Opportunities and Challenges for Alternative Fuels

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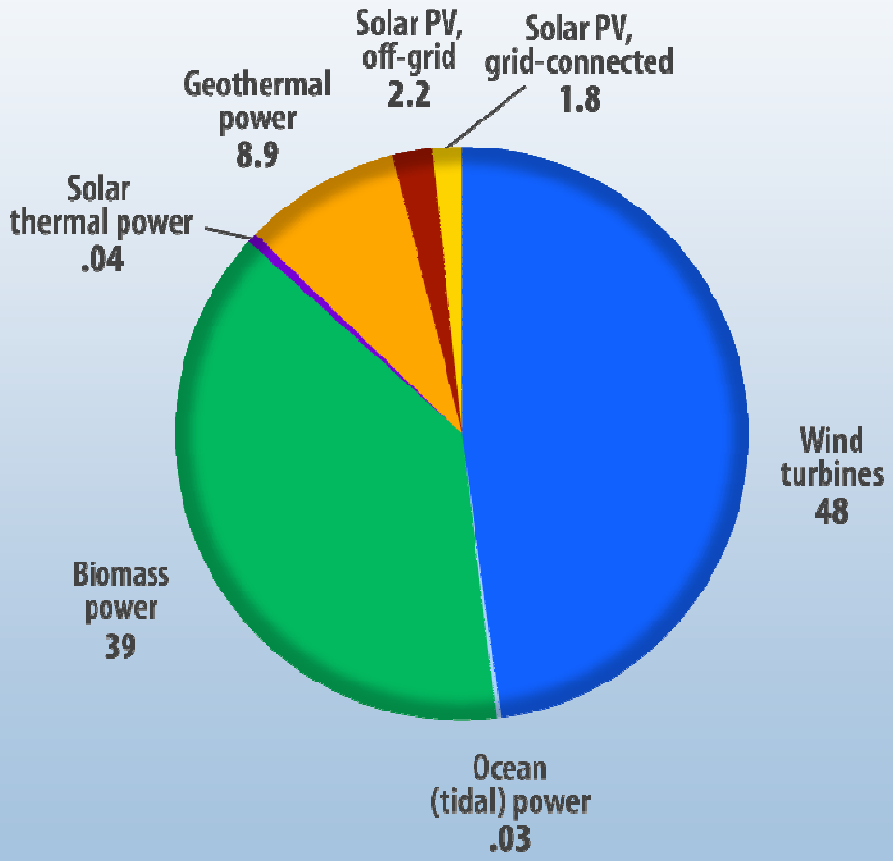
Renewable Energy Indicators

As of Year End 2004

Power Generation

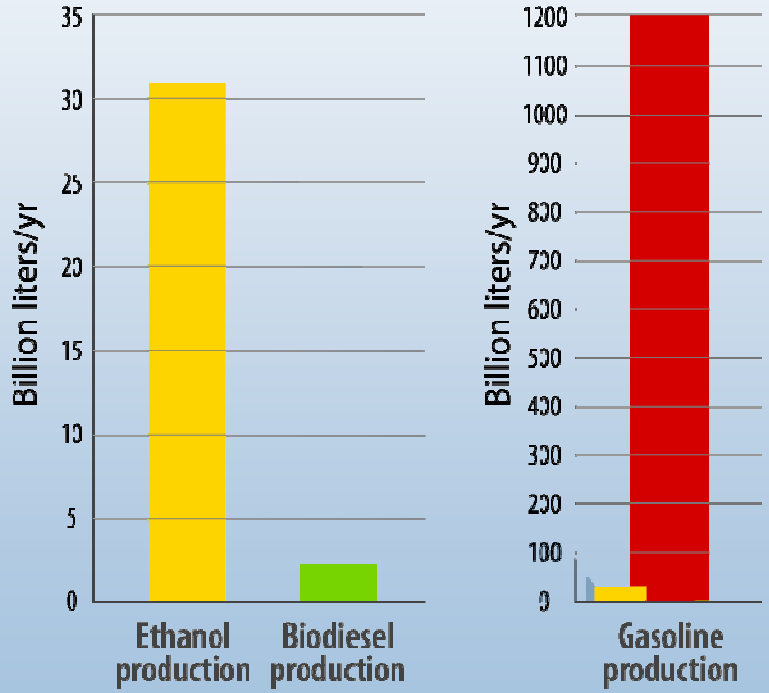
Existing Capacity* – GW



*Does not include hydropower

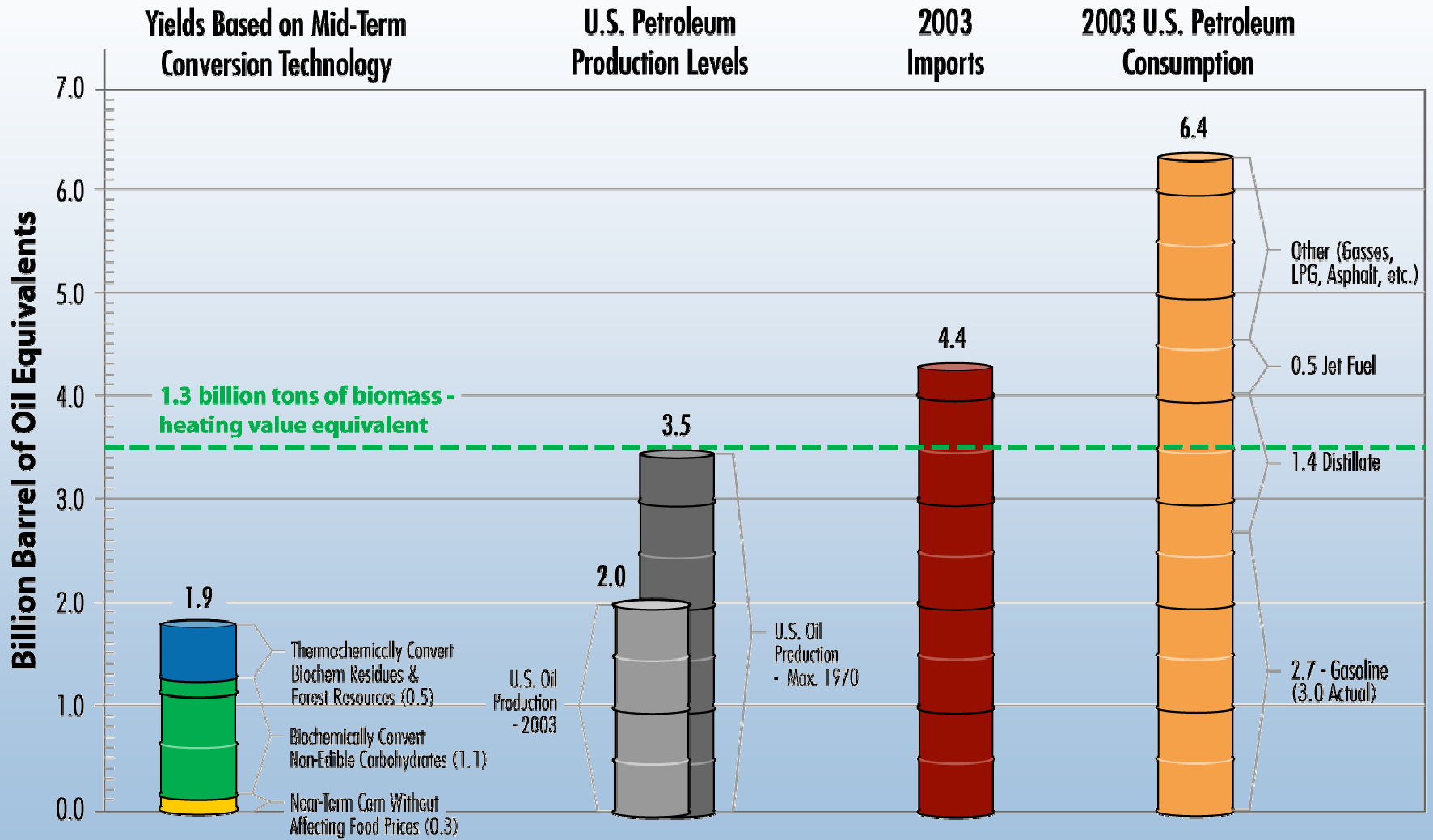
Transport Fuels

Billion liters/year



Source: REN21 Renewables 2005 Status Report,

Significance of the 1.3 Billion Ton Biomass Scenario



Based on ORNL & USDA Resource Assessment Study by Perlach et.al. (April 2005)
http://www.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf

Biofuels

Biofuels status

- Biodiesel – 75 million gallons (2005)
- Corn ethanol
  - 81 commercial plants
  - 3.9 billion gallons (2005)
  - Today's cost ~$1.35/gallon of gasoline equivalent (gge)
- Cellulosic ethanol
  - Projected commercial cost ~$3.00/gge

Potential

- 2012 goal – cellulosic ethanol ~$1.42/gge
- 2030 goal – all ethanol = 30% of transportation fuels

NREL Research Thrusts

- The Biorefinery
- Solutions to under-utilized waste residues
- Energy crops

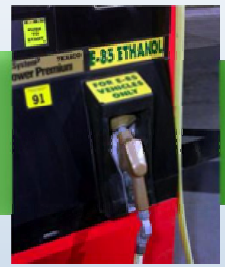
Source: U.S. Department of Energy, National Biodiesel Board, Renewable Fuels Association

Building the Supply Chain

Biomass Feedstock Supply

Biomass Feedstock Transport

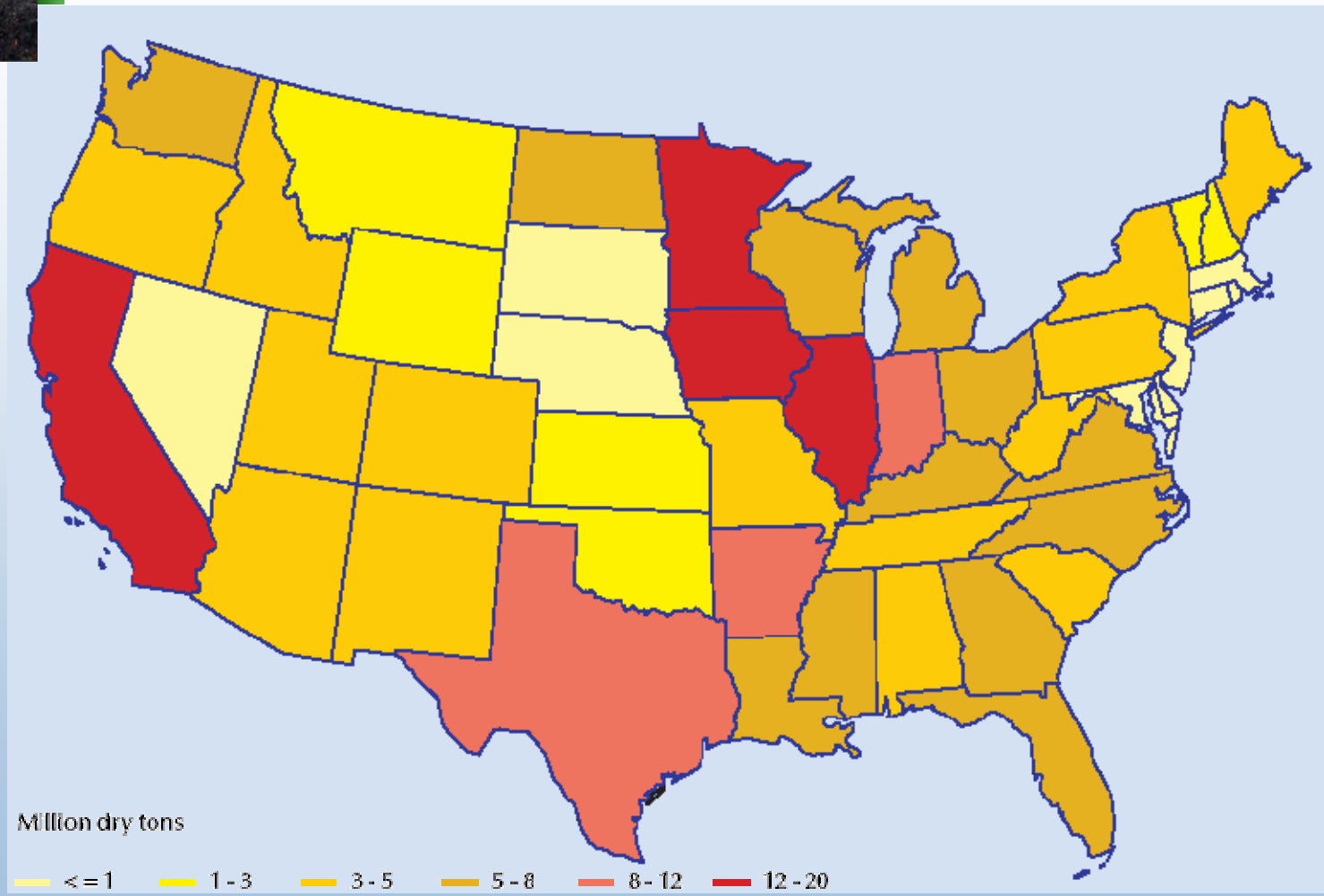
Biomass Conversion Technology



Markets: Fuels & Vehicles

Biomass Feedstock Supply

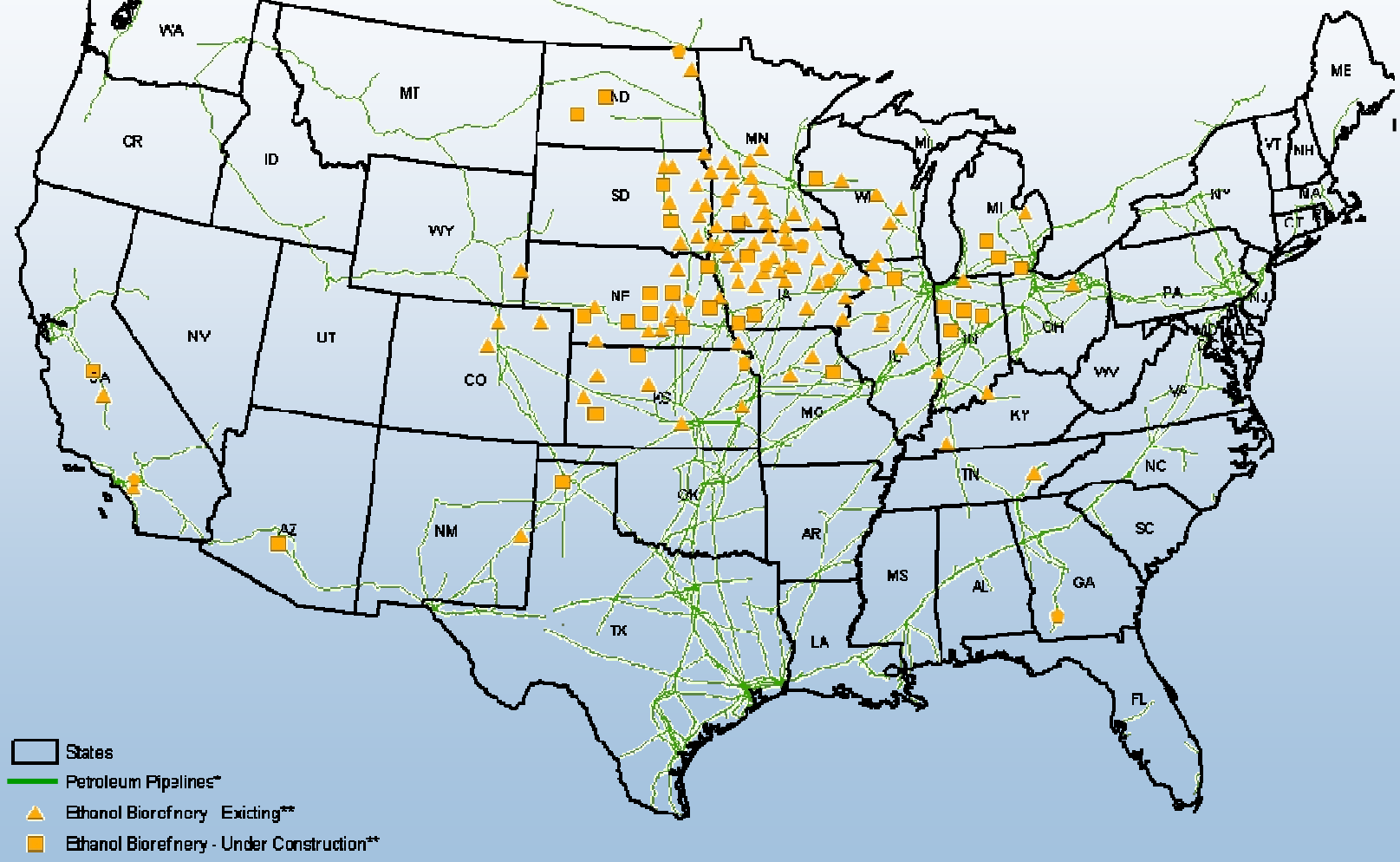
Renewable Waste Resources



Source: National Commission on Energy Policy, *Ending the Energy Stalemate*, December 2004

Biomass Feedstock Transport

Current Distribution Infrastructure



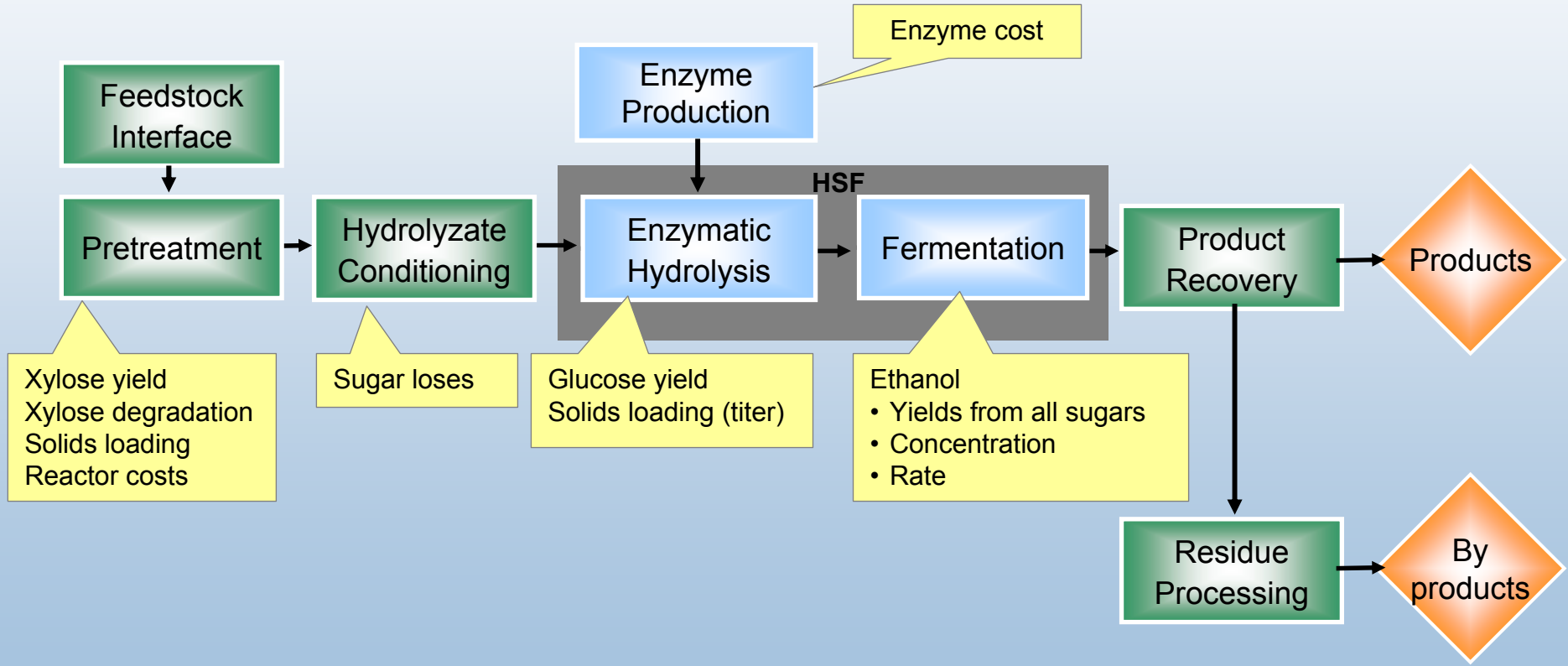
Source: MapSearch, PennWell, Renewable Fuels Association, June 2006

Biomass Feedstock Transport
Ethanol Distribution Infrastructure Hurdles

- Estimate that E85 pumps will be required in 50% of U.S. service stations
  - Public policy support may be necessary to encourage investment
- E10 and E85 may enter U.S. pipeline system
  - E10 may move through product pipelines if they are modified to trap water, sediment and to keep ethanol from other products (diesel)
  - E85 dedicated pipelines will be created to connect large producing centers to large use centers
- E85 pumps may require new or modified underground tanks at retail outlets

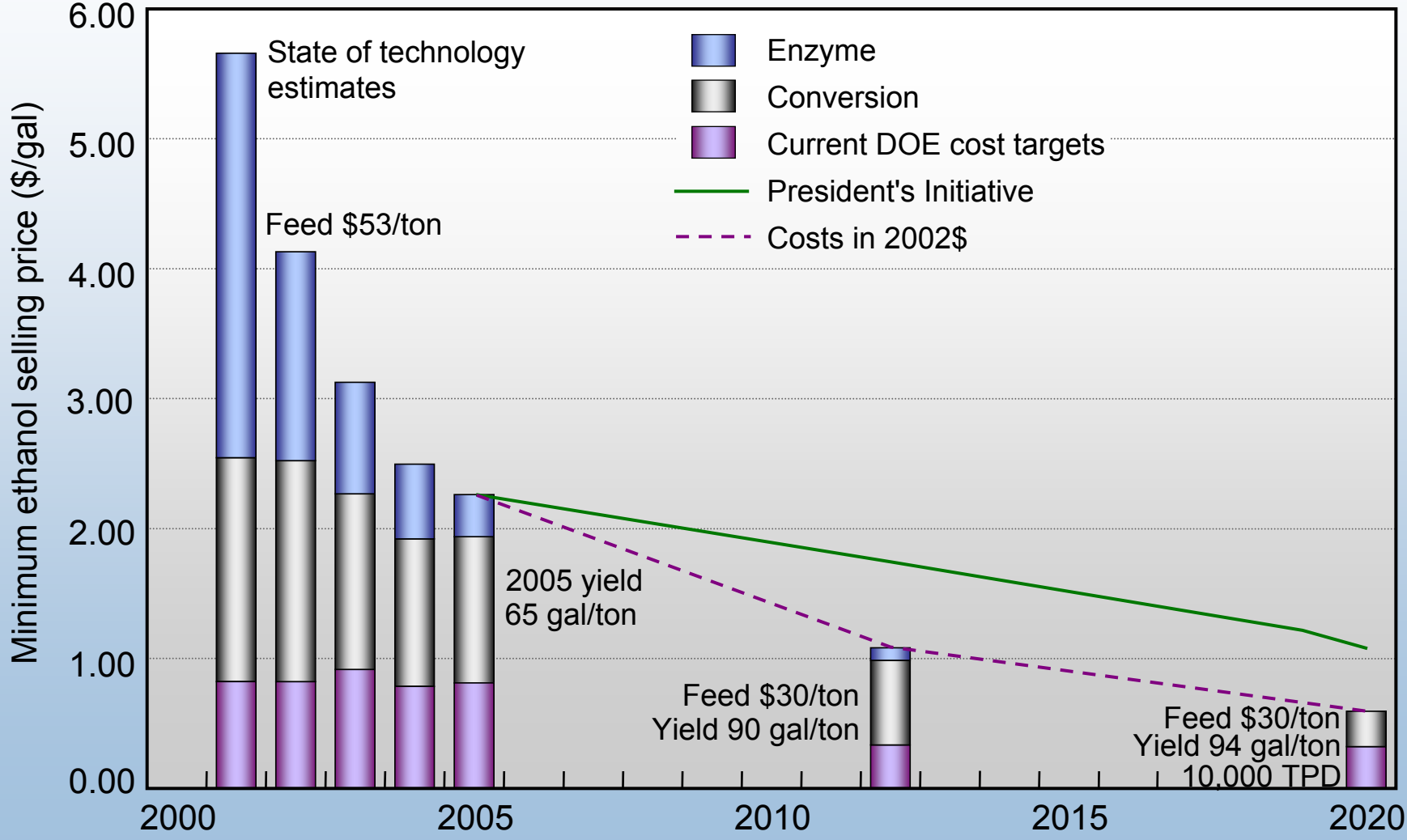
Biomass Conversion Technology

Biochemical Conversion Barrier Areas



Biomass Conversion Technology

Reducing the Cost of Ethanol from Stover



Biomass Conversion Technology

Thermochemical Conversion Barrier Areas

Feed Processing and Handling
- Size Reduction
- Storage and Handling
- De-watering
- Drying

Gasification
Pyrolysis
- Partial Oxidation
- Air blown
- Oxygen blown
- Indirect

- Flash pyrolysis
- Steam pyrolysis
- Vacuum pyrolysis

Gas Cleanup
High T Separation
- Particulate removal
- Tar reforming
- Benzene removal
- S, N, Cl mitigation

- High T Filtration
- Alkali removal

Gas Conditioning
Collection/Fractionation
- Methane reforming
- CO_2 removal
- H_2/CO adjustment
- Sulfur polishing

- Aerosol collection
- Microfiltration
- Chemical Stabilization
- Hydrotreating
- Dehydration

Fuel Synthesis
Upgrading
- C1 chemistry
  - FT liquids
  - MTG
  - Mixed OH

- Upgrading
- Production Separation

Heat & Power

Markets: Fuels & Vehicles

U.S. Transportation

	Autos	Light Trucks	Heavy Trucks	Airplanes
Share of transport fuel consumption	**39%**	**28%**	24%	9%
Fleet size – Millions	130	80	7	0.0085
New – Millions/year	8.5	8.5	0.5	Small
Median life – Years	**17**	**16**	28	22

Biggest, fastest savings

Source: SAIC/MISI

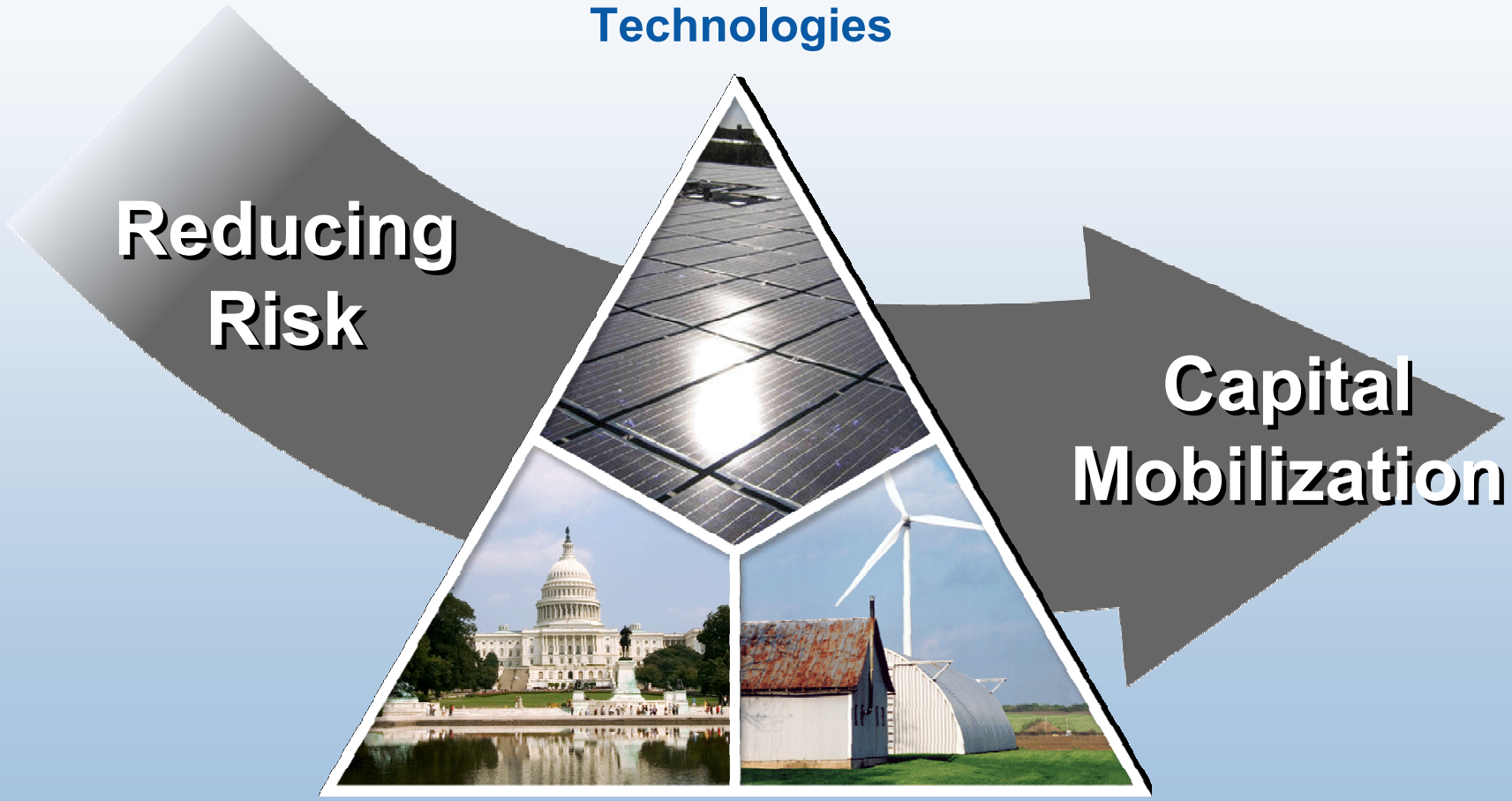
Markets: Fuels & Vehicles

Vehicle Needs

- Target to have all new light-duty vehicles being E85-compatible FFVs by 2020
  - This is a significant public policy opportunity
- May also encourage E85+ optimized FFVs to appear on large scale to help drive ethanol transition
- Next generation – Flex Fuel, Plug-in Hybrid Vehicles

30 x 30 Target

Replace 30% of 2004 motor gasoline demand with ethanol by 2030 – 60 billion gallons



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