

Biomass Energy – Making it Work!



Mark Jenner

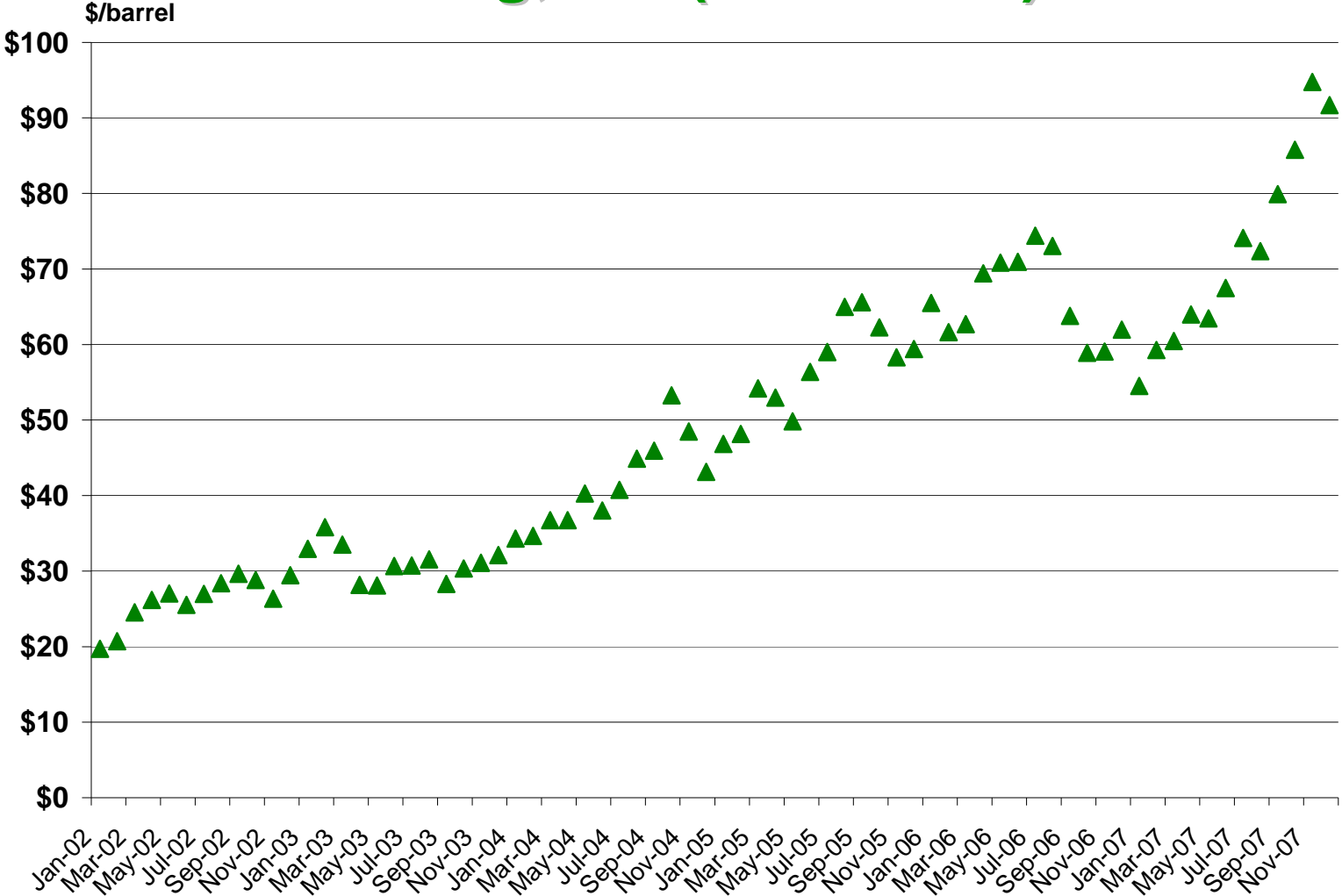
Biomass Rules, LLC

We Are In A New “Era of Bio”

- **Oil and gas shocks of 2005** – Crude oil breaks \$70/bbl. (Now it is over \$100/bbl).
- **MTBE is replaced with ethanol.** Demand for ethanol sky-rockets.
- Biofuels are “**locally grown**”/“**energy security**”
- Bioenergy is larger than the liquid fuels market. “**Bio**” industries are converging or rural America with an infusion of new revenue.
- **The world, state & local govts. gets excited about GHG** regulation. Ag learns about carbon credits.
- **The DOE commits \$1 billion to cellulosic ethanol** development. Private Industry spends even more.

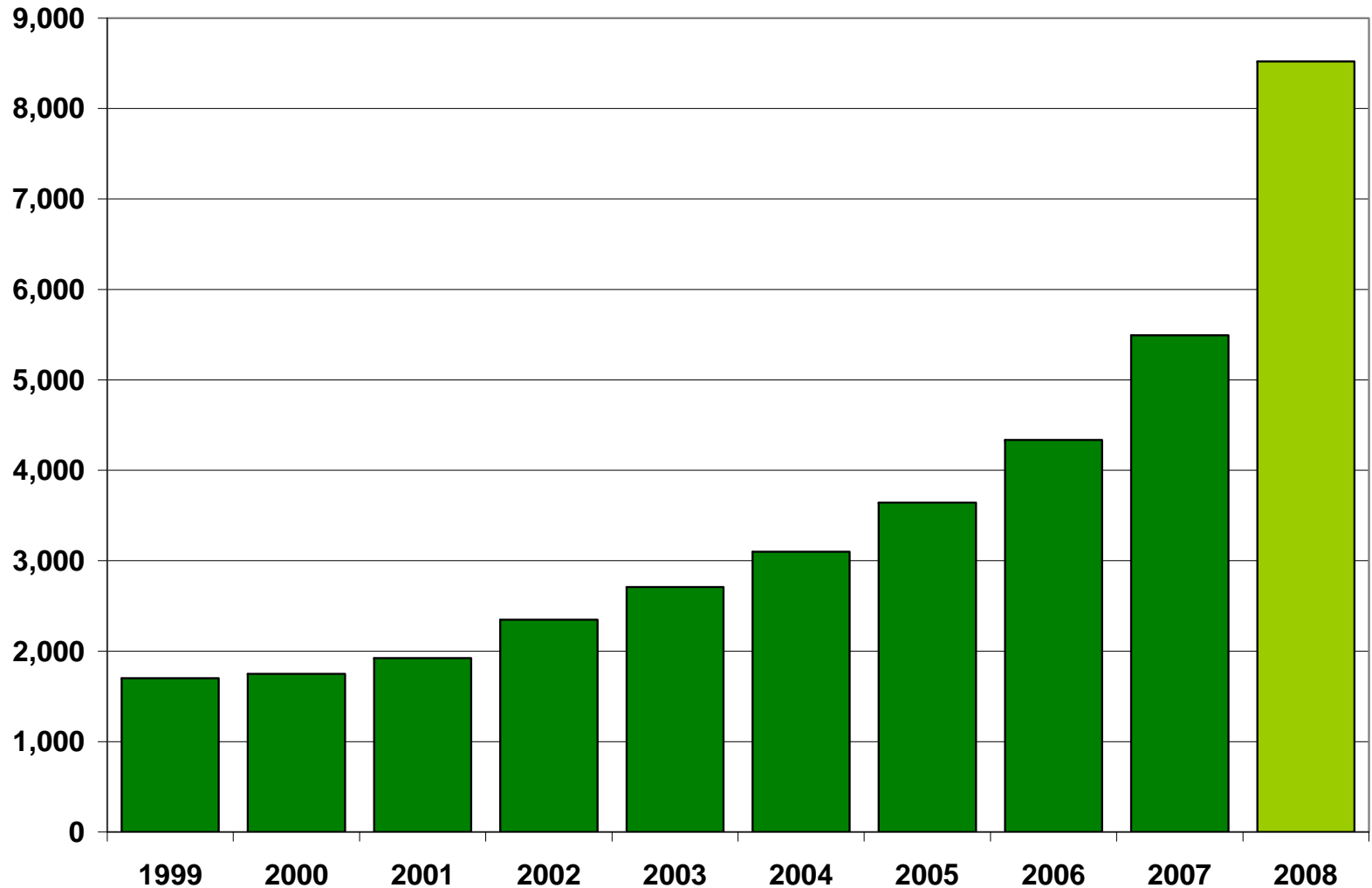
Crude Oil Spot Prices

Cushing, OK (2002-2007)



US Ethanol Response

Mil. Gal./Year



RFA data. Each year 'Jan' except 2008 which is April



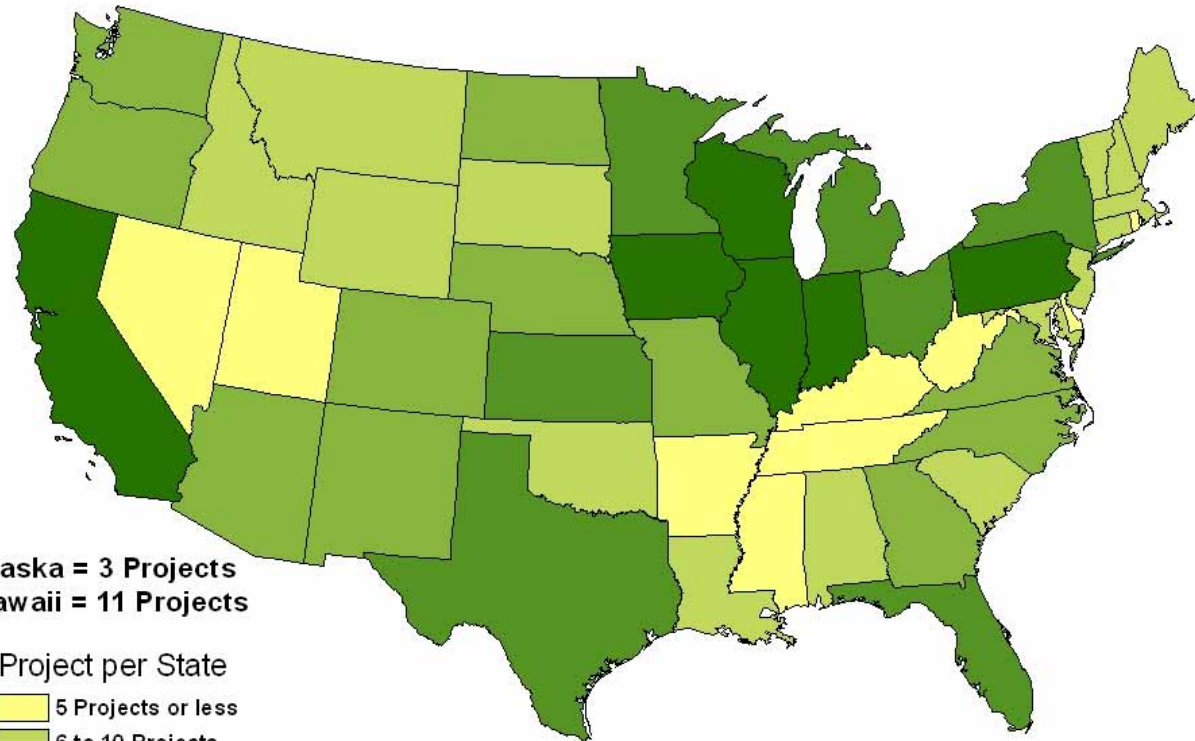
Biomass Rules
Economics / Regulation / Technology

Other Drivers of the “Era of Bio”

- **Utilities expand green power options.**
- Waste industries begin to shift from **cost-recovery** to **profit** business model.
- Renewable Fuels Standards.
- Federal procurement of bio-based products (480 products approved to date). Market standards for new products developed.
- Renewable energy tax credits.
- The EPA and bioenergy industries begin to realize **current regs are not bioenergy friendly.**

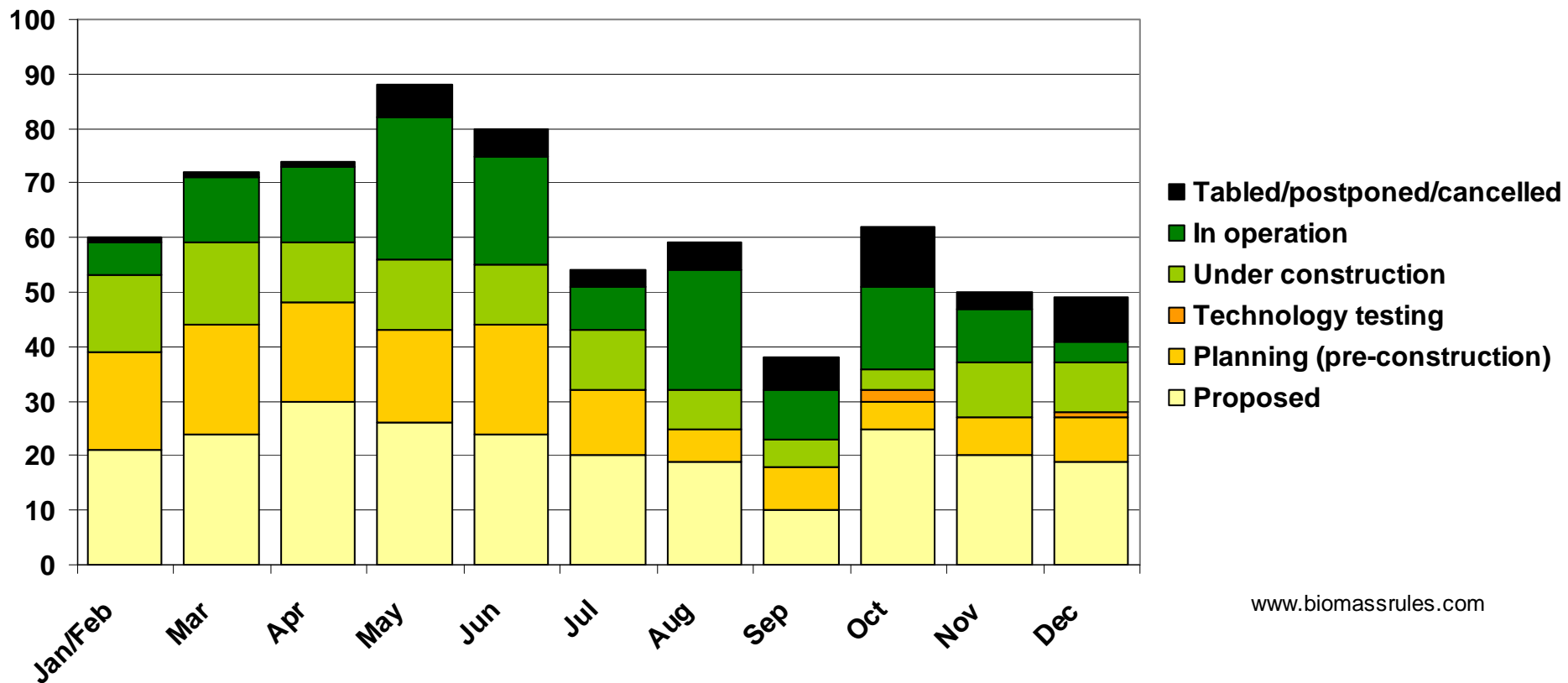
Where It Is Happening...

US Bioprojects in the News (14 months)



It Isn't All Good News...

Bioproject News Events of 2007



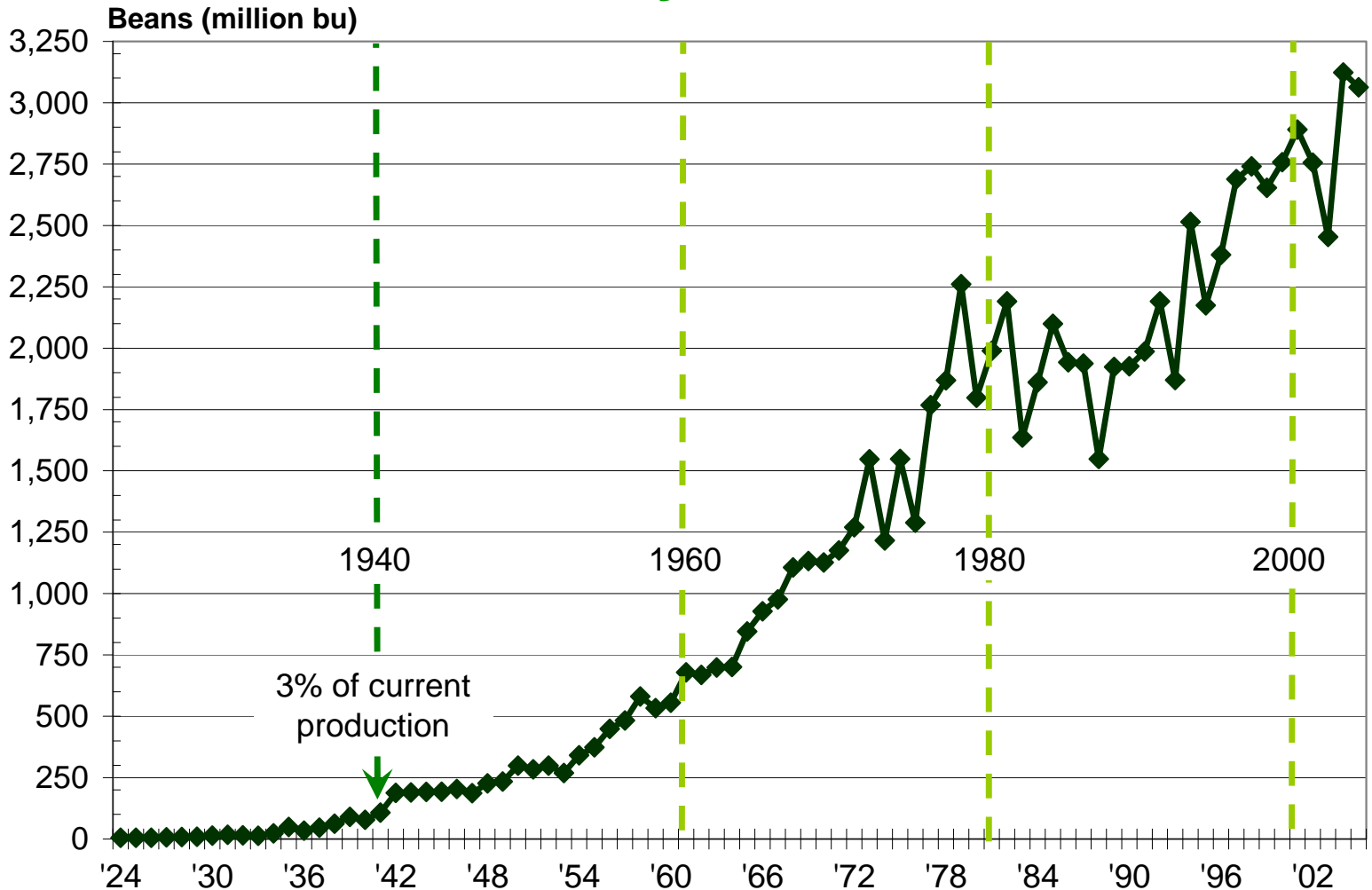
What Happened?

- Ethanol production surpassed the oxygenate (MTBE) demand. Ethanol priced dropped. Corn is over \$5/bu.
- Multiple uses of soybean oil (food) doubled the price of soybean oil – which is now higher than biodiesel.
- Bioprojects = high risk & capital financing. And the economy is in the tank.
- Is it the end of the “Era of Bio?”
- **ABSOLUTELY NOT!!!**



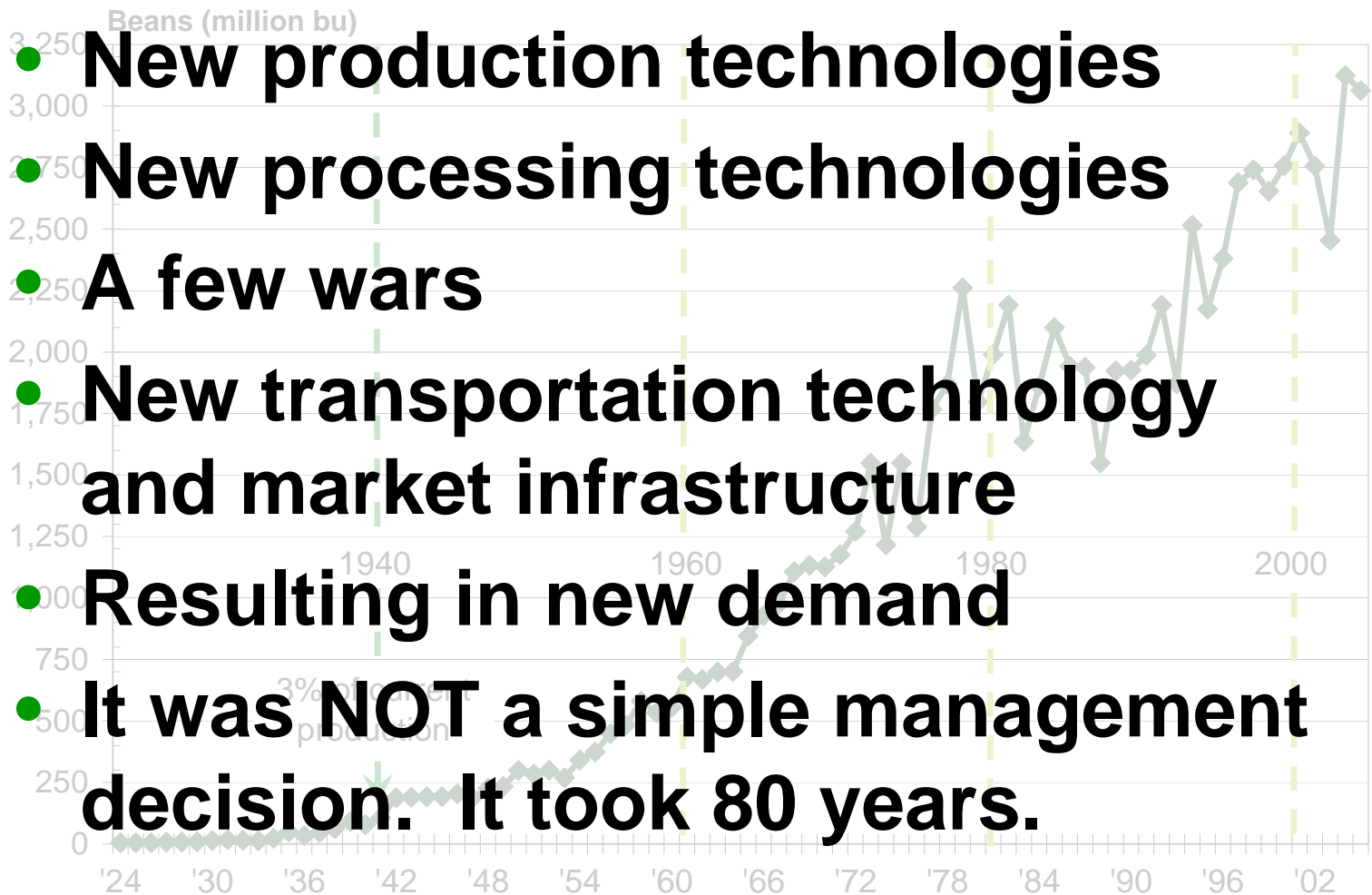
Change Takes Time...

80 Years of Soybean Production



Change Takes Time...

80 Years of Soybean Production



US Bioenergy of Yesterday

2006 Biomass Energy Energy Information Administration



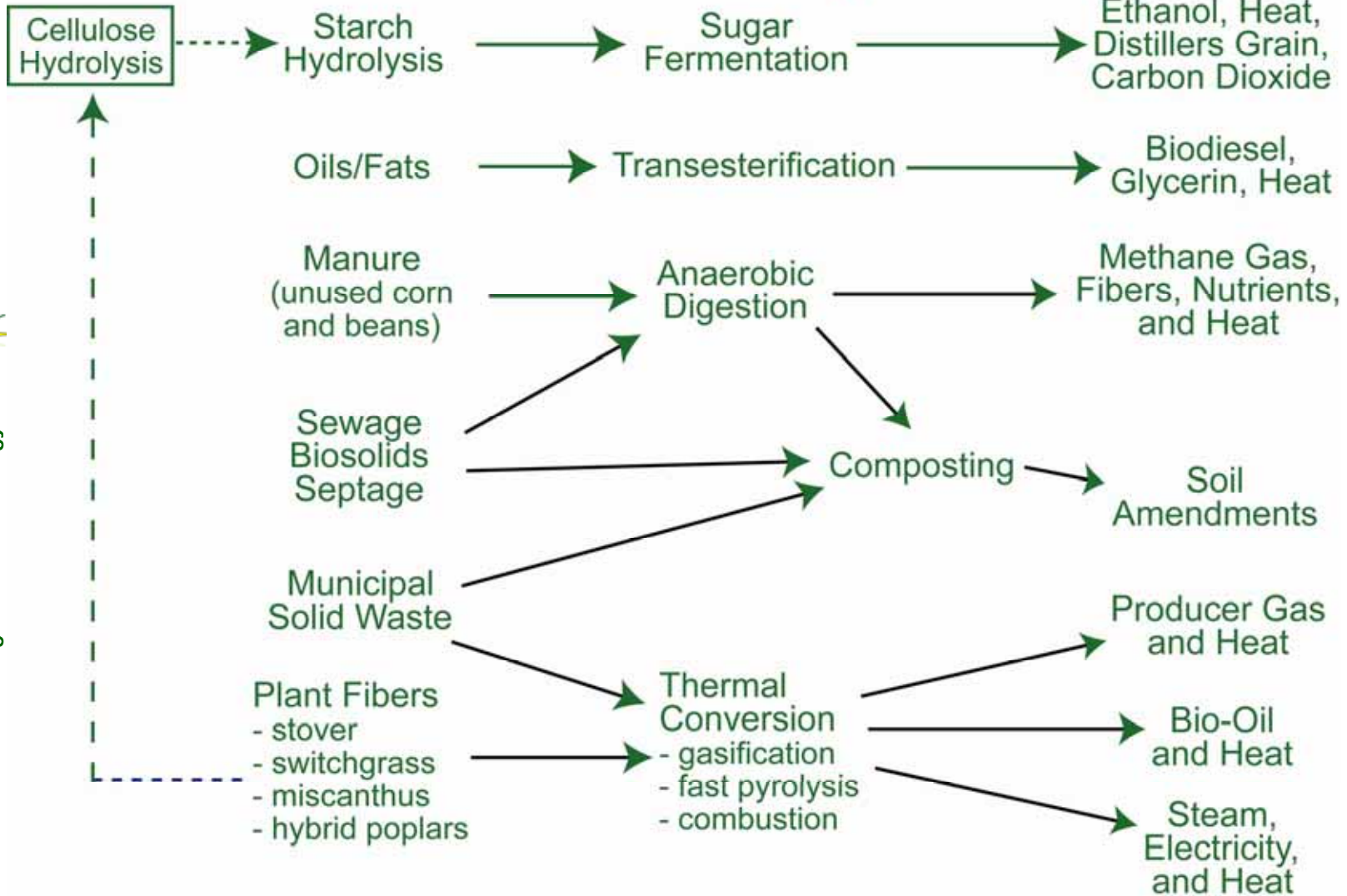
	Quad Btu
Residential	0.410
Commercial	0.102
Industrial	1.966
Transportation	0.483
Electric Power	0.412
	<hr/> <hr/>
	3.373

Biomass Energy of Tomorrow

- New feedstocks (existing/emerging)
- New conversion technologies → economies of scope/multiple output systems
- New infrastructure for storage and transportation. New investment (\$ billions)
- Biomass energy regs will replace fossil fuel environmental regs.

The Bioenergy Opportunities

Feedstocks Technologies Products



Bioenergy Opportunities

Feedstocks

Technologies

Products

Cellulose
Hydrolysis

Starch
Hydrolysis

Sugar
Fermentation

Ethanol, Heat,
Distillers Grain,
Carbon Dioxide

Oils/Fats

Transesterification

Biodiesel,
Glycerin, Heat

Manure
(unused corn
and beans)

Anaerobic
Digestion

Methane Gas,
Fibers, Nutrients,
and Heat

Sewage
Biosolids
Septage

Composting

Soil
Amendments

Municipal
Solid Waste

Producer Gas
and Heat

Plant Fibers
- stover
- switchgrass
- miscanthus
- hybrid poplars

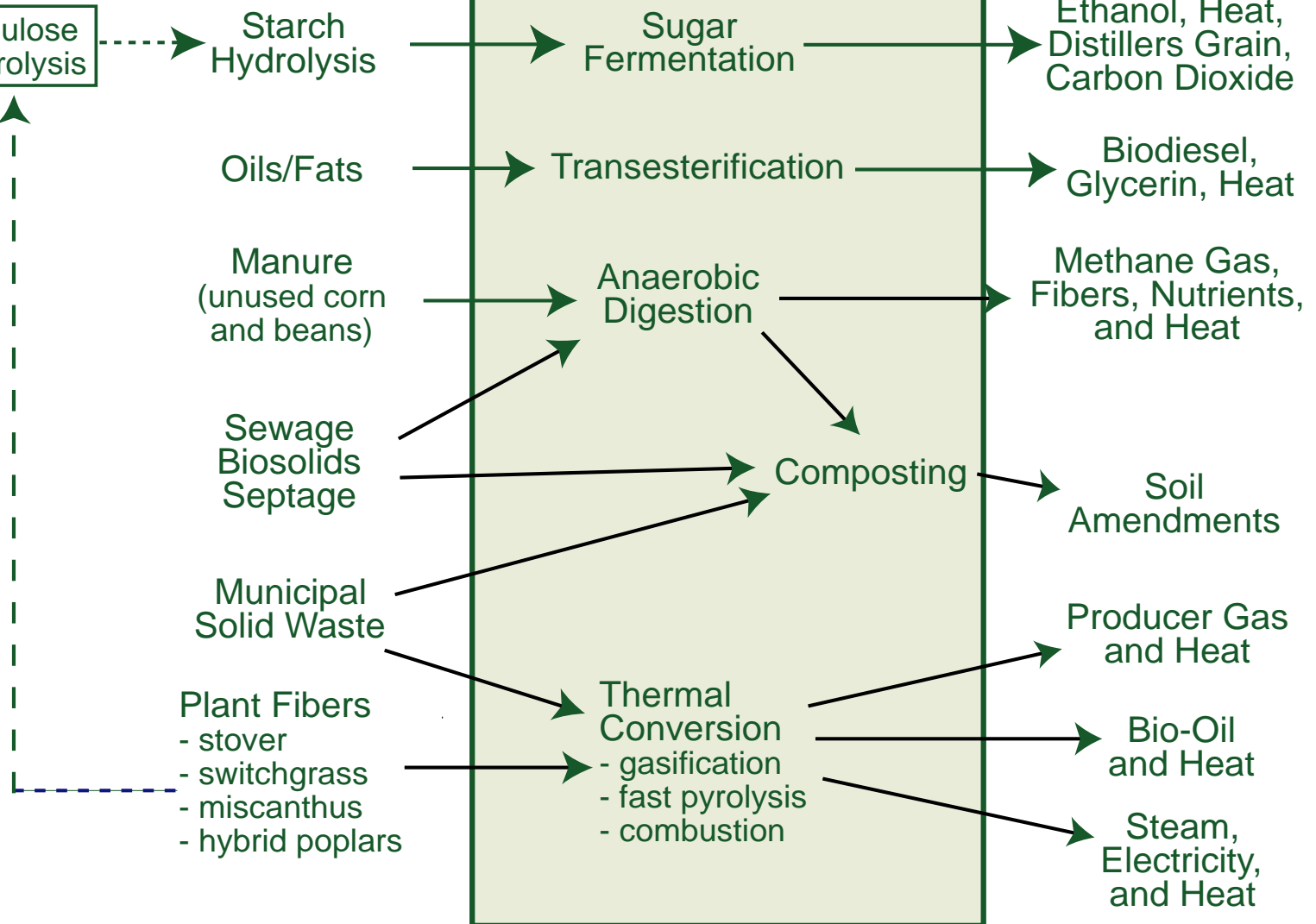
Thermal
Conversion
- gasification
- fast pyrolysis
- combustion

Bio-Oil
and Heat

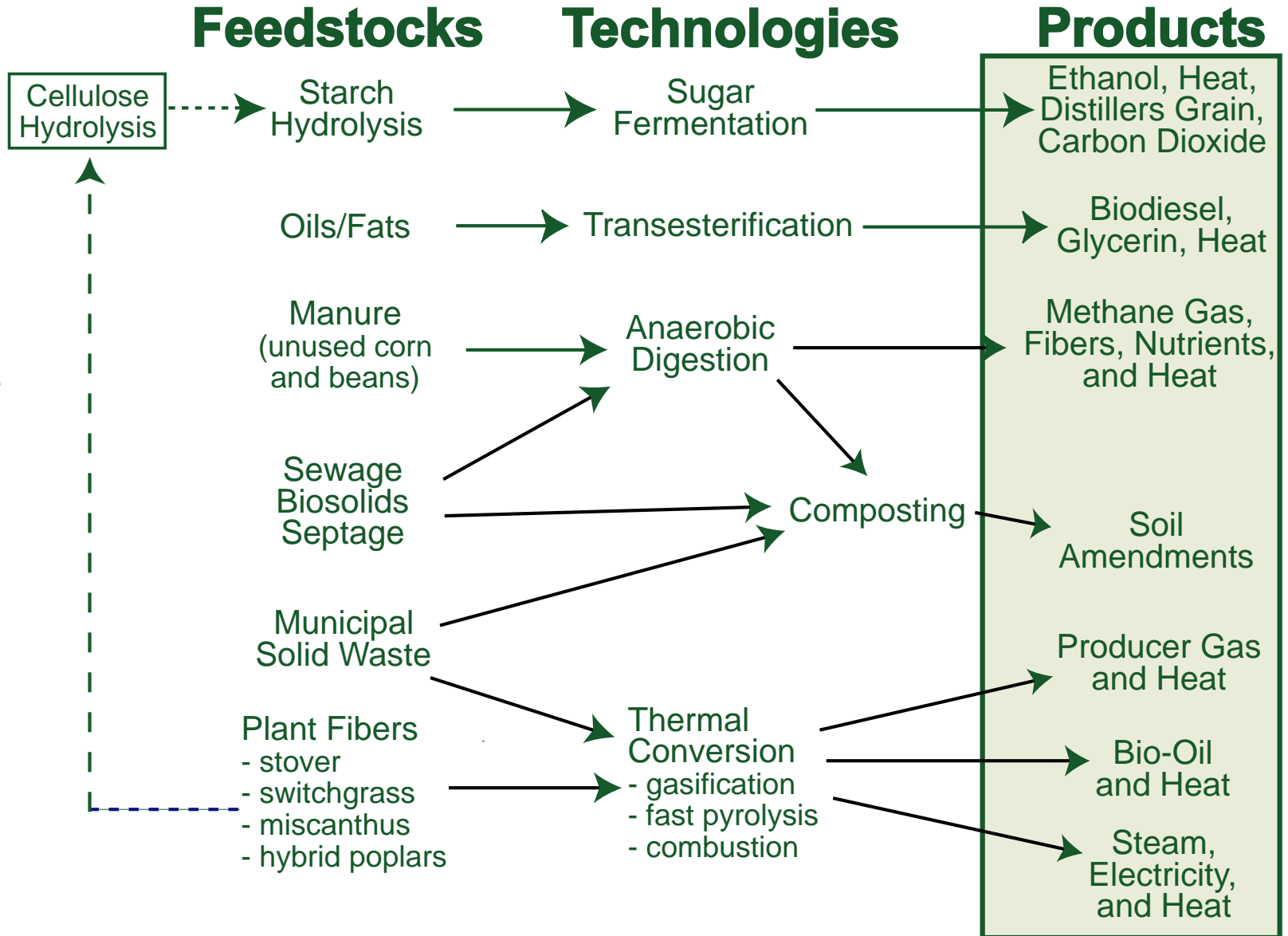
Steam,
Electricity,
and Heat



Biomass Rules
Economics / Regulation / Technology

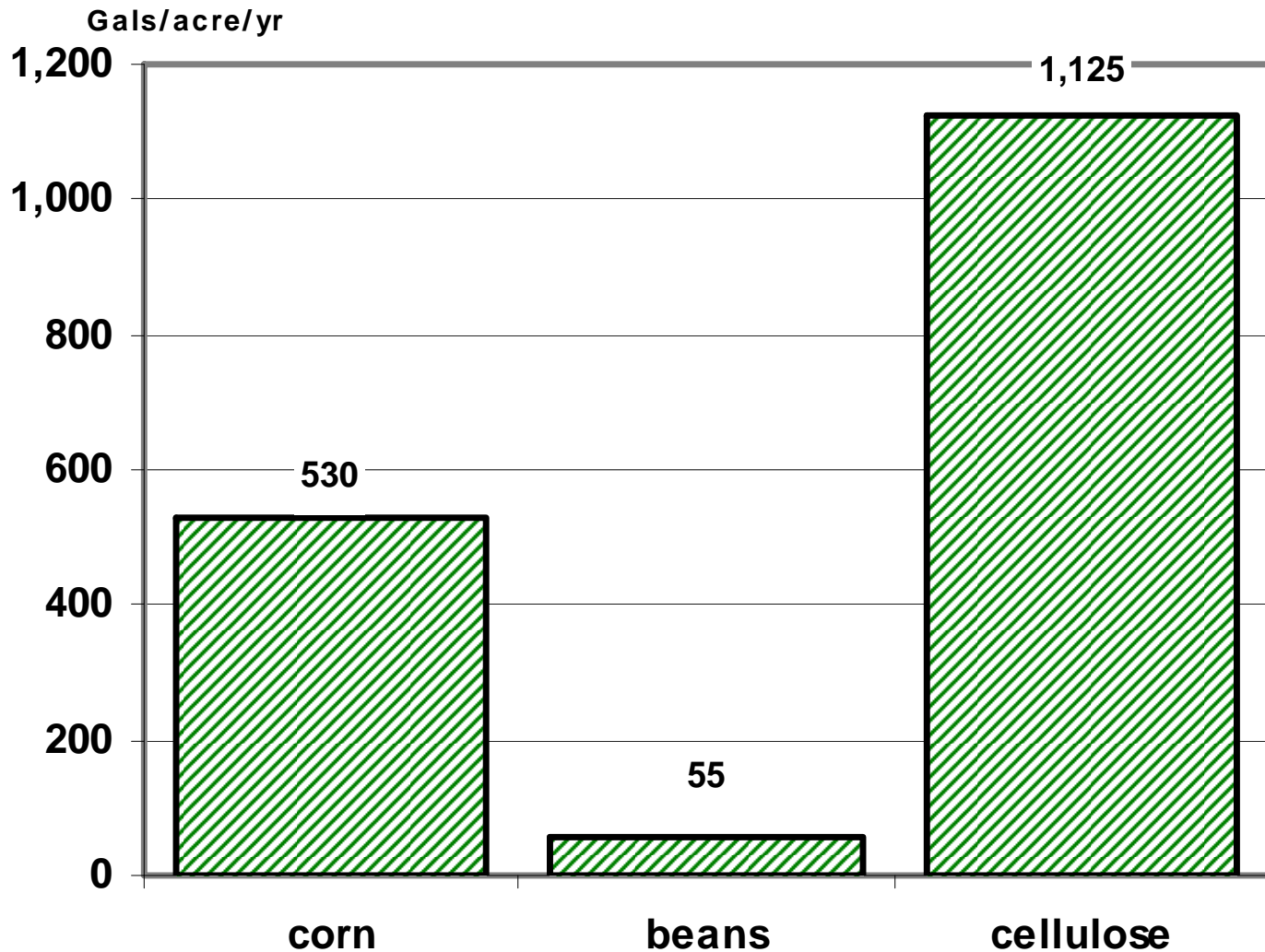


Bioenergy Opportunities



Corn/Beans are NOT Energy Crops

Gallons of Biofuel per Acre



Next Generation Fiber Crops

- Corn stover 3-4 tons/ac
- Bean stalks 1-2 tons/ac

Perennials

- Hybrid poplar (7 yrs).....10 tons/ac
- Willow (>7 yrs)..... 10 tons/ac
- Switchgrass..... 6 tons/ac
- Miscanthus.....13 tons/ac
- Arundo donax.....> 10 tons/ac



Next Generation Oil Crops

- Canola, 2,100 lbs/ac, 99 gal/ac
- Camelina, 2,000 lbs/ac, 63 gal/ac
(arid crop, might get 2 crops)
- Jatropha, 200 gal/ac
(arid crop, oil is inedible)
- **Algae, 4,000-30,000 gal/ac**
(excess CO₂, manure, sewage, other wastes)

US Algae Growth Last 12 Months

	Research	Technology Development	Commercial Production
Alabama	XXX	XXX	XXX
Arizona	XXX	XXX	
California	XXX	XXX	
Colorado	XXX	XXX	
Florida	XXX	XXX	
Hawaii		XXX	
Kansas		XXX	
Louisiana		XXX	XXX
Michigan	XXX		
Minnesota	XXX		
Montana	XXX		
Nevada	XXX	XXX	
New Mexico	XXX	XXX	
New York	XXX		
Oregon	XXX		
Pennsylvania	XXX		
Texas		XXX	XXX
Utah	XXX		

'Used' Energy Feedstocks

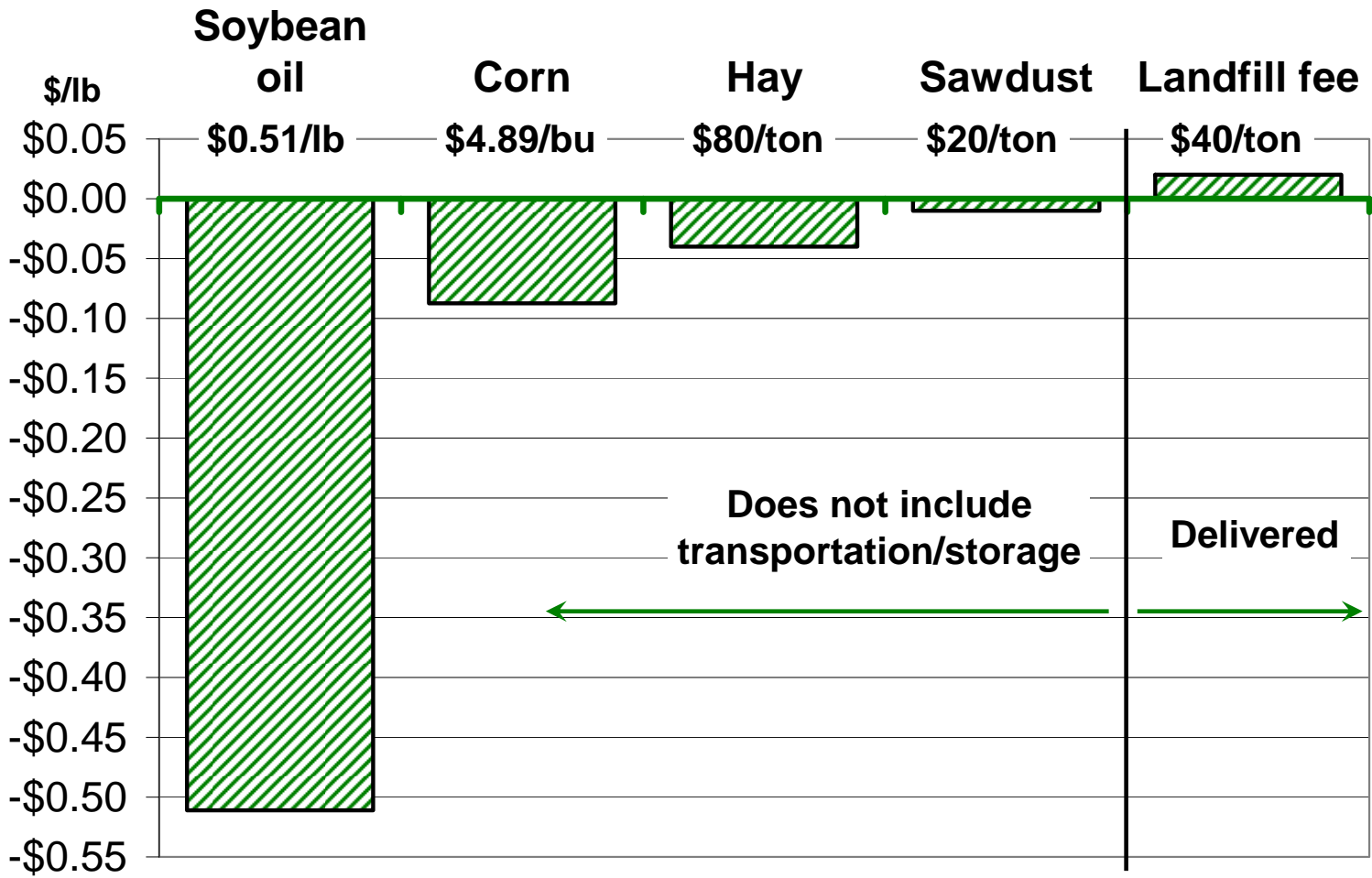
- Corn and bean crop residues
- Manure (**unused corn and soybeans**)
- Sawdust and wood chips
- Sewage/biosolids
- MSW - **180 million tons of carbon**
- Ethanol and biodiesel residuals
- Other carbon wastes

Biomass Handling is Expensive

- Biomass is less dense than coal or liquid fuels. Transportation/storage is costly.
- Agricultural fiber can be handled dry like hay/straw – or wet like silage. They are separate systems – one, or the other.
- The current solid waste systems already have the transportation and storage costs imbedded in the system.

Biomass Feedstock Costs

Commodity ←————→ Residual



2002 Economic Census “Waste” Revenue

Waste management and remediation services	Number	Total Receipts
Sale of nonhazardous waste, including compost and recovered methane gas	184	\$53,138,000
Sale of nonhazardous recyclable material	738	\$429,632,000
Nonhazardous waste to energy generation	135	\$455,625,000
		<u>\$938,395,000</u>

US = \$51 Billion Receipts

MS = \$272 Million Receipts

Bioenergy Opportunity

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Technologies

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Biomass Rules
Economics / Regulation / Technology



Biomass Conversion Technologies

- Biological Technologies
 - Biofuels (Cellulosic)
 - Methane Digestion
- Thermal Technologies
 - Biomass Boilers
 - Biomass Gasifiers
 - Biomass Pyrolysis
- Integrated Systems

Cellulosic Conversion Benchmarks

- US DOE is funding \$1 billion for cellulosic research, pilot and commercial scale projects.
- BlueFire Ethanol, CA – 70 gallons/ton
 - Exploring a 3 million gallon modular unit
- Genohol, OH, – 60-75 gallons/ton
- Masada, AL – 55-70 gallons/ton

Most recently...

- Syntec Biofuel, WA – 102 gallons/ton
- Coskata (GM), IL – 100+ gallons/ton

Biobutanol vs. Ethanol

- Butanol as a biofuel?
- BP-DuPont partnership in biobutanol development
- Mixes/blends better with conventional fuels than ethanol
- Still early in development
- Fermentation processes and equipment for both are similar

Biological Methane Technologies

- 1,400 MW of electricity from landfill gas power plants
- 100 MW of electricity from municipal wastewater treatment.
- 20 MW from manure digesters
- Methane has more value than electricity.
- Methane may not be the highest value

Biomass Boilers

- About 100 biomass power plants in the U.S. with around 1,500 MW generation capacity
- More than 100 that feed private industry.
- Newest addition is Fibrominn, 55 MW turkey manure power plant (700,000 tons)
- Co-generation (coal and biomass) is becoming more frequent. High profile Co-gen facility at Chariton Valley Power plant. 725 MW power plant fueled at 2% by switchgrass (50,000 acres/200,000 tons).



Biomass Gasifiers

- Gasifiers operate at high temperatures with restricted oxygen.
 - Volatile gases are liberated from the solid fuels without combustion.
 - Syngas is available for other uses.
- Gasification will operate an ethanol plant in Benson, MN.
- 1 billion pounds of feedlot manure will operate the 115 million gallon Panda Ethanol Plant in Hereford, TX.



Biomass Pyrolysis

- This is a solid to liquid conversion technology.
- Similar to gasification but instead of syngas, volatile gases are condensed into a bio-oil (similar to heating oil).
- Commercial scale plants are just beginning to be built.
- Dynamotive to build 10 million gallon wood to biofuels plant in Missouri.

New Bioenergy Infrastructure

- \$ Billions are being invested in:
 - Feedstock development
 - Technology research
 - Commercial plant construction
 - Transportation systems (storage systems, pipelines, rail options)
 - Delivery systems (E-85/biodiesel pumps)
- **Much of this is happening out of sight**

New Bioenergy Business Model

- Integrated Systems
 - Economies of diversification (economies of scope, or multiple outputs from an asset)
 - Internalize the transaction costs
 - Profit and cost-recovery models are merging
- Least cost, least variable feedstock
- Technology selection targets the greatest number of high-value markets
- Greatest revenue + lowest input costs
- Lower regulatory compliance cost sought

Biomass Energy Risks

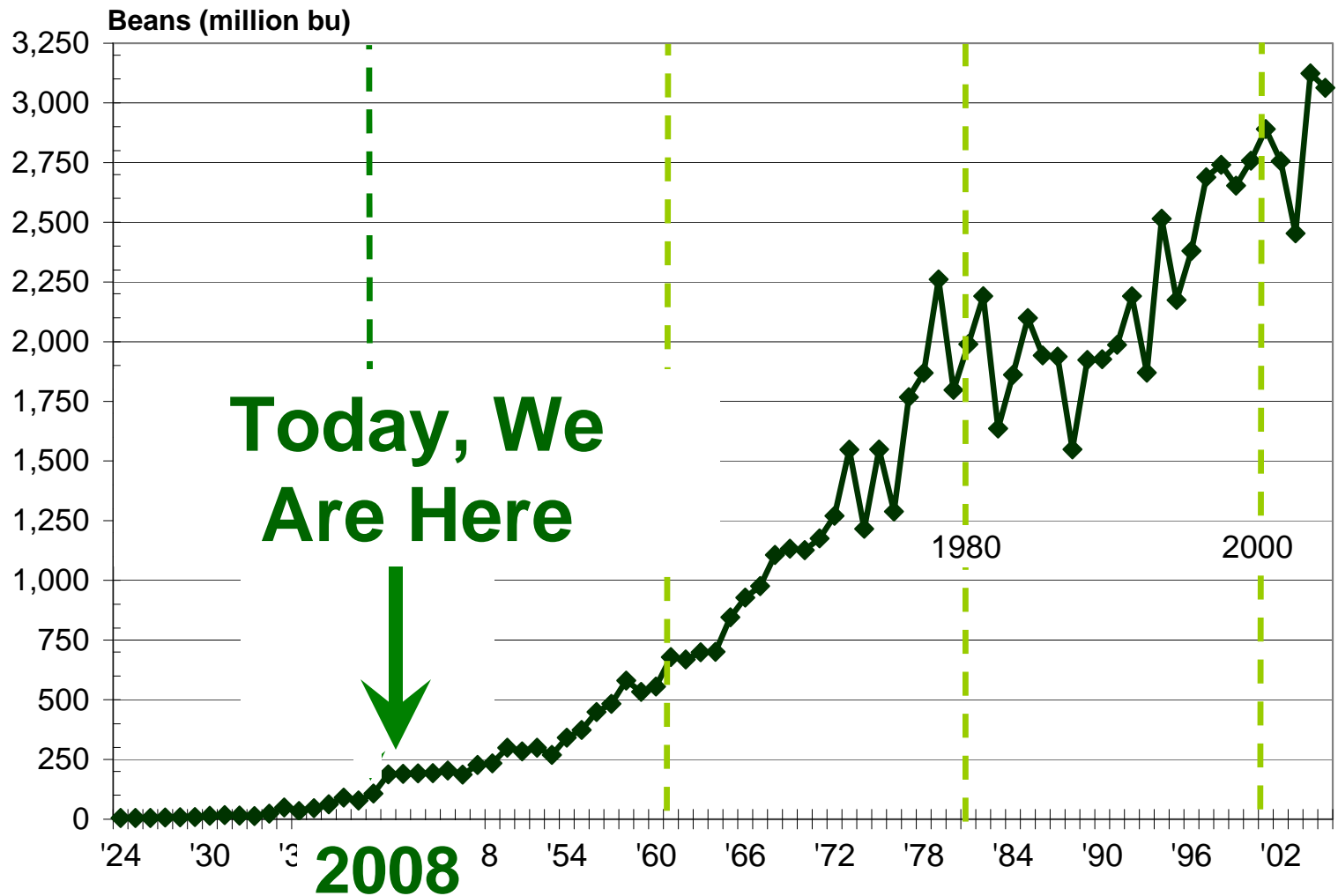
- Current agricultural, environmental, energy, commerce, and tax regulations conflict.
- Legal risks must be covered.
- Most of this has never been done.
- With these projects, the greatest risk is with the first project. After 1st success, **the line for next project forms fast!**

Conclusion

- Bioenergy production is a new frontier
- Next generation feedstocks and technologies will enhance commercial viability.
- The new bioenergy infrastructure will also shift economic viability.
- Planning today should include next-generation consideration.
- **Now is a perfect time to be involved!**

80 Years of Biomass Production

Just getting started with ethanol and biodiesel



Biomass Rules, LLC

Economics/Regulations/Infrastructure



Mark Jenner, Ph.D.

- + renewable market development
- + biomass inventory/utilization
- + streamlining regulations
- + land use / demographics

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