

Innovation for Our Energy Future

The Potential of Biofuels from Diverse Feedstocks

Matt Ringer, National Bioenergy Center
International Symposium on Biofuels, New Delhi, India

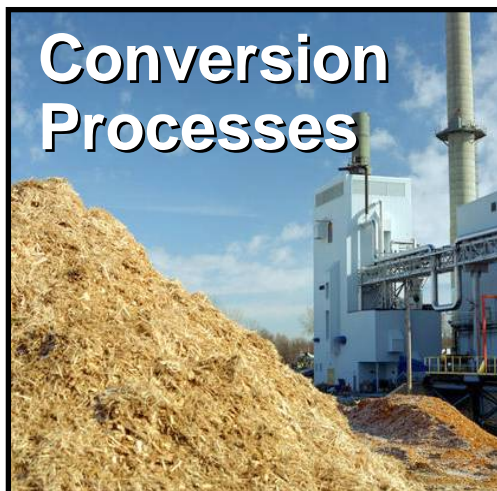
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Range of Biorefinery Concepts



- Trees
- Grasses
- Agricultural Crops
- Residues
- Animal Wastes
- Municipal Solid Waste
- Algae
- Food Oils



- Enzymatic Fermentation
- Gas/liquid Fermentation
- Acid Hydrolysis/
Fermentation
- Gasification
- Combustion
- Co-firing
- Hydroprocessing
- Trans-esterification

Products

Fuels

- Ethanol
- Biodiesel
- “Green” Gasoline & Diesel

Power

- Electricity
- Heat

Chemicals

- Plastics
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Furfural
- Fatty Acids
- Acetic Acid
- Carbon Black
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Etc.

Food and Feed

U.S. Biomass Resource Potentials

Corn (largest volume grain and source of EtOH in U.S.)

- Potential to displace 10-20% of our gasoline

Soybeans, fats & greases (largest sources of biodiesel)

- Potential to displace 5-10% of our diesel

**Food
Supplies**

Over 1 billion tons/year of lignocellulosic biomass (trees, grasses, etc.) could be available in the U.S.

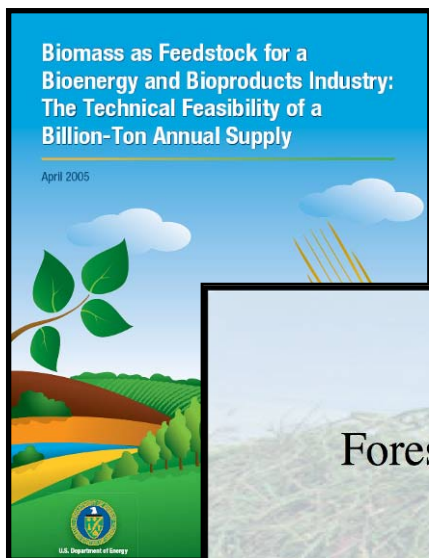
- Potential to displace 50-70% of our gasoline

**Not a Food
Supply**

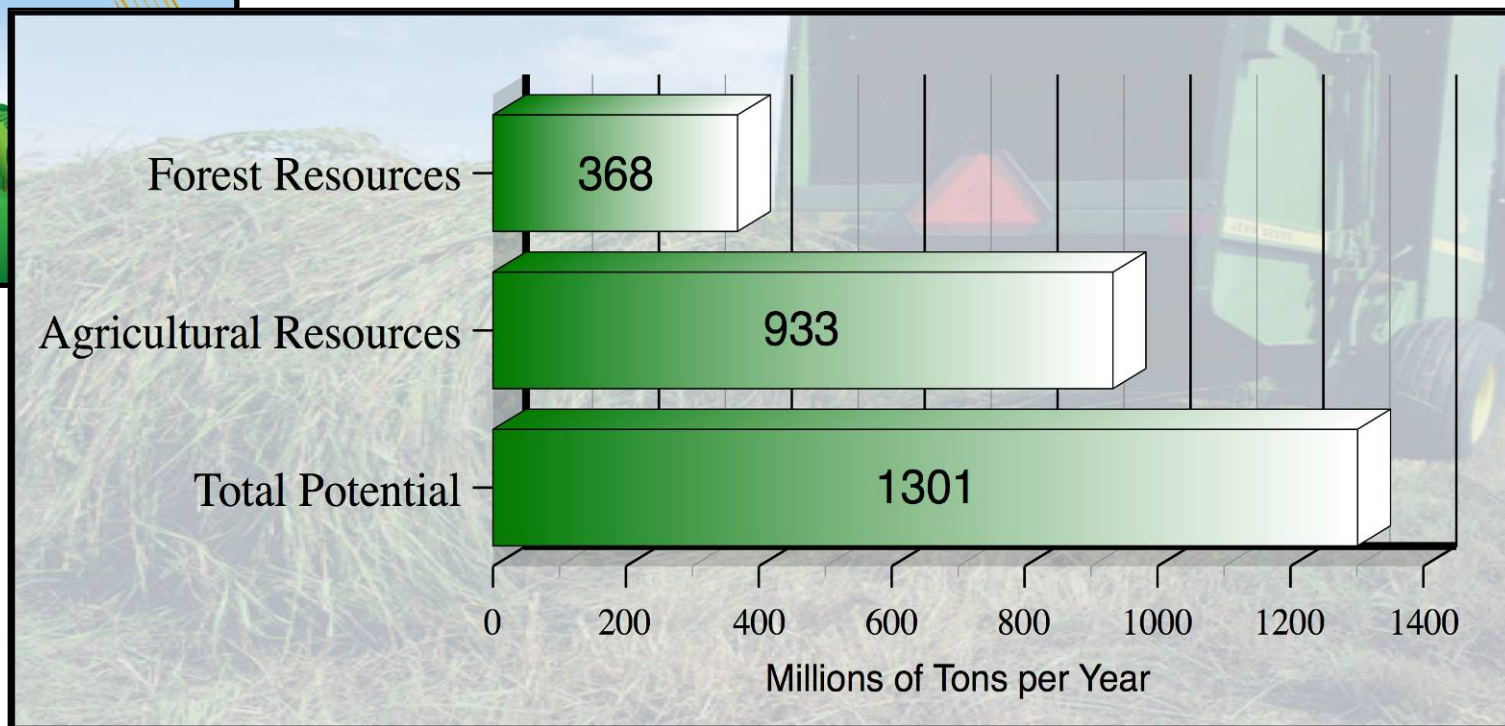
Short-term: improve cost and efficiency of corn ethanol & biodiesel

Mid to Long-term: focus on lignocellulose (trees, grasses, & residues)

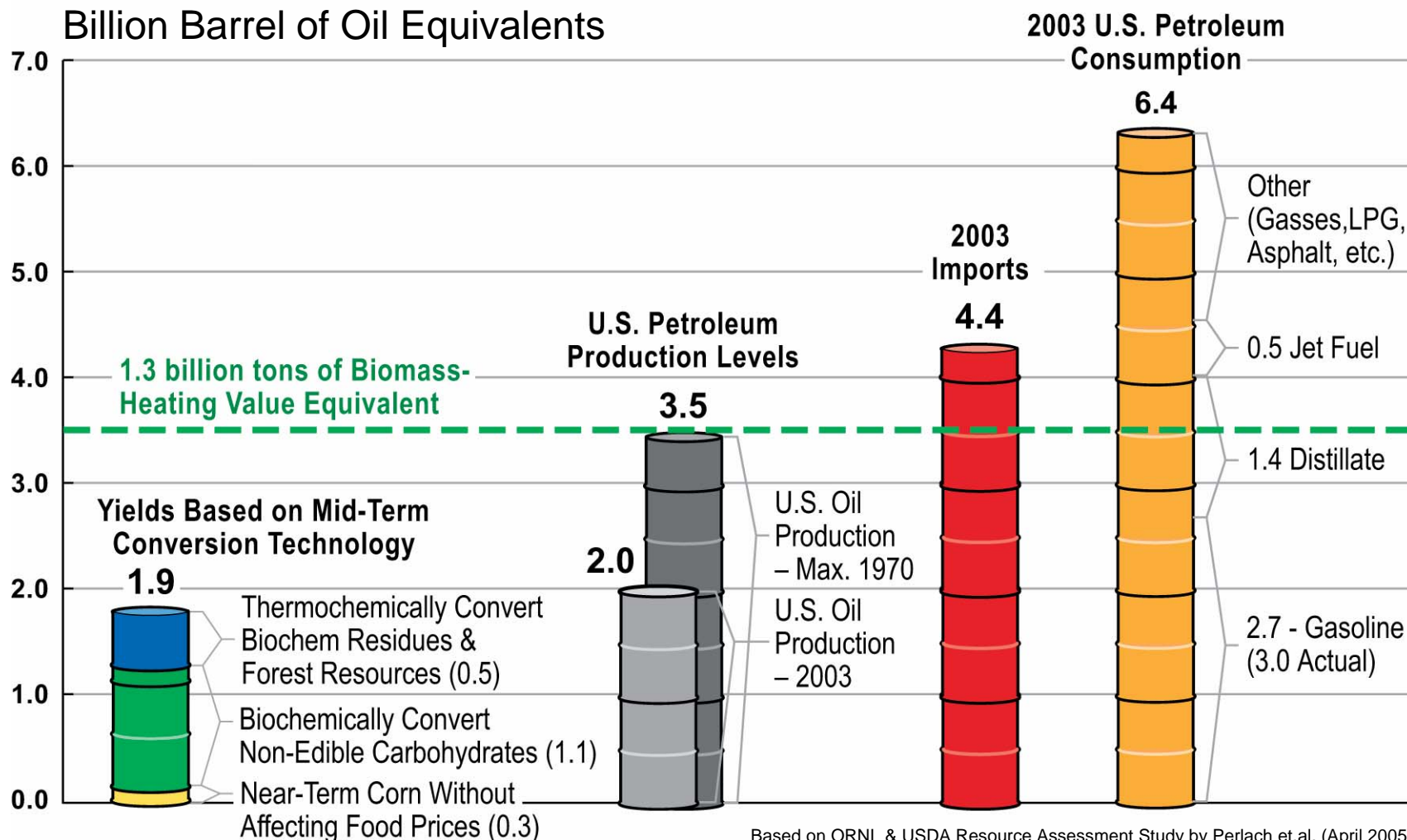
U.S. Biomass Resource Assessment



- Updated resource assessment - April 2005
- Jointly developed by U.S. DOE and USDA
- Referred to as the “Billion Ton Study”

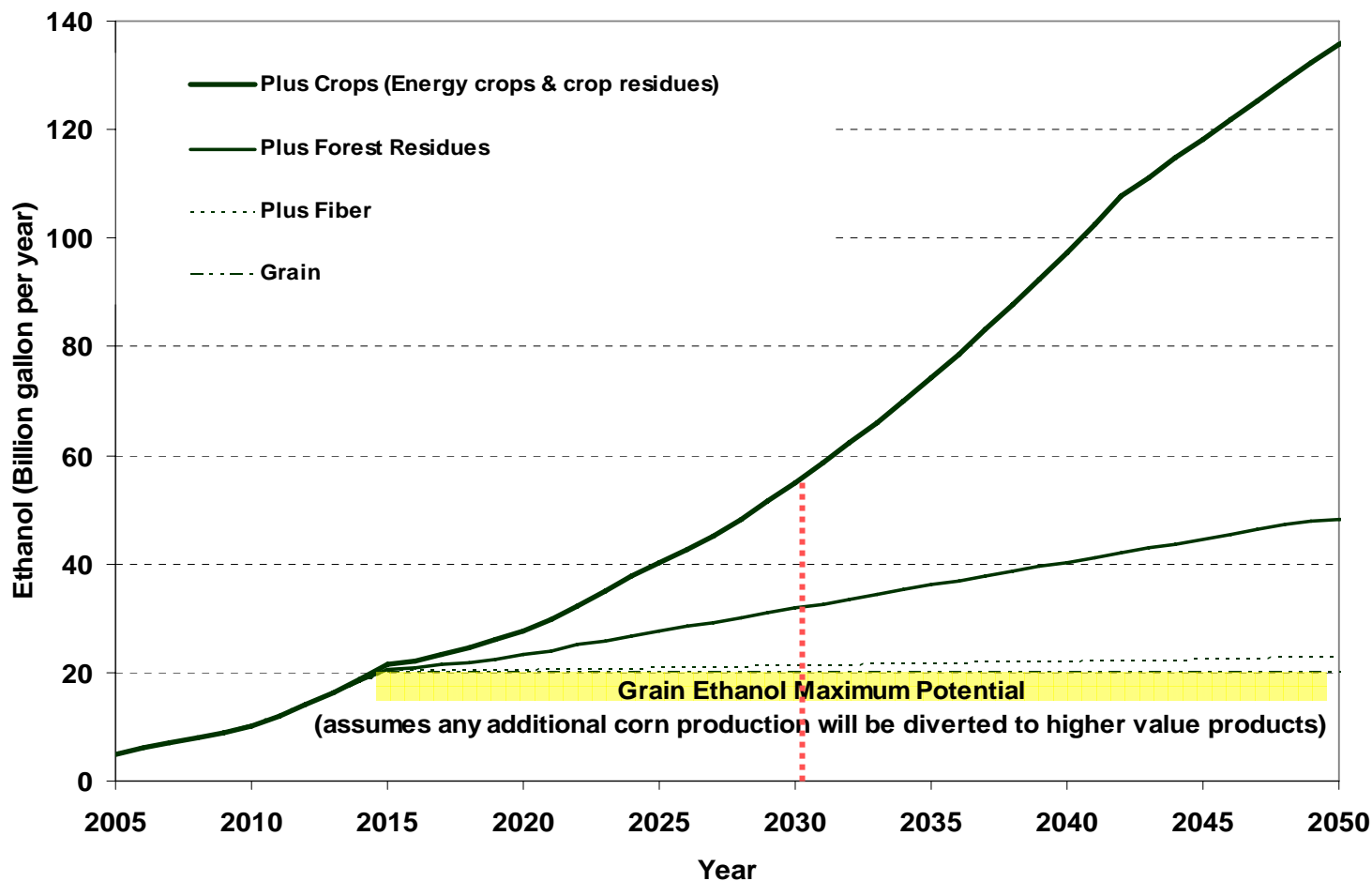


The 1.3 Billion Ton Biomass Scenario

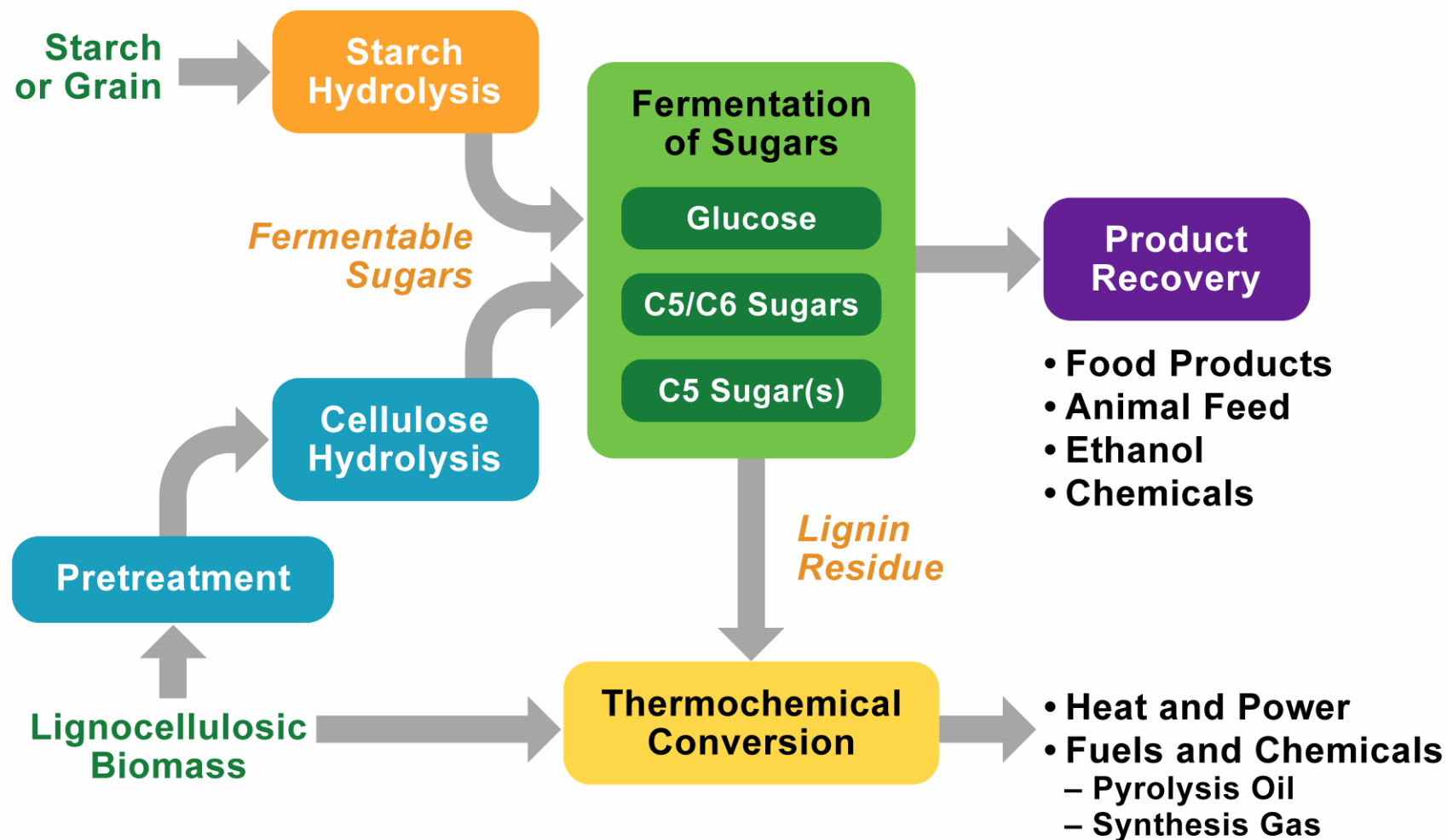


Required Growth of Cellulosic Ethanol to Supply 30% of U.S. Gasoline Demand by 2030

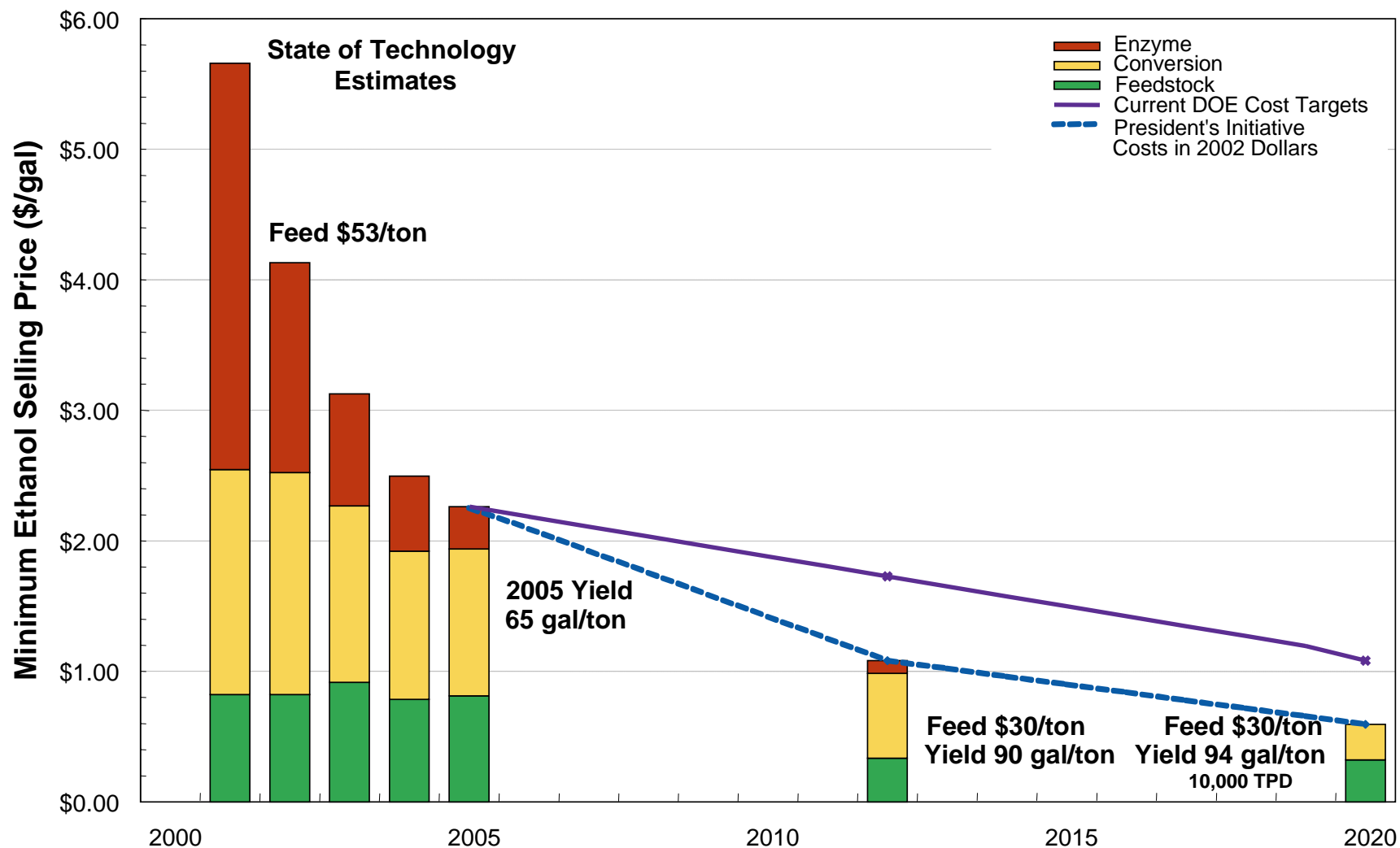
Cumulative Ethanol Production
Aggressive Technology Development Scenario



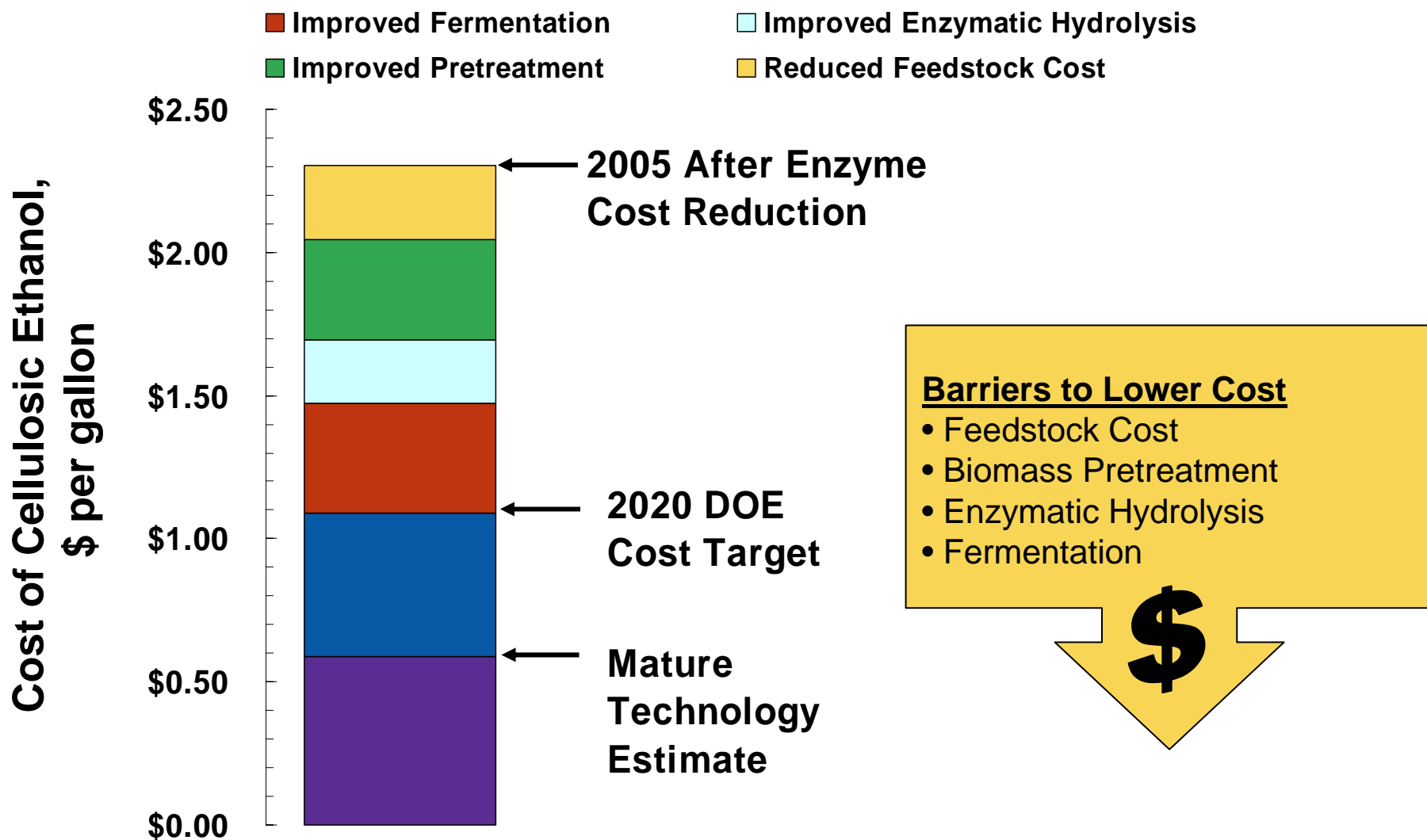
Integrated Biorefinery Elements



Reducing the Cost of Ethanol From Stover

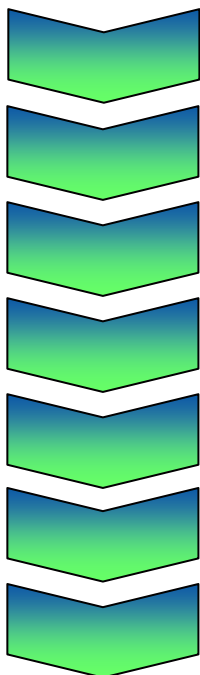


Remaining Technology and Cost Barriers



Ethanol is the 1st of Many Possible Biofuels

Near
Term



Long
Term

Ethanol – from grain, sugar, or cellulosic material

Biodiesel – transesterified vegetable oils, fats, and greases

Green Diesel – vegetable oils, fats, and greases converted to diesel by hydroprocessing

Other Fermentation Products – includes: butanol, acetates, lactates, and other possibilities

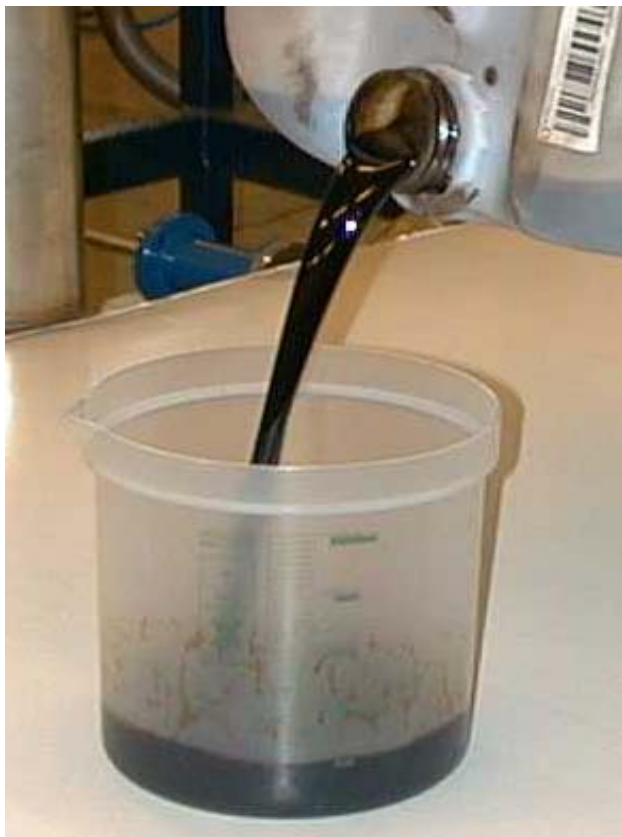
Pyrolysis Liquids – low quality liquid made by thermal processing (“thermal cracking”) of biomass

Synthesis Gas – for conversion to F-T liquids, methanol, dimethyl ether, or mixed alcohols

Algae-derived Fuels – alternative source of triglycerides and carbohydrates

Hydrocarbon Fuels – from hydrogenation of biomass constituents

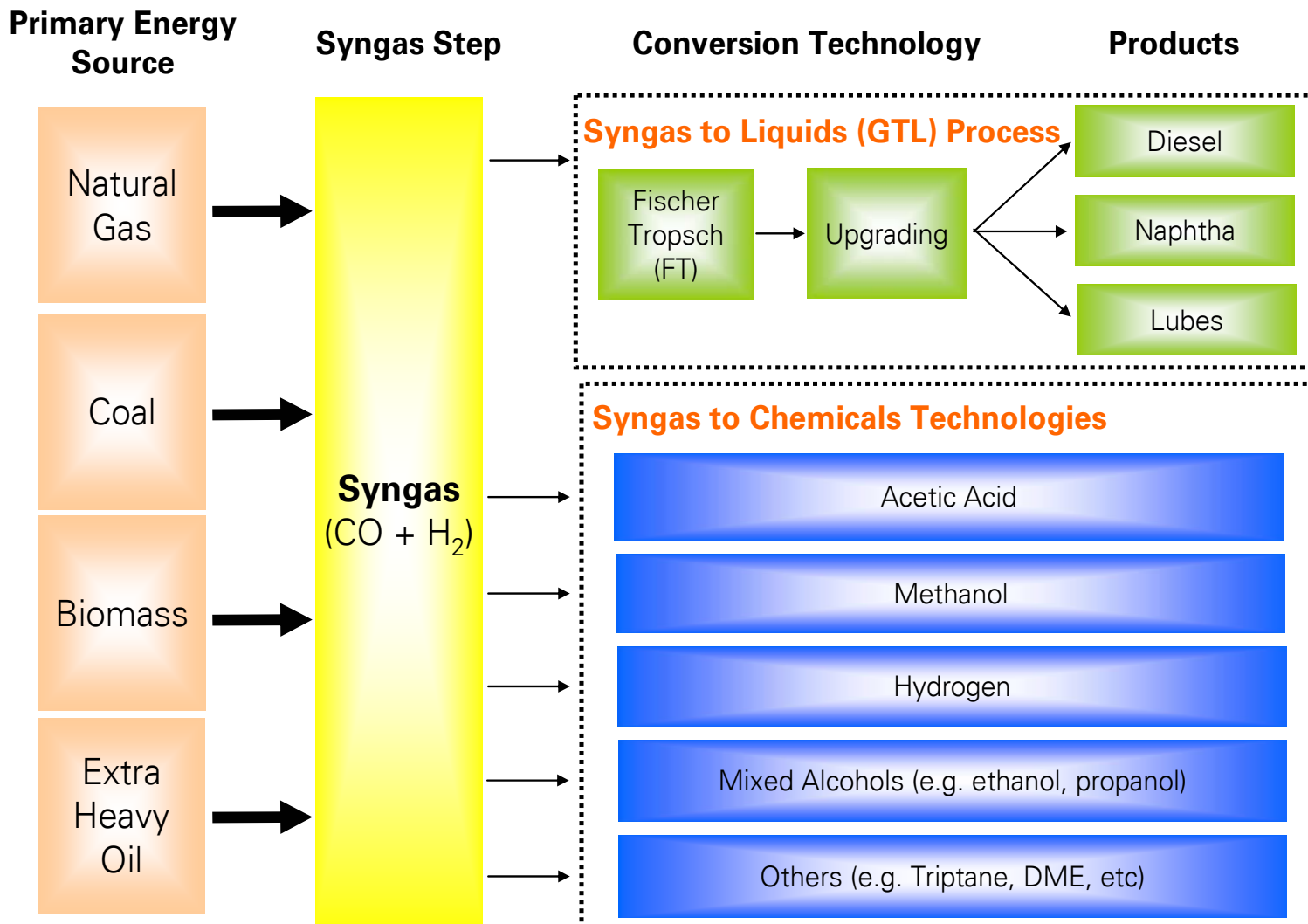
Fast Pyrolysis Bio-oil



Bio-oil is water miscible and is comprised of many oxygenated organic chemicals.

- **Dark brown mobile liquid**
- **Combustible**
- **Not 100% miscible with hydrocarbons**
- **Heating value ~ 17 MJ/kg**
- **Density ~ 1.2 kg/l**
- **Acid, pH ~ 2.5**
- **Pungent odour**
- **“Ages” - viscosity increases with time**

Biomass Gasification Integrates with Fossil Fuels



Microalgae as a Source of Biofuels



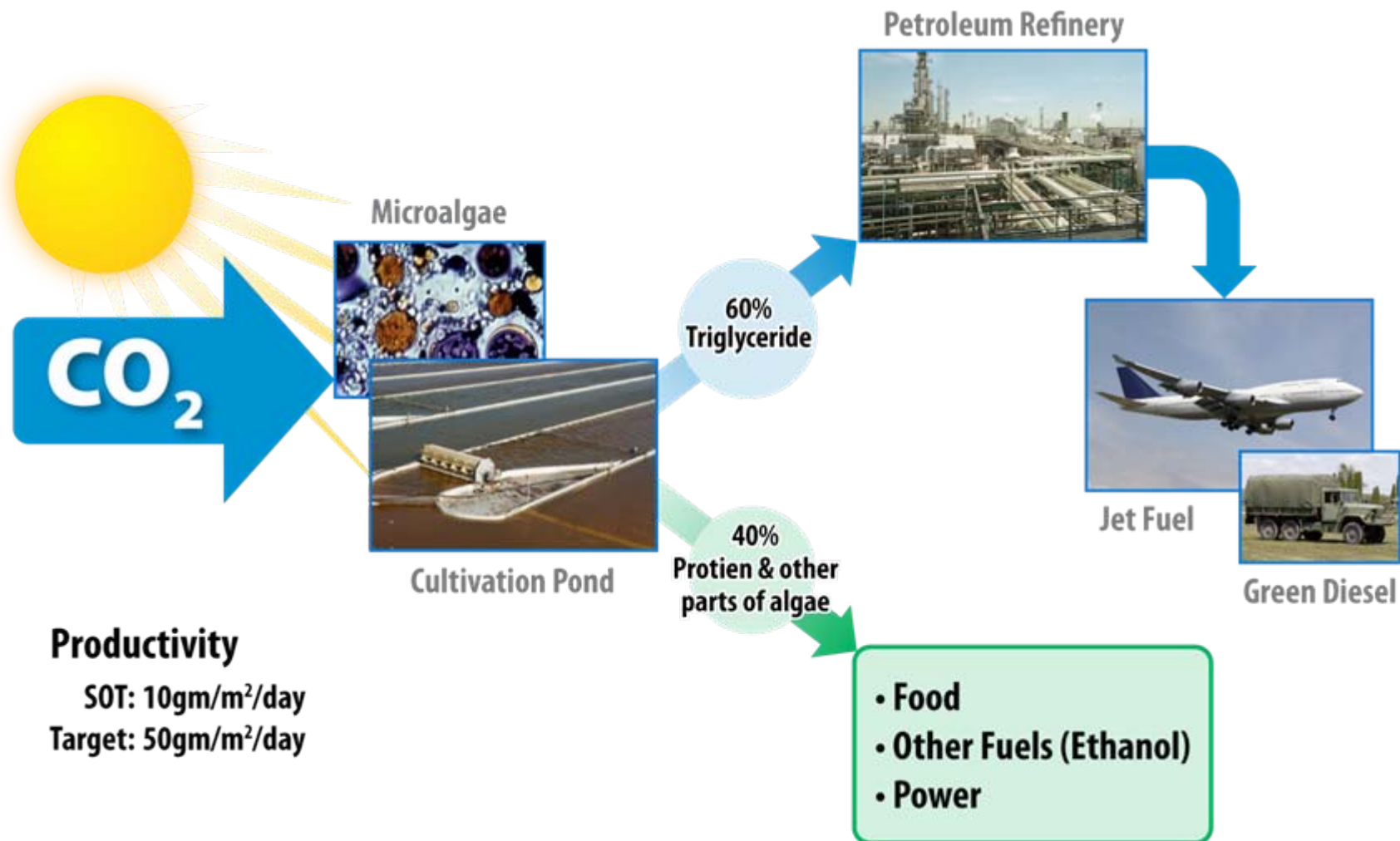
DOE's Aquatic Species Program at NREL (1978-96) provided the technical foundation for producing biodiesel from algae

The concept involves produce biofuels from:

- Sunlight
- CO₂ in fuel gases and/or vent gases
- Unproductive land
- Brackish or saline water

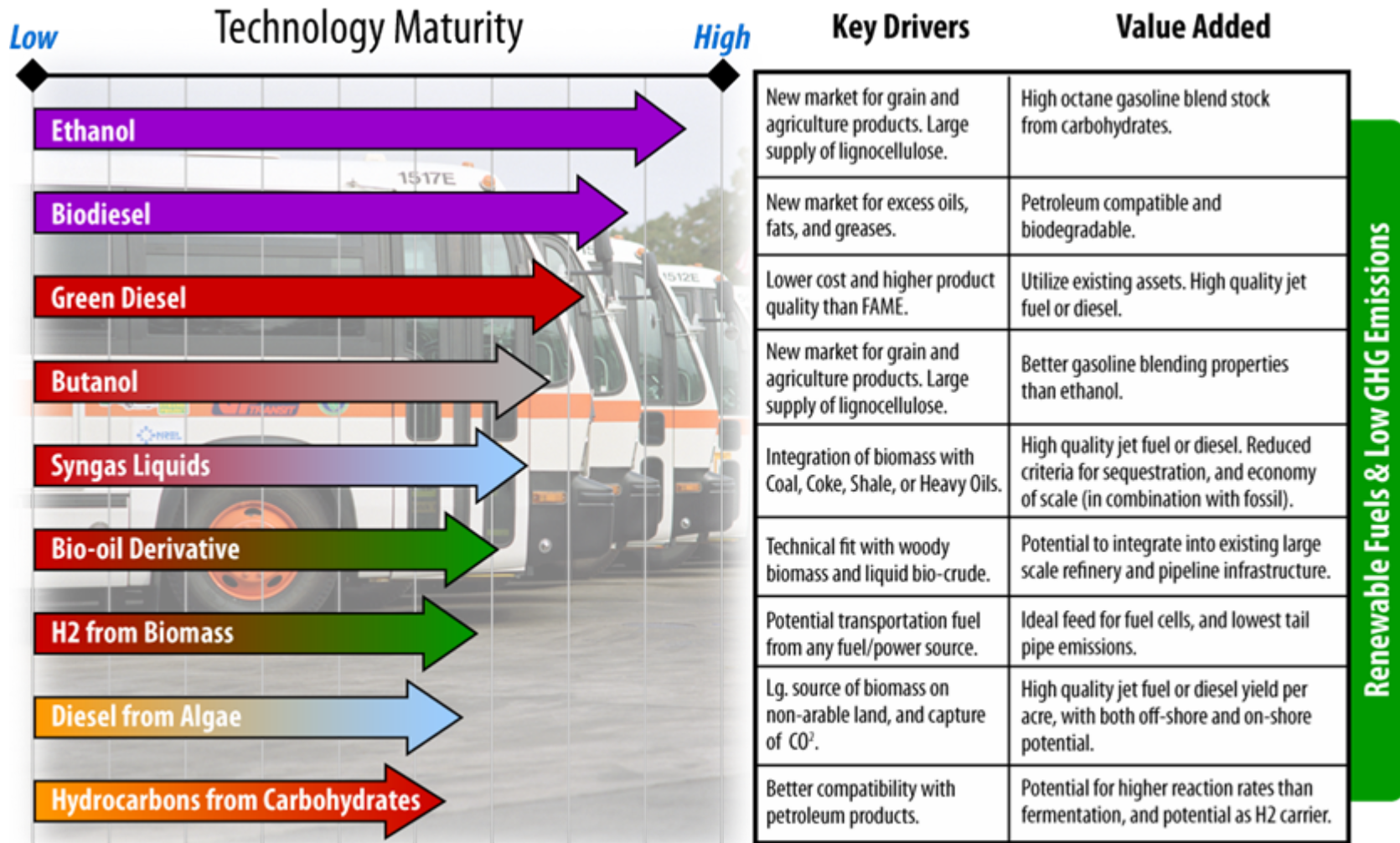
- Productivity per acre potential (~10,000 gal/acre/yr) far exceeds terrestrial plants – *R&D is needed to reach this potential!*
- NREL partnerships with petroleum refiners revealed an approach that converts algal oils in existing refineries
- Algal carbohydrates can be integrated into ethanol production







Jet Fuel From Algae



Productivity

SOT: 10gm/m²/day
Target: 50gm/m²/day


Organizations Leading the R&D

-  Grain/Agriculture
-  Coal
-  Chemical
-  Petroleum
-  Forestry
-  Academia & Startups

Renewable Fuels & Low GHG Emissions

Biomass: Summary & Conclusions



- ✓ The only domestic & renewable option for liquid transportation fuels.
- ✓ Resource base is sufficient to supply a large fraction of U.S. and Colorado needs
- ✓ A sustainable solution to meet the near-term “gap” expected to be caused by Peak Oil
- ✓ On-going R&D will create many opportunities that extend beyond today’s biopower, ethanol, and biodiesel facilities

Additional Information

DOE Biomass Program Web Site

<http://www.eere.energy.gov/biomass/>

NREL Biomass Web Site

<http://www.nrel.gov/biomass>



**Thank You for the
Opportunity**

