



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

*biomass program*

# Cellulosic Ethanol

## “The State of the Technology”

**Presentation to Midwest Research Consortium**

**Dec 13, 2006 by C. Schell & G. Petersen**

**US Department of Energy, Project Management  
Center, Golden Field Office**

Based on presentations by Dr. Dan Arvizu & D. Kaempf

Director, National Renewable Energy Laboratory and Former Program Manager, Office  
of Biomass Program, Respectively



- **Corn grain**

- Largest volume grain and source of ethanol in U.S.
- Potential to produce 13 – 20 billion gallons/year

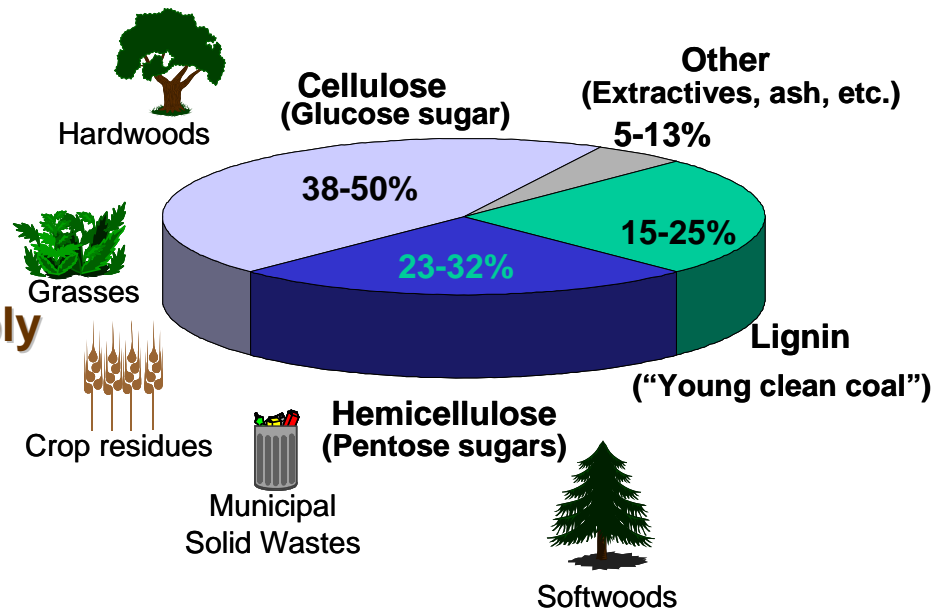
**Food Supply**



- **Cellulosic biomass**

- Over 1 billion tons/year of lignocellulosic biomass (ag & forest residues, trees, energy crops, etc.) could be available in the U.S.
- Technology needed to make the 60 billion gallon ethanol goal by 2030

**Not Food Supply**





## ■ 2012 Goal

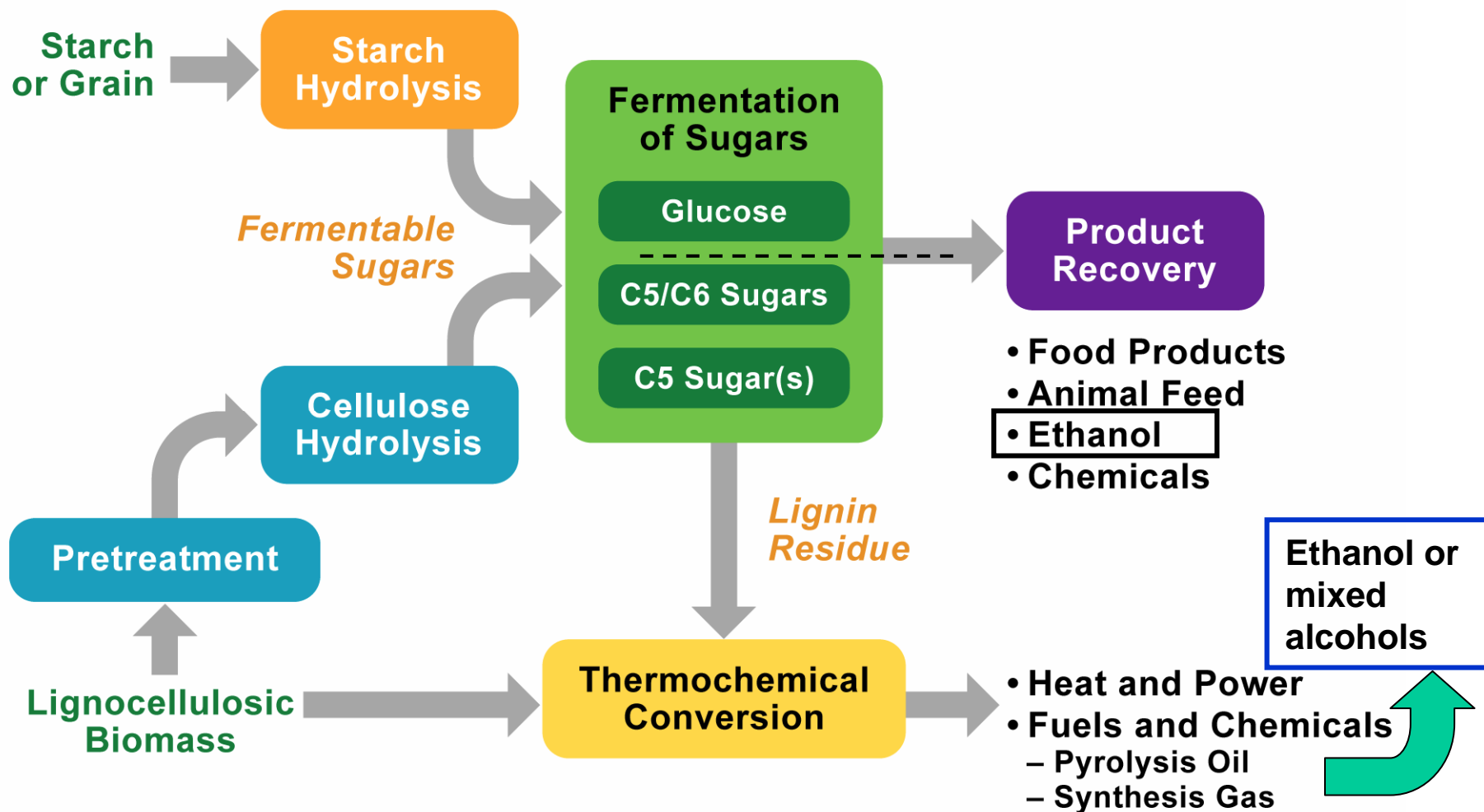
- Support research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips, stalks, ag residues or switch grass.
- The goal is to make cellulosic ethanol practical and competitive within six years (**\$1.07/gallon ethanol or as determined by further analyses**).

## ■ 2030 Goal

- Replace 30% of our current gasoline consumption with ethanol (**60 billion gallons**).

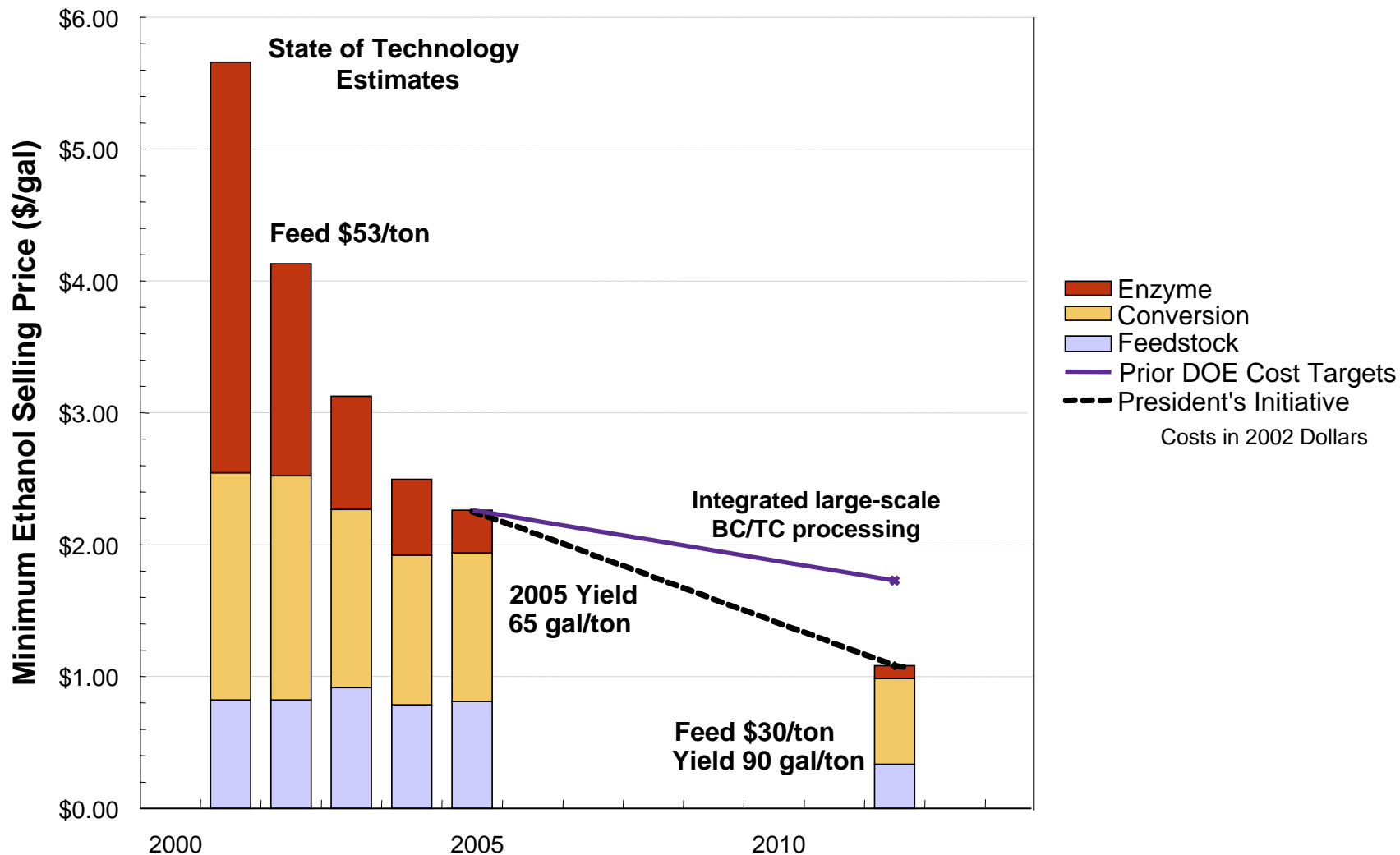


# Representative Integrated Cellulosic Ethanol Biorefinery





# Reducing the Cost of Ethanol

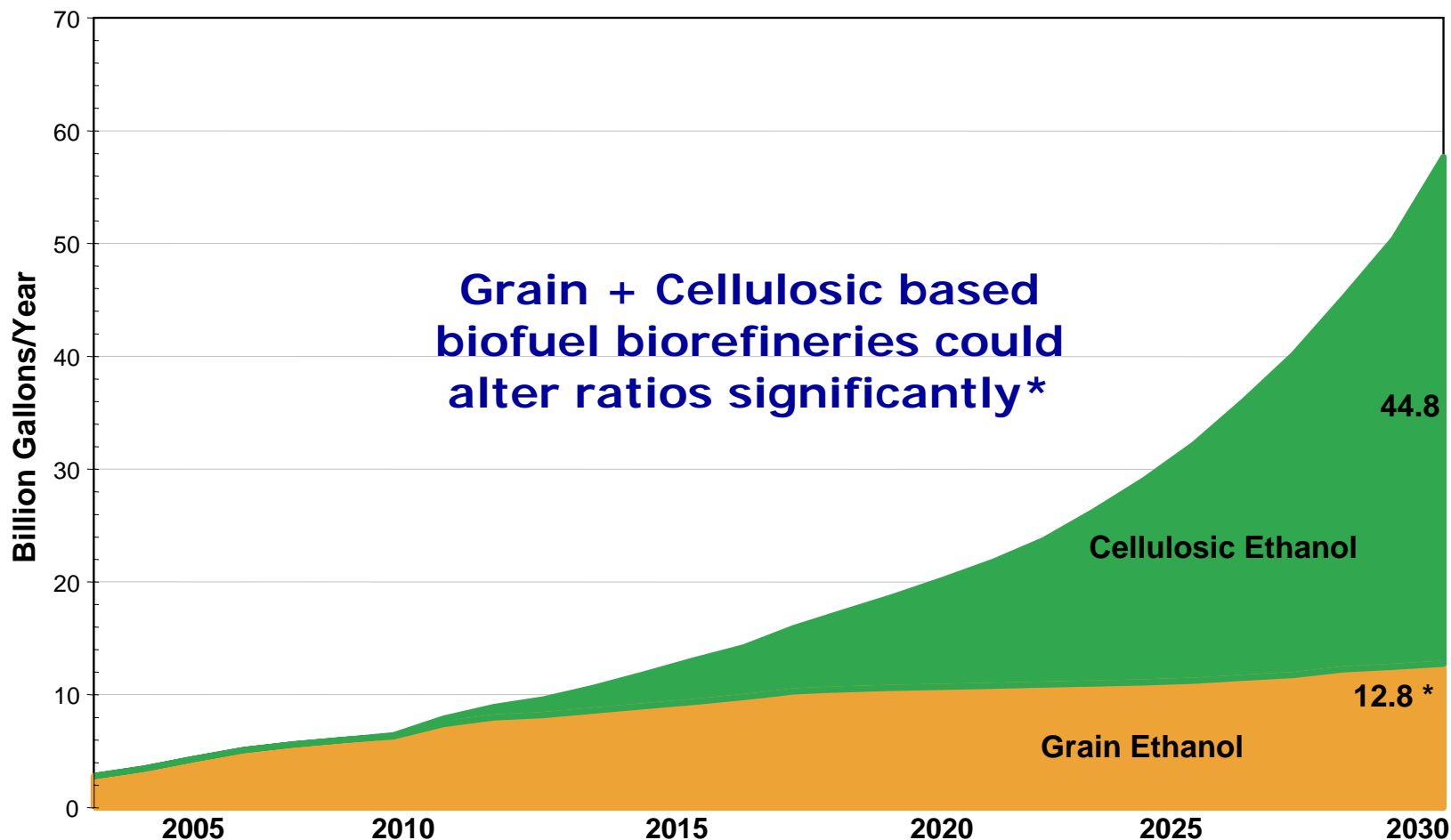


\* **Note:** Basic feedstock considered in this analysis is corn stover, which is the most likely feedstock source for reaching the 2012 cost goal. However, other cellulosic biomass feedstocks could have similar costs.



# Reaching 60 Billion Gallons of Biofuels by 2030

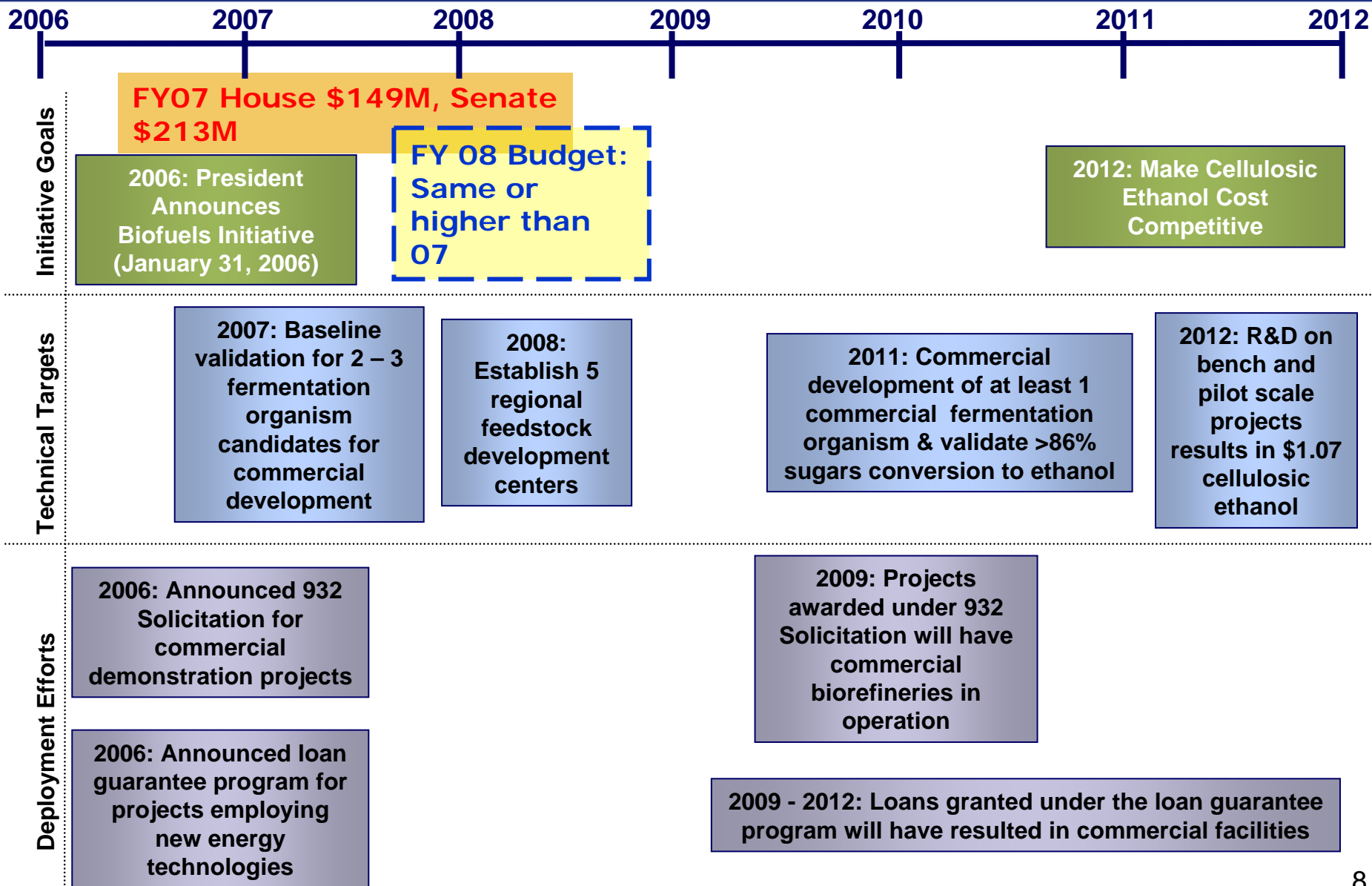
## A Scenario for Growth of Ethanol to Supply 30% of 2004 U.S. Gasoline Demand by 2030



\* Note: This number could be higher. The National Corn Growers Association predicts that as much as 18 billion gal/yr could be produced from grain. Major changes to land use, exports, etc could also have substantial impacts. Regardless, significant cellulosic ethanol will be required to meet the 2030 goal and future national needs.

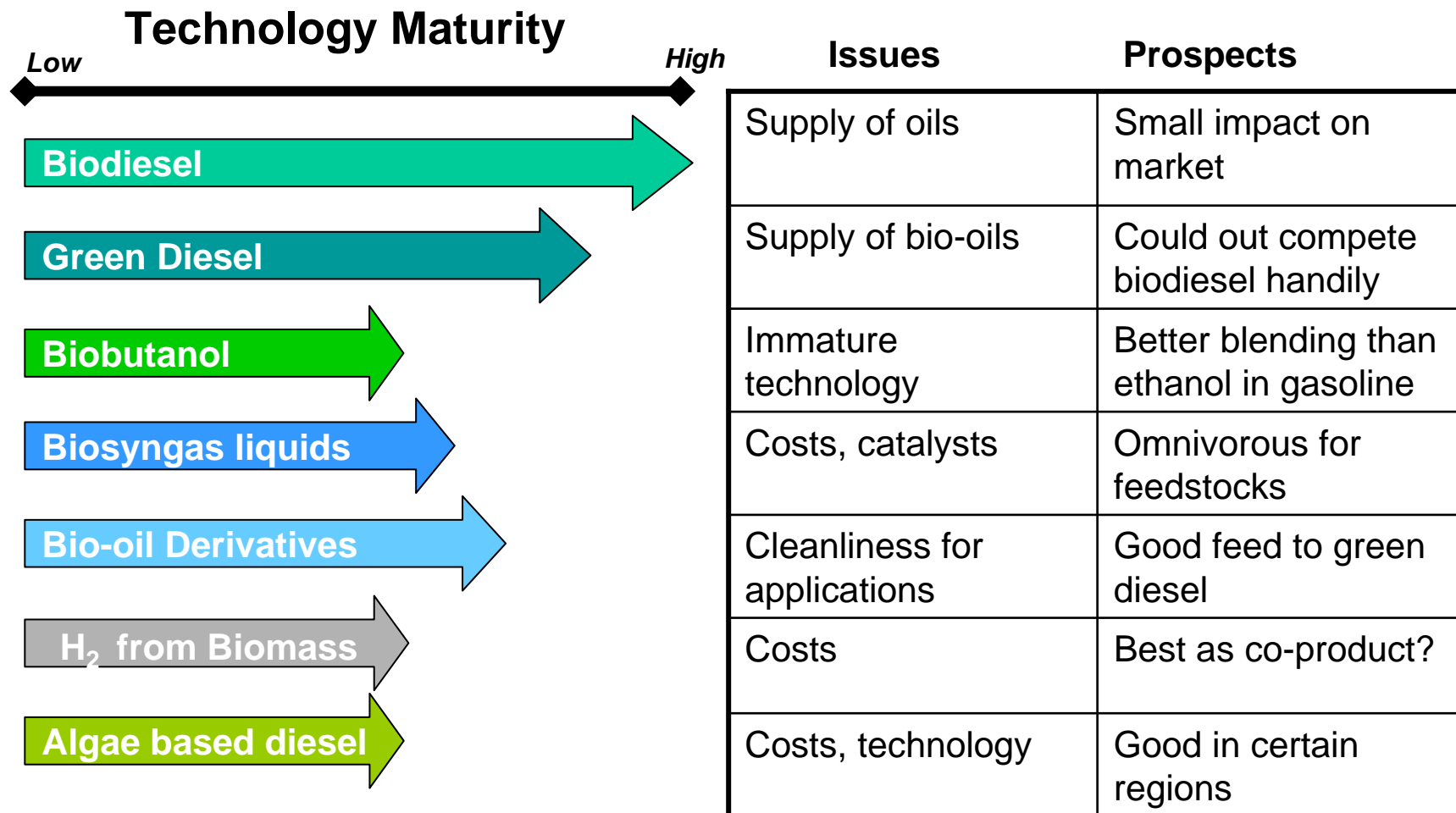


# Timeframe for R&D Successes & Commercialization





- **R&D Success required:**
  - ✓ Reduce costs associated with biochemical conversion of feedstocks, specifically enzyme and fermentation costs
  - ✓ Reduce the cost associated with thermochemical conversion of feedstocks, specifically gasification, gas cleanup, and fuel synthesis
  - ✓ 2012 goal already accelerated from original 2020 goal
- **Land-use concerns to meet long term requirements**
  - ✓ Environmental, soil carbon, sustainability
- **Immature feedstock supply systems**
  - ✓ Costs range from \$5/ton for waste wood to upwards of \$50-65/ton for ag residues (depends on need to provide value to supplier)
- **Risks associated with first-of-a-kind plants and high capital investment for integrated biorefineries**
  - ✓ Capex \$ can range from \$4 to \$9/gal ethanol (installed)
- **Lack of fuel distribution and vehicle infrastructures**
  - ✓ Estimated 20 to 40 billion dollar capital investment required



Development partners include government, academic, petrochemical, agricultural, and forestry sectors