Dr. William F. Banholzer
Executive VP and CTO
The Dow Chemical Company

The Future of Fuels and Alternative Feedstocks – Recognizing Hype vs. Practical Limitations

Engineering

Too much hype for the possible and not enough focus on the practical

Chemical Engineering is letting society down!

Business vs. Academic Success

Challenges to Society

Invention

Academic Success

Impact to Society

What people want ≠ What they will pay for ≠ What they can afford

What they will pay for impacts society

Business Success

Risk vs. Reward

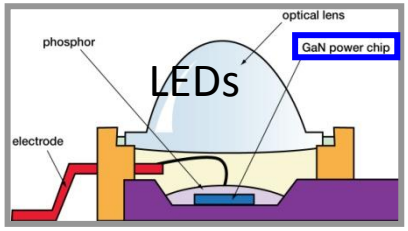
Economic Viability

Business Success vs. SCIENCE

Impact to Society = Business Success

High

Low



Ethylene Styrene Interpolymers

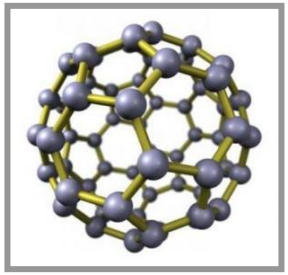
H_2 fuel cells

Electrochaea

SkyMine®

CALERA

Green Cement for a Blue Planet

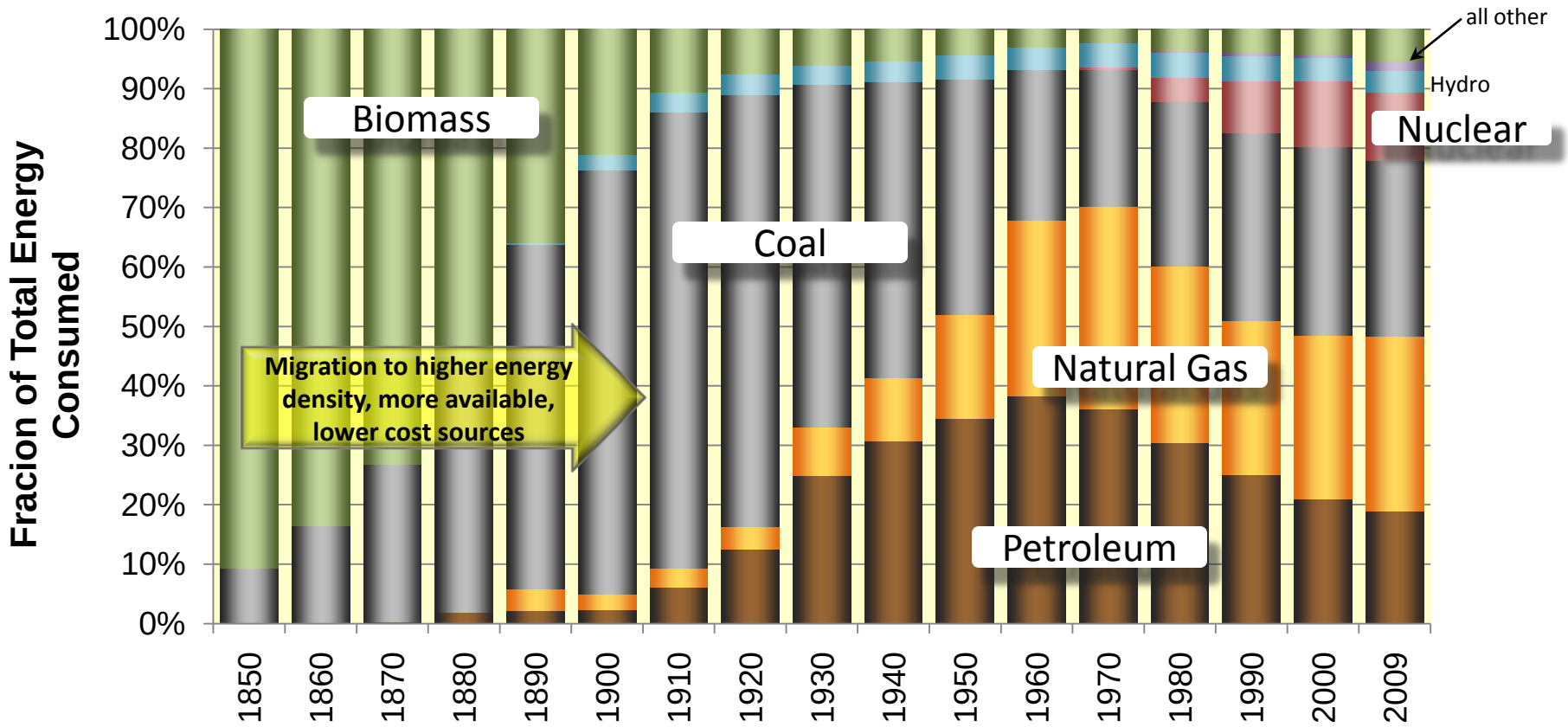


Low

Quality of Science

High

Energy Sources Have Changed



What's Changed?

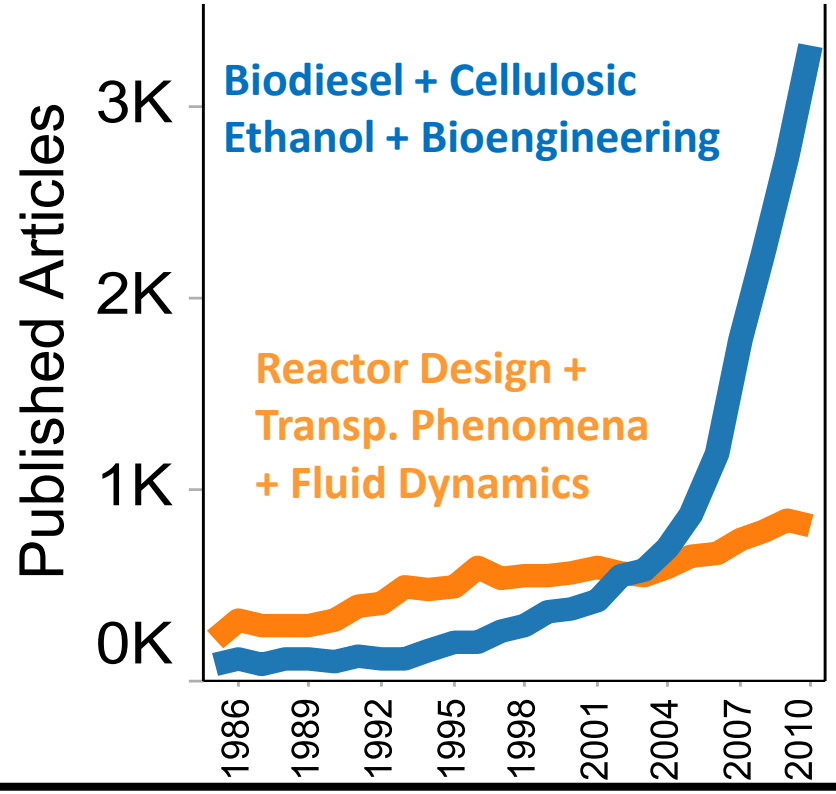
- Oil Price Rise
- CO2 awareness

Is that enough?

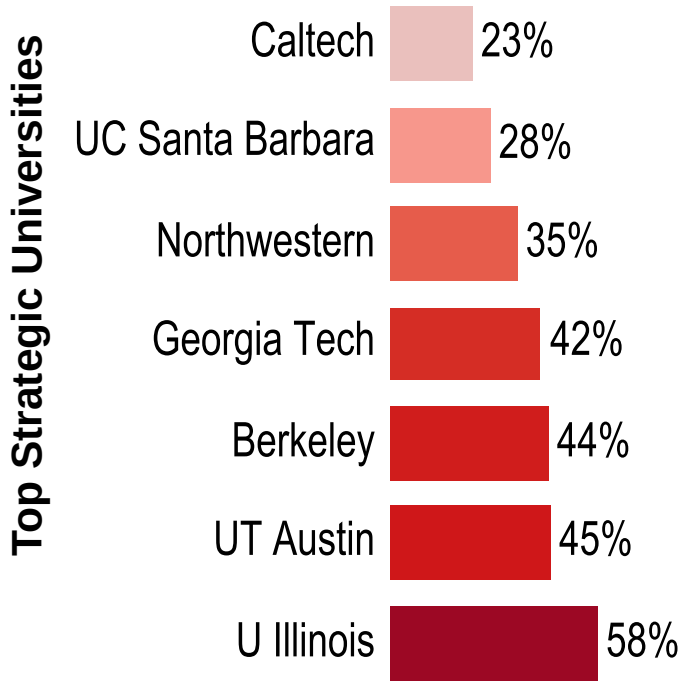
Source: IEA. EIA; US Primary Energy

Funding Follows the Hype

Published Articles Reflect the Focus on “Bio” Related Research:



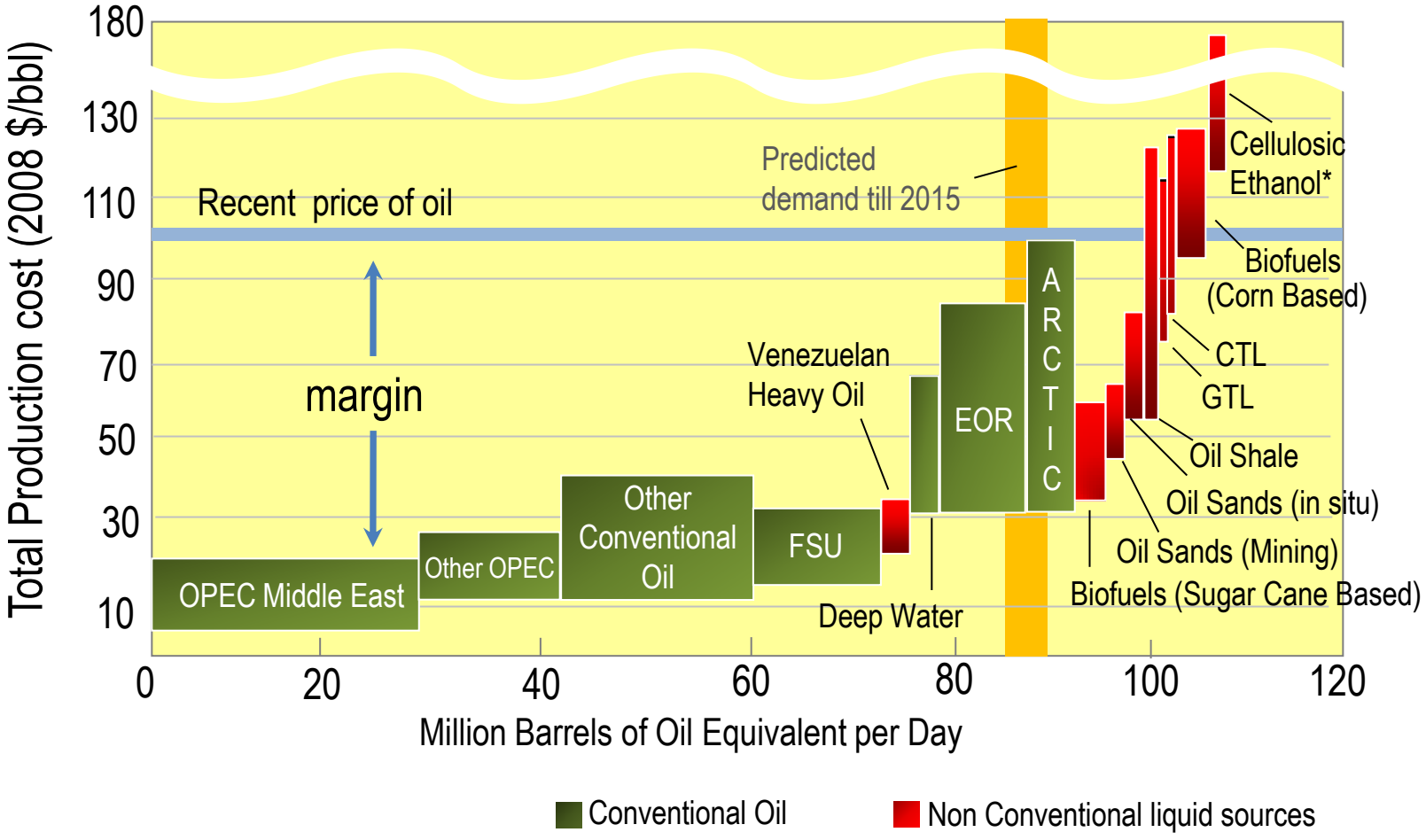
Percentage of Faculty with “Bio” Related Research Interests:



Dynamic range of the discipline is threatened by decreasing support of the traditional core research areas.

Energy Industry Dynamics

As oil price rises, new capital will flow to EOR, Arctic, Oil sands, GTL, CTL before biofuels.



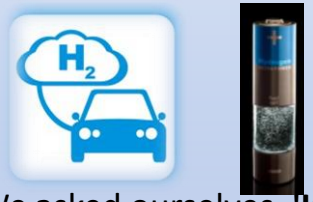
Source: IEA, EIA, Booz Allen Hamilton, DOE Biomass Multiyear Program Plan April 2011, Dow Analysis

*Based on DOE volume projections for US in 2022. DOE price target is ~$113/bbl

Recognizing Fads

The art of being wise is the art of knowing what to overlook - William James

Hydrogen Car



"We asked ourselves, '**Is it likely in the next 10 or 15, 20 years that we will convert to a hydrogen car economy?**' The answer, we felt, was 'no,'"
Steve Chu, Energy Secretary, May 2009

Corn Ethanol

"...Using land to grow fuel leads to the destruction of forests, wetlands and grasslands that store enormous amounts of carbon."

Michael Grunwald, TIME
April 2007

Biodiesel

"Biofuels are contributing to higher prices and tighter markets."
Timothy Searchinger, Princeton University
April 2011

Cellulosic Ethanol

"...the need for trucks, machinery and manpower would come during harvest, already the busiest time of the year on the farm. And that's where **a massive federal initiative into cellulosic ethanol may find its biggest bottleneck – on the farm."**
Robert Rapier

Bio Plastics

Dow launched the JV with Cargill in 1997 to develop and market PLA from corn, exited the JV in 2004.

THE WALL STREET JOURNAL.

"Sun Chips Bag to Lose Its Crunch"

Photo: Associated Press

Bio based packaging launched in 2009 but discontinued by late 2010, due to performance perception issues

Glycerin to Epi

Dow postponed in 2009 due to uncertain supply +

Natural oil Polyols

RENUVA

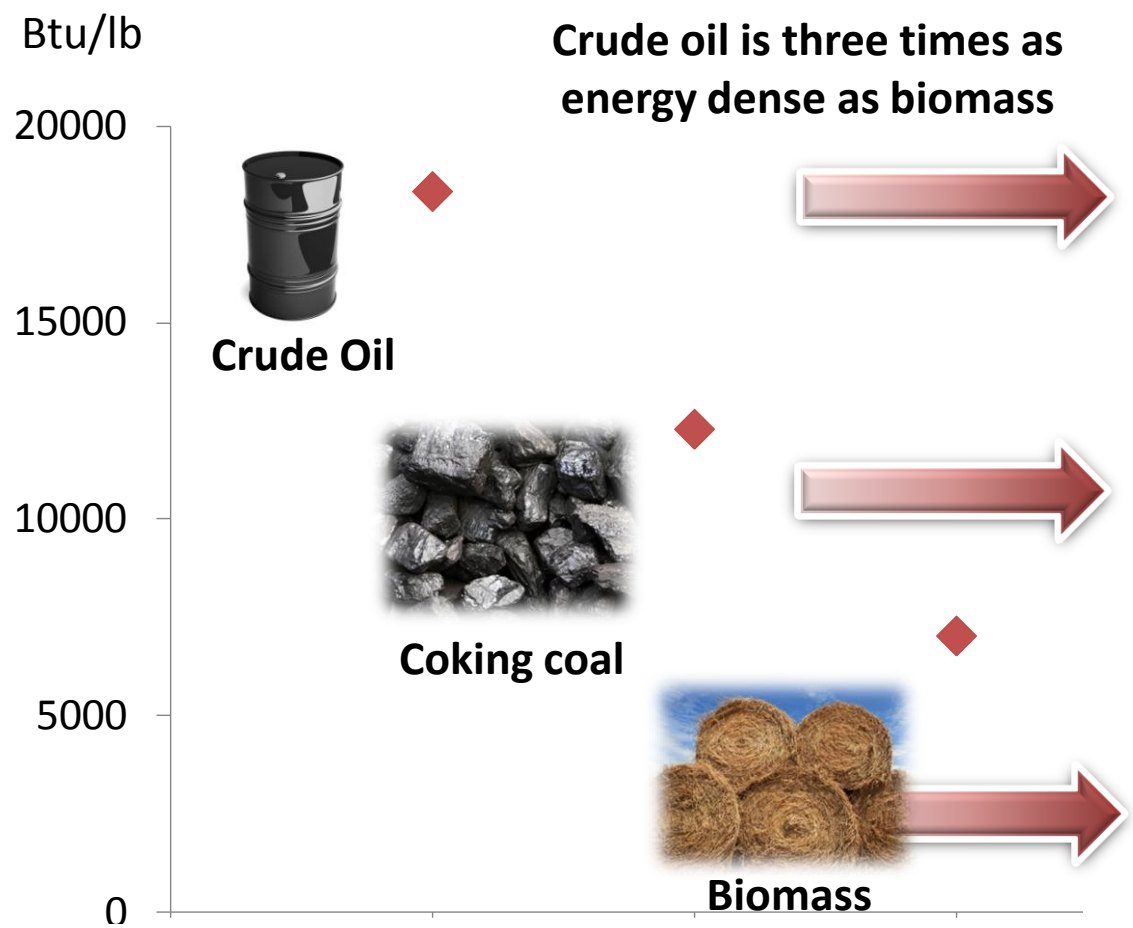
Dow Launched in 2007, exited in 2010.

Biofuels Key Issues

- **How much** ***biomass is available?***
  not enough to replace fossil fuels
- **How much** ***will the biomass cost?***
  it is not cheap!
- **How much** ***will biofuels cost?*** ***more than fossil***
- **How much** ***more are we willing to pay?*** ***no premium***
- **How realistic** ***is chemical production from biomass?***
  we already do, but chemical use doesn't address the big issues

NRC, "Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy", 4 October 2011.

Migration to Higher Energy Density Sources



Energy Equivalency	$ Capital / Usable MM Btu
1 Oil Refinery	$164
27 Power Plants	$167
60 Ethanol Refineries	$321*

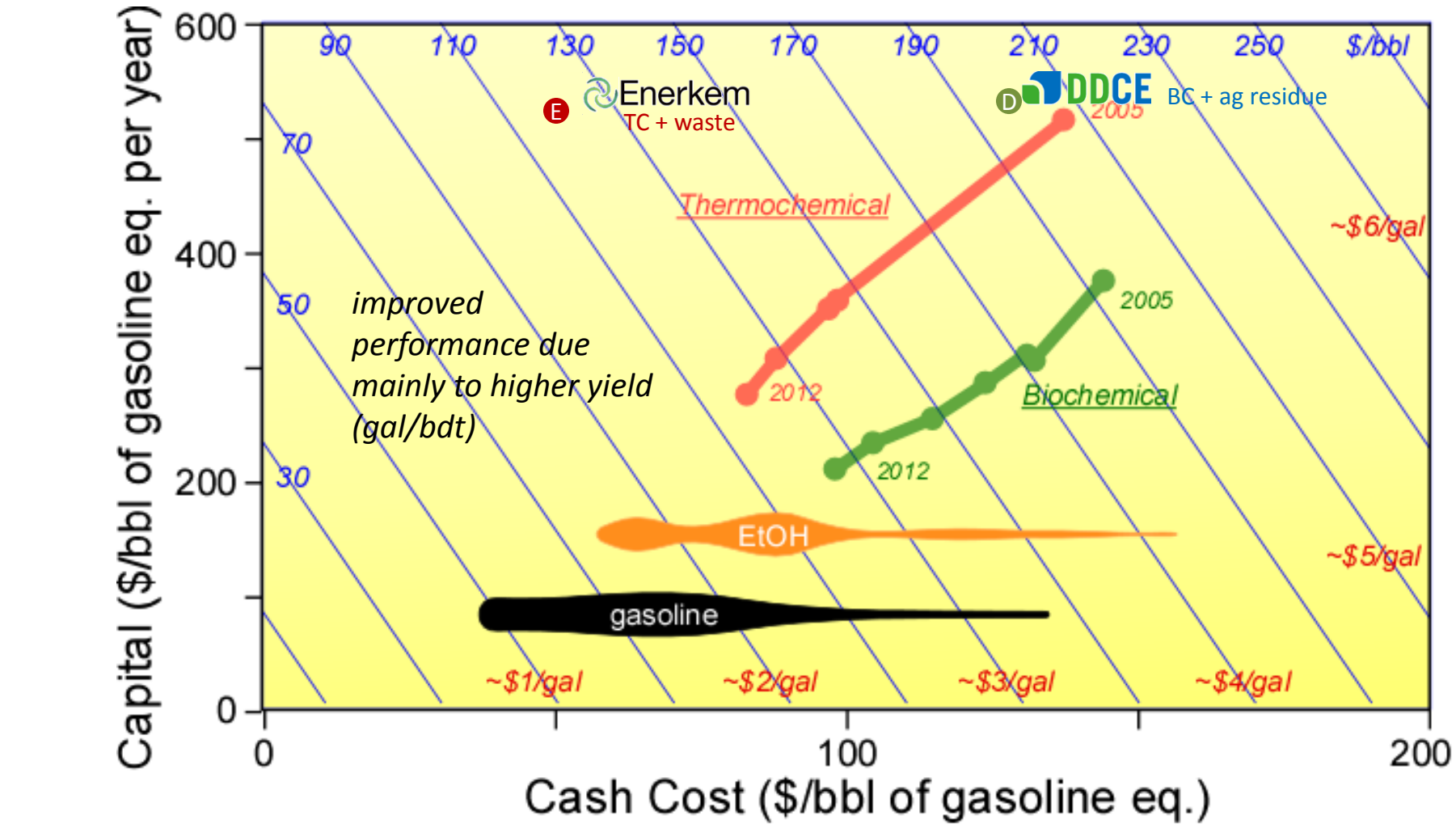
*land & water penalty not included

Energy from fossil infrastructure built over 80-100 years defines our current standard of living

Sources: Heating values from GREET, Argonne National Lab, May 2008; Refinery size and economics by Oil & Gas Journal construction update, Dec 2010; Coal fired plant economics and size from Congressional Research Service report 2008; Ethanol plant of 100 MM gal/yr from DOE targets and economics estimated internally

The Cellulosic Fad

High cash and capital costs



Sources:
Crude Oil price, CMAI, Spot Average FOB price; monthly average prices from Jan 2005 to Jan 2011
Targets from DOE for Biochemical and Thermochemical routes; Capital from Biomass Multi Year Program 201 report from DOE (revisited by DOE on Nov 2010)
Corn Ethanol from the Center of Agricultural and Rural Development from Jan 2005 to Jan 2011

Scale of Fuels Makes it Harder

Original Inv.

facebook — $41MM → Largest Social Community on Internet

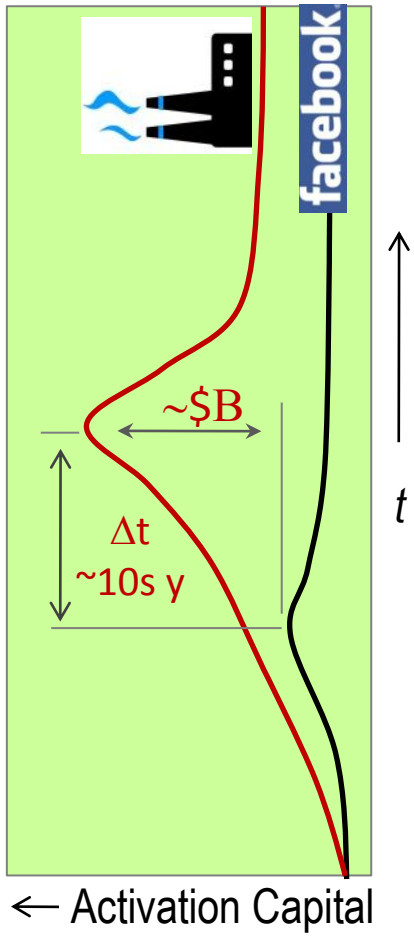
Capital for Single Plant

Nuclear Power Plant (1350MW) — $4,971MM → 0.05% of Global Electricity Generation; Revenue $1051MM/y

Pulverized Coal: CC (600MW) — $2,372MM → 0.02% of Global Electricity Generation; Revenue $441MM/y

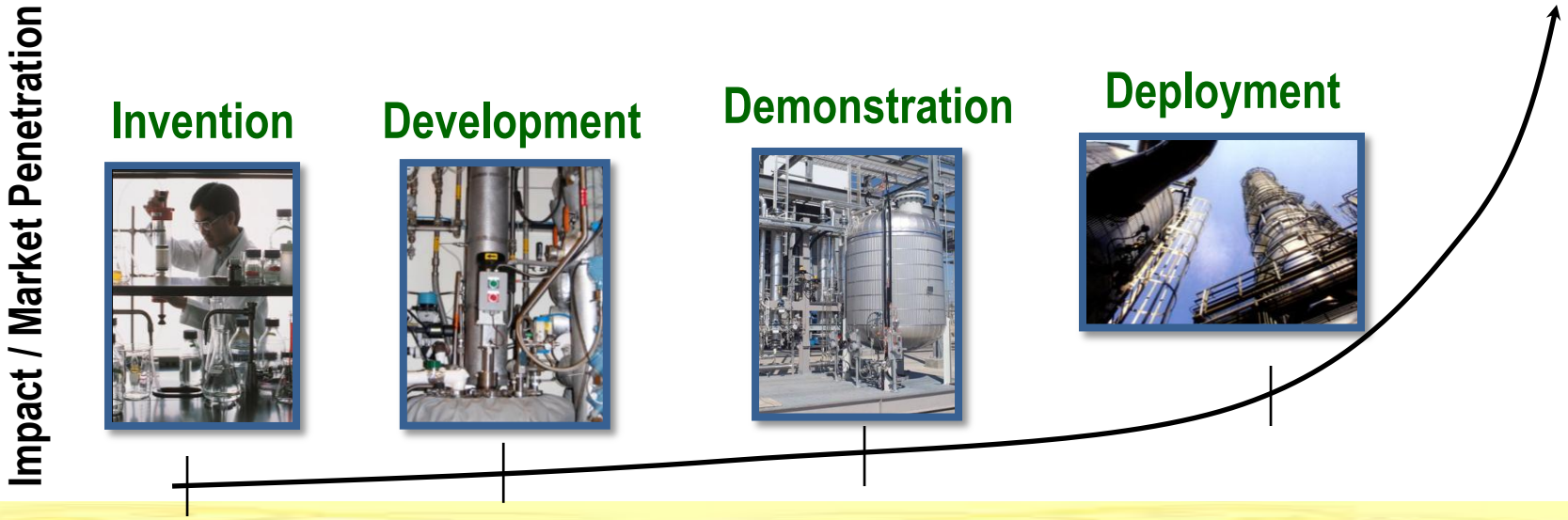
EG (400 KT/Yr) — $326MM → 2% of Global MEG Consumption

MTO (277 kiloton/Yr — $321MM → 0.3% of Global Ethylene consumption



Sources: facebook original investment showing combined amounts from Peter Thiel (PayPal cofounder), Accel Partners and Greylock Partners as described in the History of facebook on wikipedia; Power Plants: RL34746 report - Stan Kaplan - Congressional Research Service; MTO: PEP Report 261 – SRI and EG: PEP Repor 2I – SRI; **Revenues** for Power Plants calculated using 2010 electricity average retail prices (all sectors) 9.88 cents/kWh (data from DOE)

Timeline for Impact



Single Site Catalysis

	Invention	Development	Demonstration	Deployment
$		~$10s MM	~$50 MM	~$150 MM*
t	1957, 80	1980-90	1989	1991

Σ ~12 yrs

Super Critical Coal Power

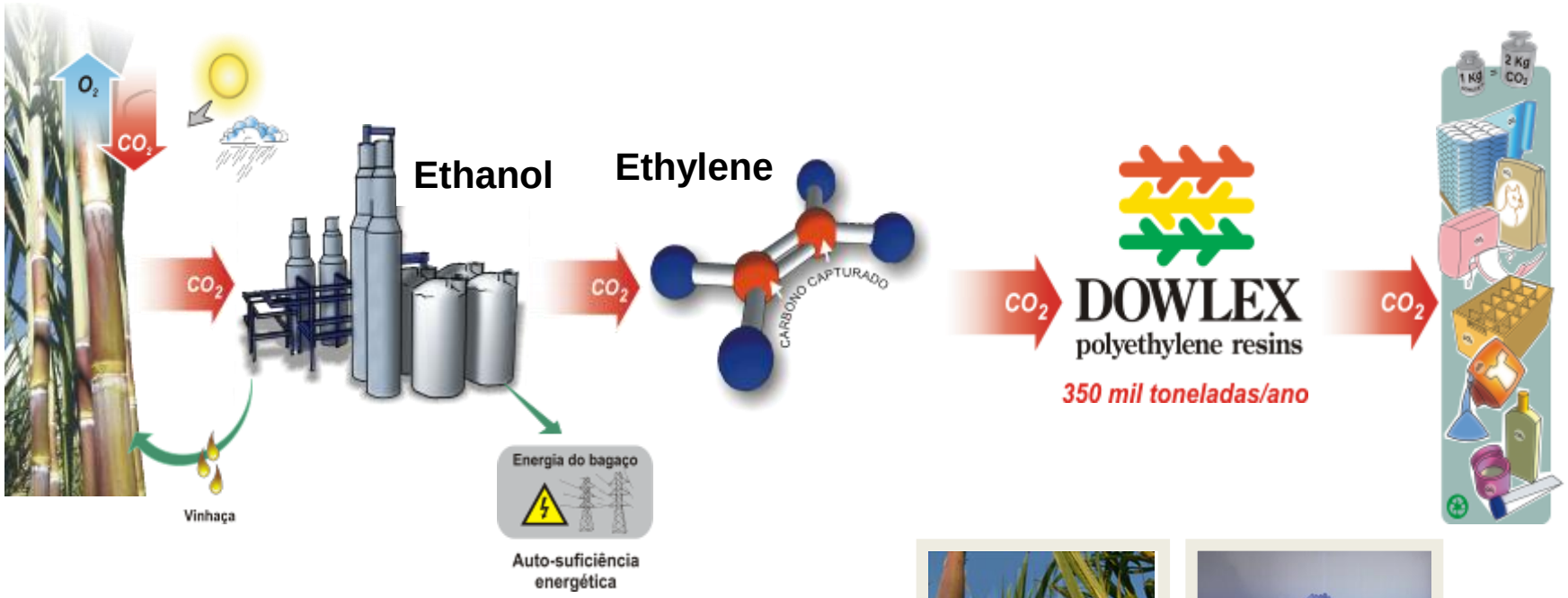
$		~$100s MM	~$500+ MM	~$2 B**
t	1920	1930 -50s	1957	1970s

Σ ~50 yrs

Sources: SRI PEP LLDPE 36E 2008, SRI PEP 153B 2001 Single site catalysts for PE Production, AEP Power Co, World Bank, EIA 2011 Energy Outlook, Electricity Market Module

*400 mT LLDPE plant, 2008$ **600 MW plant, 2009$

Alternative Feedstock - Cane to LLDPE



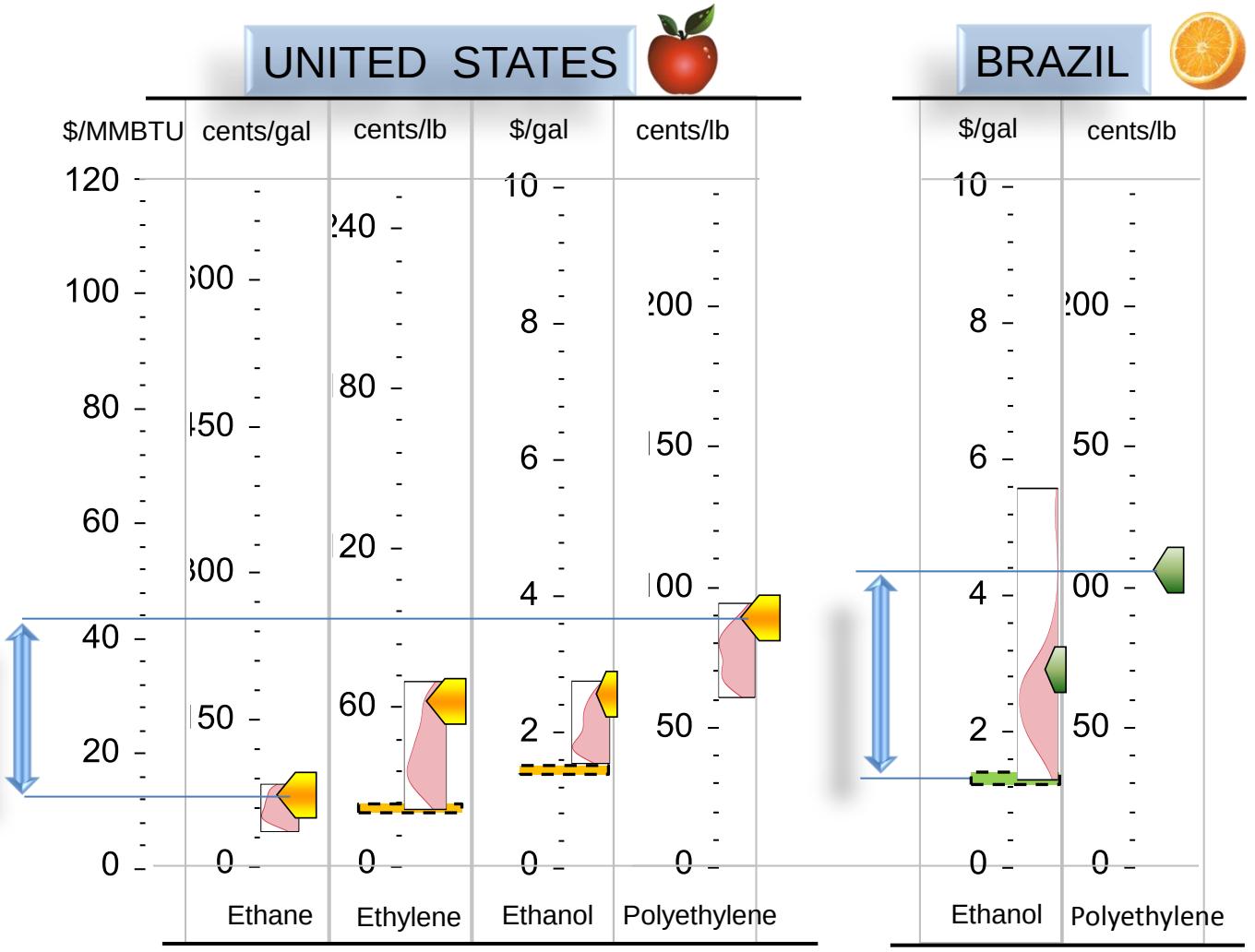
Fully-integrated facility in Brazil
Utilizes state-of-the-art Dow polymerization catalysis

Ethanol to PE – A Niche Opportunity

Market prices and selected costs on energy equivalent basis

- Existing logistics for ethanol in Brazil
- High polyethylene price in Brazil
- Ethanol price fluctuation requires integration

Area required for produce ethanol to meet global PE production ~ 1x of Minnesota at Brazil cane productivity



Costs*

USA Brazil

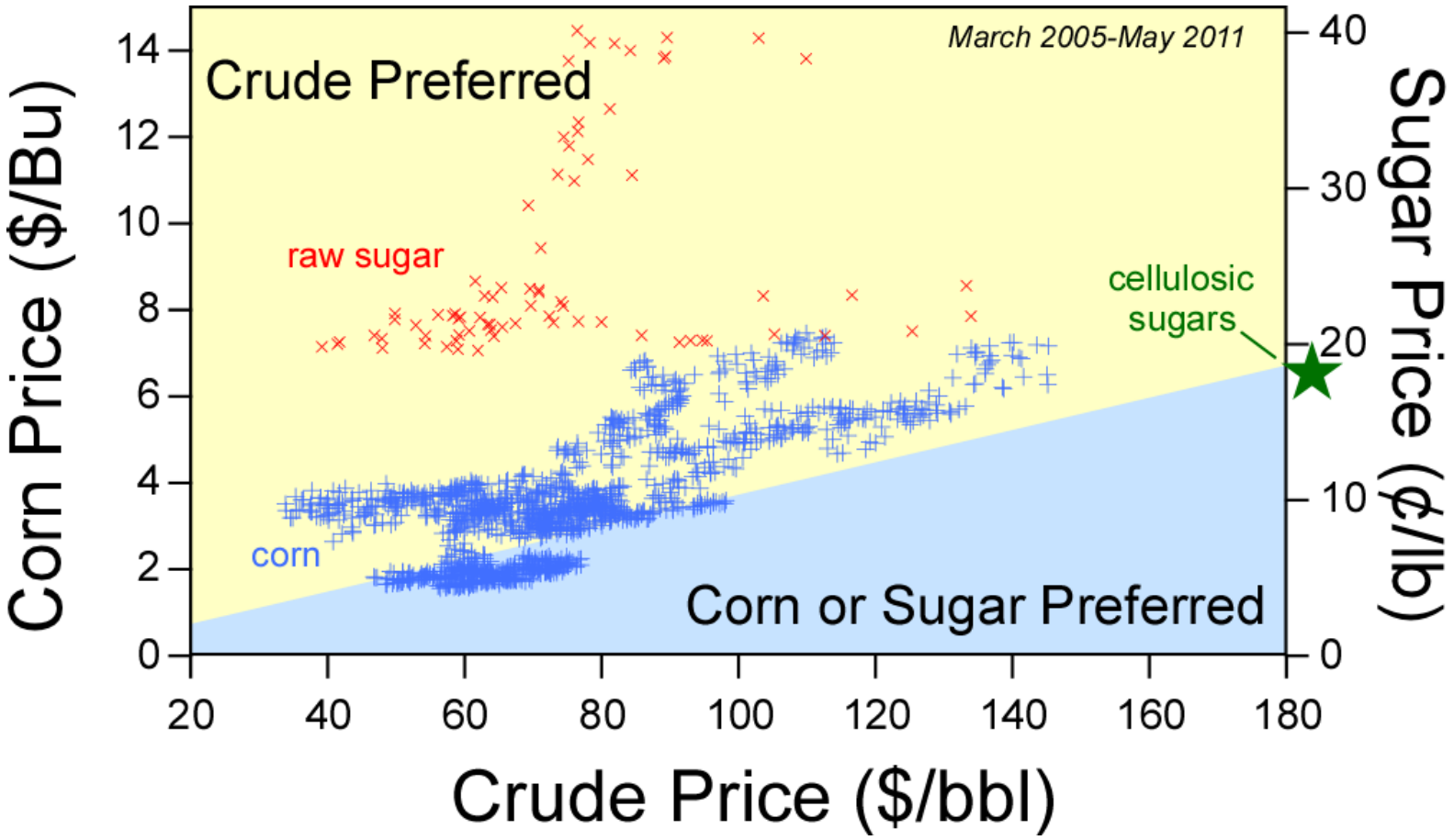
Market Prices

USA Brazil

Sources: Ethane, ethylene, polyethylene (US): **CMAI;** Ethanol US: **ICIS**, Ethanol Br: **ESALQ;** PE Brazil calculated based on market price differential Br to US. Price Densities shown for June 2009 to June 2011; Prices shown from June 2011. *Costs: 2009 US cash cost Ethylene CMAI, US EtOH cost to blender: SRI 2011; Br EtOH: Data Agro 2009 and Estado de S. Paulo 2007 adjusted to 2011 exchange rate

Bio Commodities Too Expensive

Cash cost *indifference analysis for ethylene from crude oil and bio feedstocks*



***Excludes Capital**

What are we doing?

R&D goal is to extract more earnings per dollar of investment

Dow chooses to operate where materials science expertise drives success

Energy Storage

Superior Materials:
Cathode
Anode
Electrolytes
Separator

Energy Efficiency

Superior Materials:
Energy efficiency improvements for commercial and industrial products

Energy Generation

Superior Materials:
Efficiency
Yield
Performance
Durability

Final Thoughts

- Too much hype for the possible and not enough focus on the practical
  - Incumbent fossil sources set the standard for competition
  - It takes decades to deploy a new technology
  - Scale wins and biomass availability limits biofuels scale
- Small companies access to capital makes success challenging
- Fundamental engineering judgment is crucial to long term innovation
- Can society afford to pay for a different solution?

Facts are the air of scientists. Without them you can never fly.

- Linus Pauling

Dow Supports Chemical Engineering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OCTOBER 10, 2011 | VOLUME 89, NUMBER 41 | P. 9
Dow Invests In Education
Research: Firm will spend $250 million on chemistry programs at U.S.
Marc Reisch
MASS SPECTROMETRY
Dow Chemical
Dow expects its own scientists will benefit from university research.
Dow Chemical says it will spend $250 million over the next 10 years to support breakthrough chemical technologies at
will help significantly increase the number of che
engineering Ph.D.s at the schools.
Announcing the program at an Oct. 4 investor da
Andrew N. Liveris said it will help relieve a short
attracted to careers in science, technology, engin

FUNDED UNIVERSITIES

- California Institute of Technology
- Carnegie Mellon University
- Georgia Institute of Technology
- Northwestern University
- Pennsylvania State University
- University of California, Berkeley
- UC Santa Barbara
- University of Illinois, Urbana-Champaign
- University of Michigan
- University of Minnesota
- University of Wisconsin

- $250 million total program
- foster better balance
- 10 year program
- 11 major universities
- areas
  - catalysis
  - process development
  - new materials
    - electronics
    - energy
    - transportation
    - consumer applications

Thank You