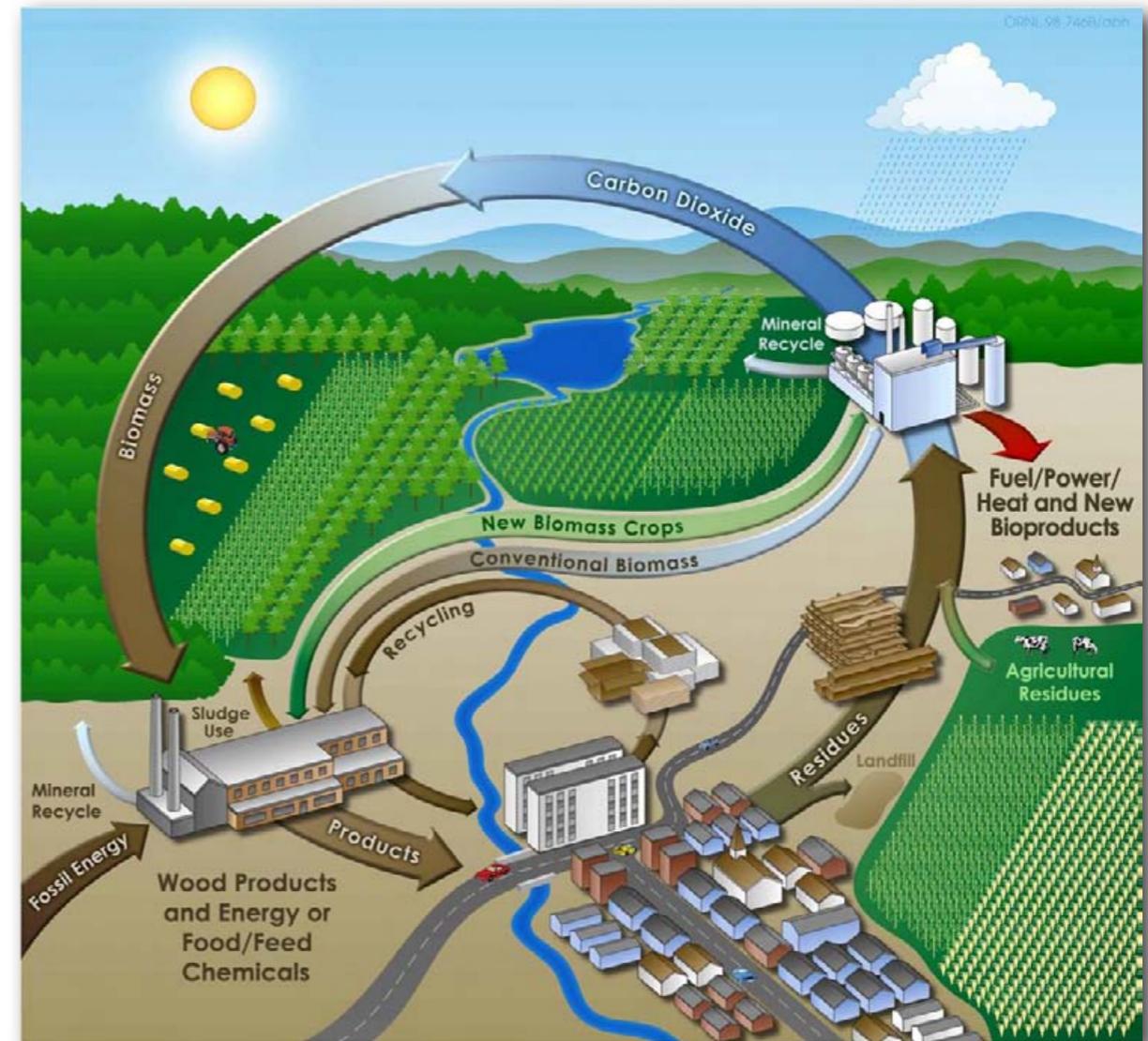


# Biofuels Emerging Technology and Economics

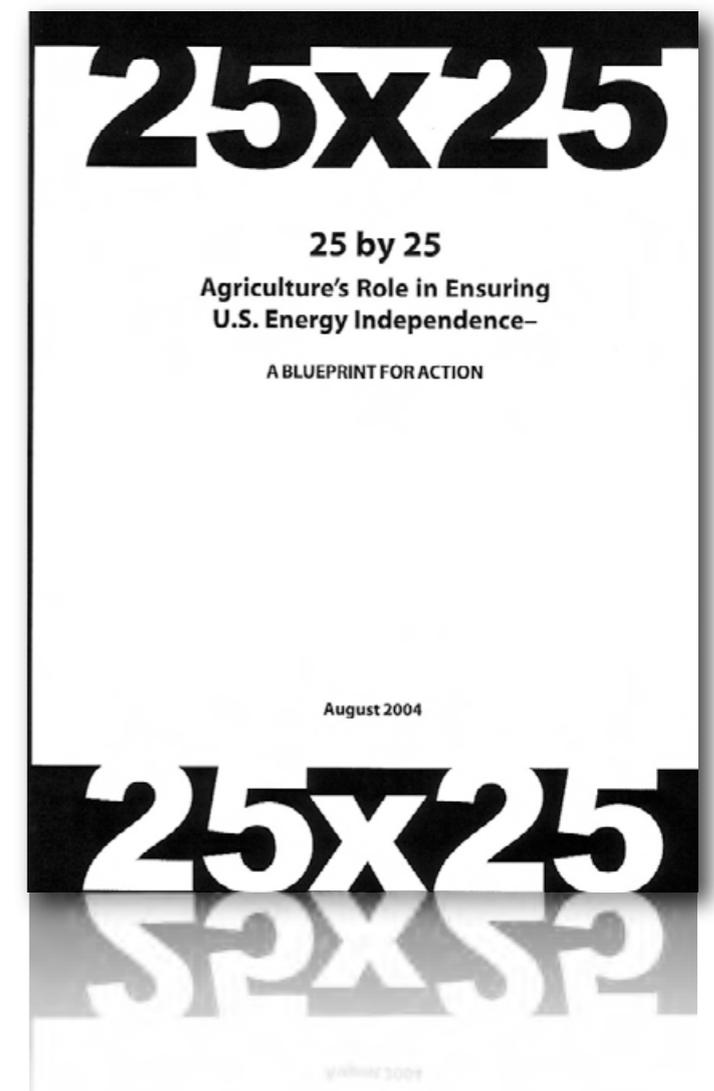
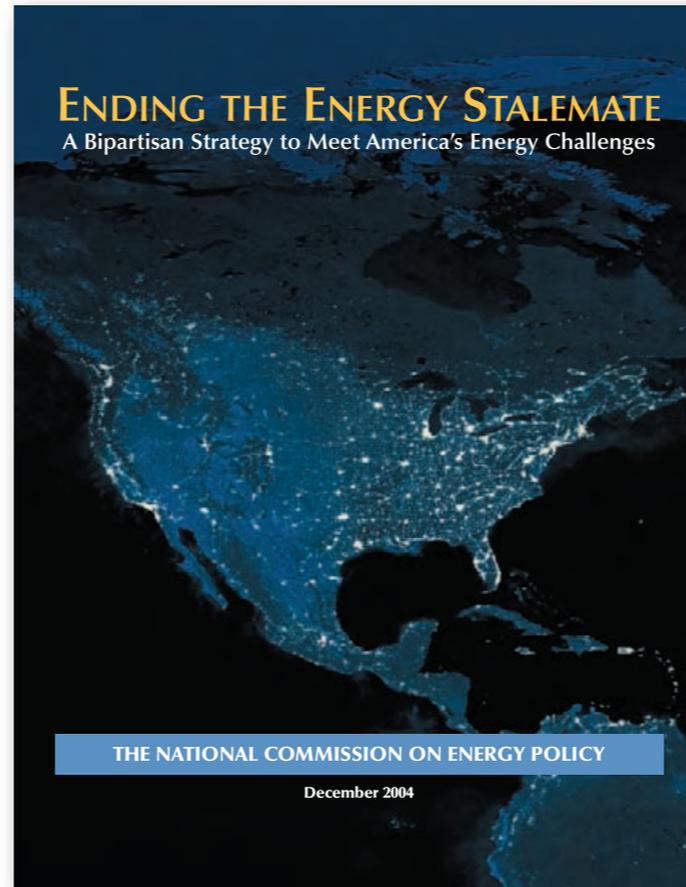
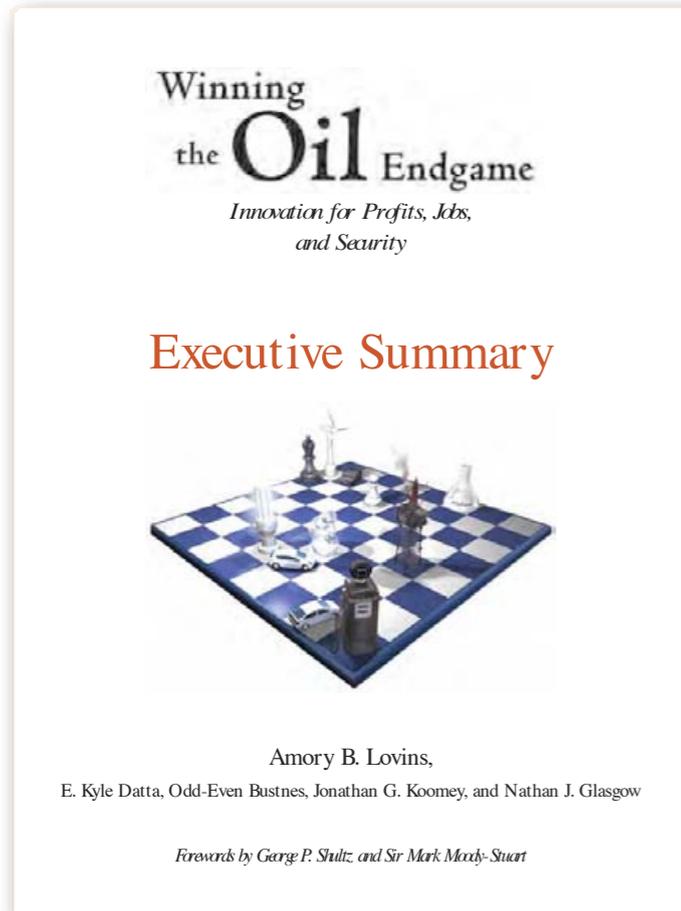
John Sheehan  
Strategic Energy Analysis  
Center  
May 18, 2006



# Overview

- The brave new world of energy, environment, biofuels, hydrogen and vehicles
- Biomass
- Rethinking the biorefinery
- A sustainable vision
- Getting there

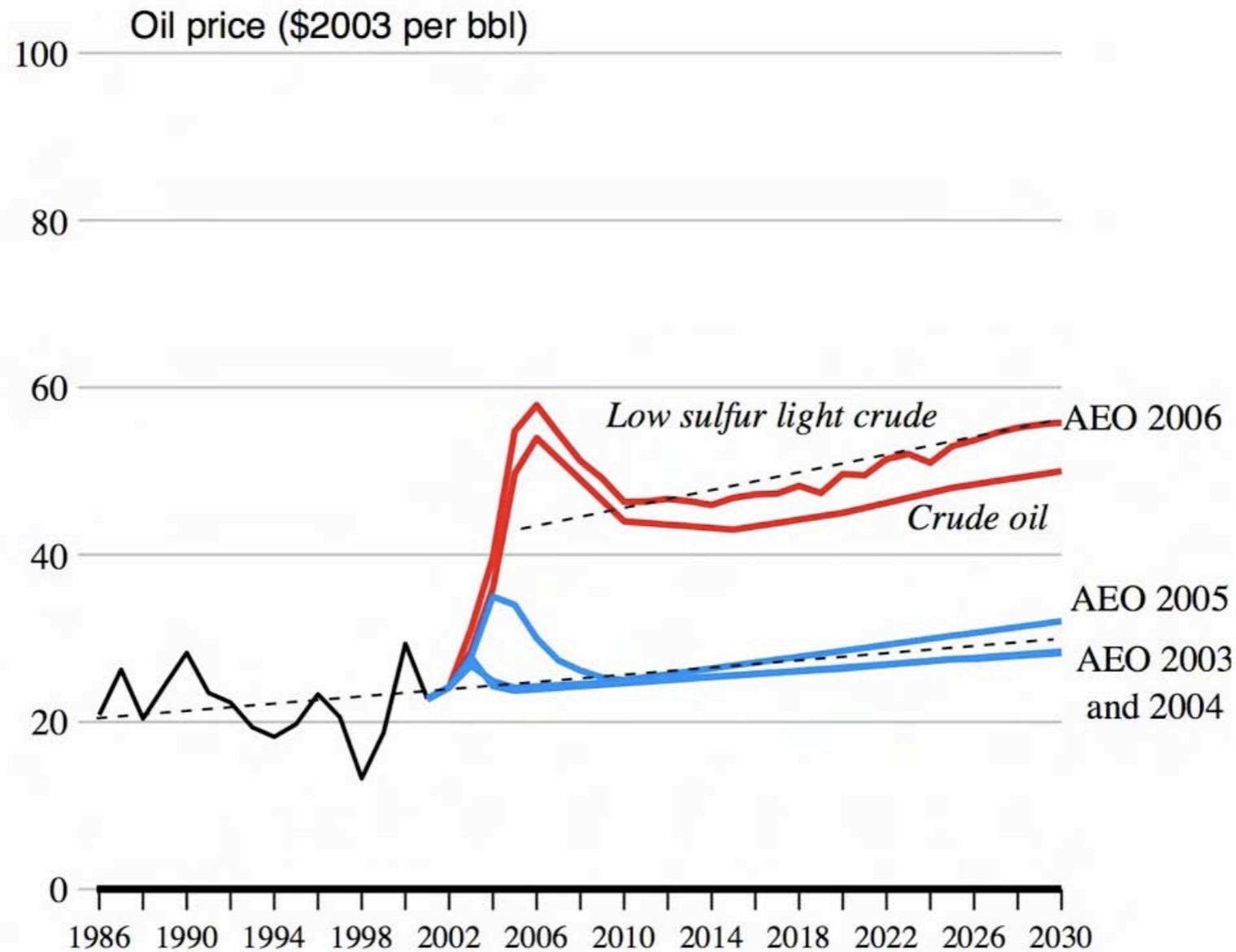




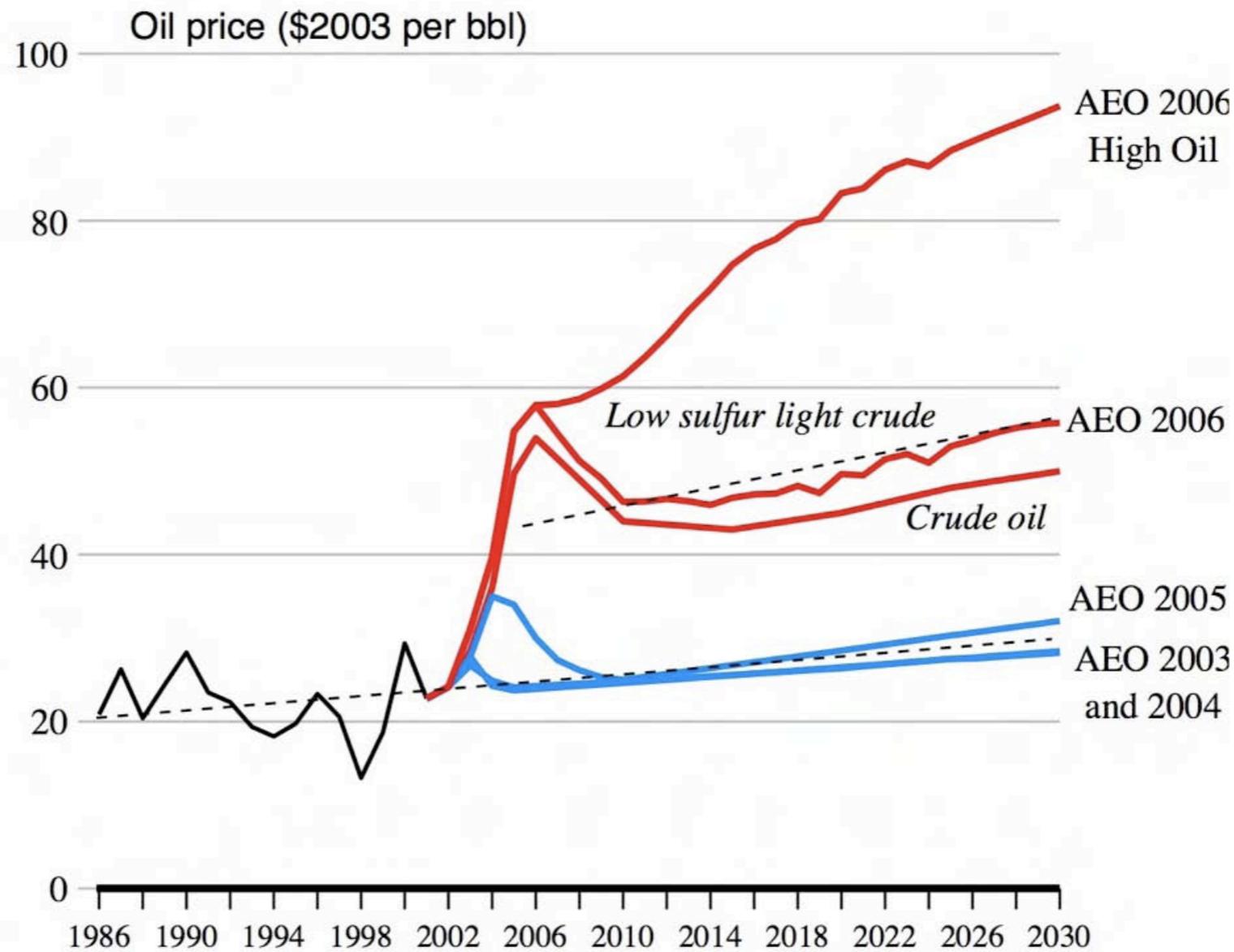
**A brave new world  
for energy**



**A brave new world  
for energy**

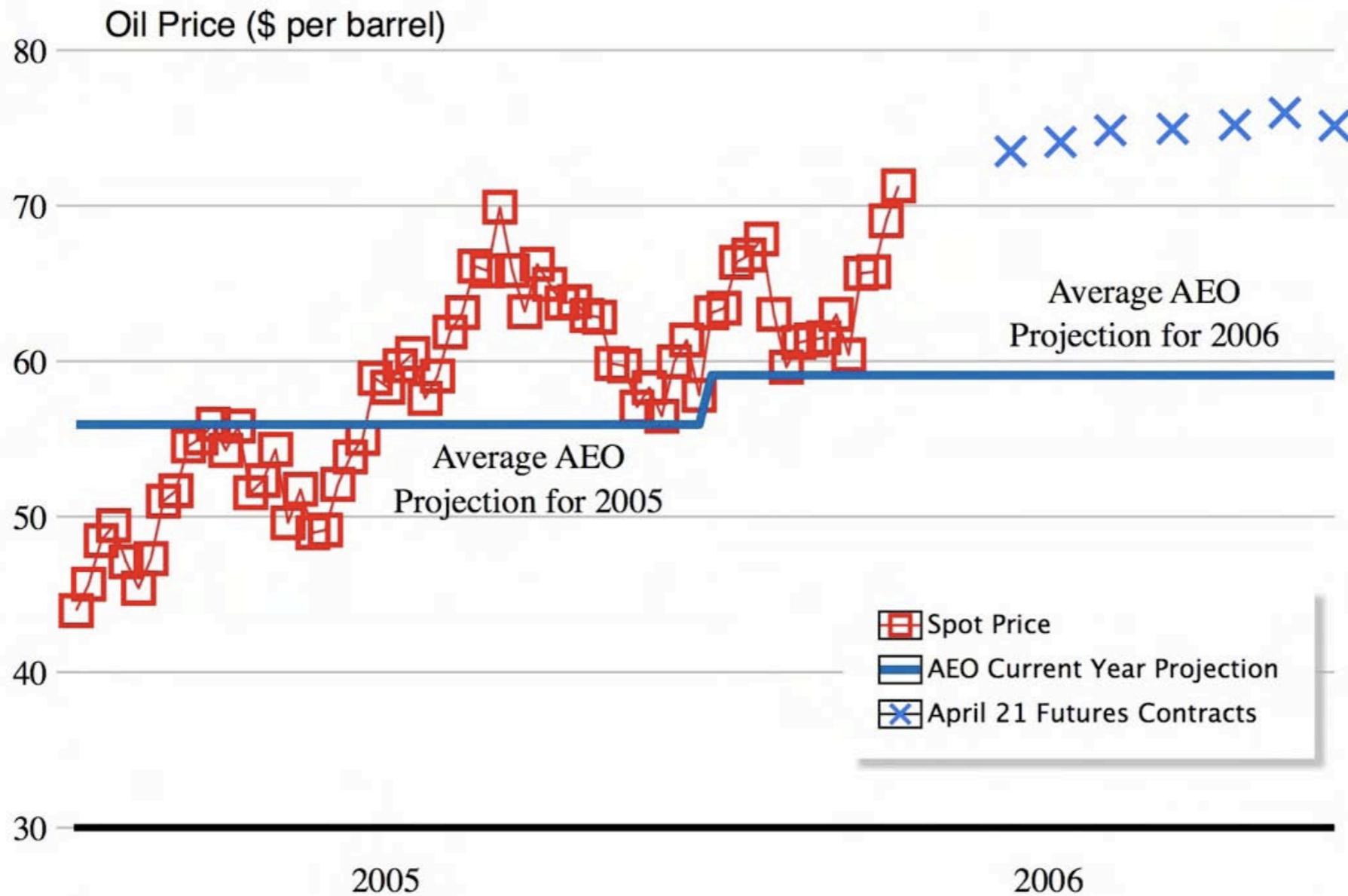


# A sea change for oil

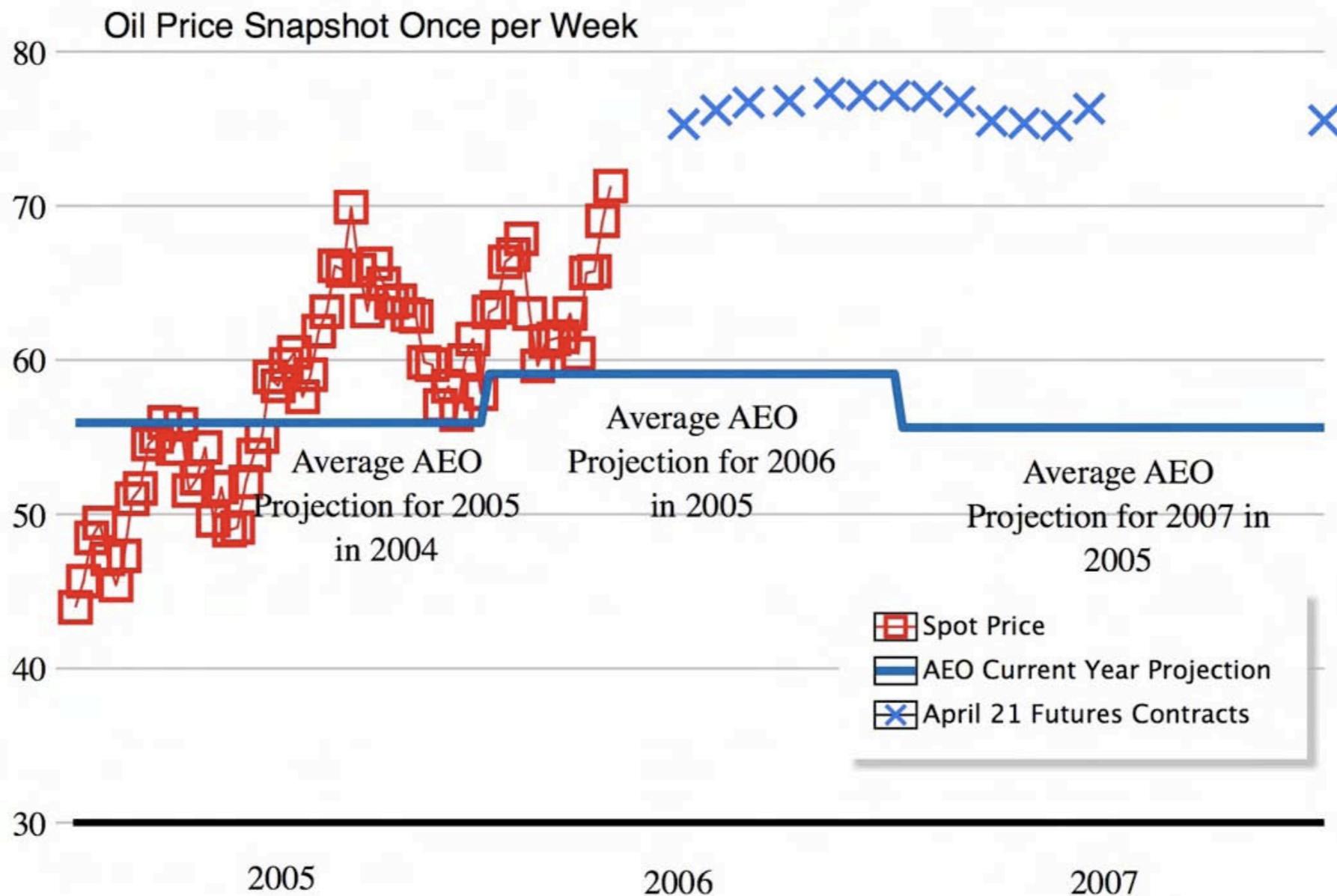


# A sea change for oil

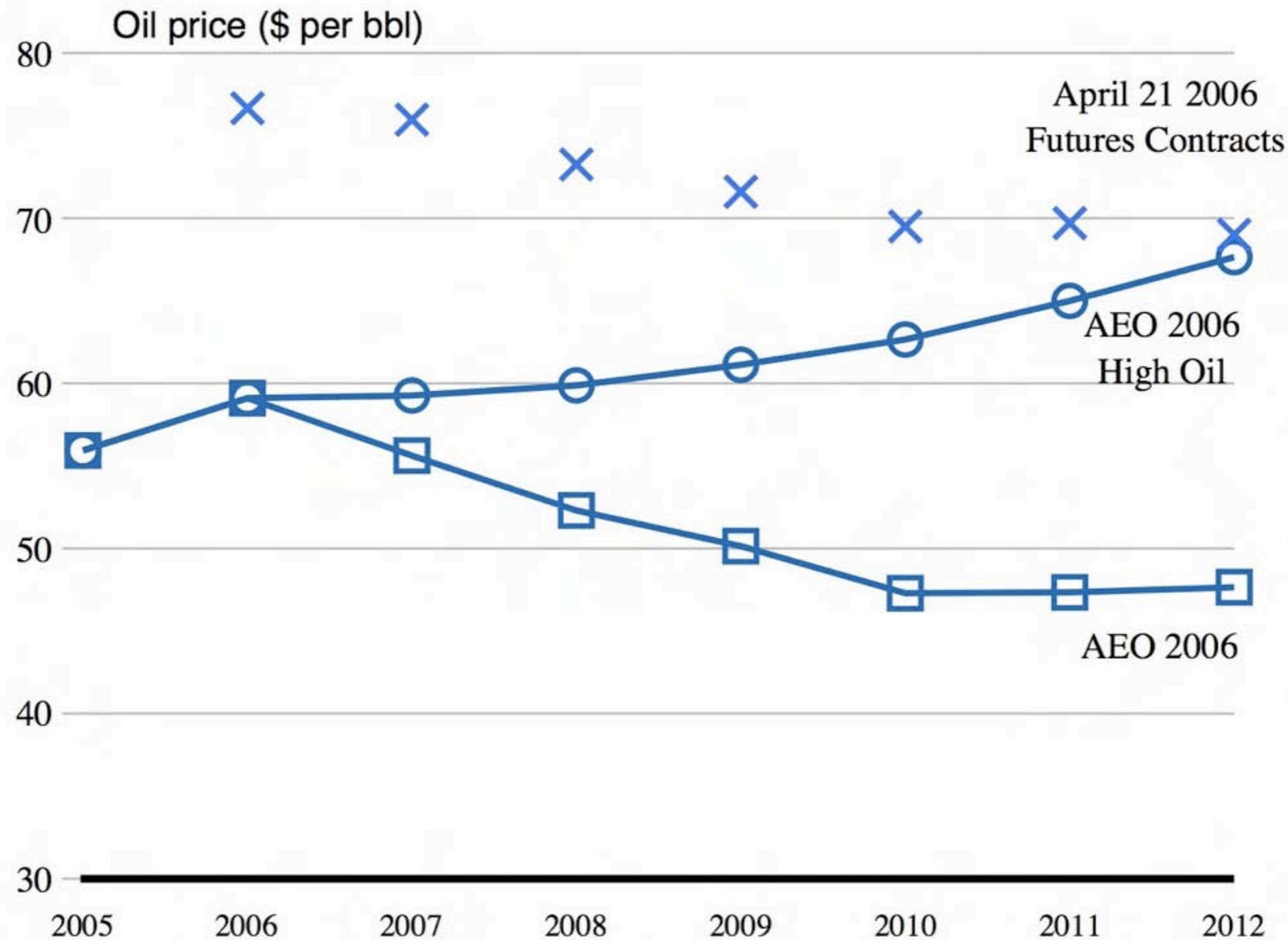
Should we believe  
the reference case or  
the high oil case?



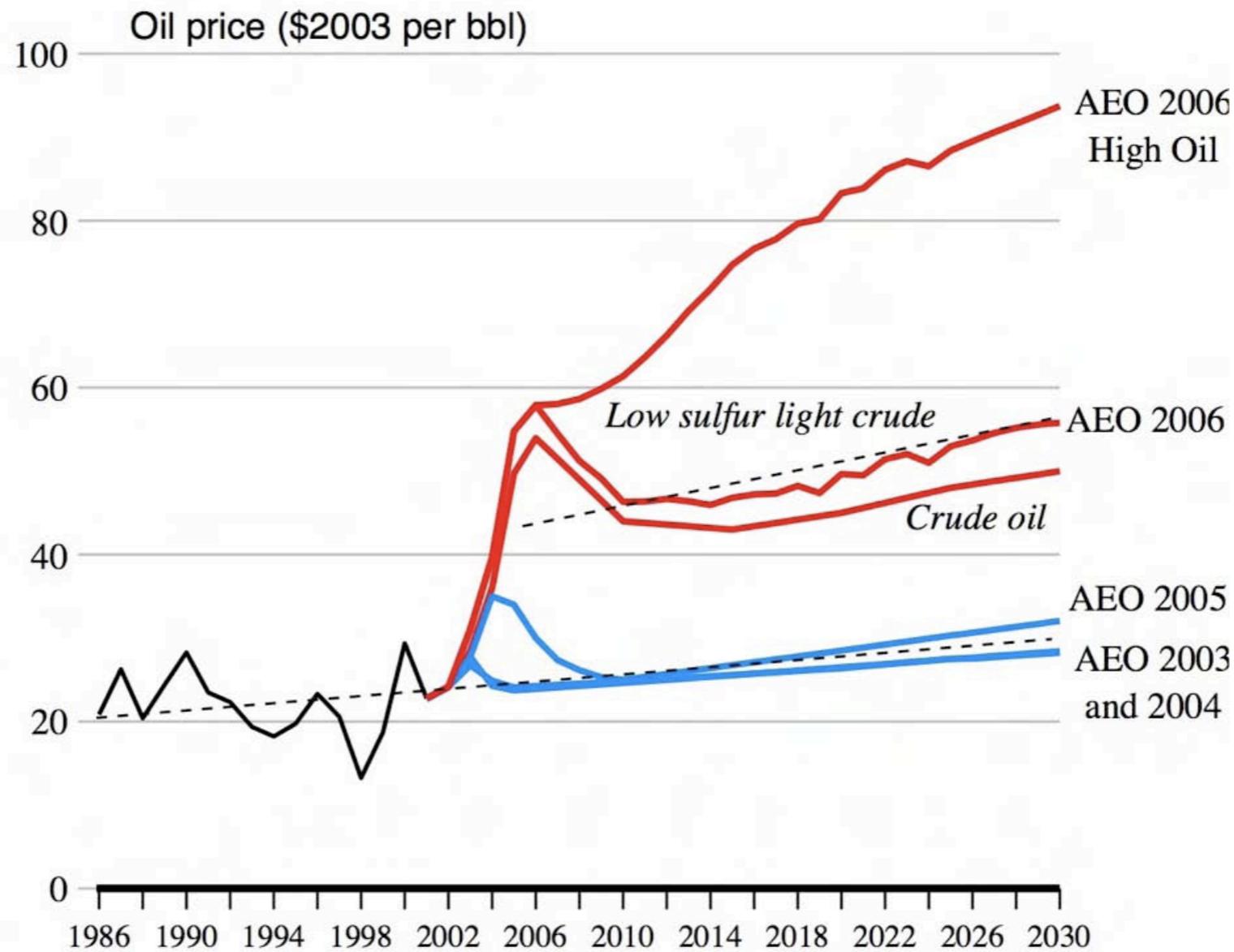
The reference case vs reality



The reference case vs reality



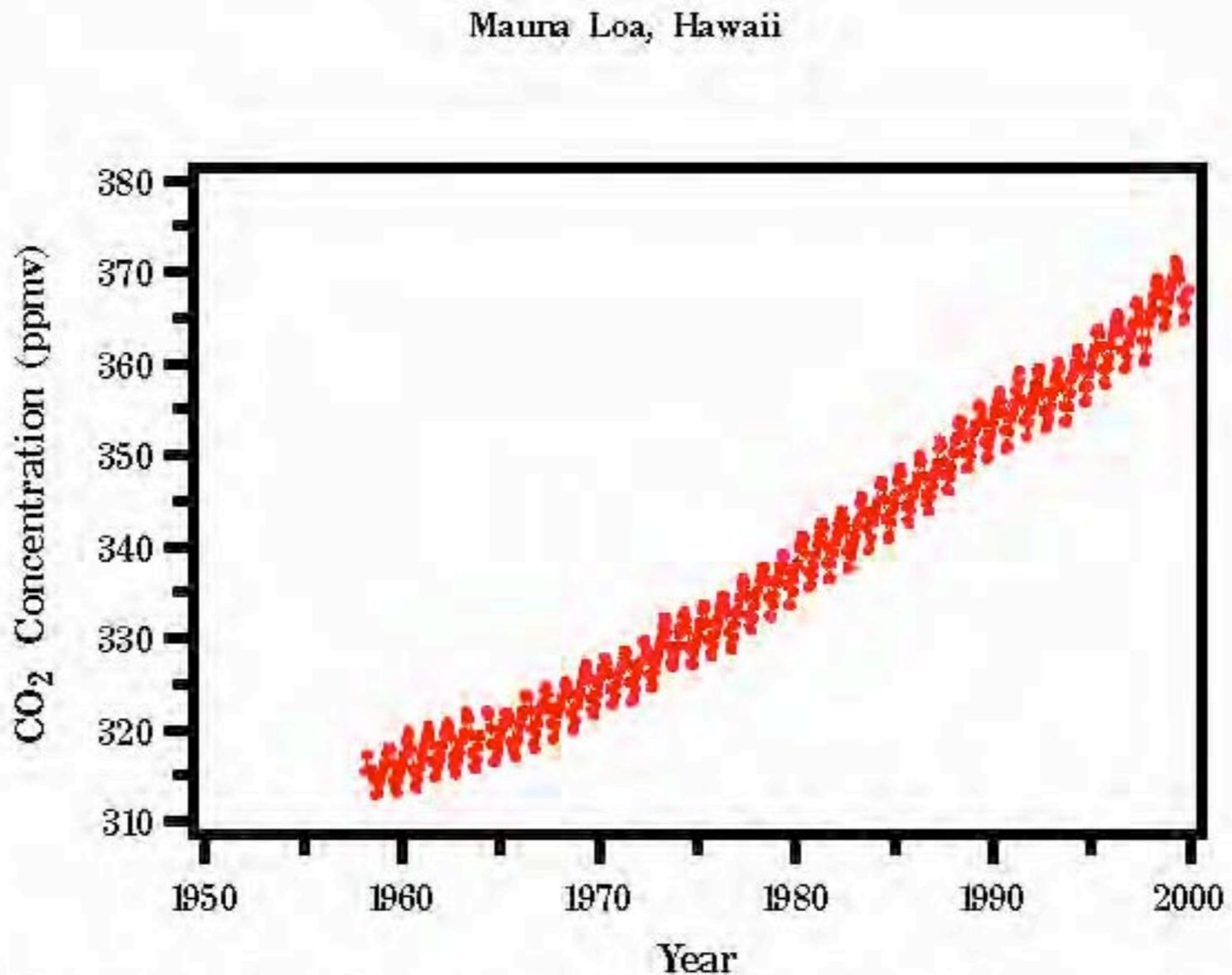
“Futures” & high oil merge



My bet is on high oil

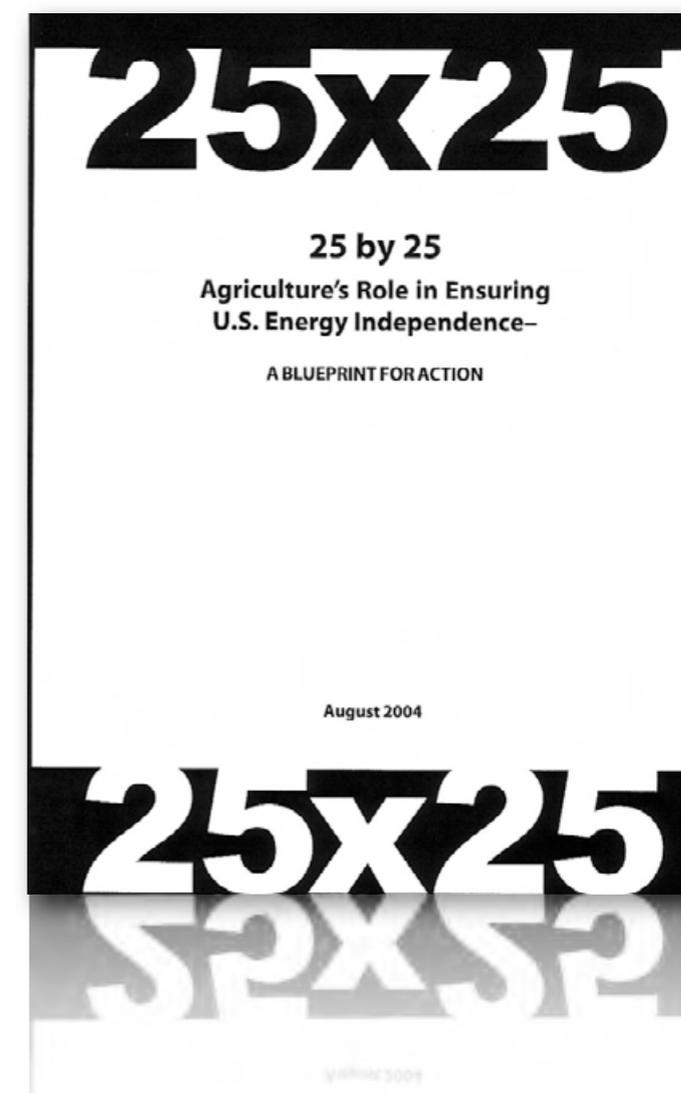
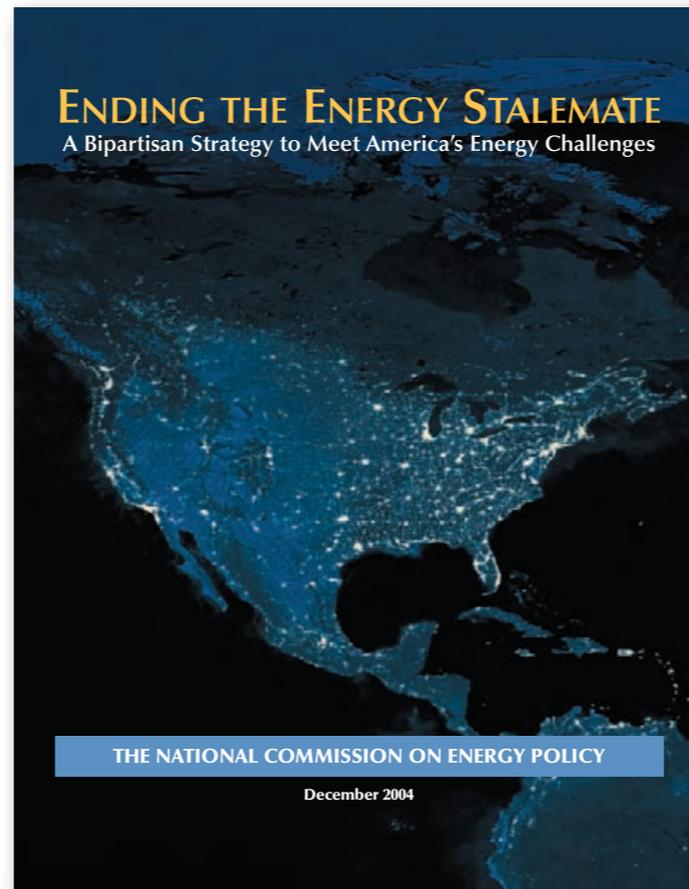
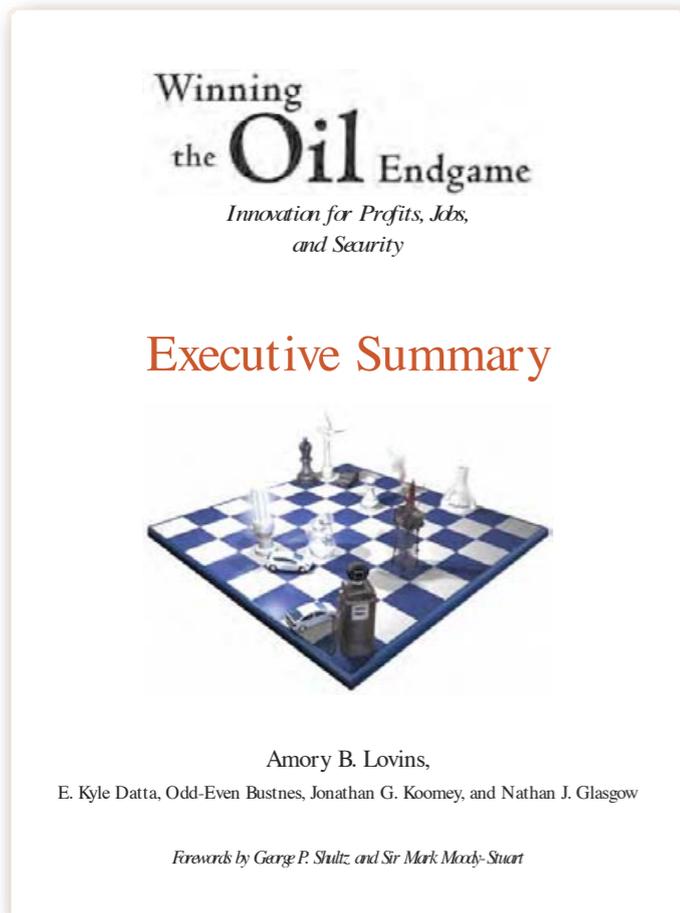


**A brave new world for  
the environment**



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

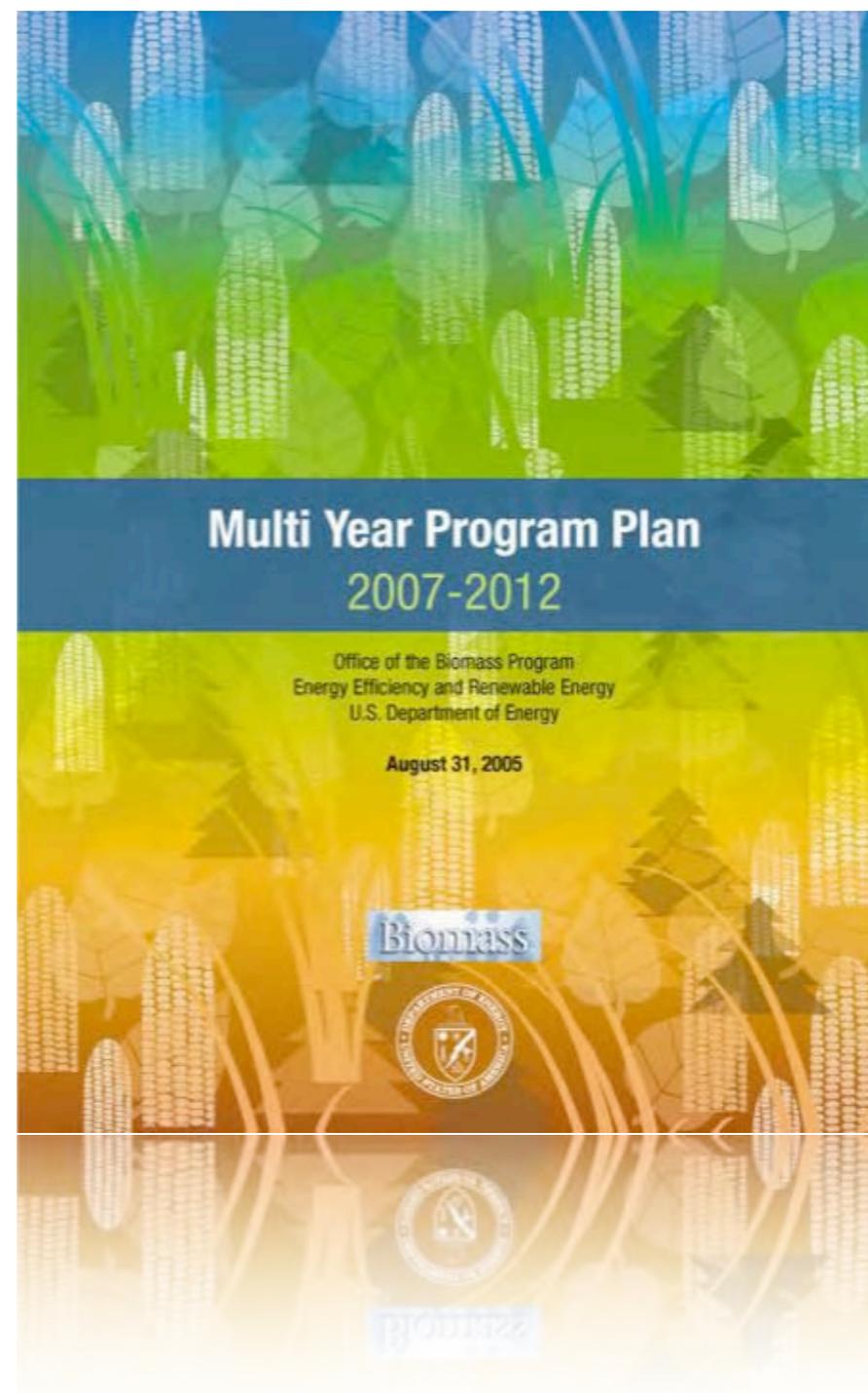
# Climate change



A brave new world  
for biofuels

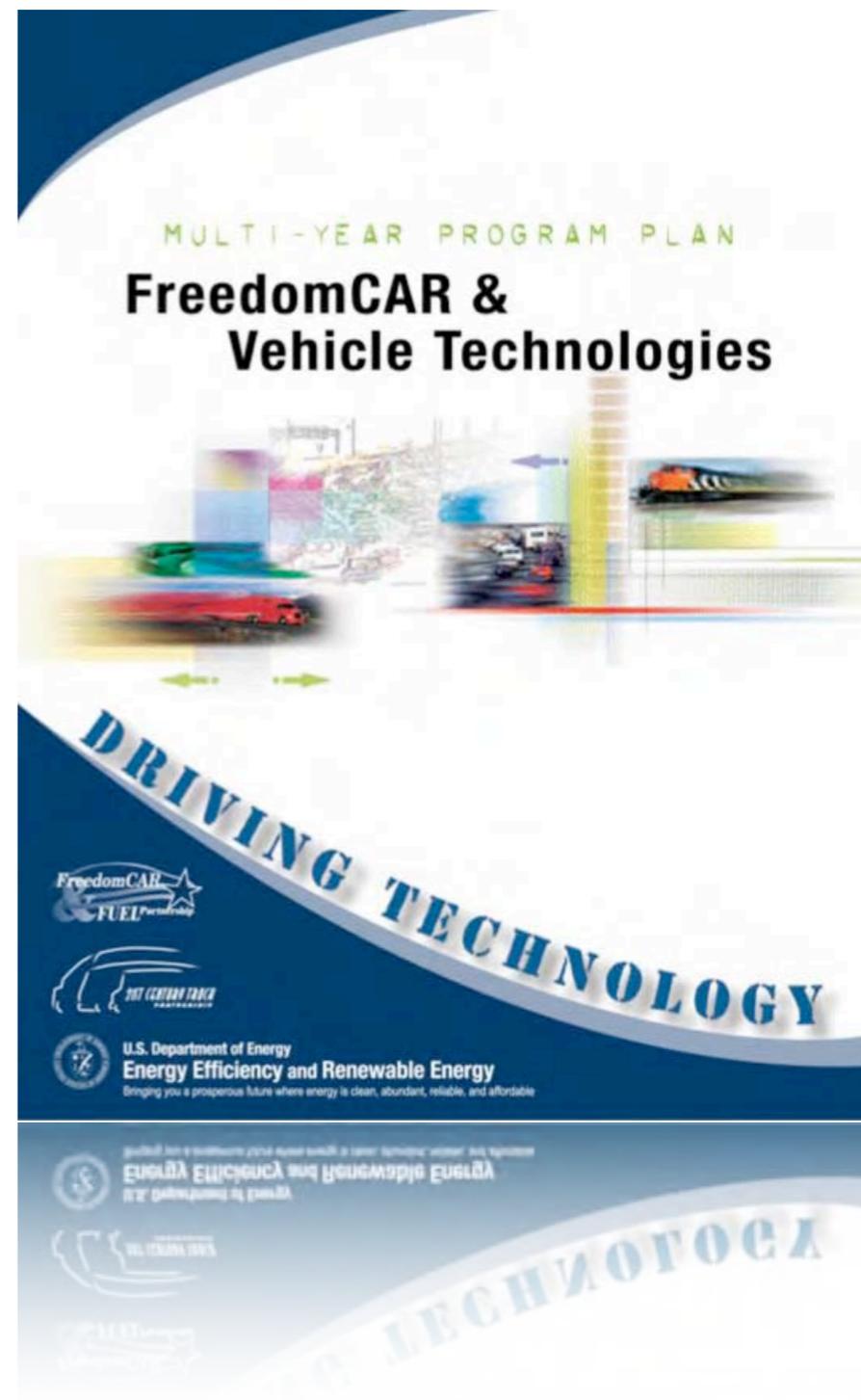
# The DOE Biomass Program

[www.eere.energy.gov](http://www.eere.energy.gov)



# The DOE Vehicles Program

[www.eere.energy.gov](http://www.eere.energy.gov)



# The DOE Hydrogen Program

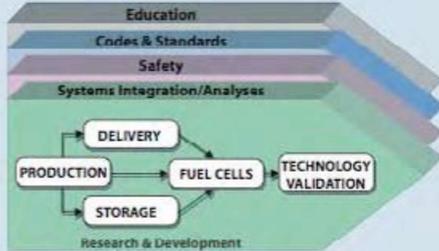
[www.eere.energy.gov](http://www.eere.energy.gov)

Paving the way  
toward a hydrogen  
energy future



## Hydrogen, Fuel Cells & Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan

Planned program activities for 2003-2010



Education  
Codes & Standards  
Safety  
Systems Integration/Analysis

DELIVERY  
PRODUCTION  
STORAGE  
FUEL CELLS  
TECHNOLOGY VALIDATION

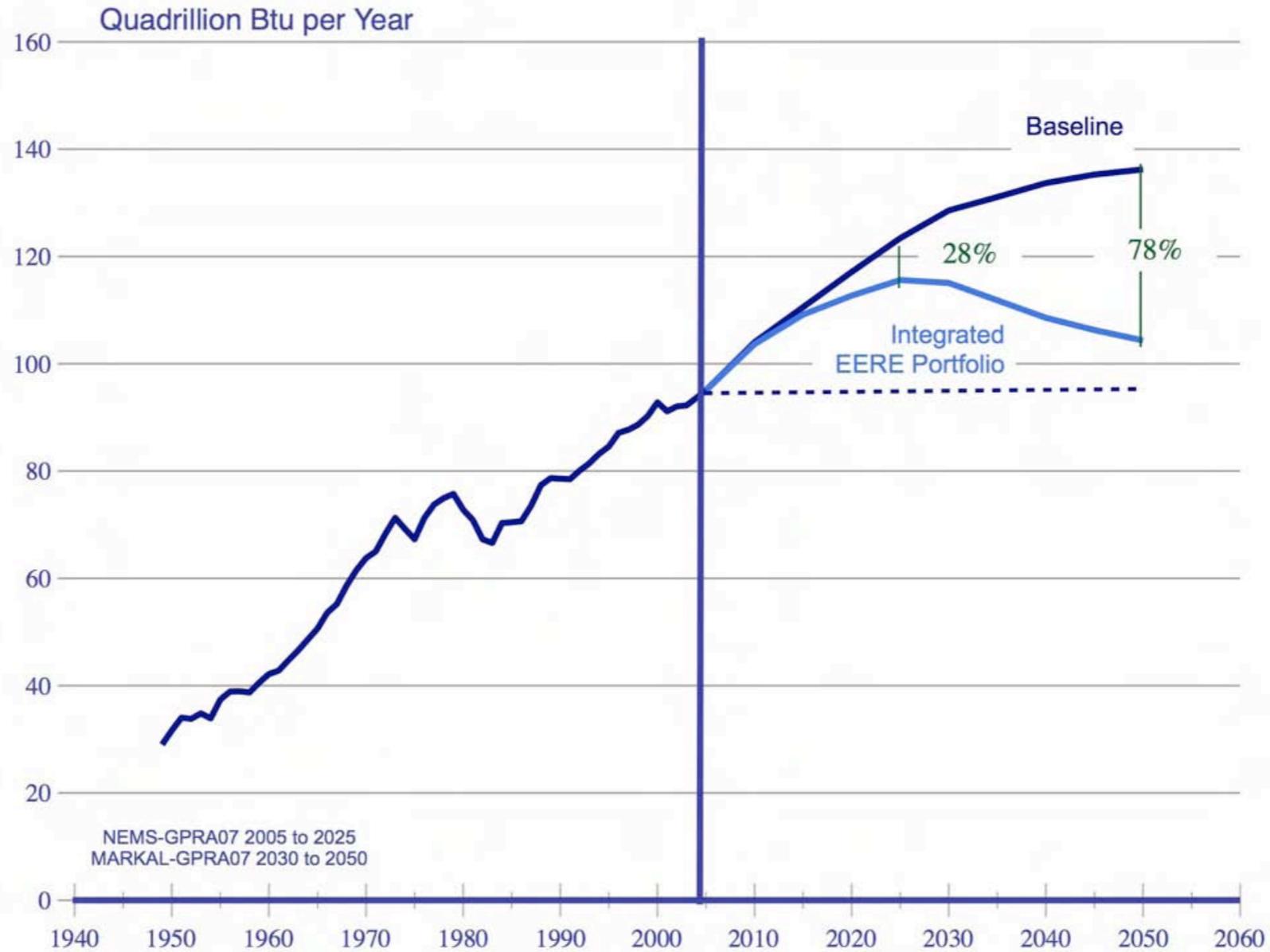
Research & Development



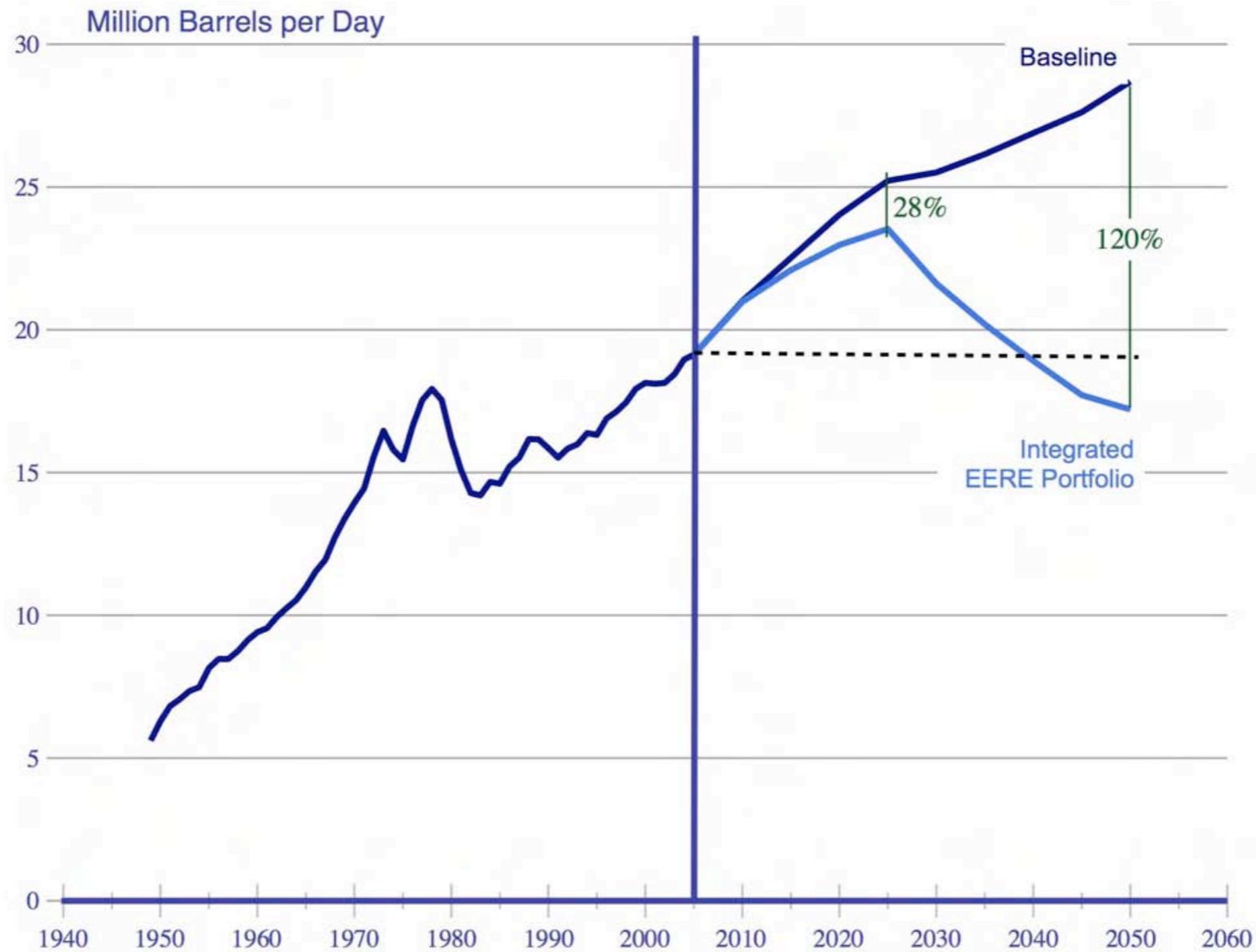
**H<sub>2</sub>**  
Economy

 U.S. Department of Energy  
**Energy Efficiency and Renewable Energy**  
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

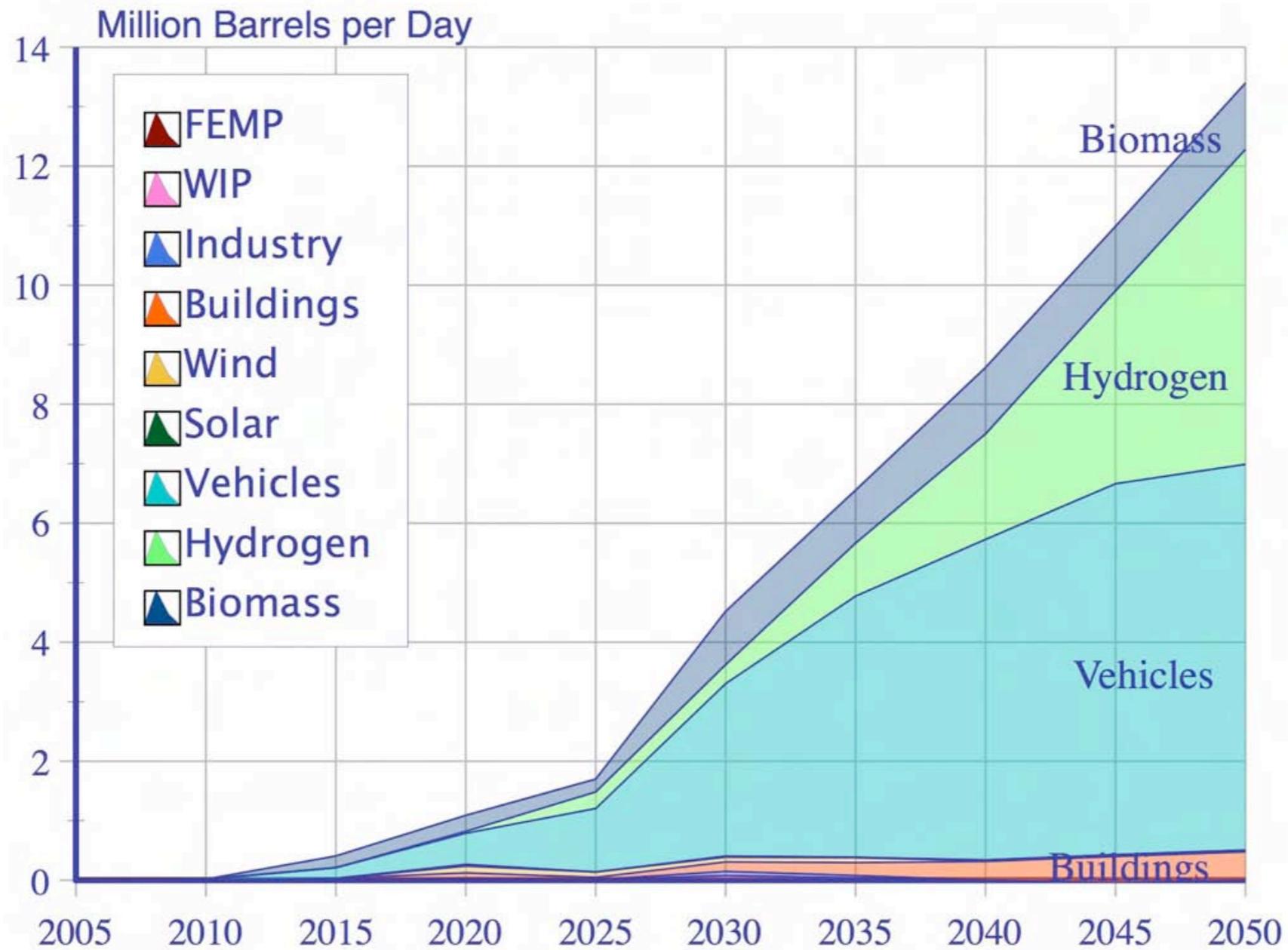
 Energy Efficiency and Renewable Energy



# Changing our energy future



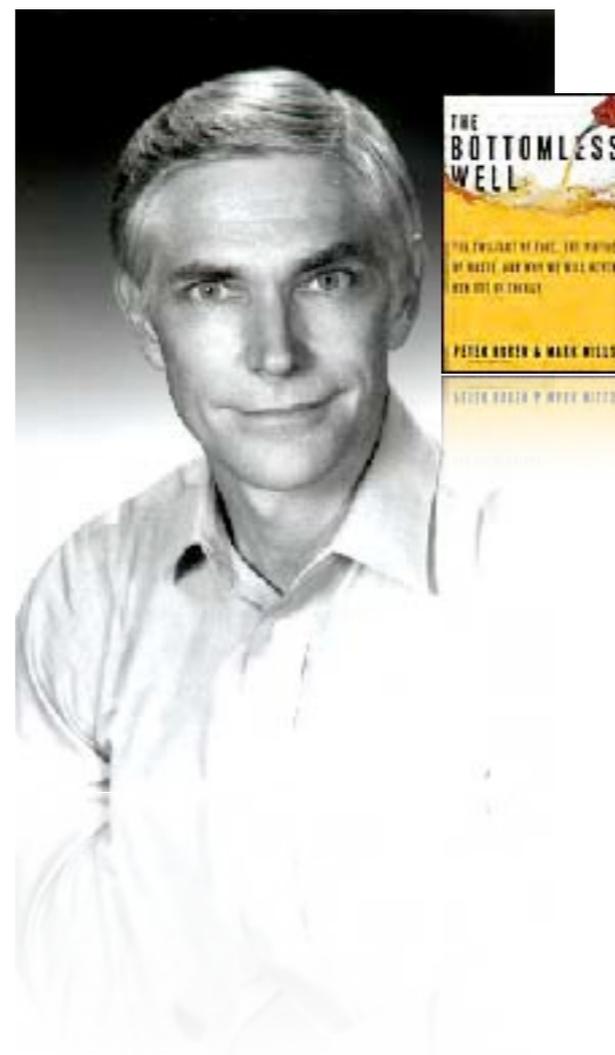
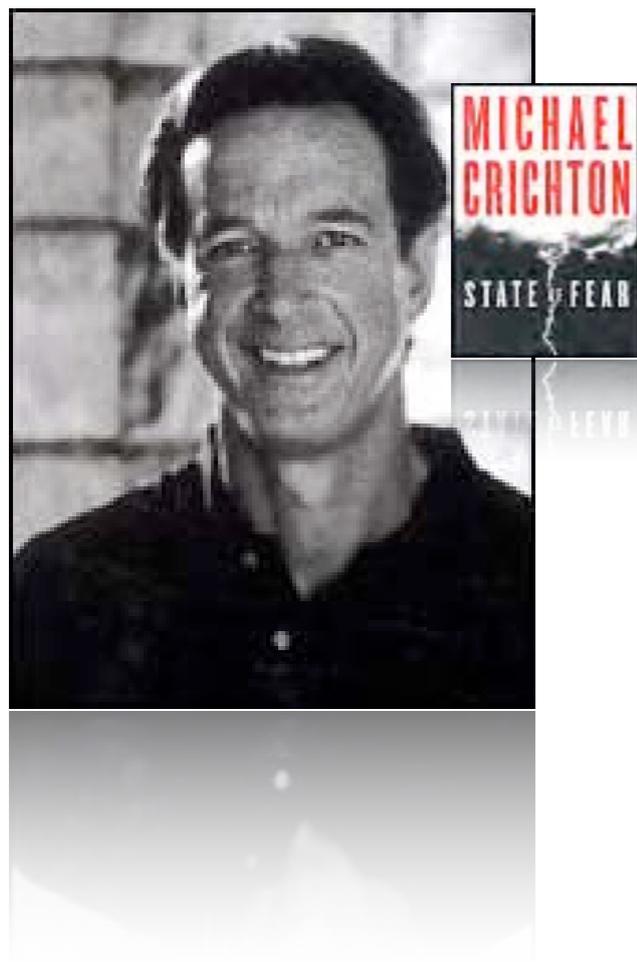
# Changing our energy future



# Changing our energy future



# Fear and loathing on the energy trail



# Fear and loathing on the energy trail

These brave new  
worlds offer  
uncertainty and  
opportunity

MSW

Forest

Ag Residues

Energy Crops



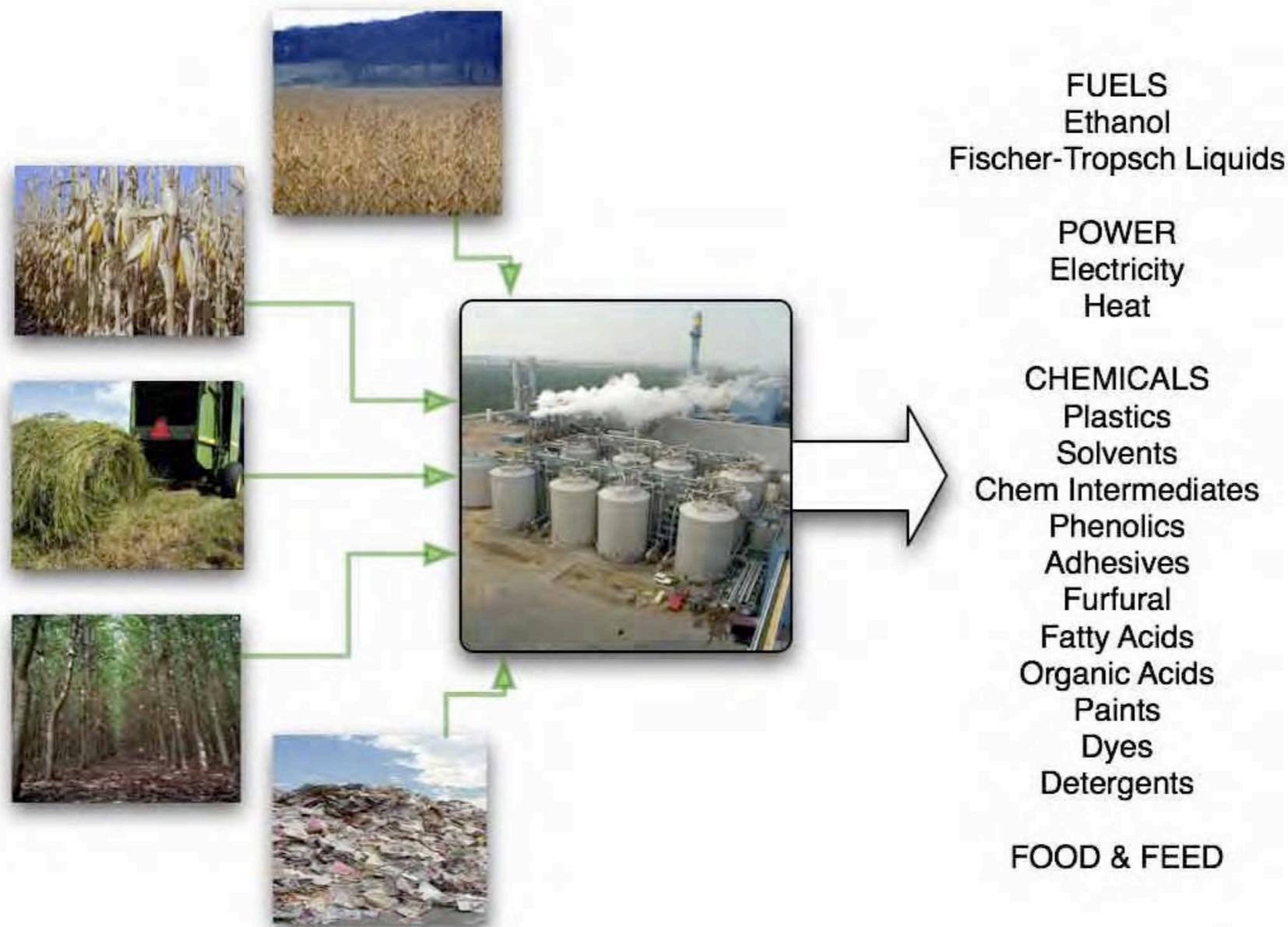
**Biomass tomorrow**



# Biomass tomorrow algae and coal

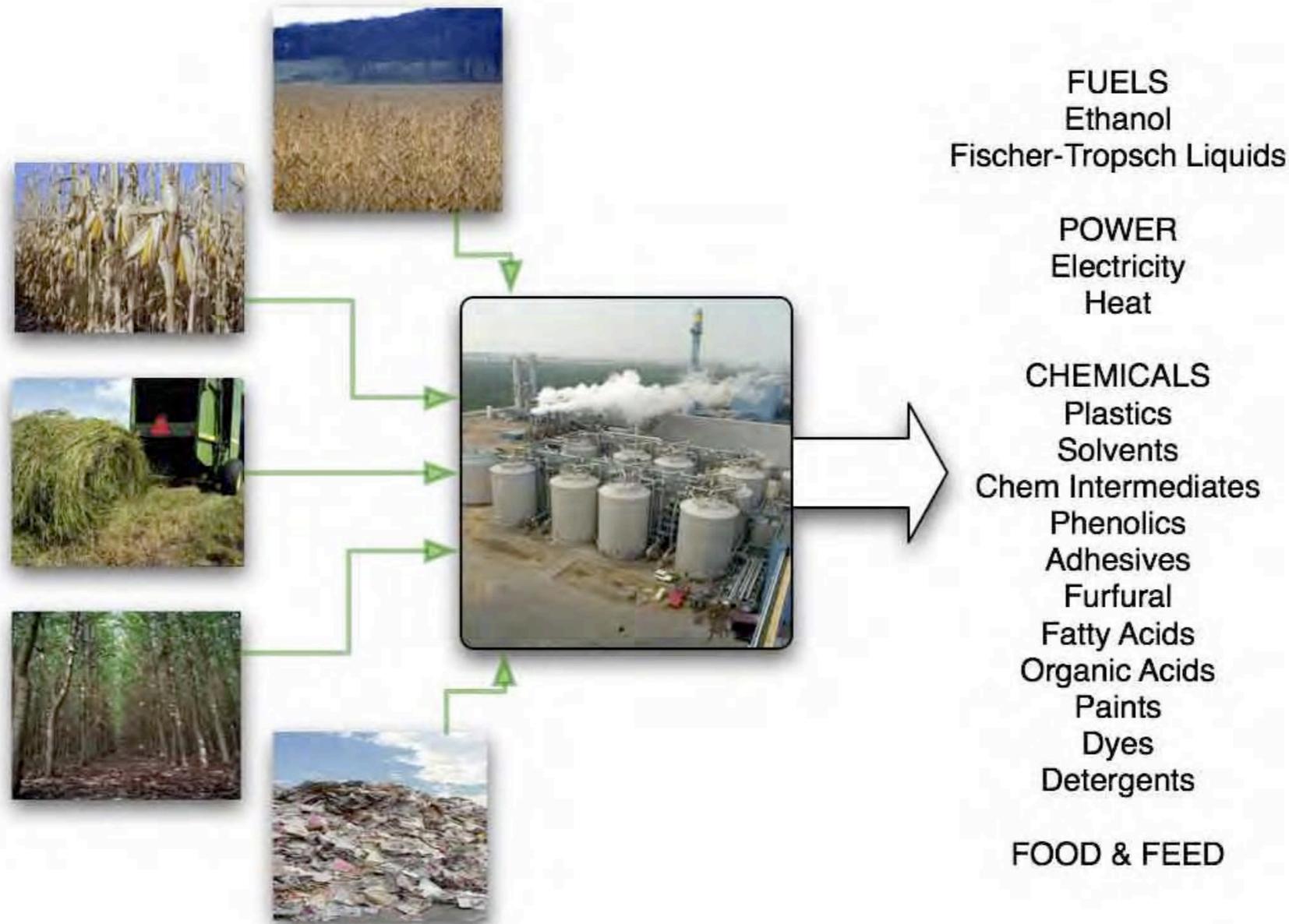
Today grains, oilseeds	Sugars Starch Oilseed lipids
Emerging and future MSW, residues, energy crops	Cellulose Hemicellulose Lignin Algal lipids

# Biomass chemistry today and tomorrow



# The biorefinery

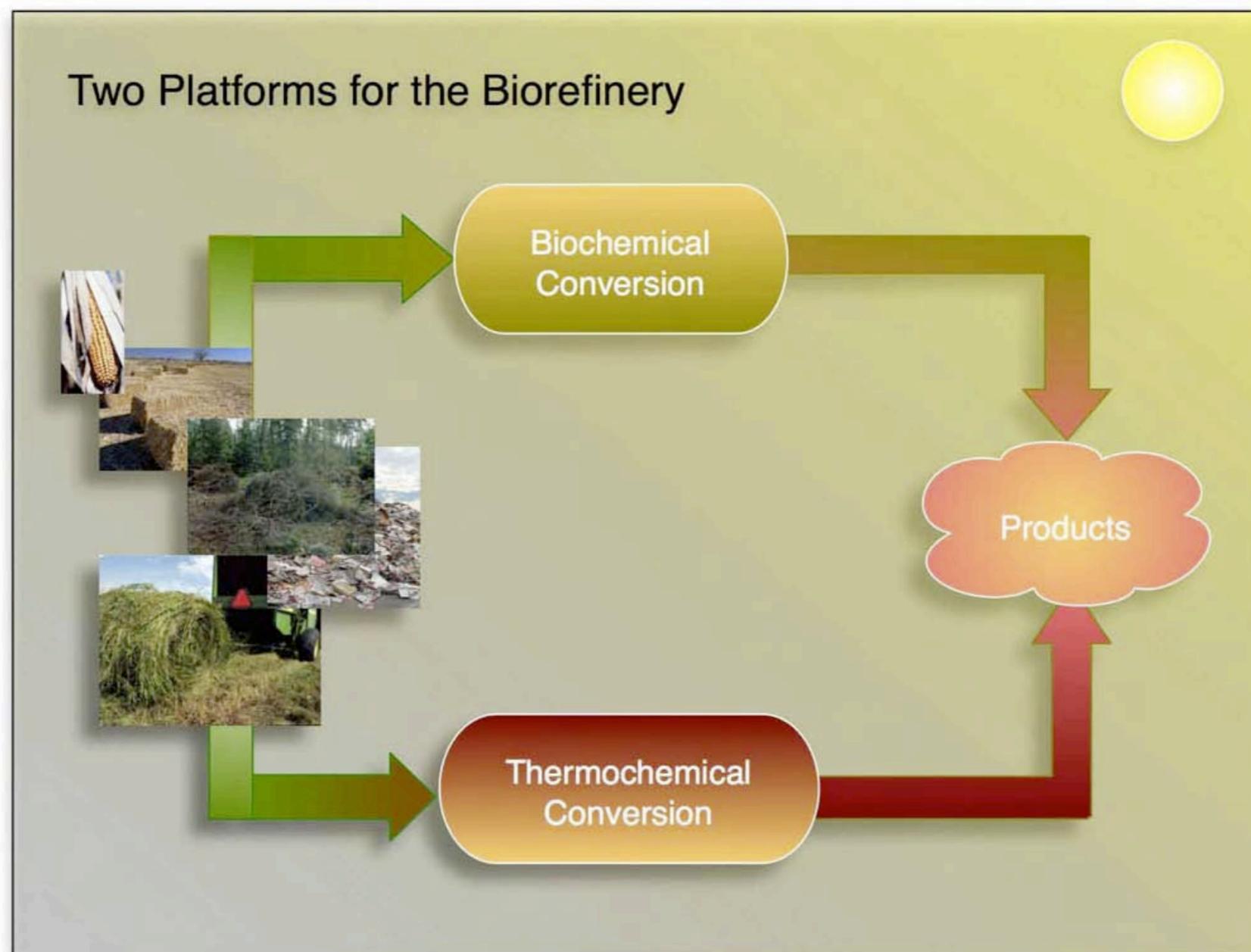
## Something for everyone?



# The biorefinery Or a case of ADD?

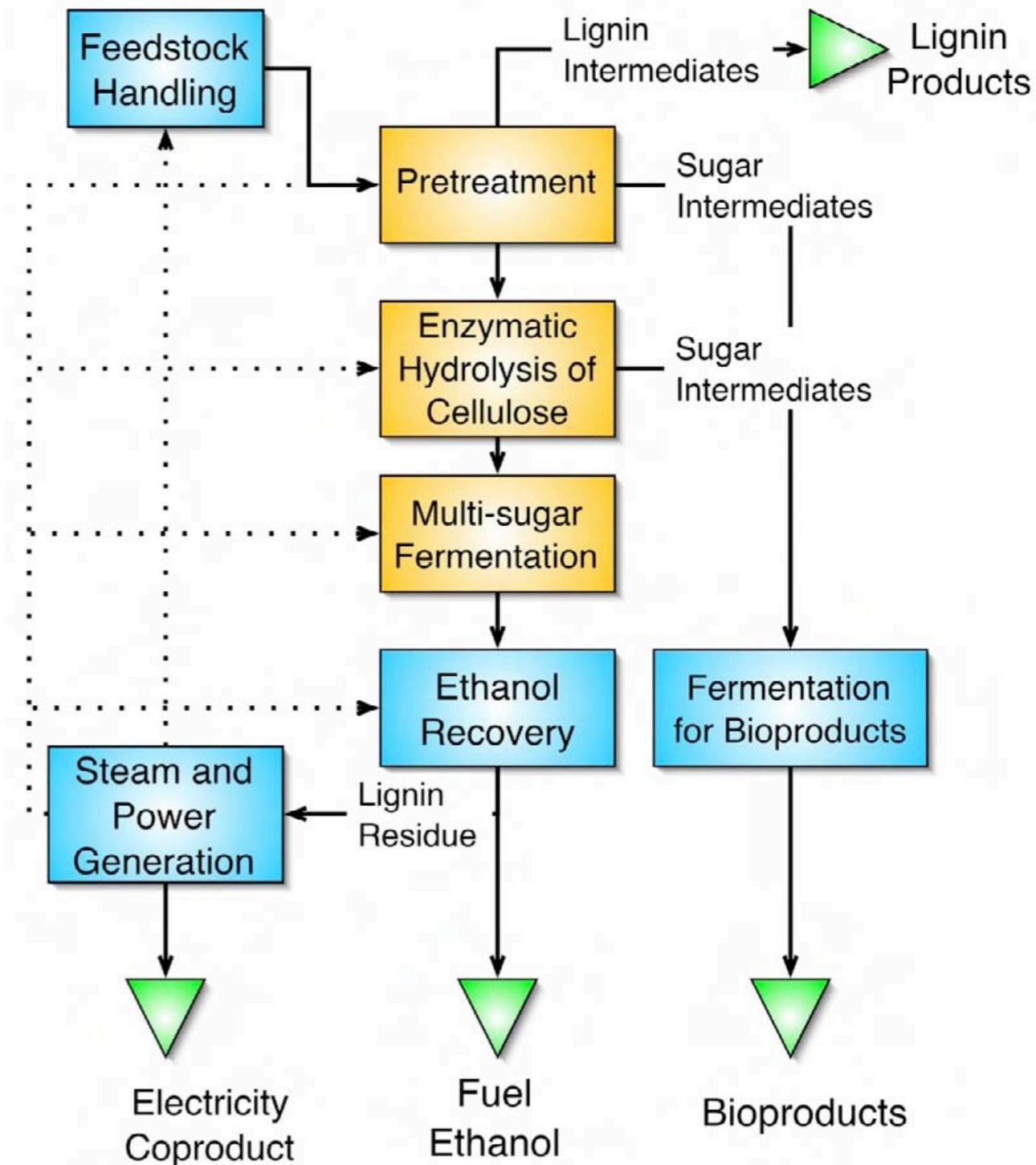
# The biorefinery

## Two main “flavors”



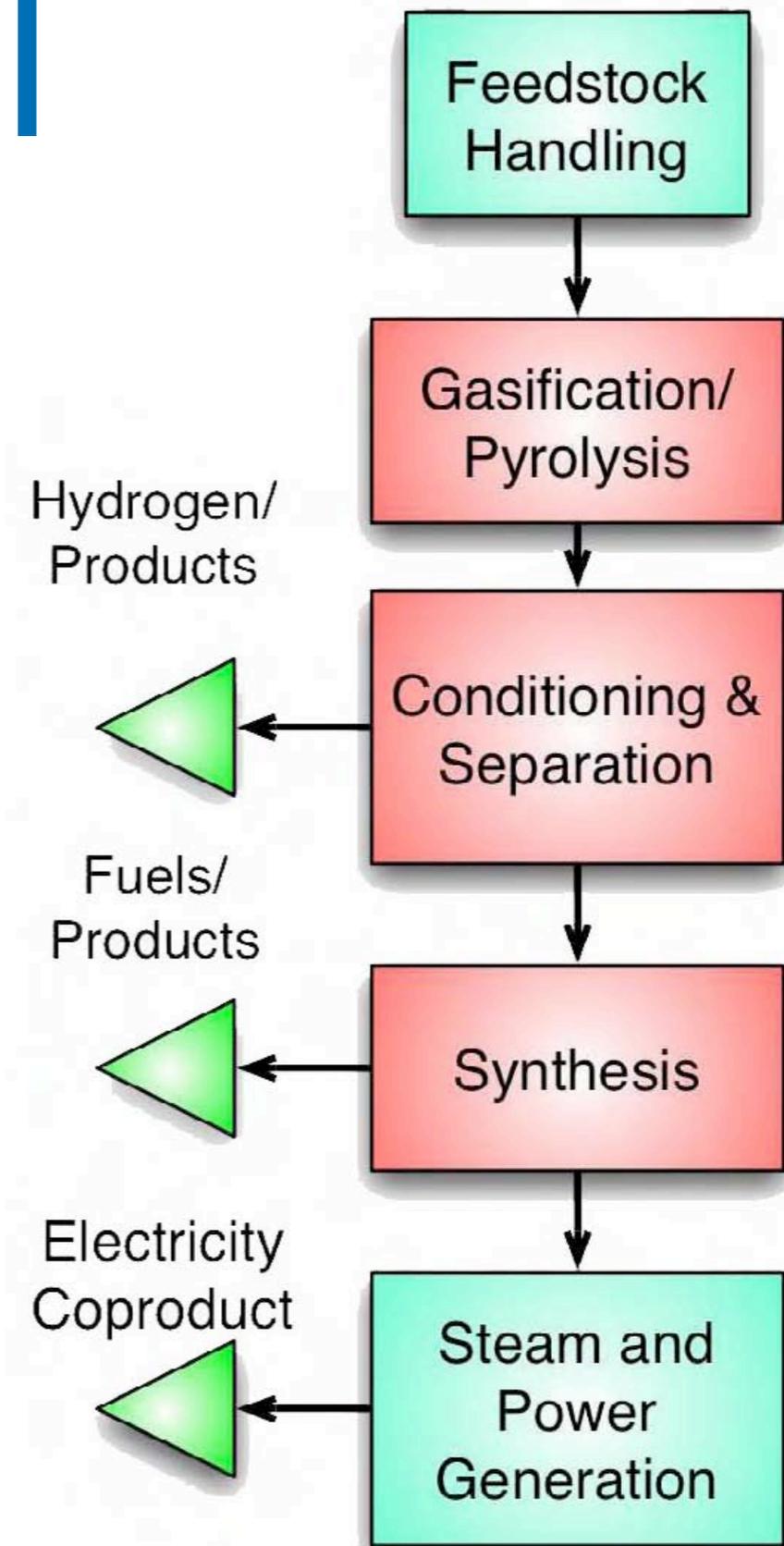
# Biochemical platform

- Pretreatment to thermochemically open up biomass structure
- Specialized enzymes called cellulases to release sugars
- Fermentation to convert multiple forms of sugars to ethanol
- Use lignin to supply heat and power

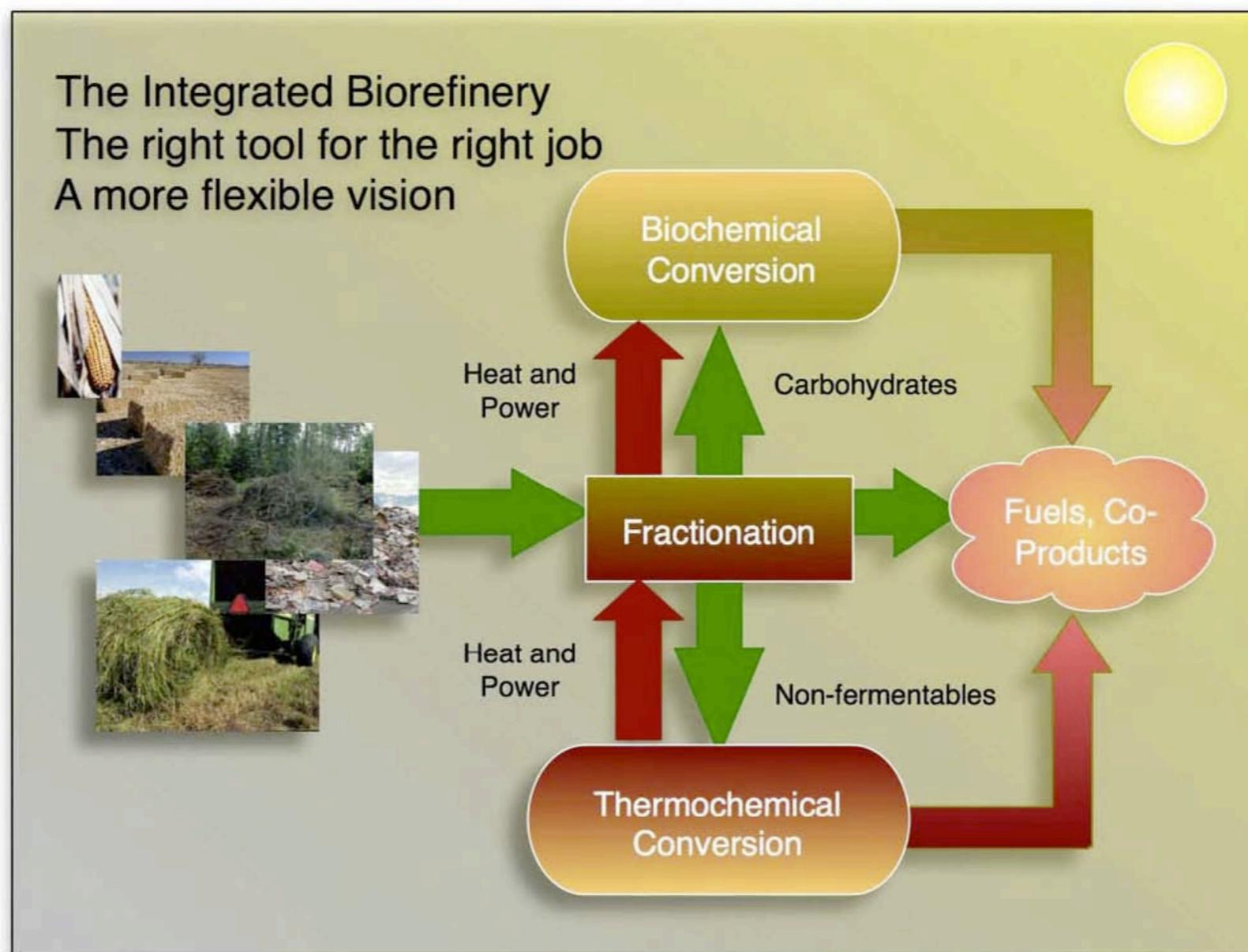


# Thermochemical platform

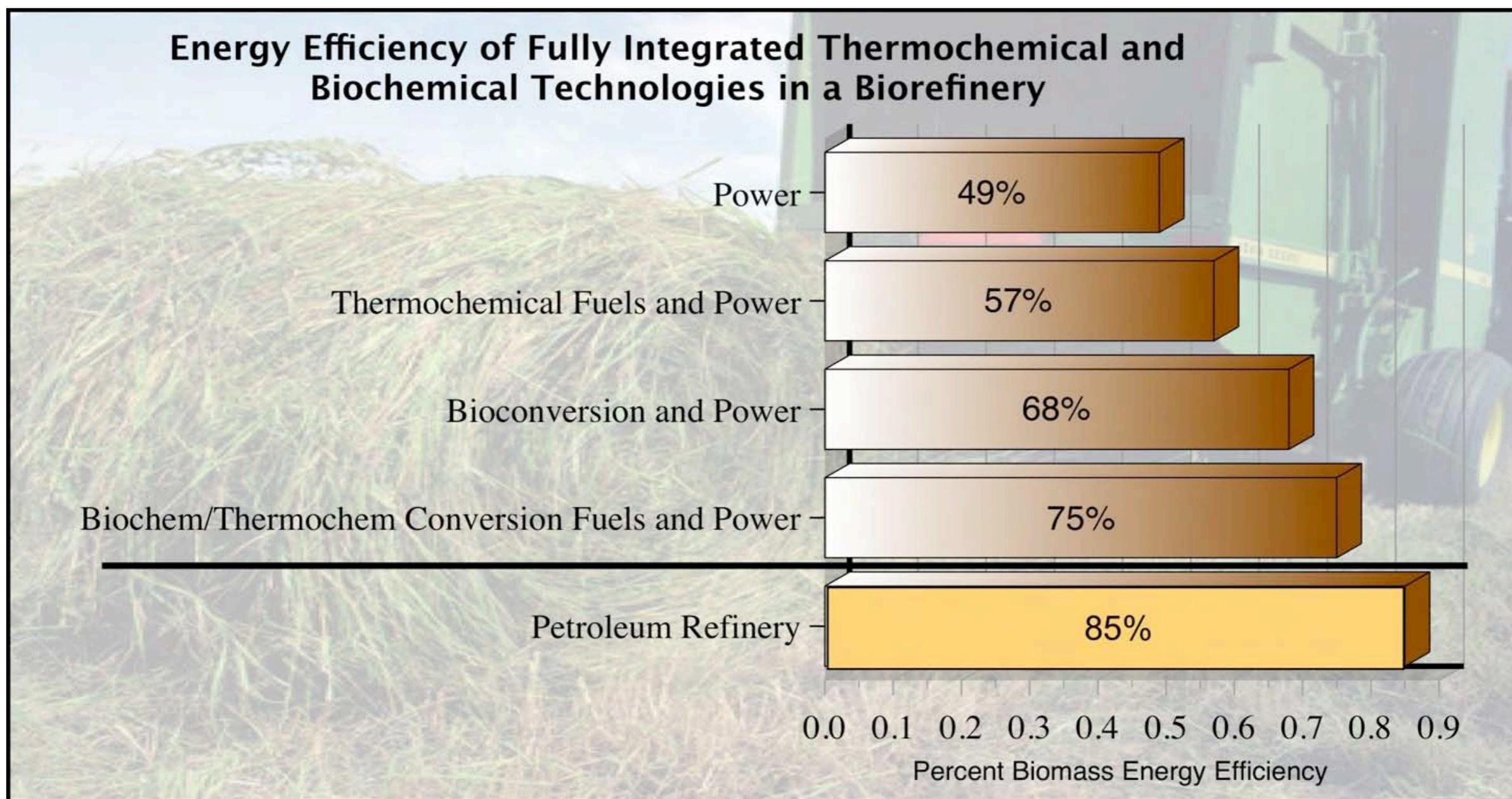
- Gasification to CO, CH<sub>4</sub>, CO<sub>2</sub> syngas
- Clean up and catalytic shifting to hydrogen
- Fischer-Tropsch synthesis of liquid fuels
- Mixed alcohols for liquid fuels
- Heat and power combined cycle

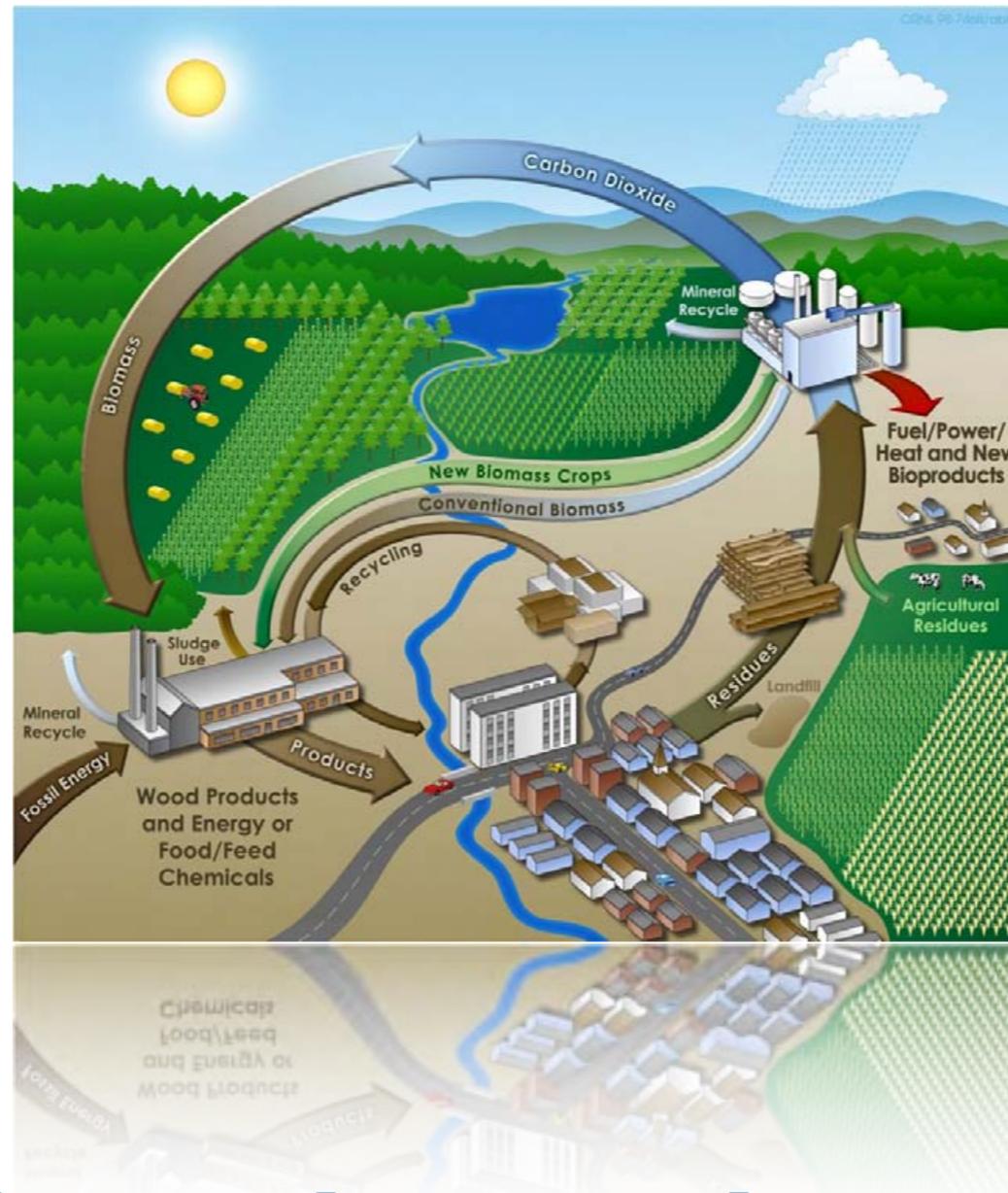


# The ultimate biorefinery



# The ultimate biorefinery





Getting there

# The President's Advanced Energy Initiative



# 30 by 30: Switchgrass enters the political vernacular



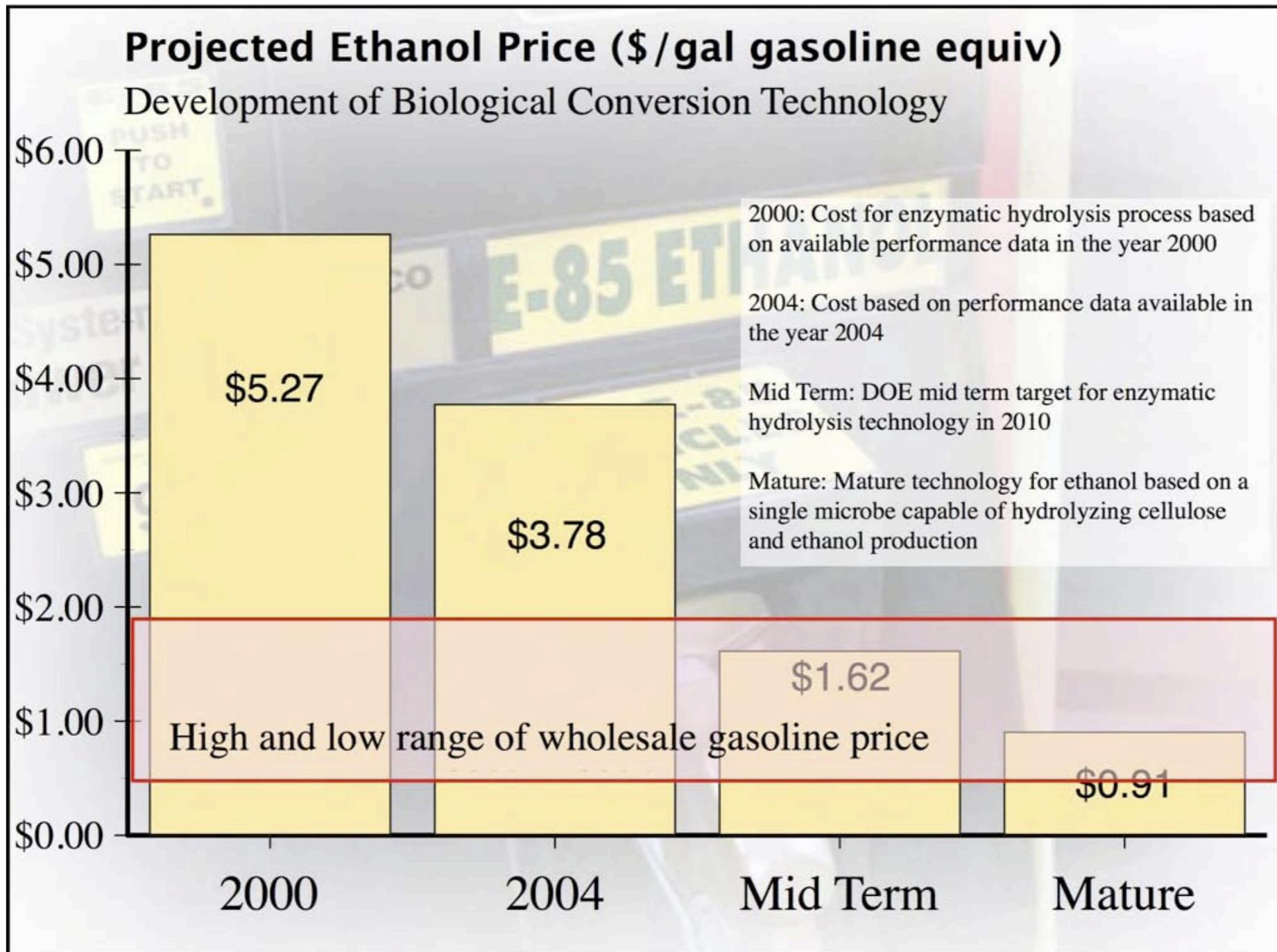
# 30% of our gasoline demand met with ethanol



...or 60 billion gallons of ethanol per year in 2030



Sounds like one of  
those far away  
goals...but it isn't.  
Meeting it will take an  
aggressiveness we  
have not so far seen.

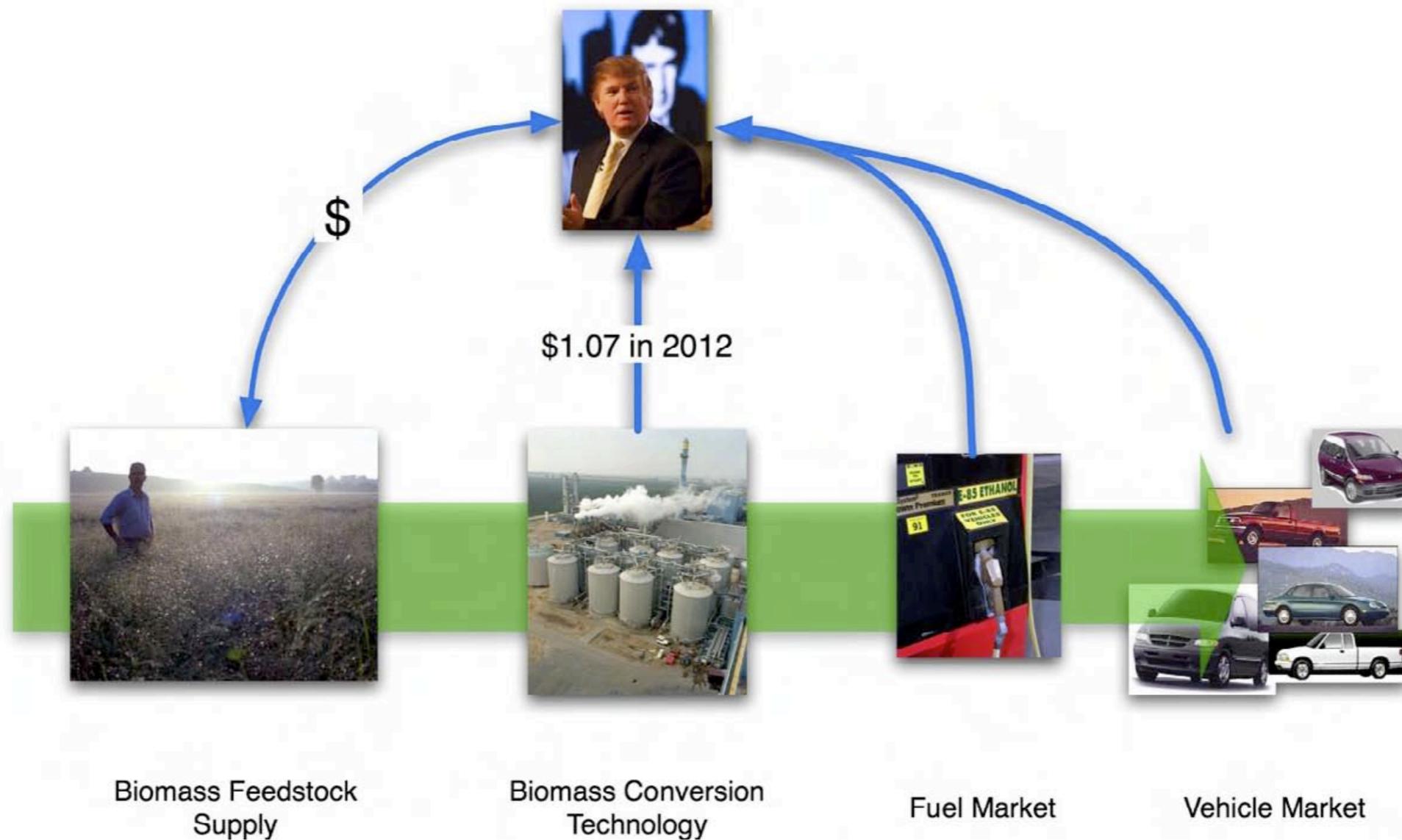


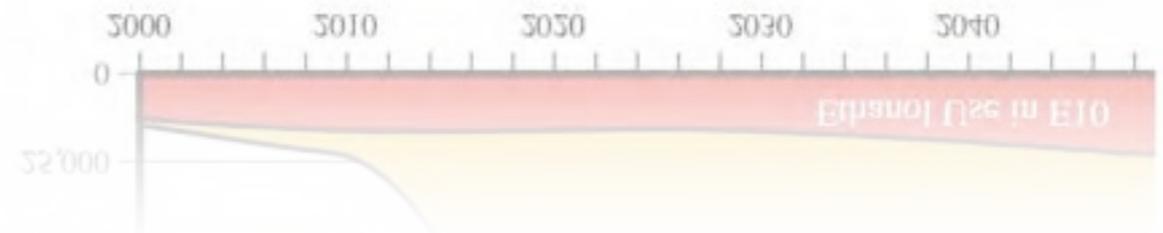
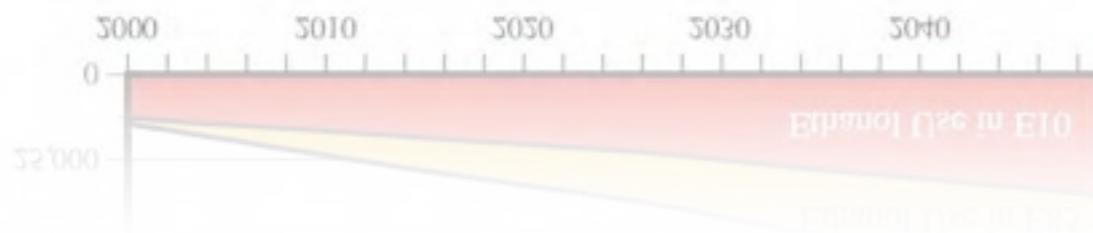
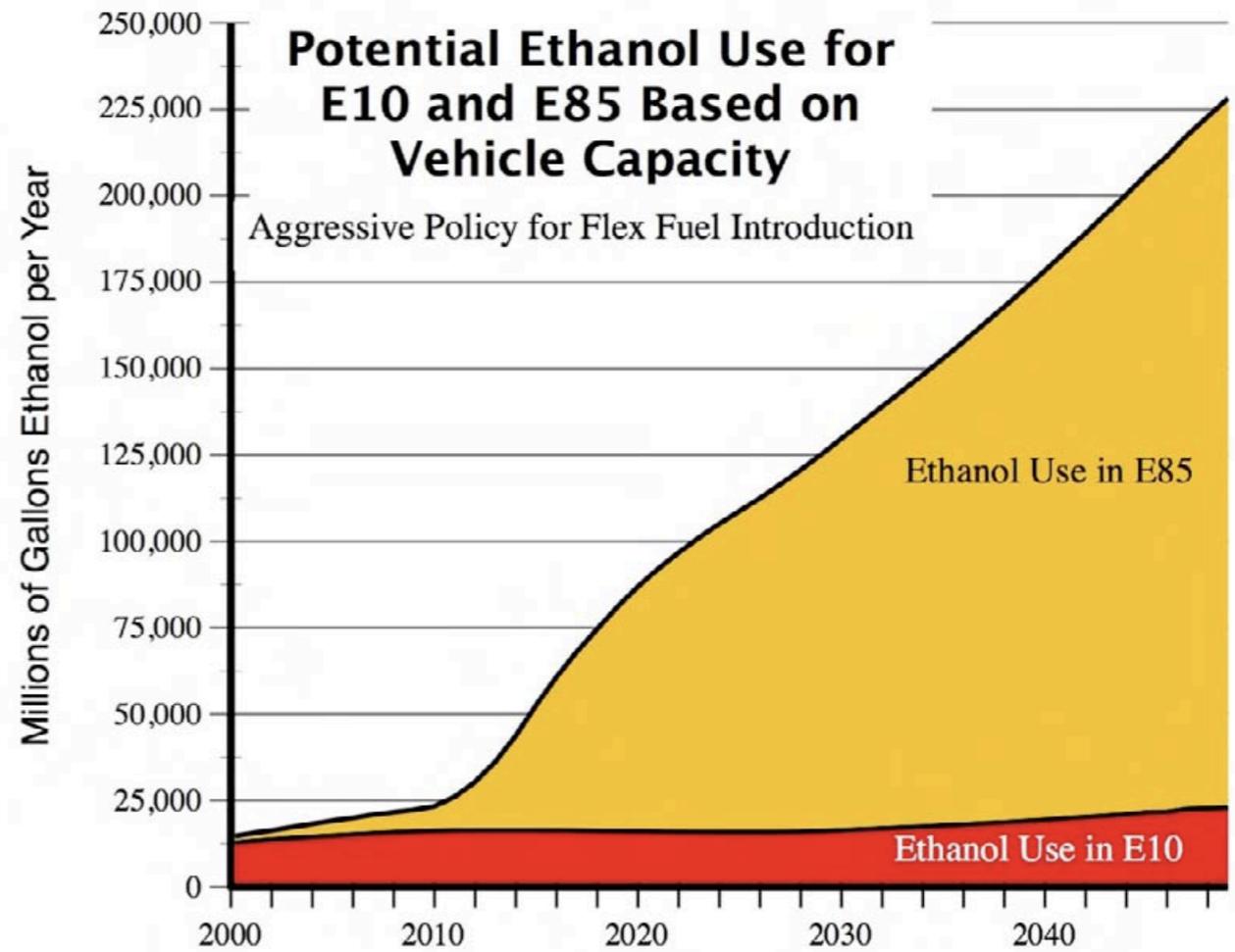
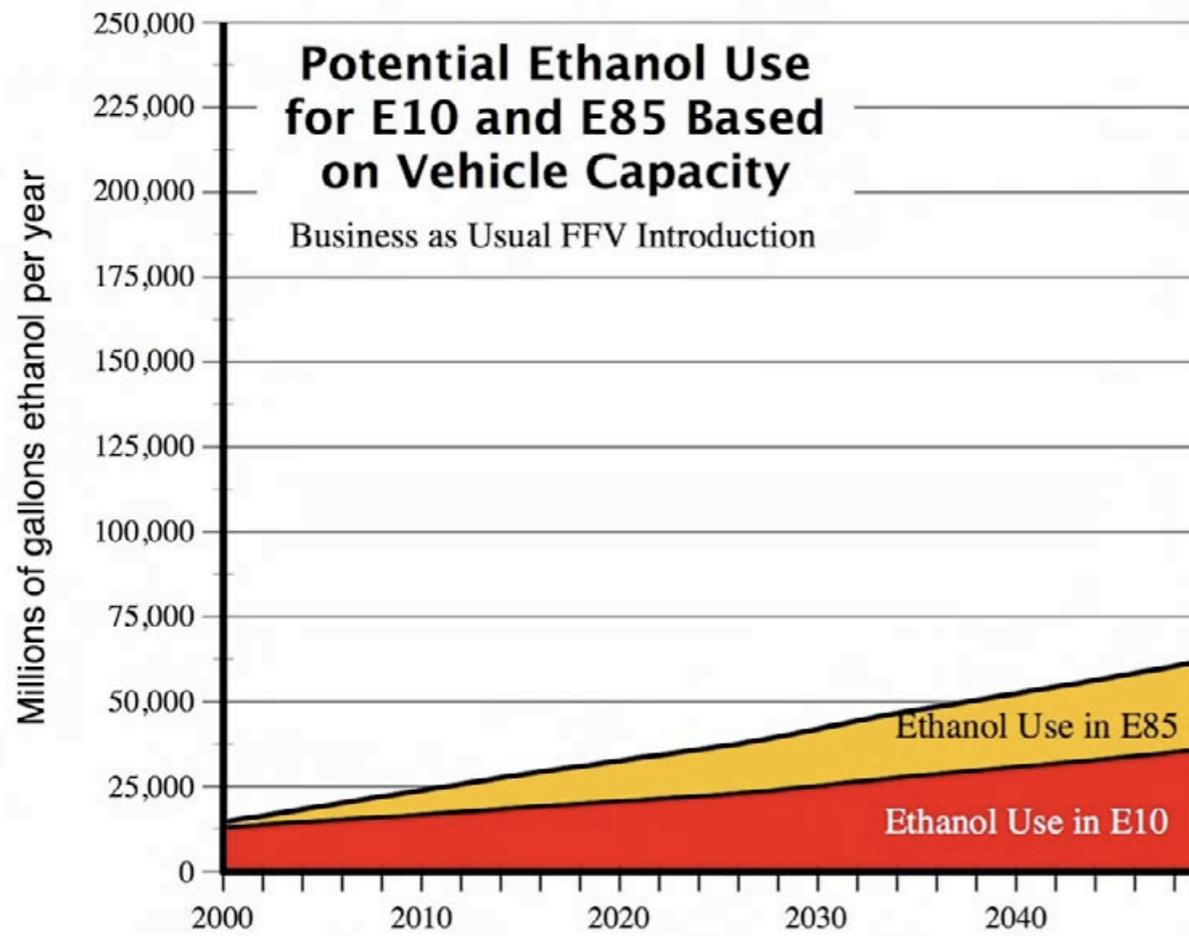
# Technology cost targets

The President's  
initiative sets the  
midterm goal as  
piloted technology  
available in the year  
2012

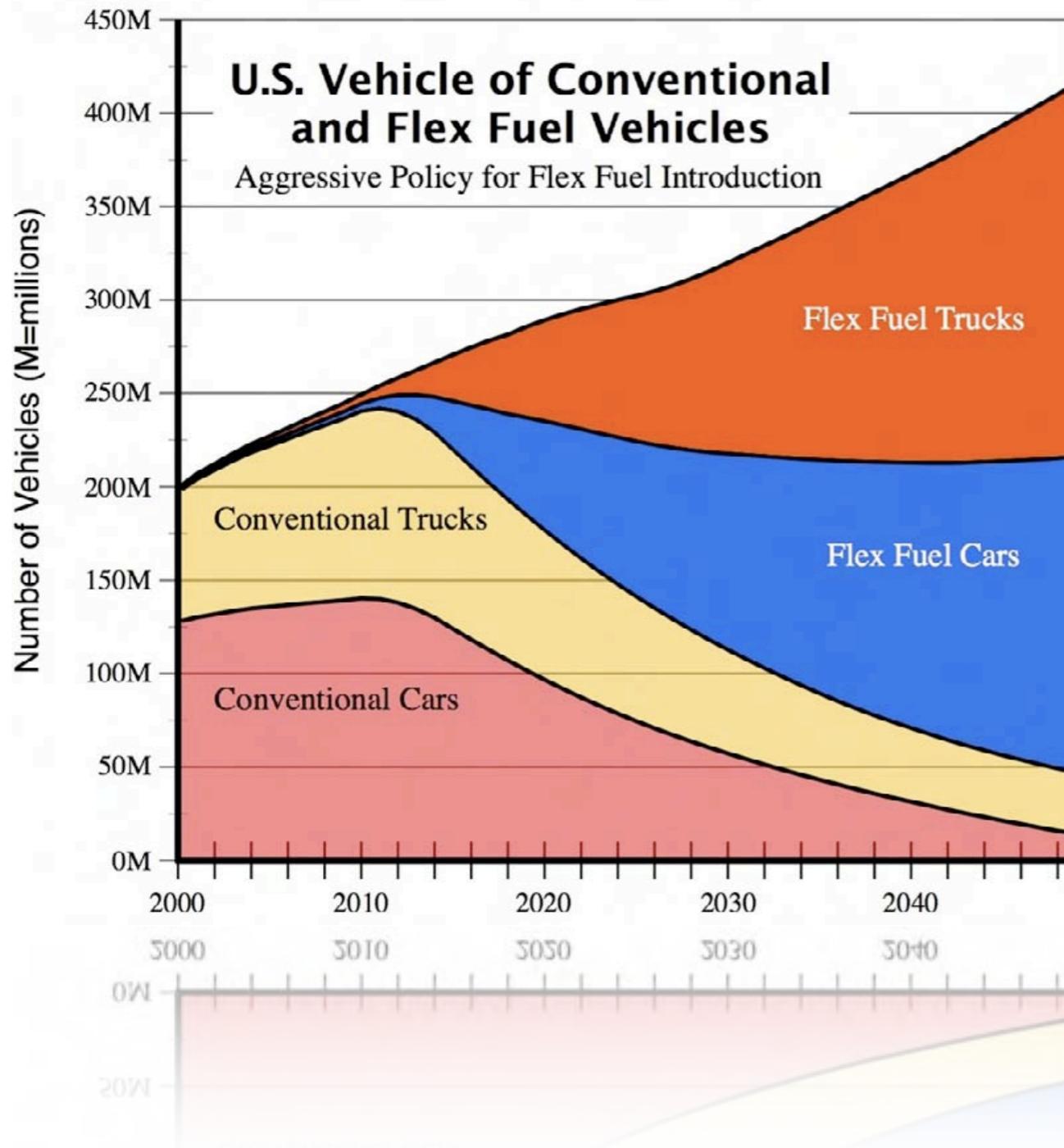
**Mature technology  
could be available as  
early as 2020**

# The biomass transition





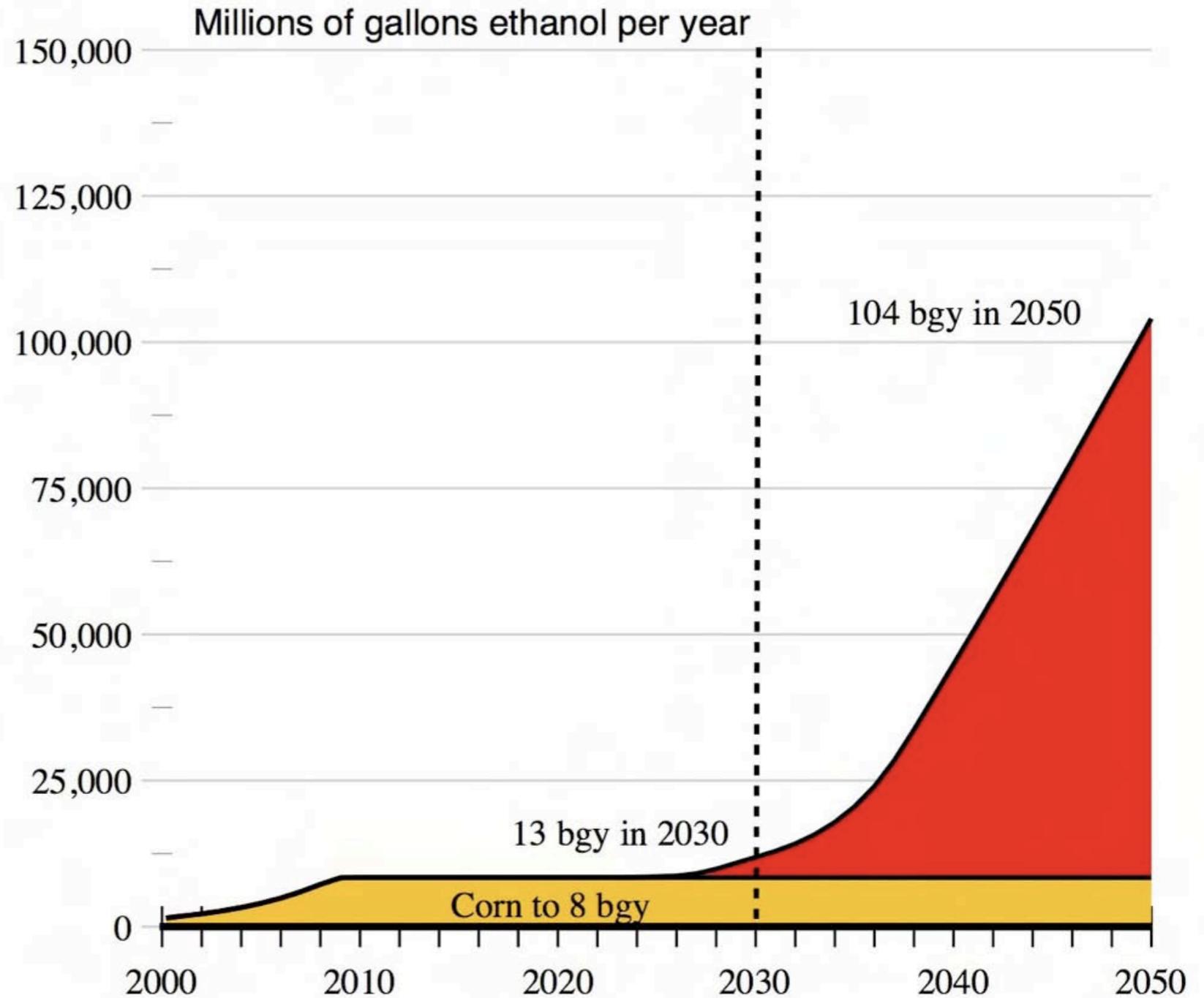
# Fuel market



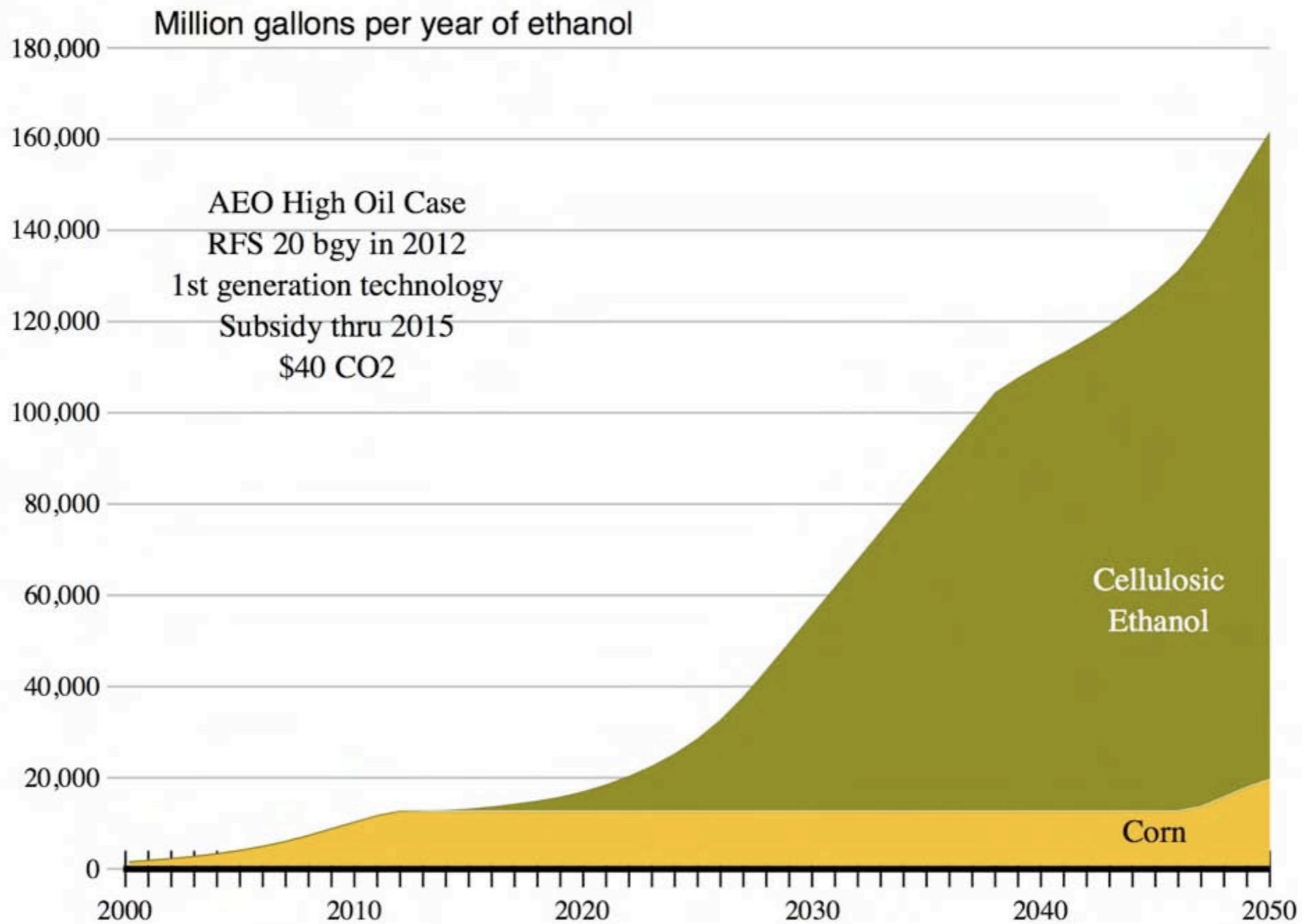
Vehicle fleet turnover model aggressive FFV introduction policy  
Ignores fuel delivery infrastructure

**Fuel market**

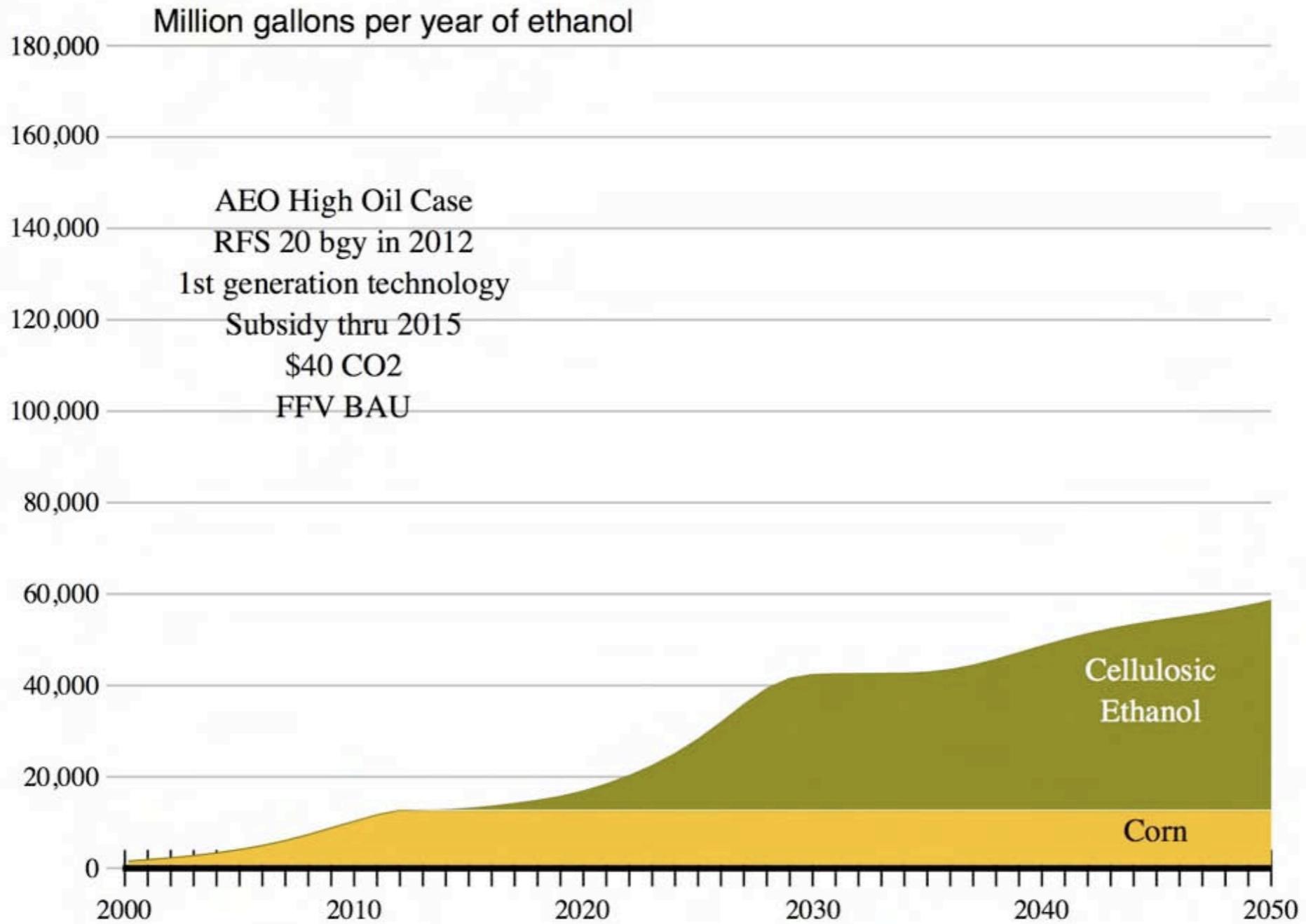
# Reference case oil future and no policy changes



# High Oil Policy Option



# FFV BAU



# Thinking big

Some day I  
want to  
replace my  
gasoline-  
electric  
hybrid  
vehicle...



# Thinking big

...with a  
biofuels-  
electric  
hybrid that  
does as  
well or  
better than  
my current  
70 mpg





I prefer to drive looking forward,  
not backward