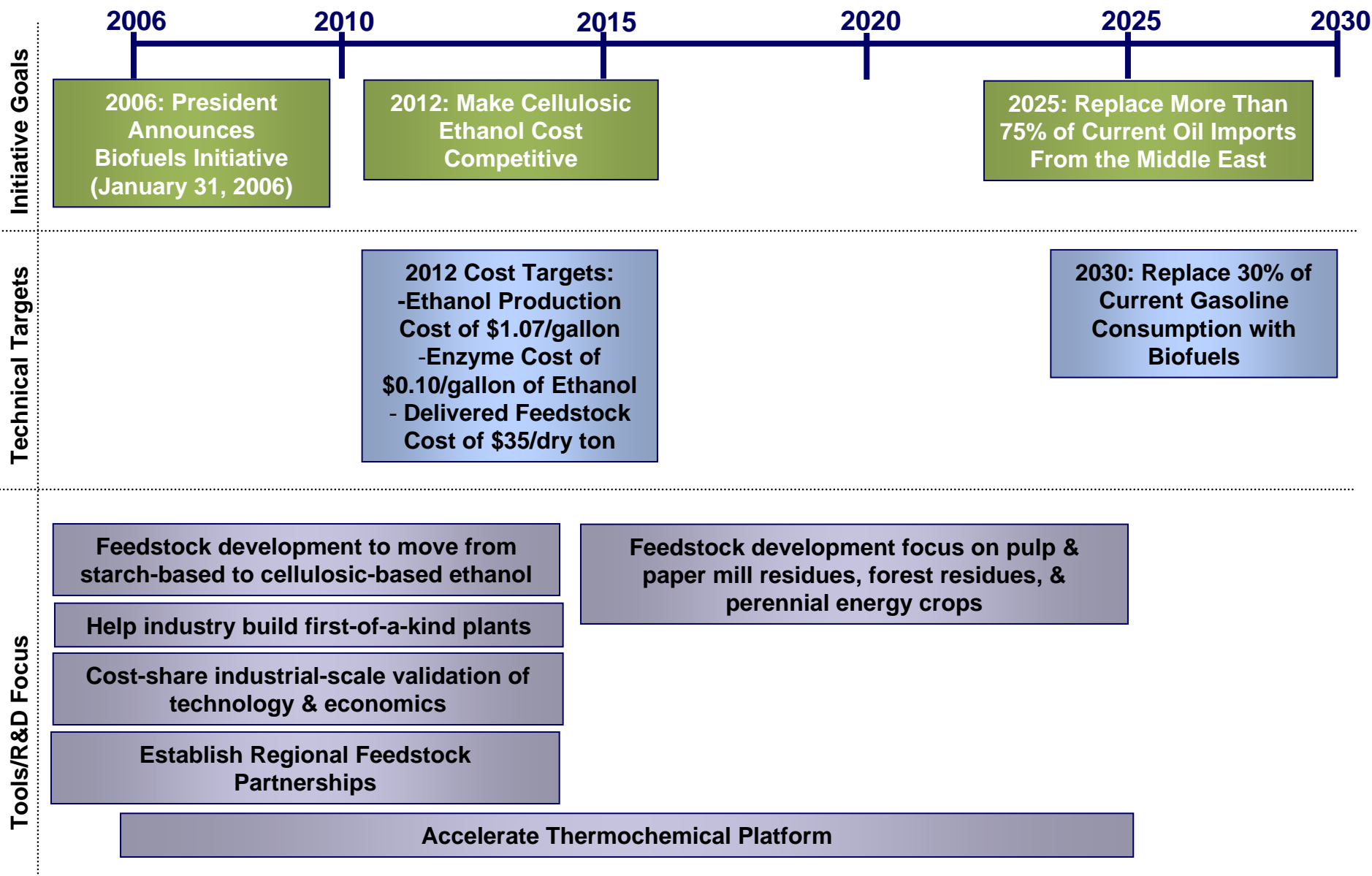
- Production of ethanol from a variety of feedstocks available across the U.S.
- Lower the production costs of cellulosic ethanol
- Conversion technology options

Research Focus

- Faster fermentation times
- Improved yield of ethanol per ton of feedstock
- Continue to reduce enzyme cost
- Improve sugar recovery and conversion
- Clean syngas for fuels synthesis
- Developing catalyst for producing fuels



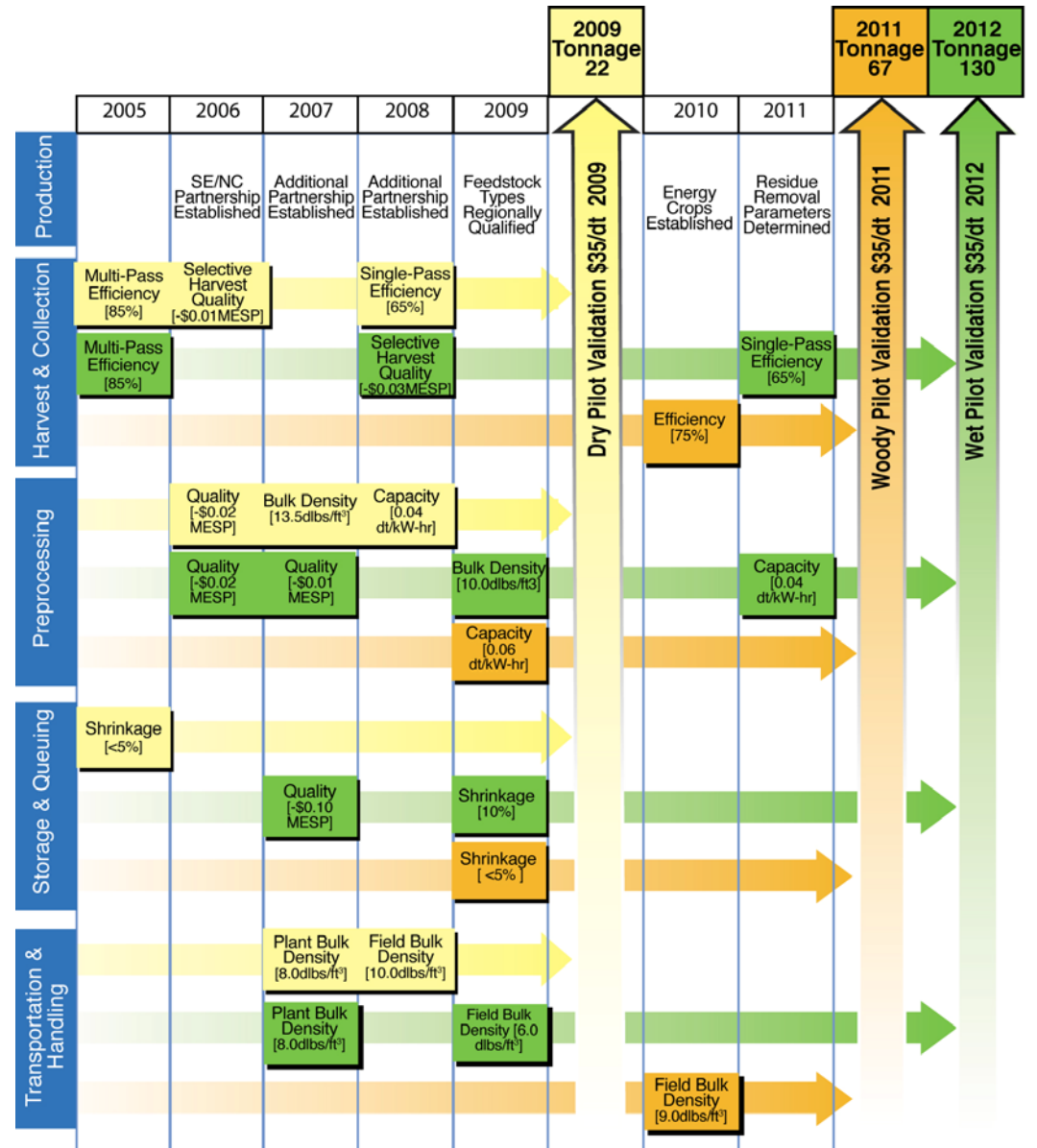
President's Biofuels Initiative Timeline





R&D Plan Designed to Answer:

- *What are the Feedstocks?*
 - Feedstock and characteristics
 - Location
- *What are the Feedstock Tonnages and Costs?*
 - Supply potential
 - Availability and demand
- *What are the feedstock locations' opportunities / constraints?*
 - Production practices
 - Infrastructure constraints
- *What are the feedstock supply options and costs?*
 - Regional engineering designs
 - Dry, wet, and woody





$$\text{Delivered Cost } [\$/\text{ton}] = \left(\text{Grower Payment } [\$/\text{ton}] \right) + \left(\frac{\text{Efficiency } [\$/\text{hr}]}{\text{Capacity } [\text{ton}/\text{hr}]} + \text{Quality } [\$/\text{ton}] \right)$$

Unit Operation \$35 End-State Design Validation

- Demonstrate continuous assembly system performance on a 50,000 to 100,000 ton scale.
- Demonstrate unit operation performance parameters are achievable at scale.
- Demonstrate adequate system reliability

Deployable PDU





Regional Partnerships (*Sun Grant Initiative, USDA, Universities, States, Commodity Groups, etc.*) are needed to answer:

- Where are the feedstocks?
- What are the Feedstock Tonnages and Costs?
- What are the feedstock locations' opportunities / constraints?



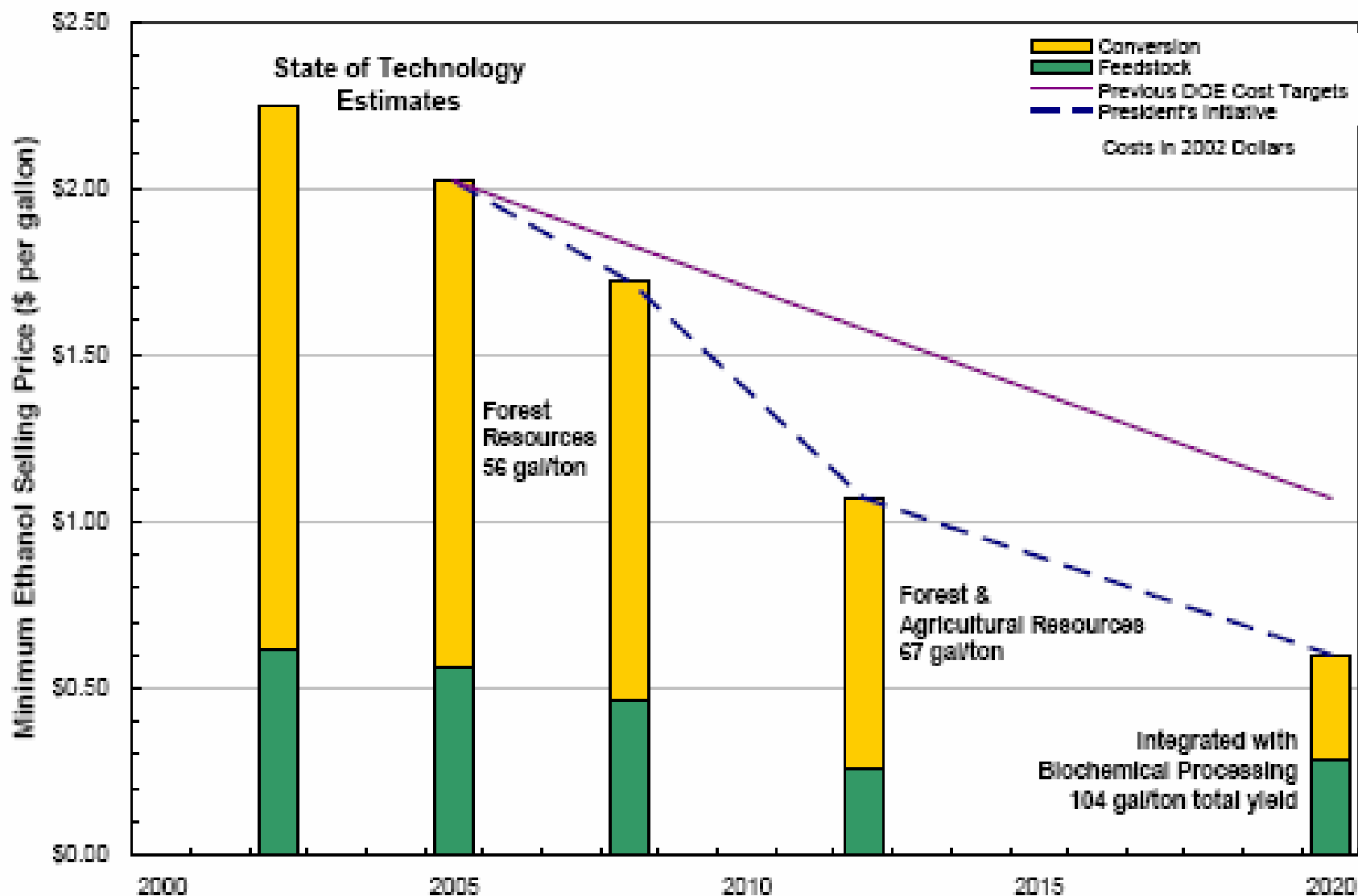
Industrial Partnerships (*Biorefining Companies, Growers, Equipment Mfg., Agribusiness, etc.*) are needed to answer:

- What are the feedstock supply options and costs?





Thermochemical Platform Cost Reduction





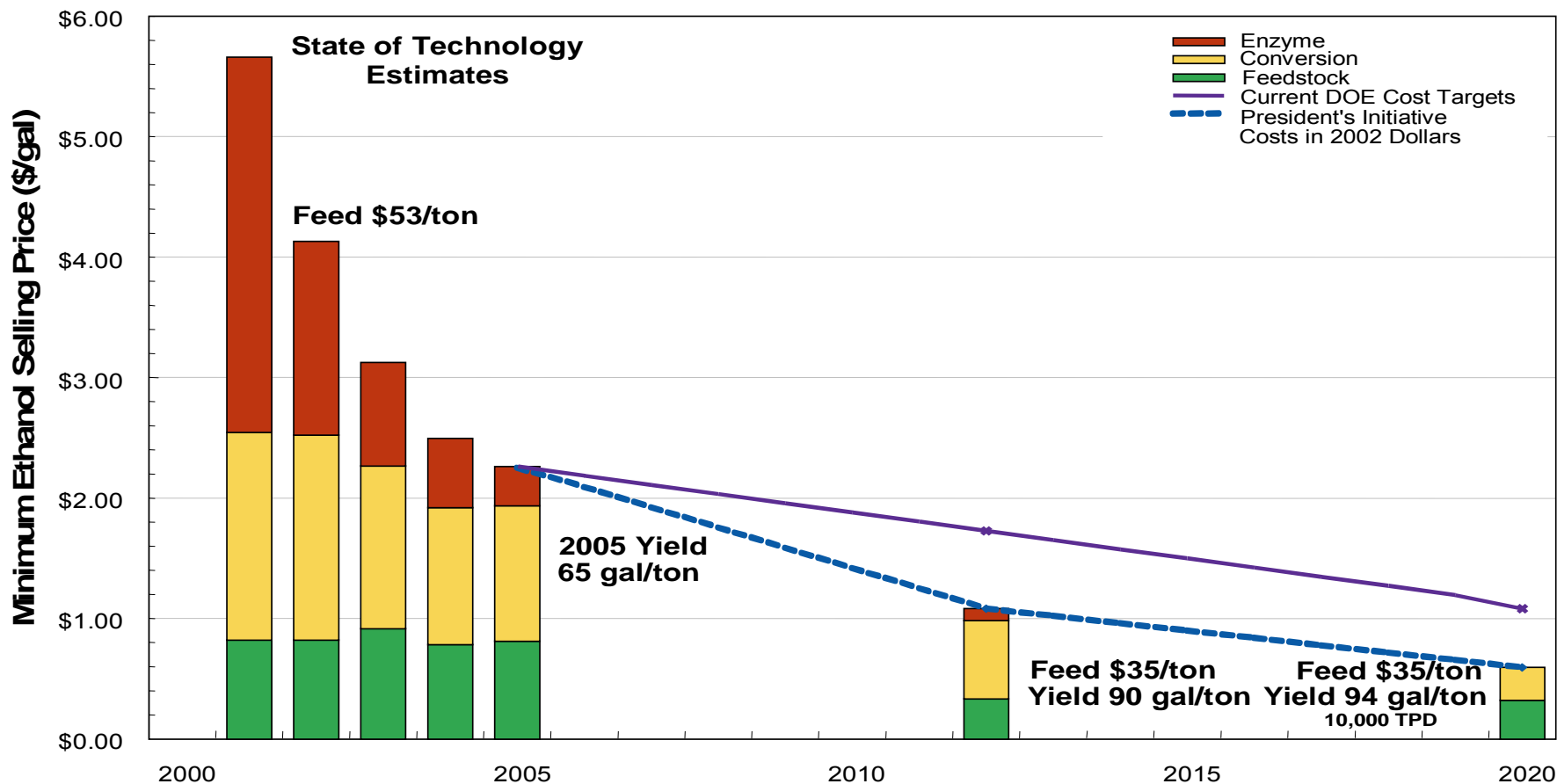
Barrier	2005	2012 Goal
Minimum Ethanol Selling Price	\$1.61	\$1.07
Higher Alcohol Co-Product Value (% market value)	85%	69%
Minimum Mixed Alcohol Selling Price (\$/gal ethanol equivalent)	\$1.80	\$1.25
Installed Capital Cost (\$/annual gal MA)	\$2.71	\$2.00
Operating Cost (\$/annual gal MA)	\$0.81	\$0.49
Ethanol Yield (gal/dry ton)	56	67
Mixed Alcohol Yield (gal/dry ton)	77	89
Feedstock Type	Wood Chips	Biorefinery Residues
Tar reformer exit methane (mol% - dry basis)	8.25	1.73
Tar reformer light HC reforming (% CH ₄ conversion)	20%	80%
Tar reformer heavy HC reforming (% benzene)	70%	99%
Tar reformer heavy HC reforming (% tar conversion)	95%	99.9%
SMR Light HC reforming (% CH ₄ conversion)	79%	N/A
Sulfur Removal	1ppmv (SMR)	50ppmv (MA)
CO ₂ Recycle (lb/lb dry feed)	1.72	0.66
Compression for fuel synthesis (psia)	2,000	1,000
Single pass CO conversion	38.5	50
Overall CO conversion	96.9	98.1
CO selectivity to alcohols	80	90

Cleanup & Conditioning





Fermentation Platform Cost Reduction





		Barrier	2005	2012 Goal
		Minimum Ethanol Selling Price	\$2.26	\$1.07
		Installed Capital per Annual Gallon	\$3.04	\$1.85
		Yield (gallon/dry ton)	65	90
Feedstock	→	Feedstock Cost (\$/dry ton)	\$53	\$35
Pretreatment	}	Xylan to Xylose	63%	90%
		Xylan to Degradation Products	13%	5%
Conditioning	}	Xylose Sugar Loss	13%	0%
		Glucose Sugar Loss	12%	0%
Enzymes	→	Enzyme Contribution* (\$/gal EtOH)	\$0.32	\$0.10
Saccharification & Fermentation	}	Combined Saccharification & Fermentation Time (d)	7	3
		Xylose to Ethanol	76%	85%
		Minor Sugars to Ethanol	0%	85%

*Model value, slightly lower than metric value



- **Commercial Demonstration of an Integrated Biorefinery System for Production of Liquid Transportation Biofuels, Biobased Chemicals, Substitutes for Petroleum-based Feedstocks and Products, and Biomass-based Heat/Power Solicitation**
 - Issued in response to EPCA 2005 Section 932
 - Closed August 10, 2006
 - Approximately \$53,000,000 is expected to be available in FY07
 - Currently reviewing 25 proposals

- **Loan Guarantee**
 - Announced by Secretary Bodman on August 7, 2006
 - \$2 billion in loan guarantees to help spur investment in projects that employ new energy technologies
 - For more information: <http://www.lgprogram.energy.gov/>

- **Fueling Infrastructure**
 - EERE E85 Infrastructure Team
 - FreedomCAR and Vehicle Technologies Program solicitation
 - Refueling infrastructure projects that include new dispensing facilities, or additional equipment or upgrades and improvements to existing refueling sites for alternative fuel vehicles (AFV)



■ Ethanolgen Solicitation

- To develop commercial microbial strains that produce ethanol from lignocellulosic derived sugars. This work needs to begin now so that such fermentative organisms will be ready for use in the integrated biorefineries being developed across the nation for commercial production of ethanol by 2012.
- **Requested** funding amounts: \$17.4 million would be available in FY07; \$7 million in FY08; \$17.5 million for FY09-10

■ Enzyme Solicitation

- To develop cellulase preparations with improved performance (activities) on pretreated selected energy crops using protein engineering principles.
- **Requested** funding amounts: \$4.5 million would be available in FY07; \$12 million in FY08; \$5 million for FY09-11