Renewable Energy Technology Opportunities: Responding to Global Energy Challenges

Sustainability Forum

February 28, 2007

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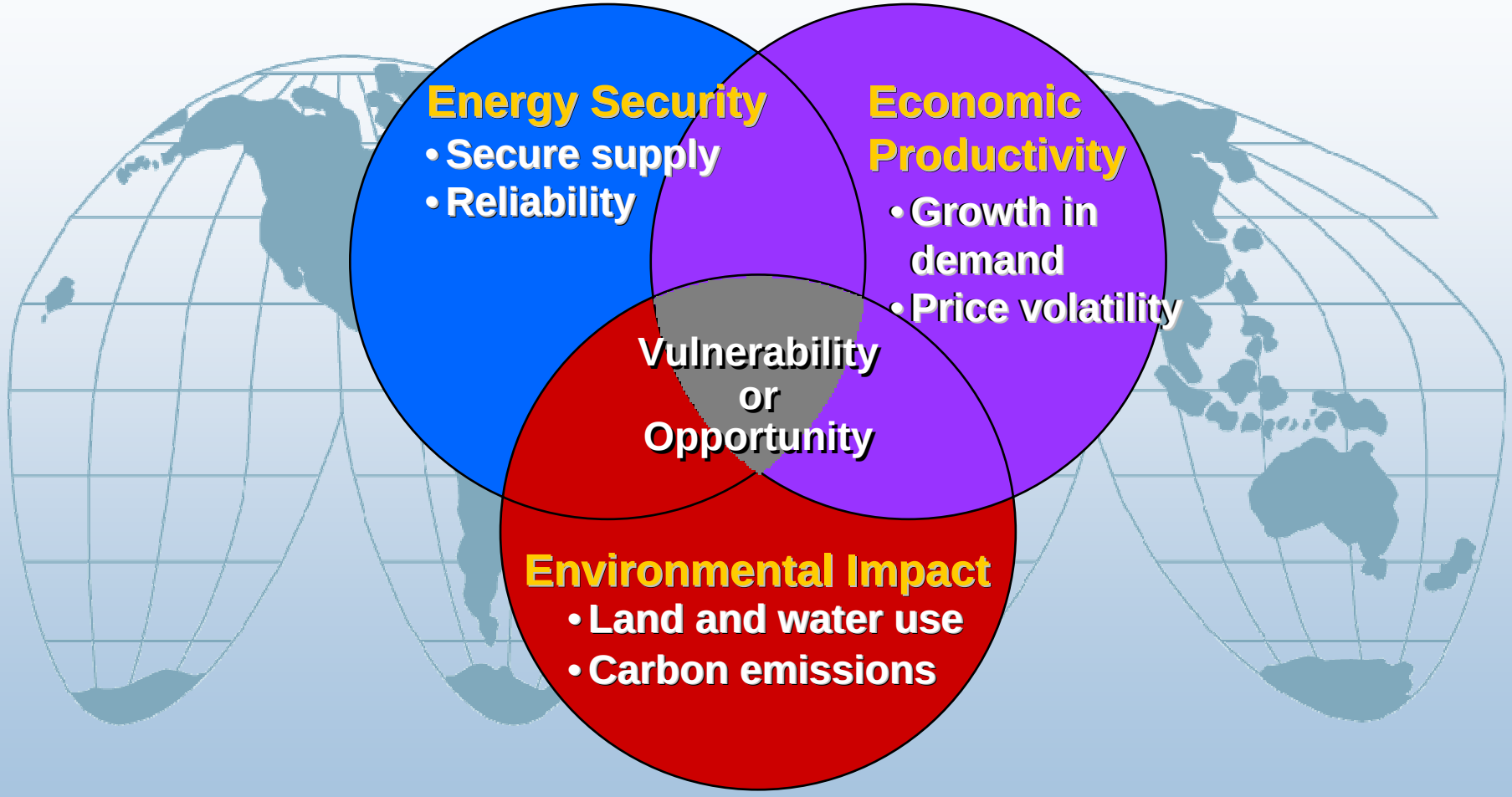
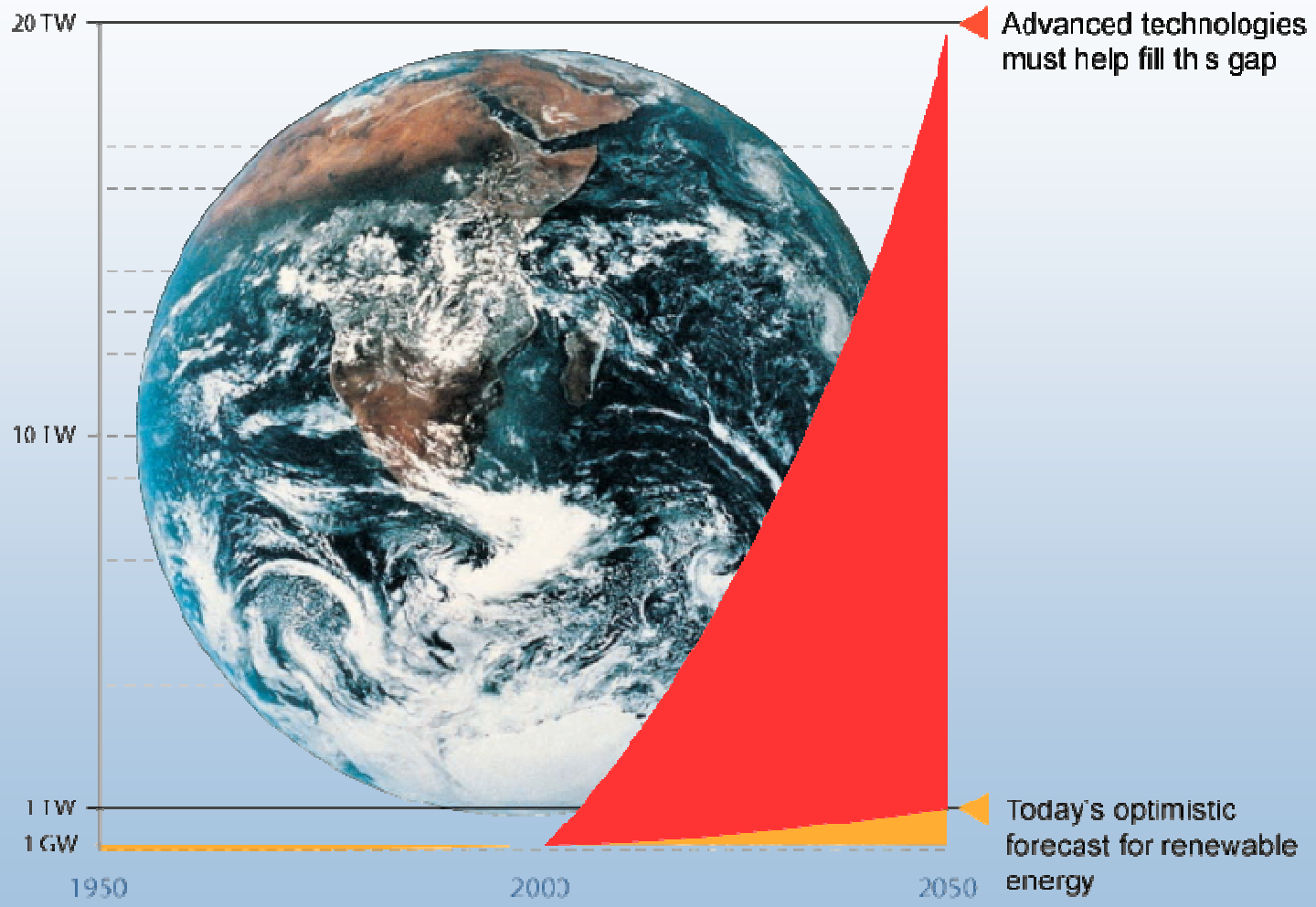
Energy Solutions Are Enormously Challenging



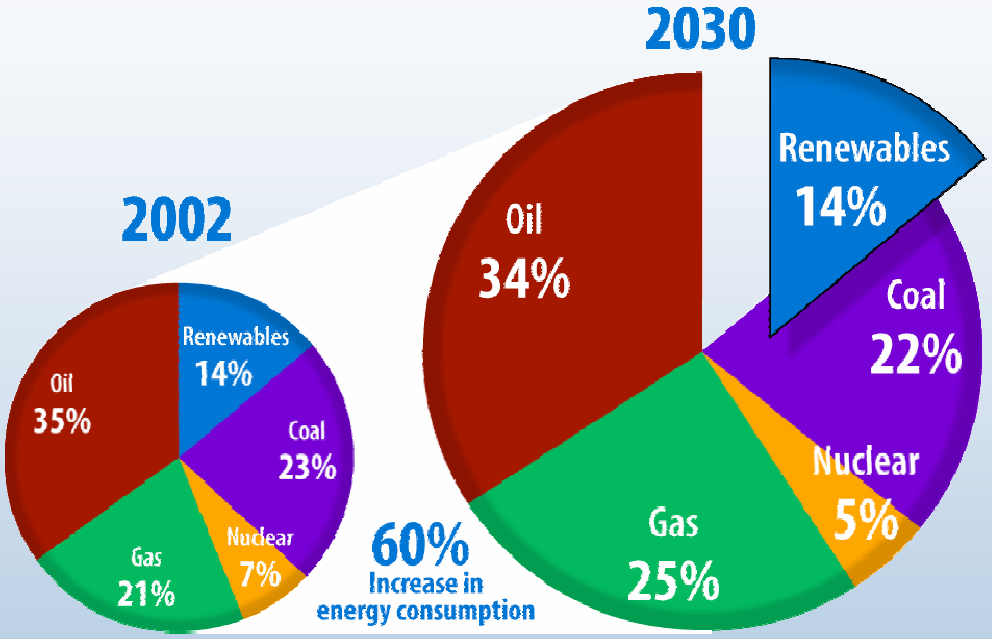
Must address all three imperatives

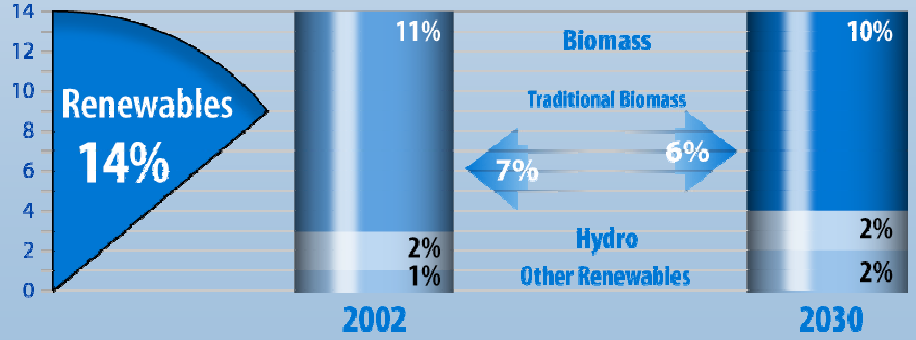
How Big is the Challenge?



Source: Arvizu, NREL

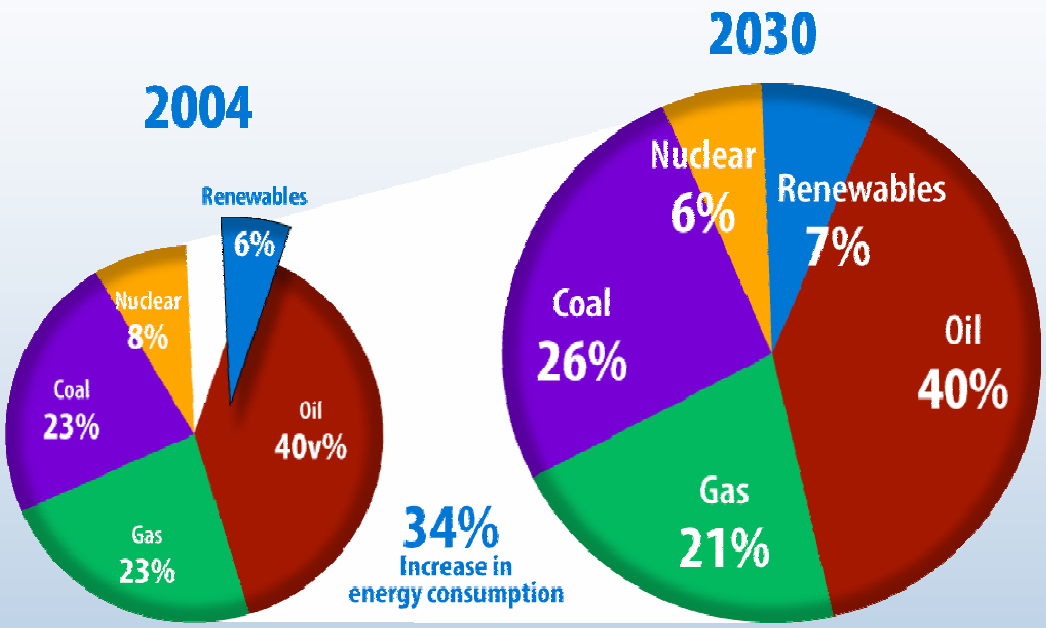
World Energy Supply and the Role of Renewable Energy

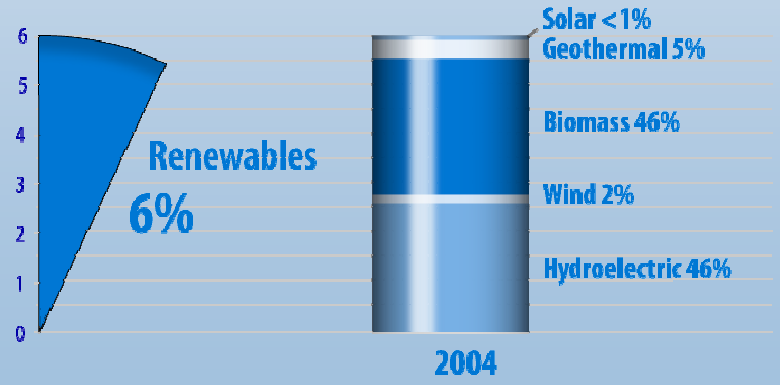




Source: OECD/IEA, 2004

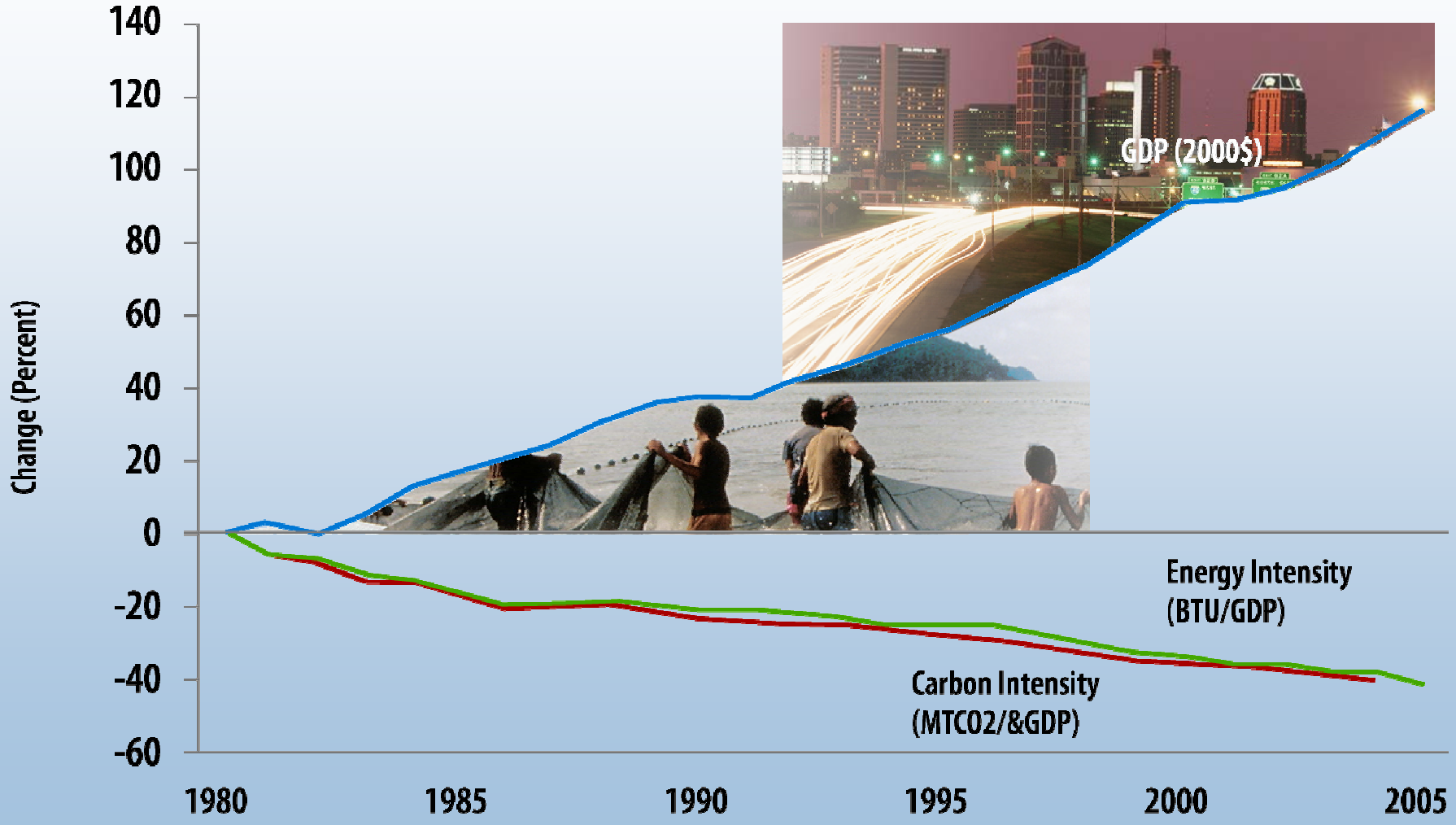
U.S. Energy Consumption and the Role of Renewable Energy





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

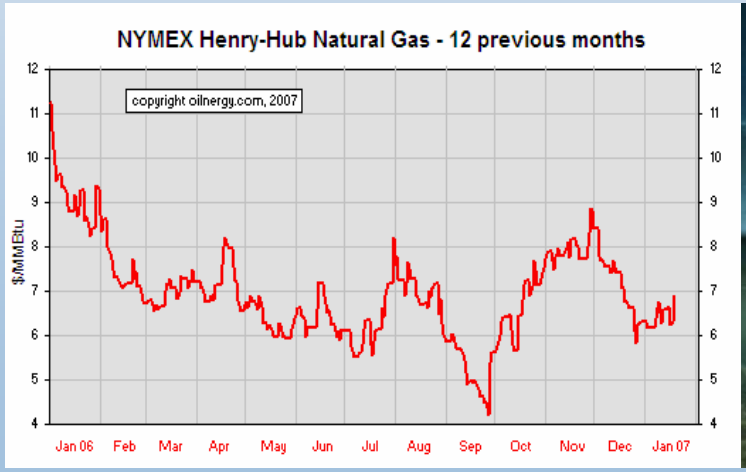
Carbon and Energy Intensity



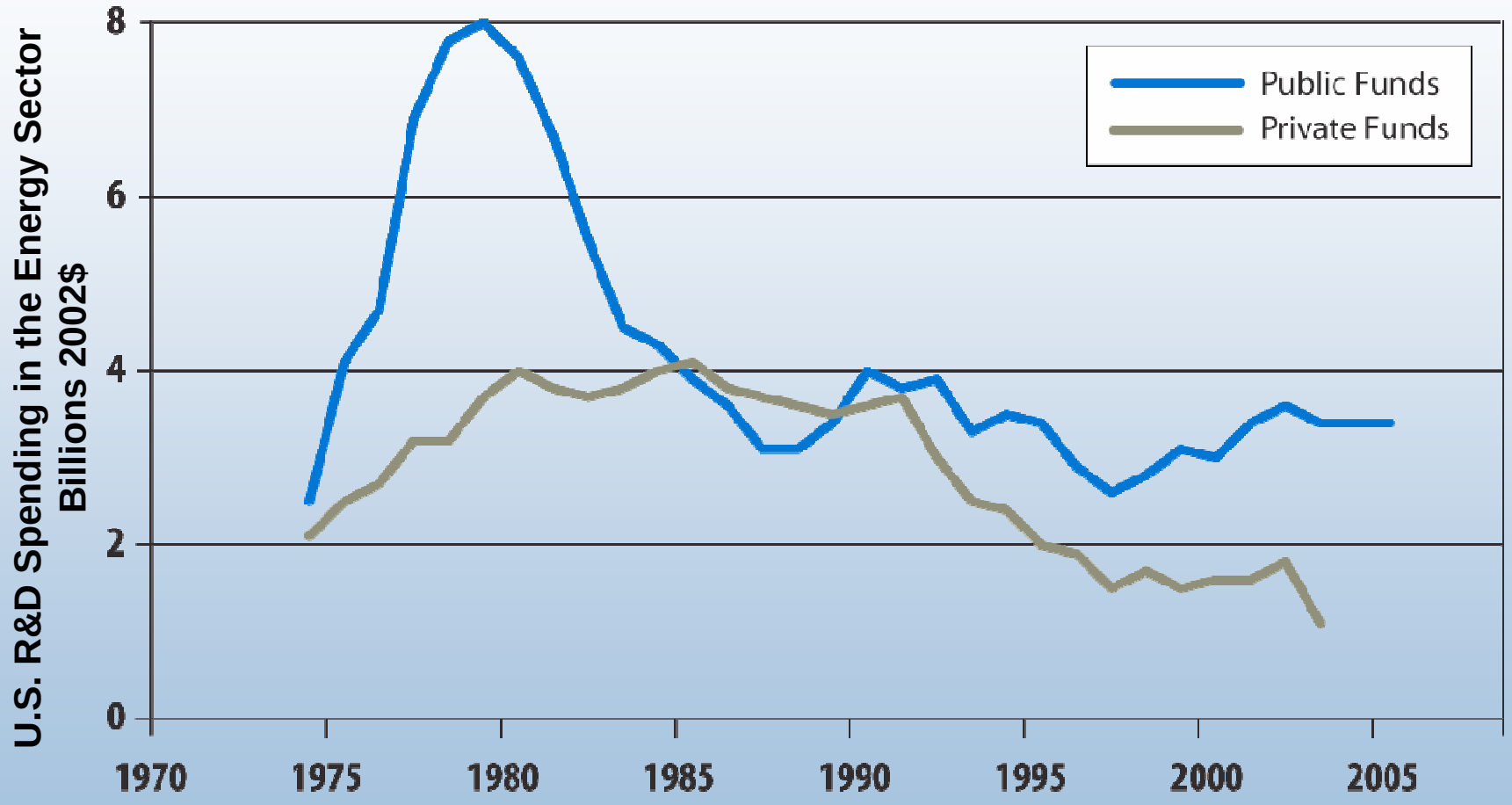
Source: Energy Information Administration, “Annual Energy Review 2005”, DOE/EIA-0384(2005), Table 1.5

Thinking Differently…
Account for Externalities

- Today's energy marketplace does not appropriately "value" certain public objectives or social goods, instead we have:
  - Price volatility
  - Serious environmental impacts
  - Underinvestment in energy innovation

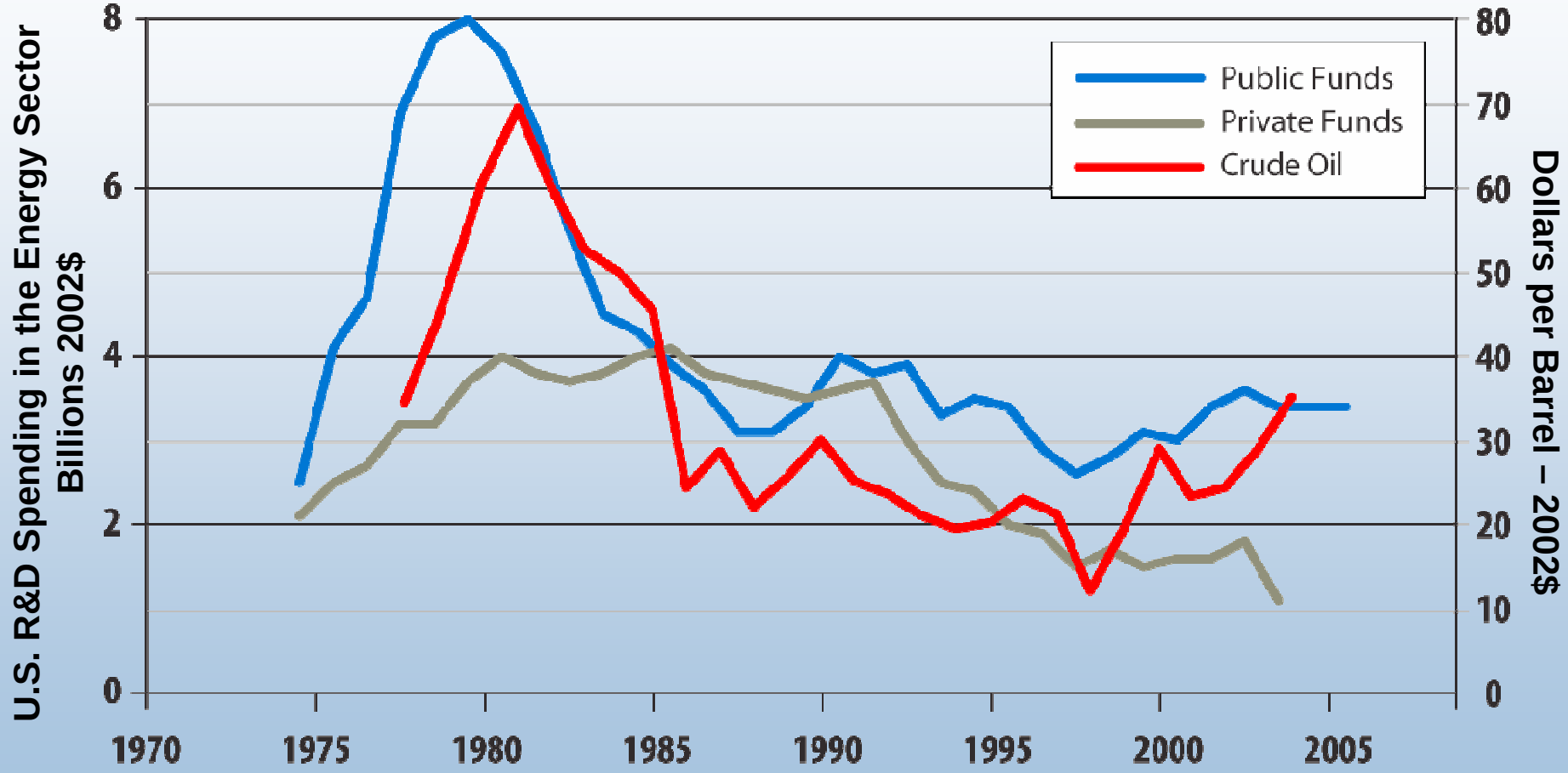


Declining Energy R&D Investments…



Source: Daniel Kammen, Gregory Nemet *Reversing the Incredible, Shrinking Energy R&D Budget* http://rael.berkeley.edu/files/2005/Kammen-Nemet-ShrinkingRD-2005.pdf
Table 10.3, Edition 25, *Transportation Energy Data Book* http://cta.ornl.gov/data/chapter10.shtml

Declining Energy R&D Investments… Reflect World Oil Price Movement

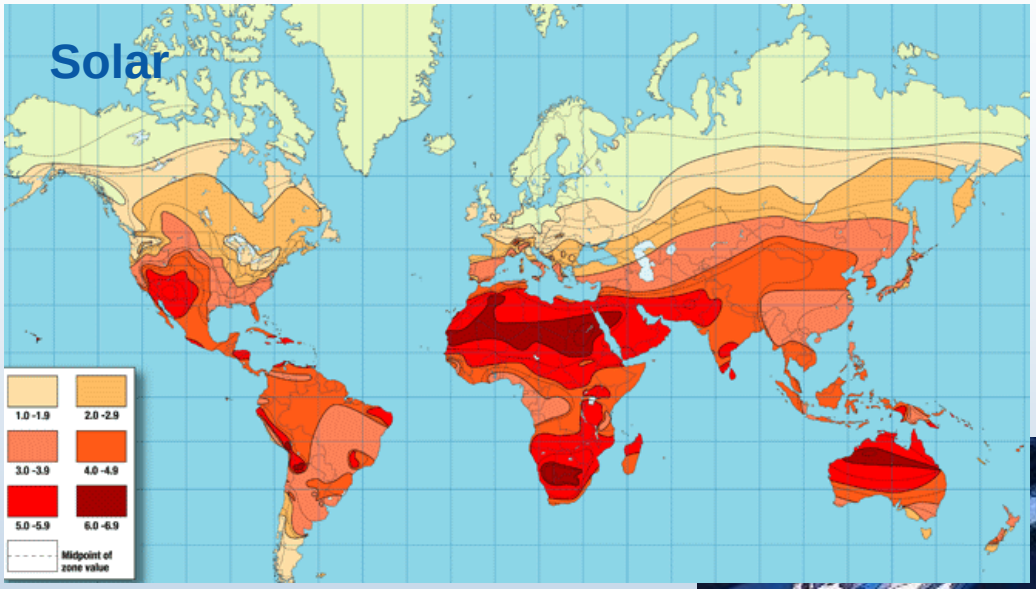


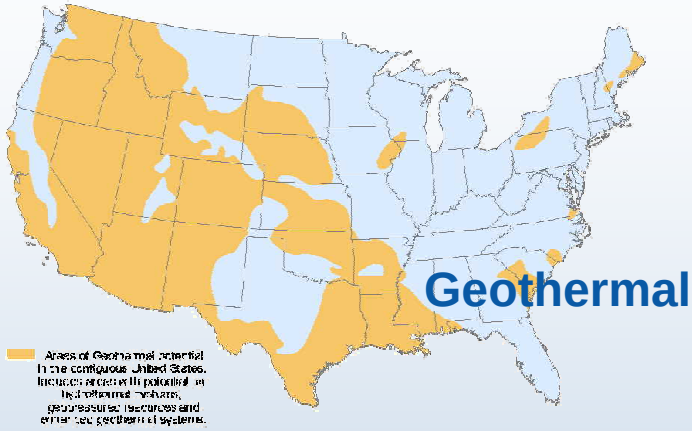
Source: Daniel Kammen, Gregory Nemet *Reversing the Incredible, Shrinking Energy R&D Budget* http://rael.berkeley.edu/files/2005/Kammen-Nemet-ShrinkingRD-2005.pdf
Table 10.3, Edition 25, *Transportation Energy Data Book* http://cta.ornl.gov/data/chapter10.shtml

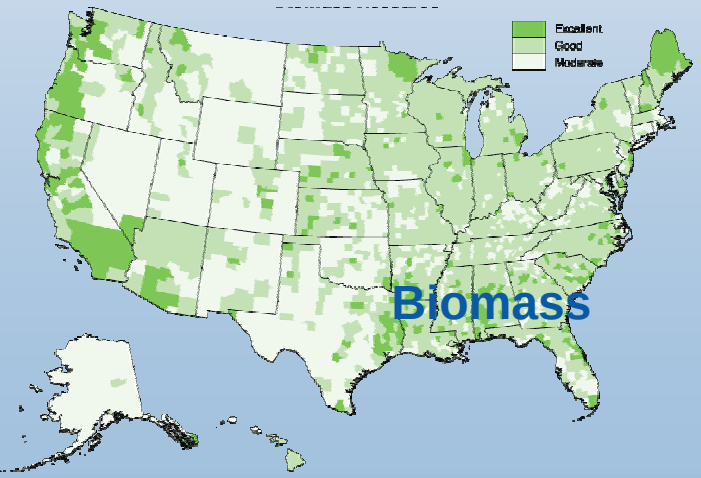
Technology-Based Solutions:
There is no single or simple answer

- Energy efficiency
- Renewable energy
- Nonpolluting transportation fuels
- Separation and sequestration of CO_2
- Next generation nuclear energy technologies
- Transition to distributed energy systems coupled with pollution-free energy carriers

Resources are Plentiful

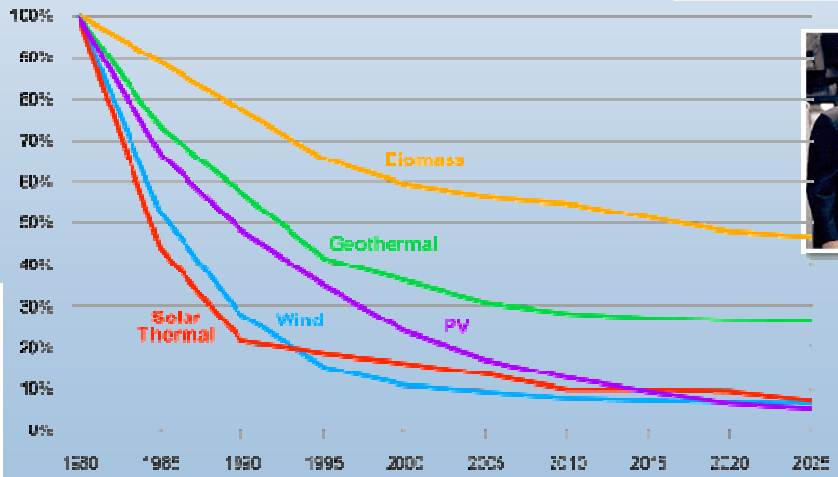






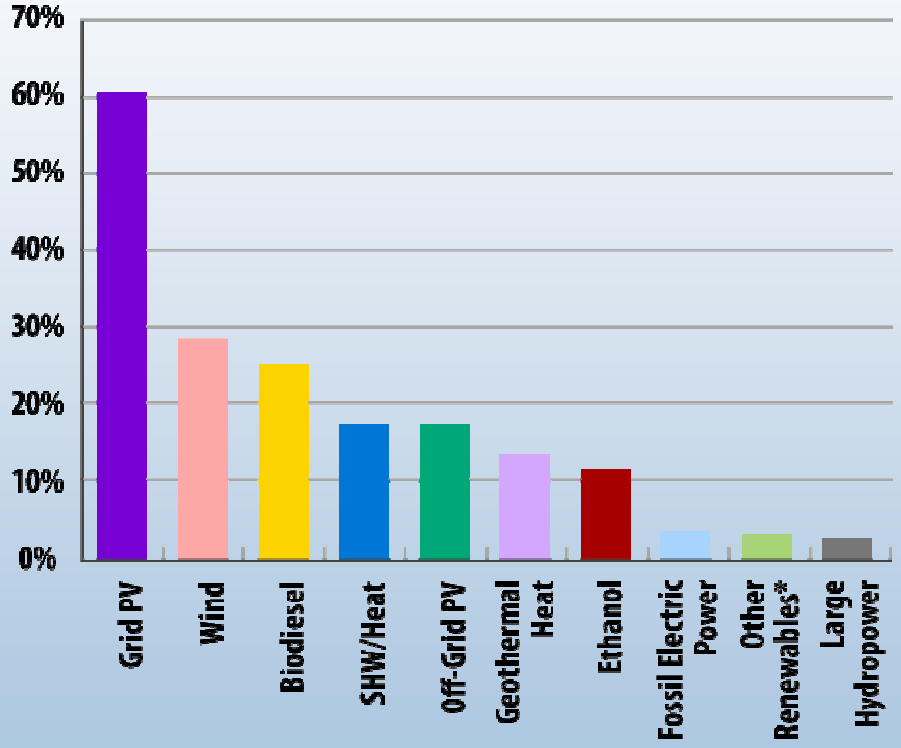
Source: http://howto.altenergystore.com/Reference-Materials/Solar-Insolation-Map-World/a43/
Pacific Northwest National Laboratory

Impressive Cost Reductions

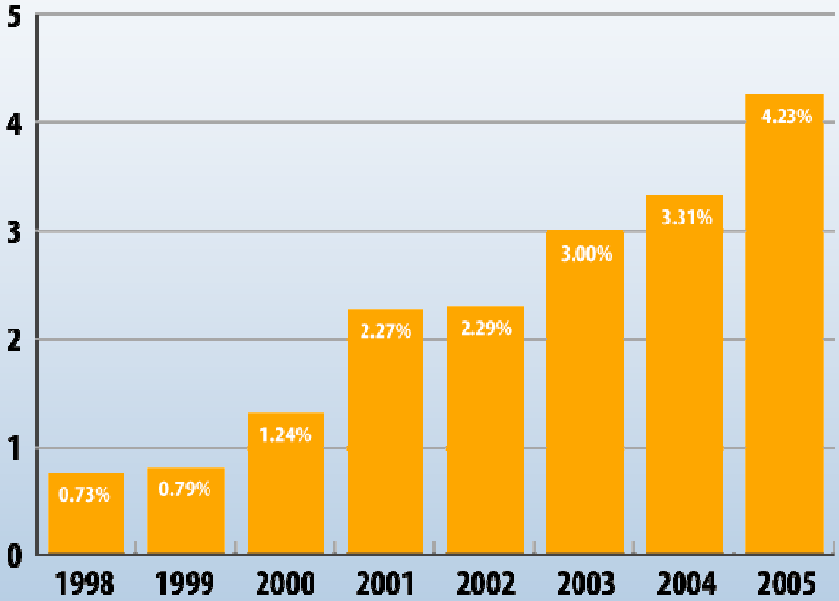


Investing in the Future

Global Renewable Energy Annual Growth Rates 2000-2004



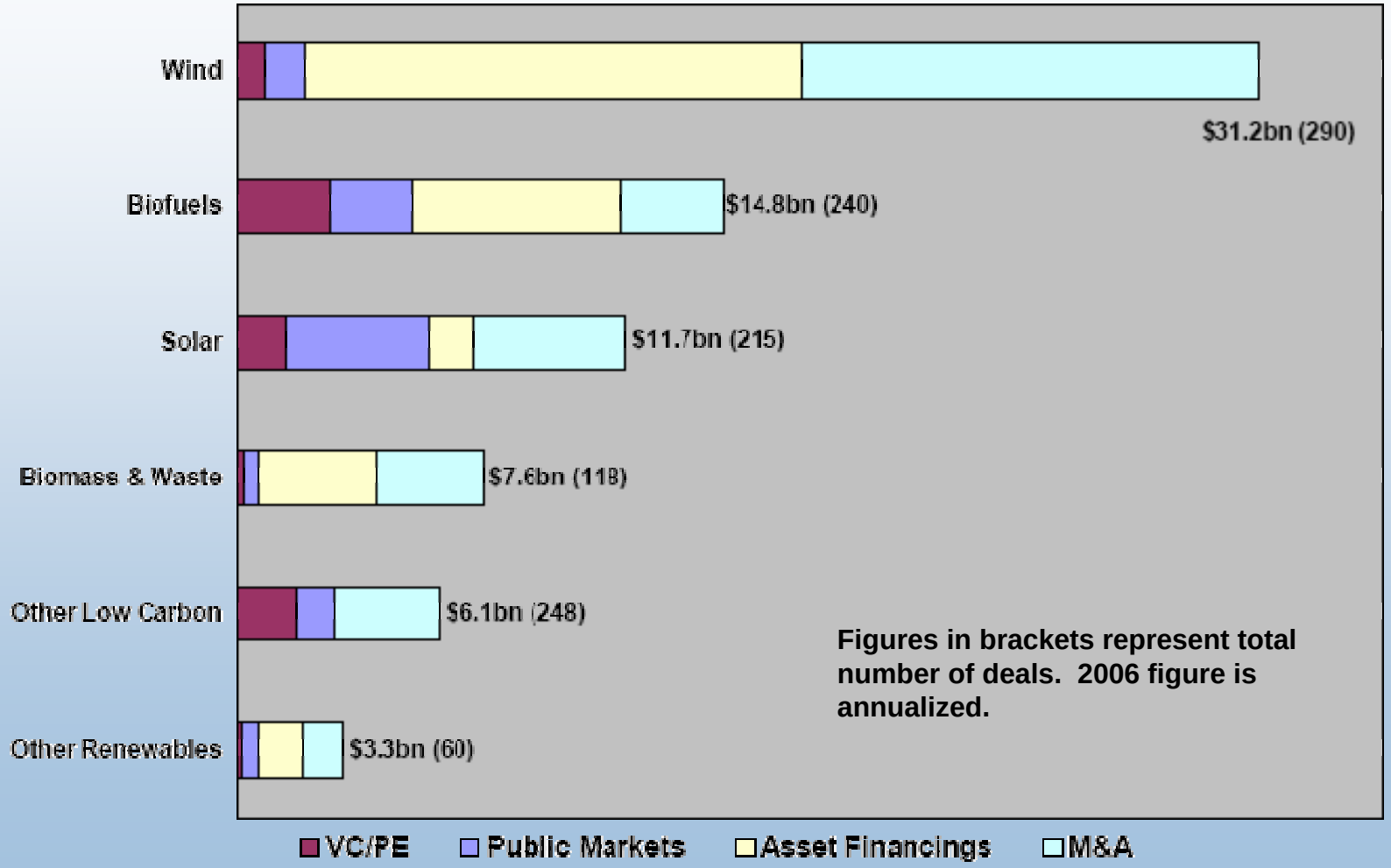
Energy-Tech Investments Percent of Total U.S. Venture Capital



$2.7B invested in private clean energy firms in North America and Europe in 2006.

Sources:
Renewables 2005 Global Status Report, REN21
Clean Energy Trends 2006, Nth Power LLC
Venture Business Resources

Investment and M&A
By Sector and Asset Class – 2006



Source: New Energy Finance, January 2007

Getting to "Significance" Involves…

Source: NREL

National Renewable Energy Laboratory

What Makes Us Unique?

- Only national laboratory dedicated to renewable energy and energy efficiency R&D
- Research spans fundamental science to technology solutions
- Collaboration with industry and university partners is a hallmark
- Research is market relevant

Energy Efficiency and Renewable Energy Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

- Wind
- Solar
- Biomass
- Geothermal

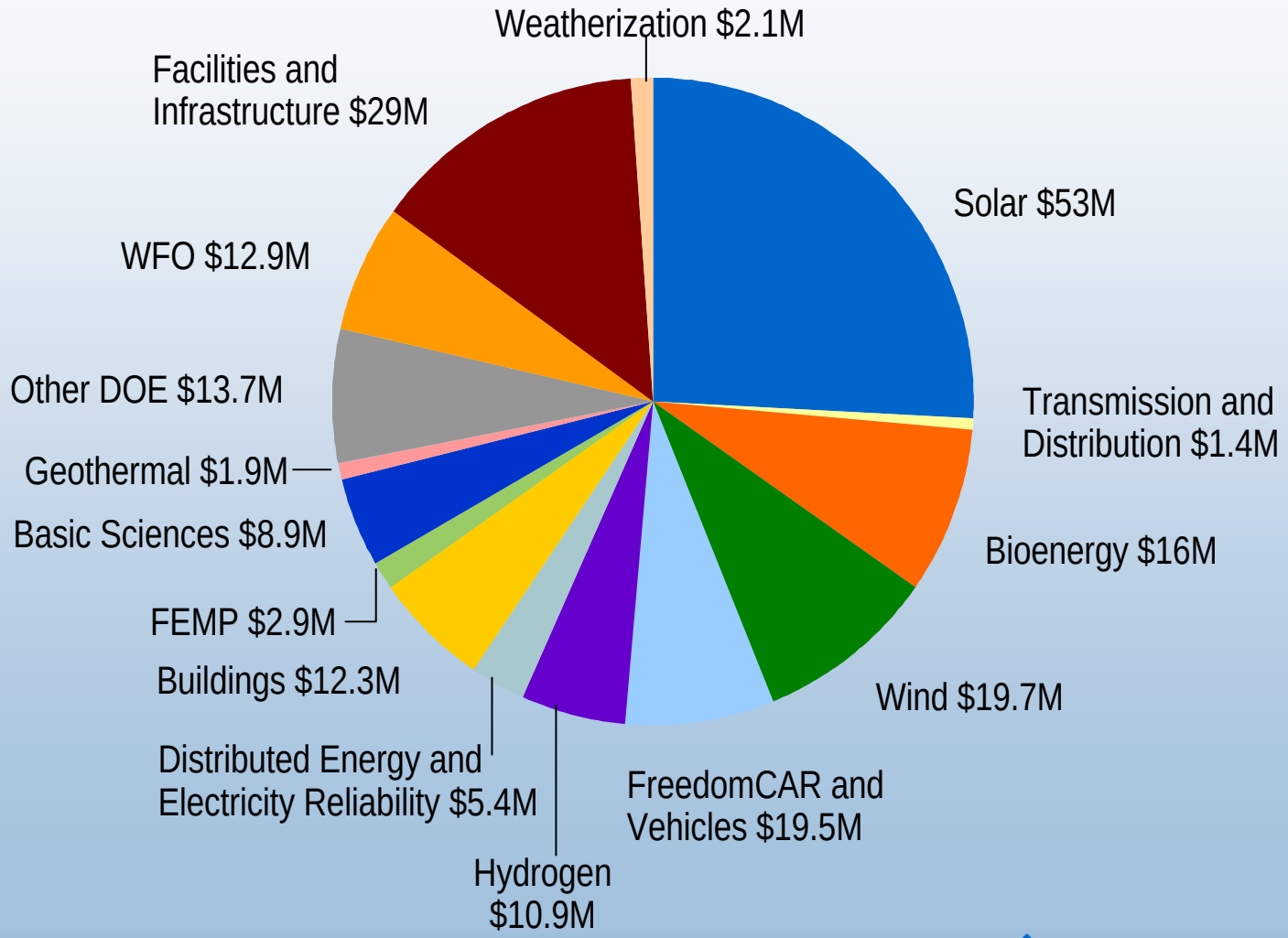
Energy Delivery and Storage

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

Foundational Science

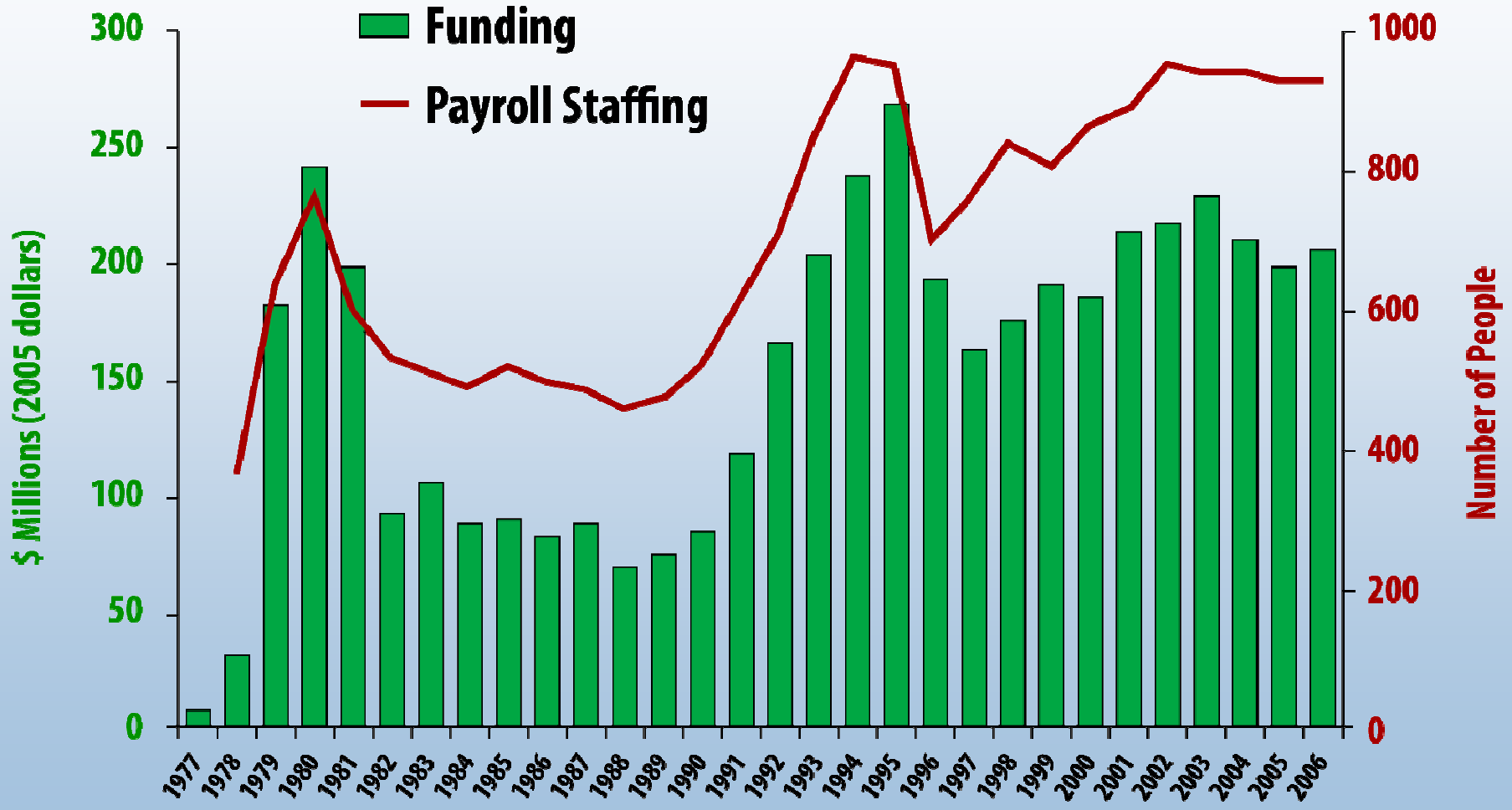
NREL FY 2006 Program Portfolio

Estimated $209.6 Million



Updated January 2007

NREL Funding and Staffing



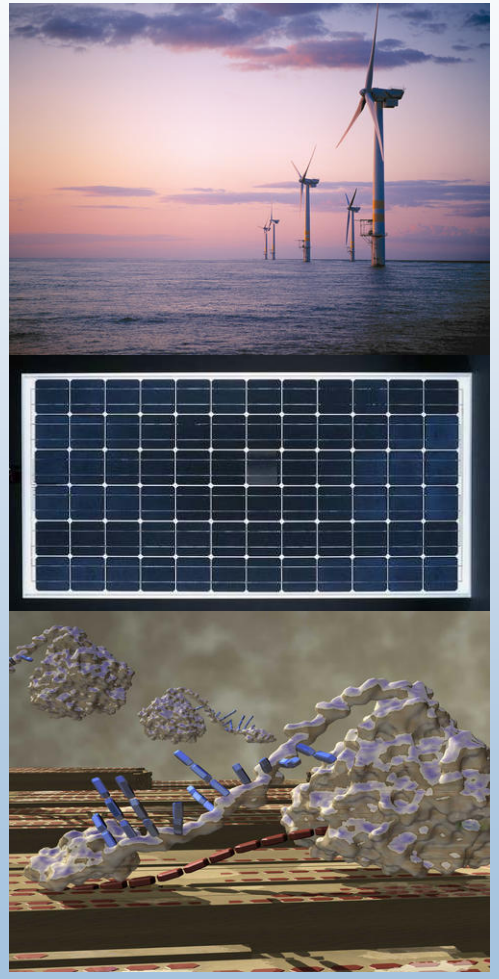
Updated September 1, 2006

Consistent Policies are Required for Long-Term Market Growth

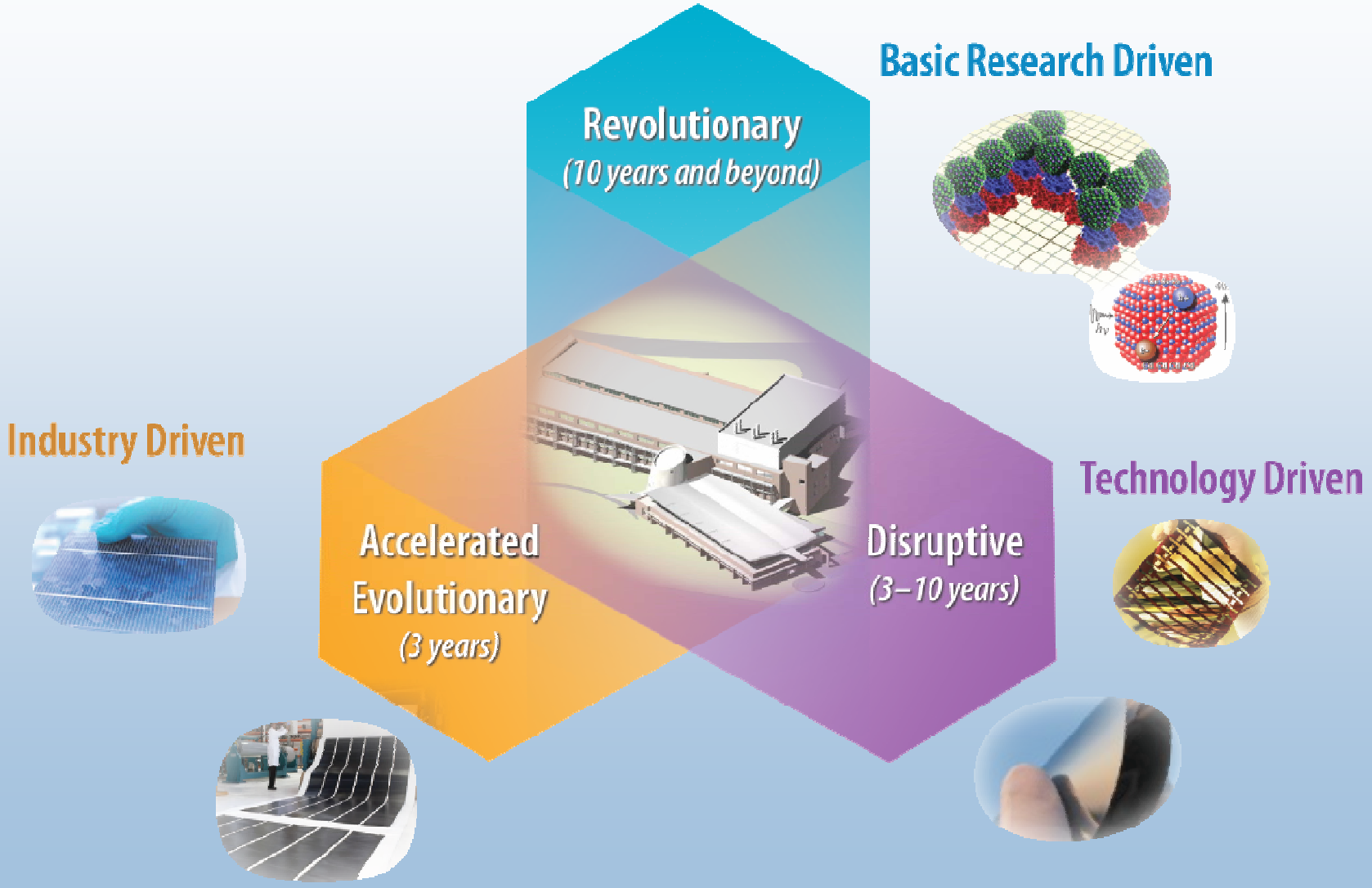
- National goals
  - Biofuels: 30% of gasoline by 2030
  - Wind: 20% of electricity generation by 2030
  - Solar: Be market competitive by 2015 for Solar PV
- Infrastructure investments required to meet these goals, for example:
  - Biofuels: 30x30 analysis estimated infrastructure cost between $8.5 and $28.5B over 23 years

Technology Innovation Challenges

- Wind
  - Next generation wind turbines
    - Improve energy capture by 30%
    - Decrease capital costs by 25%
- Solar photovoltaics
  - Improved performance through
    - process improvements
    - better materials
    - concentration
  - Harnessing nanostructures & new quantum effects
- Biofuels
  - Next generation biofuels
    - New feedstocks
    - Improved energy crops
    - Integrated biorefineries



Technology Investment Pathways

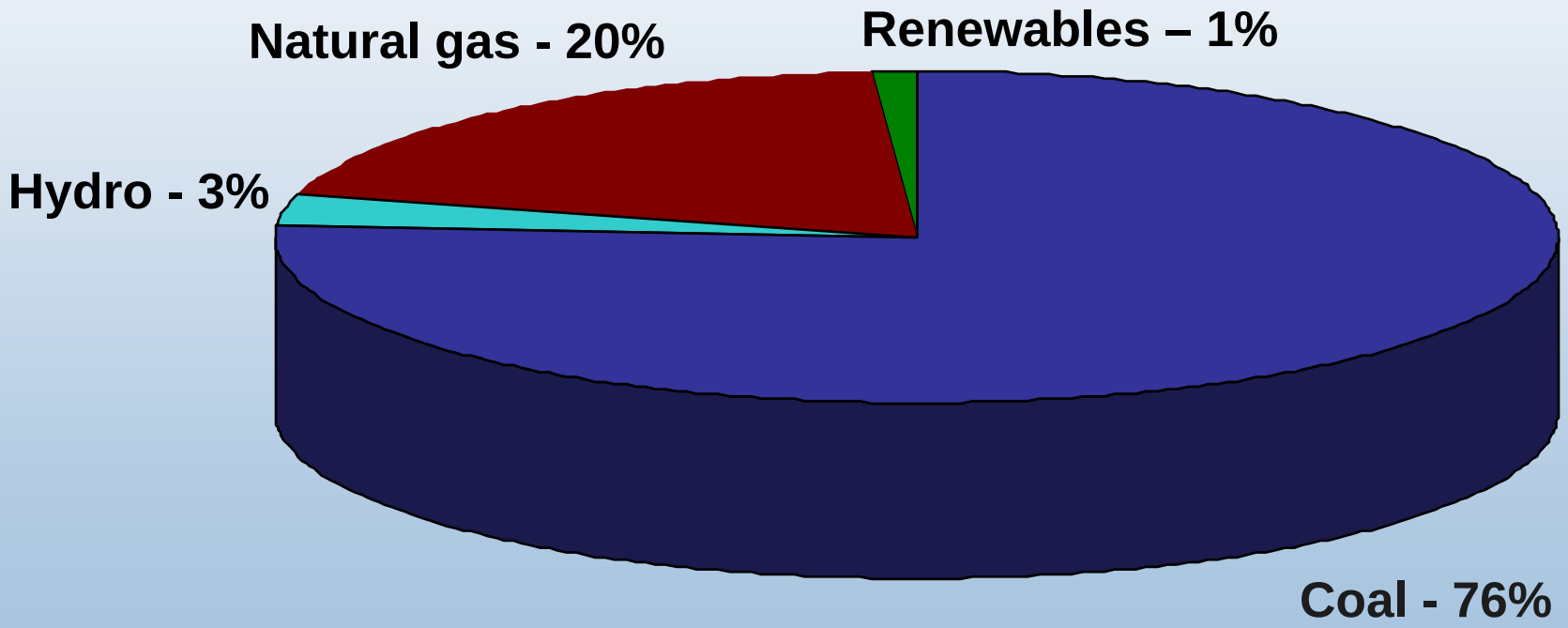


Renewable Energy: Enabling Economic Growth in Colorado

- Plentiful resources
- Centers of excellence
- Regulatory and business environment

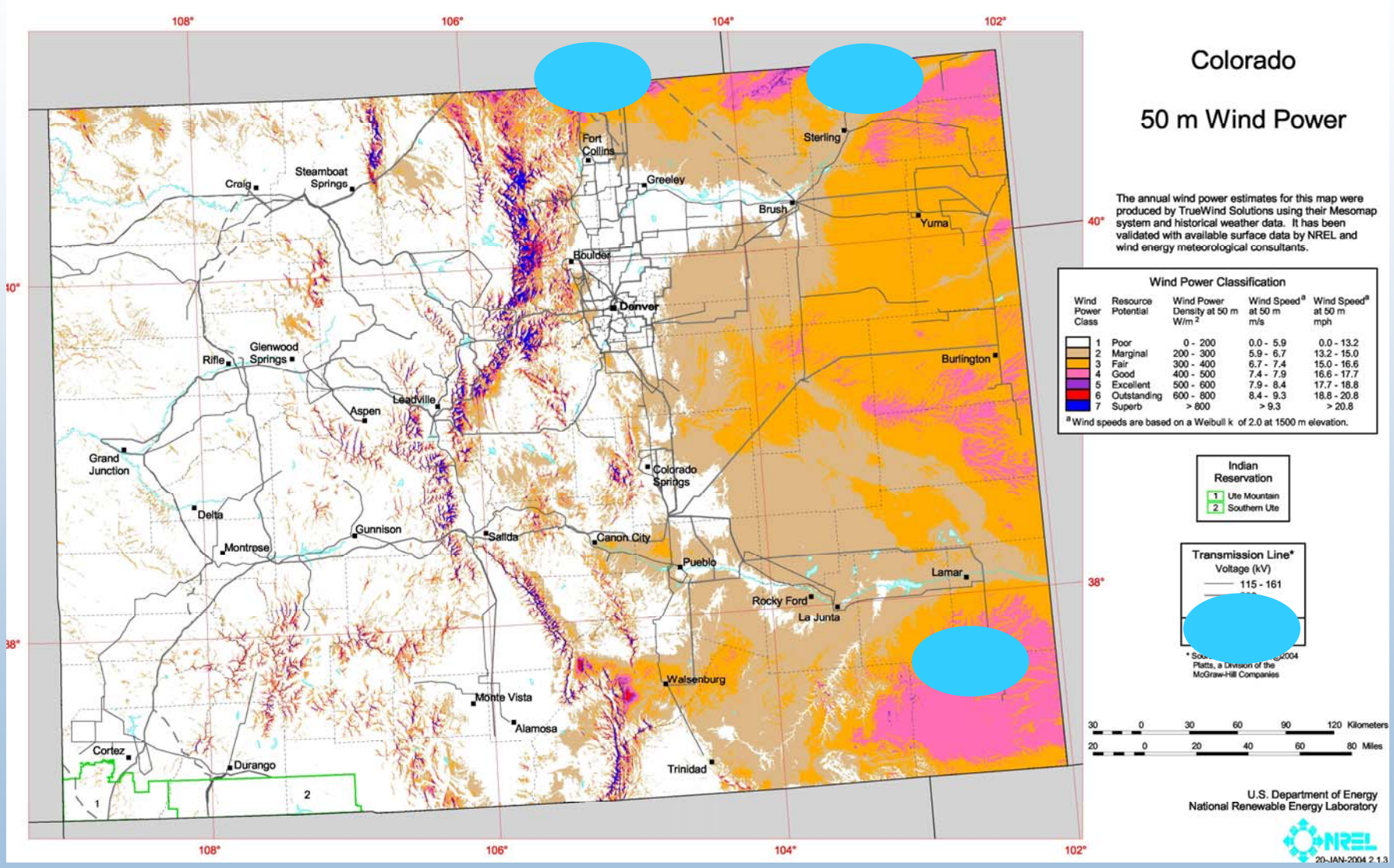
Colorado's Resource Mix

All Electric Utilities

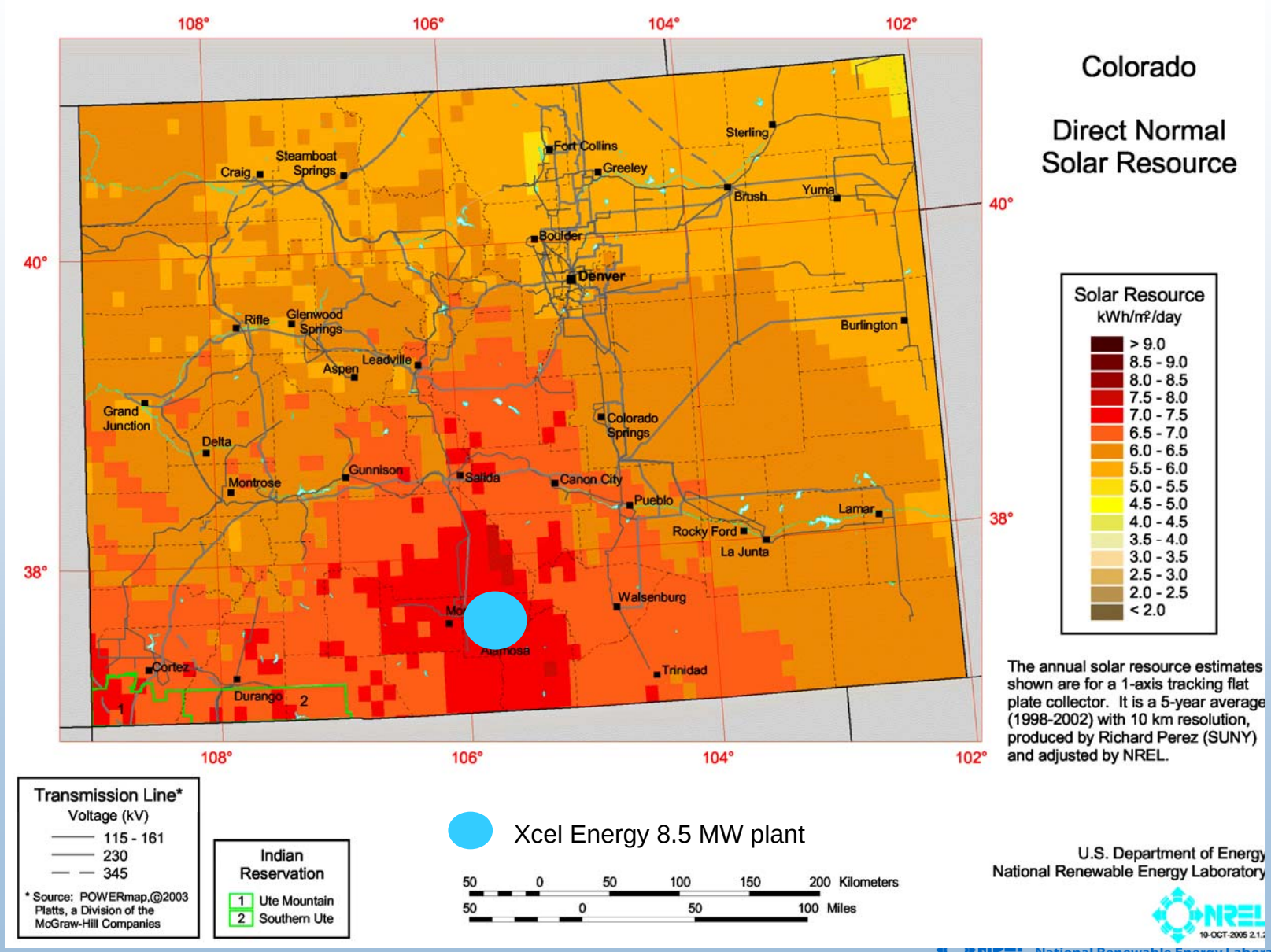


Source: Energy Information Administration, Electric Power Annual, 2003 (published January 2005)

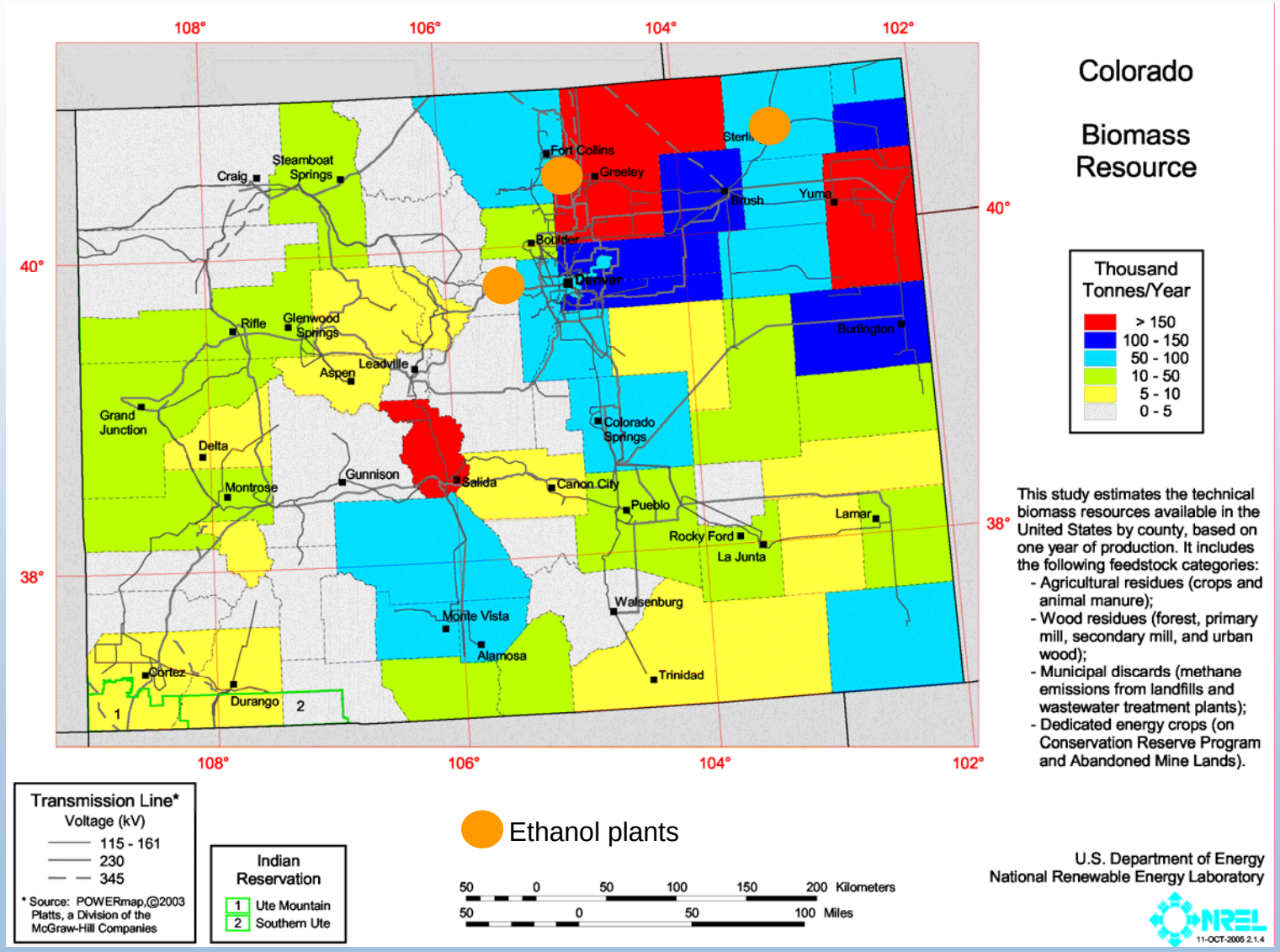
Colorado Wind Power



Colorado Solar Power



Colorado Biomass Resources



Colorado Policy Framework: Amendment 37

- Will require 110-118 MW of solar and 1,275-1,384 MW of utility-scale wind power by 2015
- NREL is providing technical assistance to Xcel Energy
  - Software for evaluating sites for off-grid and grid-connected solar rooftop commercial electricity systems

Leveraging the Federal Investment to Create New Businesses

- NREL, NIST, NOAA, NCAR
- CU, CSU and CSM
- World-class facilities

Promise of renewable energy is profound and can be realized if we…

- Aggressively seek a global sustainable energy economy
- Acknowledge and mitigate the carbon challenge with the necessary policies
- Accelerate investment in technology innovation

It is a matter of national will and leadership