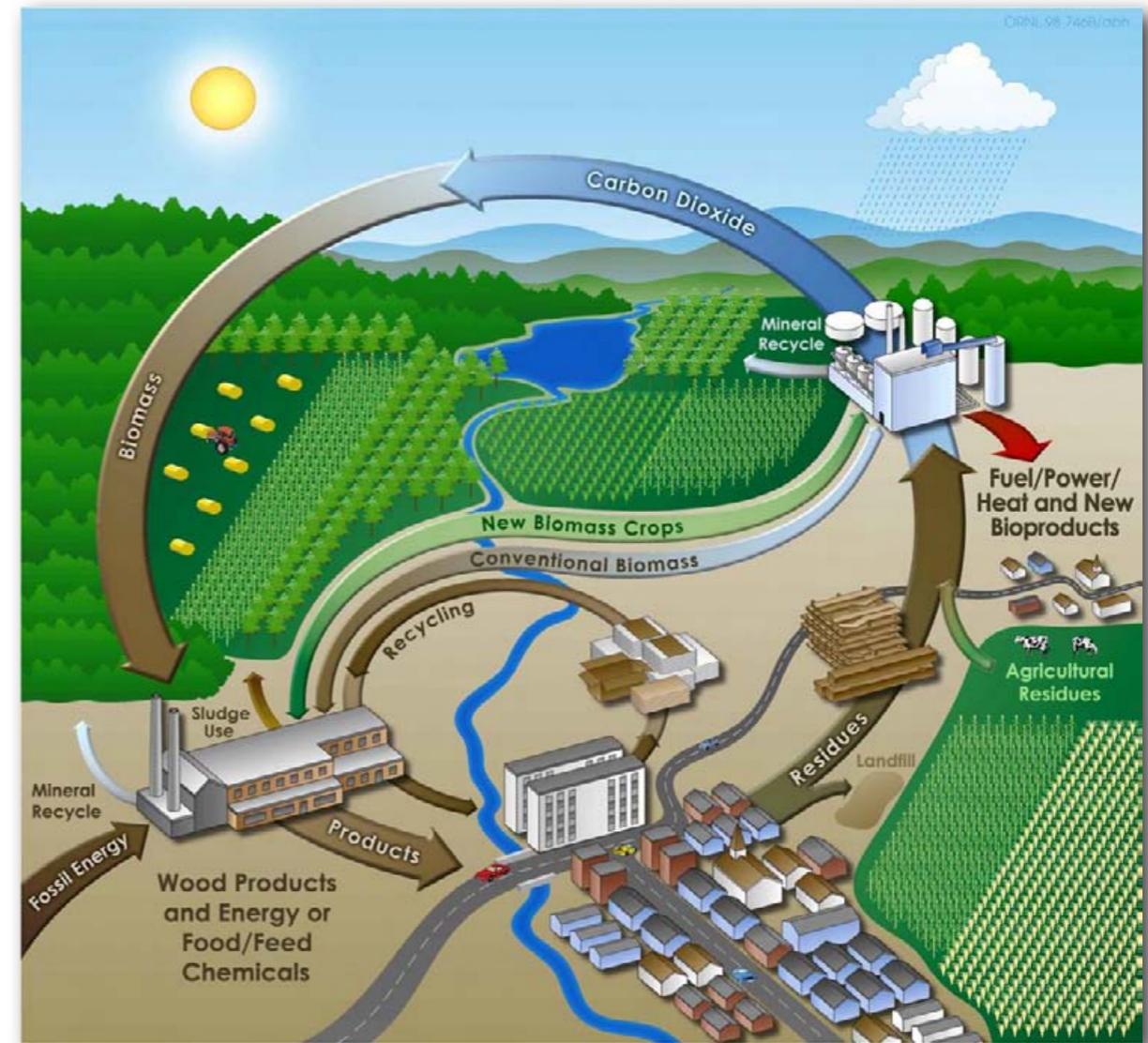


Biofuels Emerging Technology and Economics

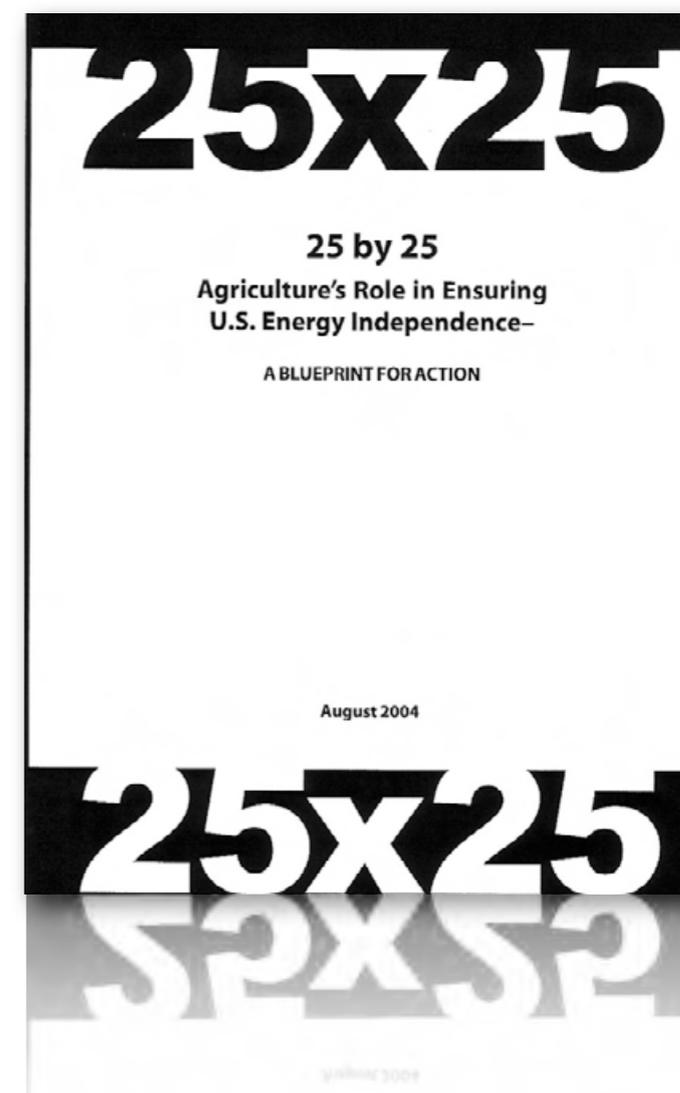
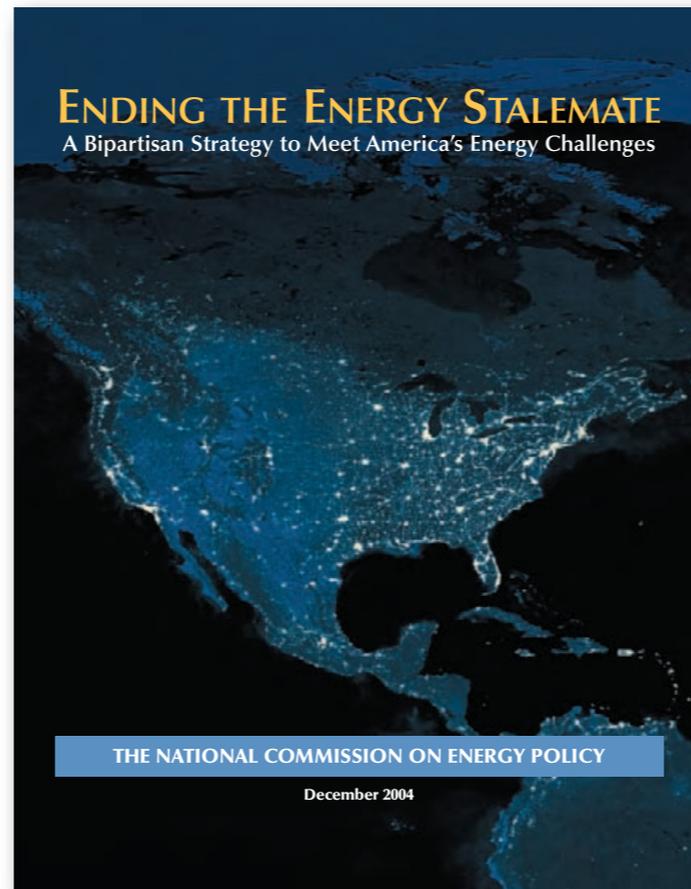
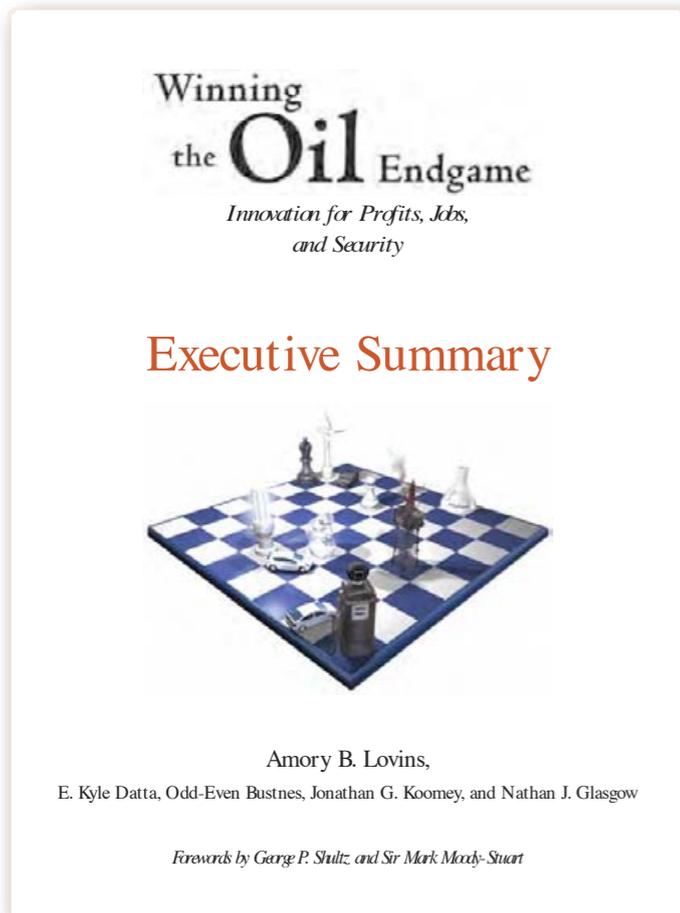
John Sheehan
Strategic Energy Analysis
Center
May 18, 2006



Overview

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

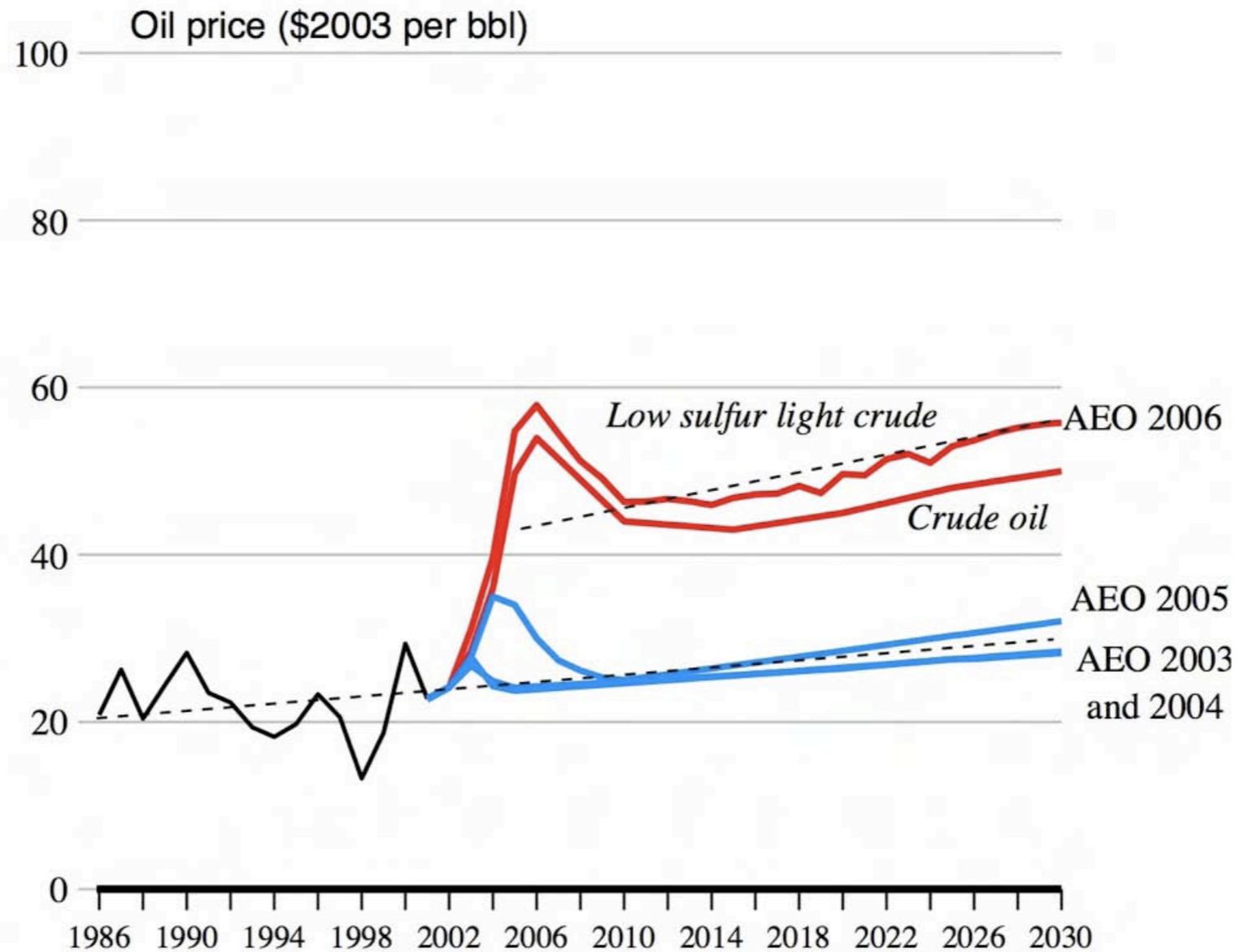




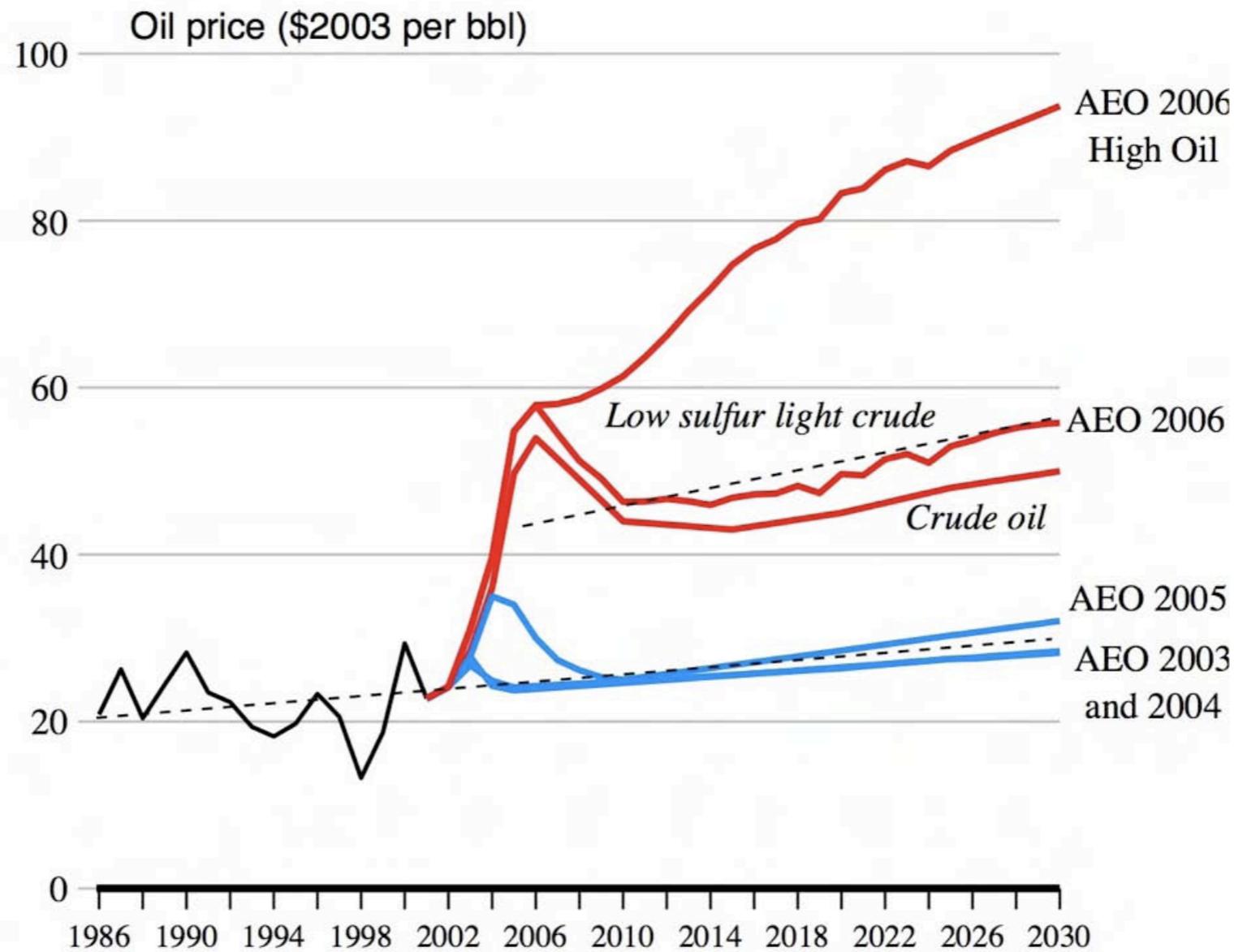
**A brave new world
for energy**



**A brave new world
for energy**

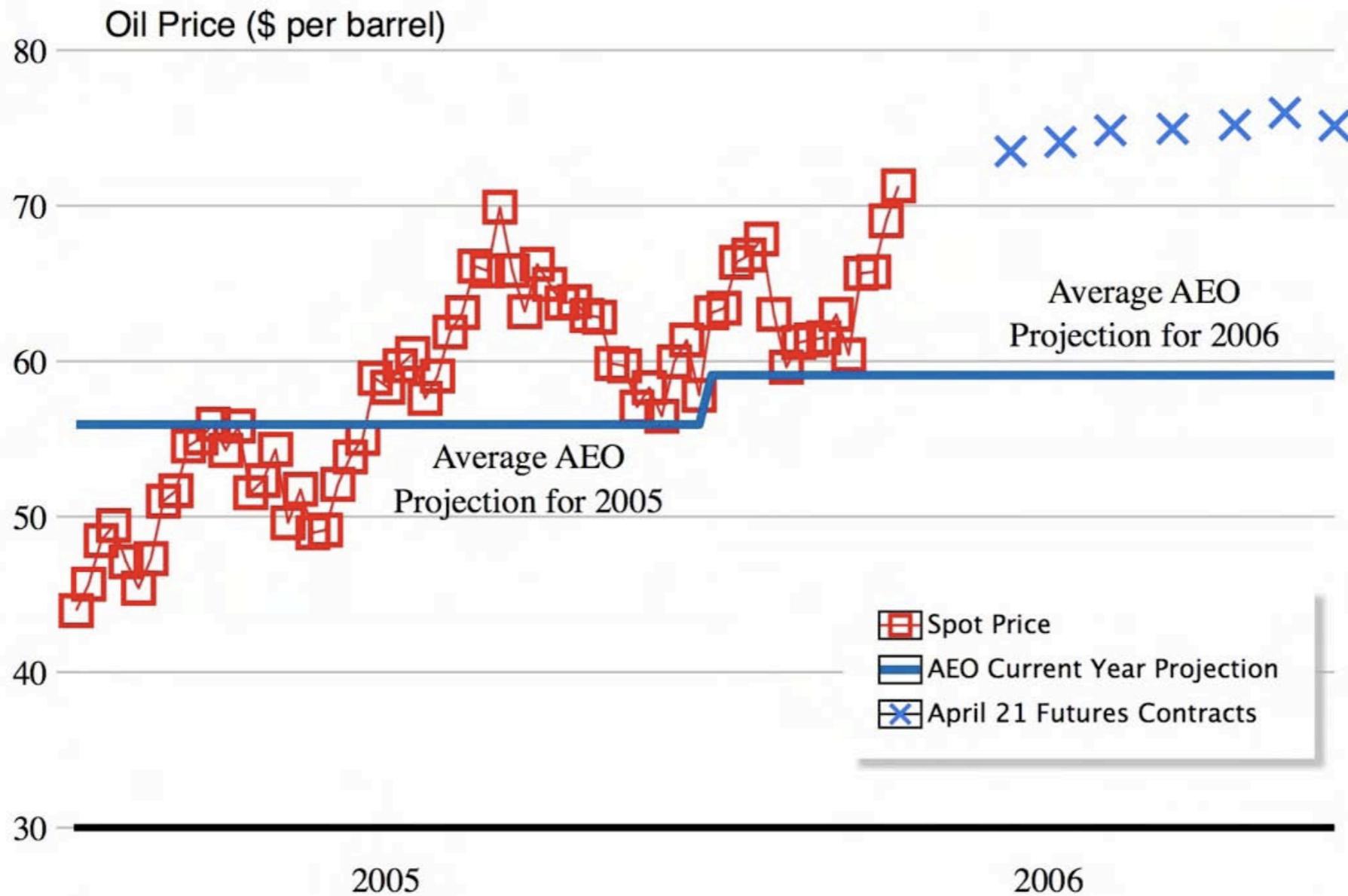


A sea change for oil

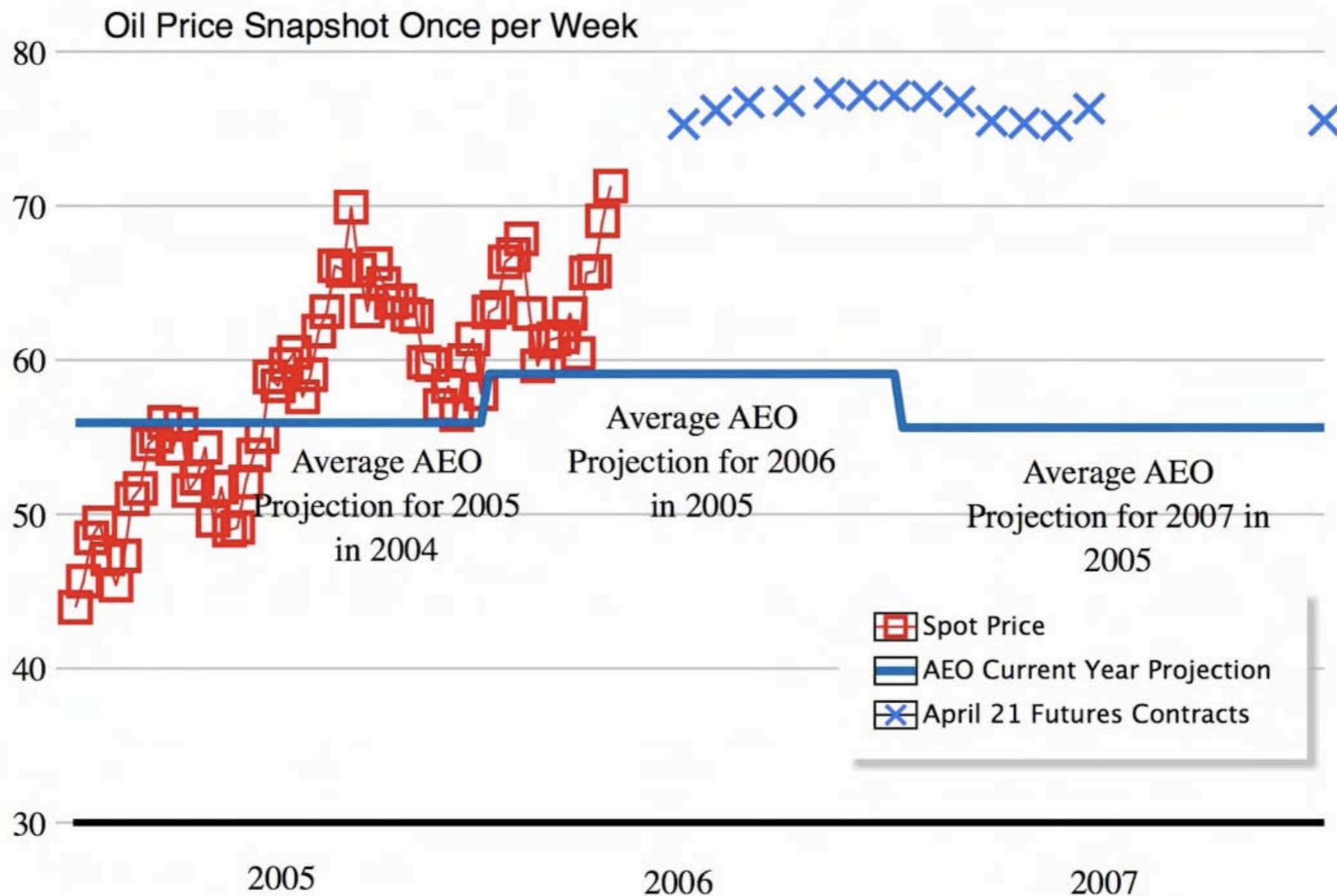


A sea change for oil

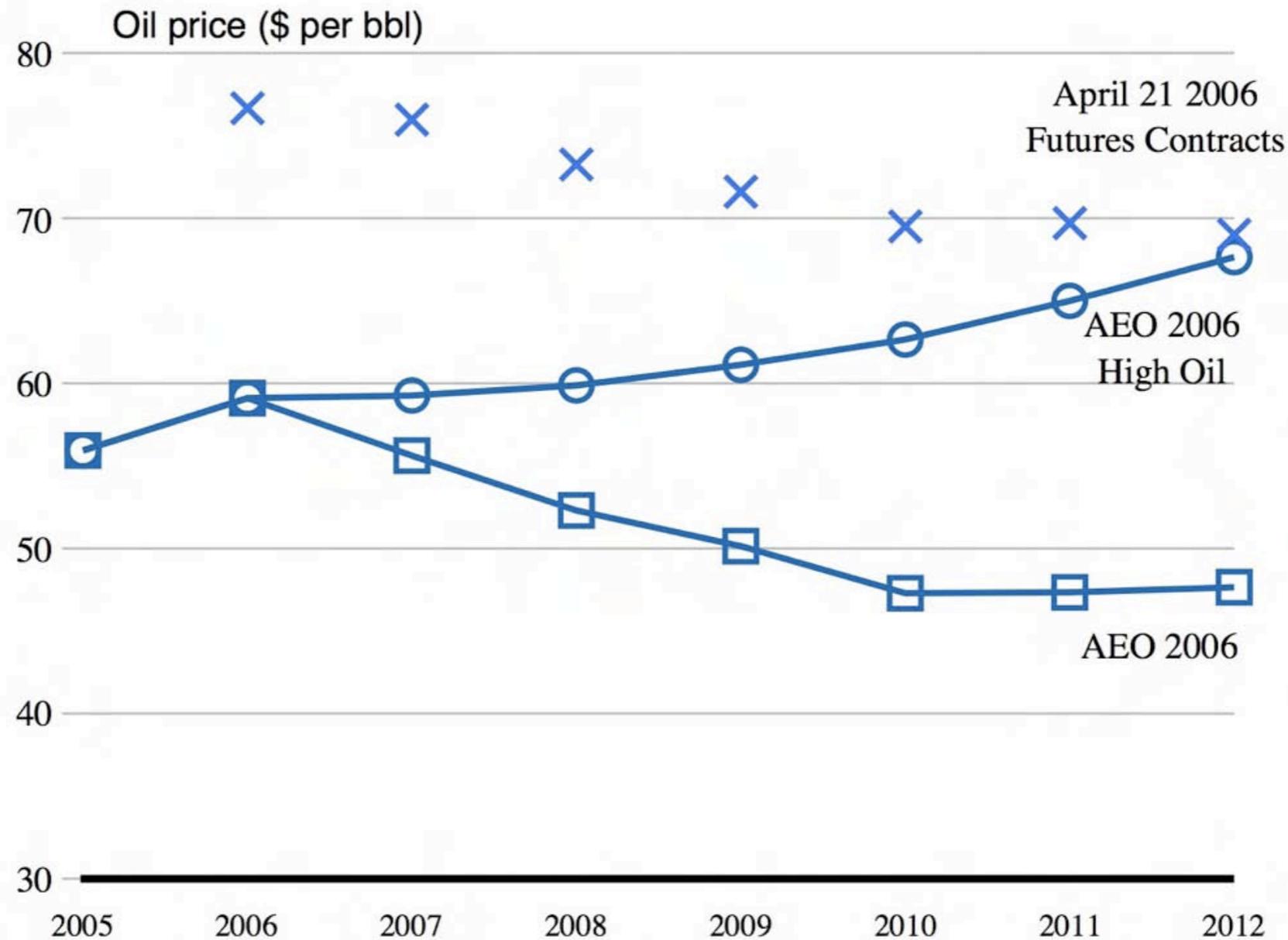
Should we believe
the reference case or
the high oil case?



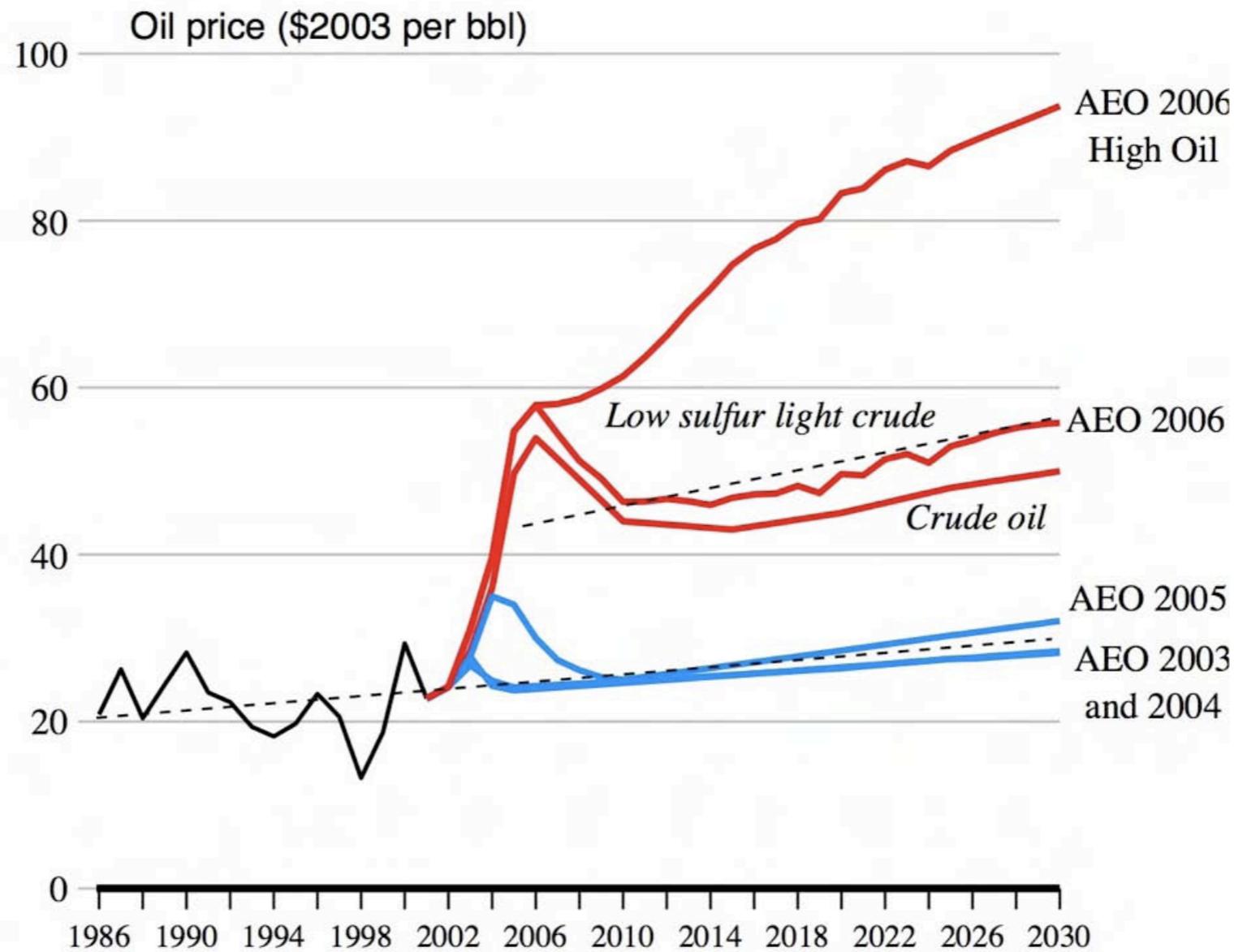
The reference case vs reality



The reference case vs reality



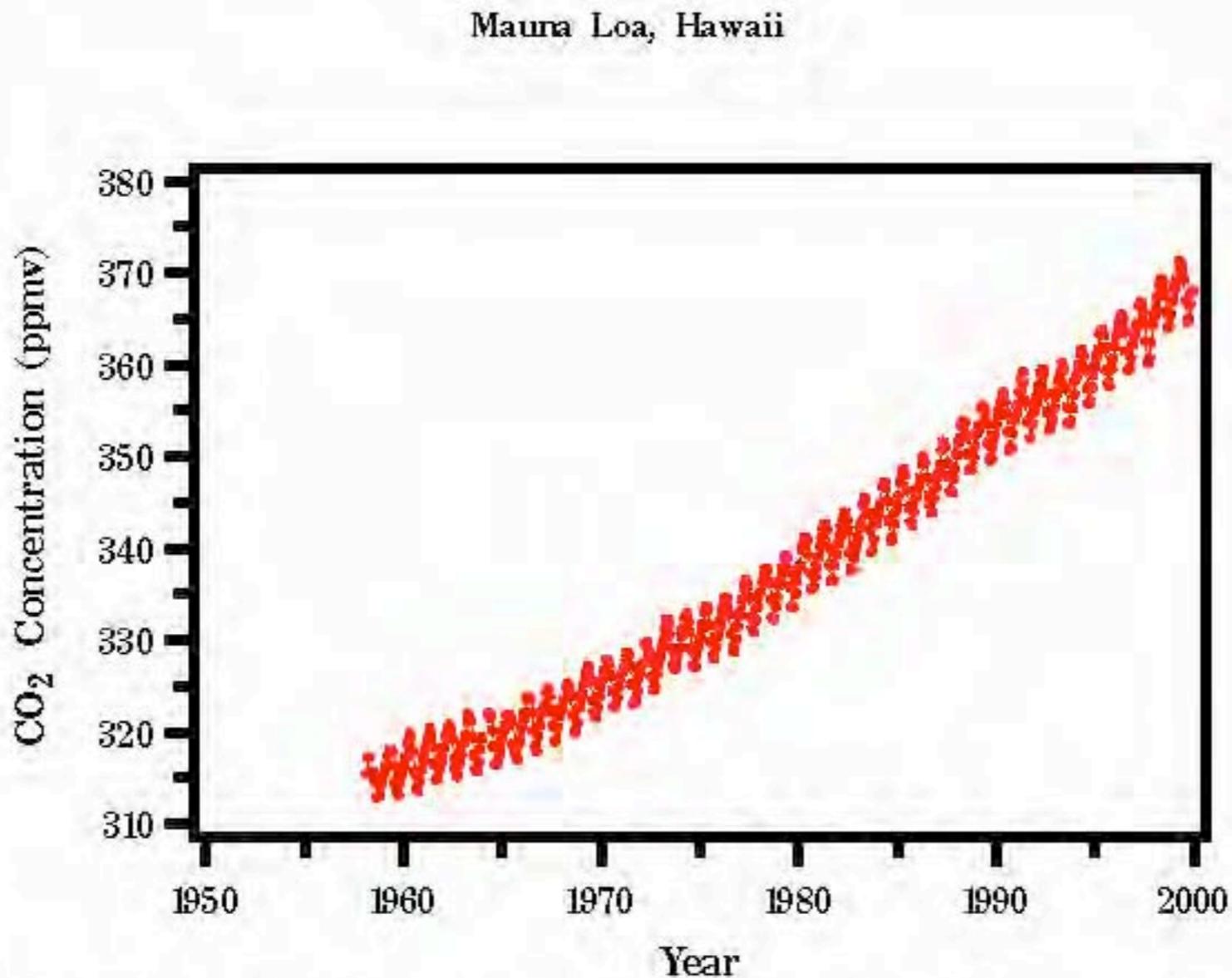
“Futures” & high oil merge



My bet is on high oil

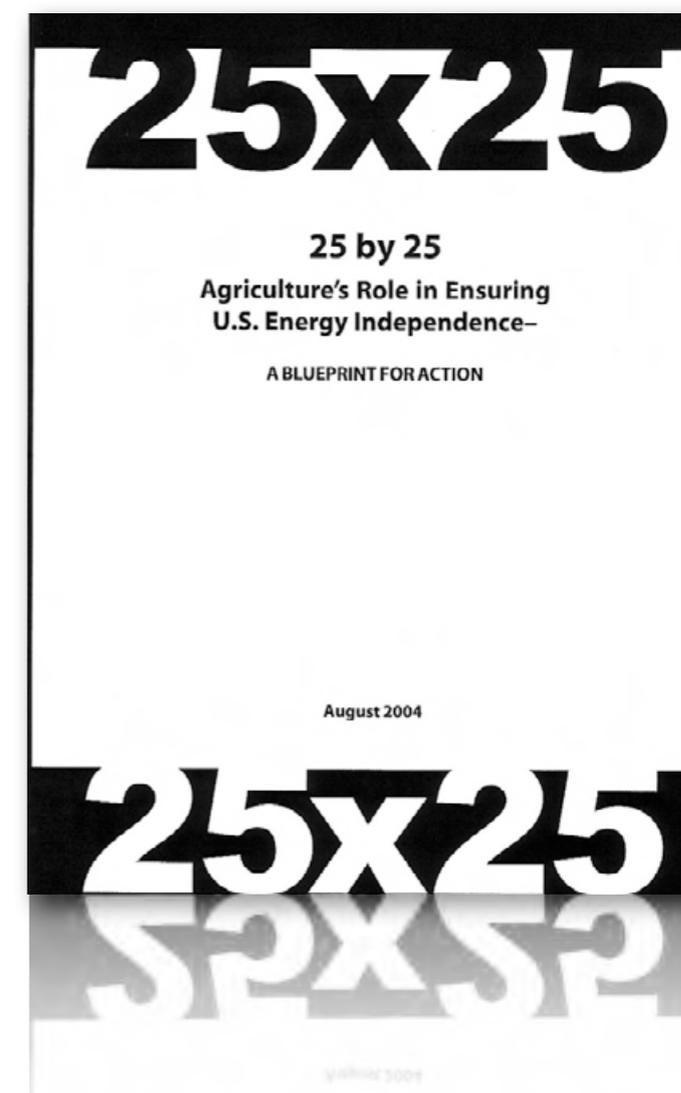
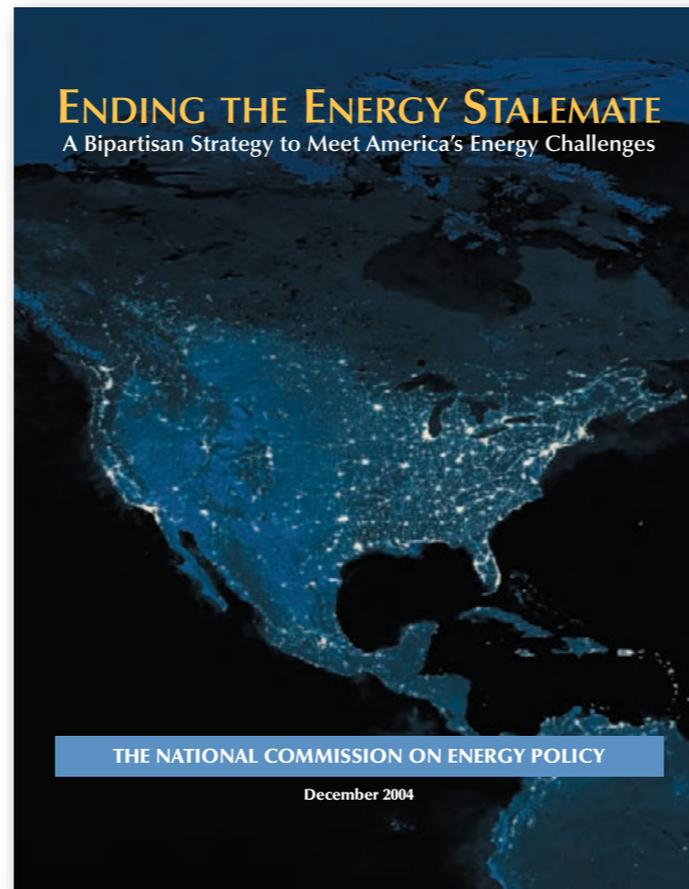
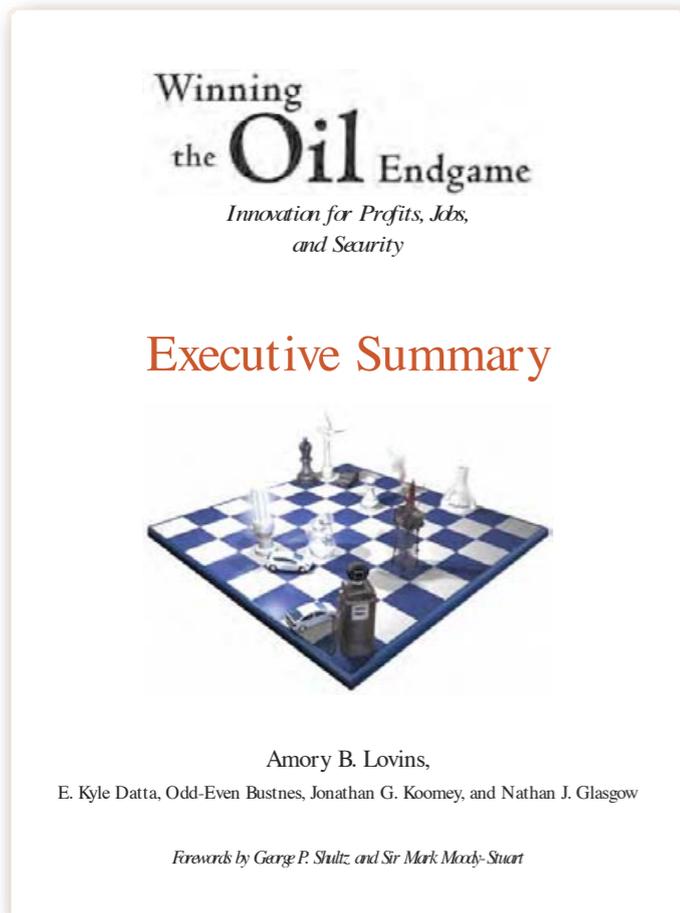


**A brave new world for
the environment**



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

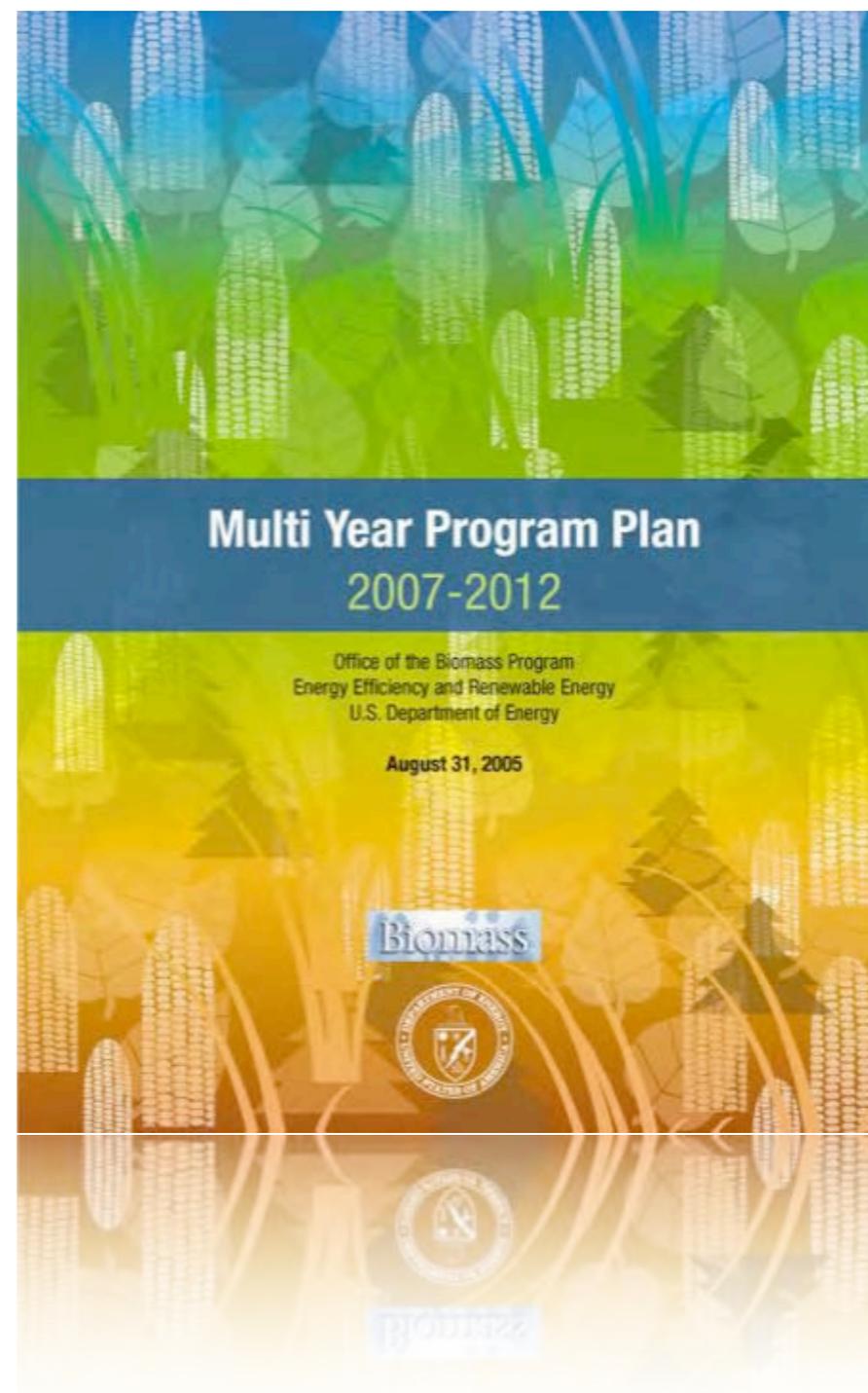
Climate change



A brave new world
for biofuels

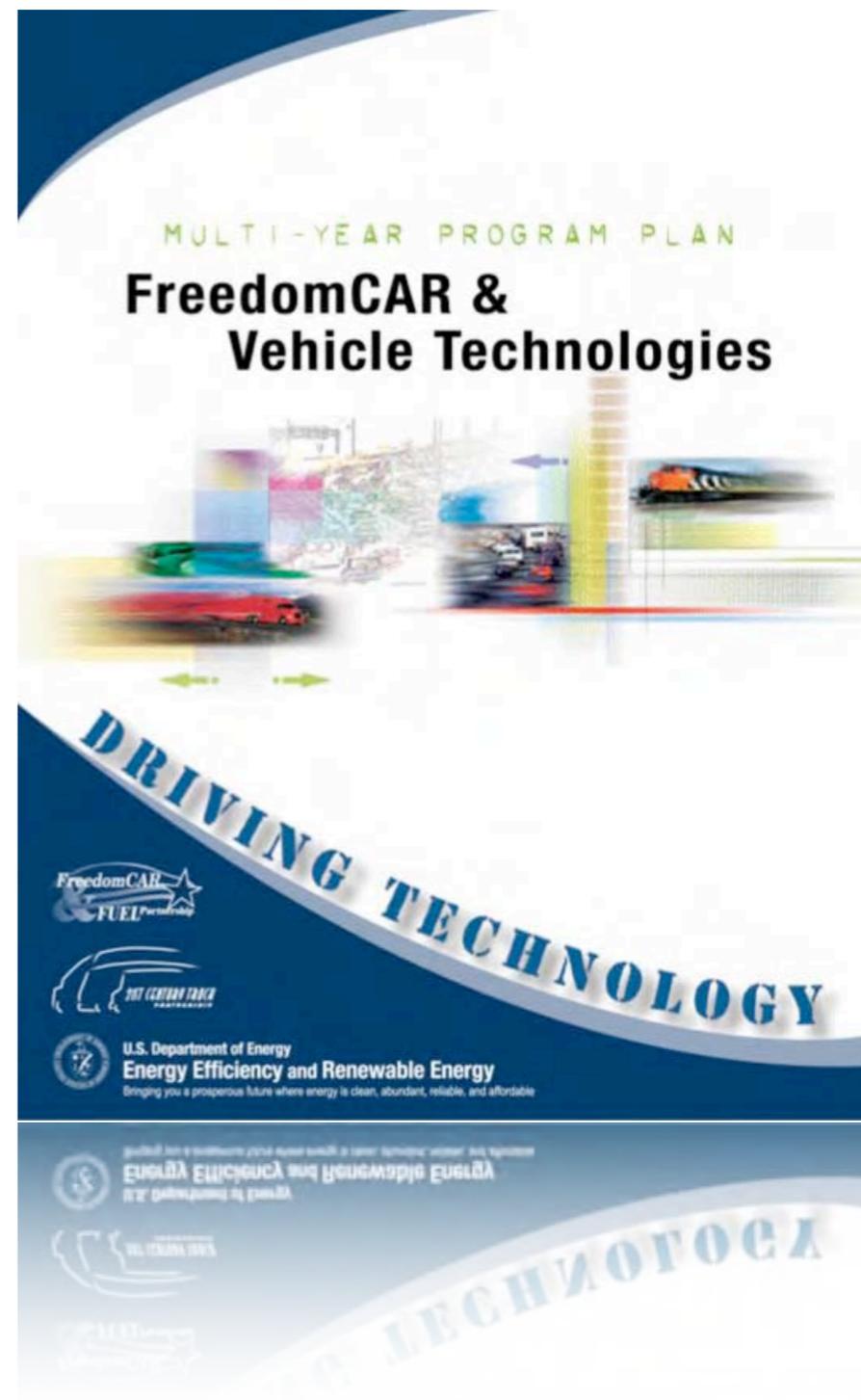
The DOE Biomass Program

www.eere.energy.gov



The DOE Vehicles Program

www.eere.energy.gov



The DOE Hydrogen Program

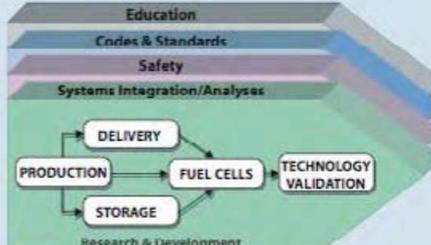
www.eere.energy.gov

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

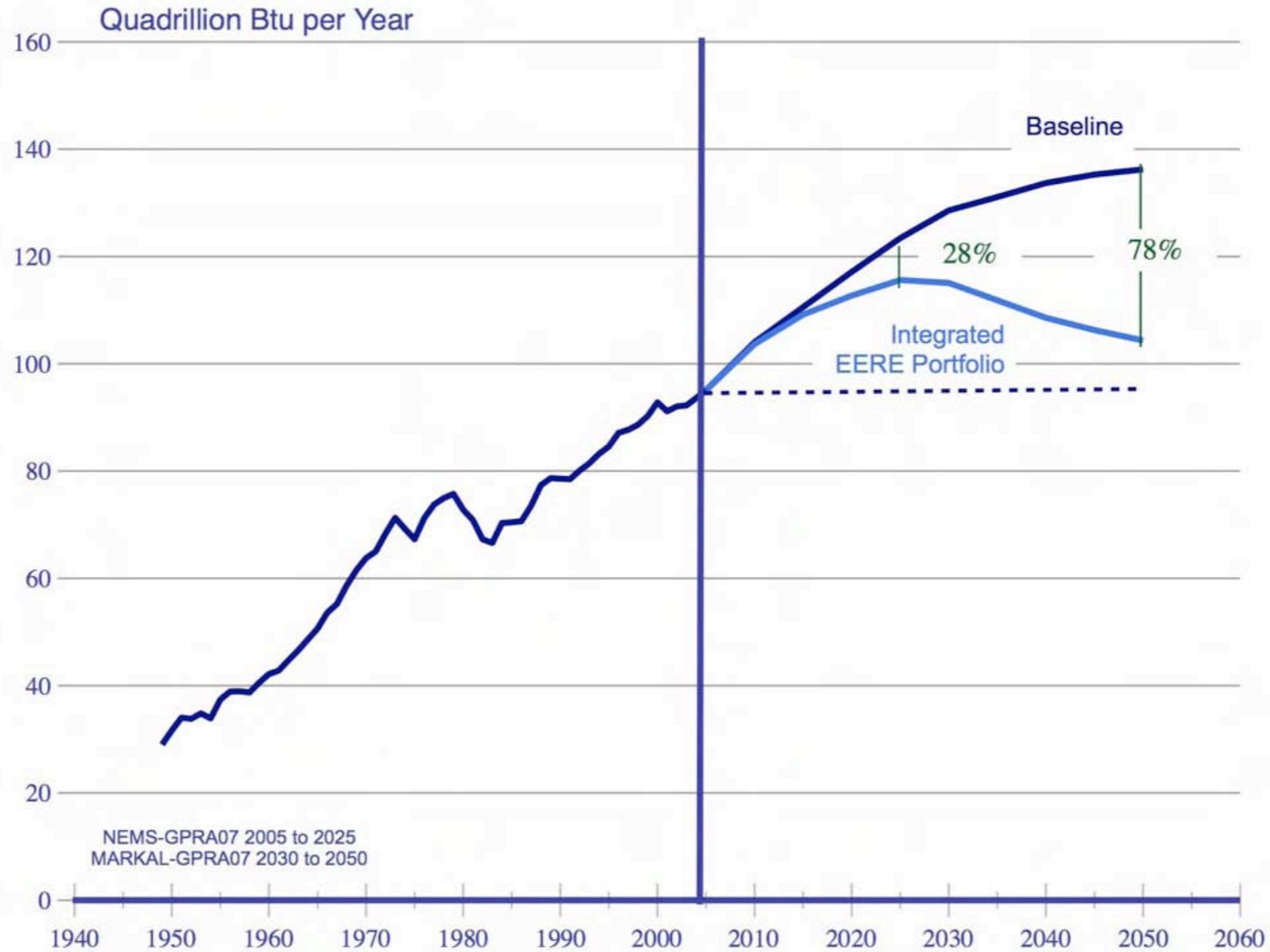
Research & Development



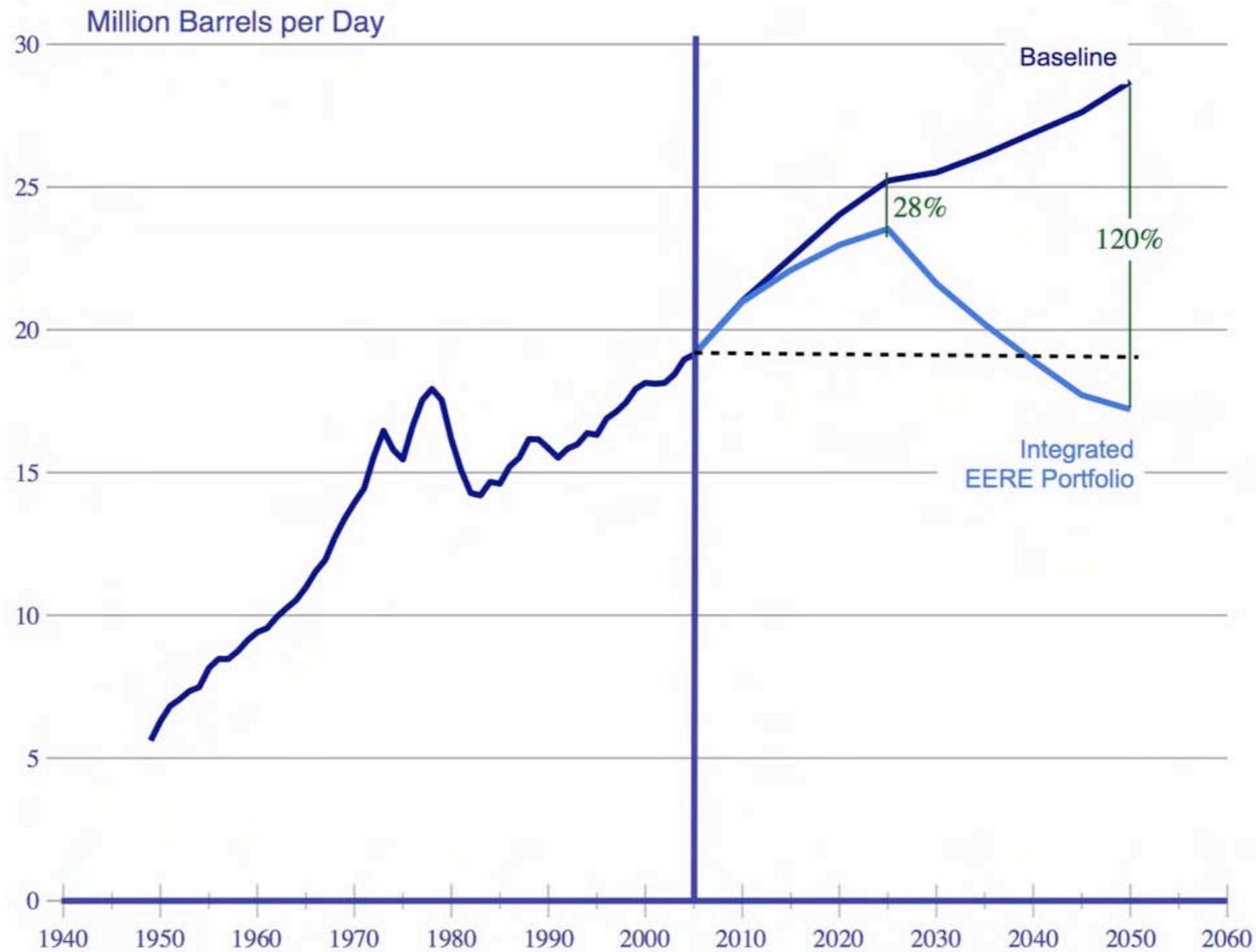
H₂
Economy

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

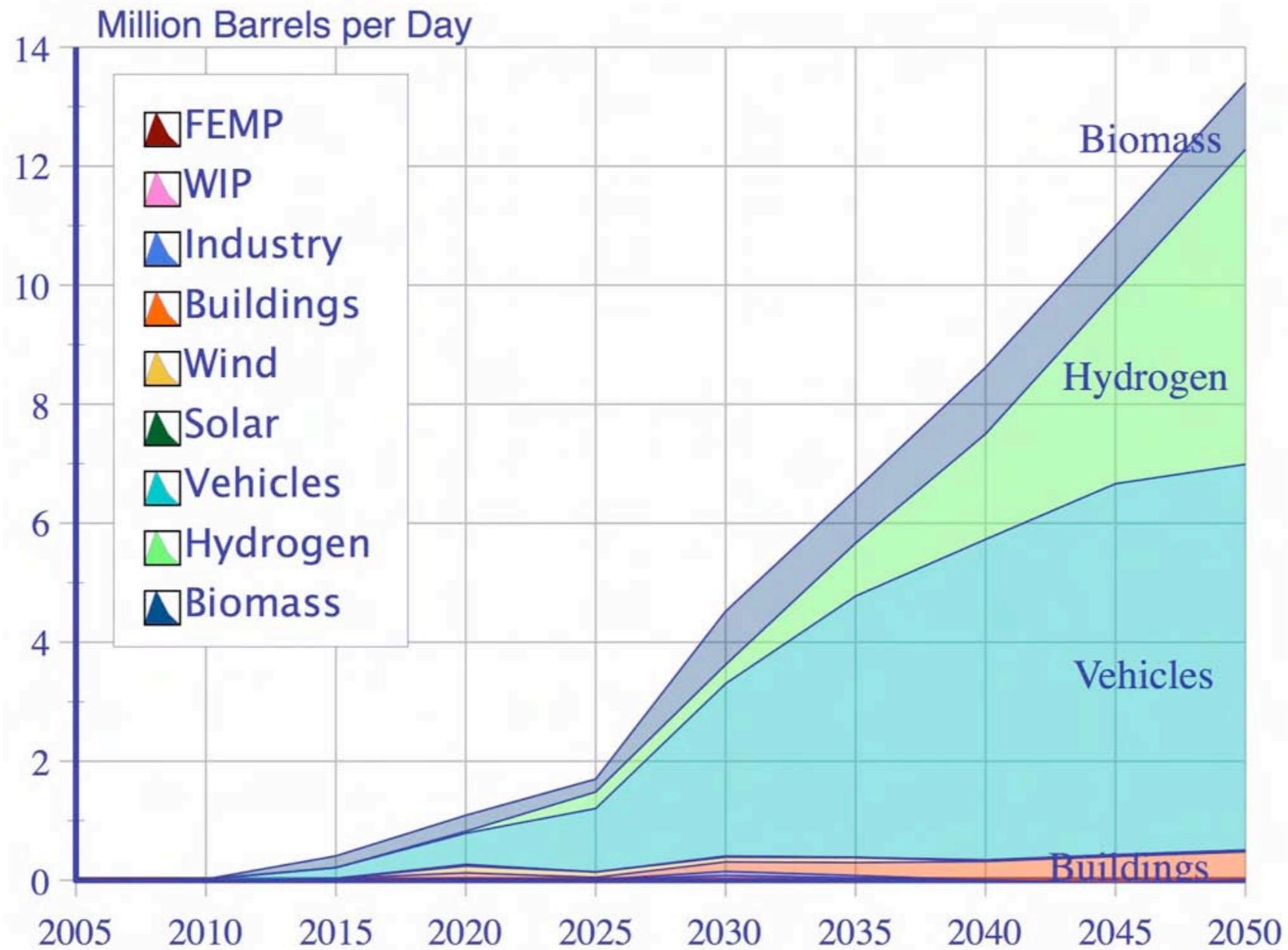
 Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable



Changing our energy future



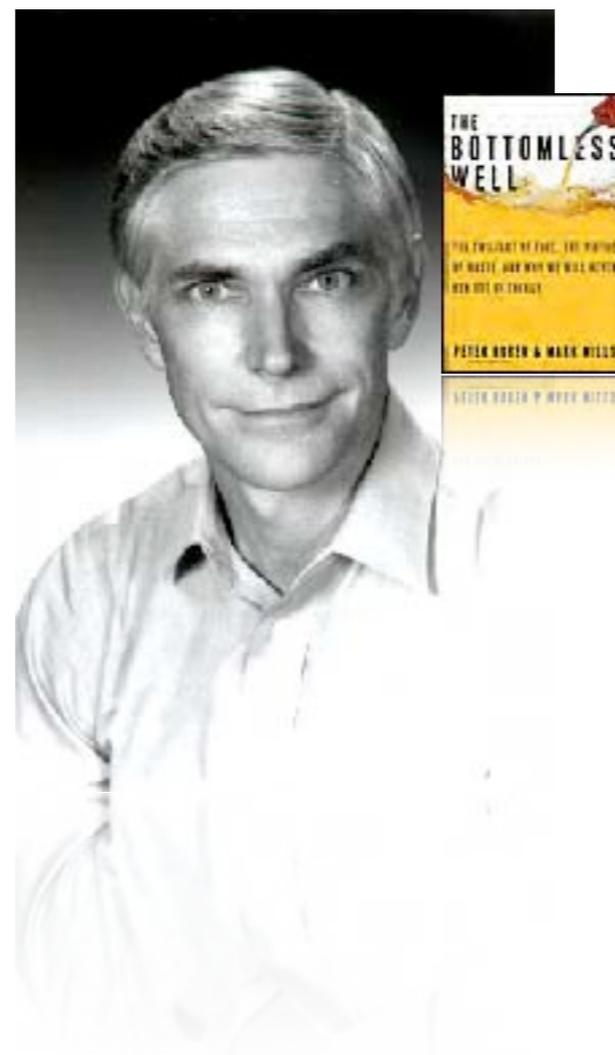
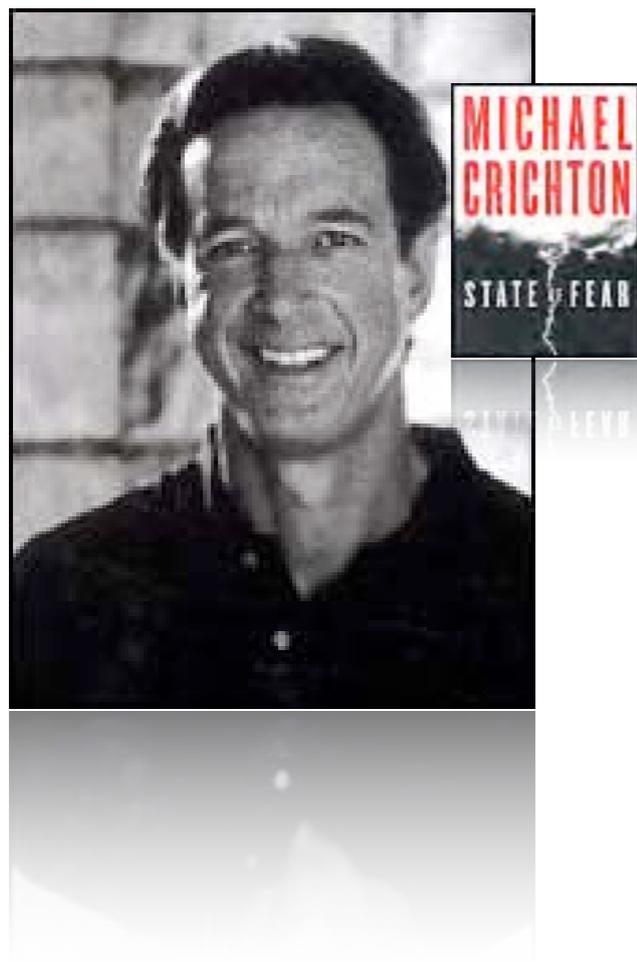
Changing our energy future



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



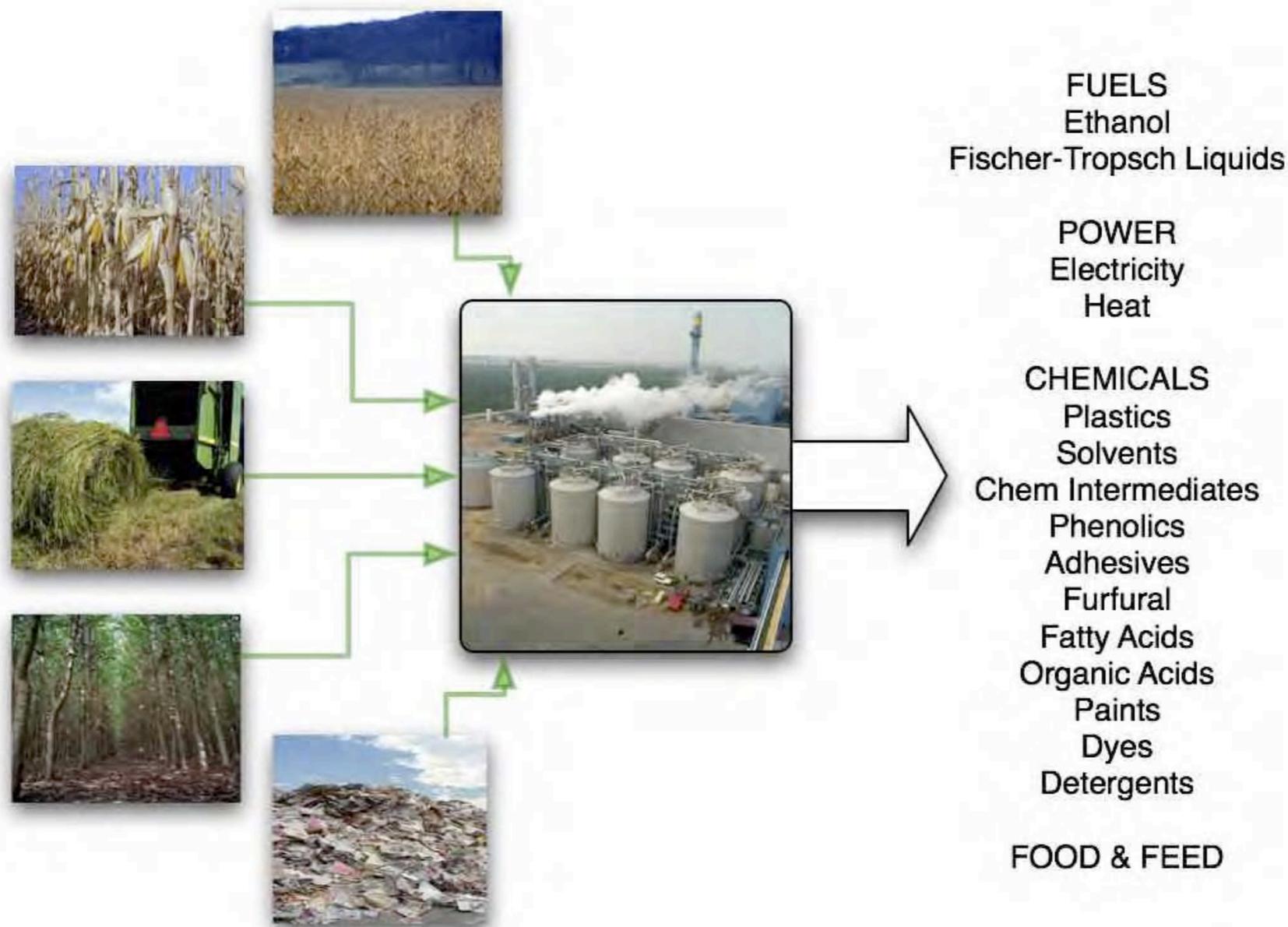
Biomass tomorrow



Biomass tomorrow algae and coal

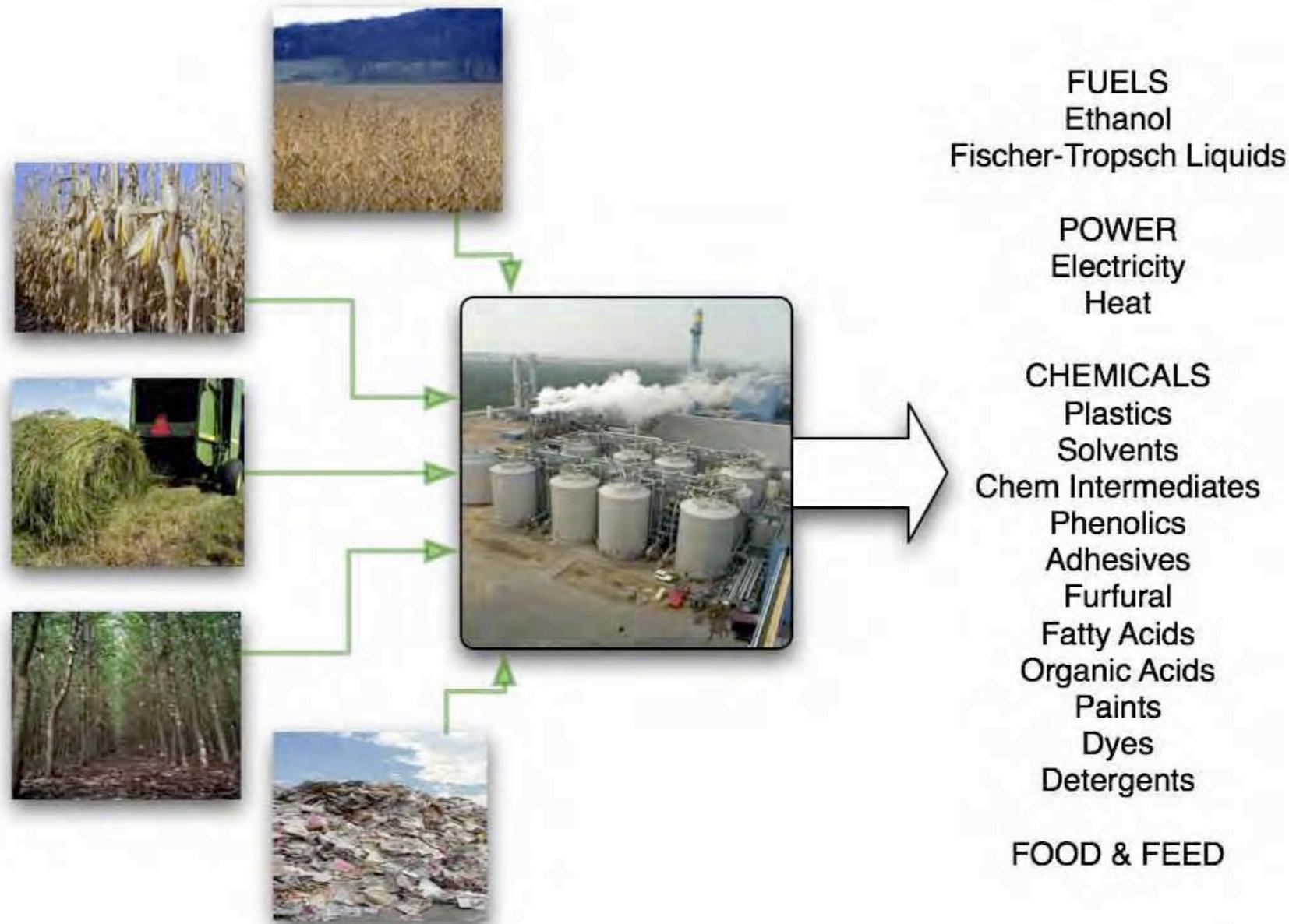
Today grains, oilseeds	Sugars Starch Oilseed lipids
Emerging and future MSW, residues, energy crops	Cellulose Hemicellulose Lignin Algal lipids

Biomass chemistry today and tomorrow



The biorefinery

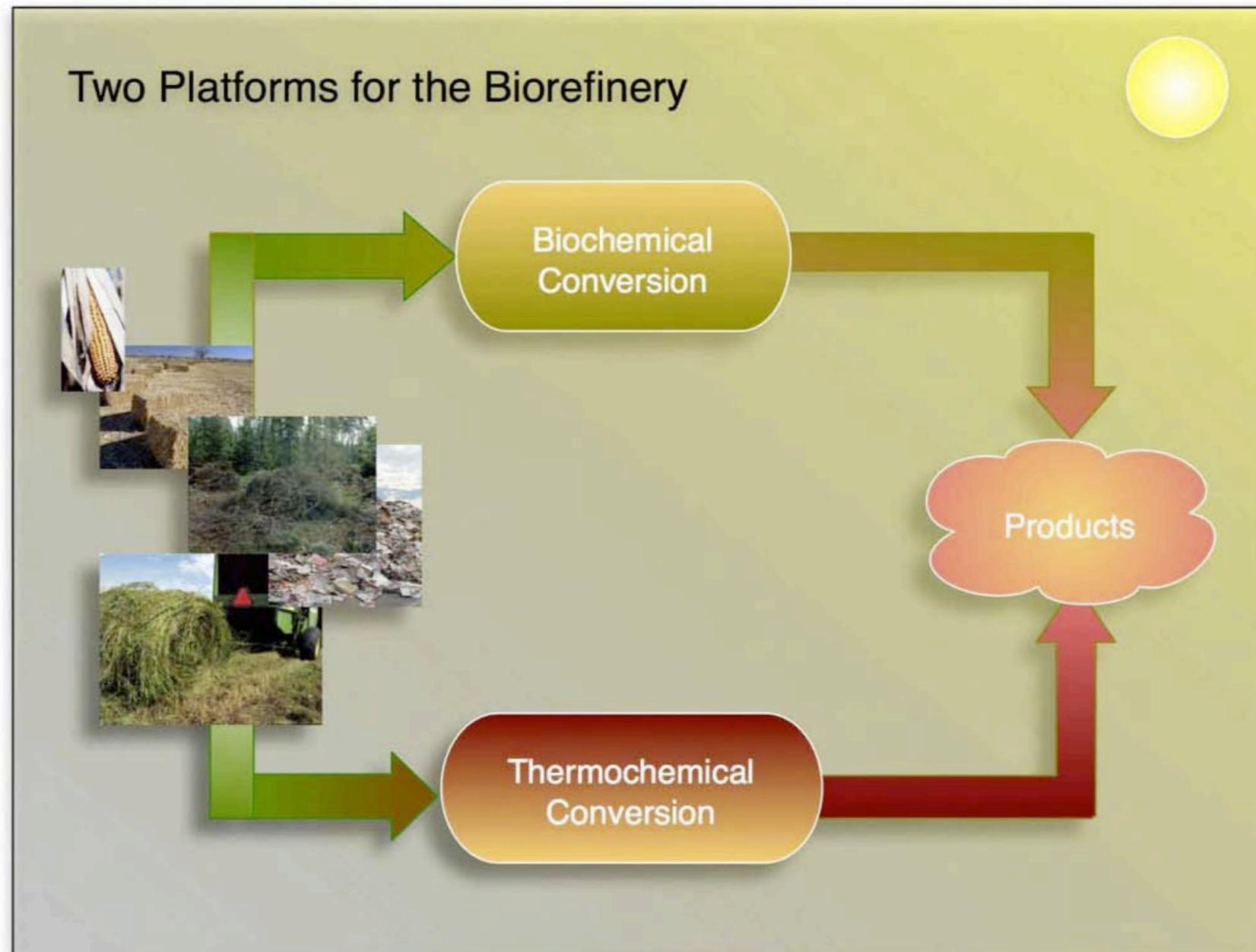
Something for everyone?



The biorefinery Or a case of ADD?

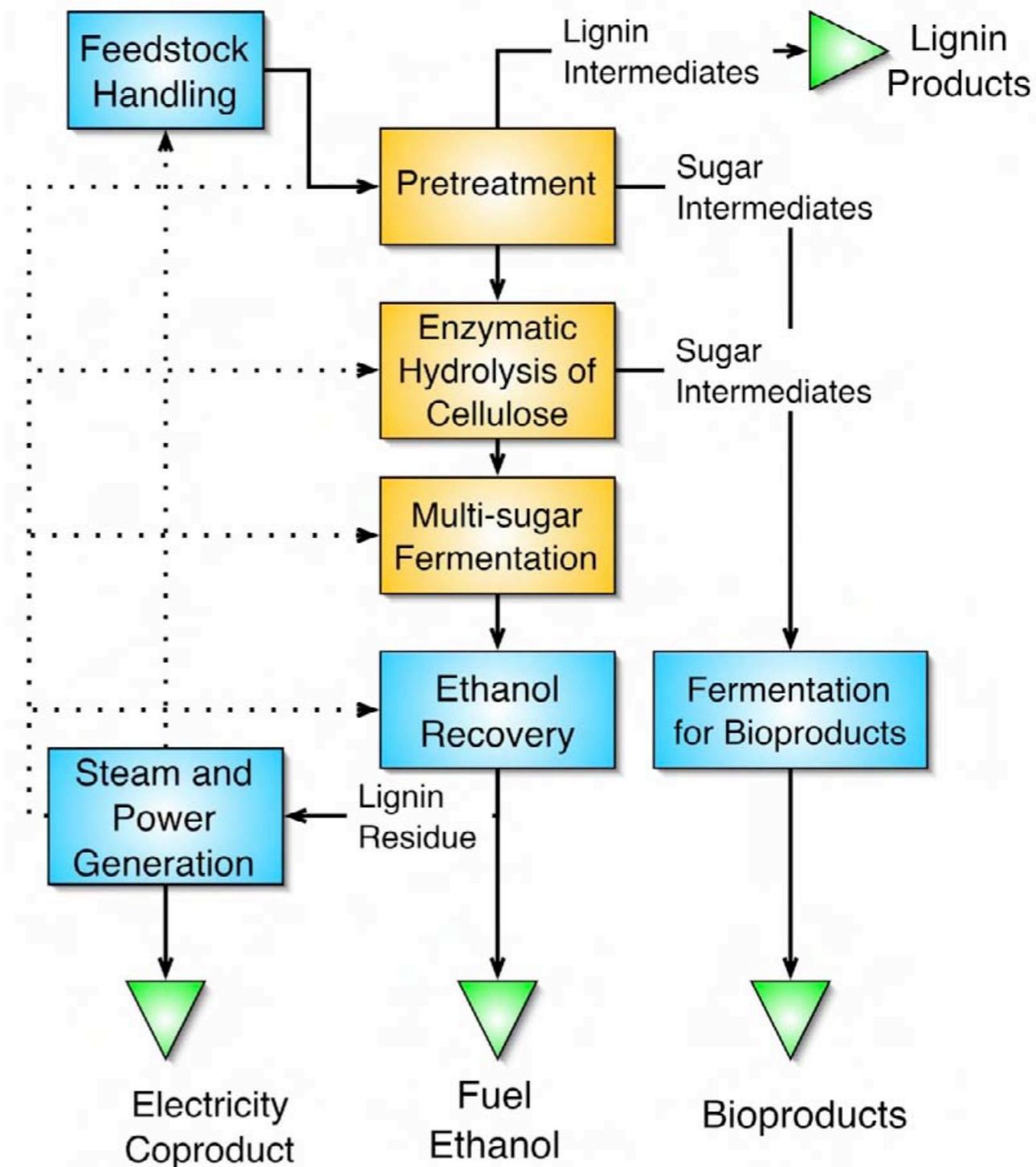
The biorefinery

Two main “flavors”



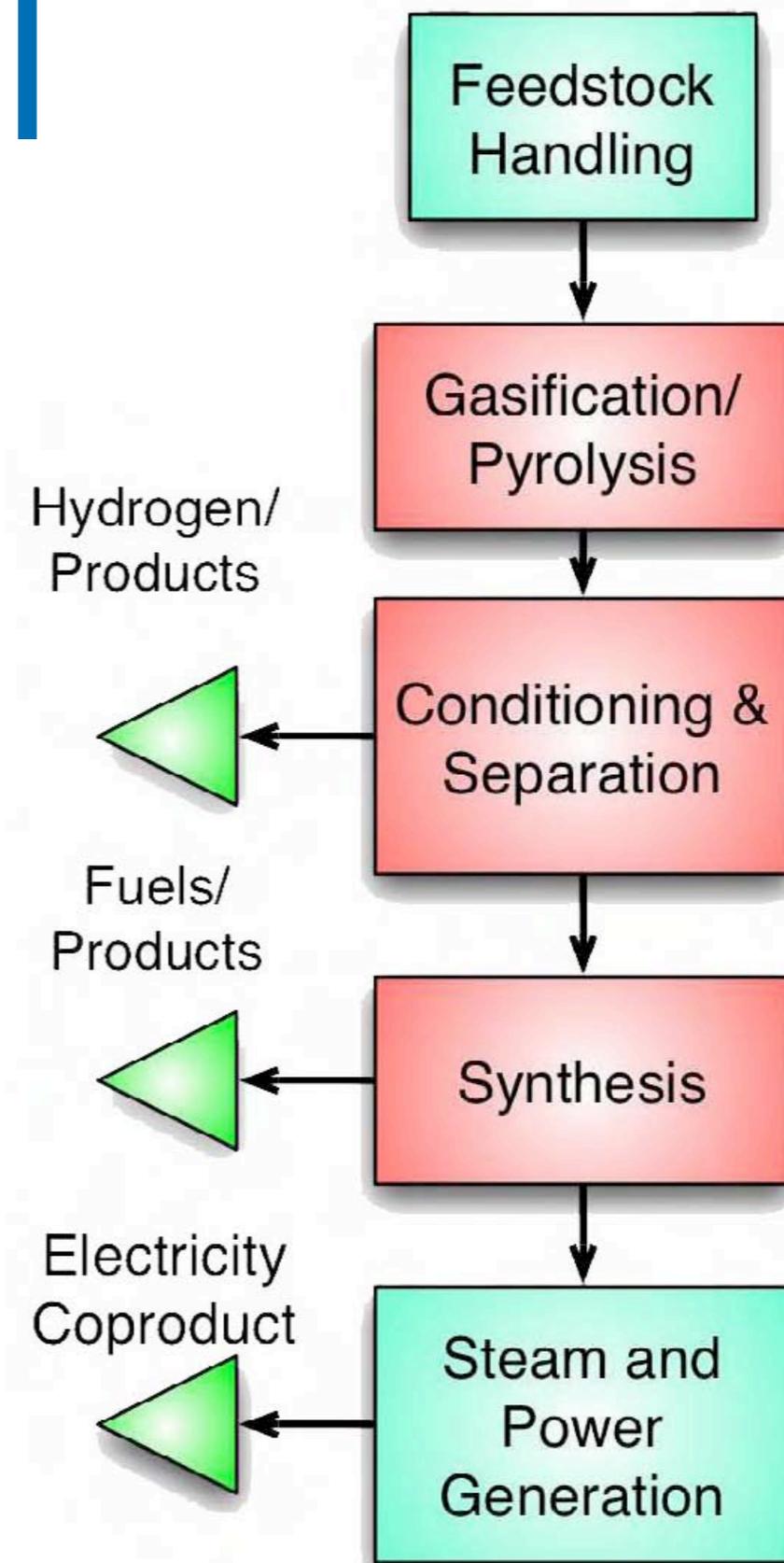
Biochemical platform

- 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

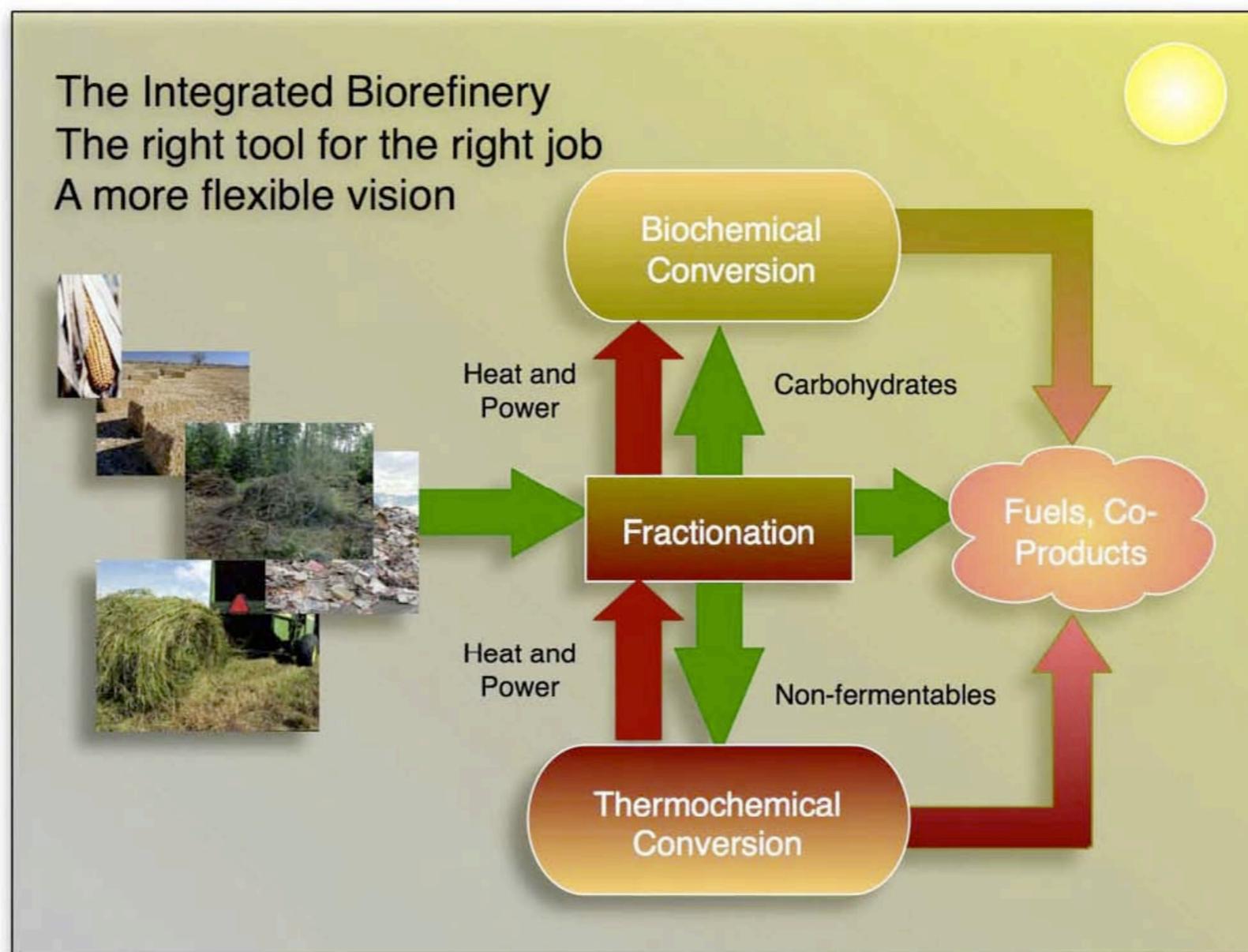


Thermochemical platform

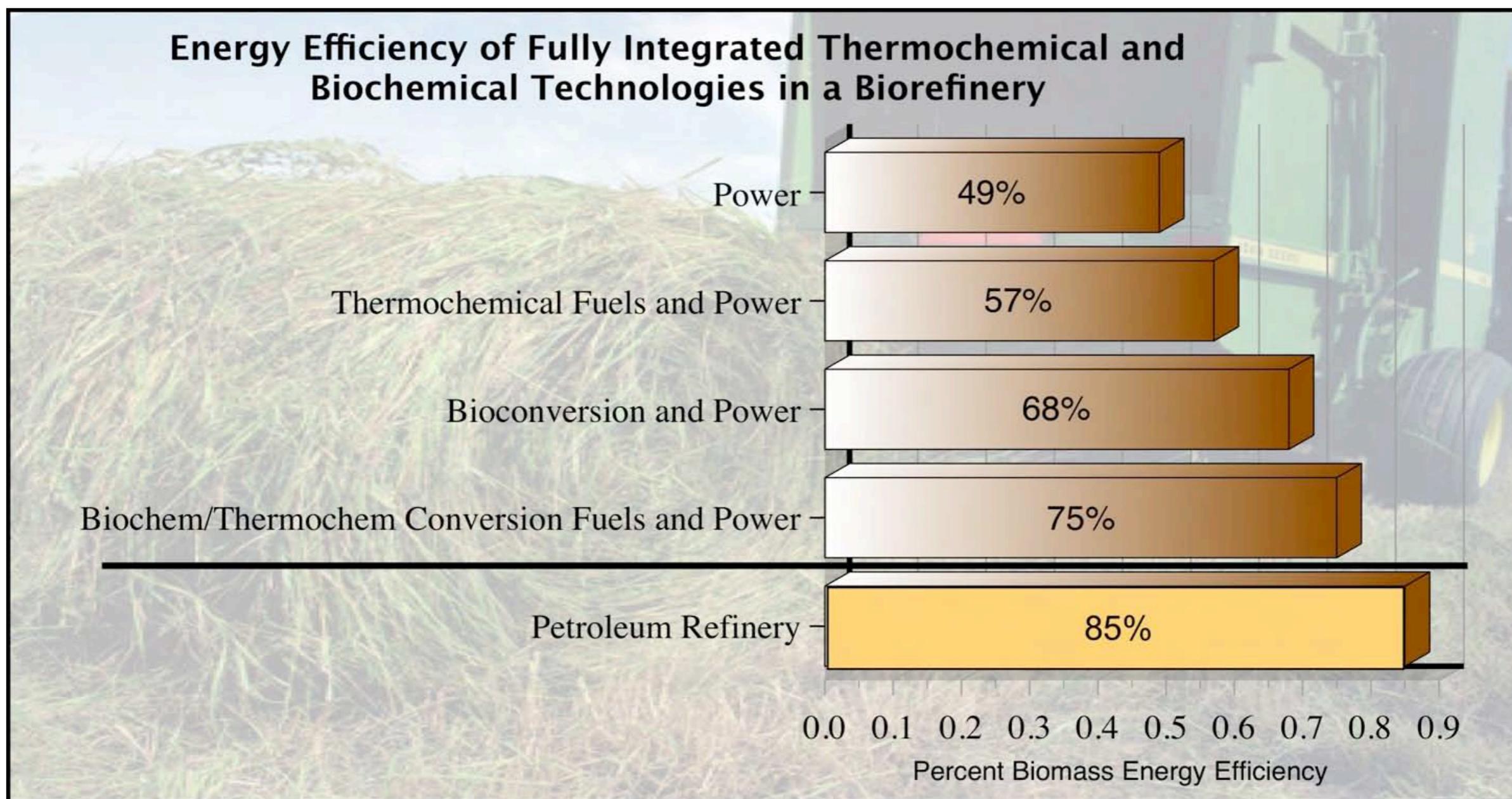
- Gasification to CO, CH₄, CO₂ syngas
- Clean up and catalytic shifting to hydrogen
- Fischer-Tropsch synthesis of liquid fuels
- Mixed alcohols for liquid fuels
- Heat and power combined cycle



The ultimate biorefinery



The ultimate biorefinery



The President's Advanced Energy Initiative



30 by 30: Switchgrass enters the political vernacular



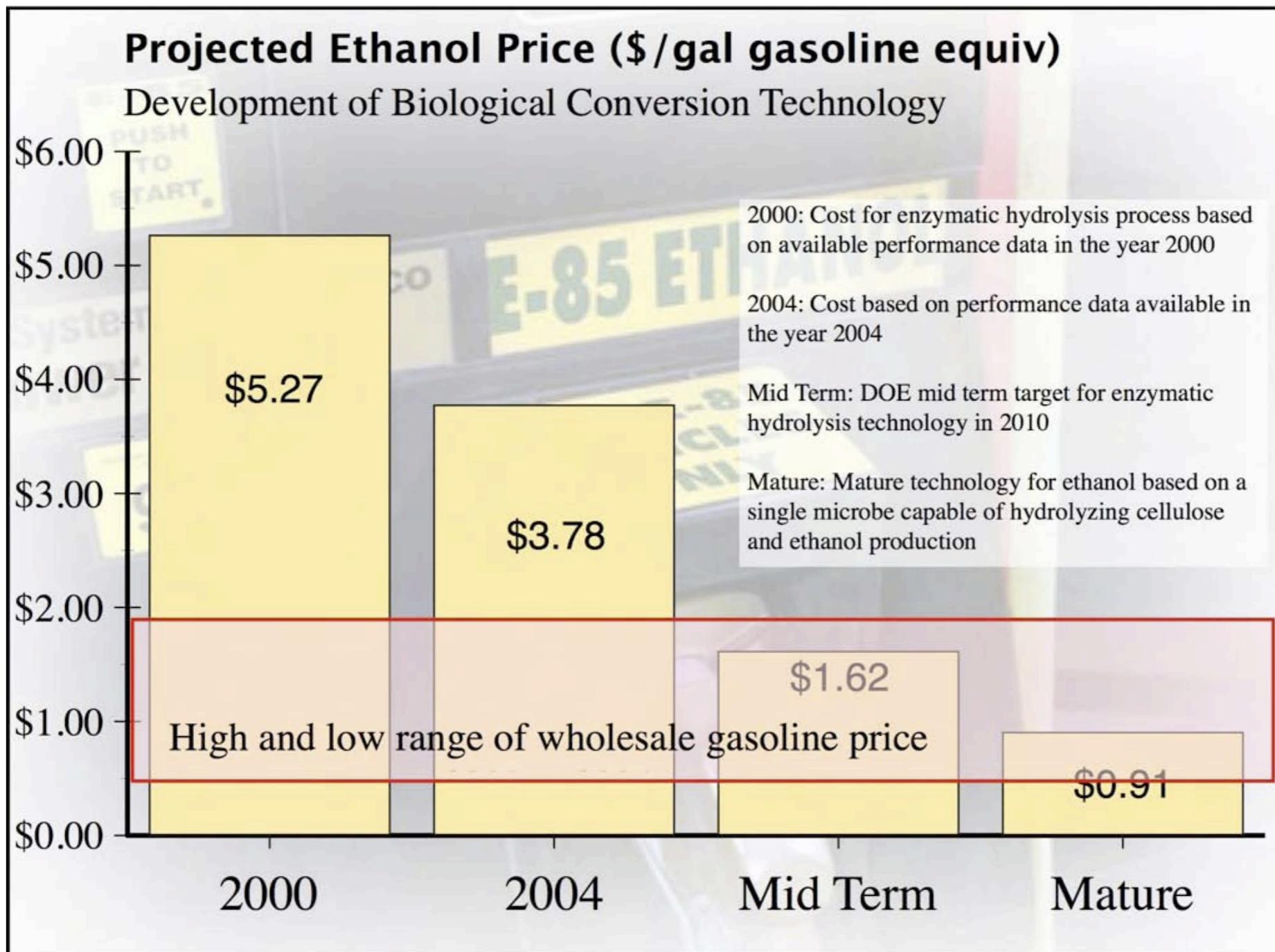
30% of our gasoline demand met with ethanol



...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.

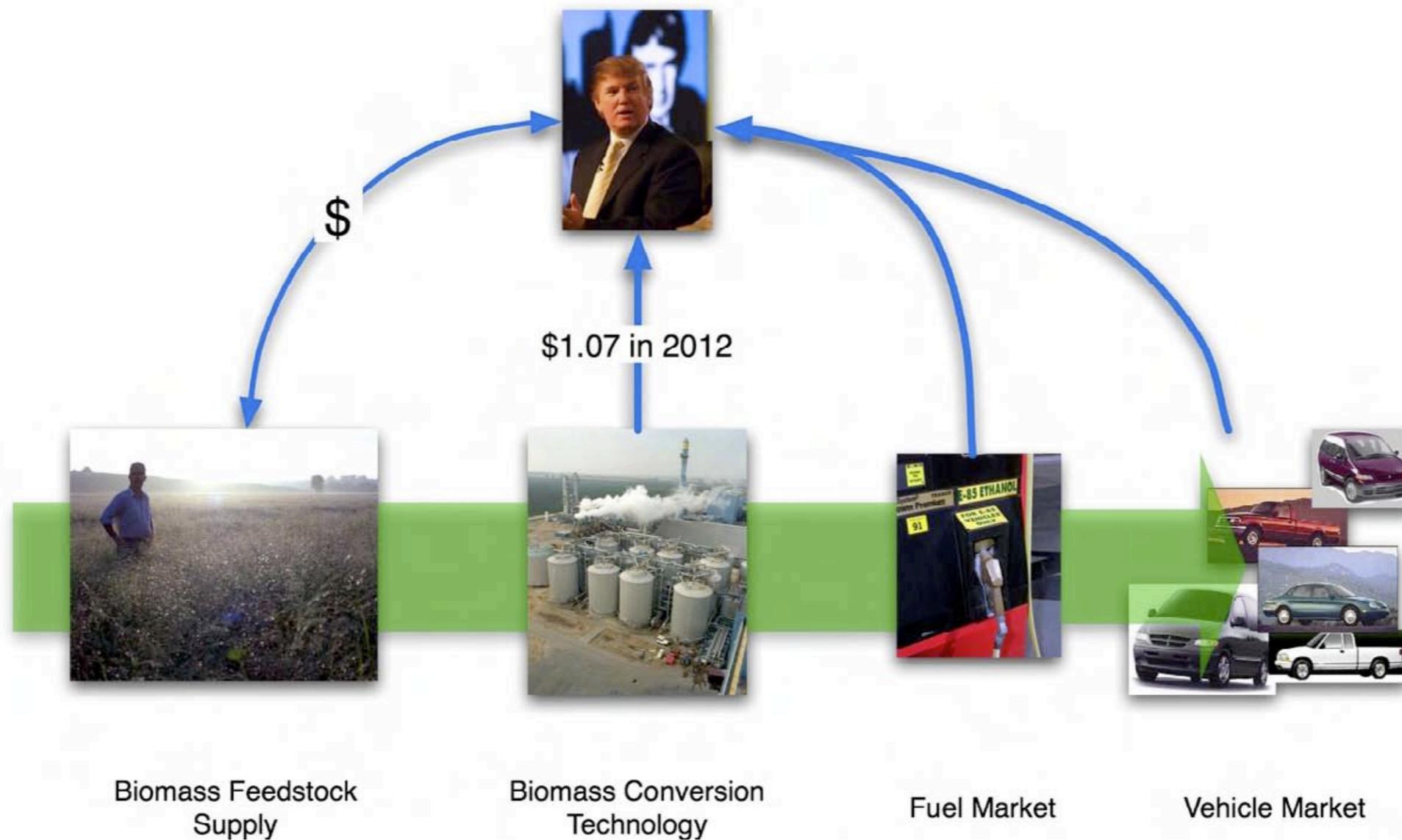


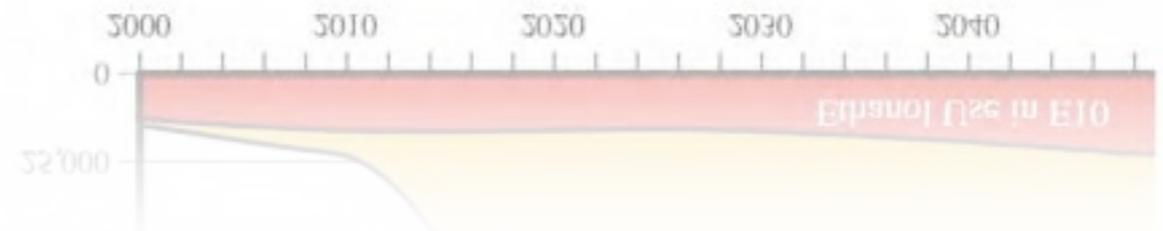
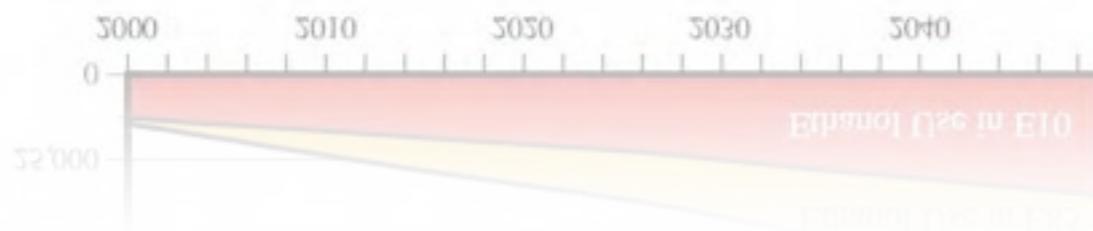
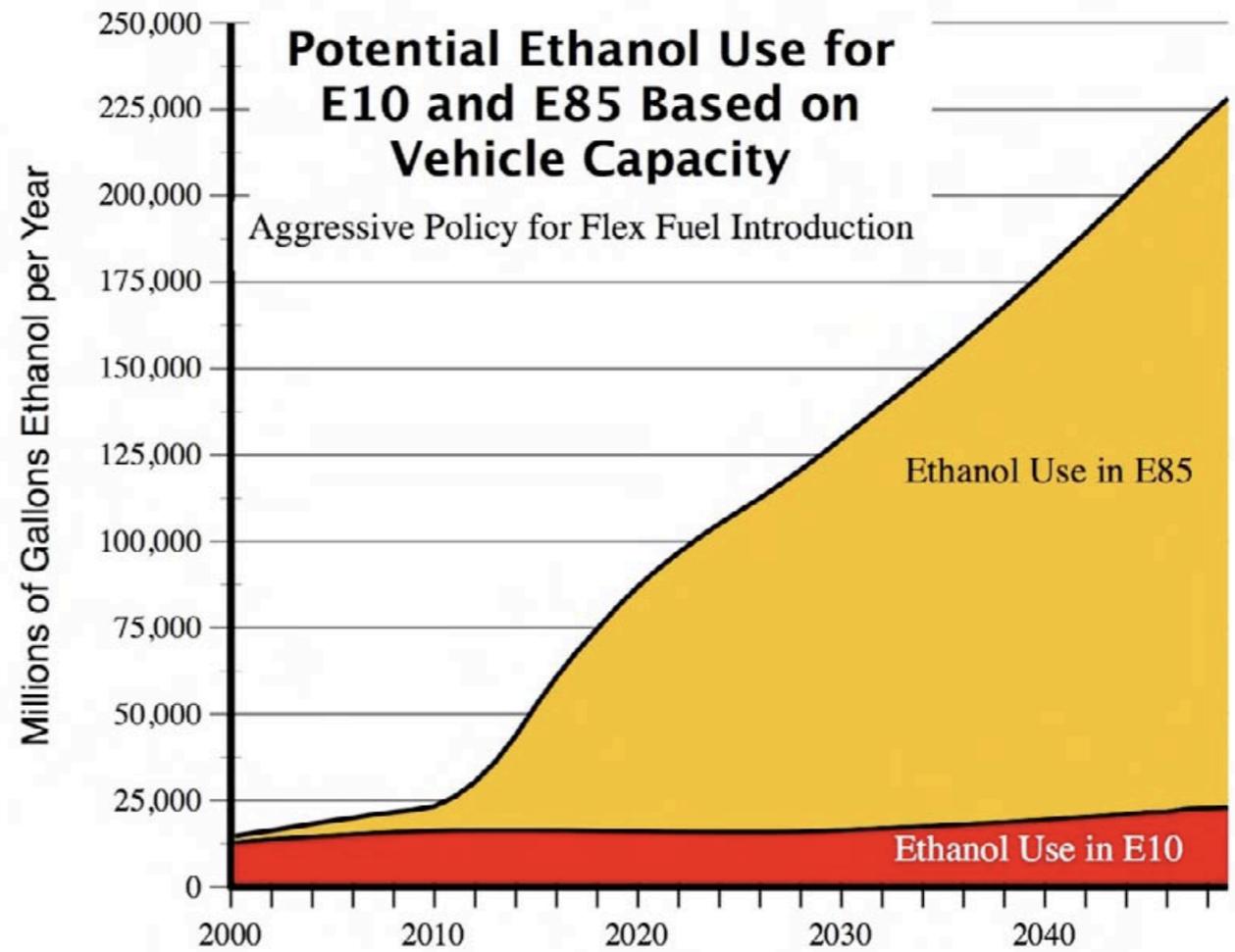
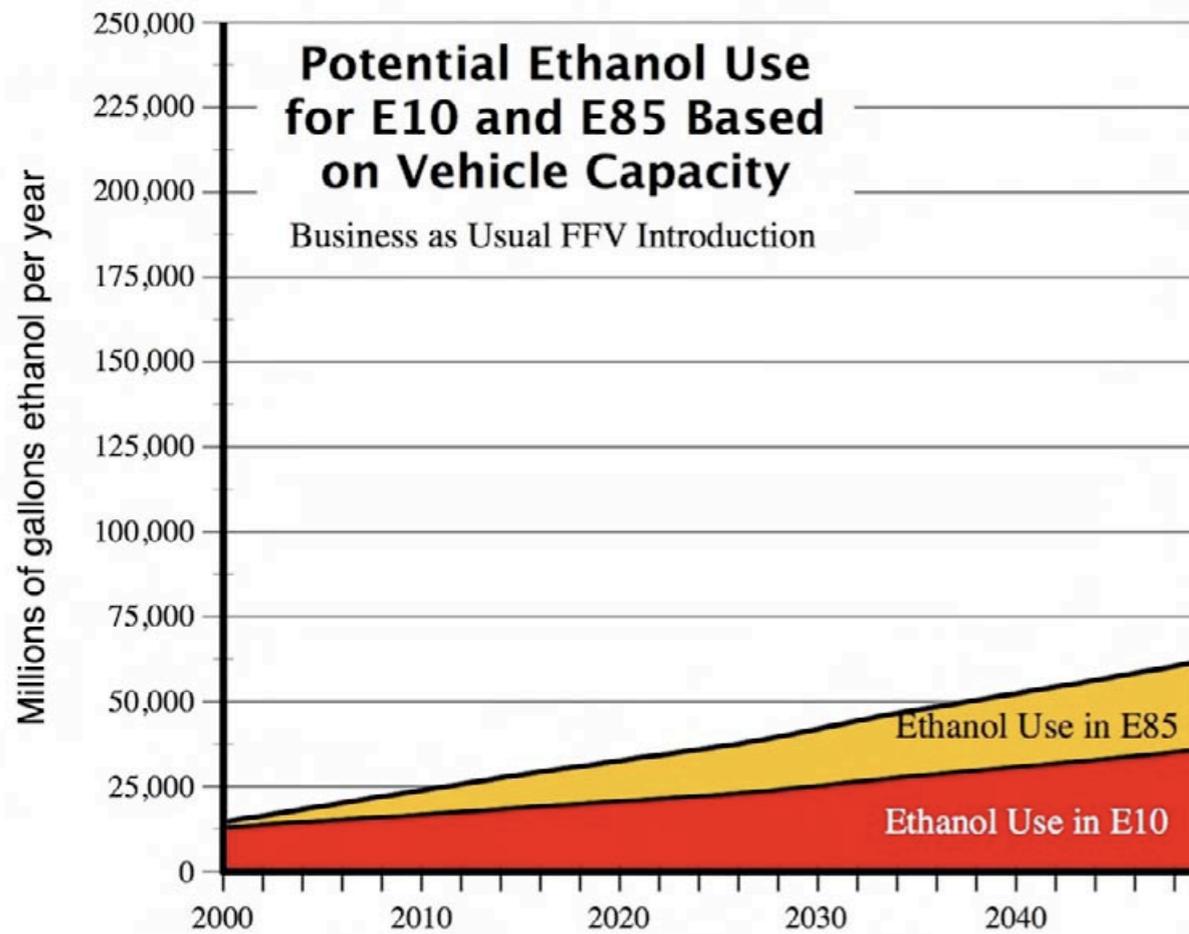
Technology cost targets

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

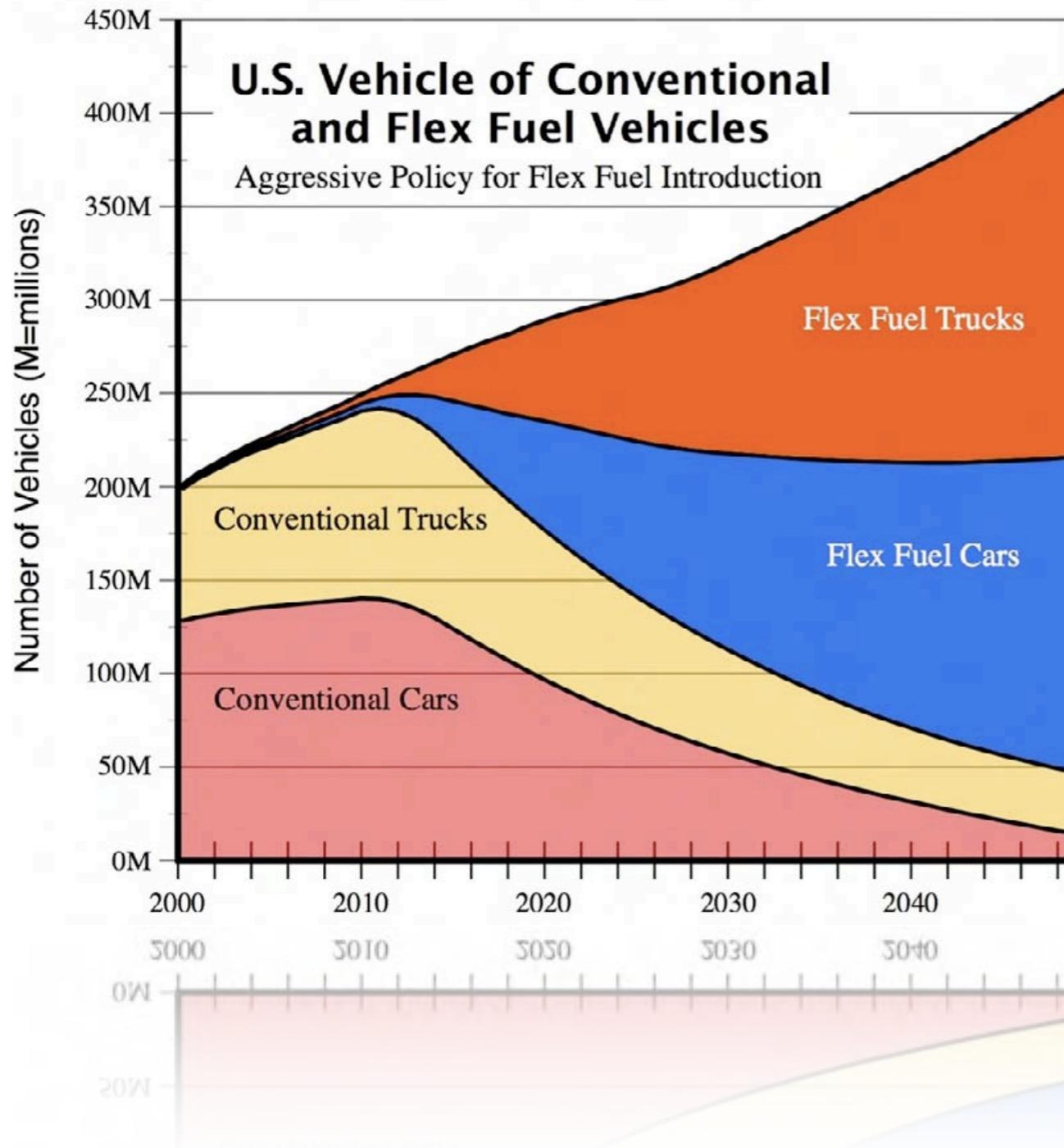
**Mature technology
could be available as
early as 2020**

The biomass transition





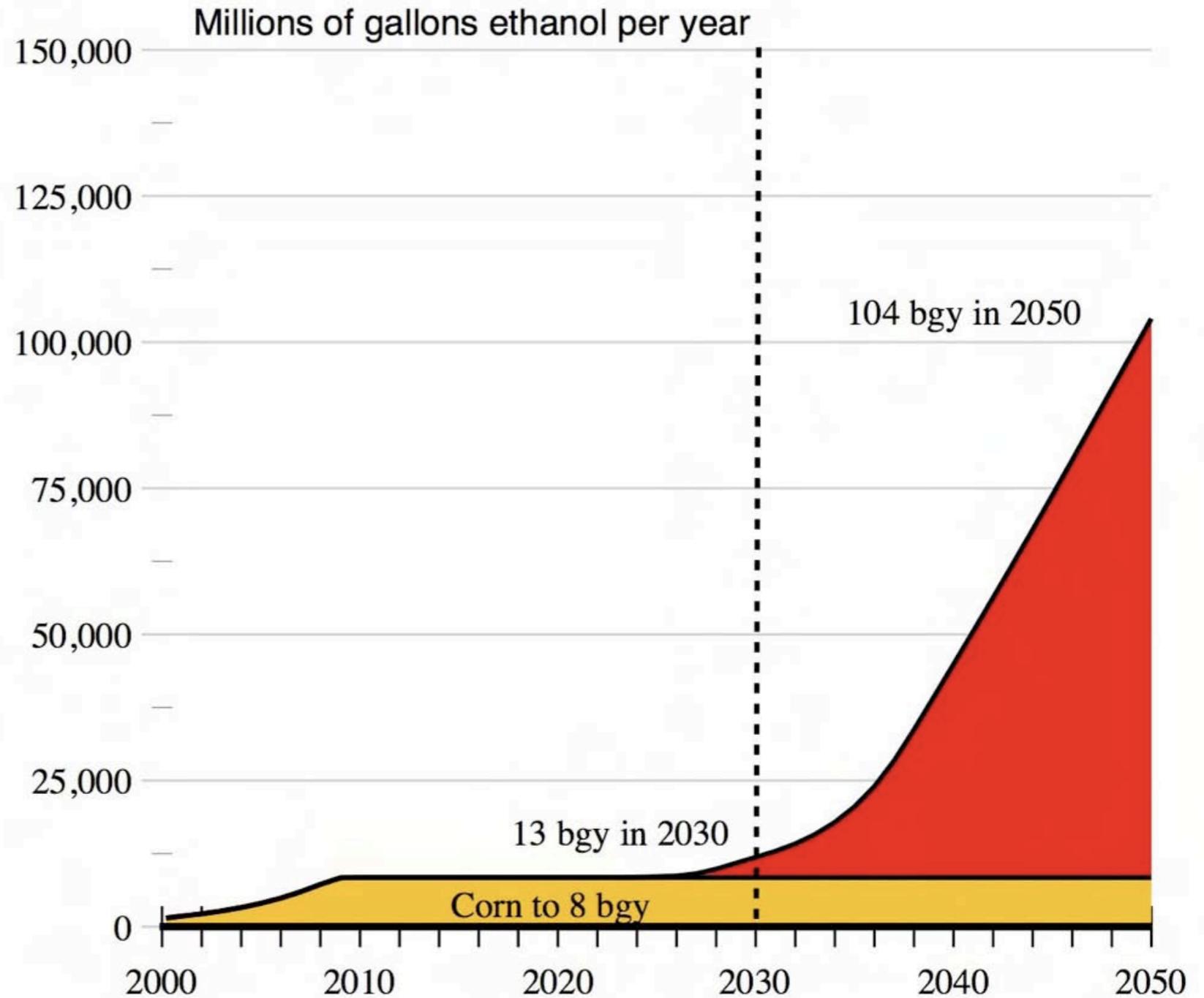
Fuel market



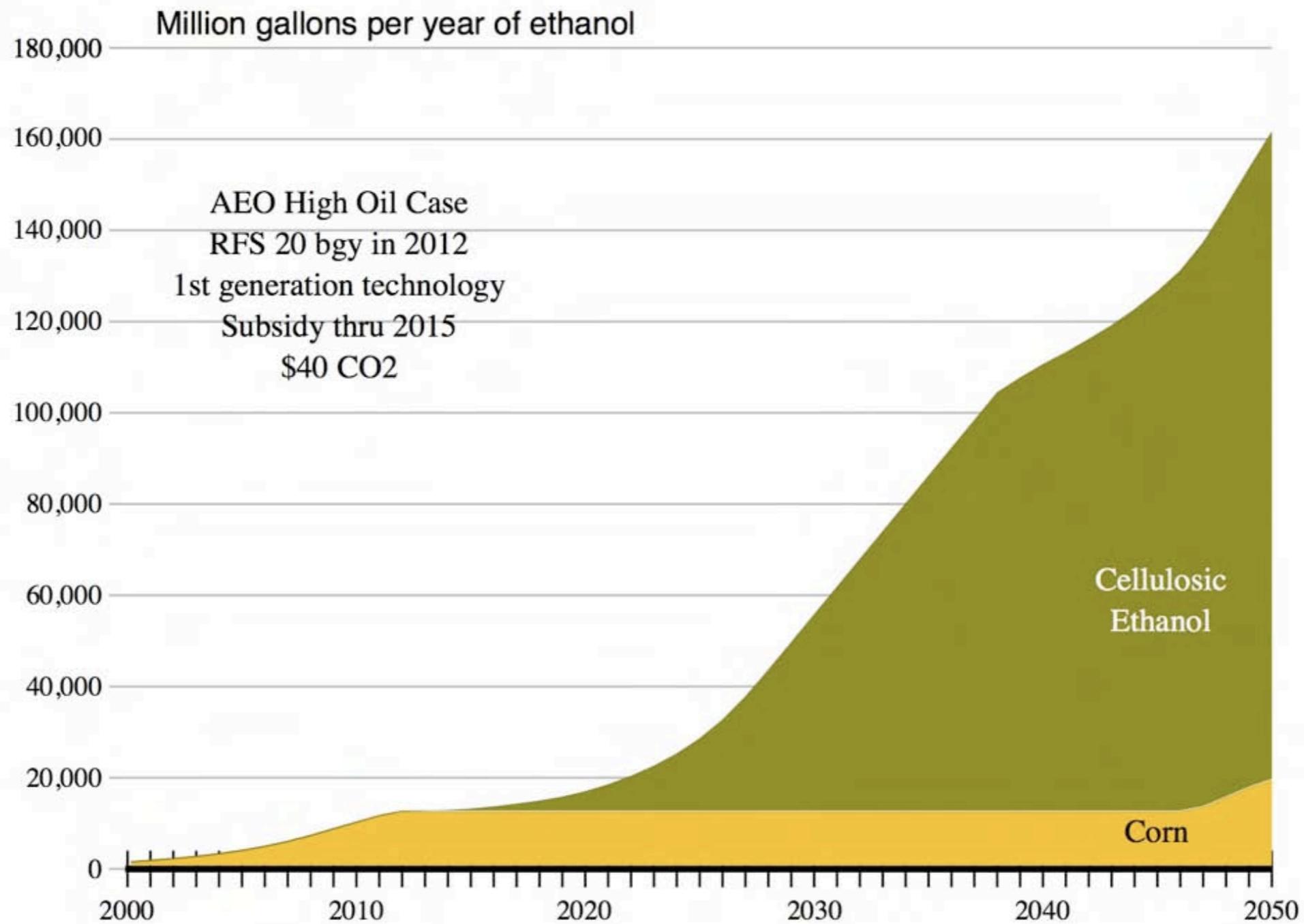
Vehicle fleet turnover model aggressive FFV introduction policy
Ignores fuel delivery infrastructure

Fuel market

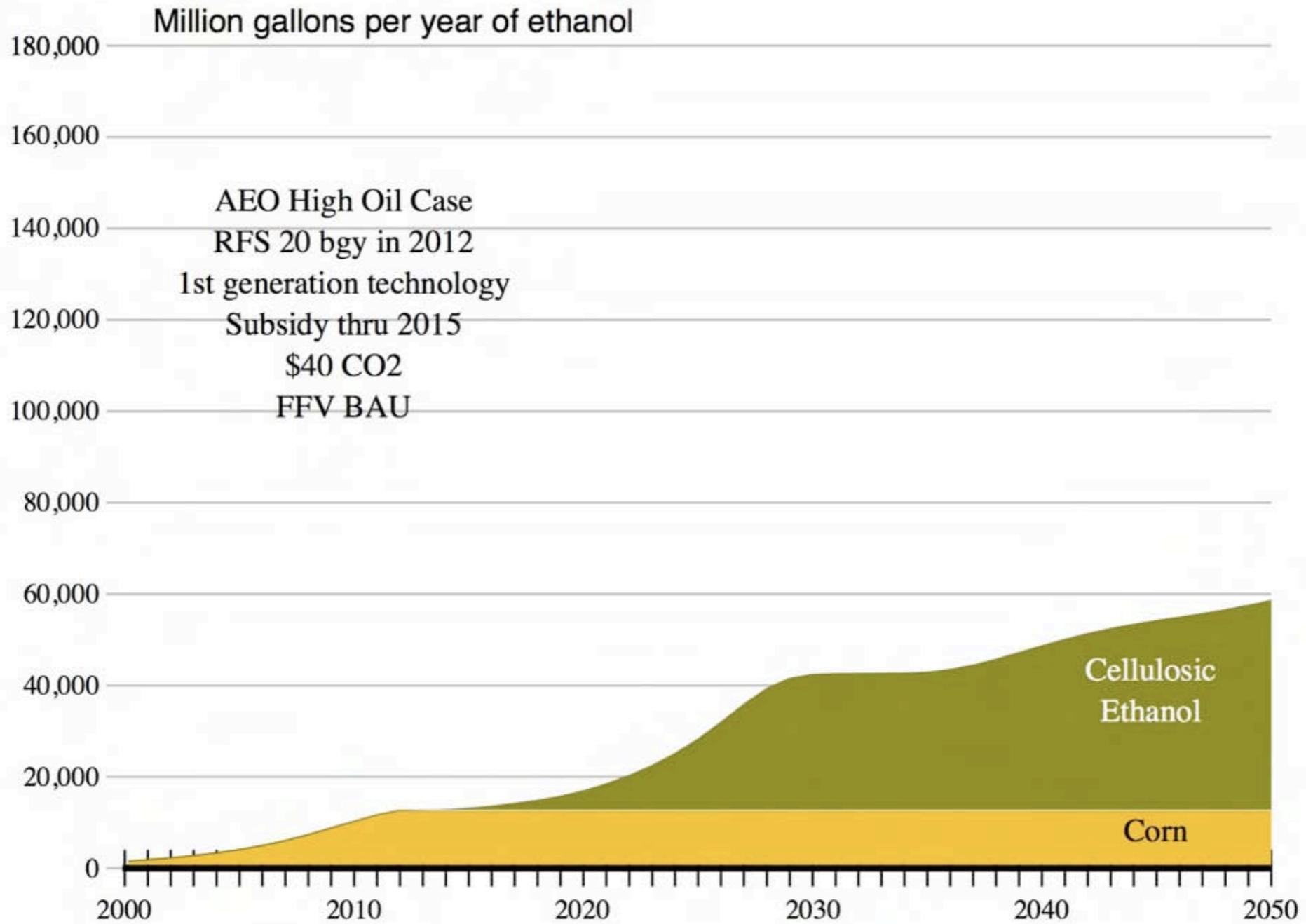
Reference case oil future and no policy changes



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