Growing A Robust Biofuels Economy in the United States

Jeff Skeer, U.S. Department of Energy
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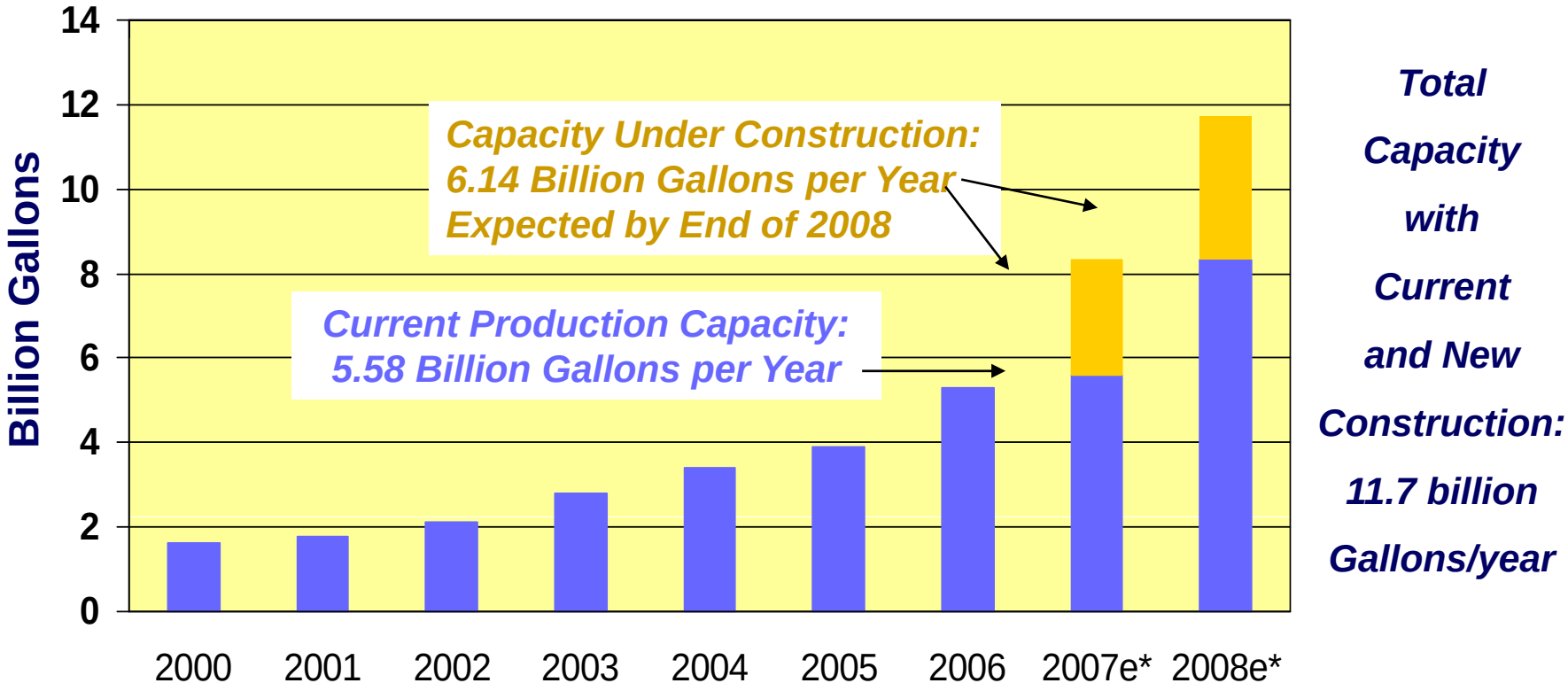
Ethanol Production Capacity in the United States is Growing Rapidly



*Estimated as of February 7, 2007. Source: Renewable Fuels Association.

Biofuels represent just 3% of US transport fuels today, but production is growing rapidly.

Ambitious Biofuels Goals

- **Cost-competitive cellulosic ethanol by 2012**
- **“20 in 10”: Reduce gasoline use 20% in 10 years**
  - **Alternative Fuels Standard to reduce gasoline use by 15% or 35 billion gallons per year by 2017.**
  - **Enhanced Corporate Average Fuel Economy (CAFÉ) standards to reduce gasoline use by 5%**
- **“30 in 30”: Displace 30% of gasoline use by 2030**
  - **Longer-term Department of Energy biofuels goal**
  - **Ramp up biofuels to 60 billion gallons per year**

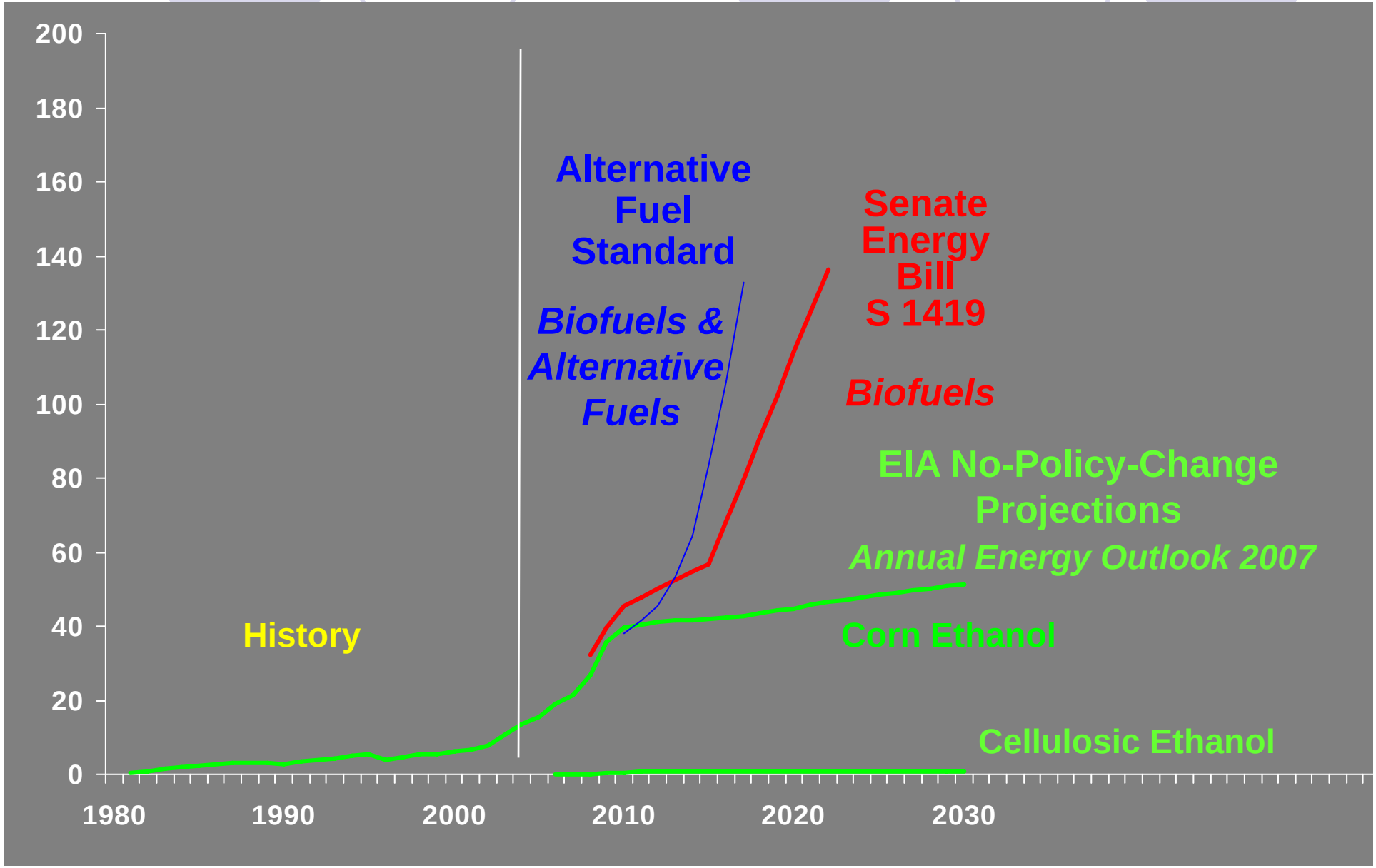
Administration and Senate Bills Have Similar Goals But Differ in Timing

Year	Billions of Gallons of Fuel Per Year		
	Administration (Alternative Fuels)	Senate (Biofuels Only)	Of Which Non Starch Ethanol Biofuels:
2010	10	12	
2011	11	12.6	
2012	12	13.2	
2013	14	13.8	
2014	17	14.4	
2015	22	15	
2016	28	18	3
2017	35	21	6
2018		24	9
2019		27	12
2020		30	15
2021		33	18
2022		36	21

Biodiesel and Butanol Get Extra Credit, But Many Alternative Fuels Can Qualify

	Gallons of Credit Per Gallon of Fuel	
	Senate	Administration
Ethanol	1.0	1.0
Biodiesel	1.4	1.4
Domestic GTL diesel	0	1.5
CTL diesel	0	1.5
Liquefied natural gas	0	1.0
Liquefied petroleum gas	0	1.1
Gaseous Hydrogen	0	1.0
Liquid Hydrogen	0	0.8
Methanol	0.8 (bio)	0.8
Butanol	1.3 (bio)	1.3
Electricity (per 6.4 kWh)	0	1.0

Comparison of Biofuel Scenarios



Provisions to Facilitate Compliance

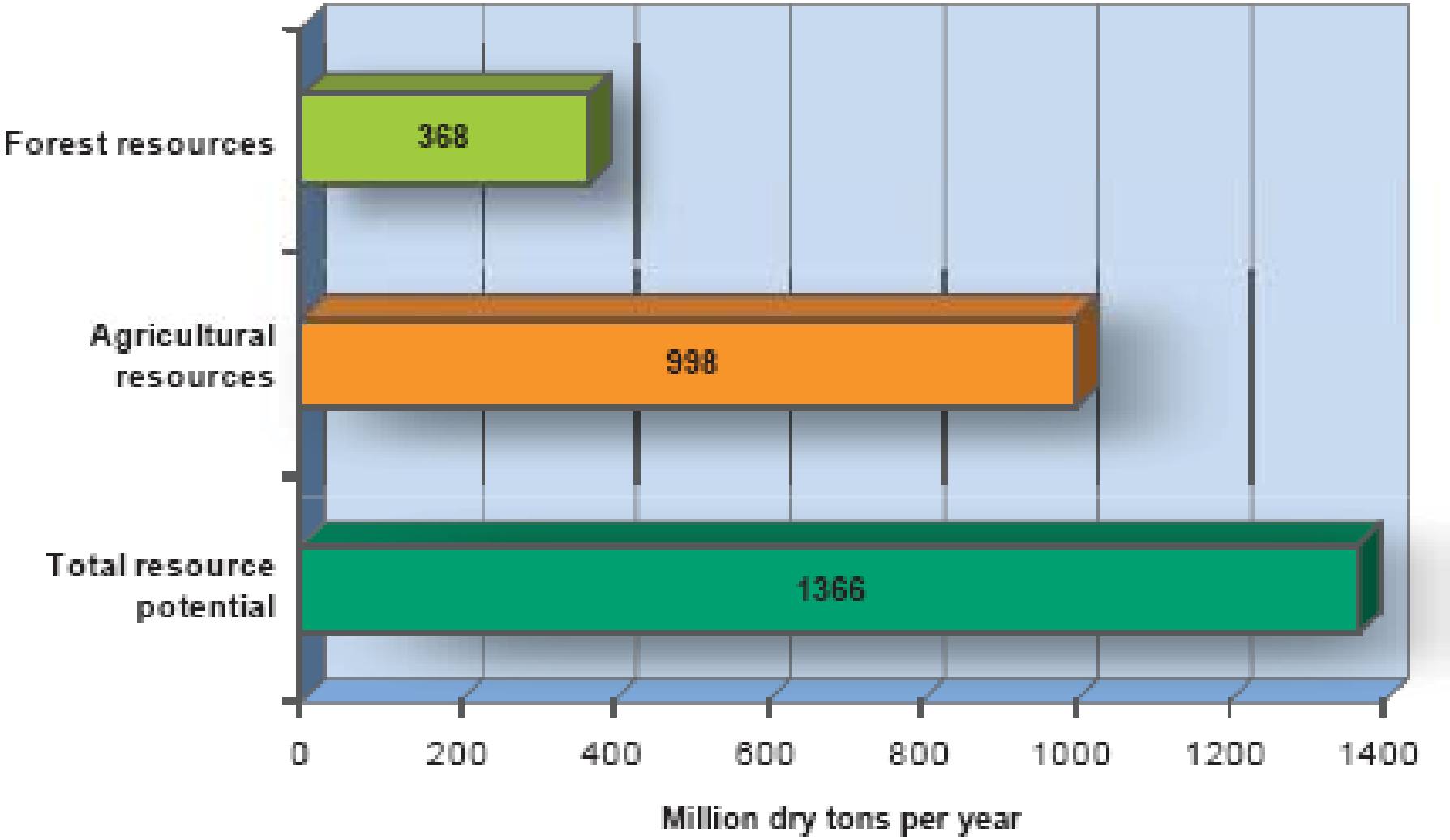
- **Complying parties could bank, sell and buy compliance credits. Banked credits would not expire in Administration bill, would last a year in Senate bill.**
- **The President would have broad discretion to issue waivers of annual volume requirements if extreme or unusual fuel supply circumstances exist.**
- **Compliance credits would be available from the Federal government at $1.00 per gasoline-equivalent gallon ($0.67/gallon of ethanol) in Administration bill.**
- **These features would limit the economic costs of the program to refiners and consumers.**

How Will We Achieve These Goals?

- **Effective Program of Technology RD&D**
  - **Understand Potential Biofuel Resources**
  - **Boost Yields of Biofuel Feedstocks**
  - **Reduce Costs of Biofuel Conversion Processes**

- **Effective Policies to Boost Private Investment**
  - **Financial Incentives for Biofuels Production**
  - **Financial Incentives for Biofuels Infrastructure**

Billiion Ton Study of Biofuel Resources



Enough to Displace 1/3 of Oil Use

- Oil use about 150 billion gallons in 2010.
- 1.3 billion t would displace over 50 Bgal.
- Does not count potential for improved automotive fuel efficiency (with 50% better efficiency, half of oil use could be displaced).
- Does not count potential for grassy feedstocks (such as corn stalks and switchgrass) that could grow on other lands.

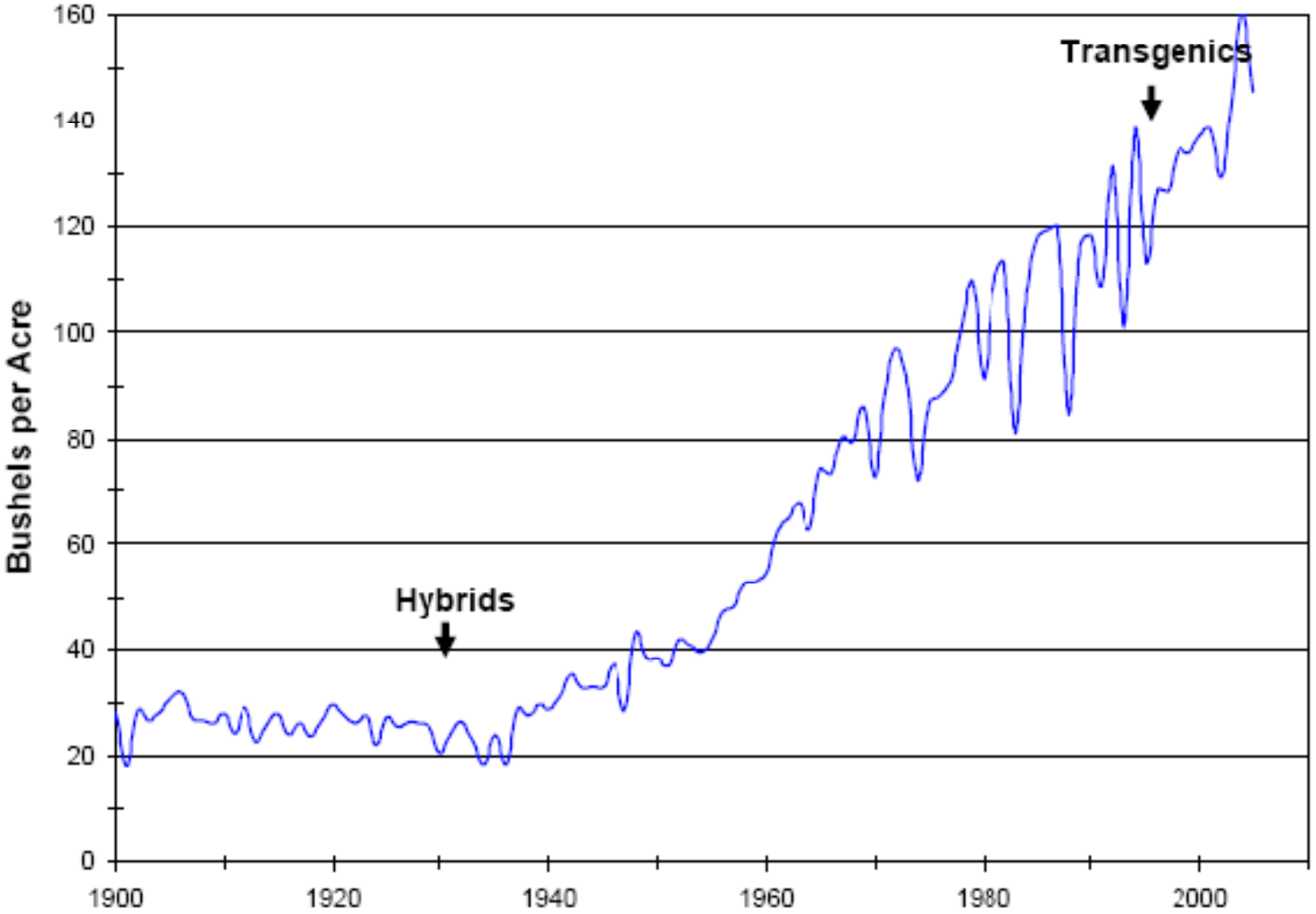
Billion Ton Study Assumptions

- Grain yields (corn, wheat) increase 50%
- Soybean residue:grain ratio up to 2:1
- 75% of crop residues recovered by harvest technology where sustainable
- All cropland managed by no-till methods
- 55 M acres for perennial bioenergy crops
- All excess manure used for biofuel
- All available residues utilized

R&D To Boost Biofuel Yields

- Yields of conventional crops have risen steadily for decades and can rise further.
- Yields of lignocellulosic crops could be greatly improved through the systematic application of genetic science.
- Grassy crops may have much higher yields than farm and forest residues, allowing needs to be met on less land and reducing costs of feedstock harvest and transport.

Corn Yields Up Four-Fold in Fifty Years



Genetic Strategies to Boost Crop Yields

- Increase feedstock per unit of land by increasing growth rate and photosynthetic efficiency.
- Increase fuel yield per ton of feedstock through better composition and structure.
- Enhance disease and pest resistance.
- Allow germination and growth in cold weather.
- Use perennial, multi-year crops with efficient nutrient use and reduced fuel input.
- Permit dense planting and easy harvesting.
- Deep roots for increased carbon sequestration, drought tolerance and nutrient uptake.

Grants to Boost Lignocellulosic Yields

- In 2006, the Department of Energy (DOE) and U.S. Department of Agriculture (USDA) awarded $5.7 million for nine projects for research on genomics that will allow woody plant tissues such as alfalfa, sorghum, wheat and other grasses to be grown in large quantities to produce renewable fuels, including ethanol.
- Also in 2006, DOE announced a grant of $1.6 million for a biotech firm, Ceres, Inc., to double the cellulosic yield of switchgrass by 2020.

Demonstration of Cellulosic Ethanol key to Meeting Biofuel Resource Potential

- Breakeven at about $80 per barrel of oil today, technology rapidly evolving to bring costs down.
- EPAct authorizes $650 million in loan guarantees.
- EPAct allows DOE to issue loan guarantees for up to 4 projects to demonstrate commercial feasibility of producing ethanol from sucrose or cellulosic biomass or municipal solid waste.
- Each project would produce at least 30 million gallons of ethanol per year and receive a loan guarantee for up to 80% of cost or $250 million.

Cost Reduction Goals for R&D on Lignocellulosic Ethanol ($ per gallon)

COST ELEMENT	2005	2009 TARGET	2012 TARGET
FEED STOCK	.90	.79	.44
PREHYDROLYSIS/TREATMENT	.44	.31	.25
ENZYMES	.32	.32	.11
SACCHARIFICATION AND FERMENTATION	.31	.27	.10
DISTILLATION AND SOLID RECOVERY	.18	.17	.17
BALANCE OF PLANT	.34	.27	.24
TOTAL	2.50	2.13	1.31

R&D to Lower Biofuel Conversion Costs

- Substantial R&D Appropriations for Biofuels:
  - **$213 million for FY2007**
  - **$251 million for FY 2008**
  - **$274 million for FY 2009**
- Of which about half is for biorefineries:
  - **$100 million in FY2007**
  - **$125 million in FY 2008**
  - **$150 million on FY 2009**
- Plus $45 million annually for biofuels science

Overcoming Technology Barriers to Reduce Costs of Biofuel Conversion

Barriers	Solutions
• High cost of enzymatic conversion	• R&D to improve effectiveness and reduce costs of enzymatic conversion
• Inadequate technology for producing ethanol from sugars derived from cellulosic biomass	• R&D on advanced micro-organisms for fermentation of sugars
• Limitations of thermochemical conversion processes	• Re-establish thermochemical conversion as second path to success
• Demonstration/integration of technology in biorefineries	• Fund loan guarantees, commercial biorefinery demonstrations, and 10% scale validation projects
• Inadequate feedstock and distribution infrastructure	• Form interagency infrastructure and feedstock teams

Biomass Program Portfolio

Removing barriers to large-scale production of cellulosic biofuels

Collaborative R&D

- **Feedstocks:** integration of feedstocks with conversion processes
- **Conversion Technologies:** biochemical and thermochemical

Integrated Biorefineries

- **Systems Integration:** feedstocks, conversion, biopower, infrastructure
- **Demonstrations:** pilot scale and commercial scale for diverse feedstocks

Infrastructure (New)

Collaborative R&D Is Producing Results

- **Achieved substantial decrease in cost of ethanol production – from over $5 to about $2.26 per gallon**
- **Developed organisms with superior ability to convert mixed sugars to ethanol – an important step toward cellulosic ethanol and the 2012 goal**
- **Developed high-value co-products like plastics, foams, and coatings from oil crops and corn sugar**

Cell phone casings made from bio-based polymers developed through DOE-industry cost-shared R&D

EPAct Push: Integrated Biorefineries

- Biorefinery projects up to $100 million each to demonstrate enzyme-based processing systems for a wide variety of lignocellulosic feedstocks.

- Encourage a wide variety of uses, including:
  - **Liquid transportation fuels**
  - **High-value biobased chemicals**
  - **Substitutes for oil-based feedstocks and products (such as plastics and polymers)**
  - **Energy as electricity or heat**

Cellulosic Biorefinery Investments

Competitively selected projects to provide up to $385 million over four years for cost-shared integrated biorefineries in six states

- **Abengoa Bioenergy Biomass of Kansas**

  Capacity to produce 11.4 million gallons of ethanol annually using ~700 tons per day of corn stover, wheat straw, milo stubble, switchgrass, and other feedstocks

- **ALICO, Inc.**

  Capacity to produce 13.9 million gallons of ethanol annually using ~770 tons per day of yard, wood, and vegetative wastes and eventually energy cane

- **BlueFire Ethanol, Inc.**

  Sited on an existing landfill, with capacity to produce 19 million gallons of ethanol annually using ~700 tons per day of sorted green waste and wood waste from landfills

Cellulosic Biorefinery Investments

- **Poet**

  Capacity to produce 125 million gallons of ethanol annually (~25% cellulosic ethanol) using ~850 tons per day of corn fiber, cobs, and stalks

- **Iogen Biorefinery Partners, LLC**

  Capacity to produce 18 million gallons of ethanol annually using ~700 tons per day of agricultural residues including wheat straw, barley straw, corn stover, switchgrass, and rice straw

- **Range Fuels (formerly Kergy Inc.)**

  Capacity to produce 40 million gallons of ethanol annually and 9 million gallons per year of methanol, using ~1,200 tons per day of wood residues and wood based energy crops

Fiscal Year 2007 Solicitations

- **10% Validation Solicitation:**
  - Demonstration plant to be built on one-tenth of the projected scale of a first-of-kind commercial facility
  - Integrated biorefinery demonstrations using cellulosic feedstocks and producing a combination of fuels, chemicals, and substitutes for petroleum-based feedstocks and products
- **Enzyme Solicitation:**
  - Second phase of cellulase development with cost-sharing industry partners
  - Create commercially available, highly effective & inexpensive enzyme systems for biomass hydrolysis
- **Thermochemical Conversion Solicitation:**
  - Integration of gasification and catalyst development

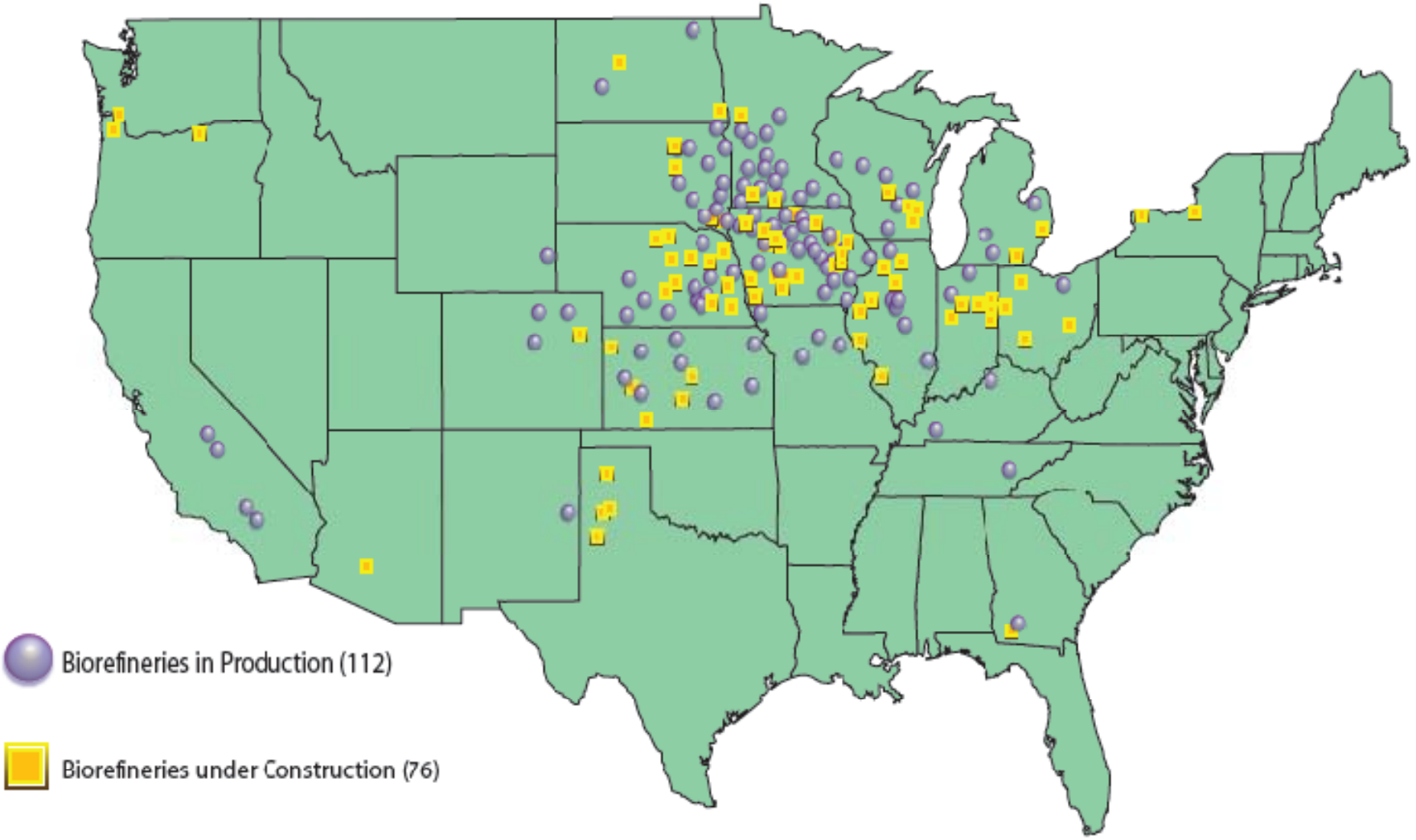
DOE Office of Science: Basic Research on Biomass

- **Invests $375 million in three new Bioenergy Research Centers to accelerate basic research on cellulosic ethanol and other biofuels.**
  - **DOE BioEnergy Science Center led by DOE's Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee.**
  - **DOE Great Lakes Bioenergy Research Center led by the University of Wisconsin in Madison, Wisconsin, in close collaboration with Michigan State University, E. Lansing.**
  - **DOE Joint BioEnergy Institute led by DOE's Lawrence Berkeley National Laboratory (LBNL).**
- **Recently issued a joint biofuels research agenda with the Department of Energy's Office of Energy Efficiency and Renewable Energy – *Breaking the Biological Barriers to Cellulosic Ethanol*.**

Policies to Boost Biofuels Production in the Energy Policy Act of 2005

- Section 932: **Commercial Integrated Biorefinery**
  - Secretary Bodman recently announced six awards
  - $53 million in FY 2007 budget request
- Section 941: **Revisions to Biomass R&D Act of 2000**
  - *Vision* document (November 2006); updated *Roadmap* (May 2007)
- Section 942: **Cellulosic Ethanol Reverse Auction**
  - Request For Information and Options papers completed
  - $5 million requested for FY 2008
- Sections 1510, 1511, and Title XVII: **Loan Guarantees**
  - DOE issued guidelines for the first Loan Guarantees under Title XVII in August 2006
  - Loans for conversion of Municipal Solid Waste and cellulosic biomass to fuel ethanol and other commercial byproducts also considered.

Ethanol Plants Mainly in Corn Belt



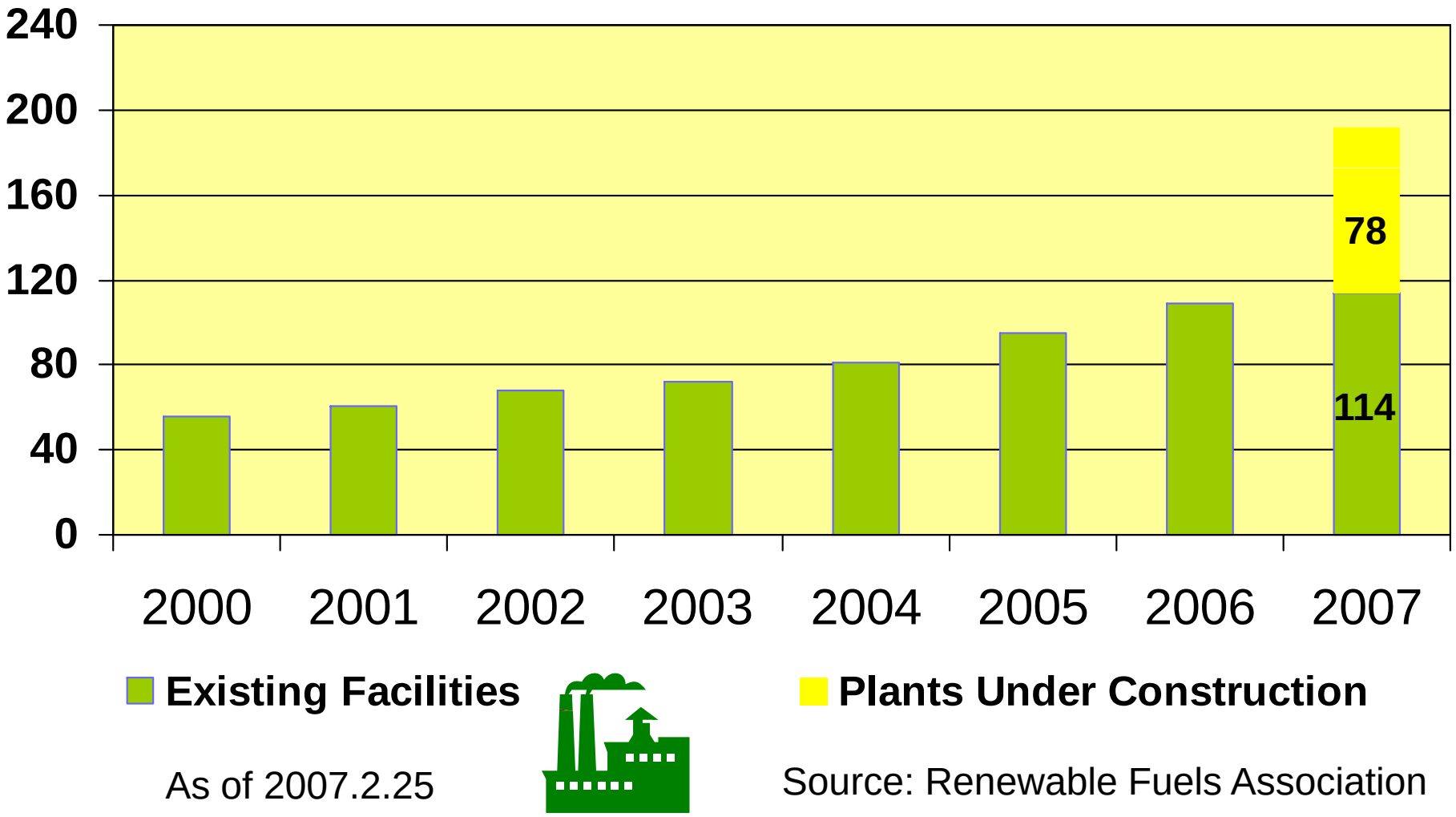
State Production Tax Credits (2001)

- N. Dakota, Wyoming: $0.40/gallon ethanol
- Montana: $0.30/gallon ethanol
- Minnesota, Missouri, Oklahoma, Wisconsin: $0.20/ gallon ethanol
- Nebraska: $0.18/gallon ethanol for new capacity, $0.075/gallon for expanded capacity.
- Kansas: $0.075/gallon for new capacity, $0.05/gallon for existing capcity.

Further State Support for Biofuels

- **26 states** have passed legislation supporting biofuels.
- Four states have enacted **mandates for E10** (Minnesota [also E20], Hawaii, and Montana, and Oregon).
- New York state has announced $20 million program for the development of a **cellulosic ethanol pilot facility**.
- Georgia has given a construction permit for a plant that is to start production of 20 million gallons/year in 2008. The plant will **convert woody waste to ethanol** via synthesis gas and has a final size of 100 million gallons/year.
- On July 19, 2007 the Governor of Michigan announced that Michigan will host the construction of the first **cellulosic ethanol plant based on fermentation technologies and woody waste as a feedstock**.

U.S. Ethanol Production Facilities



As of 2007.2.25

Source: Renewable Fuels Association

Federal Excise Tax Exemption Encourages Ethanol Blends

- Since 1979, federal government has exempted 5.3 cents per gallon of 10% ethanol blend (equivalent to 53 cents/gallon of ethanol) of the 18.3 cent per gallon excise tax on gasoline.
- Cost may be more than offset by reduced agricultural support payments; Department of Agriculture estimated in 2001 that sale of corn for ethanol production boosted corn prices by $0.25 to $0.30 per bushel (about 12 percent).

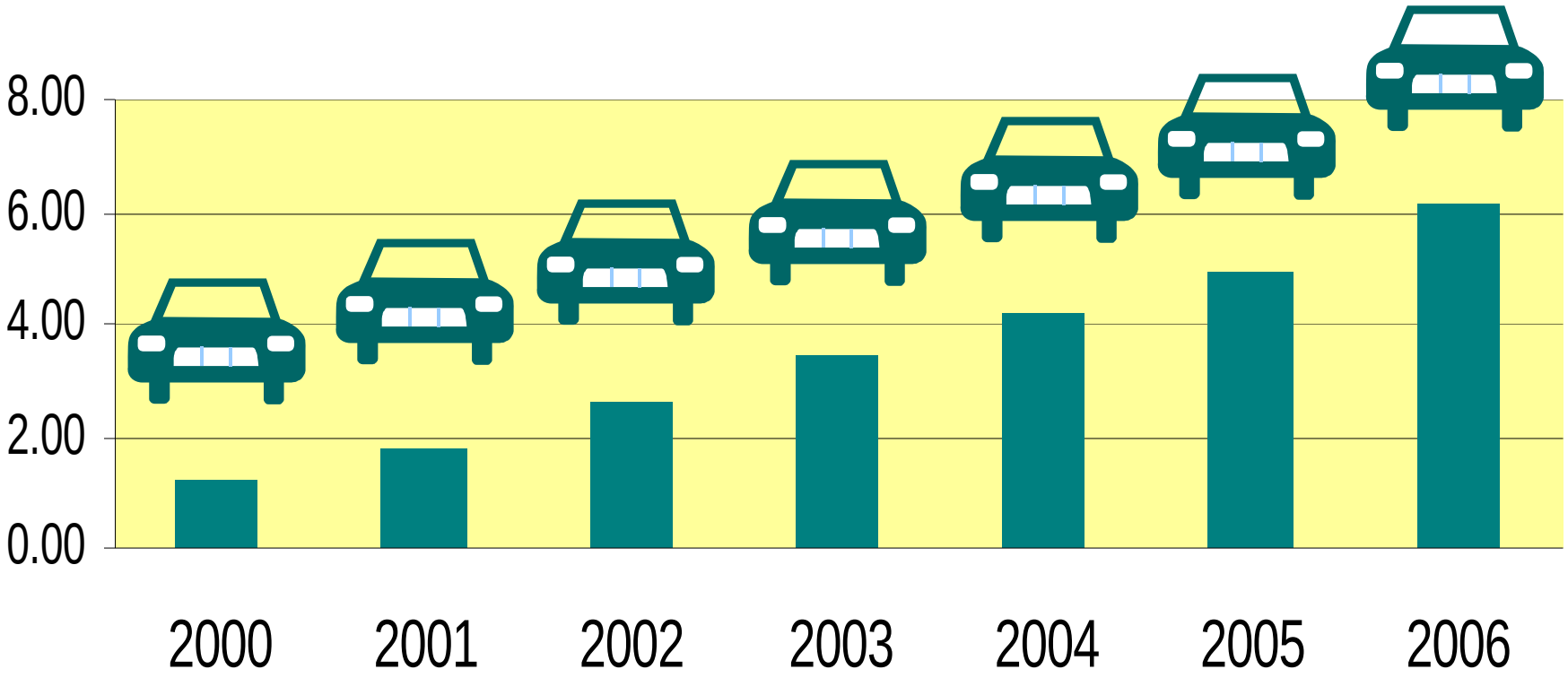
Environmental Regulations Boost Ethanol as an Oxygenate in Fuel

- Carbon Monoxide: 1990 Amendments to Clean Air Act required regions with high levels of CO to use oxygenated fuels – such as ethanol blends – in the winter. Affected 16 regions in 10 states.
- Smog and Ground-Level Ozone: Clean Air Act Amendments require reformulated gasoline to minimize ozone production in about 30% of gasoline sold. In 2001, 87% of RFG used methyl tertiary butyl ether (MBTE), but it contaminates groundwater and is therefore being phased out. Ethanol can substitute for MBTE very well.

Ethanol Replacing MBTE in Blends

- **MTBE groundwater contamination led several States (including California and New York) to ban MBTE.**
- **Environmental Protection Agency (EPA) denied State petitions to waive the oxygenate requirement.**
- **Ethanol was needed to fulfill the oxygenate requirement, to replace the blending values of MTBE (octane, aromatic replacement) and to provide sufficient energy density per unit of volume.**
- **The Energy Policy Act of 2005 resolved the MTBE situation by eliminating the oxygenate requirement and established, instead, a Renewable Fuel Standard that ensured a growing market for fuel ethanol.**

Millions of Fuel Flexible Vehicles

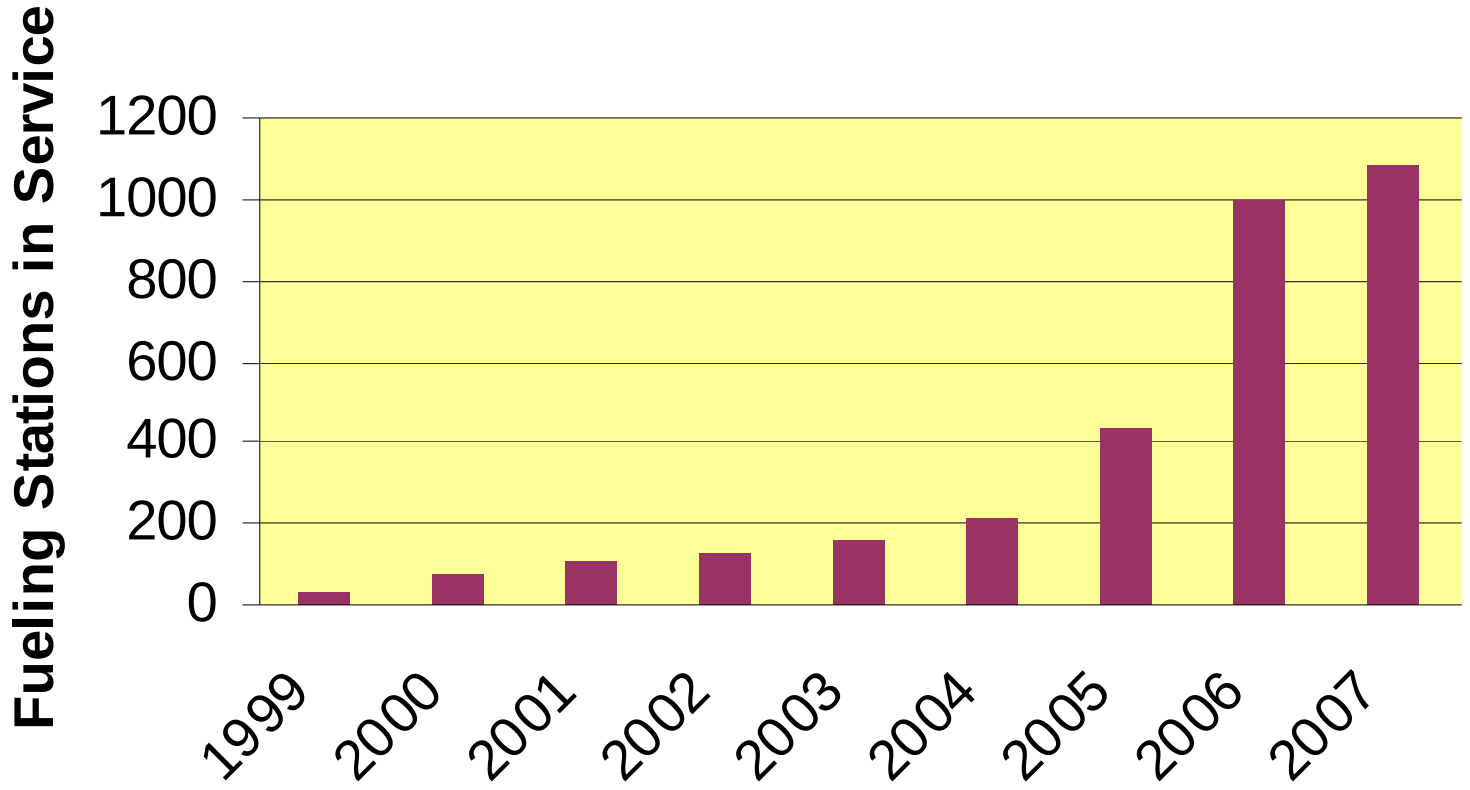


Fuel-Flexible Vehicle Situation

- Over 6 million on the road, most not labeled: there are proposals to require FFVs be labeled.
- Auto industry has sometimes promoted actively, with full-page print ads and TV commercials.
- Auto makers have received FFV credits against Corporate Average Fuel Economy Standards.
- Some senators have suggested requiring that all new vehicles be fuel-flexible after allowing a period for assembly line retooling.
- But FFVs are said to cost just $30-$100 extra to manufacture and are easy to sell, so the market may continue to grow voluntarily.

E85 Filling Stations in the U.S.

Source: Alternative Fuels Data Center, March 8, 2007



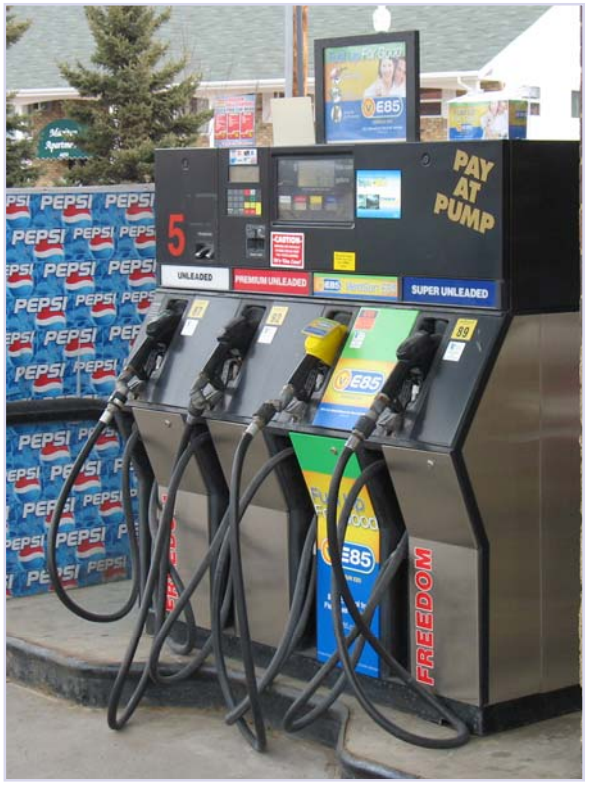
Ethanol Infrastructure Incentives

- Energy Policy Act of 2005 provides up to a $30,000 tax credit for an E85 fueling station.
- State Infrastructure Programs are diverse:
  - **New York State Thruway will have renewable fuel pumps (ethanol or biodiesel) at all 27 service areas.**
  - **Illinois program yielded 100 new E85 stations for just $500,000, or $5,000 per station (plus $2,000 private contribution for $7,000 per station total)**
  - **Iowa and Minnesota also very active (corn states).**
- Now have 1200 stations (2/3 of 1% of 180,000).
  - **Roughly tripled from 2005 to 2007**
  - **Concentrated in Midwest Corn Belt**

Auto Makers Building Biofuel Infrastructure

- Ford and VeraSun Energy will establish a "Midwest Ethanol Corridor" by converting 40 existing fuel pumps in Illinois and Missouri to E85, raising regional E85 availability by a third.
- GM announced that it will add 26 new E85 pumps in the greater Chicago area through a partnership with VeraSun Energy and Shell.
- GM has started a national advertising program called “live green, go yellow” to promote E85.
  - **http://www.gm.com/company/onlygm/**

An Ethanol Station in Minnesota



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- **See**: http://www1.eere.energy.gov/biomass/

Thanks for listening!