Colorado Forum

April 5, 2006

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Director, National Renewable Energy Laboratory

National Renewable Energy Laboratory

- 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 that is ***market relevant***

Energy Efficiency & Renewable Energy Technology Development Programs

NREL R&D Portfolio

Efficient Energy Use

- Vehicle Technologies
- Building Technologies
- Industrial Technologies

Renewable Resources

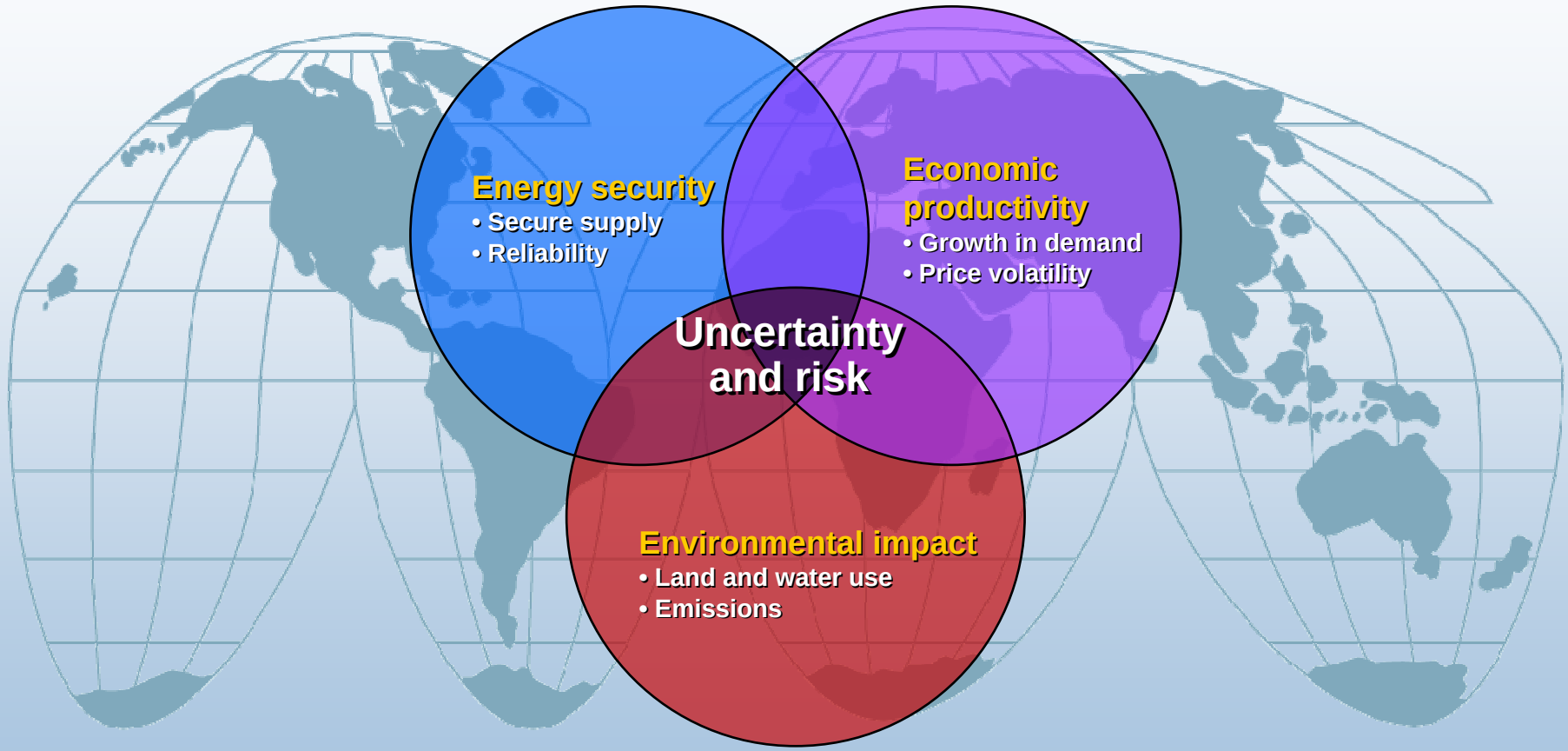
- Wind
- Solar
- Biomass
- Geothermal

Energy Delivery & Storage

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

Foundational Science

Energy Solutions are Enormously Challenging

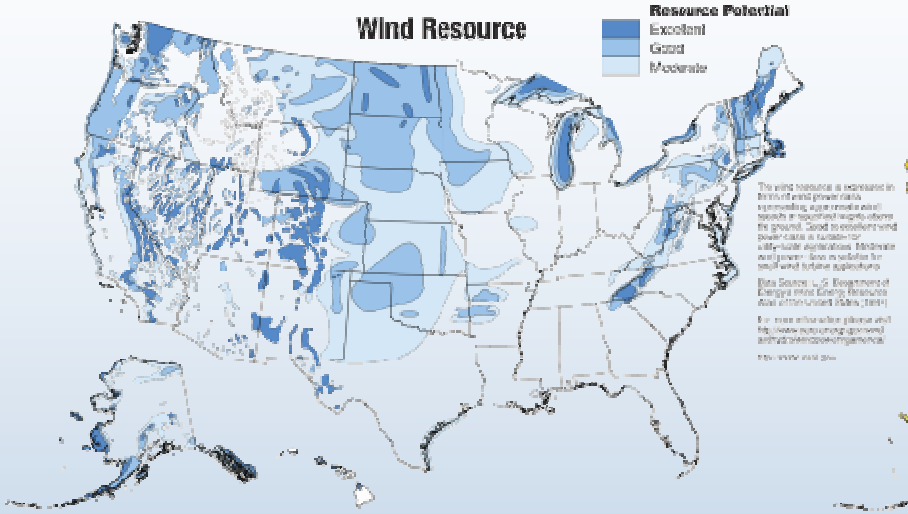


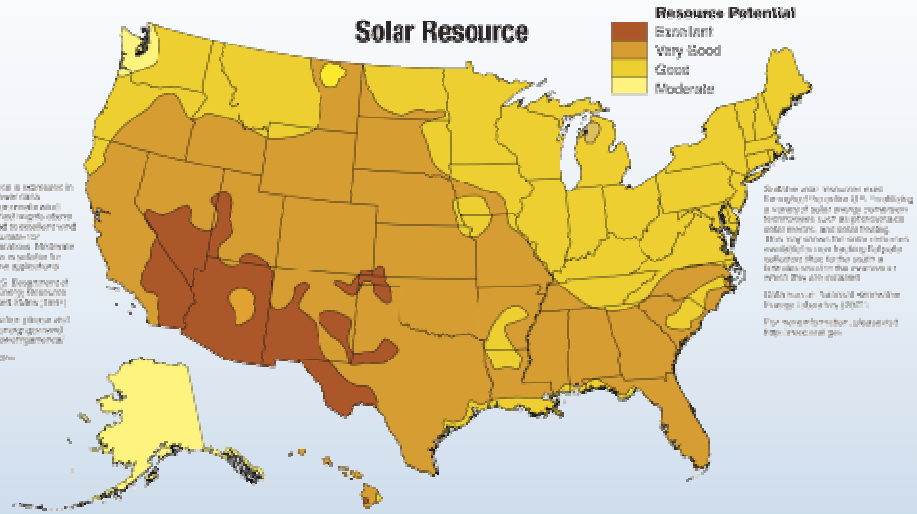
We need a balanced portfolio of options

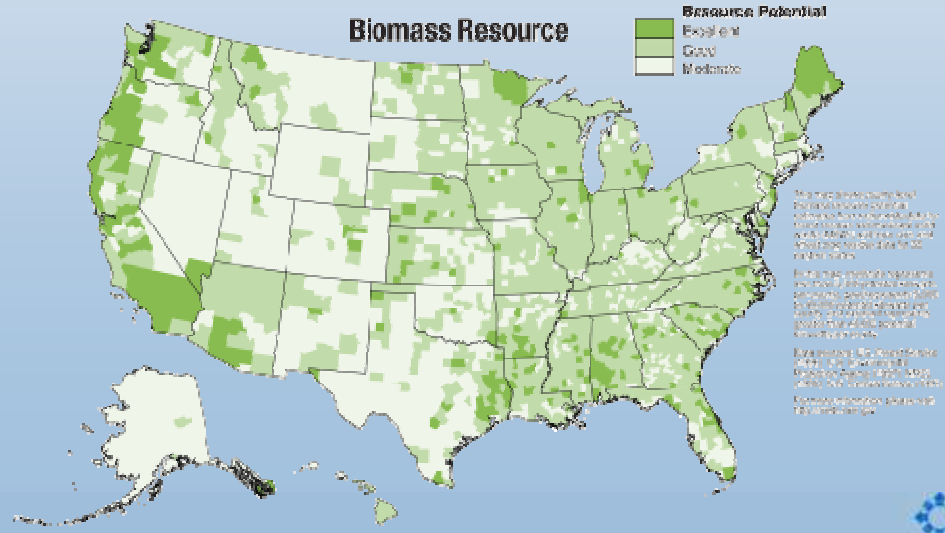
Will Renewable Energy Have a Significant Impact? Three Key Questions

- Is there enough resource?
- Is it worth the effort – value?
- Can we get the costs down?

National Resources

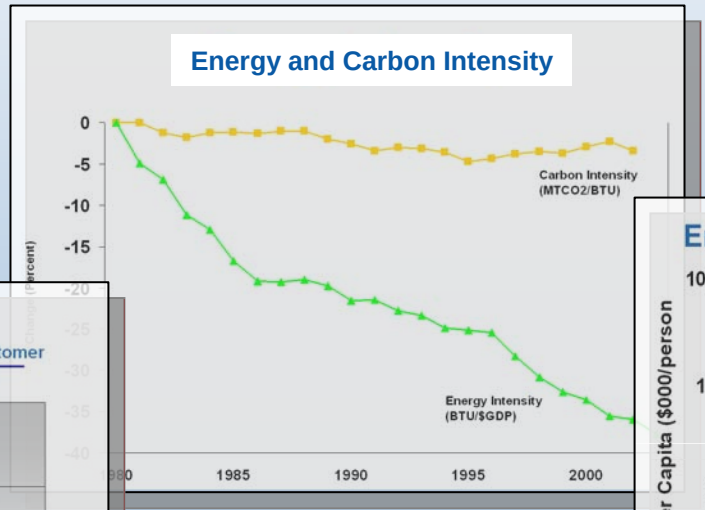


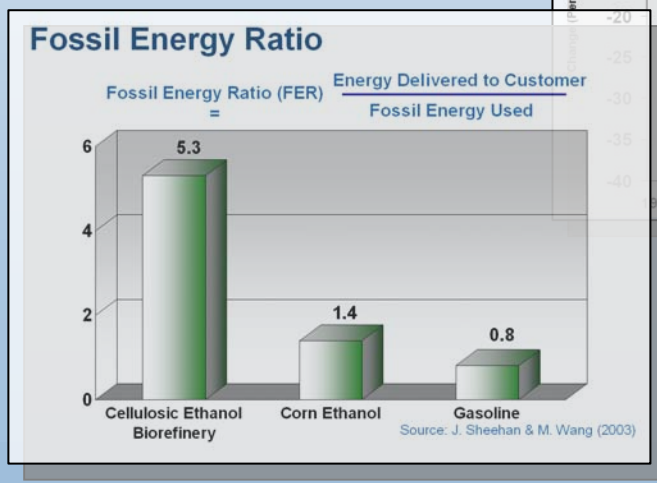


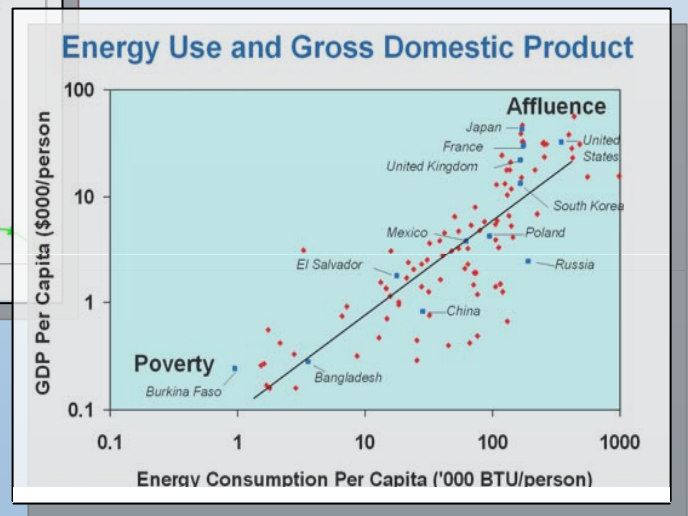


Capturing the Value of Renewable Energy

- Energy Balance
- Carbon Balance
- Economic Balance

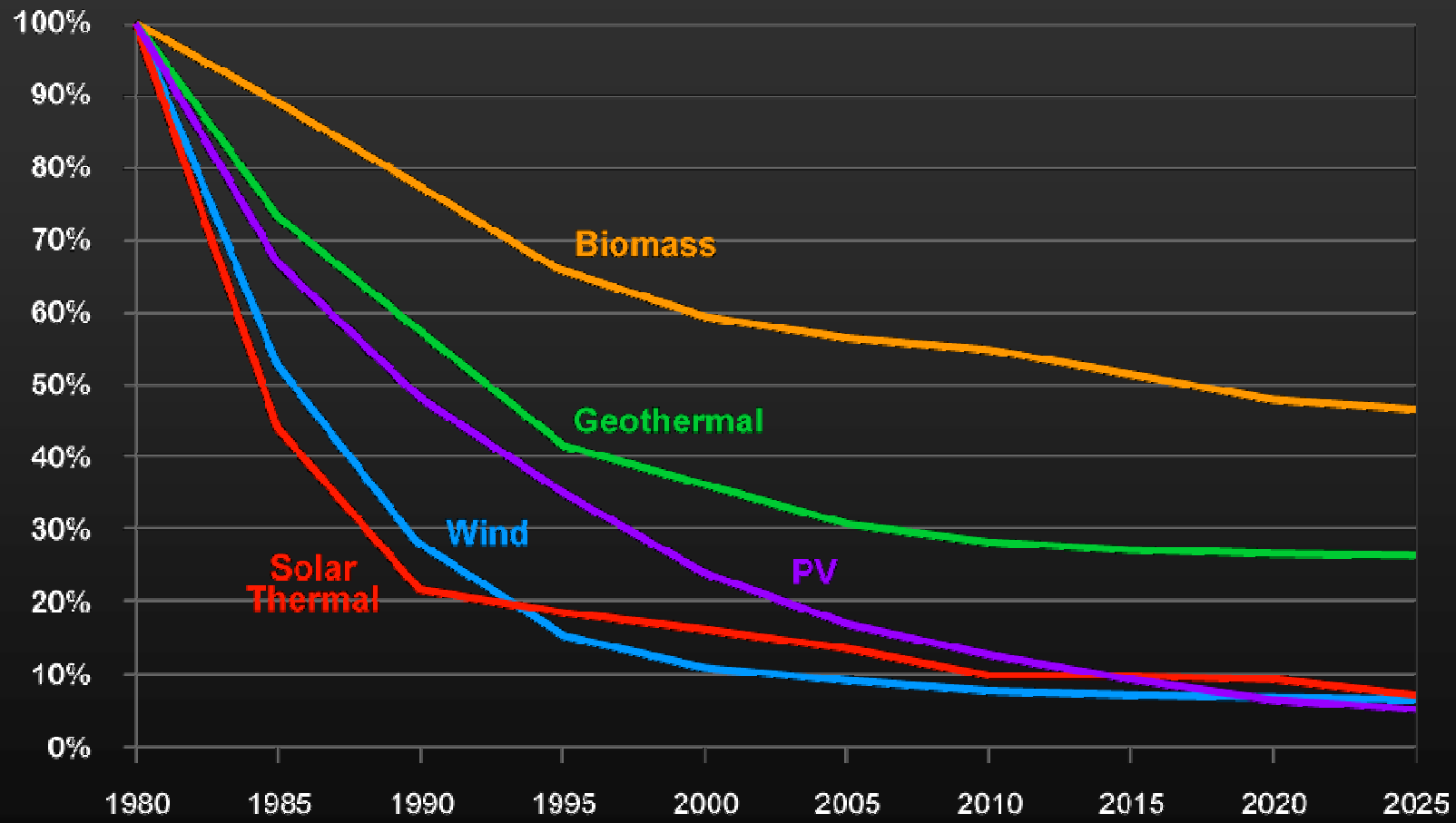






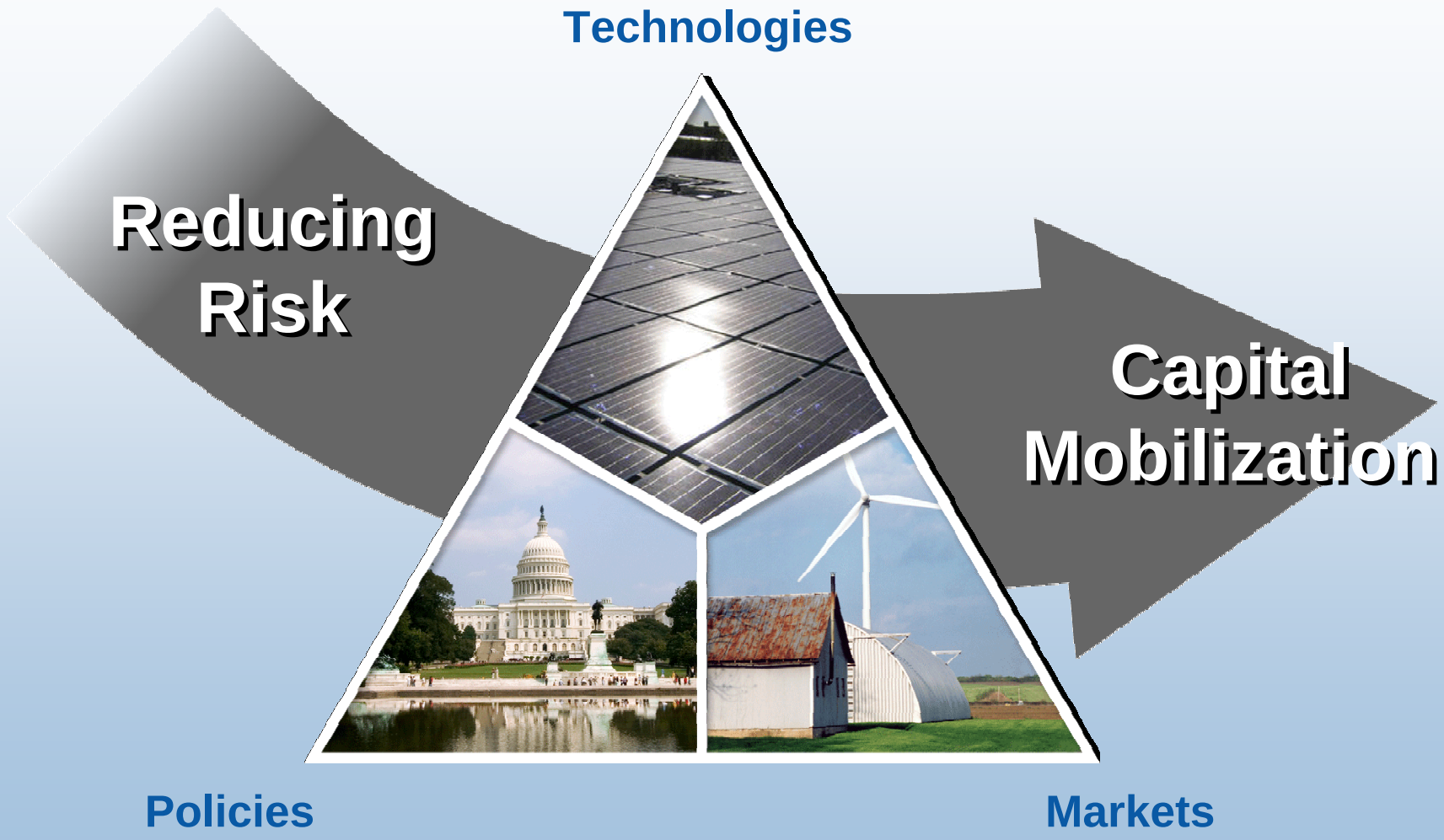
Renewable Energy Electricity Generation Costs as Percentage of 1980 Levels:

Historical and Projected



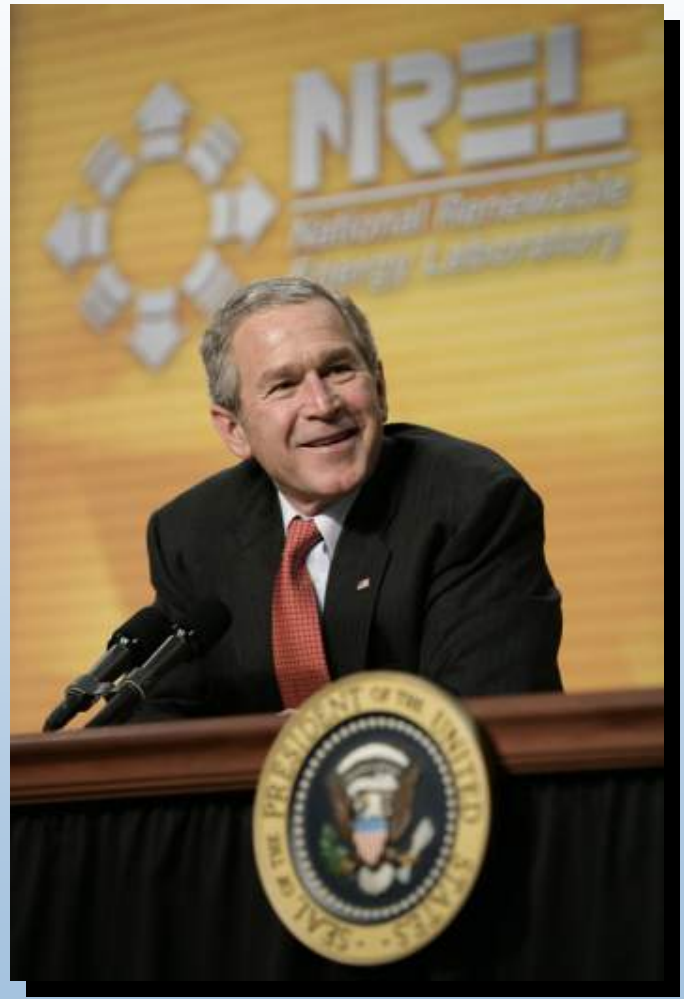
Source: NREL 2005, 2002

Increasing Renewables in the Energy Mix



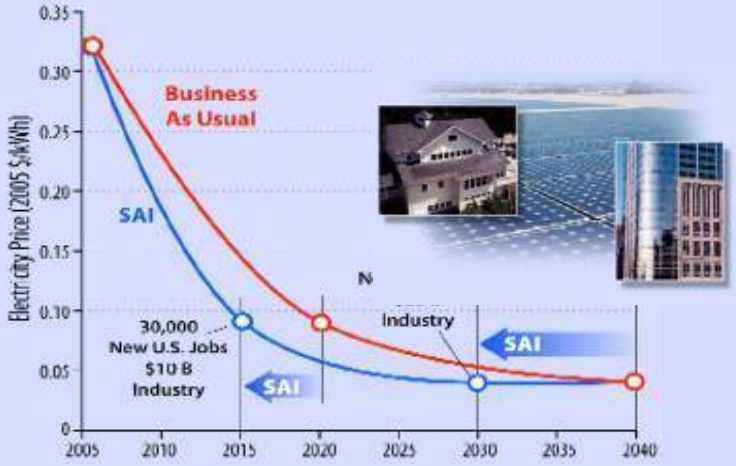
President's Advanced Energy Initiative 2007 Budget

- 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

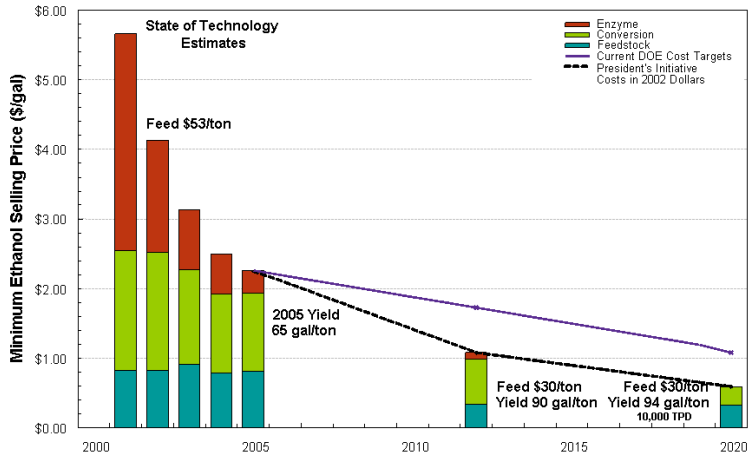


Value to the Nation: Initiatives will Accelerate Progress

Solar America Initiative



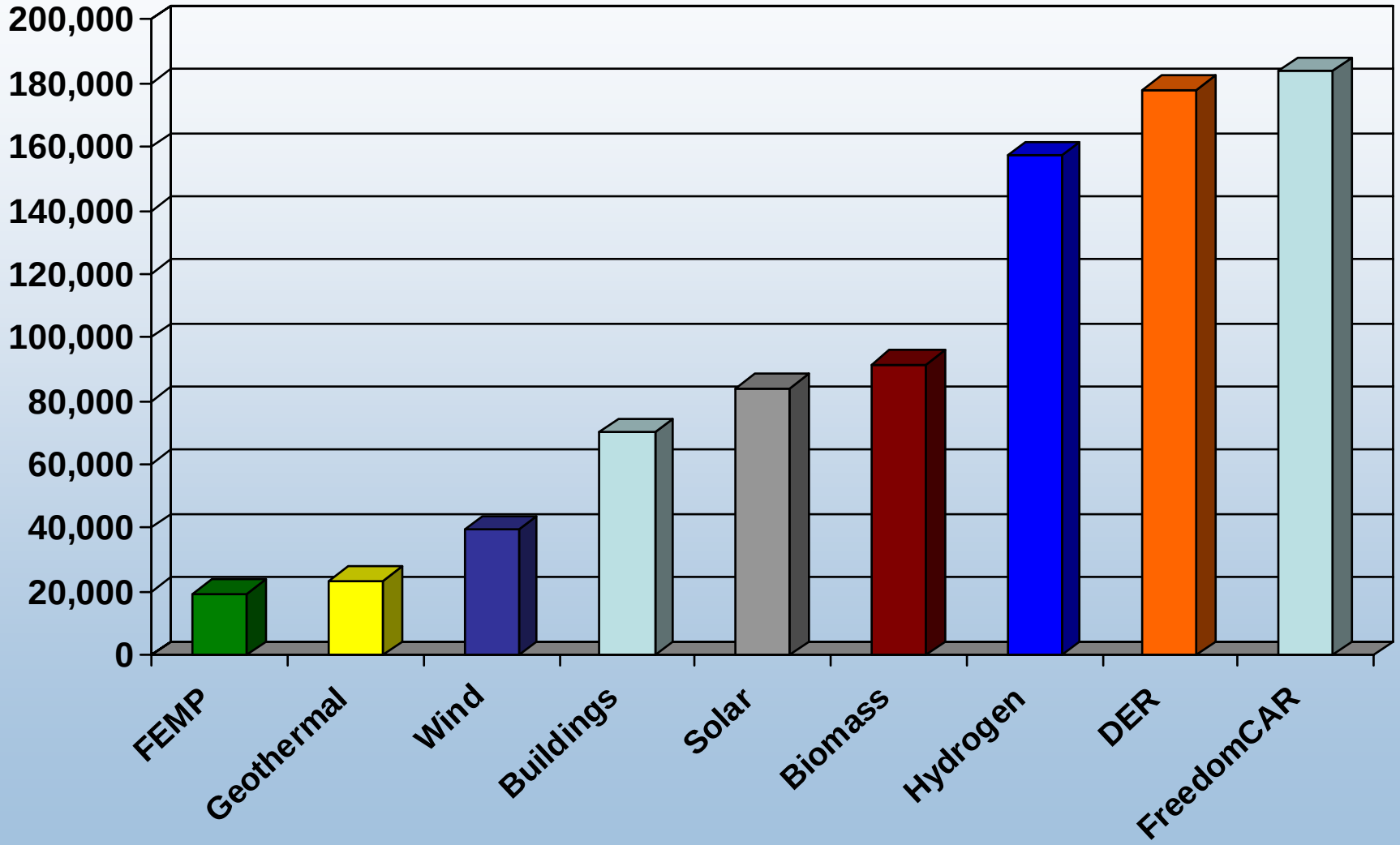
Biorefinery Initiative



Hydrogen Fuel Initiative

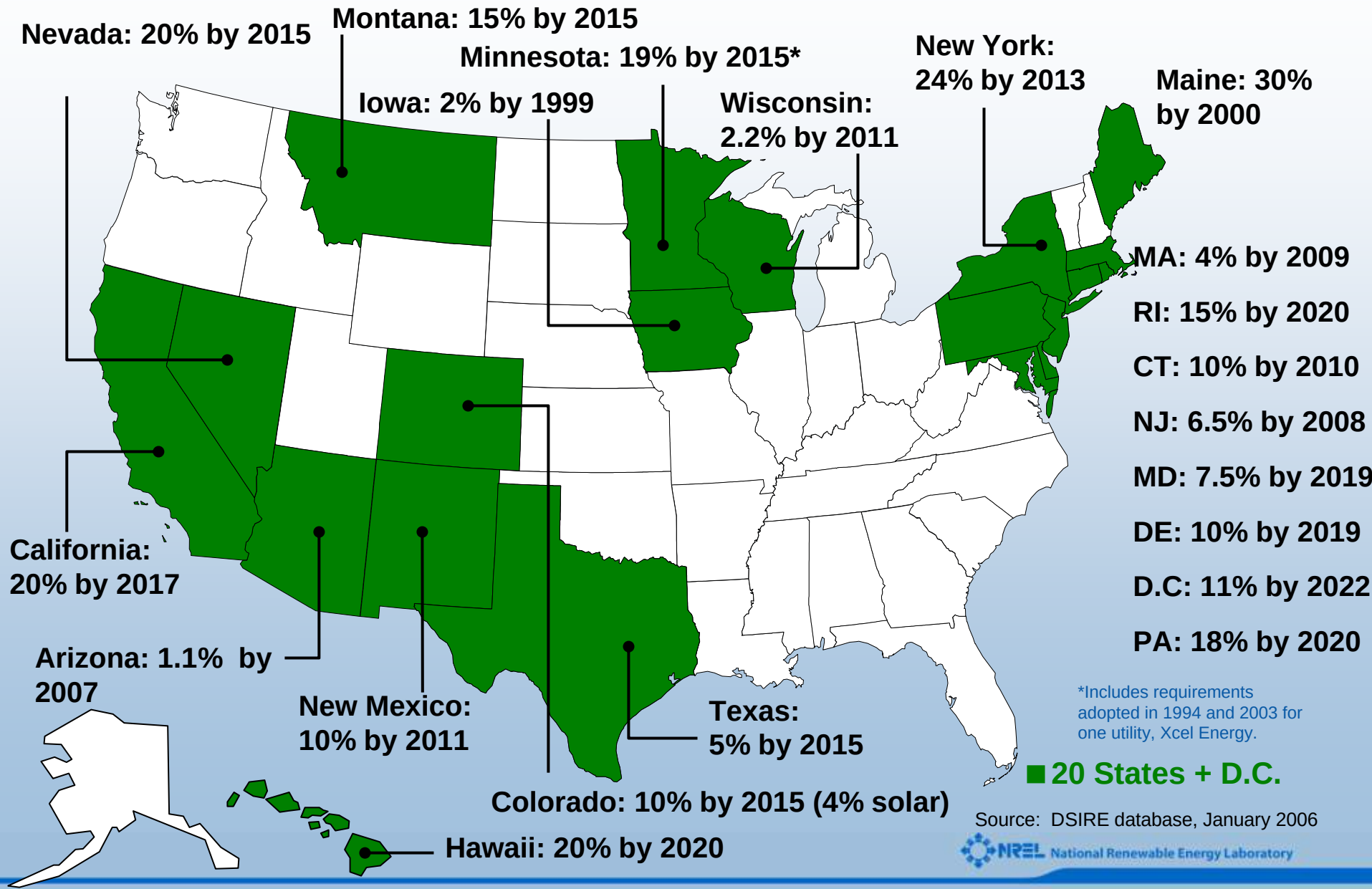
Without a different approach, meeting these aggressive goals is a high-risk proposition

Renewable Energy R&D
FY06 Appropriations
(in $1,000s)



State Policy Framework

Renewable Electricity Standards



*Includes requirements adopted in 1994 and 2003 for one utility, Xcel Energy.

■ 20 States + D.C.

Source: DSIRE database, January 2006

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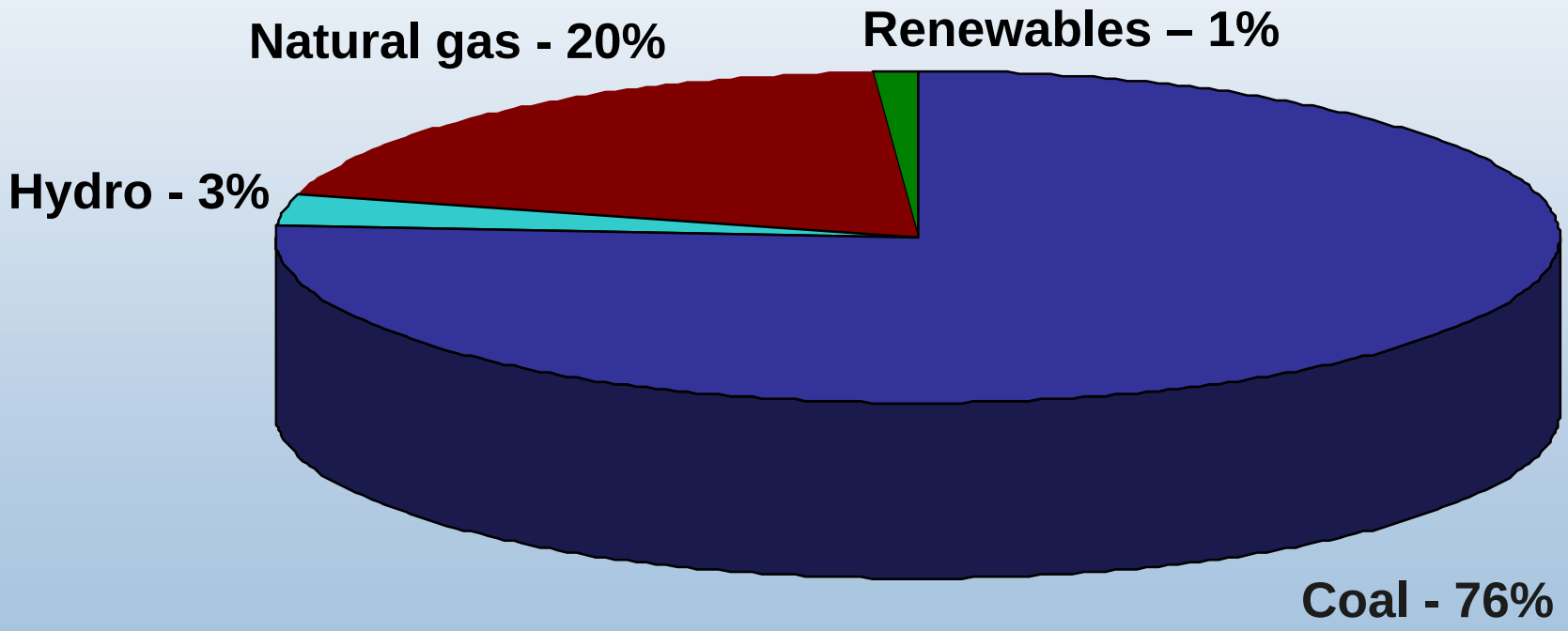
Renewable Energy: Enabling Economic Growth in Colorado

- Plentiful resources
- Centers of Excellence
- Favorable regulatory and business environment

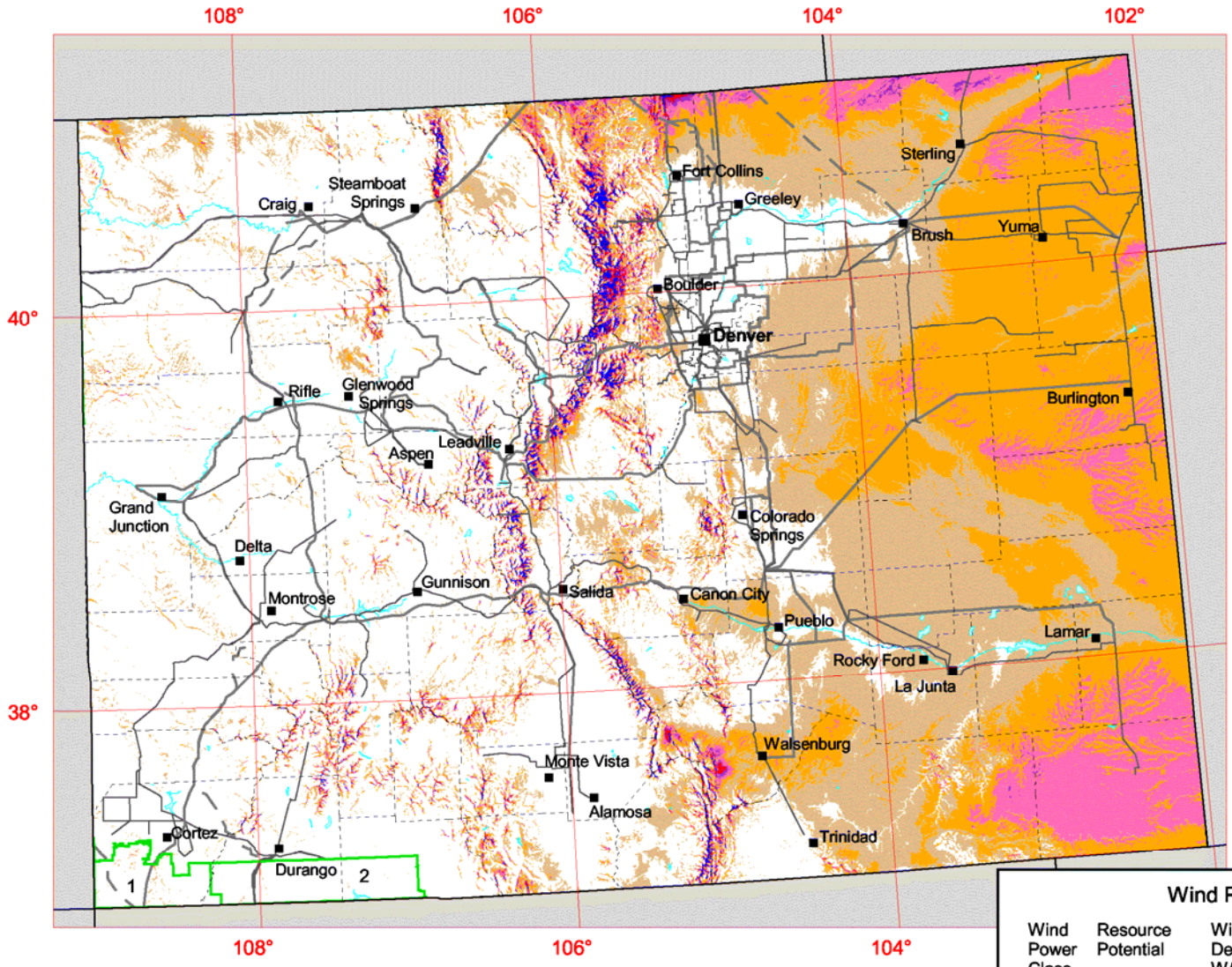
Colorado's Resource Mix
All Electric Utilities



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

Colorado

50 m Wind Power



Transmission Line*

Voltage (kV)

- 115 - 161
- 230
- 345

* Source: POWERmap,©2003 Platts, a Division of the McGraw-Hill Companies

The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.9	0.0 - 13.2
2	Marginal	200 - 300	5.9 - 6.7	13.2 - 15.0
3	Fair	300 - 400	6.7 - 7.4	15.0 - 16.6
4	Good	400 - 500	7.4 - 7.9	16.6 - 17.7
5	Excellent	500 - 600	7.9 - 8.4	17.7 - 18.8
6	Outstanding	600 - 800	8.4 - 9.3	18.8 - 20.8
7	Superb	> 800	> 9.3	> 20.8

[a] Wind speeds are based on a Weibull k of 2.0 at 1500 m elevation.

50 0 50 100 150 200 Kilometers

50 0 50 100 Miles

Indian Reservation

1 Ute Mountain
2 Southern Ute

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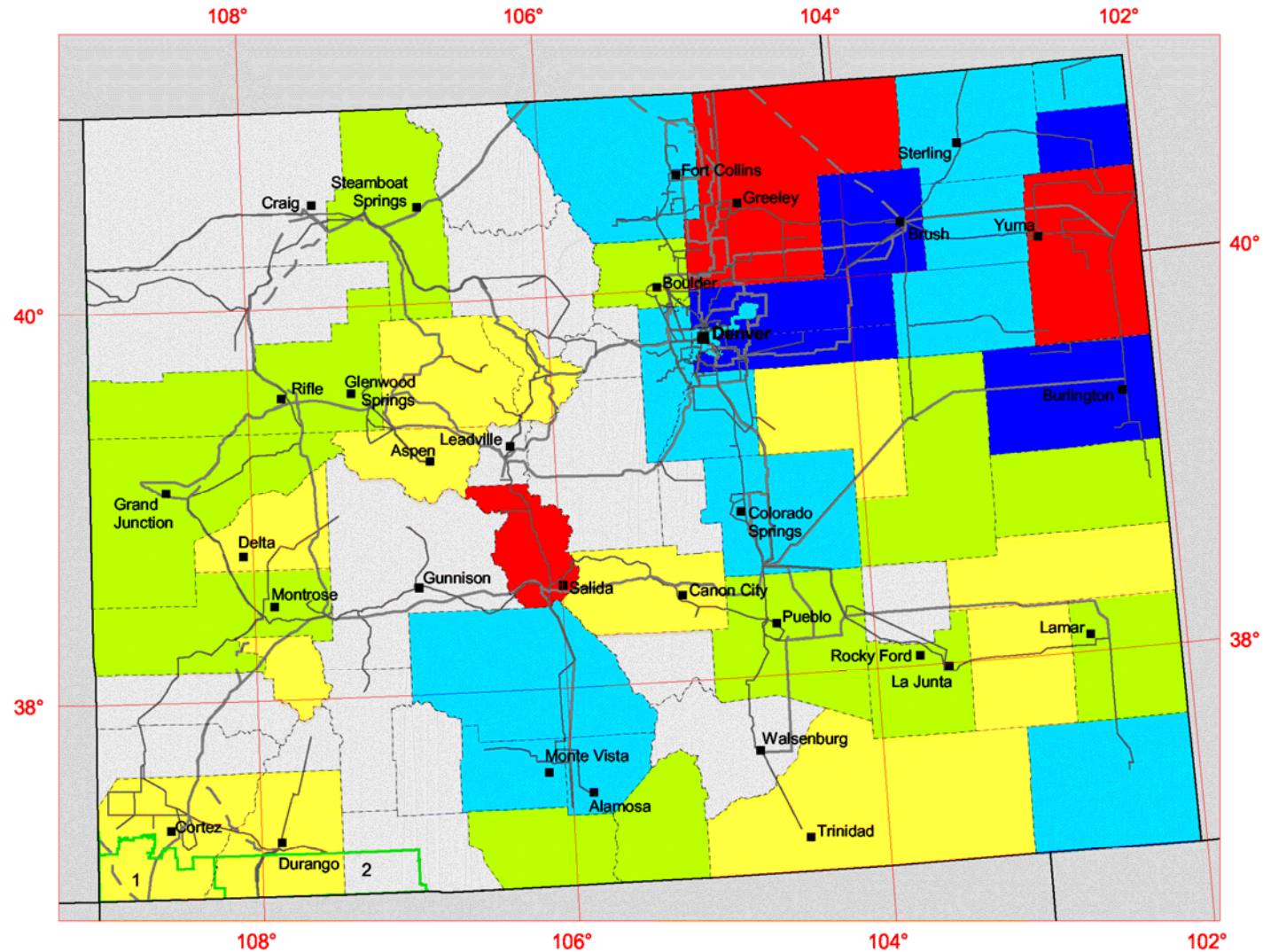
National Renewable Energy Laboratory

09-DEC-2003 2.1.1



Colorado

Biomass Resource

Thousand Tonnes/Year

- > 150
- 100 - 150
- 50 - 100
- 10 - 50
- 5 - 10
- 0 - 5

This study estimates the technical biomass resources available in the United States by county, based on one year of production. It includes the following feedstock categories:

- Agricultural residues (crops and animal manure);
- Wood residues (forest, primary mill, secondary mill, and urban wood);
- Municipal discards (methane emissions from landfills and wastewater treatment plants);
- Dedicated energy crops (on Conservation Reserve Program and Abandoned Mine Lands).

This data is still under review by NREL.

Transmission Line*
Voltage (kV)
- 115 - 161
- 230
- 345

* Source: POWERmap,©2003 Platts, a Division of the McGraw-Hill Companies

Indian Reservation
- 1 Ute Mountain
- 2 Southern Ute

50 0 50 100 150 200 Kilometers
50 0 50 100 Miles

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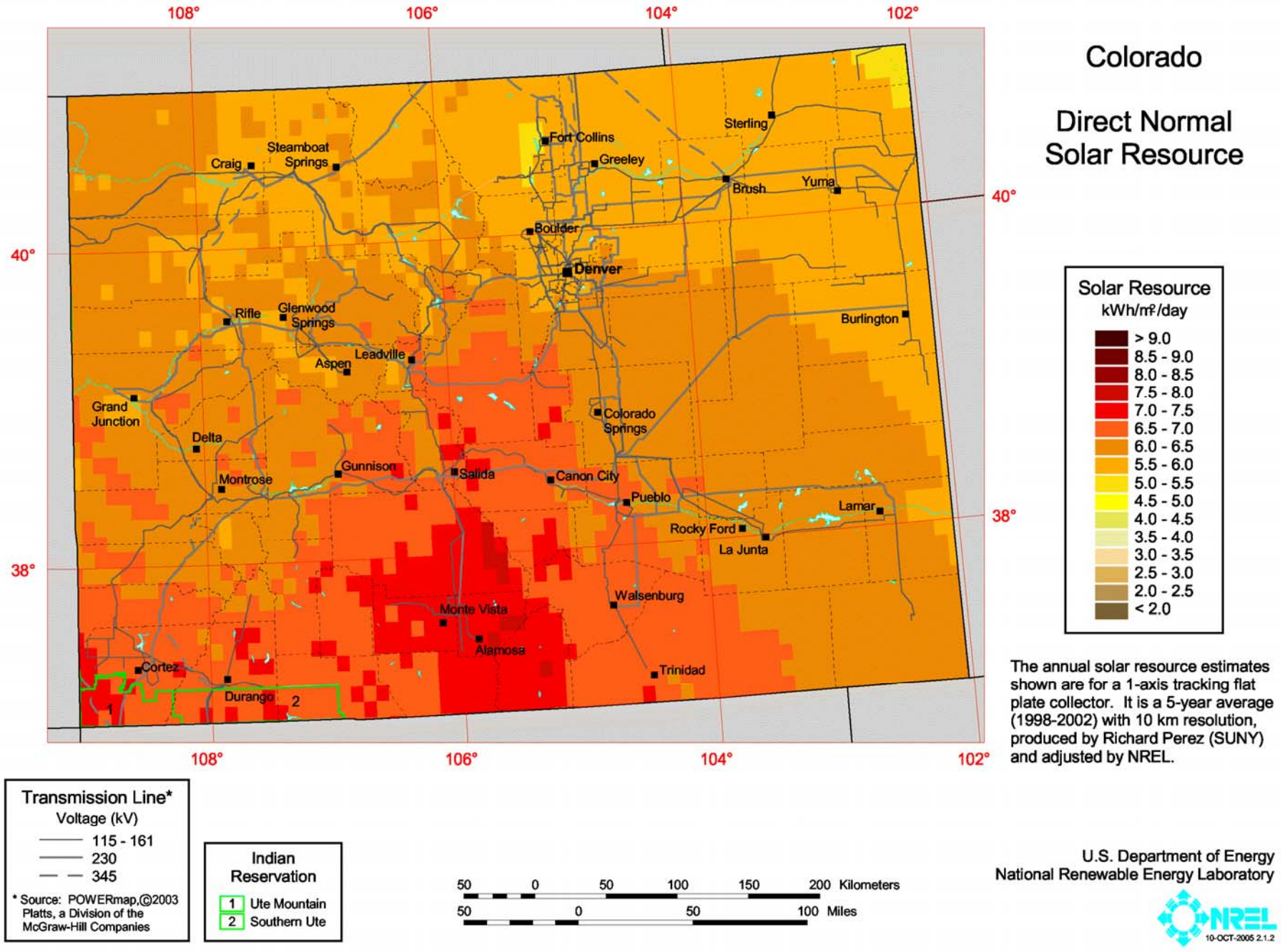
National Renewable Energy Laboratory

NREL
11-OCT-2005 2.1.4



The annual solar resource estimates shown are for a 1-axis tracking flat plate collector. It is a 5-year average (1998-2002) with 10 km resolution, produced by Richard Perez (SUNY) and adjusted by NREL.

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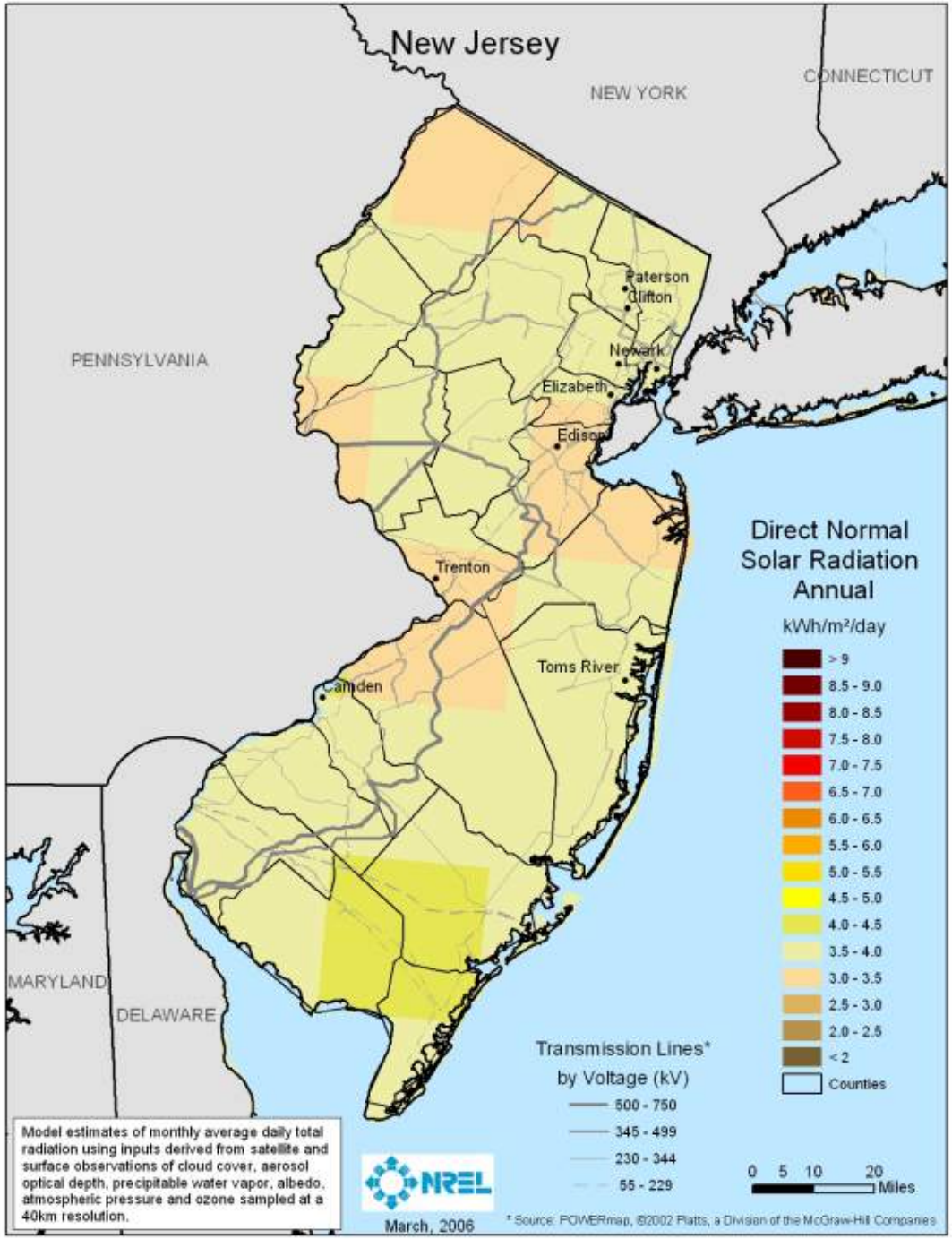
10-OCT-2005 2.1.2


New Jersey
NEW YORK
CONNECTICUT
PENNSYLVANIA
MARYLAND
DELAWARE
Paterson
Clifton
Newark
Elizabeth
Edison
Trenton
Camden
Toms River
Direct Normal Solar Radiation Annual
kWh/m²/day
> 9
8.5 - 9.0
8.0 - 8.5
7.5 - 8.0
7.0 - 7.5
6.5 - 7.0
6.0 - 6.5
5.5 - 6.0
5.0 - 5.5
4.5 - 5.0
4.0 - 4.5
3.5 - 4.0
3.0 - 3.5
2.5 - 3.0
2.0 - 2.5
< 2
Counties
Transmission Lines*
by Voltage (kV)
500 - 750
345 - 499
230 - 344
55 - 229
0 5 10 20
Miles
Model estimates of monthly average daily total radiation using inputs derived from satellite and surface observations of cloud cover, aerosol optical depth, precipitable water vapor, albedo, atmospheric pressure and ozone sampled at a 40km resolution.
NREL
March, 2006
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies

The New Jersey Story

New Jersey

- Growing its PV market at a faster rate than any other state despite a moderate resource
- Progressive public policies - RPS, System Benefits Fund, interconnection standards, and net metering legislation and rules

Other Progressive States' Stories

California

- Meaningful financial incentives: rebates for PV are priced sufficiently to have resulted in 80 MW of reservations.
- Significant financial resources: Systems Benefit Fund paid for deployment and R&D projects since utility sector re-regulated.

Texas

- Meaningful financial incentives: RPS has a significant penalty for non-compliance.
- Significant market impact: RPS credited with jumpstarting the wind market. Clear goals, stated in terms of actual capacity rather than as a proportion of the total energy mix.

Colorado Policy Framework: Amendment 37

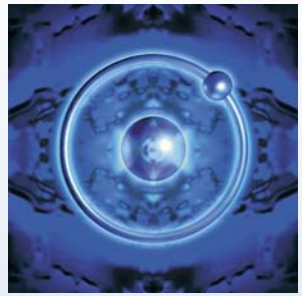
- Will require 110-118 MW of solar and 1,275-1,384 MW of utility-scale wind power by 2015
- NREL is providing technical assistance to Xcel Energy
  - Software for evaluating sites for off-grid and grid-connected solar rooftop commercial electricity systems

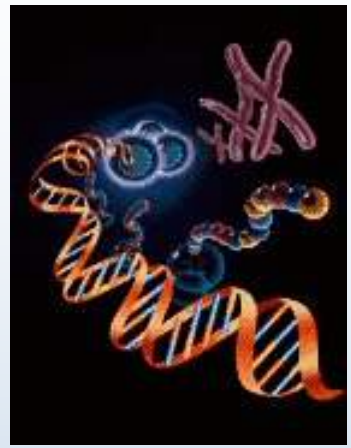
Leveraging the Federal Investment to Create New Businesses

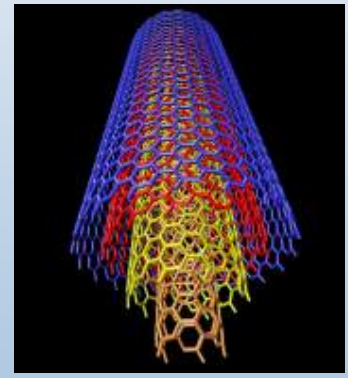
- NREL, NIST, NOAA, NCAR
- Universities
- World-class facilities

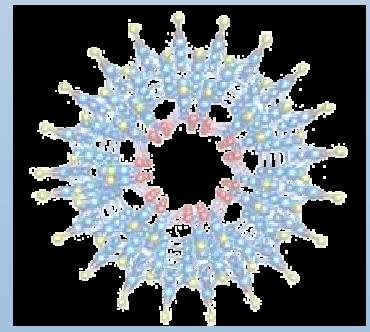
Directions in Energy Science and Technology: The Future Promise

- Supercomputers
- Genomics
- Nanoscience
- Fusion applications
- Cellulosic and biofuels applications
- Hydrogen









Nano/Bio/Info

Conclusion

- Unique opportunity – national sense of urgency about energy
- Integration of energy efficiency and renewable energy will largely be local, distributed
- Progressive states will capitalize on renewable energy's benefits earlier than others

The U.S. Department of Energy's

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