

Renewable Energy: Providing Solutions from America's Working Lands

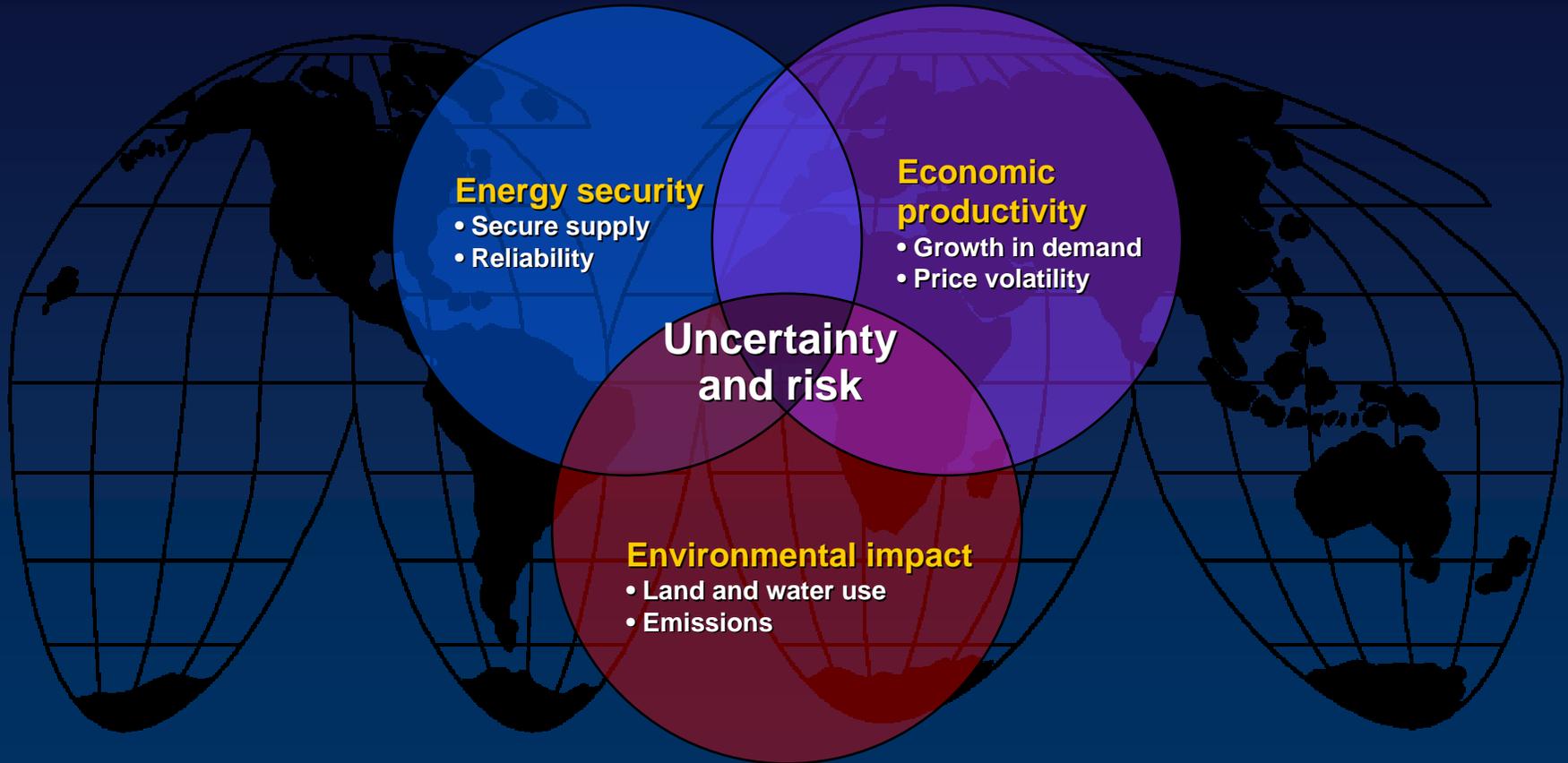
National Agriculture and Forestry Renewable Energy Summit

March 8, 2006

Dan E. Arvizu

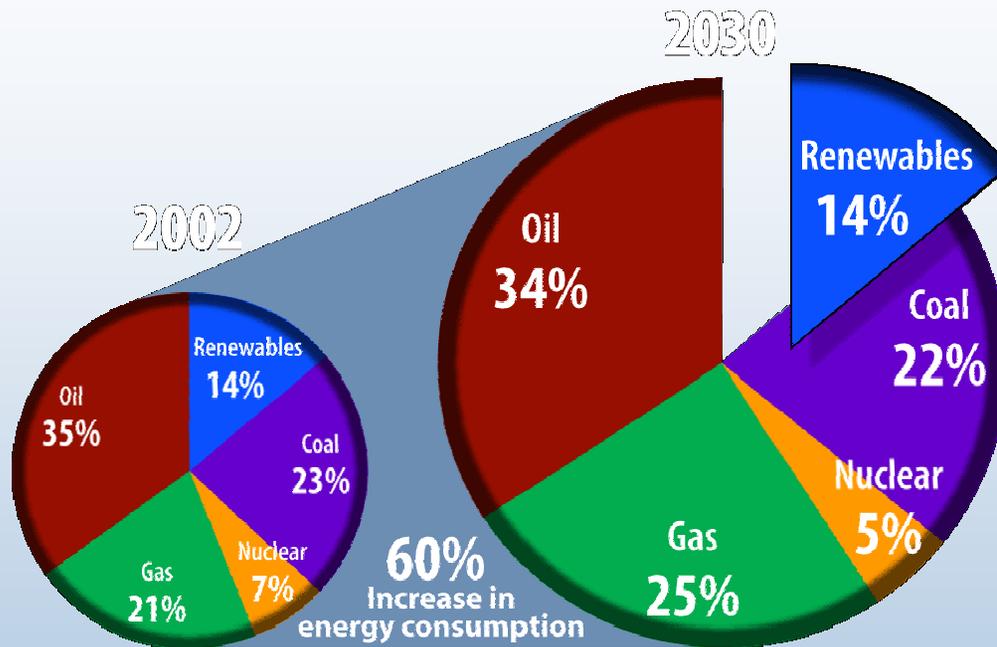
Director, National Renewable Energy Laboratory

Energy Solutions are Enormously Challenging

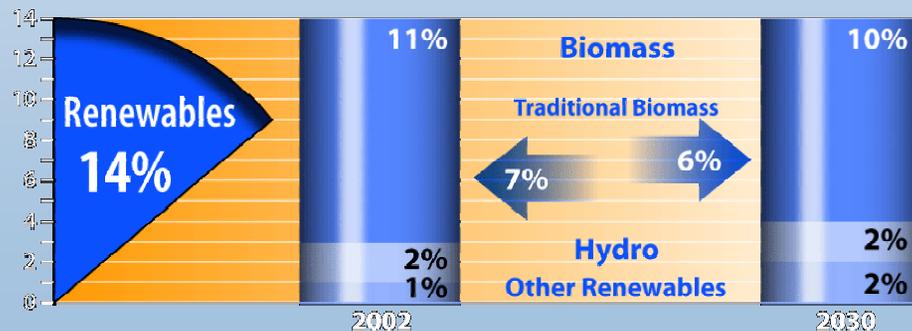


We need a balanced portfolio of options

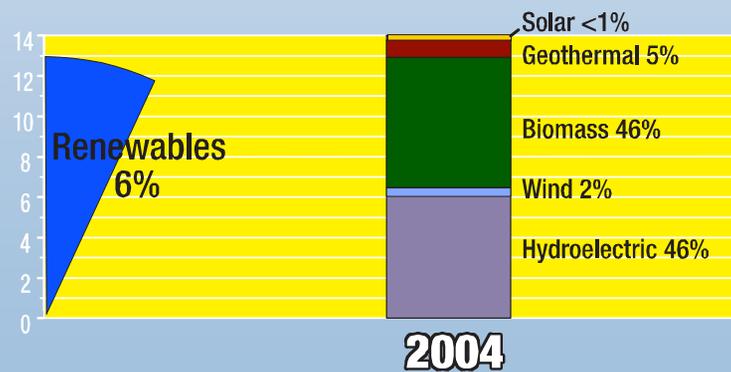
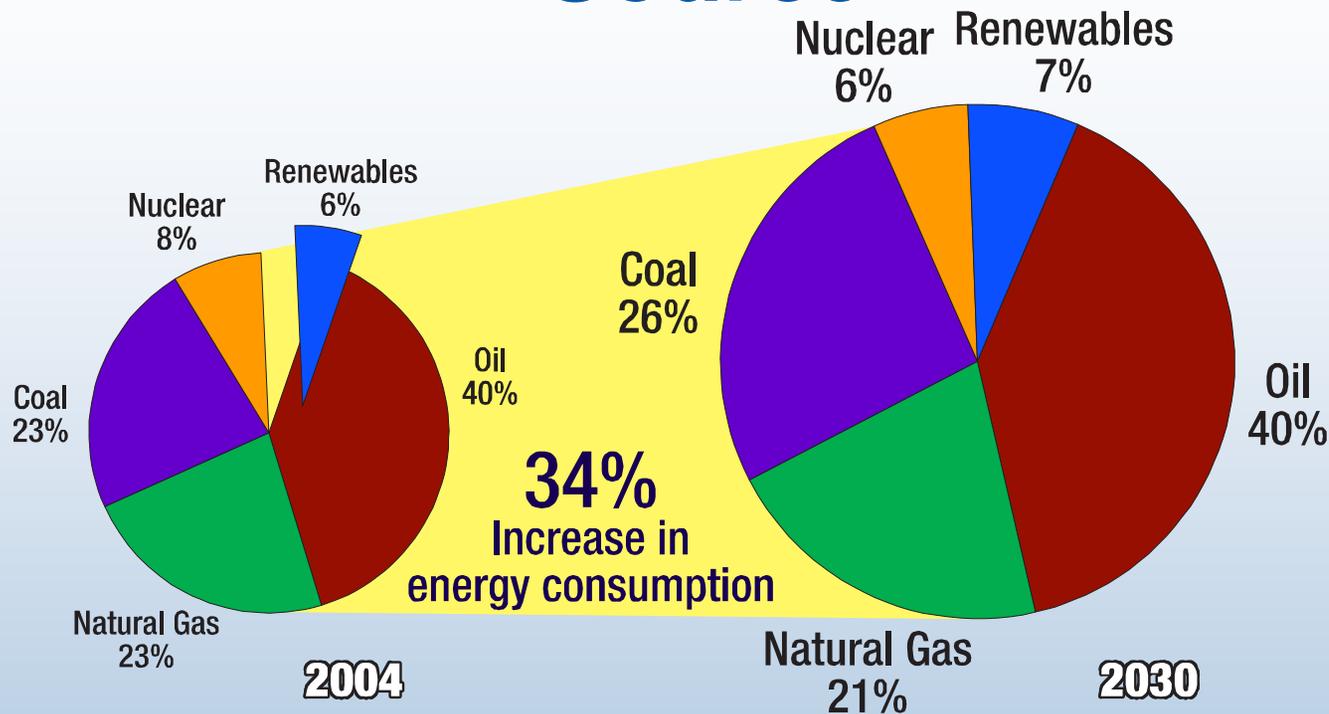
The Role of Renewables in the World Energy Supply



Source: OECD/IEA, 2004



U.S. Energy Consumption by Source



Source: Energy Information Administration, Annual Energy Outlook 2006, Table D4

Technology-based Solutions:

There is no single nor simple answer

- Energy efficiency
- Renewable energy
- Non-polluting transportation fuels
- Separation and capture of CO₂ from fossil fuels
- Next generation of nuclear fission and fusion technology
- Transition to smart, resilient, distributed energy systems coupled with pollution-free energy carriers, e.g. hydrogen and electricity



Energy Efficiency & Renewable Energy Technology Development Programs

NREL R&D Portfolio

Renewable Resources

- Wind
- Solar
- Biomass
- Geothermal



Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies



Energy Delivery & Storage

- Electricity Transmission & Distribution
- Alternative Fuels
- Hydrogen Delivery and Storage

Foundational Science

Science at the Leading Edge of Energy Efficiency Research

Significant improvements are anticipated through:

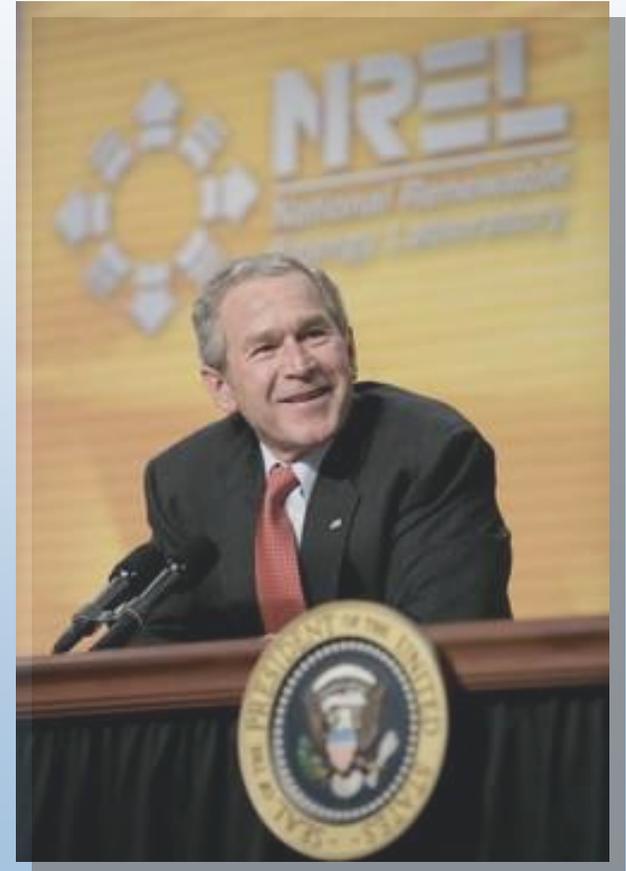
- Super-strong lightweight materials
- Smart roofs
- Solid state lighting
- Superconducting electric T&D

New discoveries will have broad impact on daily life



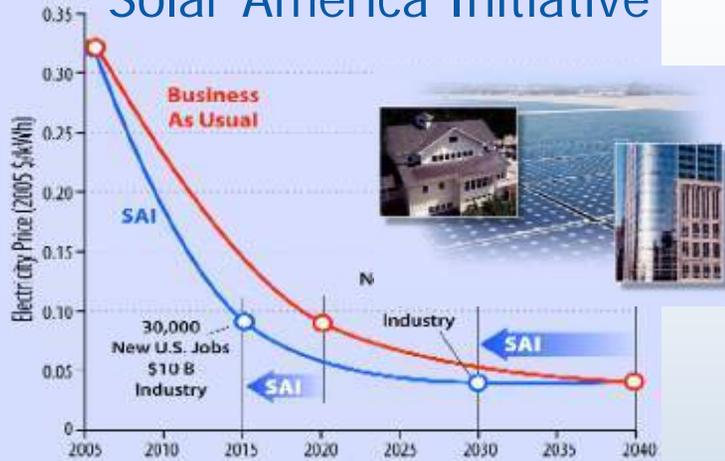
President's Advanced Energy Initiative 2007 Budget

- National goals to address American “addiction to oil”
- 22% increase in DOE “clean energy” funding
- Major new R&D investments in solar, wind, biorefinery and hydrogen fuel cells

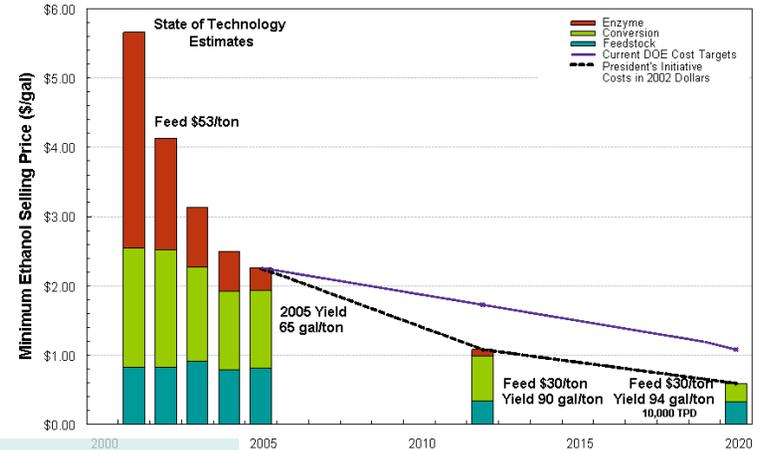


Accelerating Progress is Expected

Solar America Initiative



Biorefinery Initiative



Hydrogen Fuel Initiative



Without a Different Approach, Meeting these Aggressive Goals is a High-Risk Proposition

Wind

Status:

- 9,200 MW
- Cost 4-6¢/kWh (unsubsidized)

Potential:

- 3¢/kWh (onshore) by 2012
- 5¢/kWh (offshore) by 2012



NREL Research Thrusts

- Low-wind speed turbines
- Advanced power electronics
- Technology transfer to ocean-based systems

Solar

Status:

- 450 MW
- Cost 20-30¢/kWh

Potential:

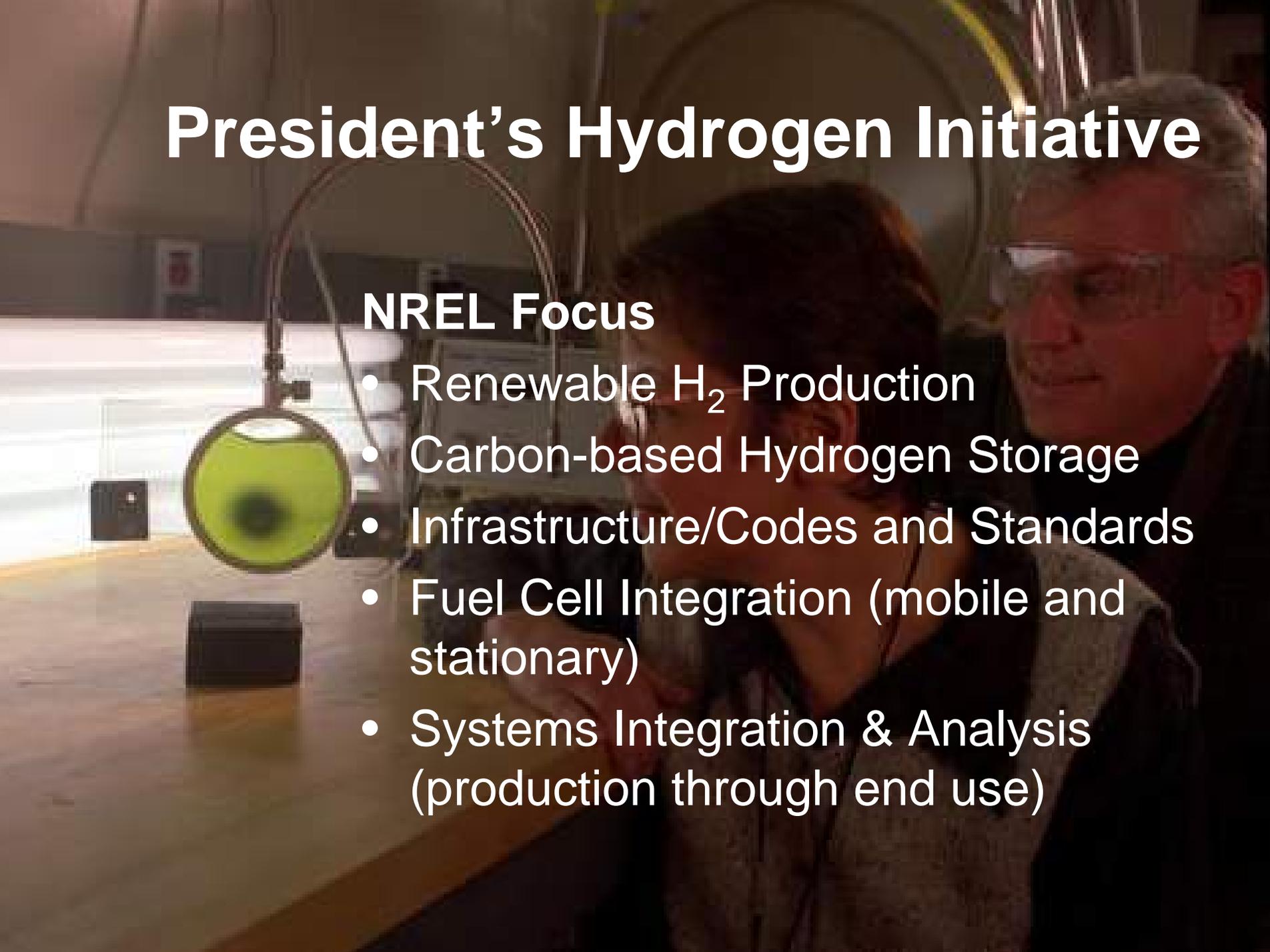
- 2020 goal: 6¢/kWh



NREL Research Thrusts

- Higher efficiency devices
- New nanomaterials applications
- Advanced manufacturing techniques

President's Hydrogen Initiative

The background of the slide shows a laboratory environment. On the left, a round-bottom flask containing a bright green liquid is suspended from a metal stand. In the center and right, two individuals are visible. The person in the foreground is a woman with dark hair, wearing safety glasses and a dark lab coat, looking towards the right. Behind her, a man with short grey hair and safety glasses is also looking to the right. The overall scene is dimly lit, with the primary light source coming from the left, highlighting the flask and the people's faces.

NREL Focus

- Renewable H₂ Production
- Carbon-based Hydrogen Storage
- Infrastructure/Codes and Standards
- Fuel Cell Integration (mobile and stationary)
- Systems Integration & Analysis (production through end use)

Biomass/Biofuels

Biofuels status:

- Biodiesel – 75 million gallons (2005)
- Corn ethanol
 - 81 commercial plants
 - 3.9 billion gallons (2005)
 - ~\$1.22/gal



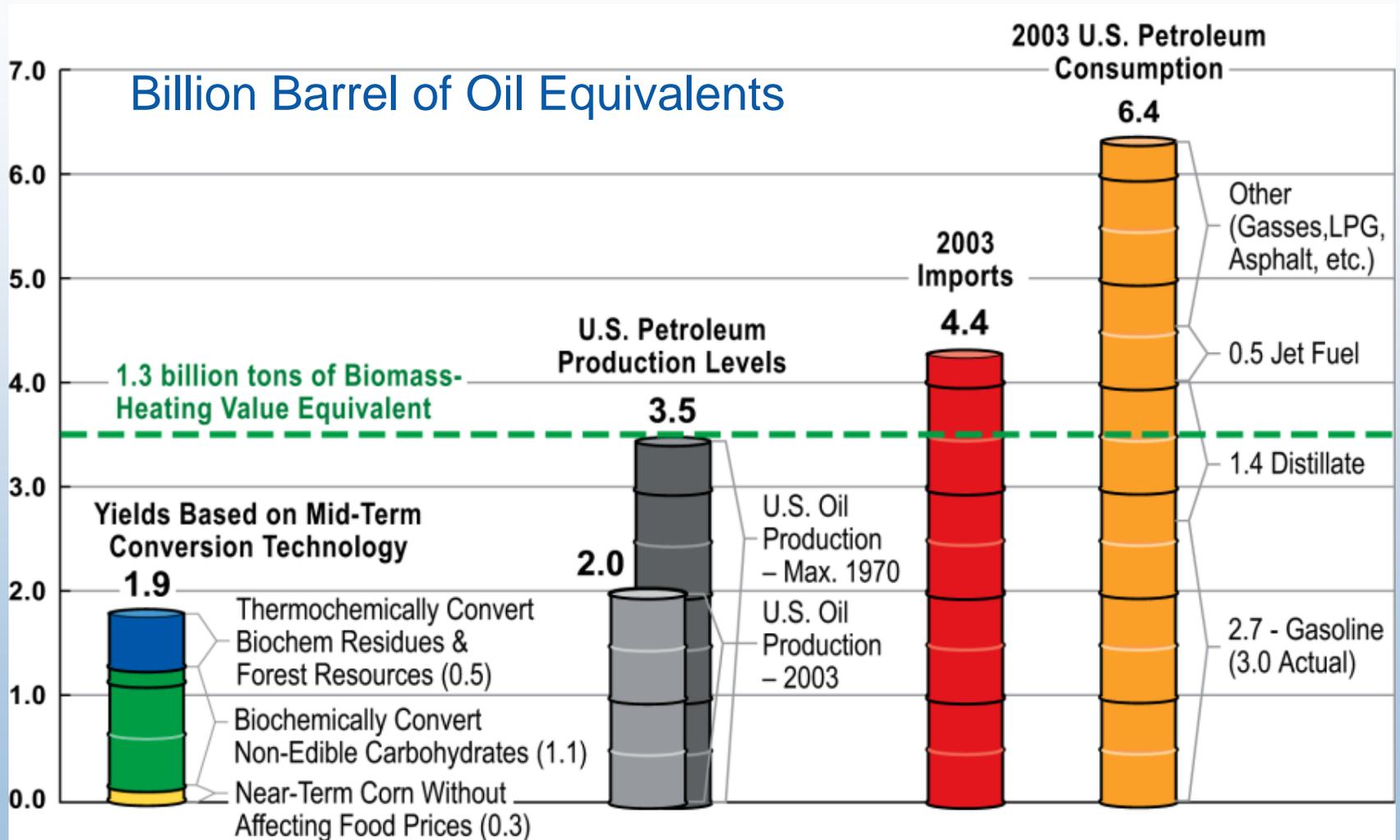
Potential:

- 2030 goal – cellulosic ethanol = 30% of transportation fuels

NREL Research Thrusts

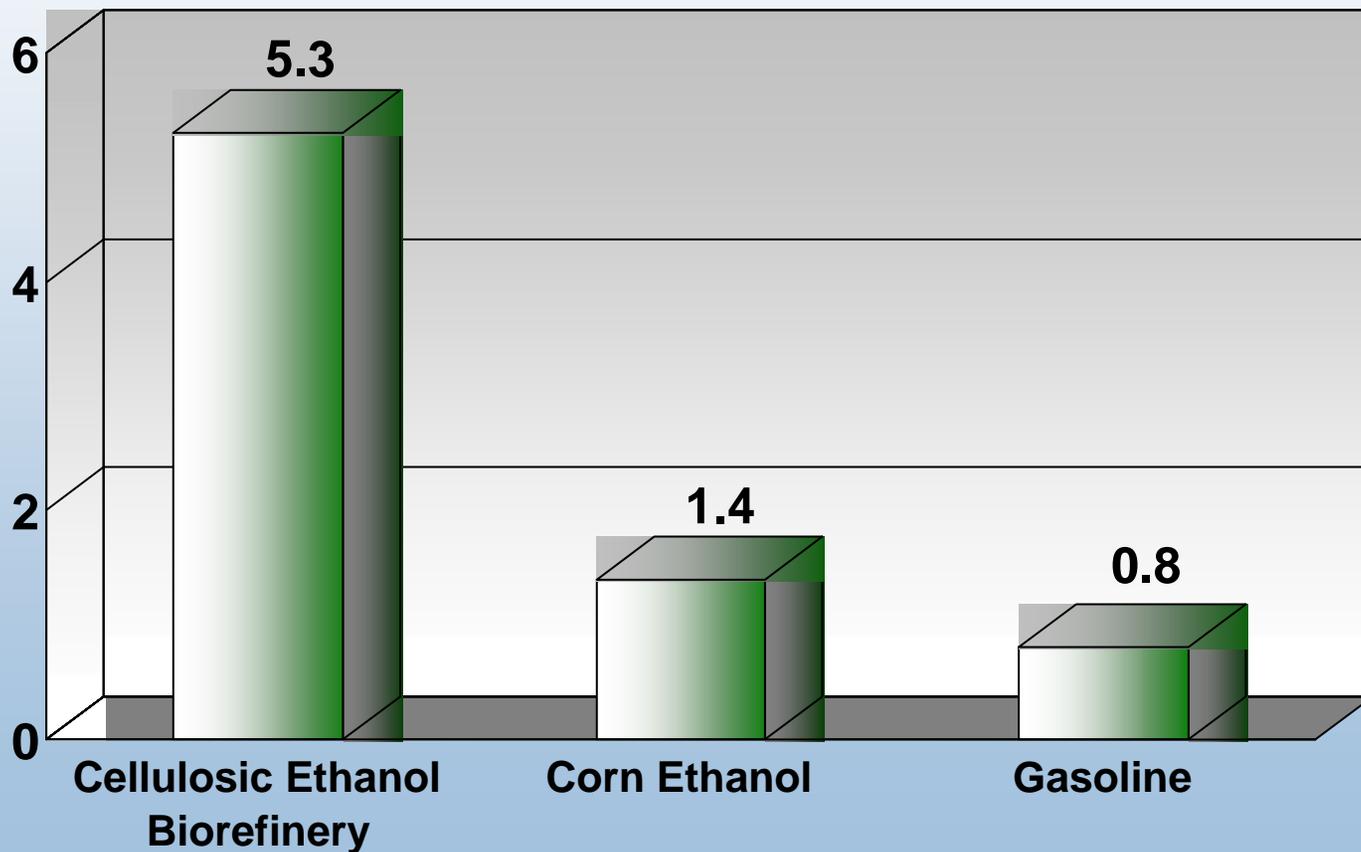
- The Biorefinery
- Solutions to under-utilized waste residues
 - Agriculture
 - Forestry
 - Urban
- Advanced agriculture (energy crops) enabled by plant genomics and bioscience

The 1.3 Billion Ton Biomass Scenario

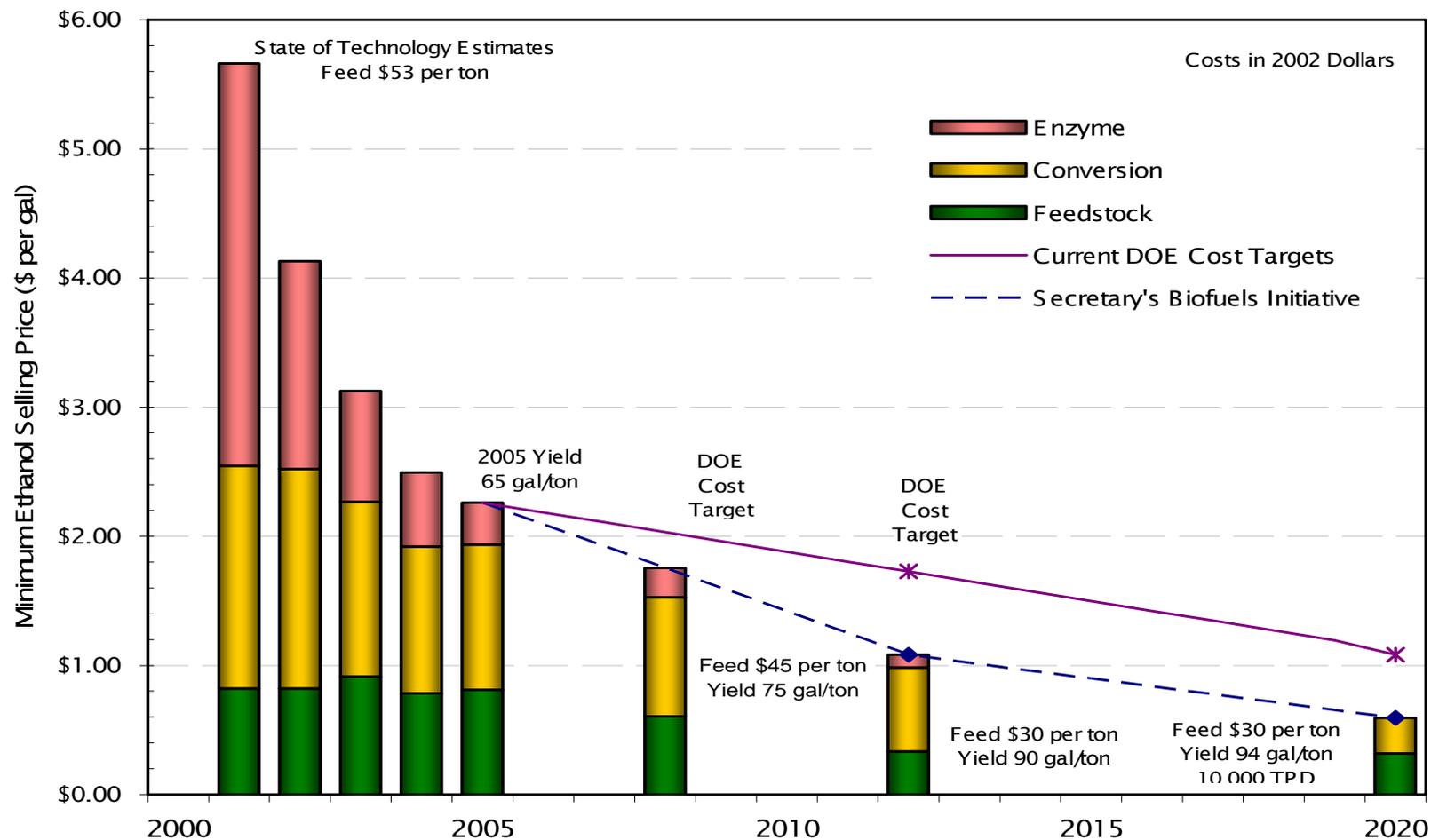


Fossil Energy Ratio

$$\text{Fossil Energy Ratio (FER)} = \frac{\text{Energy Delivered to Customer}}{\text{Fossil Energy Used}}$$



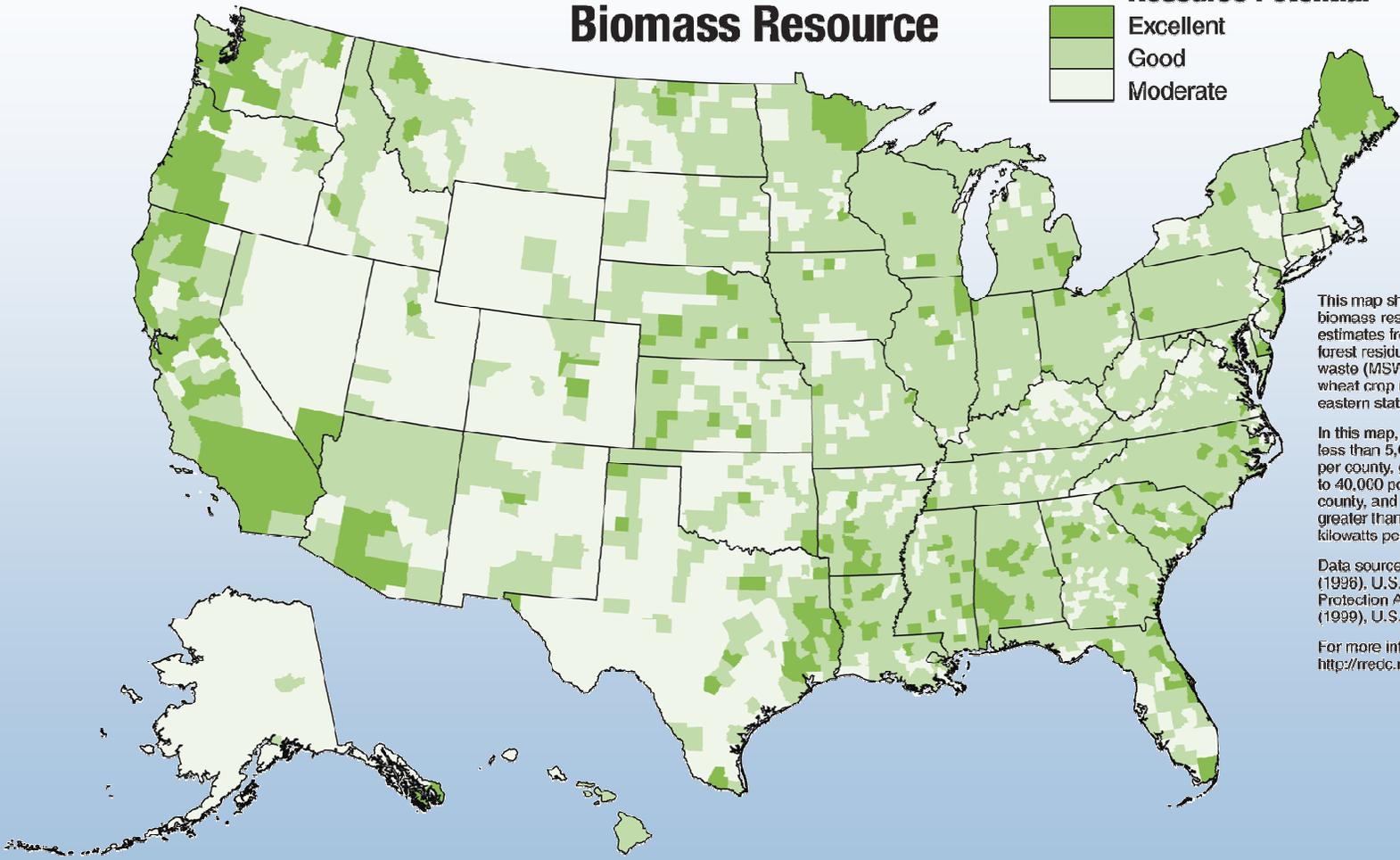
Biochemical Conversion Pathway Cost Targets



Biomass Resource

Resource Potential

- Excellent
- Good
- Moderate



This map shows county-level biomass resource potential estimates from nationwide data for forest residue and municipal solid waste (MSW); and from corn and wheat crop residue data for 36 eastern states.

In this map, moderate represents less than 5,000 potential kilowatts per county, good represents 5,000 to 40,000 potential kilowatts per county, and excellent represents greater than 40,000 potential kilowatts per county.

Data sources: U.S. Forest Service (1996), U.S. Environmental Protection Agency (1997), NREL (1999), U.S. Census Bureau (1997)

For more information, please visit <http://recc.nrel.gov>

The U.S. Department of Energy's National Renewable Energy Laboratory

www.nrel.gov



Golden, Colorado