

The Place of Colorado and the U.S. in the Global Renewable Energy Economy

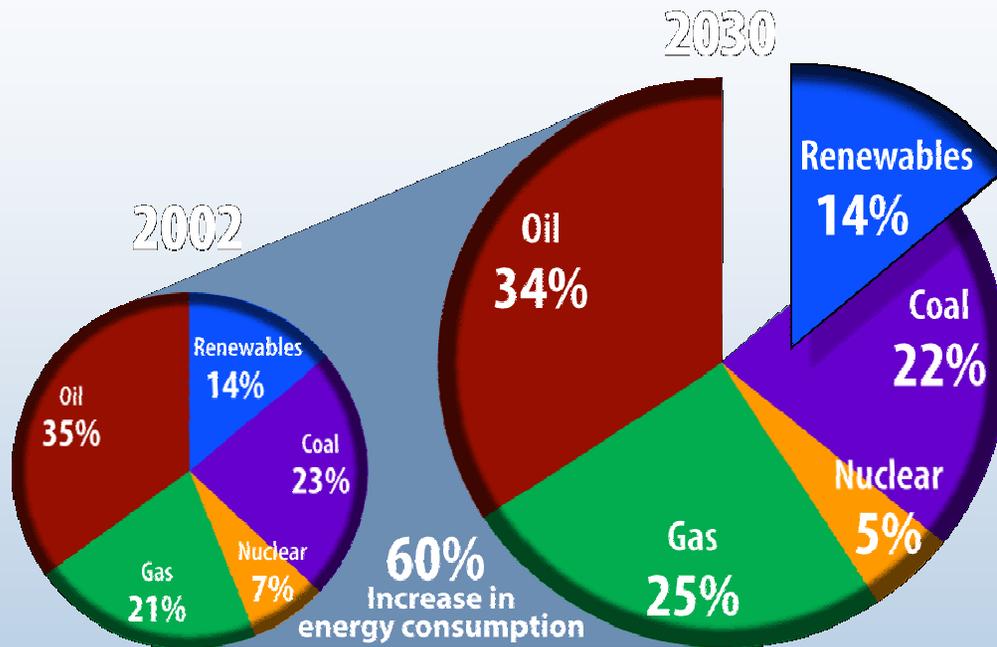
**Presented at the
Colorado Renewable Energy Summit**

January 11, 2006

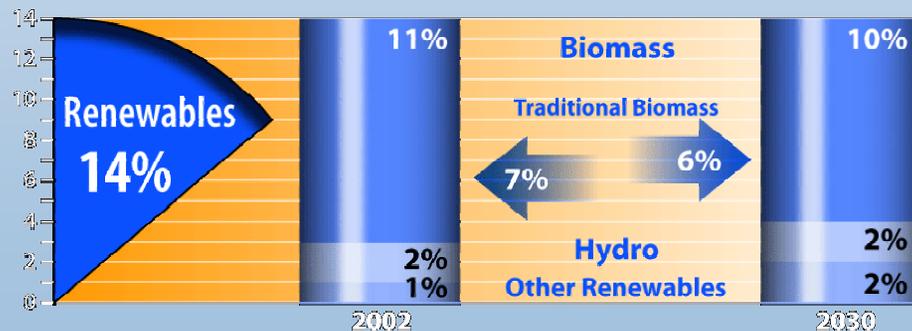
Dr. Dan E. Arvizu

Director, National Renewable Energy Laboratory

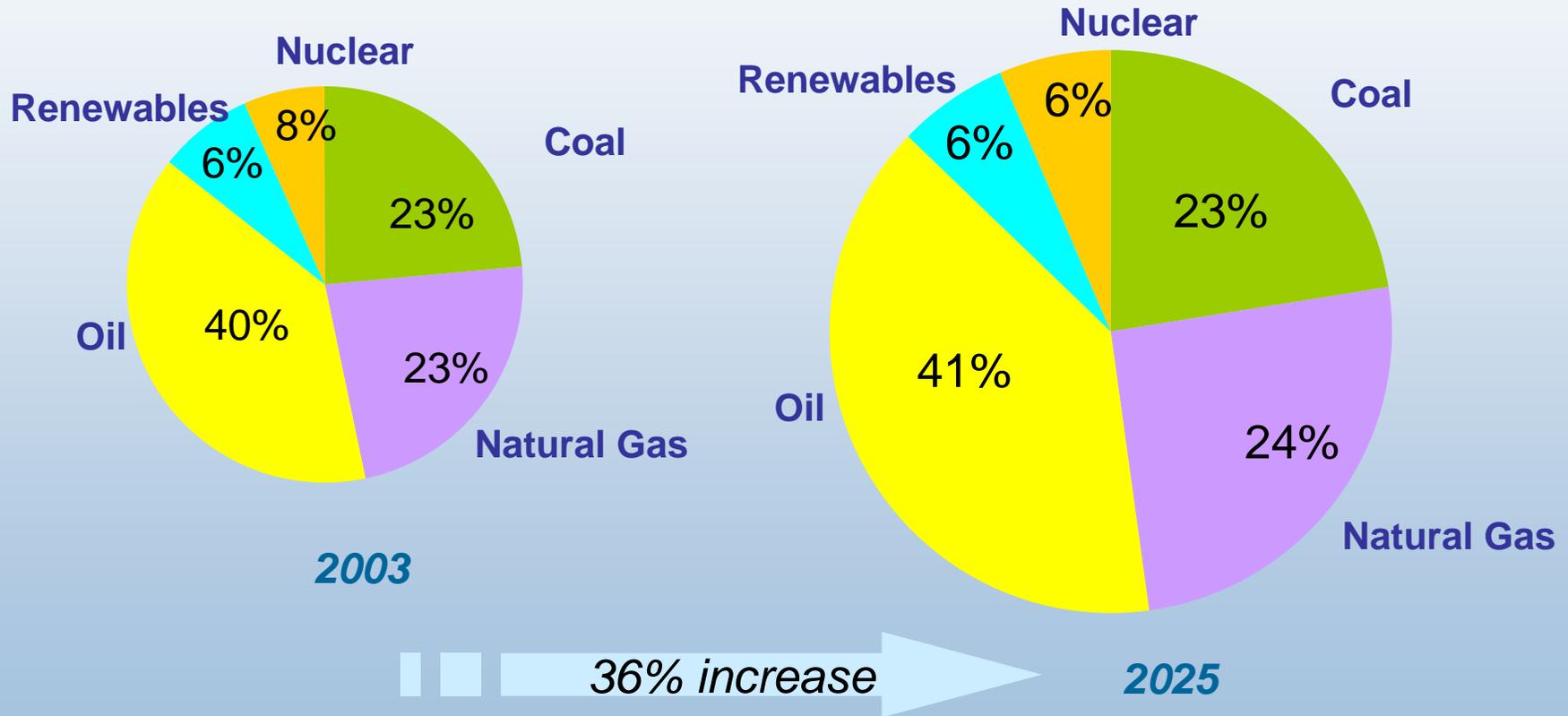
The Role of Renewables in the World Energy Supply



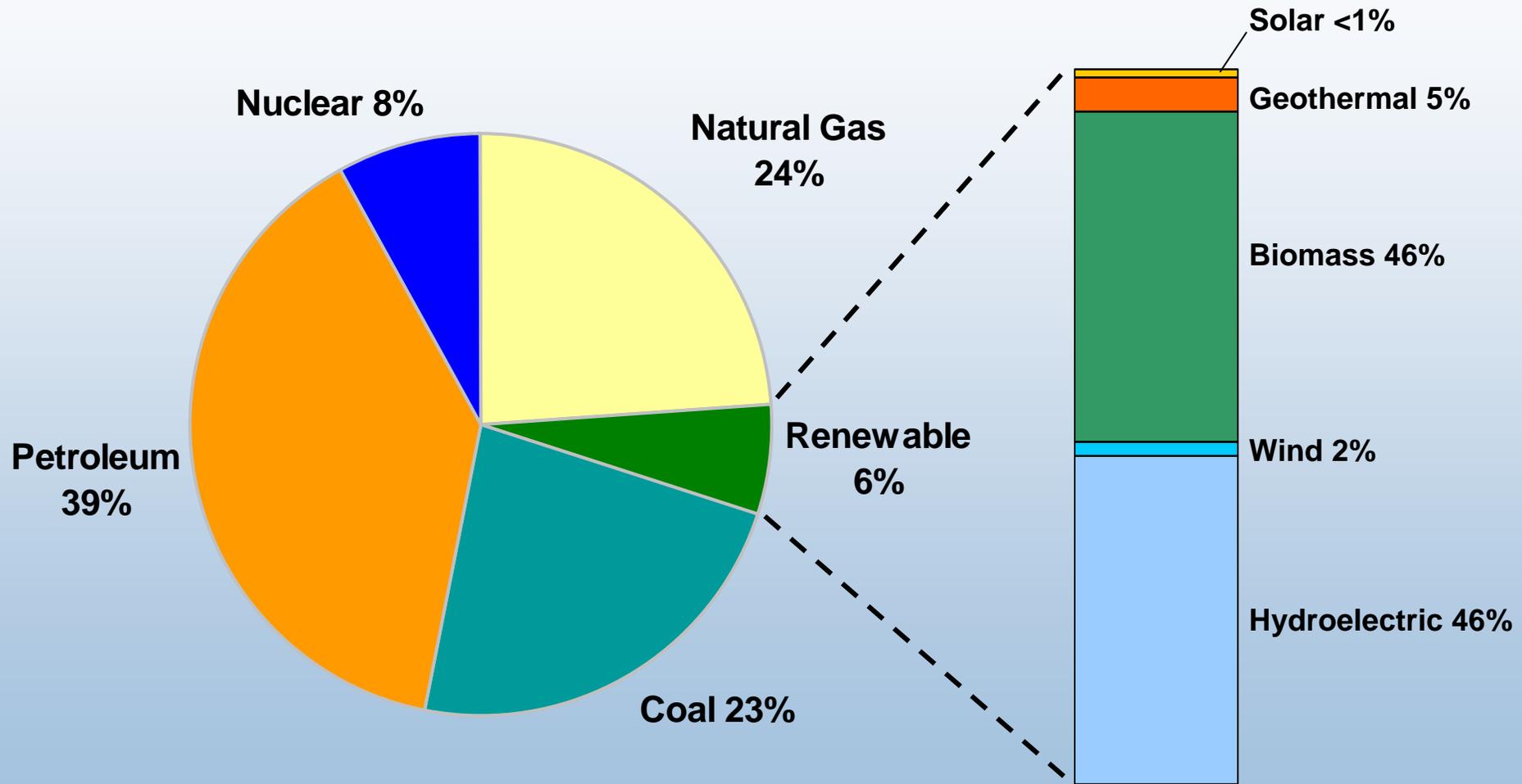
Source: OECD/IEA, 2004



U.S. Energy Consumption by Source

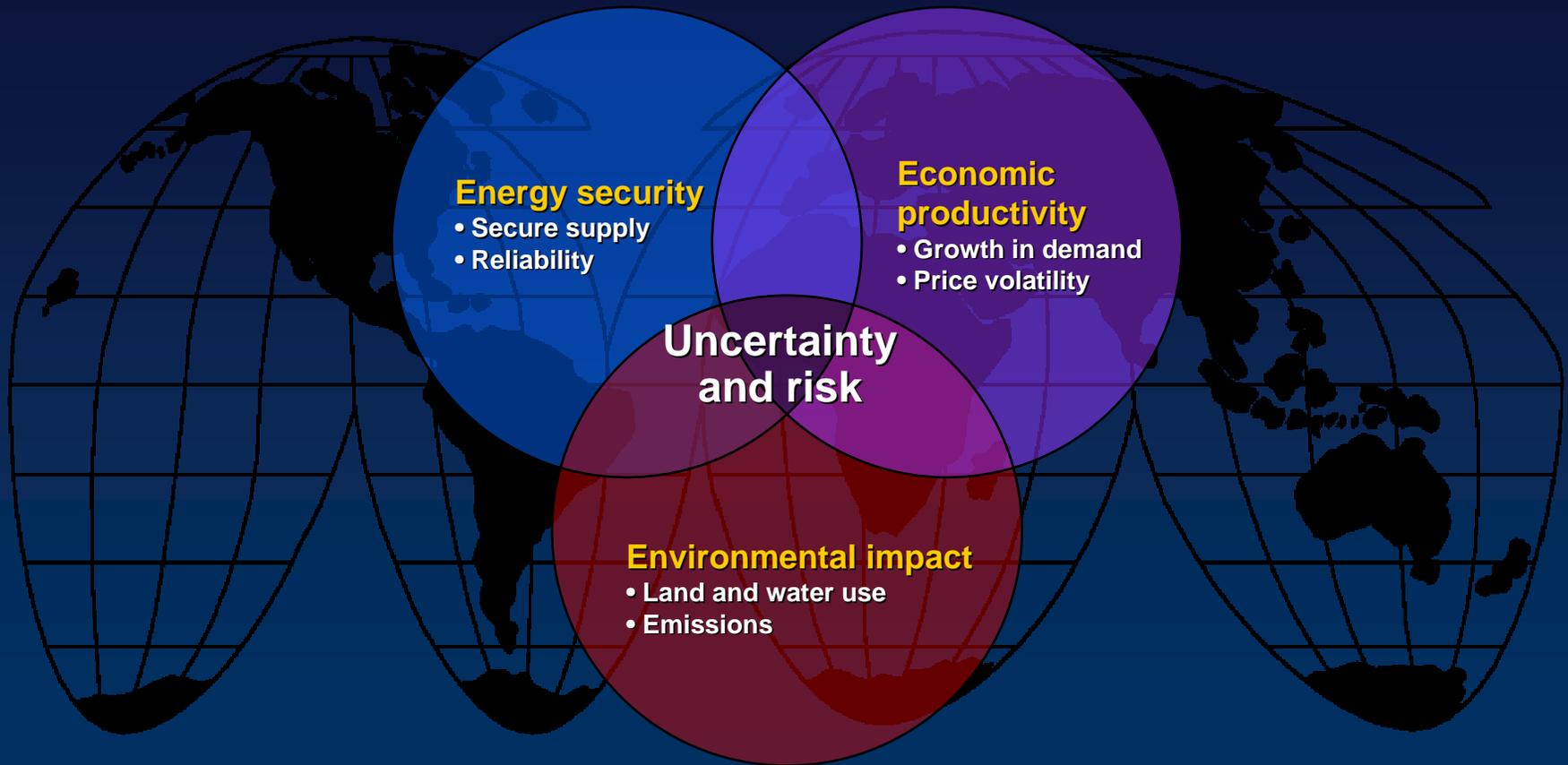


The Role of Renewables in the U.S. Energy Supply - 2003



Source: AEO 2004 tables (released in December 2003) based on US energy consumption. Overall breakdown Table A1 (Total Energy Supply and Disposition), and Renewable breakdown Table A18 (Renewable Energy, Consumption by Section and Source).

Energy Solutions are Enormously Challenging



We need a balanced portfolio of options

A Quarter Century of Energy R&D Contributions

Total U.S. Energy R&D = \$100B

Renewable Energy R&D = \$14B



Created a commercial nuclear power option



Reduced emissions from coal-fired power plants



Enhanced oil recovery from wells



Enabled hybrid vehicles to enter the market



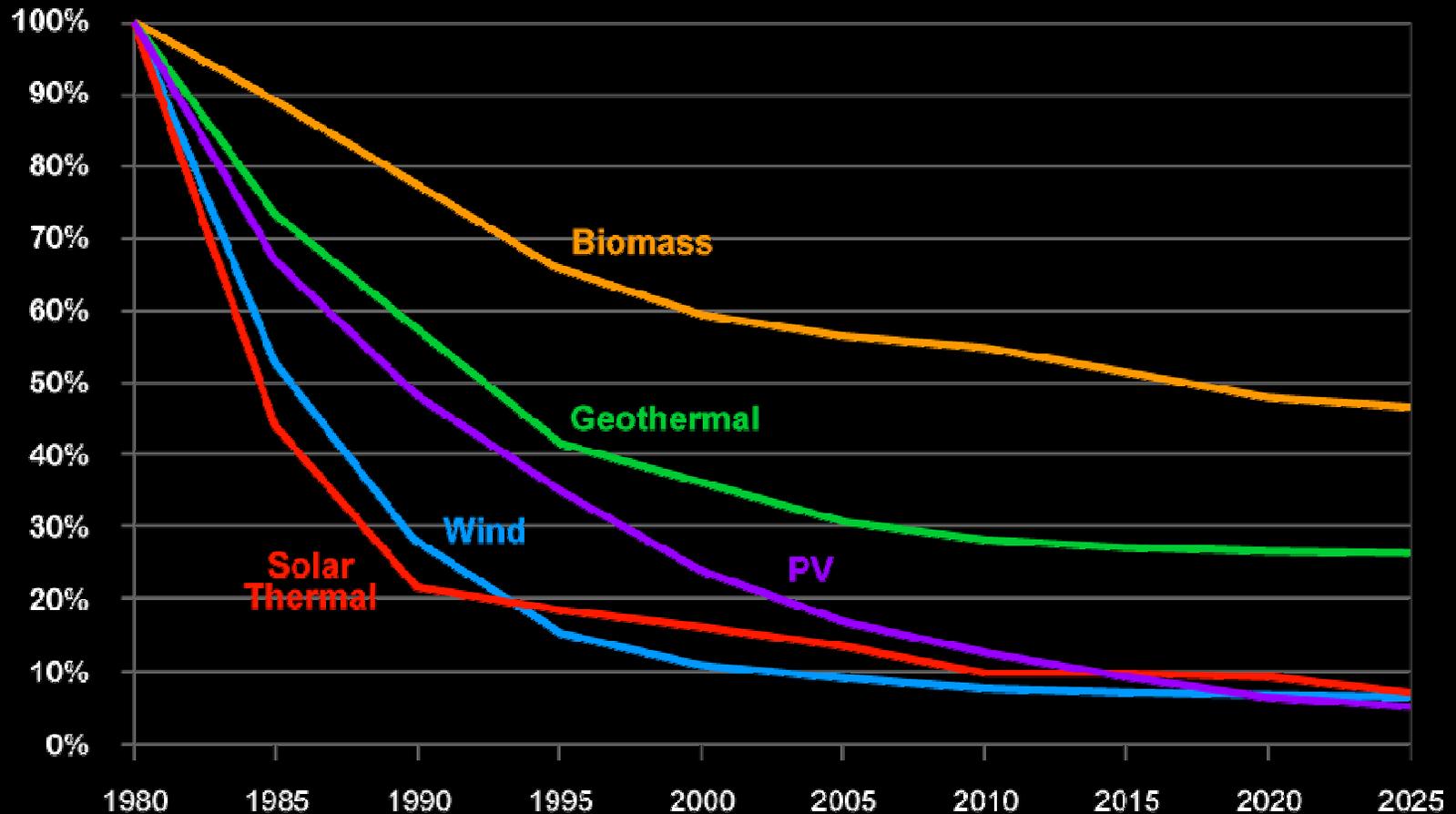
Brought utility-scale wind into our generation mix



Improved energy productivity

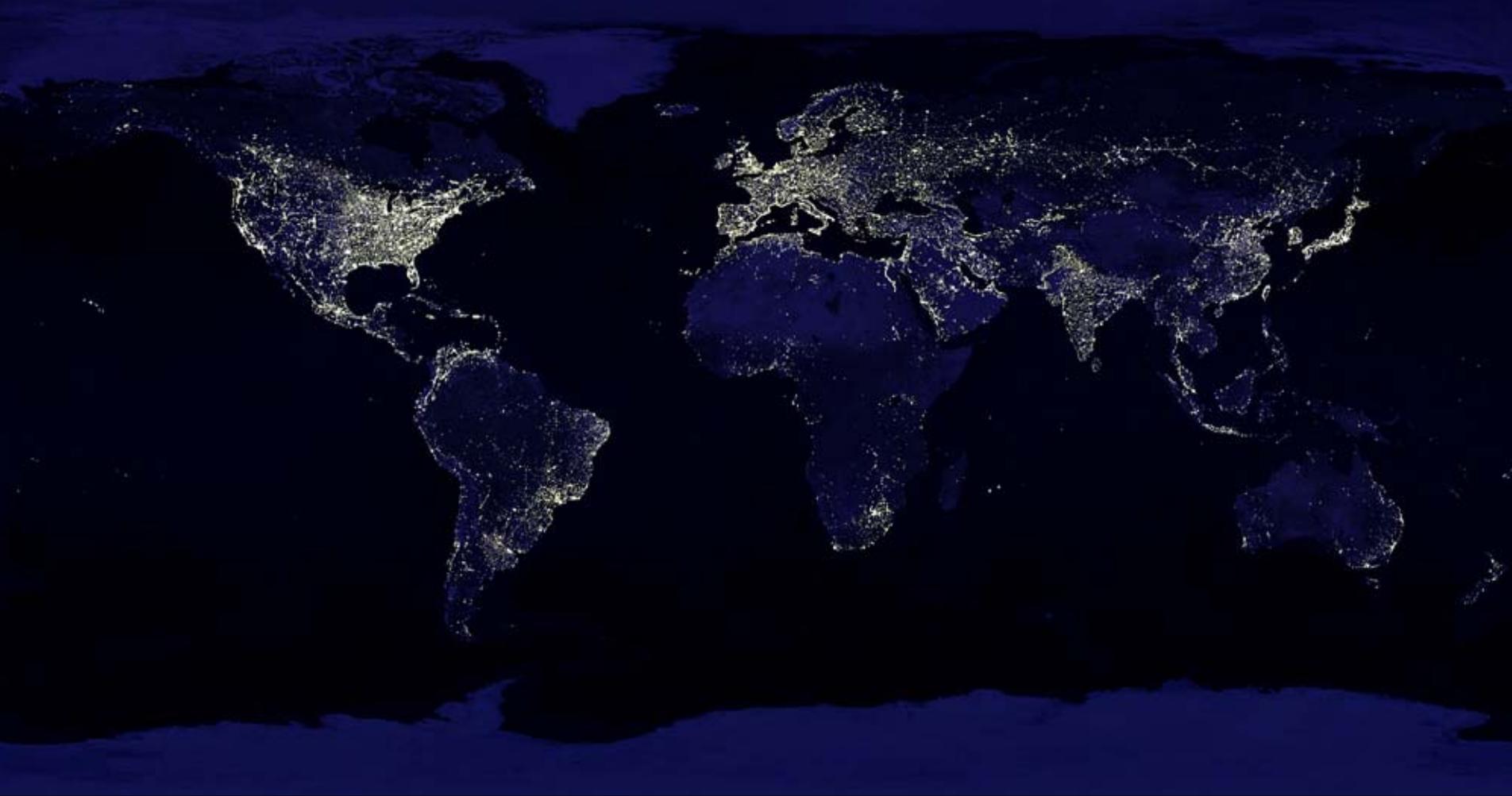
Technology innovations have had a significant impact

Renewable Energy Electricity Generation Costs as Percentage of 1980 Levels: Historical and Projected

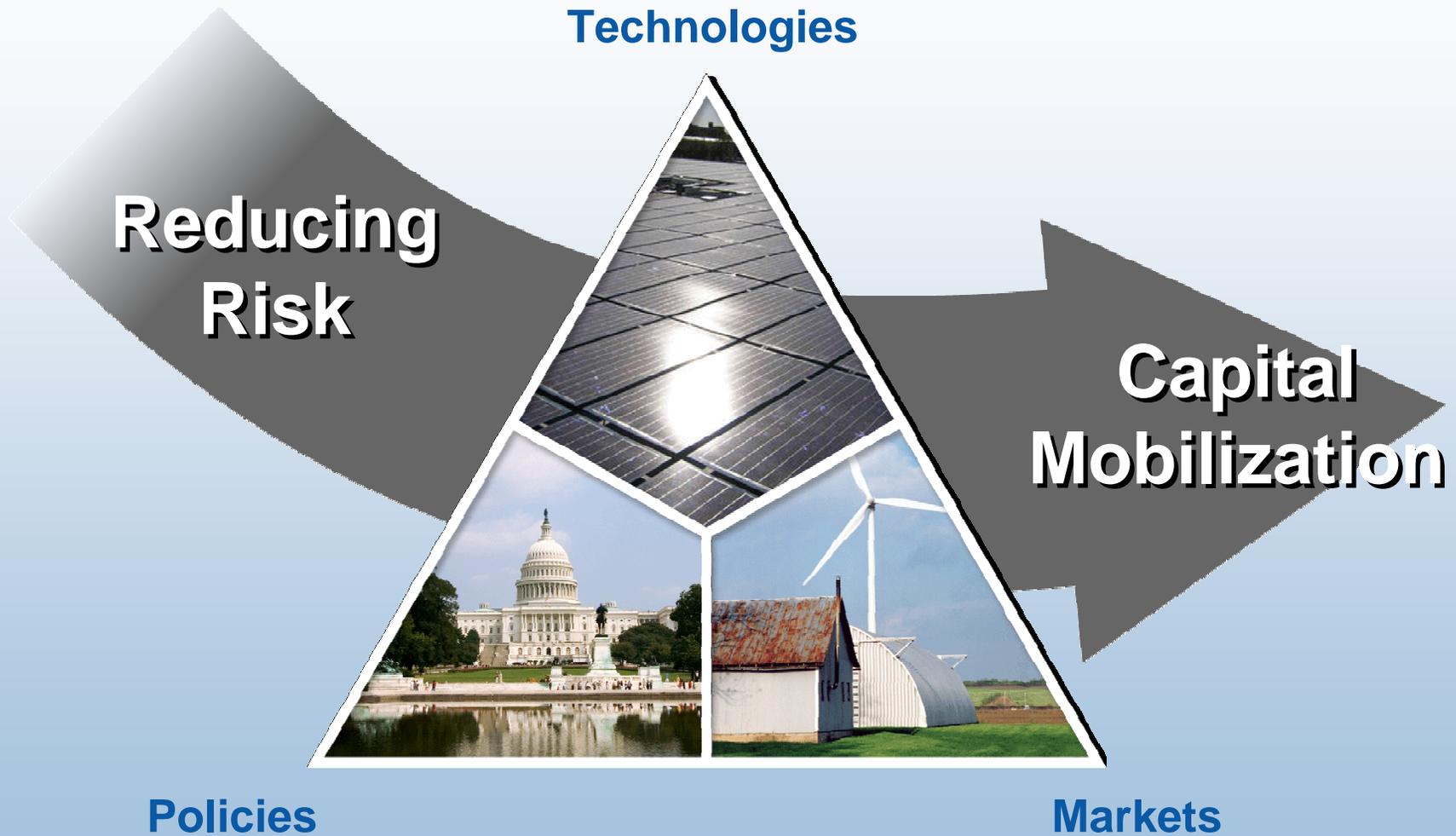


Source: NREL 2005, 2002

Will Renewables Have Significant Impact to Change the Energy Future?



Getting There Involves...



Today's Energy Infrastructure

Supply & Conversion



Oil
Coal
Natural Gas

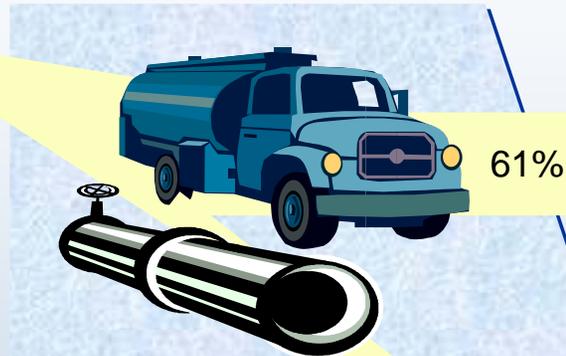


Nuclear

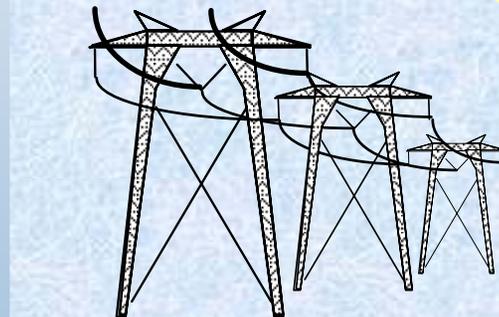


Hydro
Wind
Solar
Biomass
Geothermal

Transmission & Distribution



61%



39%

Rejected energy 62%

Utilization



27%



40%



33%

100 Quads

...inadequate to meet the needs of the future

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

Source: Oak Ridge National Laboratory

Solar/Photovoltaics

Status:

- 150 MW
- Cost 20-30¢/kWh

Potential:

- 2020 goal: 6¢/kWh



NREL Research Thrusts

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

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-windspeed turbines
- Advanced power electronics
- Technology transfer to ocean-based systems

Biomass/Biofuels

Biofuels status:

- Biodiesel – 15 million gallons (2002)
- Corn ethanol
 - 81 commercial plants
 - 3.4 billion gallons (2004)
 - ~\$1.22/gal



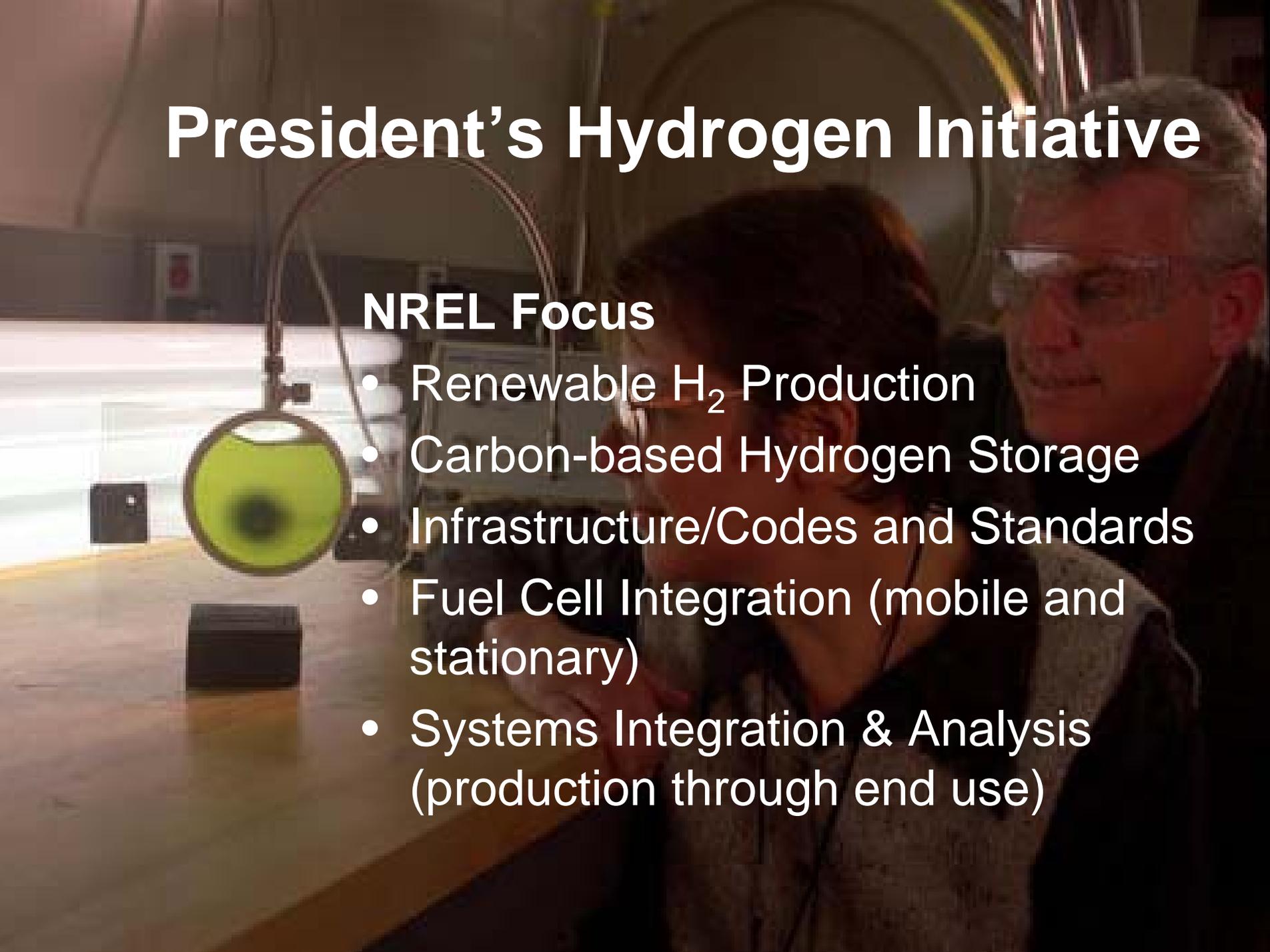
Potential:

- 2030 goal – cellulosic ethanol = 20% 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

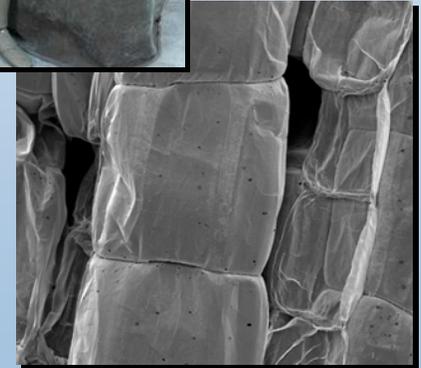
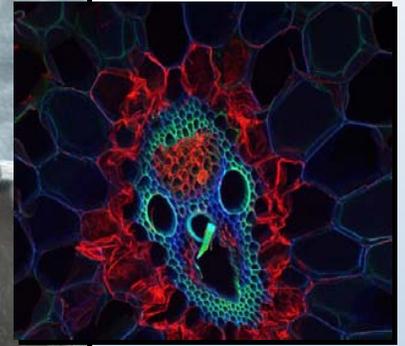
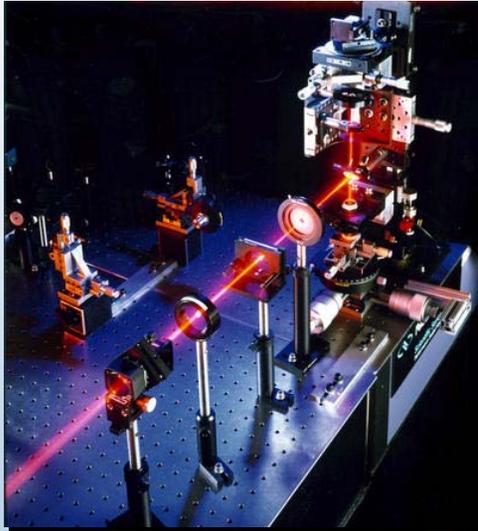
President's Hydrogen Initiative



NREL Focus

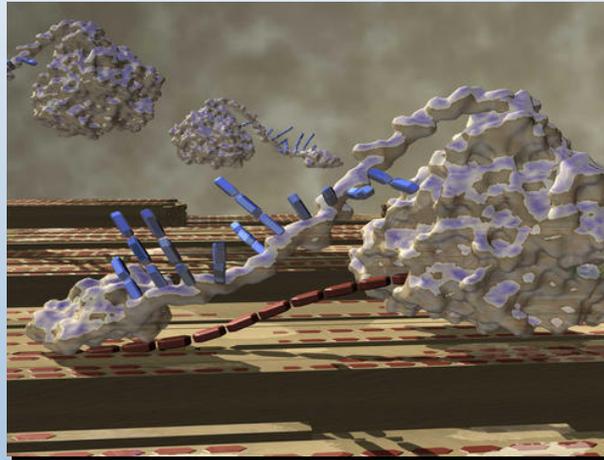
- Renewable H₂ Production
- Carbon-based Hydrogen Storage
- Infrastructure/Codes and Standards
- Fuel Cell Integration (mobile and stationary)
- Systems Integration & Analysis (production through end use)

New Discoveries in Science and Engineering are Helping to Fulfill the Promise of Renewable Energy



Renewable Energy “Game Changers”

- Nano-structures for PV
- Lignocellulosic conversion for biofuels
- Hydrogen production from renewables



Renewable Energy: A Potential Engine for Economic Growth in Colorado

- Plentiful resources
- NREL and university R&D centers
- Targeted industry for economic development



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

www.nrel.gov



Golden, Colorado