Biofuels: Think outside the Barrel

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July 2006

Ver 3.2

Implausible Assertions ?

We don't need oil for cars & light trucks

We definitely don't need hydrogen!

We don't need new car/engine designs/distribution

Rapid changeover of automobiles is possible!

Little cost to consumers, automakers, government

Not so Magic Answer: Ethanol

Cheaper Today in Denver (May' 06)!

Cheaper Today in Brazil!

Plausible?

Brazil "Proof": FFV's 4% to ~80% of car sales in 3 yrs!

Petroleum use reduction of 40% for cars & light trucks

Ethanol cost @ $0.75/gal vs Petroleum @ $1.60-2.20/gal

Rumor: VW to phase out of all gasoline cars in 2006?

Brazil Ethanol ~ 60-80% reduction in GHG

Brazil: $50b on oil imports "savings"!

Possible?

5-6m US FFV vehicles, 4b gals ethanol supply, blending

California: Almost as many FFV's as diesel vehicles!

US prod. costs: Ethanol $1.00/gal vs Gasoline $1.60-$2:20/gal

Rapid (20%+) increase of US ethanol production in process

Easy, low cost switchover for automobile manufacturers

Why Ethanol?

Today's cars & fuel distribution (mostly)

Today's liquid fuel infrastructure (mostly)

Cheaper in produce (and sell?)

Leverages current trends: FFV's, Hybrids, Plug-ins,..

Part of fuel market via "blending" - just add E85

What makes it Probable?

Interest Groups

Land Use

Energy Balance

Emissions

Kickstart?

Why Ethanol?
The Interest Group Story

Multiple Issues, One Answer

- **Cheaper fuel** for consumers (Cheap Hawks)
- More **energy security** & diversified sources (Right wingers)
- Higher **farm incomes** & **rural employment** (Sodbusters)
- Significant **carbon emission reduction** (Greens)
- Faster GDP growth, Lower Imports & energy prices

….. farmers, automakers, evangelicals, retailers, consumers, conservatives, security hawks, greens are all on the same page

Land Use: Reality (20-50 years)

- **NRDC: 114m acres for our transportation needs**
- **Jim Woolsey/ George Shultz estim. 60m acres**
- **Khosla: 40-60 m acres**

…. not including “the future” & “other sources”

- **Ethanol from municipal & animal waste, forest**
- **Direct/new synthesis technologies**

Energy Crops: Miscanthus

1 years growth without replanting!

20 tons/acre? (www.bical.net)
10-30 tons/acre (www.aces.uiuc.edu/DSI/MASGC.pdf)

Biomass Will Make a Difference

Turning South Dakota into…

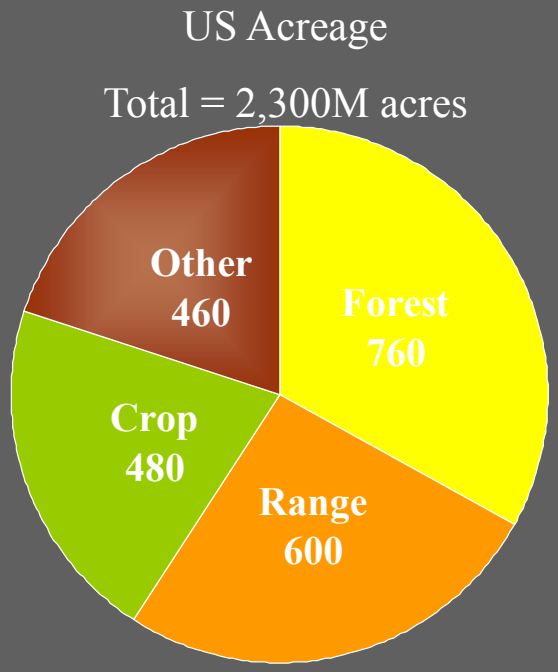
	Today	Tomorrow
Farm acres	44 Million	44 Million
Tons/acre	5	15
Gallons/ton	60	80
Thousand barrels/day	857	**3,429**

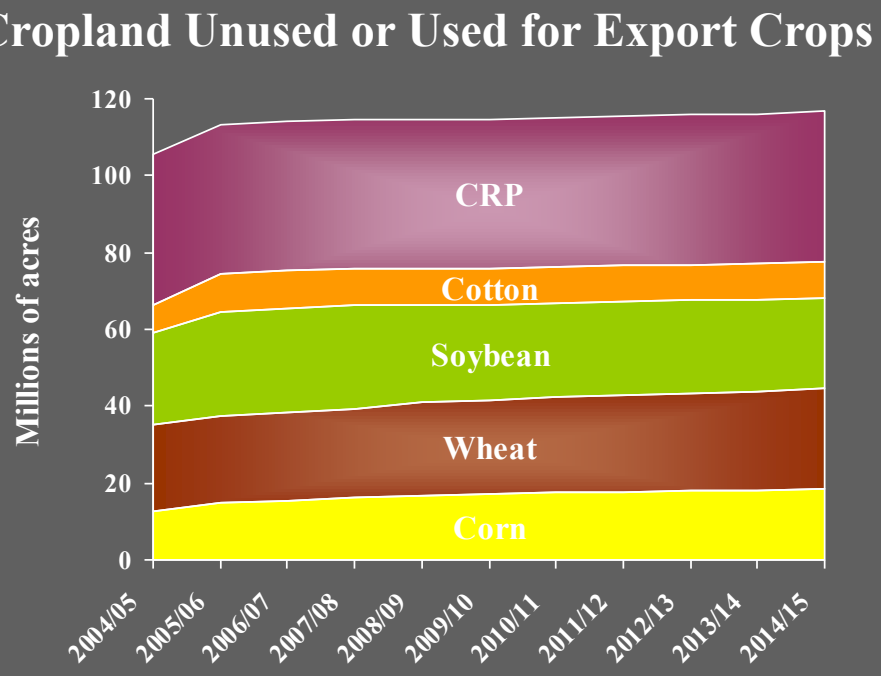
…a member of OPEC?!

	Thousand barrels/day
Saudi Arabia	9,400
Iran	3,900
South Dakota	*3,429*
Kuwait	2,600
Venezuela	2,500
UAE	2,500
Nigeria	2,200
Iraq	1,700
Libya	1,650
Algeria	1,380
Indonesia	925
Qatar	800

Source: Ceres Company Presentation

Export Crop Lands Can Supply ALL our Gasoline Needs





In 2015, 78M export acres plus 39M CRP acres could produce 384M gallons of ethanol per day or ~75% of current U.S. gasoline demand

Source: Ceres Company Presentation

Wrong Question: Energy Balance

ARGONNE NATIONAL LABORATORY

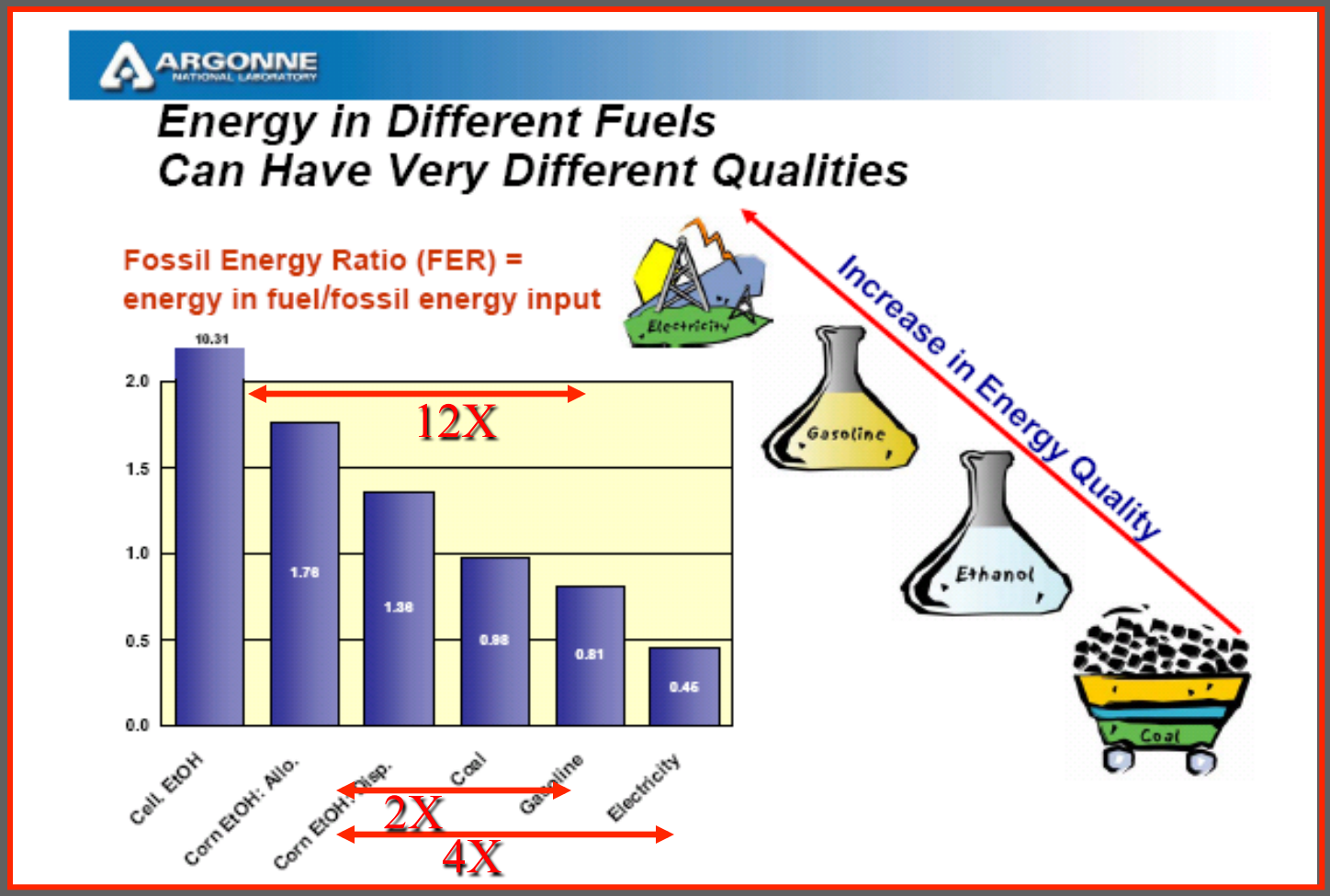
Conclusions

- Energy balance value for a given energy product alone is not meaningful in evaluating its benefit
- Any type of fuel ethanol helps substantially reduce transportation's fossil energy and petroleum use, relative to petroleum gasoline
- Corn-based fuel ethanol achieves moderate reductions in GHG emissions
- Cellulosic ethanol can achieve much greater energy and GHG benefits

(For more information, please visit the GREET model website at http://greet.anl.gov)

Fossil Fuel Use: Argonne Study

Fossil Energy Balance of Electricity is 25% of Corn Ethanol

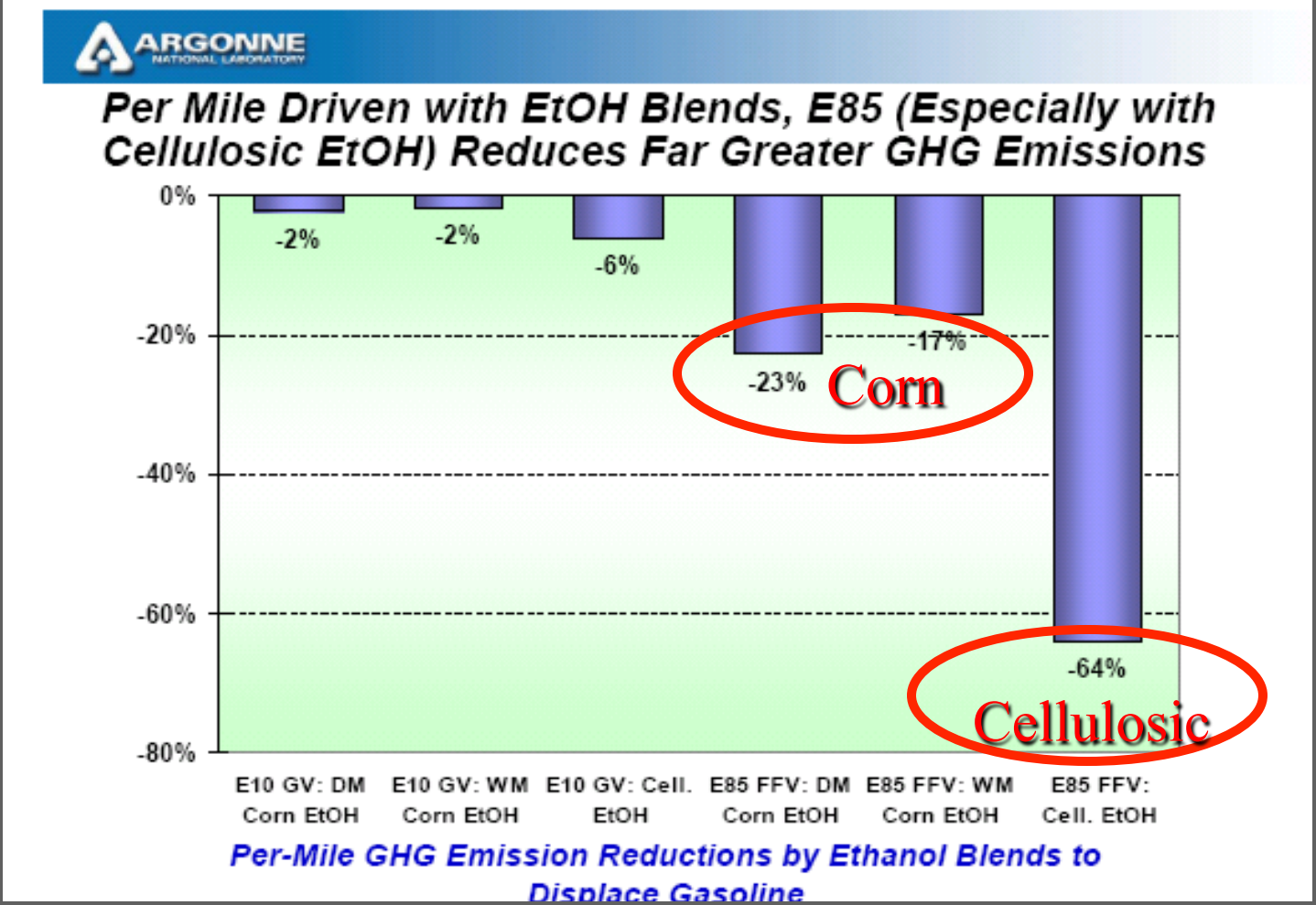


Legend

EtoH	=	Ethanol
Allo.	=	Allocation
Disp.	=	Displacement

Red: Khosla Comments

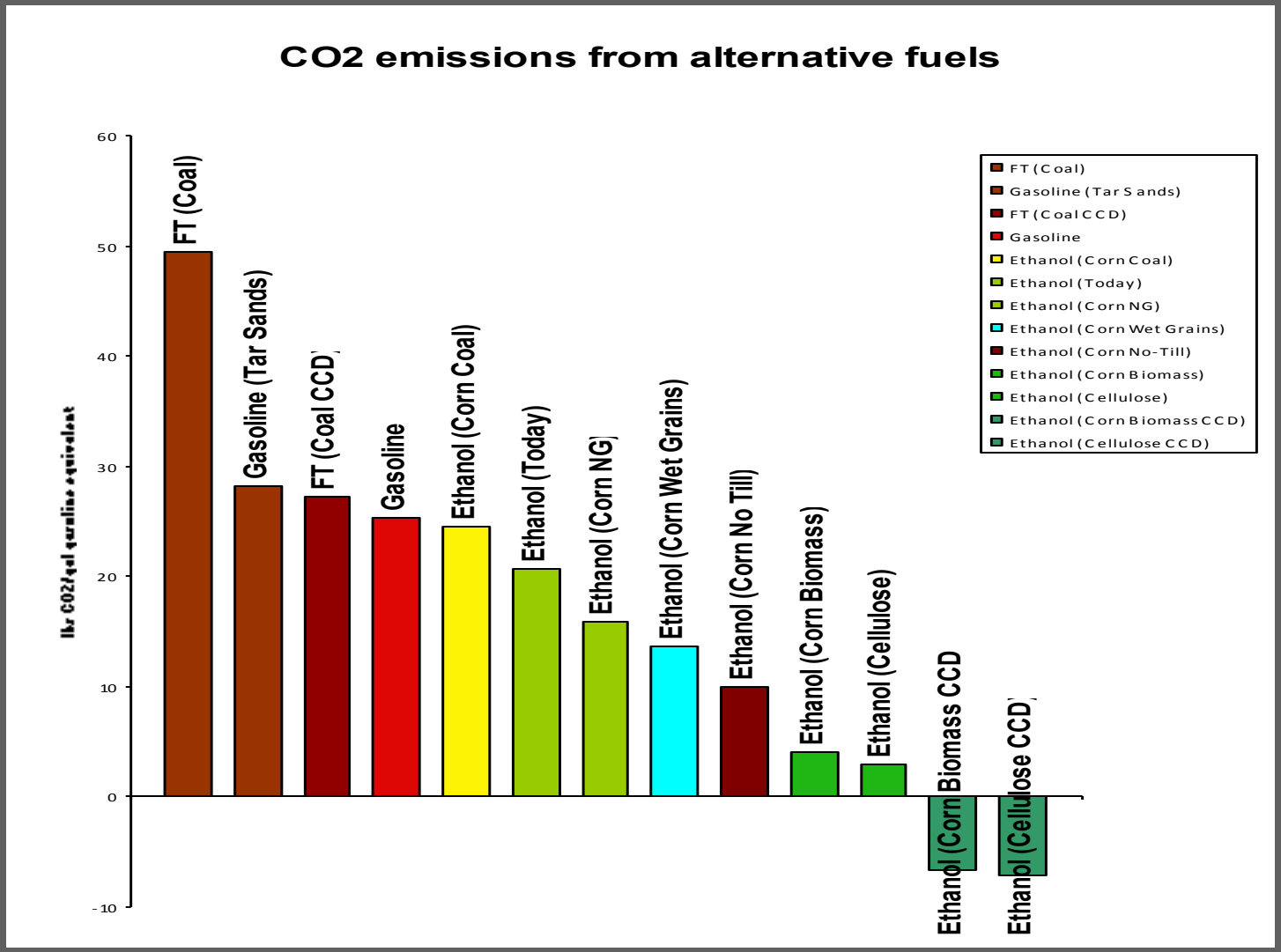
Right Question #1: GHG per Mile Driven



Right Question #2: Petroleum Use Reduction

- Answer: Even corn ethanol has a 90% reduction in Petroleum
- Trick: Fossil Energy is not the same as Petroleum

Energy Balance: Not Your Father's Ethanol



Different Corn Ethanol Production Methods Have different Emissions

Source: NRDC

Great (5X) Energy Balance for "E3 Biofuels" Corn Ethanol

The E3 BioSolution's
-a solid waste mangmt. facility
-an ethanol plant
-An animal feeding operation

…. into a self-sustaining, closed loop system.

E3 system
•virtually eliminates water, air and odor pollution
•produces ethanol using little or no fossil fuel,

NRDC Report - "Ethanol: Energy Well Spent"

- "corn ethanol is providing important petroleum savings and greenhouse gas reductions"
- "very little petroleum is used in the production of ethanol …..shift from gasoline to ethanol will reduce our oil dependence"
- "cellulosic ethanol simply delivers profoundly more renewable energy than corn ethanol"

Don't let best be the enemy of the good

Emission Levels of Two 2005 FFVs

(grams per mile @ 50,000 miles)

Vehicle Model	Fuel	NOx (CA std.=0.14)	NMOG (CA std.=0.10)	CO (CA std.=3.4)
2005 Ford Taurus	E85	0.03	0.047	0.6
	Gasoline	0.02	0.049	0.9
2005 Mercedes-Benz C 240	E85	0.01	0.043	0.2
	Gasoline	0.04	0.028	0.3

source: California Air Resources Board, On-Road New Vehicle and Engine Certification Program, Executive Orders; http://www.arb.ca.gov/msprog/onroad/cert/cert.php

In Defense of Corn Ethanol

TRAJECTORY, TRAJECTORY, TRAJECTORY

- Ethanol: from 500 to 3000 gallows per acre
- Reduces market risk – Funds cellulsoic ethanol
- Primes Infrastructure for cellulosic ethanol, biohols
- Compatible with hybrids, plug-ins, light-weighting,…

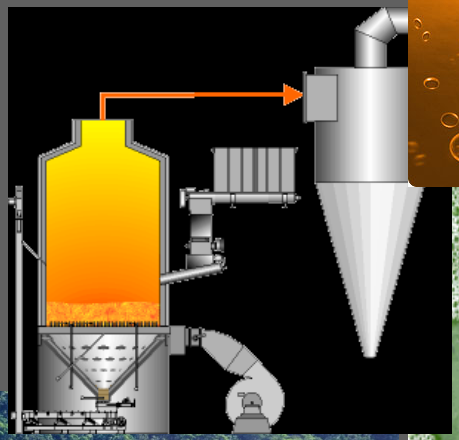
- Alternatives
  - Biodiesel trajectory from 500 gallons per acre to 700 gpc?
  - Electric: higher technology risk on batteries, higher consumer cost
  - Biohols compatible if electrics get better, cheaper, greener,..

Look Beyond "what is" to "what can be"
Revolution thru Evolution is Easier

Technology Progression

Synthetic Biorefinery

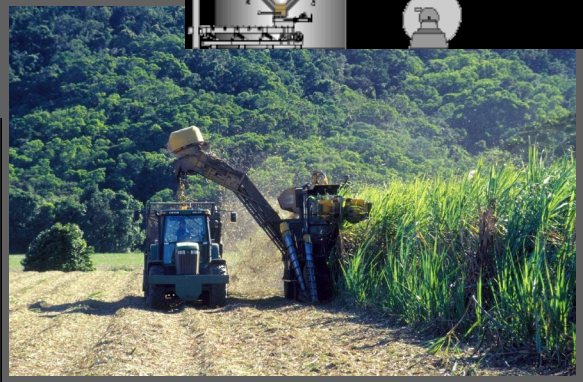
Gasification



Other Synthesis?

Algae

Corn



Cellulosic Bioethanol

Technology Improvements

- Bioengineering
  - Enzymes
  - Plant engineering
- Process & Process Yields
  - Process Cost
  - Pre-treatment
  - Co-production of chemicals
  - Process Yield gals/ ton
  - Consolidated bioprocessing
- Energy crops
  - Miscanthus
  - Switch grass
  - Poplar
  - Willow
- "Out of the Box"
  - Thermochemical
  - Synthetic Biology
  - Better Fuels !!!
  - Better Chemistries
  - ????????

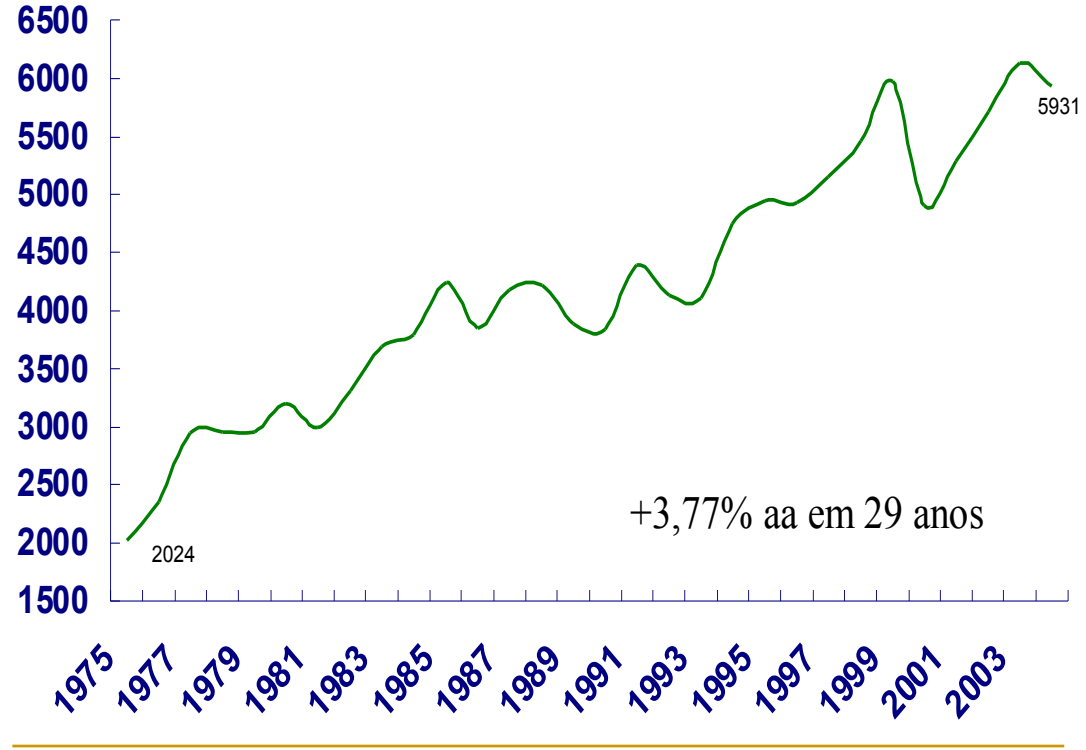
Companies & Technologies

- Celunol
- Clearfuels
- Canavialis
- Edenspace
- Agrivada
- Mascoma
- Synthetic Genomics
- Alellyx
- Syntec
- Choren
- Unannounced….

- Novozyme
- Genencor
- Diversa
- Iogen
- Ceres
- BRI
- Xenothol
- Corn Ethanol Cos
- Dupont/BP (Butanol)
- MSW to Ethanol
- Big guys….

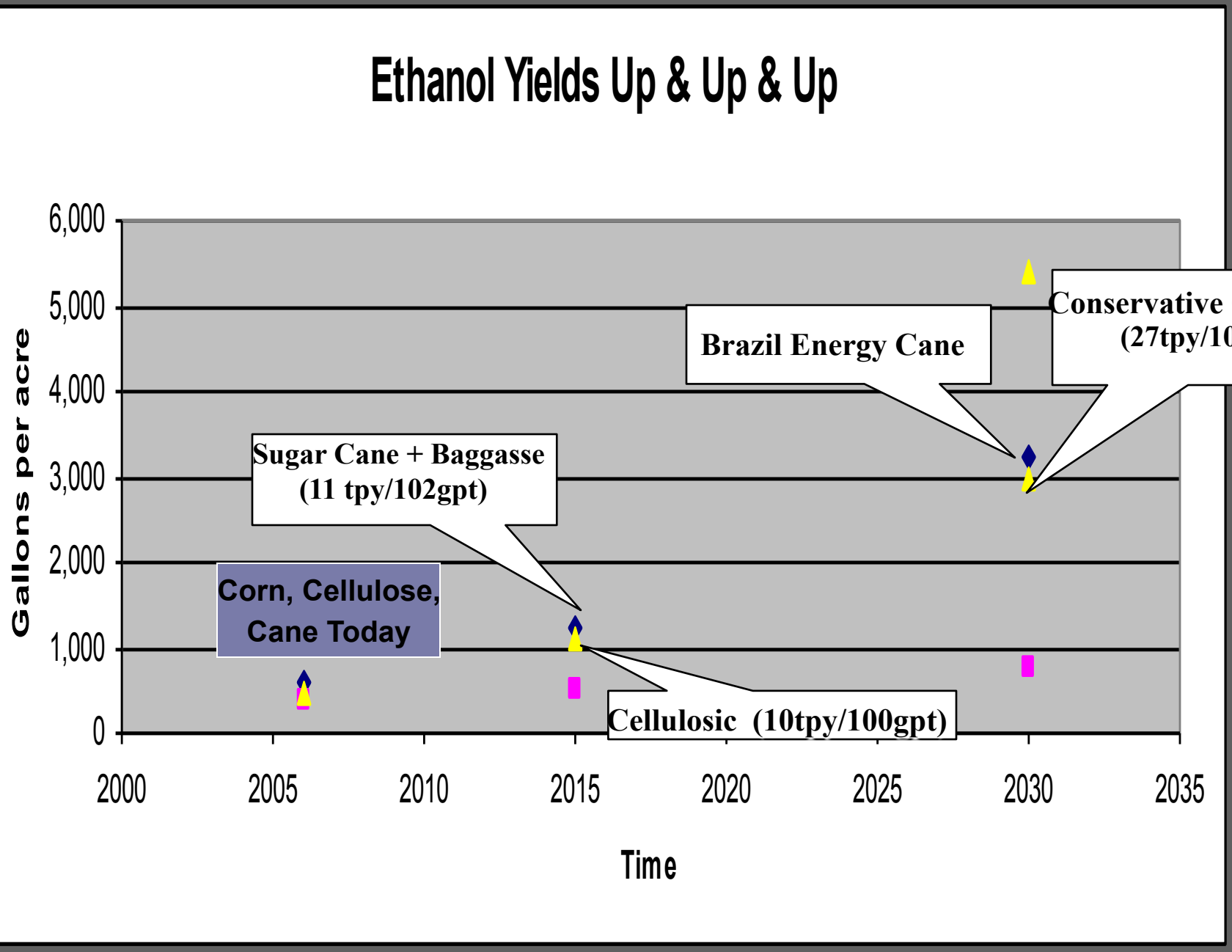
Brazil sugar-cane/ethanol learning curve

Liters of ethanol produced per hectare since between 1975 to 2004



30,000??

Large Improvements Are Not Just For Silicon



Three Simple Action Items

- Require 70% new cars to be Flex Fuel Vehicles
  … require yellow gas caps on all FFV's & provide incentives to automakers

- Require E85 ethanol distribution at 10% of gas stations
  …. for owners or branders with more than 25 stations;

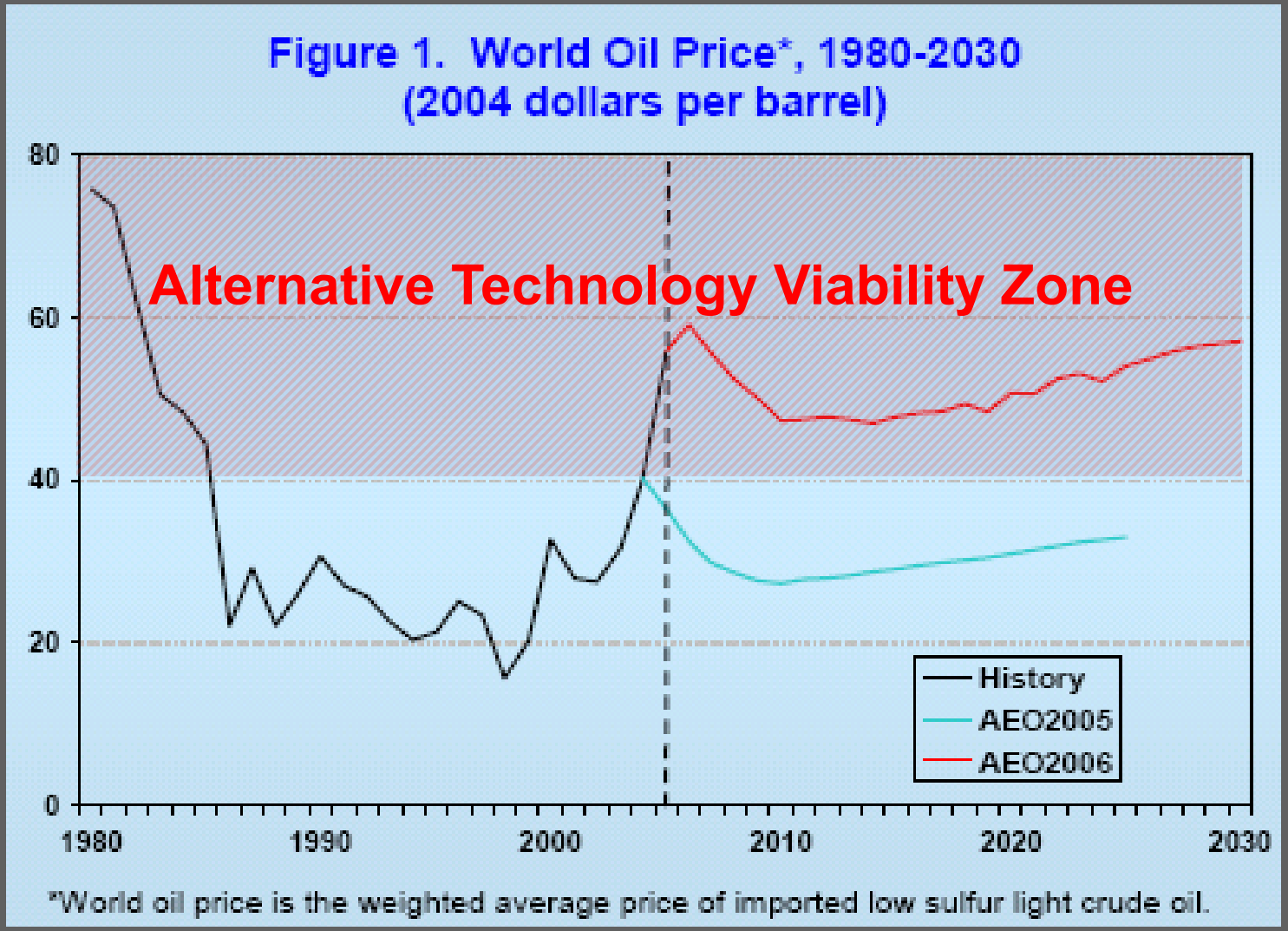
- Make VEETC credit variable with oil price ($0.25-0.75)
  …. providing protection against price manipulation by oil interests

....ensuring investors long term demand and oil price stability

Other "Helpful" Action Items

- Switch ethanol credit from blenders to "producers" (for 5yrs only for new plants)
- Allow imports of foreign ethanol tax free for E85 only; extend RFS
- Provide "cellulosic" credits above "ethanol" credits; monetize energy act credit
- Institute RFS for E85 & cellulosic ethanol
- Switch CAFÉ mileage to "petroleum CAFÉ mileage"; reform & strengthen CAFE
- Loan guarantees for first few plants built with any "new technology"
- Institute a carbon cap and trade system
- Switch subsidies (same $/acre) to energy crops

Why Now?
Projected World Oil Prices (EIA)



Source: EIA Reports

RISK: Oil vs. Hydrogen vs. Ethanol

	Oil	Hydrogen	Biofuels
Energy Security Risk	High	Low	Low
Cost per Mile	Med	Med-High	Low
Infrastructure Cost	Very Low	Very High	Low
Technology Risk	Very Low	Very High	Low
Environmental Cost	Very High	Med-Low	Low
Implementation Risk	Very Low	Very High	Low
Interest Group Opposition	Very High	High	Low
Political Difficulty	?	High	Low
Time to Impact	-	Very high	Low

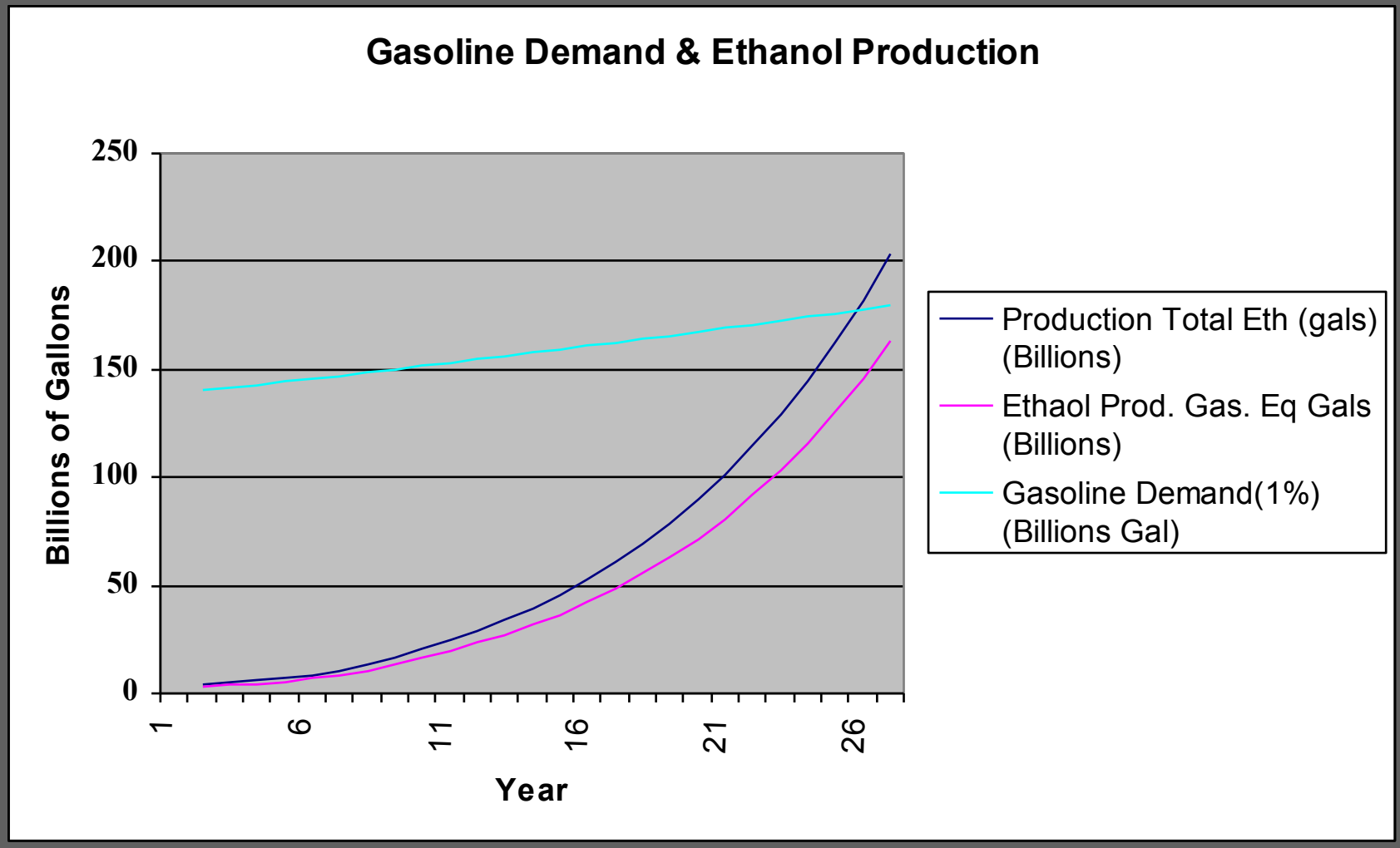
Source: Khosla

A Darwinian IQ Test?

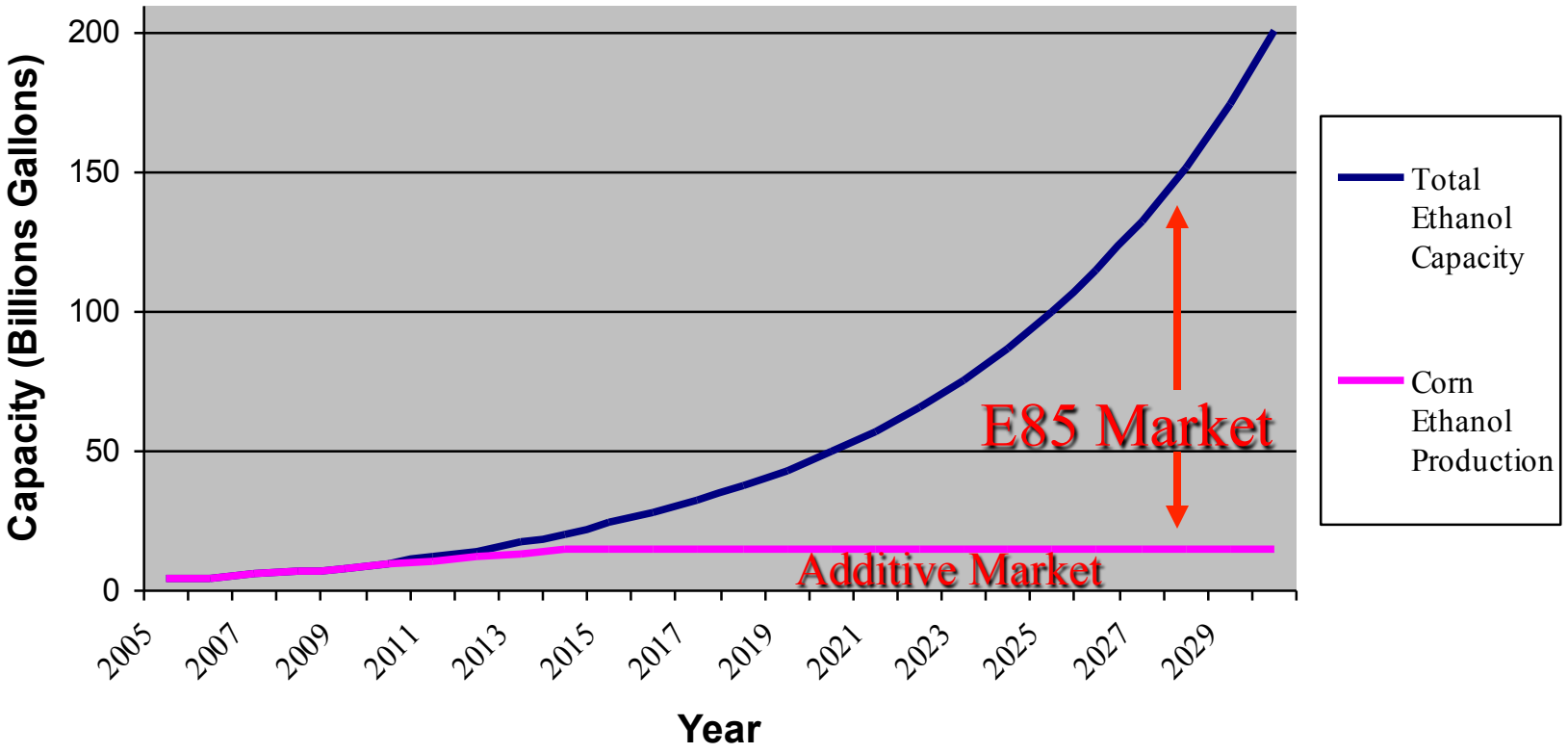
- Feed mid-east terrorism or mid-west farmers?
- Import expensive gasoline or use cheaper ethanol?
- Create farm jobs or mid-east oil tycoons?
- Fossil fuels or green fuels?
- ANWR oil rigs or “prairie grass” fields?
- Gasoline cars or cars with fuel choices?

What Could Happen!

Demand/Supply Projections



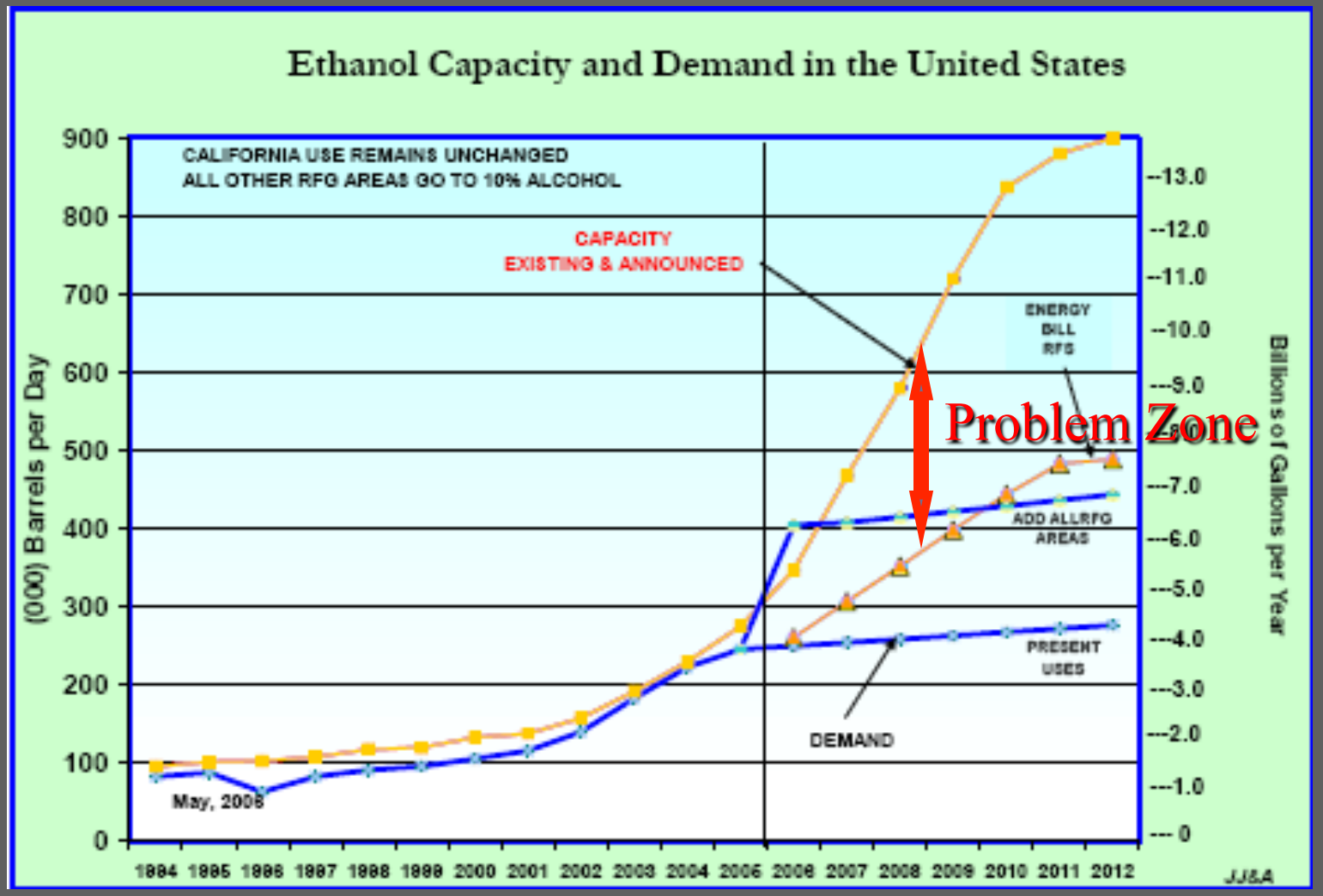
Ethanol Supply Projections



Projected supply of 173B gallons ethanol for FFV's by 2030

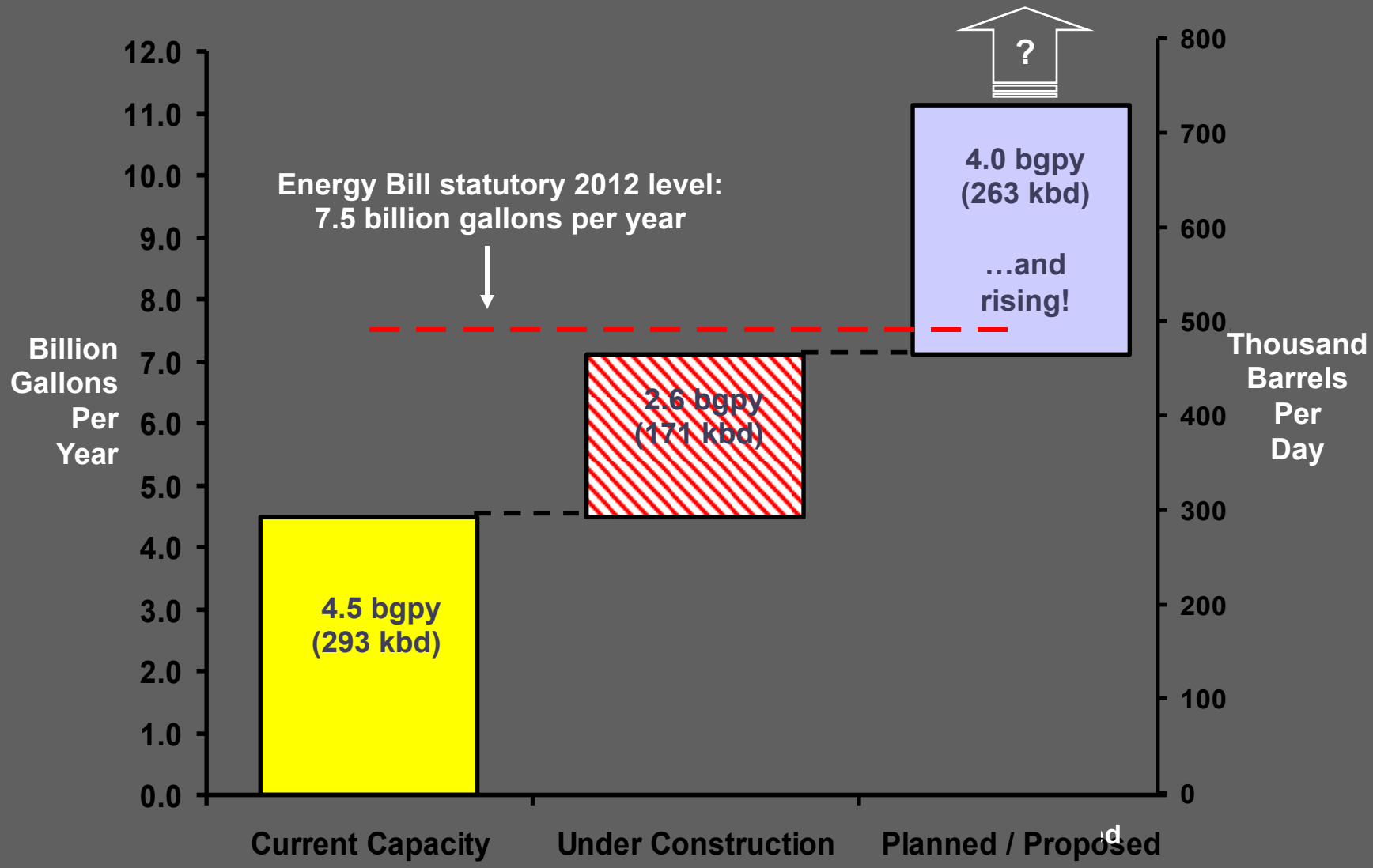
We Must Kick Start the E85 Market!!

What is Happening…



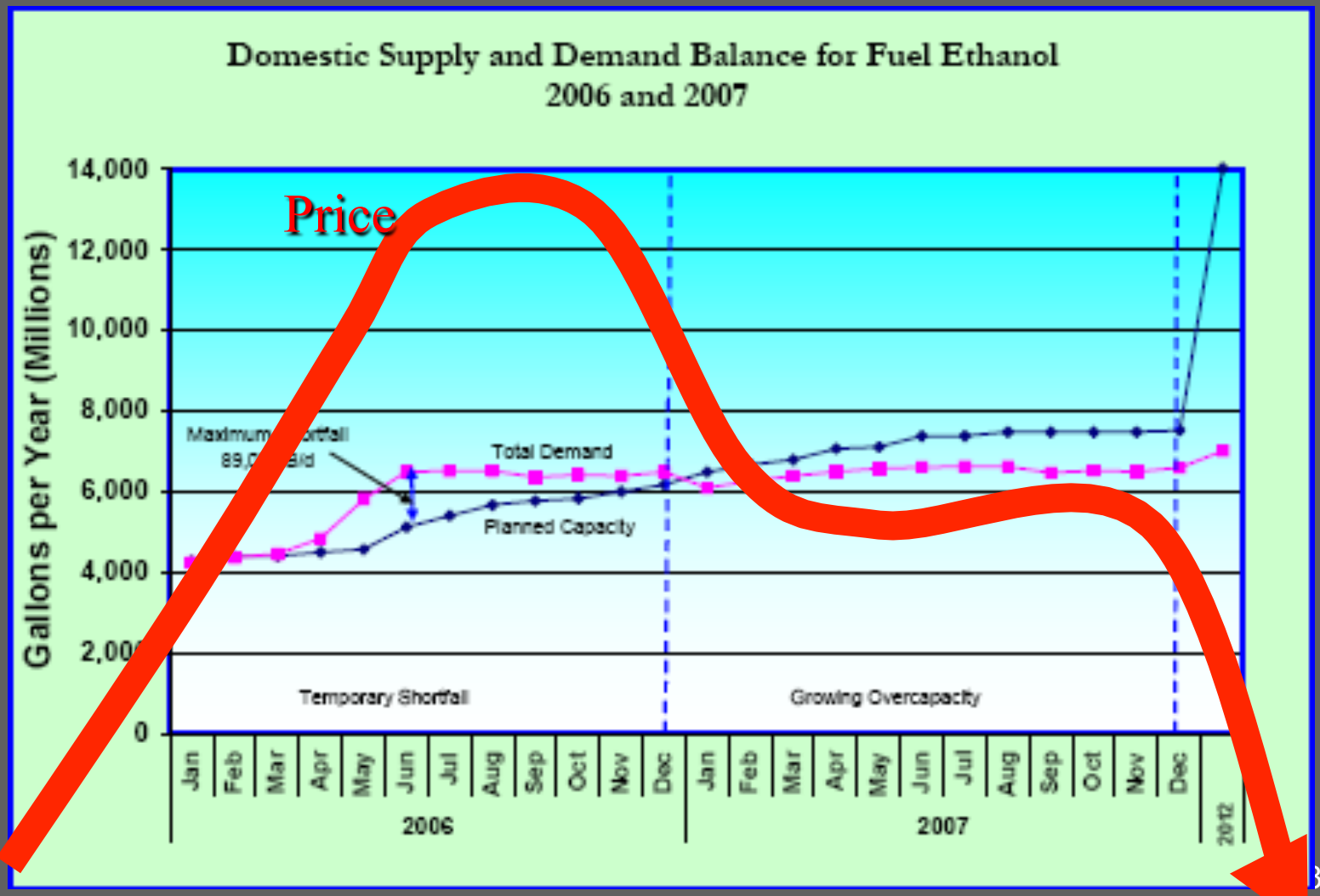
Source: JJ&A Fuel Blendstock Report

US Ethanol Capacity Build-up



Source: Cambridge Energy Research Associates, Renewable Fuels Association

Short Term Demand/Supply Forecast



Source: JJ&A Fuel Blendstock Report ; Price trend estimates by Vinod Khosla

My Favorite FFV . . .

SAAB 9-5 Launched May’05 with +25hp with E85

25% mileage reduction going to 18%

Another big ethanol mileage increase when hp held to gasoline hp

Bad Questions, Bad Data, Wrong Questions, Wrong Answers, and more…

- The False Hope of Biofuels (James Jordan & James Powell, Washington Post, July 2, 2006)
  - Wrong questions: Not energy balance but balance versus gasoline or electricity
  - Wrong data: bushels per acre, gallons per bushel,
  - Use energy content not mileage- who cares about energy balance? Upside?
  - "some researchers even claim that…" – what about many others?
  - Moralizing about food – what about oil excesses? Is President Lulu wrong?
  - Selective facts – quote impractical corn stover but ignore DOE Report
  - Judgment calls – gallons per acre

    …and more!

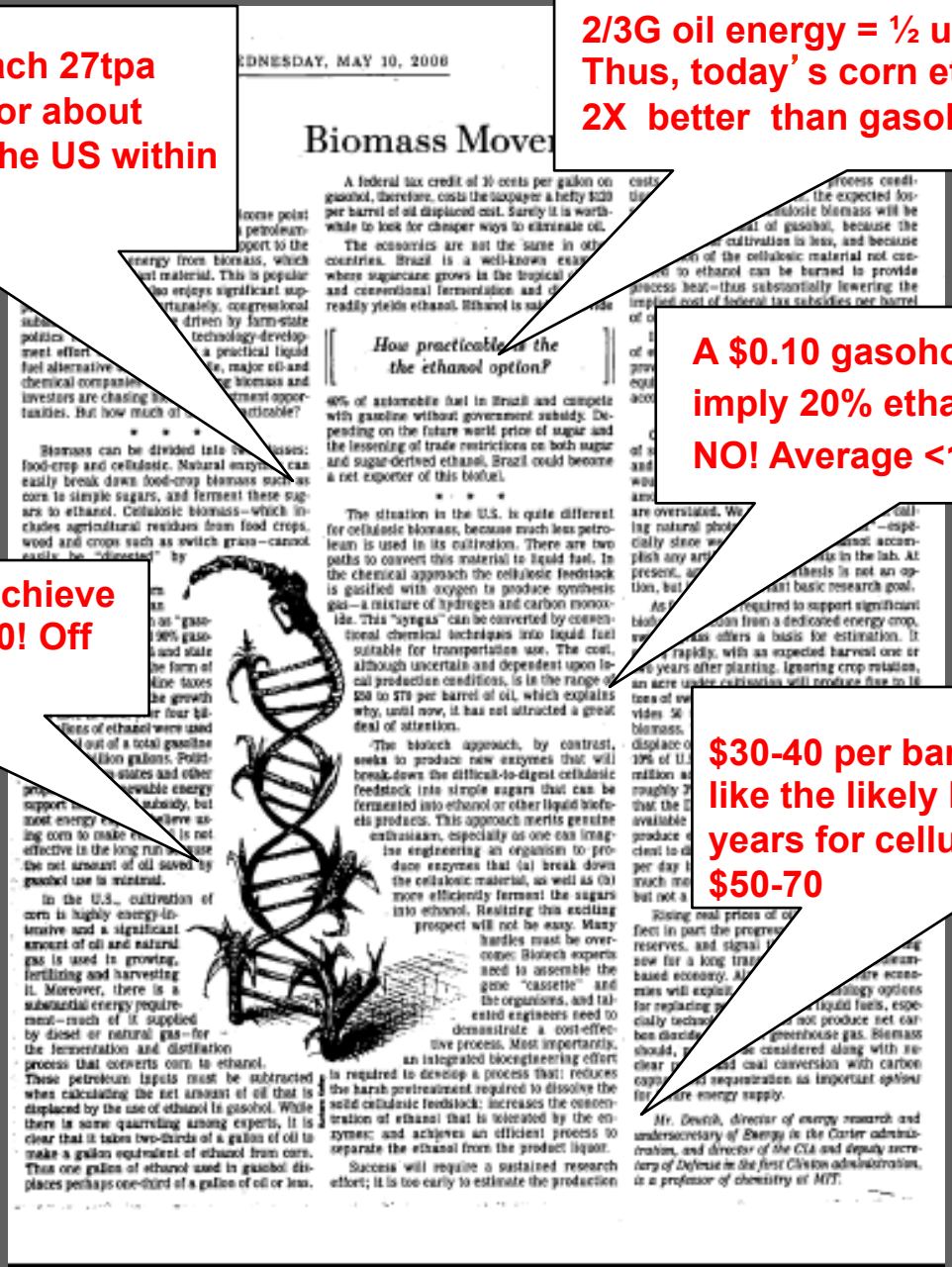
Conservatively we will reach 27tpa &110 gallons per dry ton or about 3000 gallons per acre in the US within 25 years. Error by 5-7X!!!

2/3G oil energy = ½ unit of gasoline. Thus, today's corn ethanol is 2X better than gasoline

A $0.10 gasohol credit would imply 20% ethanol blend… NO! Average <10%

Optimistically, we could achieve 5,000 gallons/acre by 2030! Off by 10X?

$30-40 per barrel oil price seems like the likely breakeven within 5-7 years for cellulosic ethanol NOT $50-70



EDNESDAY, MAY 10, 2006

Biomass Mover

A federal tax credit of 10 cents per gallon on gasohol, therefore, costs the taxpayer a hefty $120 per barrel of oil displaced cost. Surely it is worthwhile to look for cheaper ways to eliminate oil.

The economics are not the same in other countries. Brazil is a well-known example where sugarcane grows in the tropical climate and conventional fermentation and distillation readily yields ethanol. Ethanol is sold at the pump

How practicable is the the ethanol option?

40% of automobile fuel in Brazil and competes with gasoline without government subsidy. Depending on the future world price of sugar and the lessening of trade restrictions on both sugar and sugar-derived ethanol, Brazil could become a net exporter of this biofuel.

* * *

The situation in the U.S. is quite different for cellulosic biomass, because much less petroleum is used in its cultivation. There are two paths to convert this material to liquid fuel. In the chemical approach the cellulosic feedstock is gasified with oxygen to produce synthesis gas—a mixture of hydrogen and carbon monoxide. This "syngas" can be converted by conventional chemical techniques into liquid fuel suitable for transportation use. The cost, although uncertain and dependent upon local production conditions, is in the range of $50 to $70 per barrel of oil, which explains why, until now, it has not attracted a great deal of attention.

The biotech approach, by contrast, seeks to produce new enzymes that will break down the difficult-to-digest cellulosic feedstock into simple sugars that can be fermented into ethanol or other liquid biofuels products. This approach merits genuine enthusiasm, especially as one can imagine engineering an organism to produce enzymes that (a) break down the cellulosic material, as well as (b) more efficiently ferment the sugars into ethanol. Realizing this exciting prospect will not be easy. Many hurdles must be overcome: Biotech experts need to assemble the gene "cassette" and the organisms, and talented engineers need to demonstrate a cost-effective process. Most importantly, an integrated bioengineering effort is required to develop a process that: reduces the harsh pretreatment required to dissolve the solid cellulosic feedstock; increases the concentration of ethanol that is tolerated by the enzymes; and achieves an efficient process to separate the ethanol from the product liquor.

Success will require a sustained research effort; it is too early to estimate the production

Biomass can be divided into two classes: food-crop and cellulosic. Natural enzymes can easily break down food-crop biomass such as corn to simple sugars, and ferment these sugars to ethanol. Cellulosic biomass—which includes agricultural residues from food crops, wood and crops such as switch grass—cannot

In the U.S., cultivation of corn is highly energy-intensive and a significant amount of oil and natural gas is used in growing, fertilizing and harvesting it. Moreover, there is a substantial energy requirement—much of it supplied by diesel or natural gas—for the fermentation and distillation process that converts corn to ethanol. These petroleum inputs must be subtracted when calculating the net amount of oil that is displaced by the use of ethanol in gasohol. While there is some quarreling among experts, it is clear that it takes two-thirds of a gallon of oil to make a gallon equivalent of ethanol from corn. Thus one gallon of ethanol used in gasohol displaces perhaps one-third of a gallon of oil or less.

Mr. Deutch, director of energy research and undersecretary of Energy in the Carter administration, and director of the CIA and deputy secretary of Defense in the first Clinton administration, is a professor of chemistry at MIT.

WSJ Oped: Myths & Bad Data Abound!!

Myths Galore!

- Energy Balance – Not your father's ethanol
- Not enough cropland – only if you try to make pigs fly!
- Food prices or the best thing for poverty?
- Lower energy content, lower mileage – in which engine?
- More expensive or poorly managed? US oil or Saudi oil?
- Existing infrastructure – for E85 or additive? Some or all pumps?
- Dubious environmental benefits – as additive E20 or E85?
- Cellulosic ethanol – real or not?
- Free marketeers hell or level playing field?

Only the Negative Studies are Cited!

Positive Energy Balance	**Negative Energy Balance**
Lorenz & Morris (1995) Wang et al. (1999) Agri Canada (1999) Shapouri et al (1995,2002, 2004) Kim & Dale (2002, 2004) Graboski (2002) Delucchi (2003) NR Canada (2005)	Pimentel & Patzek

White House Memo (2005): "It is notable that only one study in the last ten years shows a negative energy balance"

Developing Oil vs Ethanol

Chevron's Tahiti field will cost $5.5 billion be expensive to operate being in 24,000 feet of deep ocean. It will generate 125,000 barrels of oil a day or about a billion gallons of gasoline and similar amounts of other products. The same capital investment could produce 4 billion gallons of ethanol capacity (and other animal feed products) at little risk.

“Free Markets?”: GAO List of Oil Subsidies

- Excess of Percentage over cost depletion” worth $82 billion dollar subsidy
- Expensing of exploration and development cost - $42 billion subsidy.
- Add on alternative fuel production credit (read oil shales, tar sands etc).
- Oil and gas exception from passive loss limitation
- Credit for enhanced oil recovery costs
- Expensing of tertiary injectants

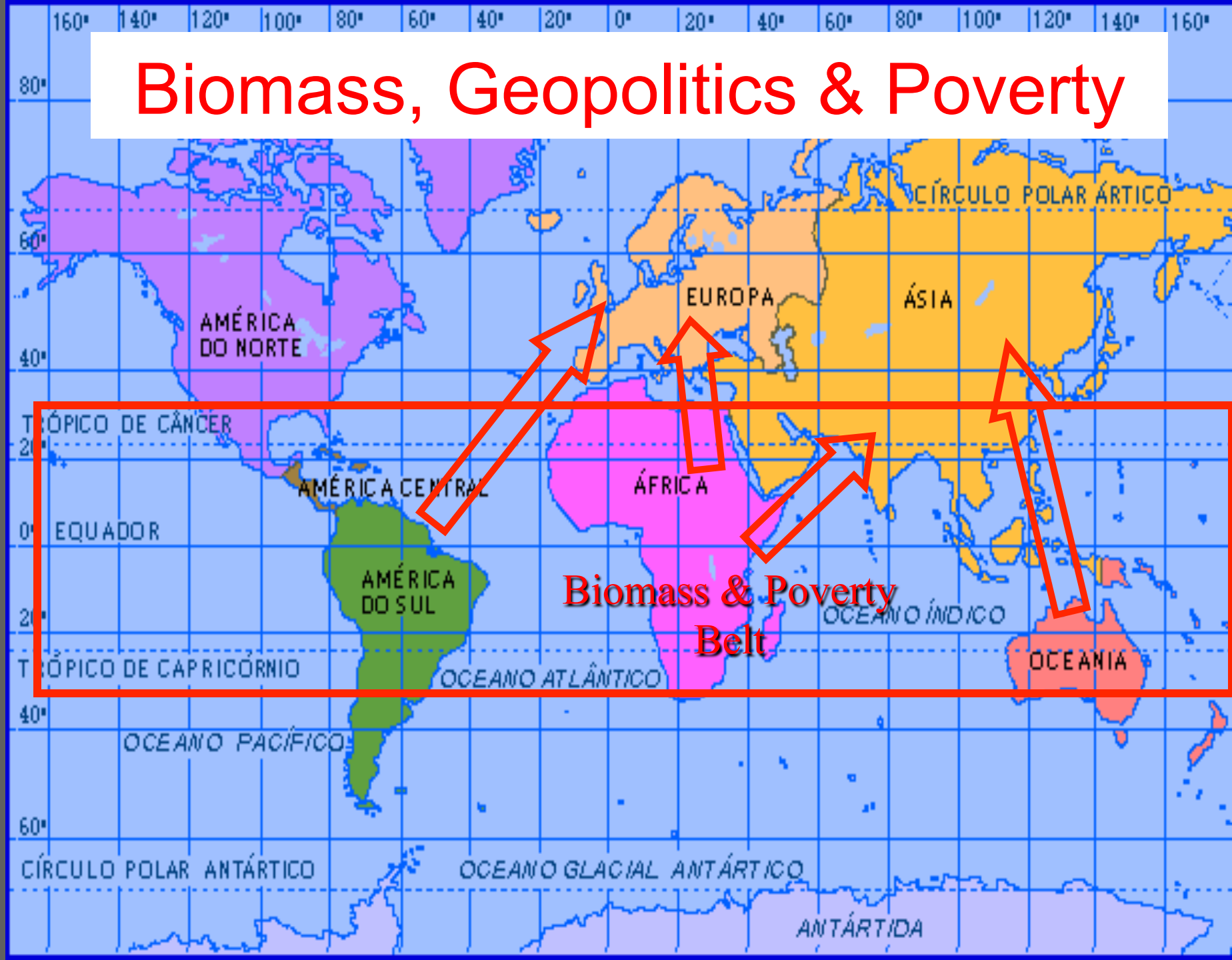
…and other esoteric tools the oil lobby has inserted into various legislation
…and the indirect costs

- Katrina royalty relief to the tune of $7b
- Health-care costs of the air pollution they generate,
  Environmental cleanup costs when they have a spill,
  Cost of defense in the Mideast to stabilize the supply of crude oil,
  Cost of global warming and related damage
  ….indirect subsidies have been variously estimated at from a few tens of cents to many dollars per gallon

The Possible at "NORMAL" Margins!

June 2006, Aberdeen , South Dakota

Biomass, Geopolitics & Poverty



Comments?

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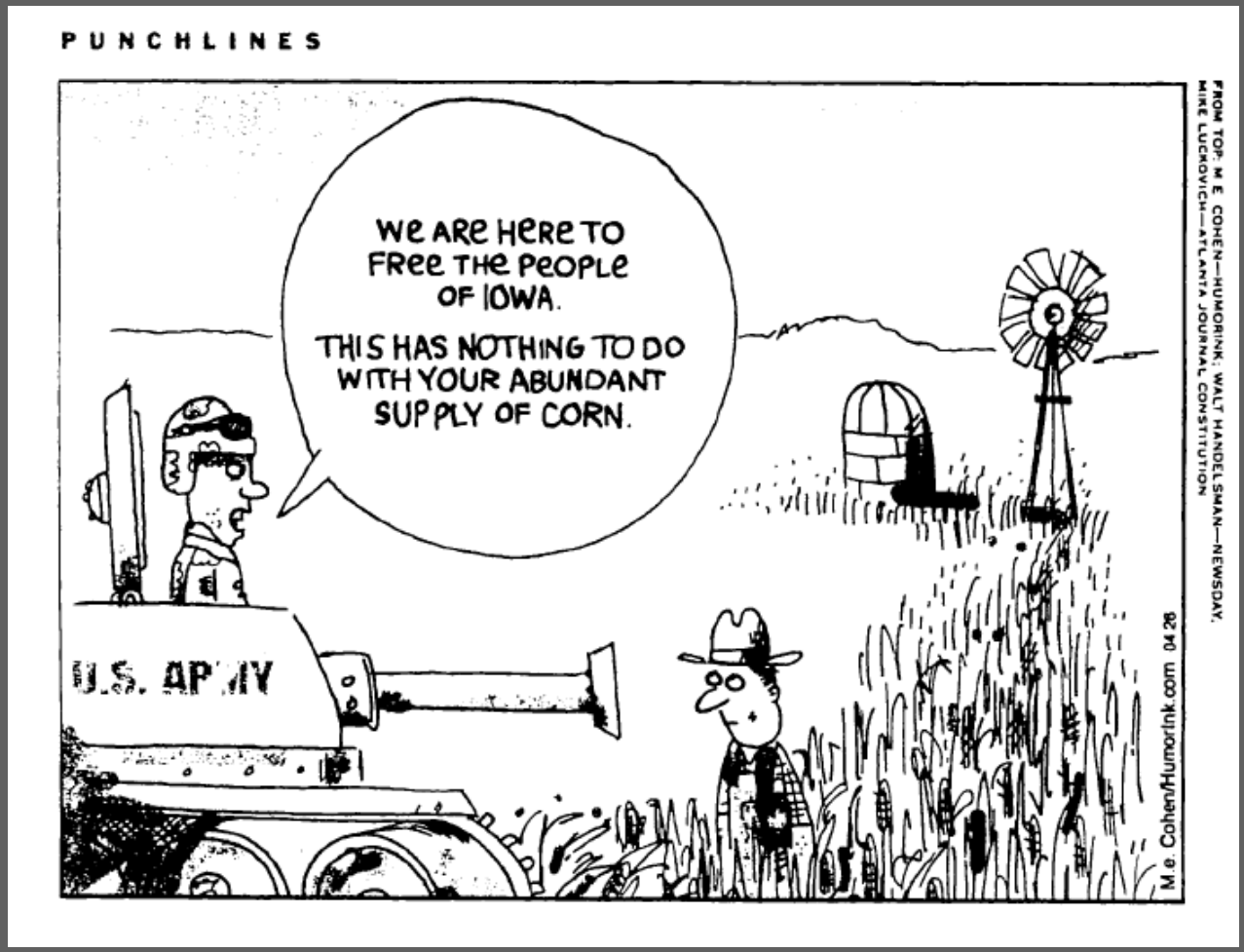


Side Bars

Flex Fuel Vehicles (FFV)

Little incremental cost to produce & low risk

Consumer choice: use EITHER ethanol or gasoline

Easy switchover for automobile manufacturers

Fully compatible with Hybrid cars

Incremental Cost of FFV

- Sensor $70 (needed anyway in modern cars; not an additional cost)
- "Other" costs $30
- Amortized Certification & Calib. $10 (volume cars)

Automakers adopting FFV's!

- 2006
  - Ford 200-300K
  - GM 250K
  - Chrysler 100K+
- 2007
  - GM 400K
  - Chrysler 250K
- 2008
  - GM 600K
  - Chrysler 500K

Data from Chrysler PR, GM slides and Ford handout

Petroleum Displacement

GASOLINE SAVINGS OF 477 GALLO

(ASSUMES 11,000 MILES/YEAR)*

E85 FFV ON E85
12 MPG
(EPA ADJUSTED COMBINED)

E85 FFV ON GASOLINE
16 MPG
(EPA ADJUSTED COMBINED)

** PERSONAL TRANSPORTATION STUDY - OAK RIDGE NAT. L*

GM

Hybrid or FFV?

	Hybrid	FFV
Cost	$3000	$30
Gasoline Savings (11000 m/yr; 14mpg)	157	477

Oil Companies Discouraging Use!

More Resistance!!!

Misinformation about need for periodic gasoline refills in Brazil

Land Use

Land Use Possibilities

- **Dedicated intensive energy crop plantations**
- **"Export crop" lands**
- **Crop rotate row crops & "prairie grass" energy crops**
- **CRP lands planted with "prairie grasses" or equivalent**
- **Co-production of ethanol feedstocks & animal protein**
- **Waste from currently managed Lands**

Potential for Billion Tons of Biomass

"In the context of the time required to scale up to a large-scale biorefinery industry, an annual biomass supply of more than 1.3 billion dry tons can be accomplished with relatively modest changes in land use and agricultural and forestry practices"

Technical Feasibility of a Billion-Ton Annual Supply
US Department of Energy Report , April 2005.
http://www.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

…. Or a 130billion++ gallons per year!

Miscanthus vs. Corn/Soy

- Lower fertilizer & water needs
- Strong photosynthesis, perennial
- Stores carbon & nutrients in soil
- Great field characteristics, longer canopy season
- Economics: +$3000 vs -$300 (10yr profit per U Illinois)

Energy Crops: Switch Grass

- Natural prairie grass in the US; enriches soil
- Less water; less fertilizer; less pesticide
- Reduced green house gases
- More biodiversity in switchgrass fields (vs. corn)
- Dramatically less topsoil loss
- High potential for co-production of animal feed

Farmers Are Driven By Economics

Per acre economics of dedicated biomass crops vs. traditional row crops

	Biomass	Corn	Wheat
Grain yield (bushel)	N/A	162	46
Grain price ($/bushel)	N/A	$2	$3
Biomass yield (tons)	15	2	2
Biomass price ($/ton)	$20	$20	$20
Total revenue	**$300**	**$364**	**$178**
Variable costs	$84	$168	$75
Amortized fixed costs	$36	$66	$36
Net return	**$180**	**$120**	**$57**

Source: Ceres Company Presentation

Biomass as Reserves: One Exxon every 10 yrs!!

1 acre = 209 barrels of oil*

100M acres = 20.9 billion barrels

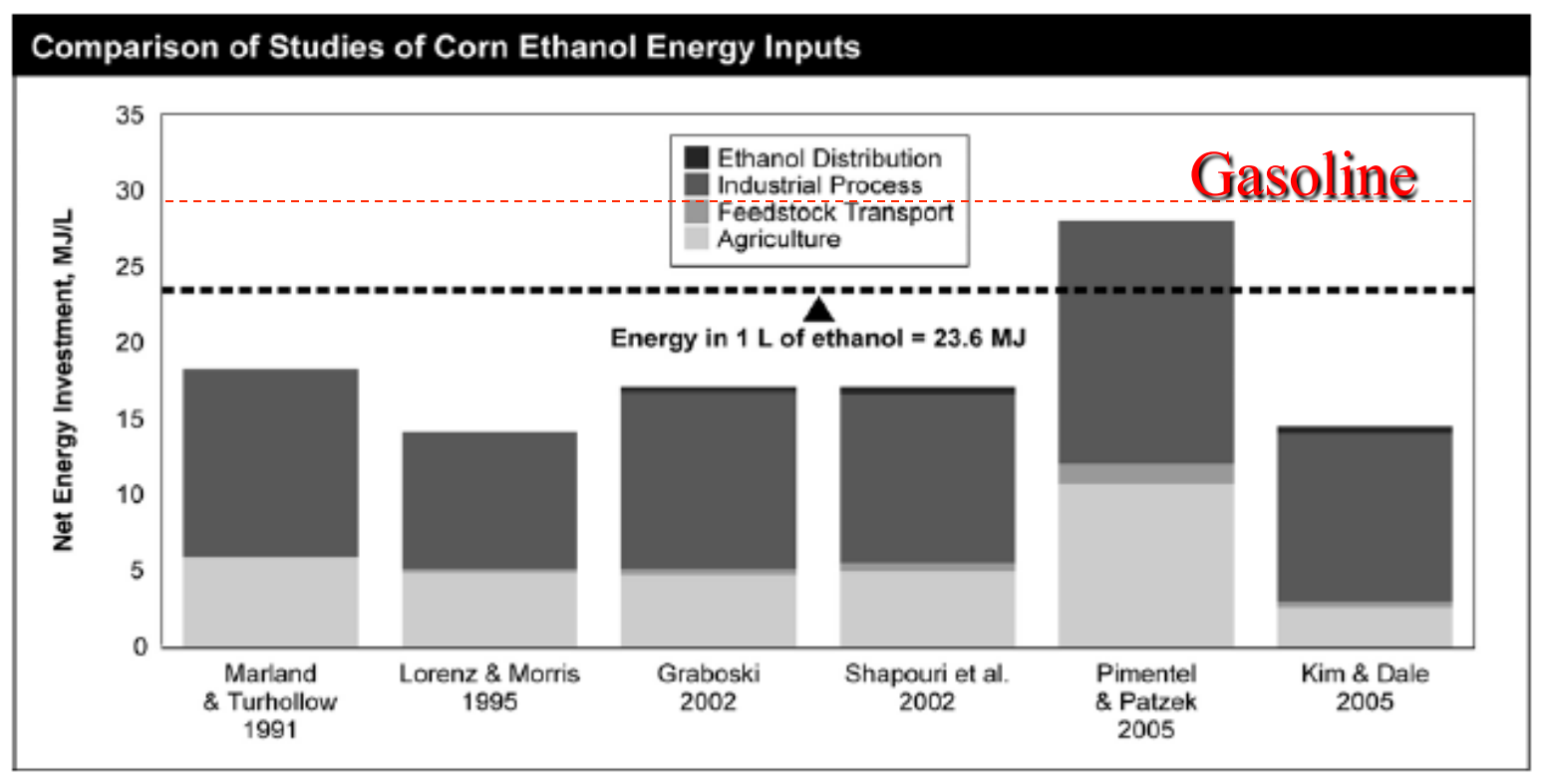
	Proven Reserves (billion barrels)
Exxon Mobil	22.20
BP	18.50
Royal Dutch Shell	12.98
Chevron	9.95
Conoco Phillips	7.60

* Assumes 10 yr contract

Source: Energy Intelligence (data as of end of 2004);Ceres presentation

Energy Balance
&
Fossil Fuel Use Reductions

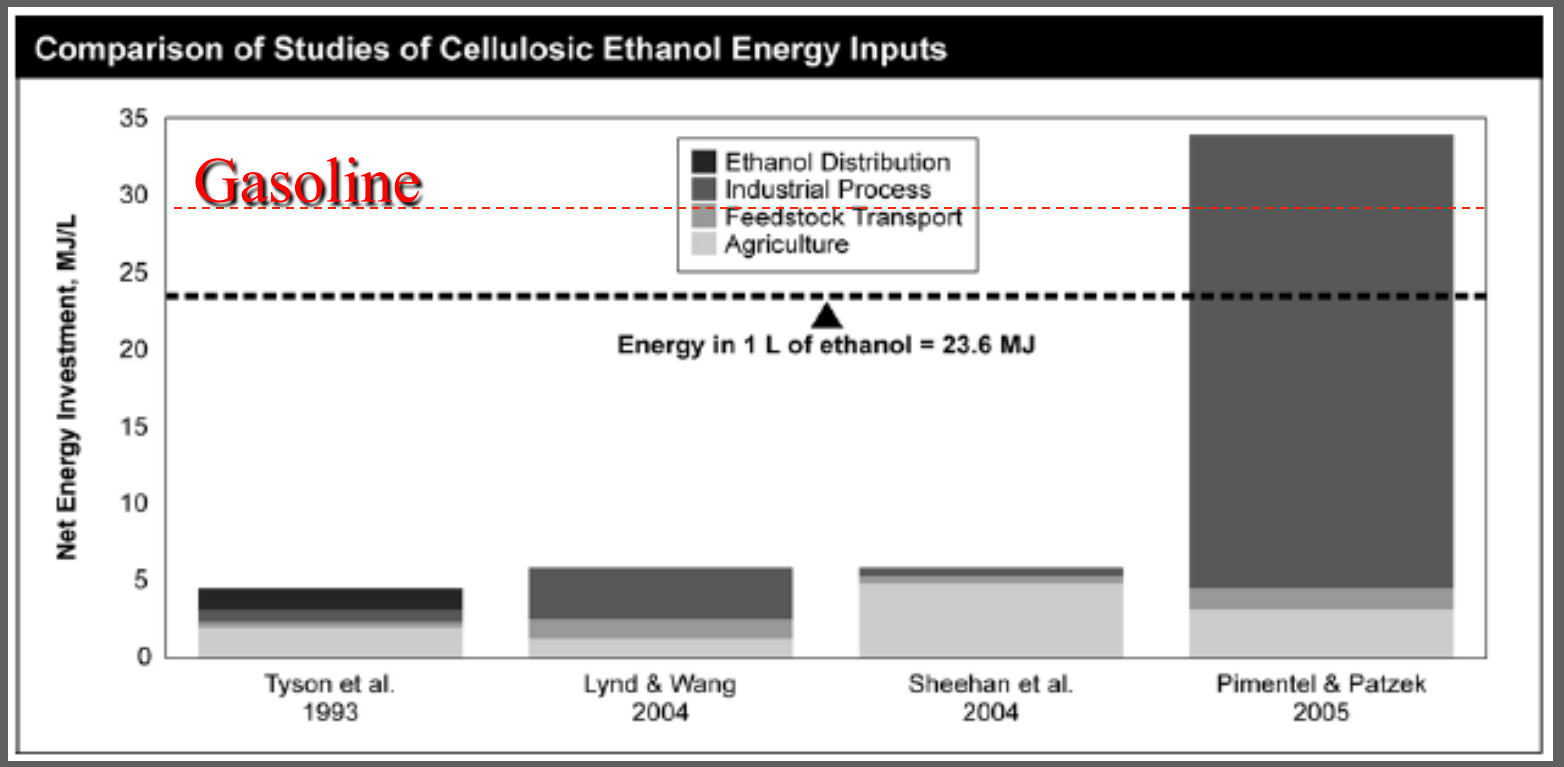
NRDC Report - "Ethanol: Energy Well Spent"



"It is notable that Pimental is the only study in the last ten years to show a negative balance" – White House Memo, 2005

Red: Khosla Comments

NRDC Report - "Ethanol: Energy Well Spent"



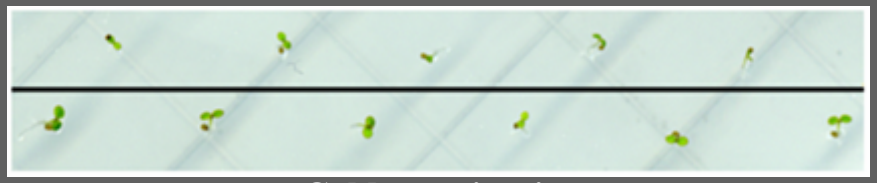
Red: Khosla Comments

Ceres: What one company is doing…

Expanding Usable Acreage…

Drought tolerance

Heat tolerance



Cold germination

Drought recovery

Drought Inducible Promoters

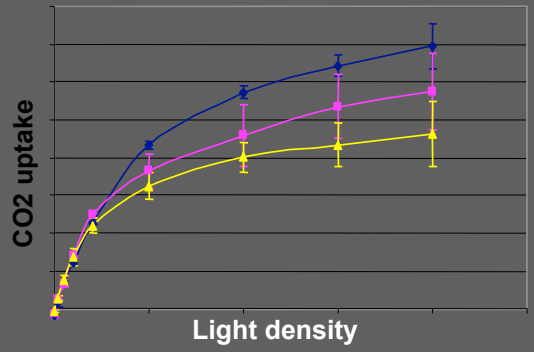
Salt tolerance

Source: Ceres Company Presentations

Increasing Tons per Acre…

Increased biomass

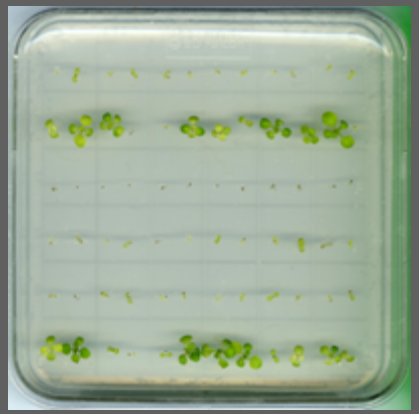
Flowering time



Photosynthetic Efficiency

Shade tolerance

Stature control

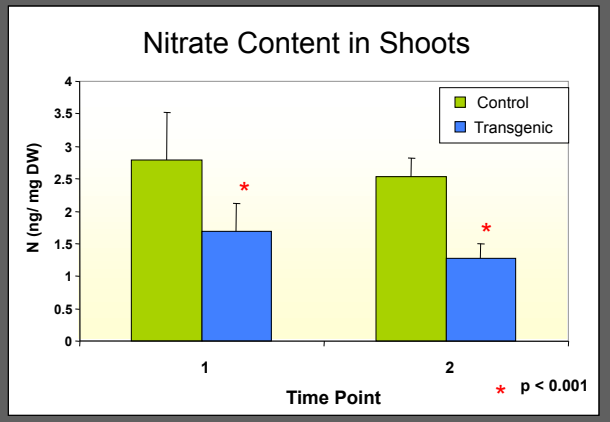


Herbicide tolerance

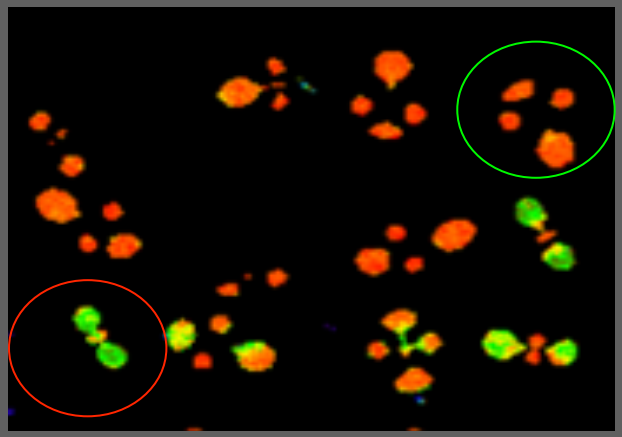
Source: Ceres Company Presentations

Reducing Dollars per Acre…

Nitrogen uptake



Nitrogen partitioning

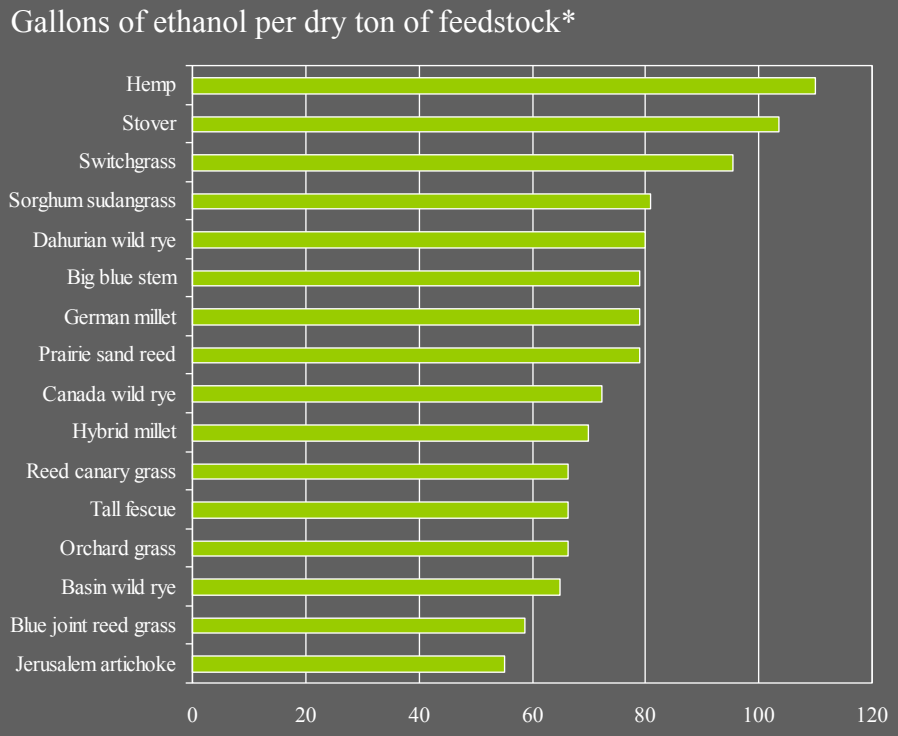


Photosynthetic efficiency under low nitrogen

Increased root biomass

Source: Ceres Company Presentations

Increasing Gallons per Ton…



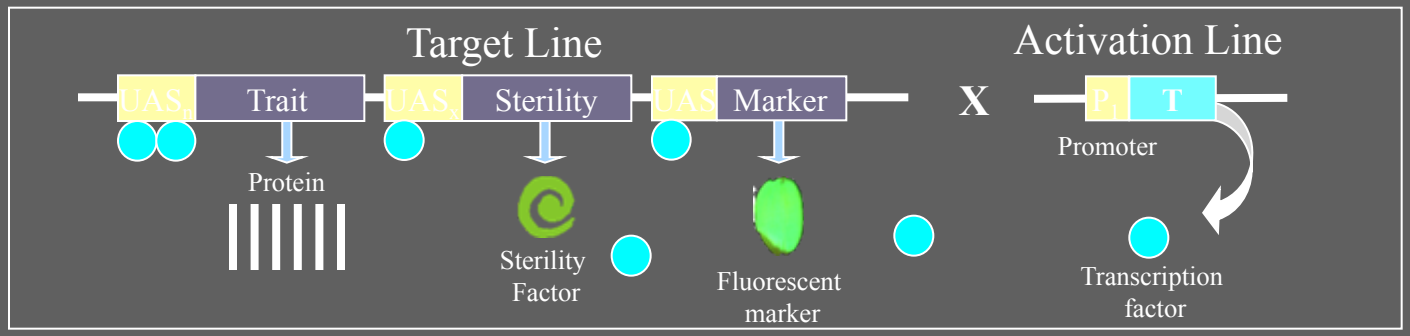
Composition
(How much carbohydrate is there?)

Plant structure
(How easy is it to access and digest?)

*Data represents theoretical yields as reported by Iogen

Source: Ceres Company Presentations

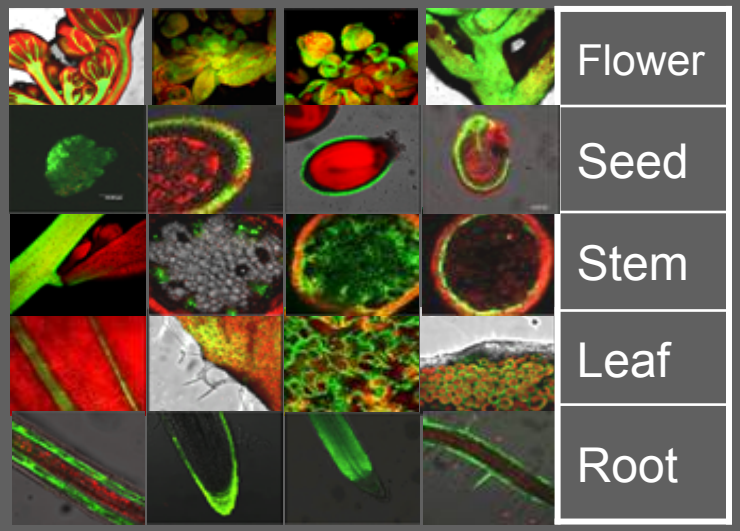
Reducing Cost Through Enzyme Production…



Ceres' proprietary gene expression system

Ceres promoter

Industry standard promoter



Tissue-specific promoters

Source:Ceres Company Presentations

Ceres : Developing Commercial Energy Crops

Generating Plant Material for DNA Libraries to be Used in Molecular Assisted Breeding

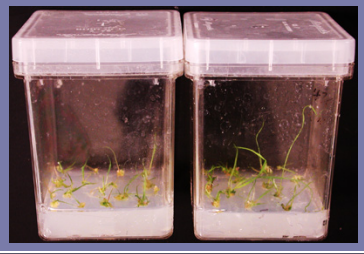
1 day after trimming

Re-growth after 15 days

Transformation with Ceres' Traits

Embryogenic callus

Shoot regenerated from callus



Plant regeneration

Ceres expects to have proprietary commercial varieties ready for market in 2-3 years and transgenic varieties in 5-7

Source: Ceres Company Presentations

Strategy & Tactics

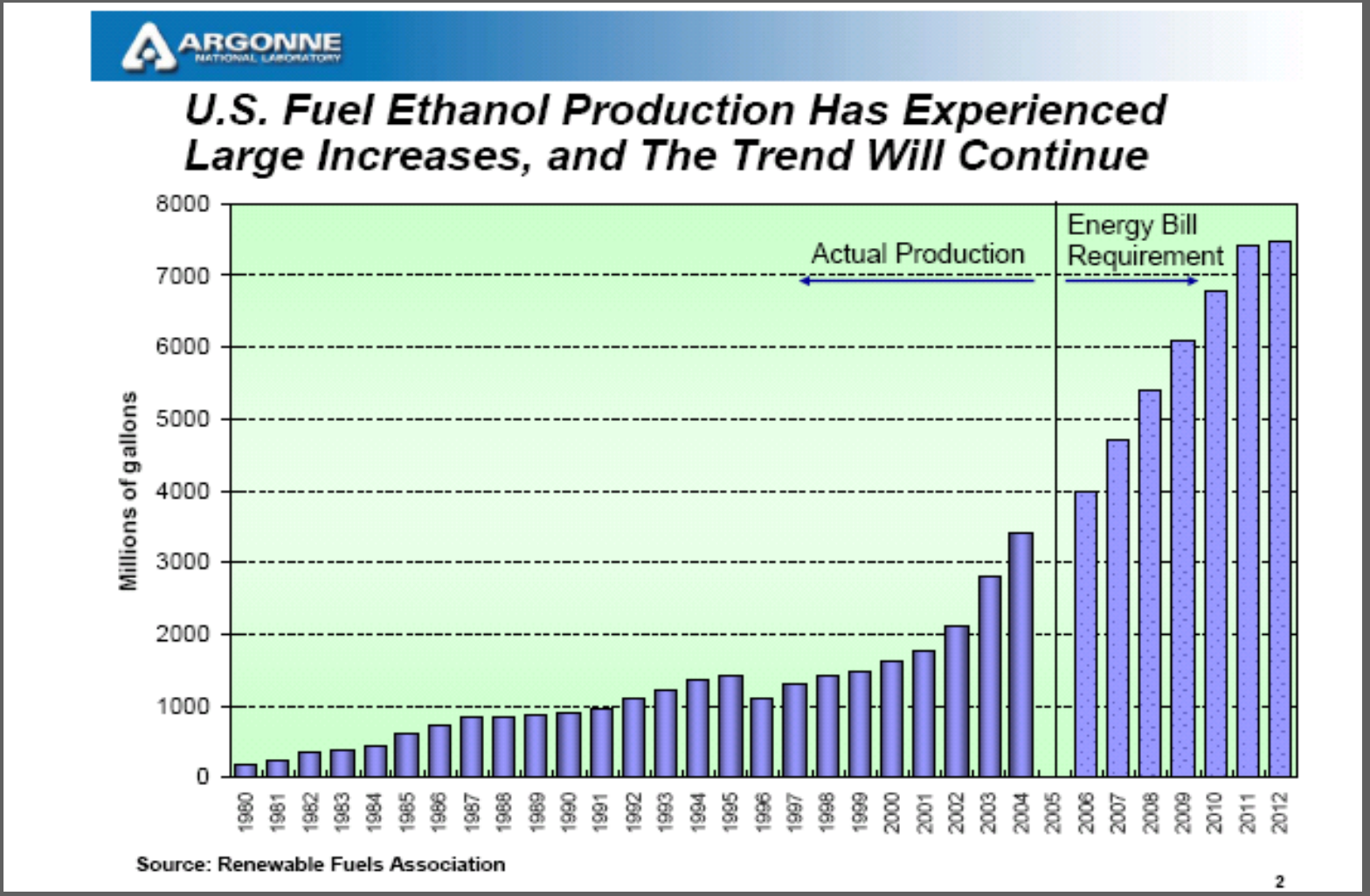
- Choice: Oil imports or ethanol imports?
- GDP – “beyond food to food & energy “ rural economy
- Add $5-50B to rural GDP
- Better use for subsidies through “energy crops”
- Rely on entrepreneurs to increase capacity
- Biotechnology & process technology to increase yields

Status: United States

E85 Availability and Appeal

September 2005

Ethanol Capacity Expansion is Underway



Ethanol FFVs Are Here!
California's Motor Vehicle Population

Vehicle Type	Gasoline	Diesel	**Ethanol FFV**	Hybrid gas/ elec	CNG	Electric	LPG/ other	H2
Light-Duty	24,785,578	391,950	**257,698**	45,263	21,269	14,425	538	13
Heavy-Duty	372,849	471,340	**--**	--	5,401	806	1,172	--

source: California Energy Commission joint-agency data project with California Department of Motor Vehicles. Ethanol FFV data as of April 2005; all other data as of October 2004.

Costs

	Wet Mills	Dry Mills	Overall Weighted Average
Electricity & Fuel	$0.112/gallon	$0.131/gallon	$1.118/gallon
Operating Labor, Repairs and Maintenance	$0.124/gallon	$0.109/gallon	
Yeast, Enzymes, Chemicals and Other	$0.114/gallon	$0.090/gallon	
Administration, Insurance and Taxes	$0.038/gallon	$0.037/gallon	
All Other Costs	$0.072/gallon	$0.051/gallon	
Total Cash Costs	$0.46/gallon	$0.42/gallon	
Combined with Net "NET" cost of corn	$0.48/gallon	$0.53/gallon	$0.94/gallon
Depreciation (plant & Equip)	$0.10-$0.20	$0.10-$0.20	
Note: Capital costs of ethanol production are estimated to be between $1.07/gallon to $2.39/gallon, varying with facility type, size, and technology.			

Source: Encyclopedia of Energy (Ethanol Fuels , Charlie Wyman)

NY Times Poll (3/2/2006)

- Washington mandate more efficient cars – 89%
- No on Gasoline tax -87%
- No on Tax to reduce dependence on foreign oil -37%
- No on gas tax to reduce global warming – 34%

References

- NRDC Report: “Growing Energy” (Dec 2004)
- http://soilcarboncenter.k-state.edu/conference/carbon2/Fiedler1_Baltimore_05.pdf
- George Schultz & Jim Woolsey white paper “Oil & Security”
- Rocky Mountain Institute: “Winning the Oil Endgame”
- http://www.unfoundation.org/features/biofuels.asp
- http://www.transportation.anl.gov/pdfs/TA/354.pdf
- The Future of the Hydrogen Economy (http://www.oilcrash.com/articles/h2_eco.htm#8.2)
- Fuel Ethanol: Background & Public Policy Issues (CRS Report for Congress, Dec. 2004)

ETHANOL: MARKET PERSPECTIVE

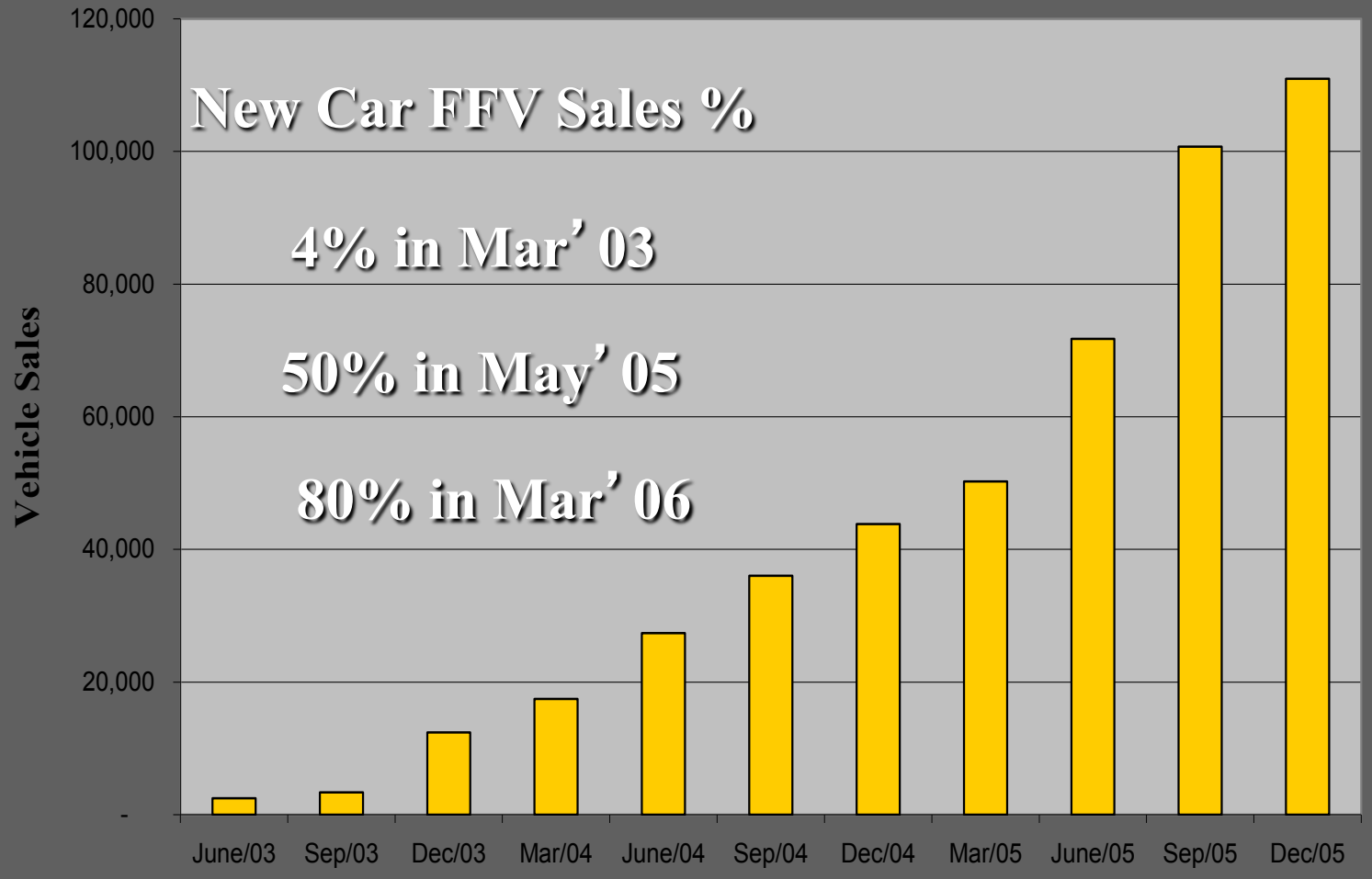
Luiz Carlos Corrêa Carvalho
Sugar and Alcohol Sectorial Chamber,
Ministry of Agriculture, Brazil

Assessing the Biofuels Option

Joint Seminar of the International Energy Agency,
the Brazilian Government and the
United Nations Foundation
Paris, 20 – 21 June 2005

Brazil: A Role Model

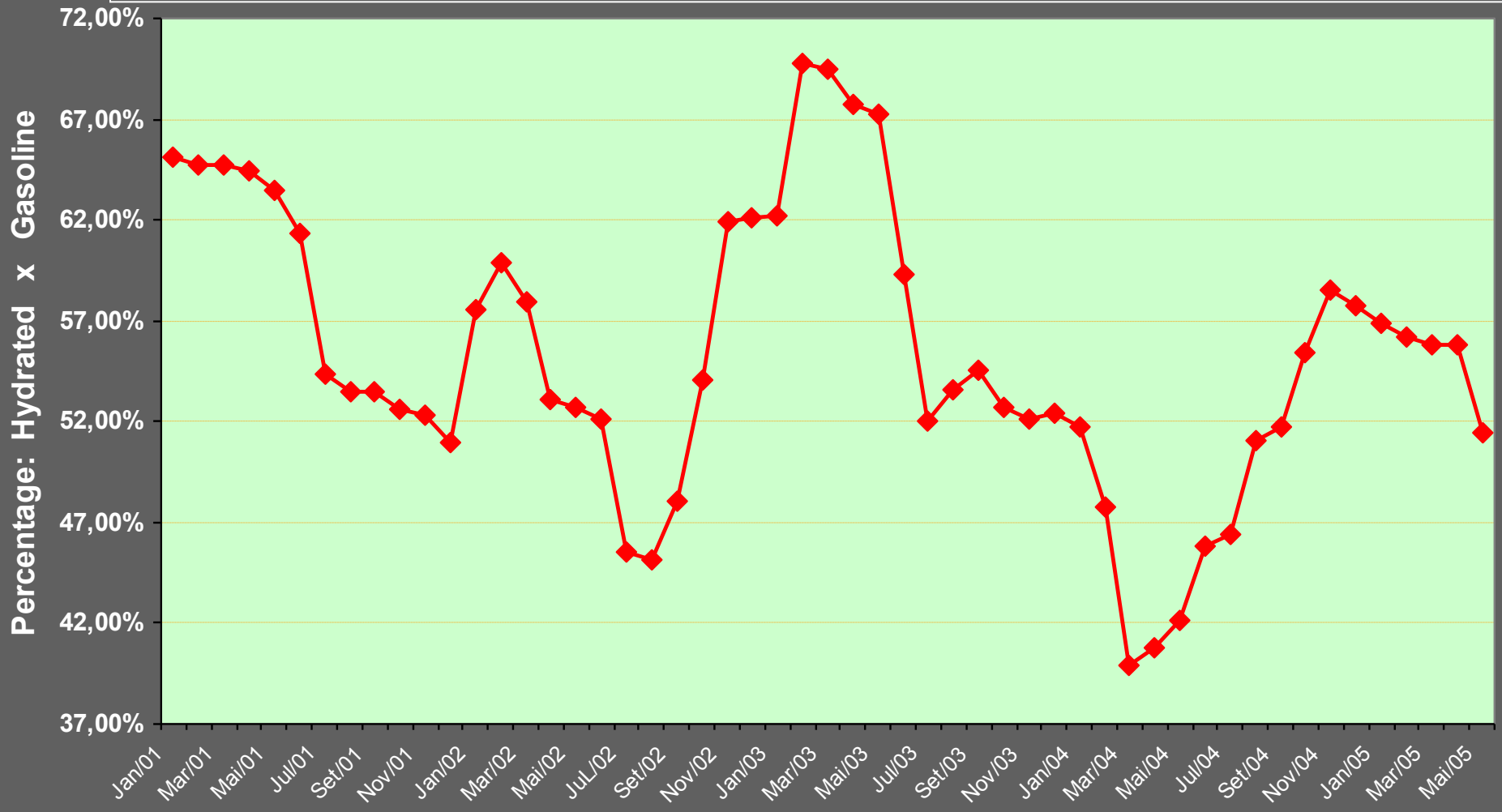
Can Rapid Adoption of FFV Happen?



Nearly 8x increase in sales in only 2 years

Consumer Price Ratio

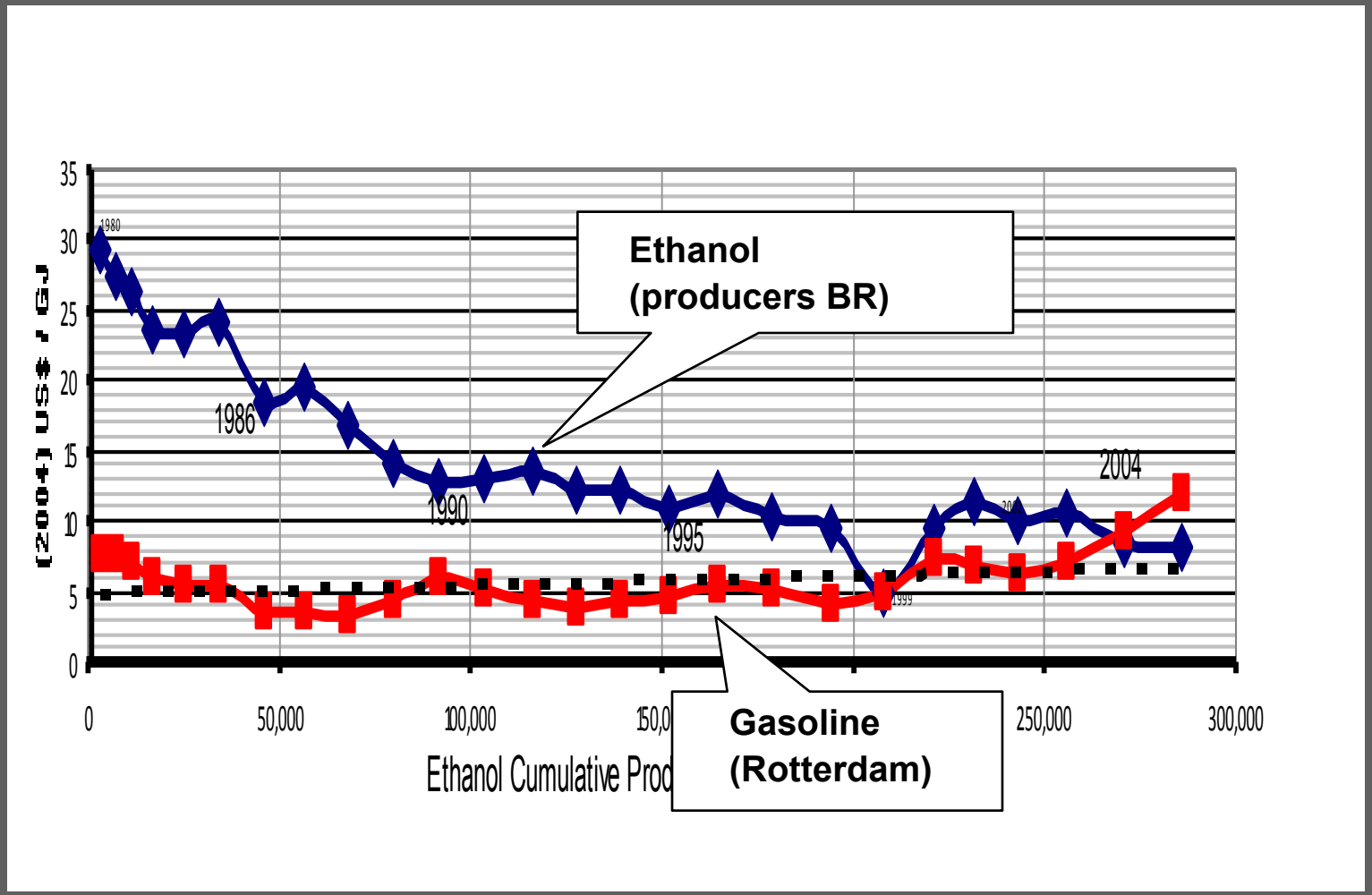
* São Paulo (SP)



Source: Honorable Roberto Rodrigues, Minister of Agriculture, Brazil (Assessing Biofuels Conf., June 2005)

SOURCE: MAPA

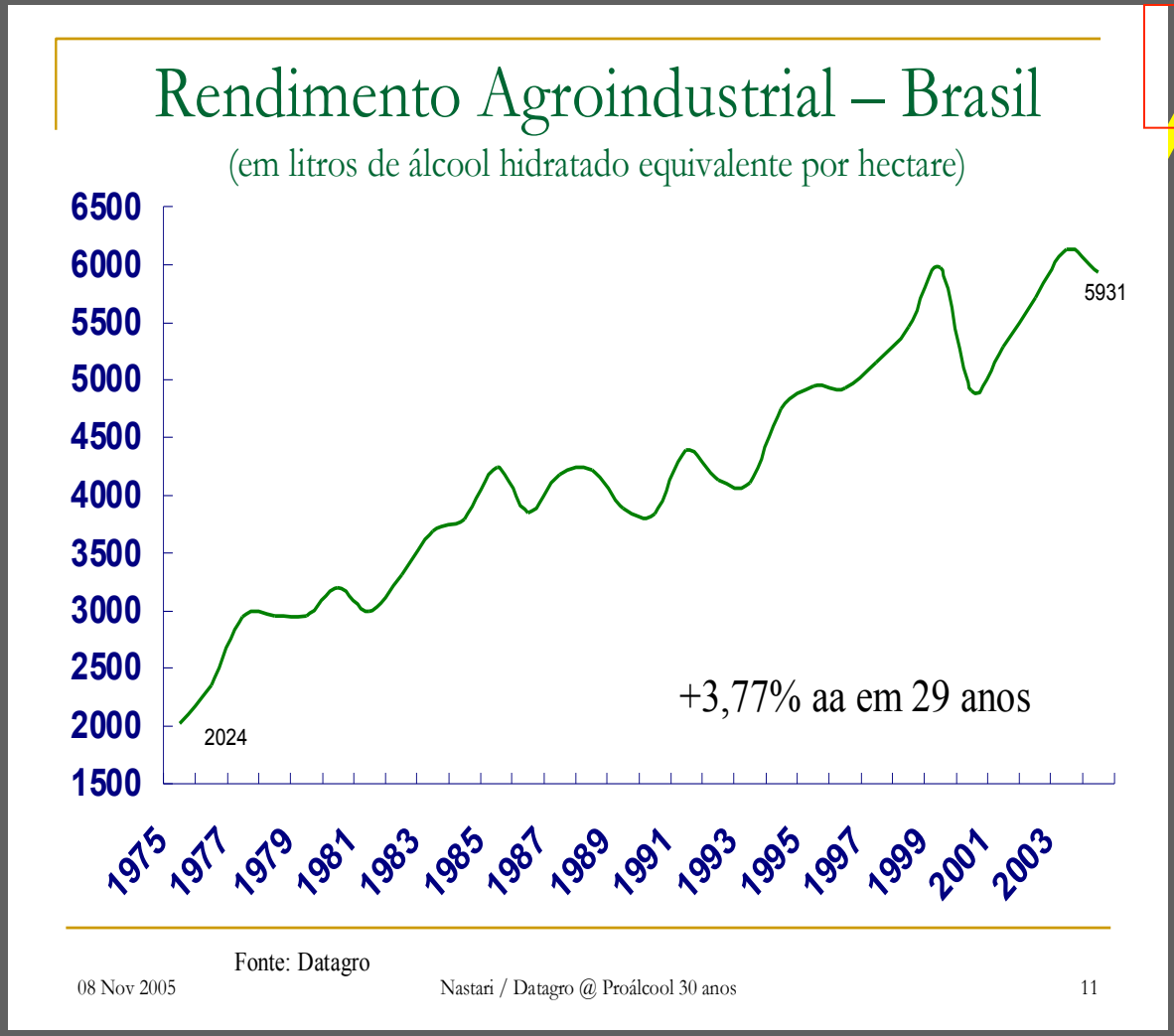
Ethanol: LEARNING CURVE



(J Goldemberg, 2004)

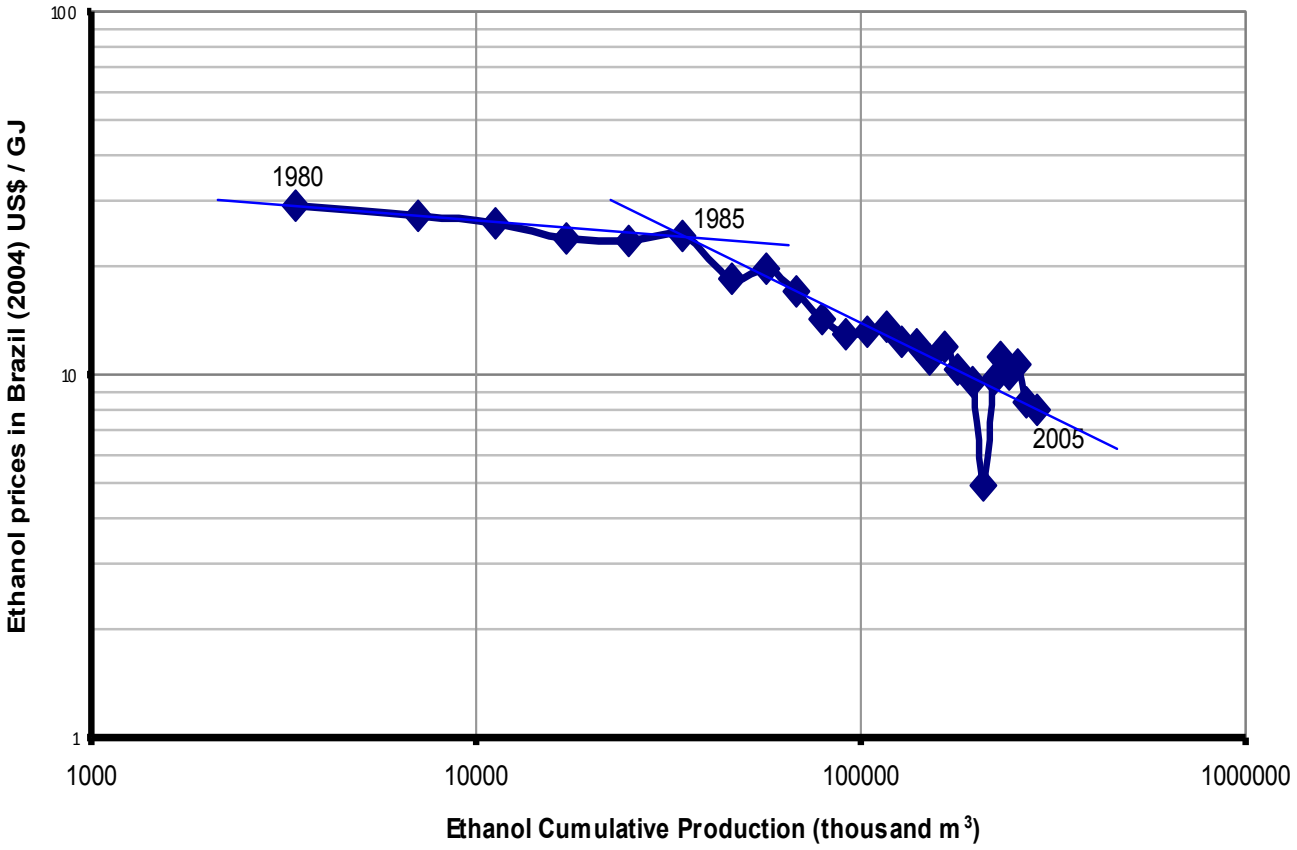
Brazil sugar-cane/ethanol learning curve

Liters of ethanol produced per hectare since between 1975 to 2004



30,000??

Ethanol Cost vs. Production Experience



The Ethanol application as vehicular fuel in Brazil.

Brazilian Automotive Industry Association - ANFAVEA

Energy & Environment Commission

Henry Joseph Jr.

LIFE CYCLE GHC EMISSIONS IN ETHANOL PRODUCTION AND USE

	Kg CO_2 equiv./ t cane	
	Average	Best Values
Emissions	34,5	33,0
Avoided Emissions	255,0	282,3
Net Avoided Emissions	220,5	249,3
Anhydrous Ethanol	2,6 to 2,7 t CO_2 equiv./m^3 ethanol	

Source: Leal, Regis, CO2 Life Cycle Analysis of Ethanol Production and Use, LAMNET, Rome, may 2004

Comparative Energy Balance

Raw Material	Total Energy Ratio
Corn	1,21
Switchgrass	4,43
Sugarcane	8,32

Source: Leal, Regis, CO2 Life Cycle Analysis of Ethanol Production and Use, LAMNET, Rome, may 2004

ETHANOL AND EMPLOYMENT

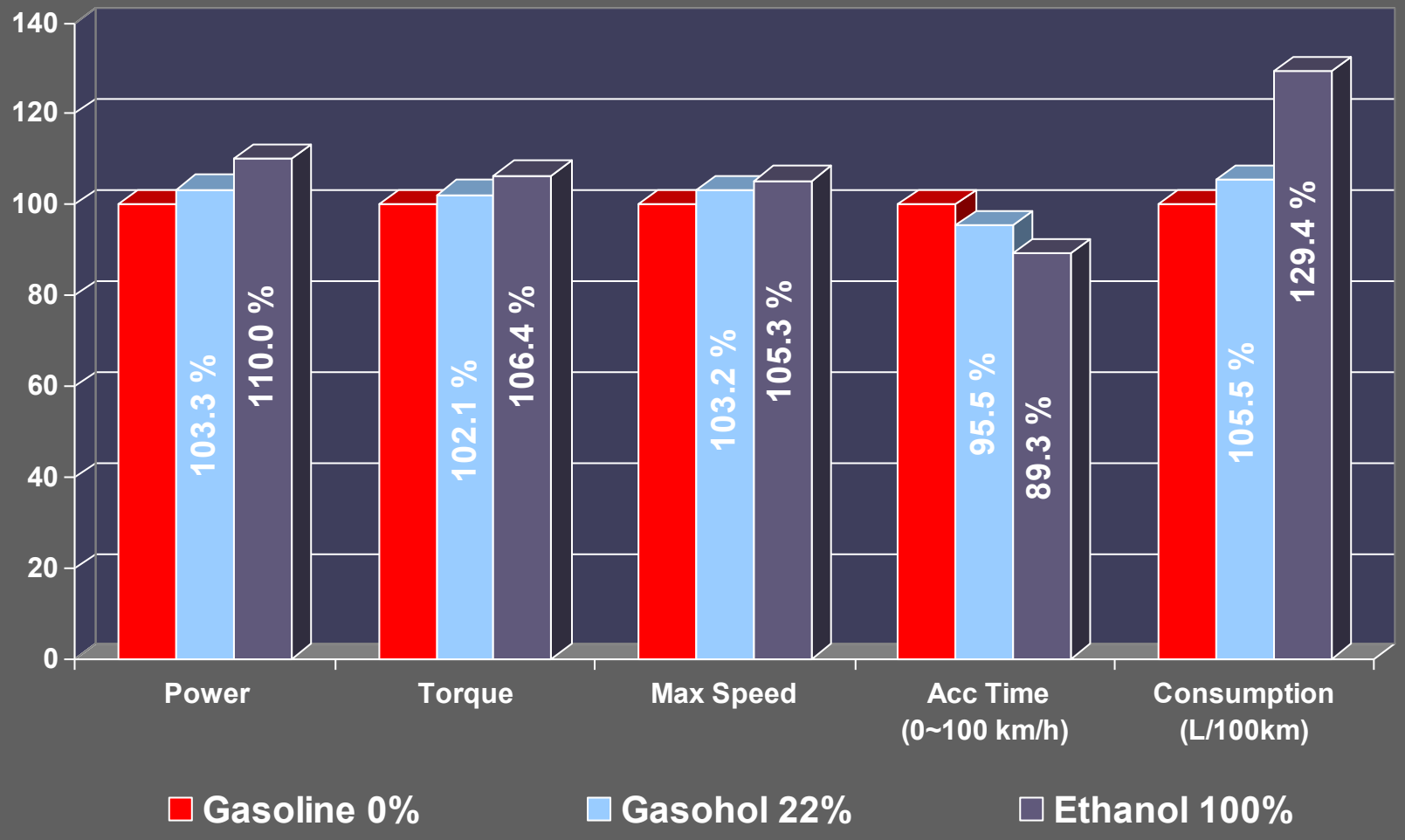
(IN THE PRODUCTION OF THE VEHICLE AND OF FUEL)

VEHICLES	RATIO OF EMPLOYMENTS
ETHANOL	21,87
"C" GASOLINE	6,01
"A" GASOLINE	1

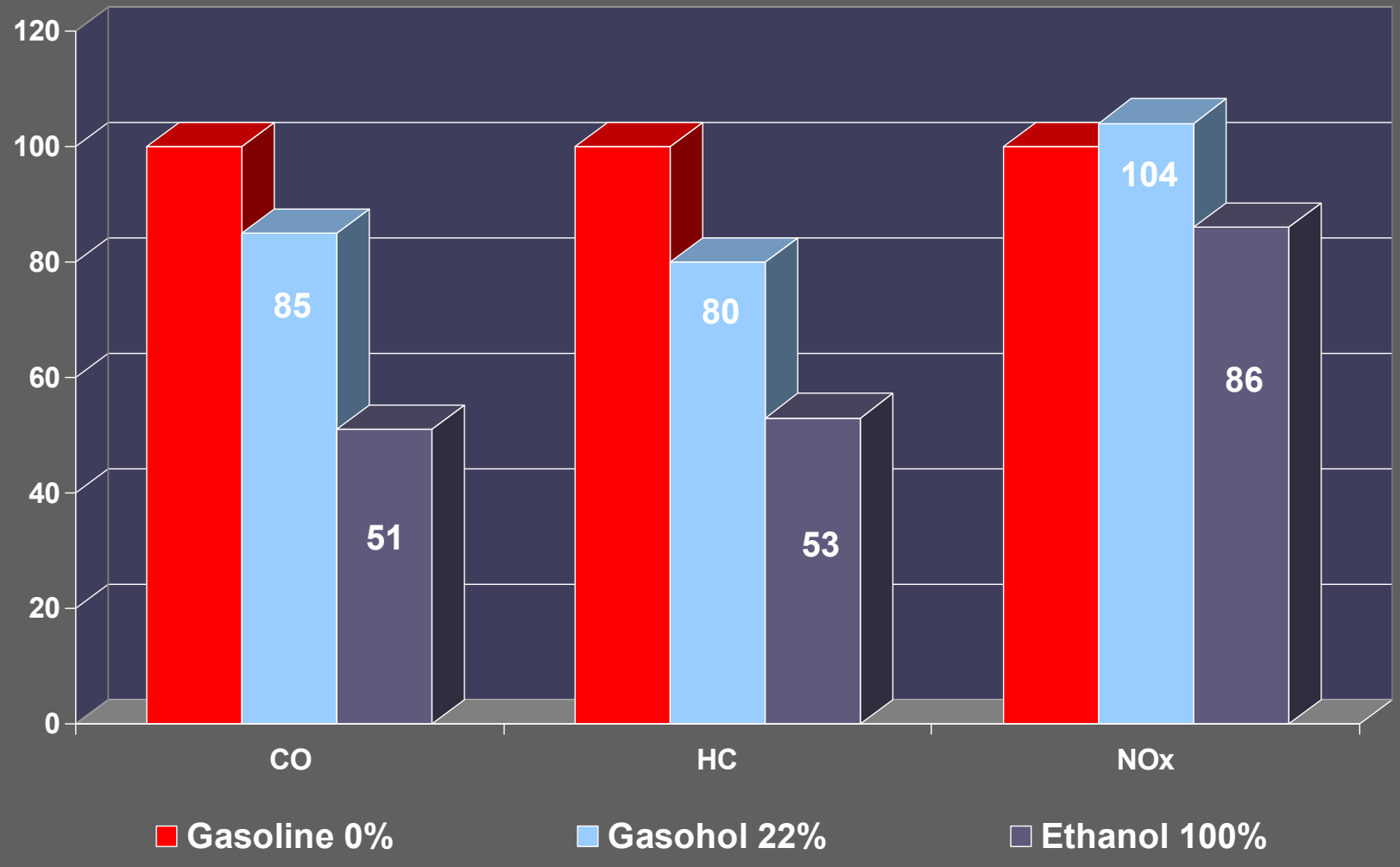
Considering that an ethanol driven vehicle consumes, on average, 2.600 litres of ethanol per year (one million litres of ethanol, per year, generates 38 direct jobs);for gasoline, spends 20% less fuel (one million litres of gasoline, per year, generates 0,6 direct jobs); "C" gasoline contains 25% ethanol.

Source: Copersucar/Unica/ANFAVEA/PETROBRAS

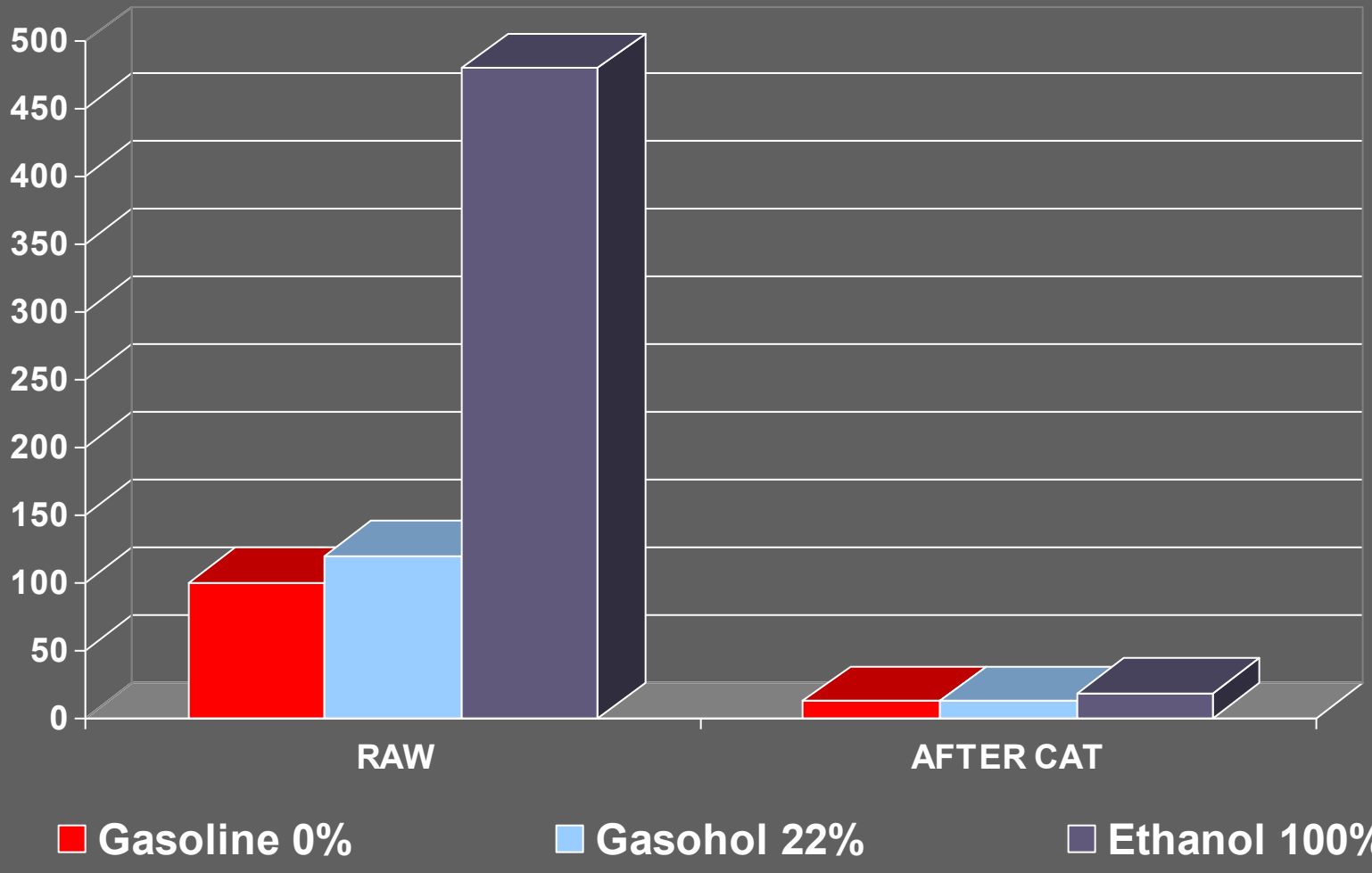
8. Relative Performance of Ethanol Engines



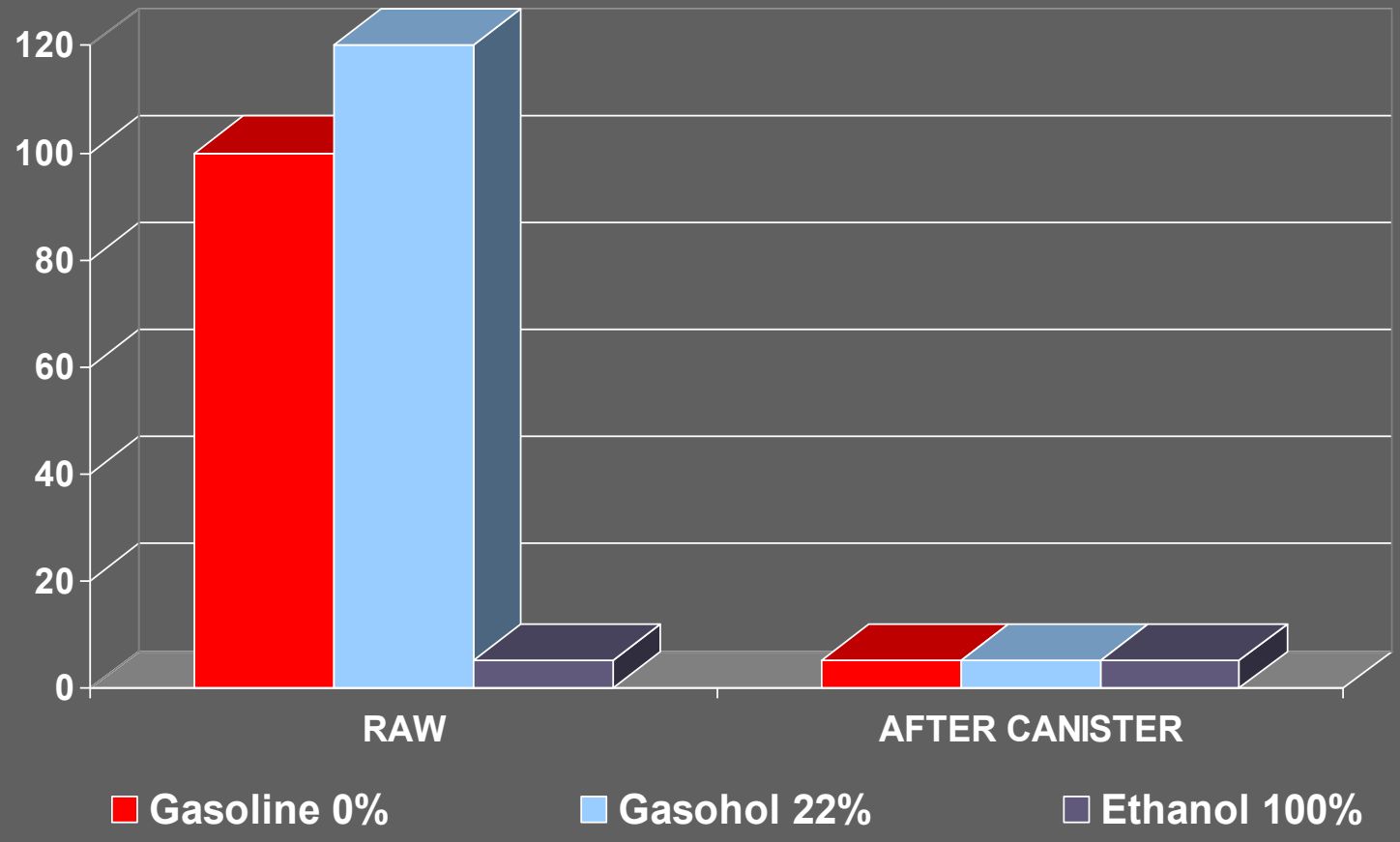
10. Comparative Raw Exhaust Emission

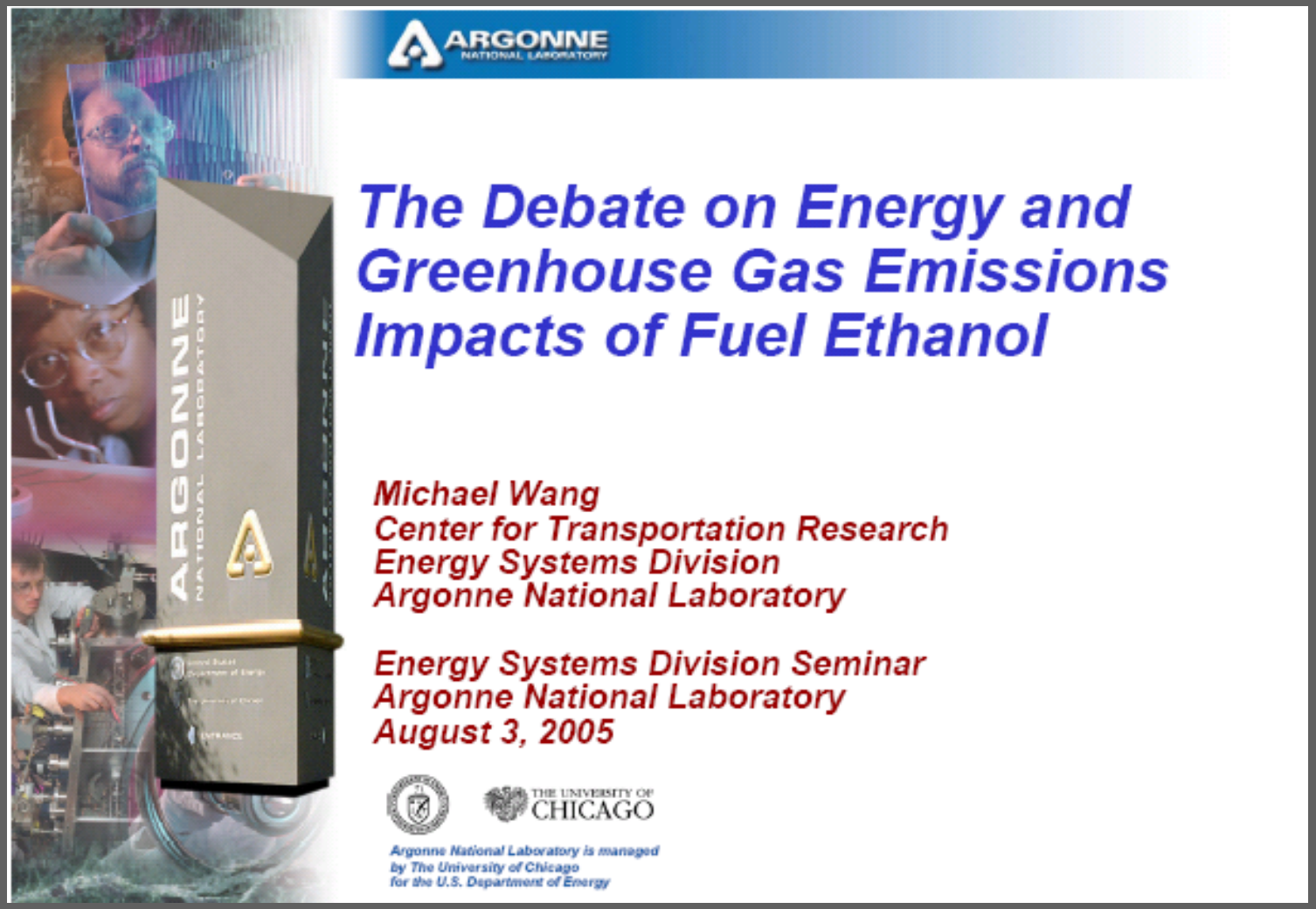


15. Comparative Aldehyde Emission



16. Comparative Evaporative Emission





http://www.transportation.anl.gov

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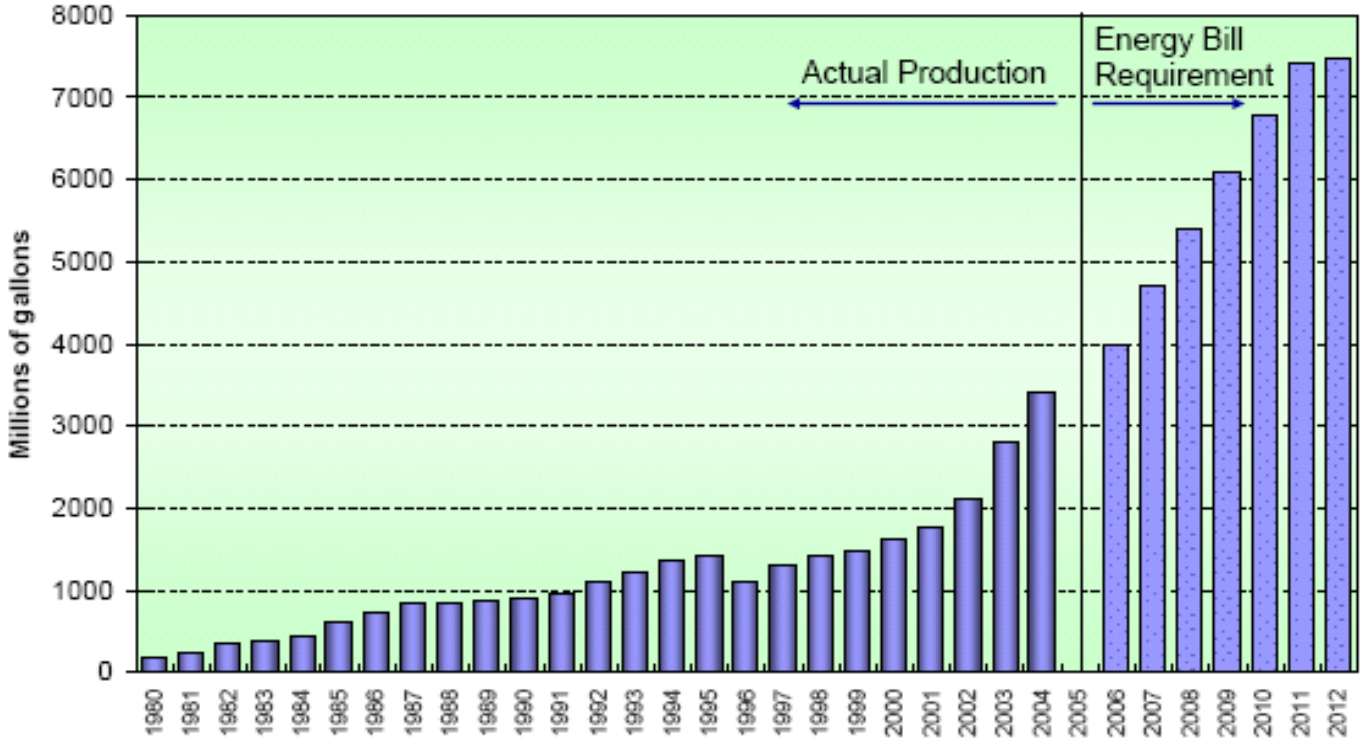
U.S. Fuel Ethanol Production Has Experienced Large Increases, and The Trend Will Continue



Source: Renewable Fuels Association

2

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Allocation Method for Animal Feed Is a Critical Factor in Determining Ethanol's Energy and Emission Results

Allocation Method	Wet milling	Dry milling
Weight	52%	51%
Energy content	43%	39%
Process energy	36%	41%
Market value	30%	24%
Displacement	~16%	~20%

- Weight and energy methods no longer used
- Process energy allocation values are from USDA 2004
- Some studies did not consider co-products at all

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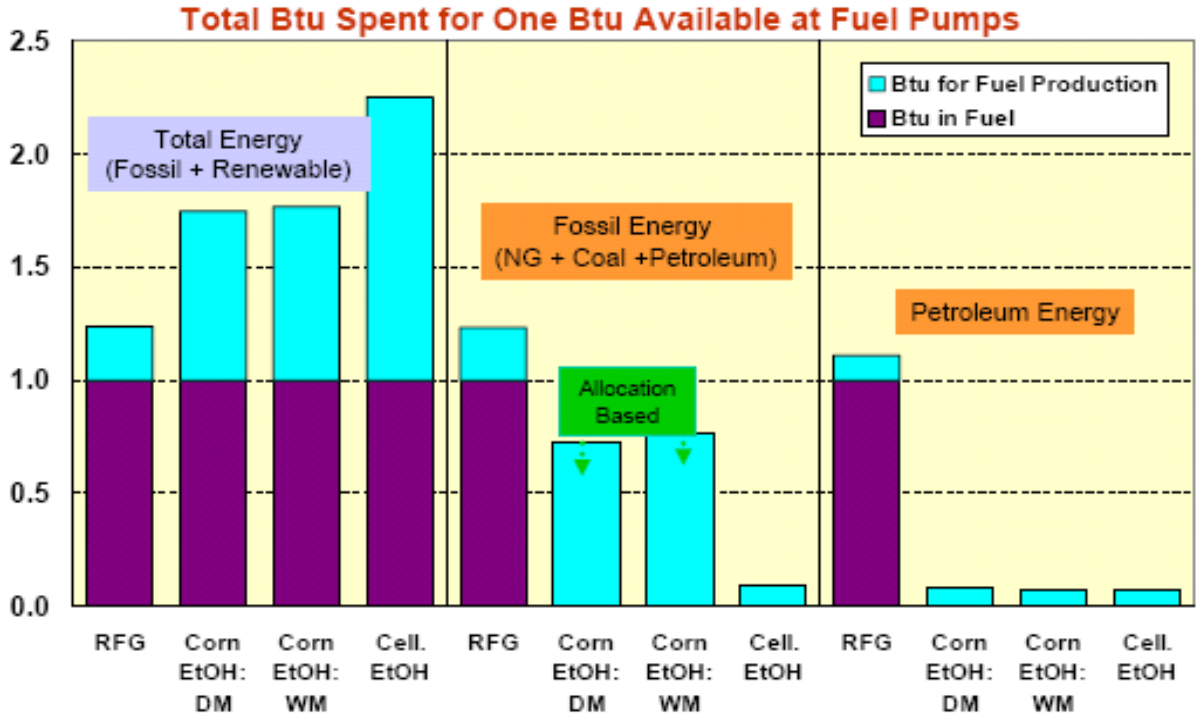
Energy Benefits of Fuel Ethanol Lie in Reductions in Fossil Energy and Petroleum Use



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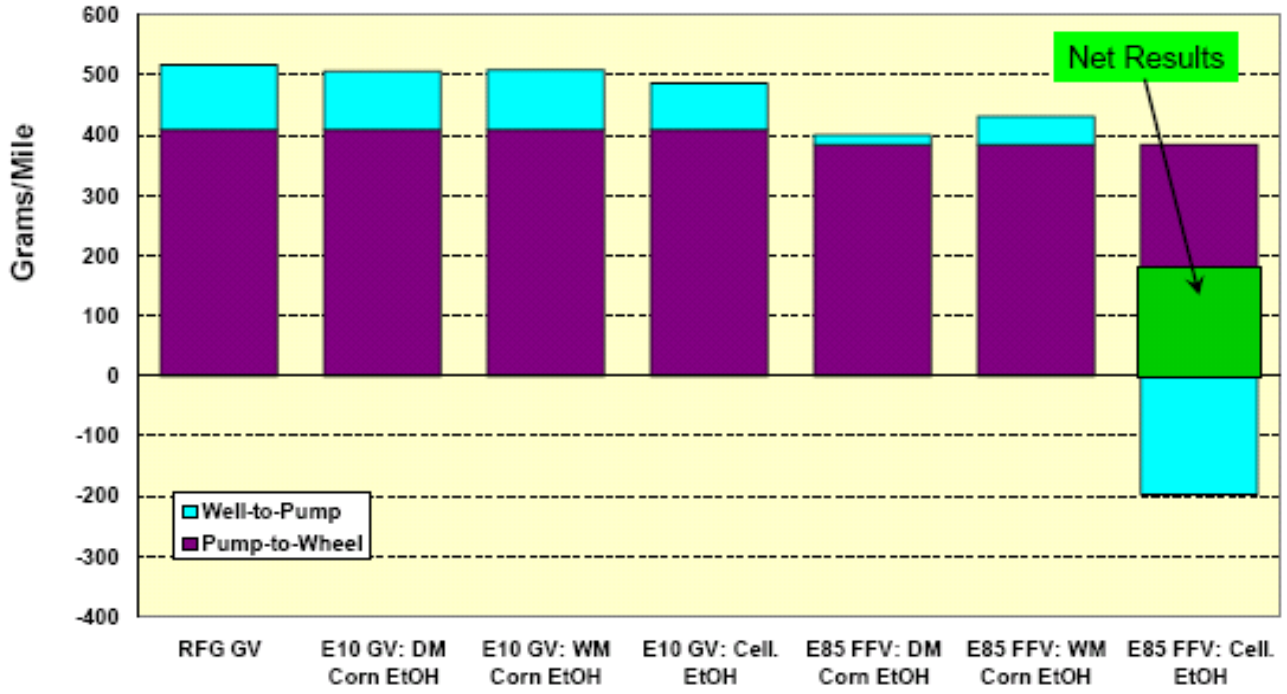
Per-Mile GHG Emission Results Show Larger Benefits of E85 Blend and Cellulosic Ethanol



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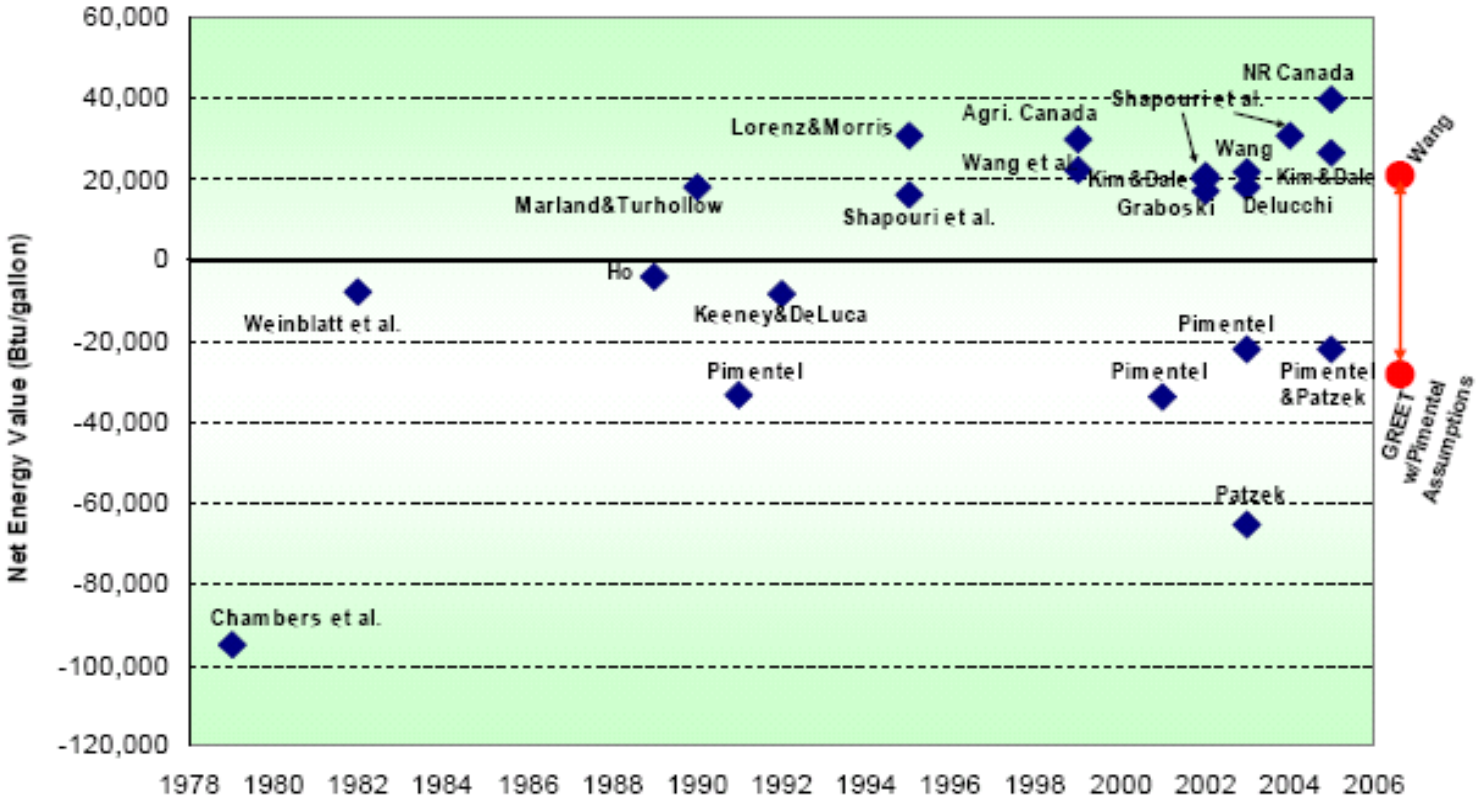
Most of the Recent Corn EtOH Studies Show a Positive Net Energy Balance



Energy balance here is defined as Btu content a gallon of ethanol minus fossil energy used to produce a gallon of ethanol

Characteristics of an Ideal Crop: Miscanthus

Characteristics of an ideal biomass energy crop present (+) in corn, short rotation coppice and *Miscanthus*, developed in part from Long (1994).

Crop characteristic	Corn	Short-rotation coppice	*Miscanthus*
C_4 photosynthesis	+		+
Long canopy duration		+	+
Perennial (no need for annual tillage or planting)		+	+
No known pests or diseases			+
Rapid growth in spring to out compete weeds		+	+
Sterile; prevent 'escape'			+
Stores carbon in soil (soil restoration and carbon sequestration tool)		+	+
Partitions nutrients back to roots in fall (low fertilizer requirement).			+
Low nutrient content i.e. < 200 mg MJ^{-1} nitrogen and sulphur (clean burning)		+	+
High water use efficiency	+		+
Dry down in field (zero drying costs)			+
Good winter standing (harvest when needed; zero storage costs)		+	+
Utilizes existing farm equipment	+		+
Alternative markets (high quality paper, building materials and fermentation)	+	+	+

Source :http://www.aces.uiuc.edu/DSI/MASGC.pdf

Economics of Miscanthus Farming

Annual and extended projected costs and profits for two cropping systems in Central Illinois over a 10 year period.

Costs ($ ha^{-1})	Corn/Soybean[1] rotation			*Miscanthus*[2] energy crop			
	Corn	*Soy*	**10 years**[3]	*1st year*	*2nd year*	*3rd–10th*	**10 years**
Fertilizer	131	47	**621**	62	60	23	**242**
Pesticides	77	79	**520**	15	0	0	**15**
Seed	84	47	**445**	316	0	0	**316**
Crop Drying	17	5	**77**	0	0	0	**0**
Machinery repair, fuel, hire	67	59	**423**	45	101	95	**635**
Labor	89	84	**580**	84	82	77	**562**
TOTAL VARIABLE COSTS	464	321	**2657**	521	242	195	**1770**
Machinery overhead, housing, depreciation, non-land interest	257	198	**1533**	22	58	54	**360**
Land	373	373	**2496**	373	362	341	**2496**
TOTAL OTHER COSTS	630	571	**4029**	395	420	396	**2856**
TOTAL ALL COSTS	1094	892	**6686**	916	662	591	**4626**
Yield (tons ha^{-1})	*10.5*	*3.5*					
Yield, (dry tons ha^{-1})				*0*	*17*	*35*	
Value ($ ton^{-1})	*98*	*195*		*40*	*39*	*38*	
GROSS REVENUE ($ ha^{-1})	1020	681	**5783**	0	663	1330	**7527**
NET PROFIT[4] ($ ha^{-1})	–74	–210	**–903**	–916	1	739	**2900**

[1] Corn and soybean costs and average yields for Central Illinois after (Hoeft et al. 2000) and prices based on Chicago Board of Trade Dec. 2002 futures.

[2] Miscanthus seed costs based on (Lewandowski et al. 2000) and harvest costs assuming cutting and baling as for corn silage. Machinery costs from University of Minnesota Extension and Illinois Farm Business Farm Management Association. A predicted yield of 35 t/ha for Central IL is assumed (Figure 1), and a price of $40/t. This compares to $44 /t proposed by (McLaughlin et al. 2002) for US biomass crops and an EU suggested price of $49 /t (Bullard 2001).

[3] Total values over 10 years, discounted annually at 3%.

[4] Farm gate price, excluding subsidies.

Source: http://www.aces.uiuc.edu/DSI/MASGC.pdf

Hydrogen vs. Ethanol Economics

- Raw Material Costs: cost per Giga Joule (gj)
  - Electricity @$0.04/kwh = $11.2/gj (Lower cost than natural gas)
  - Biomass @$40/ton = $2.3/gj (with 70% conversion efficiency)

- Hydrogen from electricity costly vs. Ethanol from Biomass
- Hydrogen from Natural Gas no better than Natural Gas
- Cost multiplier on hydrogen: distribution, delivery, storage
- Higher fuel cell efficiency compared to hybrids not enough!
- Hydrogen cars have fewer moving parts but more sensitive, less tested systems and capital cost disadvantage

Reference: The Future of the Hydrogen Economy (http://www.oilcrash.com/articles/h2_eco.htm#8.2)

Hydrogen vs. Ethanol

- Ethanol: US automakers balance sheets ill-equipped for hydrogen switchover
- Ethanol: No change in infrastructure in liquid fuels vs. gaseous fuels
- Ethanol: Current engine manufacturing/maintenance infrastructure
- Ethanol: switchover requires little capital
- Ethanol: Agricultural Subsidies are leveraged for social good
- Ethanol: Faster switchover- 3-5 years vs 15-25yrs
- Ethanol: Low technology risk
- Ethanol: Incremental introduction of new fuel
- Ethanol: Early carbon emission reductions

Three of Ten Important Sources

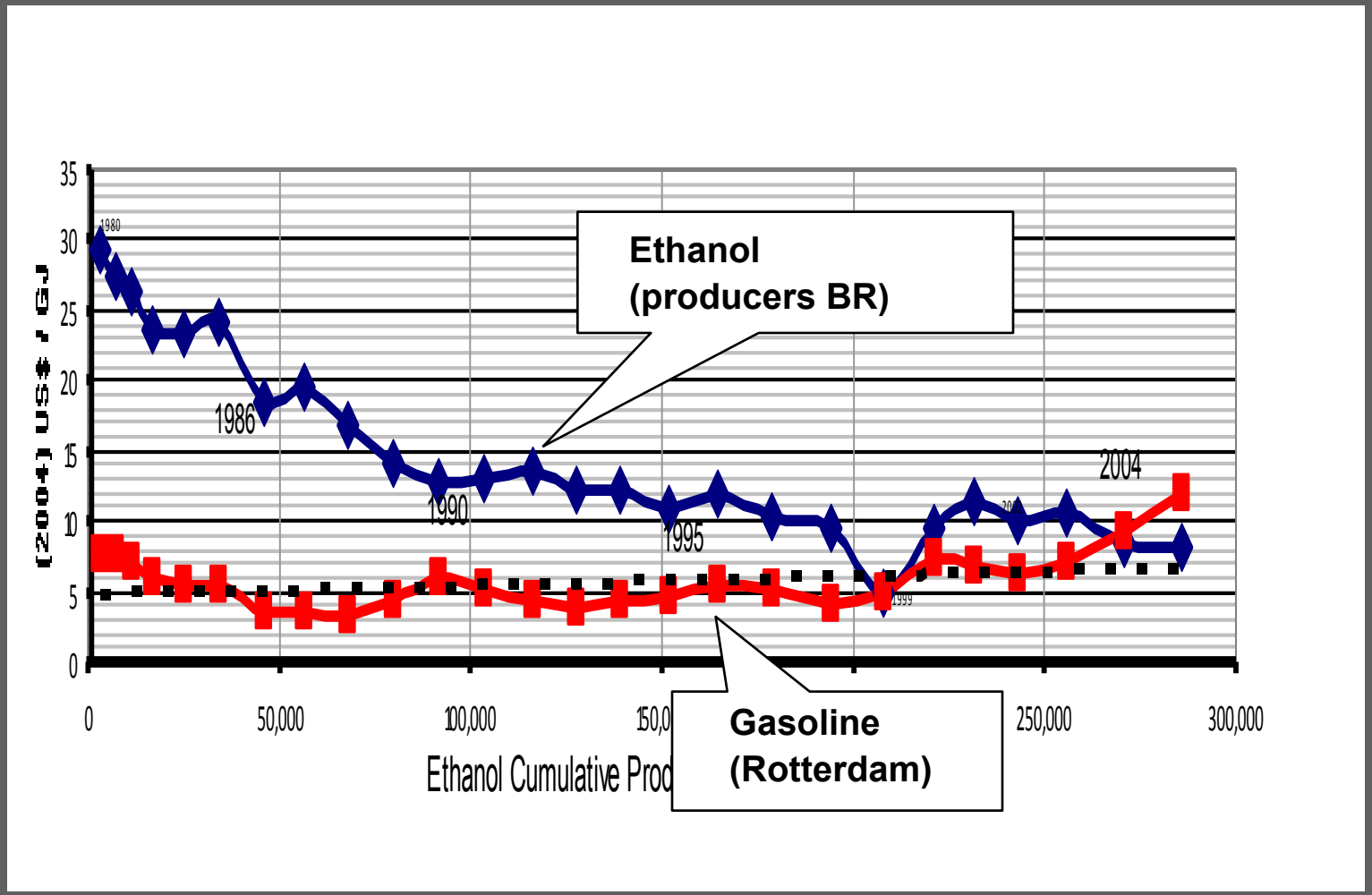
- Production of corn stover and stalks from other grains (wheats, oats) totals well over 250 million dry tons. A combination of different crop rotations and agricultural practices (e.g. reduced tillage) would appear to have potential for a large fraction of these residues to be removed. For example, although complete removal of corn stover would result in a loss of about 0.26 tons of soil carbon per year, cultivation of perennial crops (e.g. switchgrass, Miscanthus) adds soil carbon at a substantially higher rate. Thus, a rotation of switchgrass and corn might maintain or even increase soil fertility even with 100% stover removal. This, however, brings up questions about the length of time land might be grown in each crop, since switchgrass would benefit from longer times to distribute the cost of establishment while corn would benefit from short times to maintain productivity and decrease losses due to pests. It is likely that some crop other than switchgrass as it exists today would be best for incorporation into a relatively high frequency rotation with corn. Targets for crop development could be identified and their feasibility evaluated.

- Winter cover crops grown on 150 million acres (½ tons/acre) = 300 million tons of cellulosic biomass

- In recent years, U.S. soybean production has averaged about 1.2 tons of dry beans per acre annually. Given an average bean protein mass fraction of about 0.4, the annual protein productivity of soybean production is about 0.5 tons protein per acre. Perennial grass (e.g. switchgrass) could likely achieve comparable protein productivity on land used to grow soybeans while producing lignocellulosic biomass at about a rate of about 7 dry tons per acre annually. The limited data available suggest that the quality of switchgrass protein is comparable to soy protein, and technology for protein extraction from leafy plants is rather well-established. The 74 million acres currently planted in soybeans in the U.S. could, in principle, produce the same amount of feed protein we obtain from this land now while also producing over 520 million tons of lignocellulosic biomass. Alternatively, if new soy varieties were developed with increased above-ground biomass (option 4, Table 1), this could provide on the order of 350 million tons of lignocellulosic biomass – although soil carbon implications would have to be addressed.

Source: Lee R. Lynd, "Producing Cellulosic Bioenergy Feedstocks from Currently Managed Lands,"

Ethanol: LEARNING CURVE

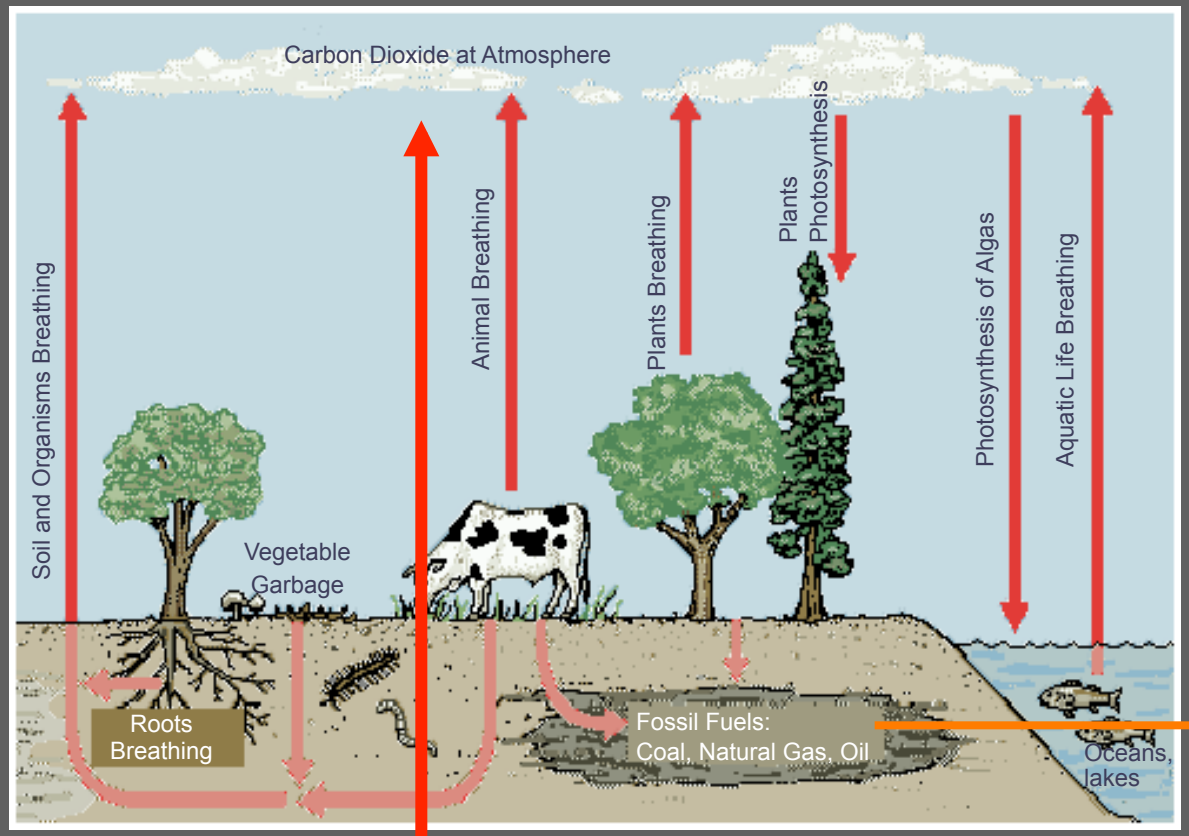


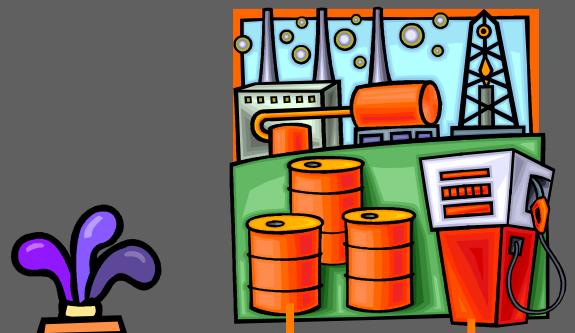
(J Goldemberg, 2004)

Tutorial

- http://www.eere.energy.gov/biomass/understanding_biomass.html

11. The Fossil Fuels





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Comparative Results Between Ethanol and Gasoline Are More Relevant to Policy Debate