Role for Coal Energy Generation
National Coal RD&D Opportunities

Lacing up our shoes!
at
Combustion Technology
University Alliance Workshop

September 12 and 13, 2002

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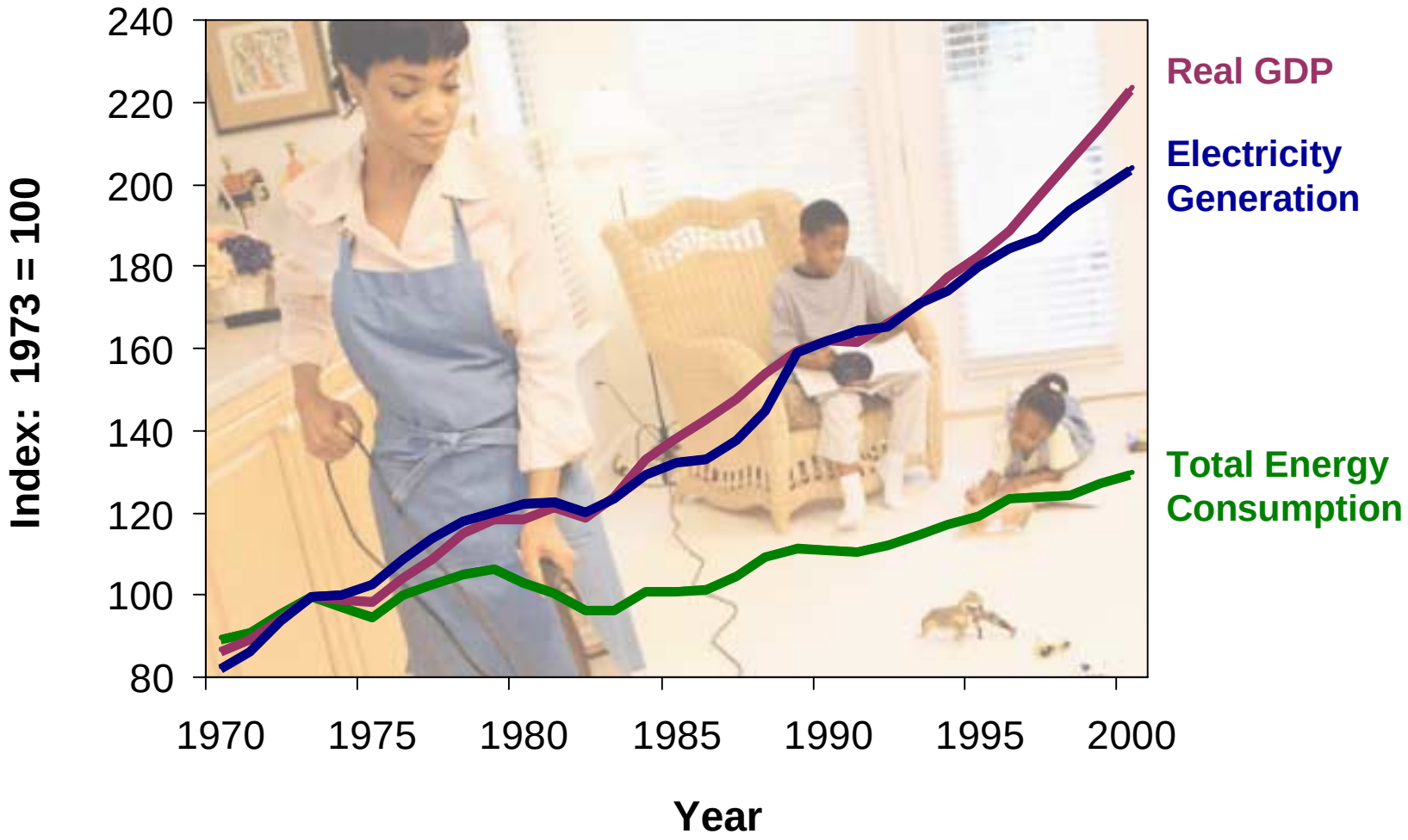
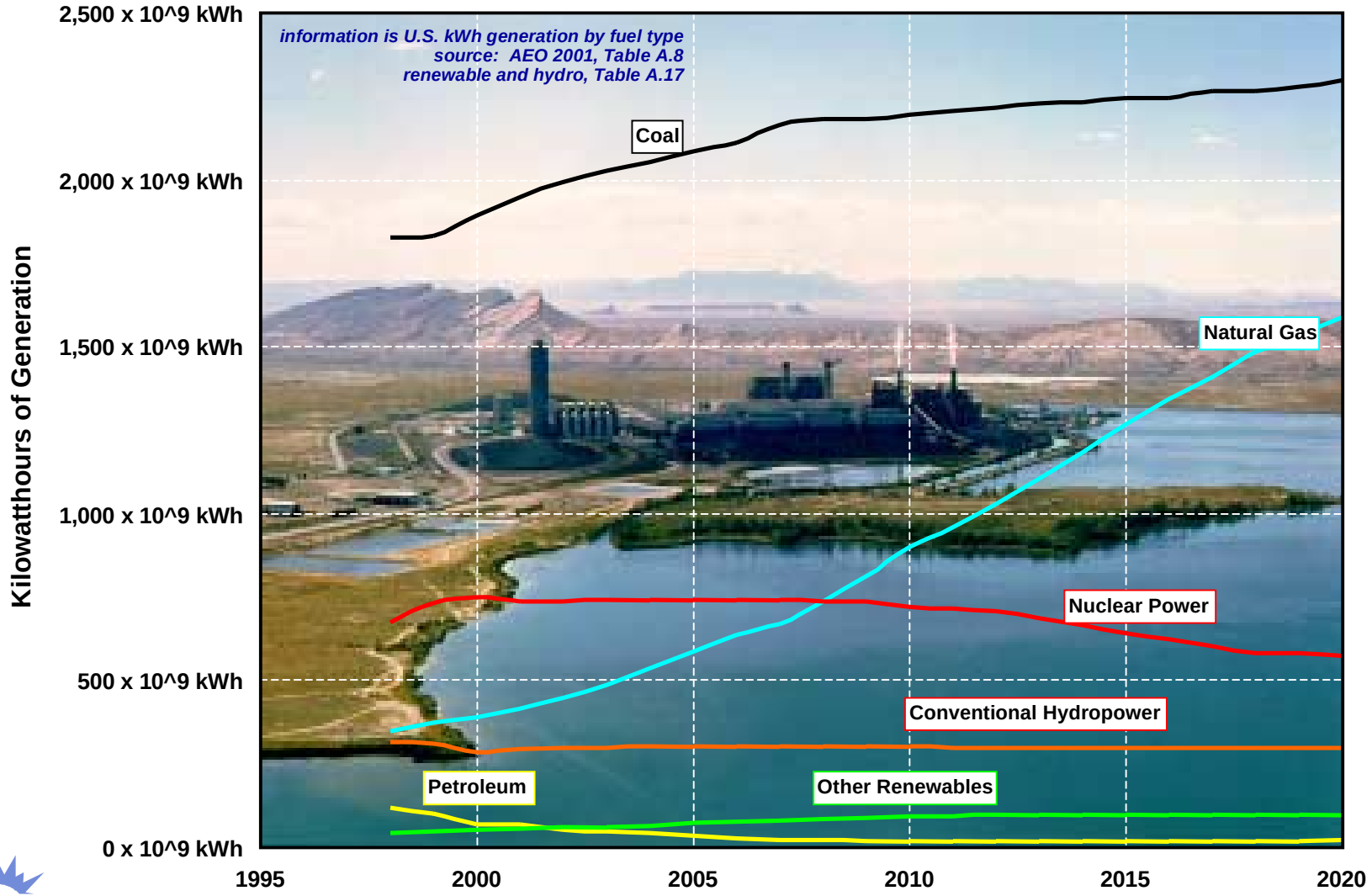
www.netl.doe.gov

Economic Growth Linked to Electricity

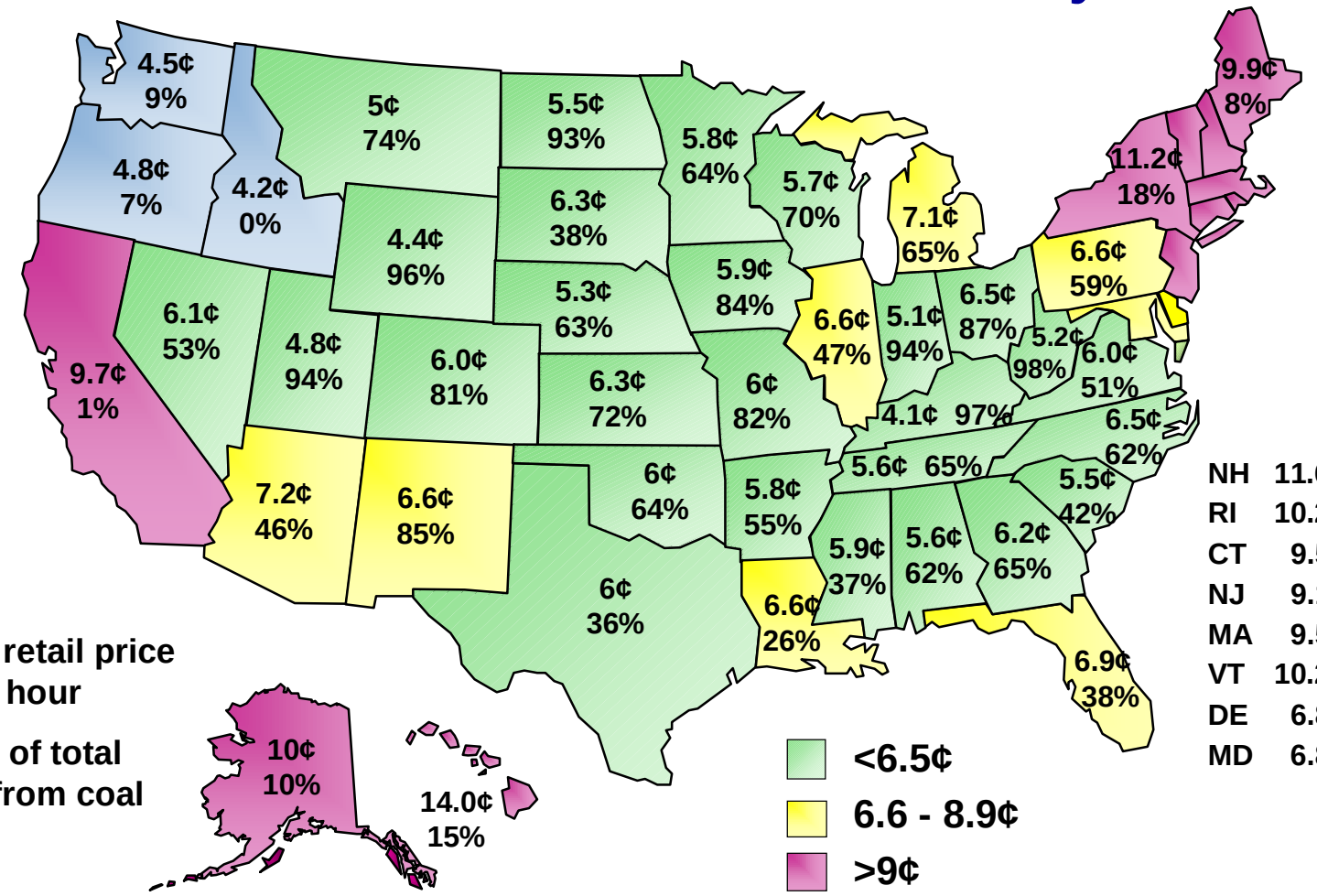


GDP: U.S. DOC, Bureau of Economic Analysis
Energy & Electricity: EIA, AER Interactive Data Query System

EIA Expectation Electric Generation kWh by Fuel Type



Coal Use Translates to Secure, Reliable, Affordable Electricity



¢ = average retail price per kilowatt hour

% = percent of total generation from coal

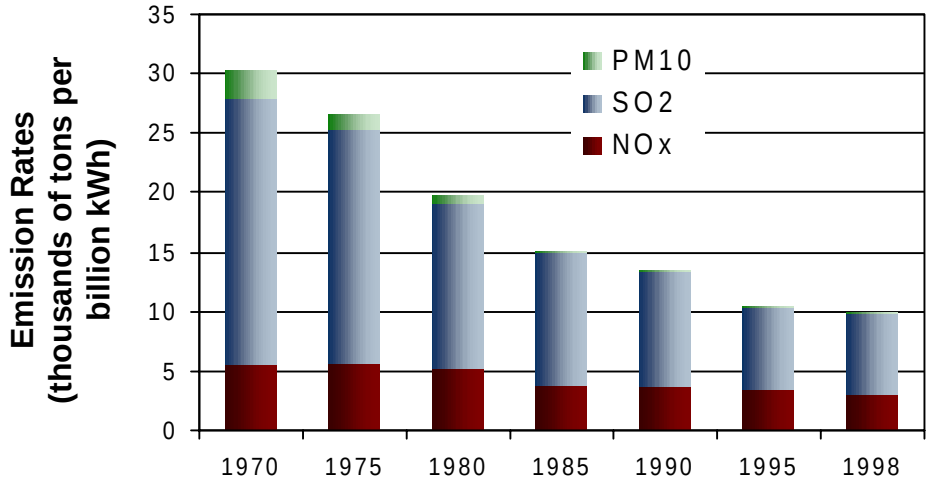
NH	11.6¢	26%
RI	10.2¢	0%
CT	9.5¢	11%
NJ	9.1¢	17%
MA	9.5¢	30%
VT	10.2¢	0%
DE	6.8¢	69%
MD	6.8¢	56%

Peabody Coal/DOE/EIA

Much Progress in Reducing Emissions Since 1970

- **National emissions down**
  - SO_2 emissions down 70%
  - NO_x emissions down 45%
  - All while coal use doubled

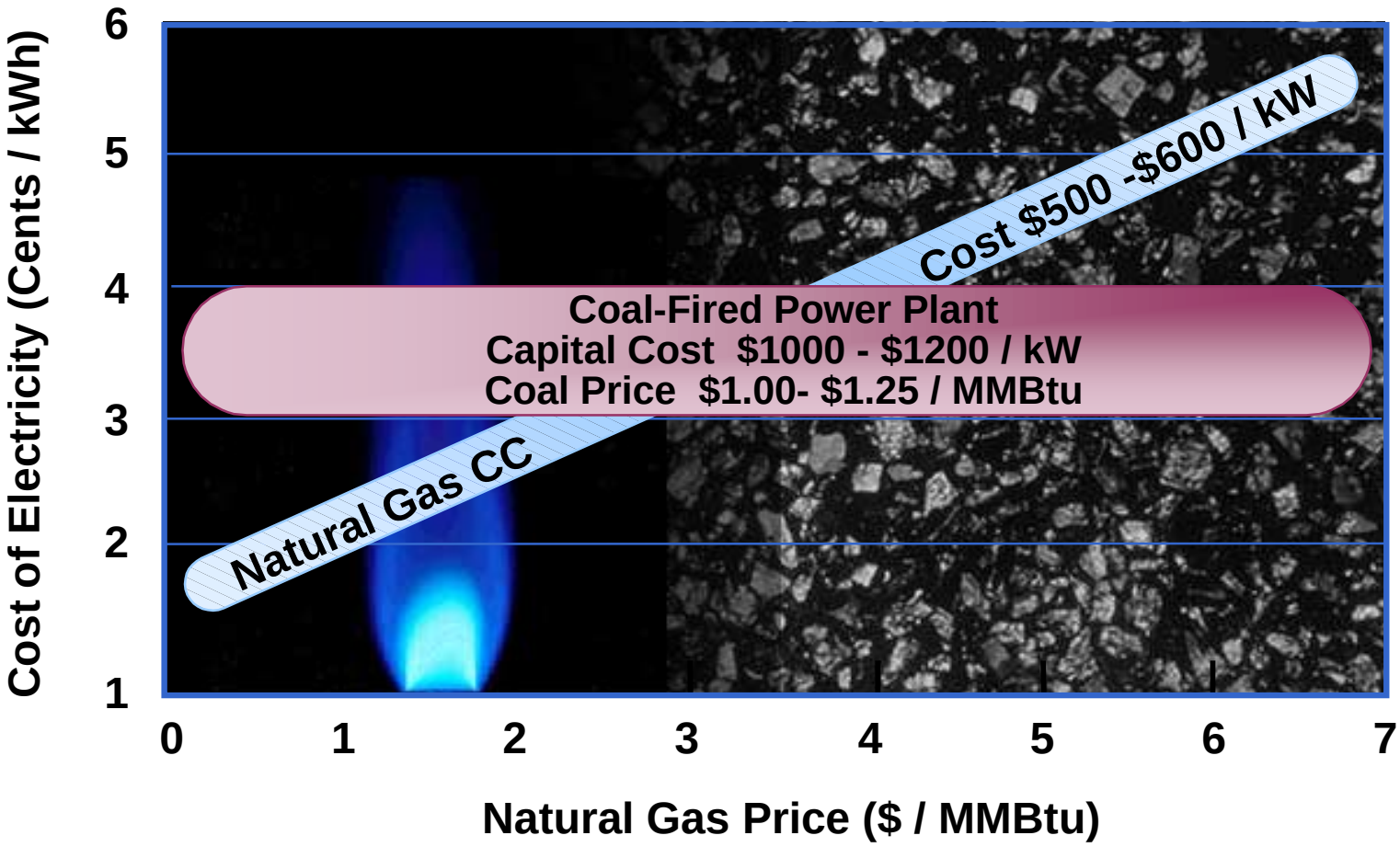
Individual coal plant emissions down



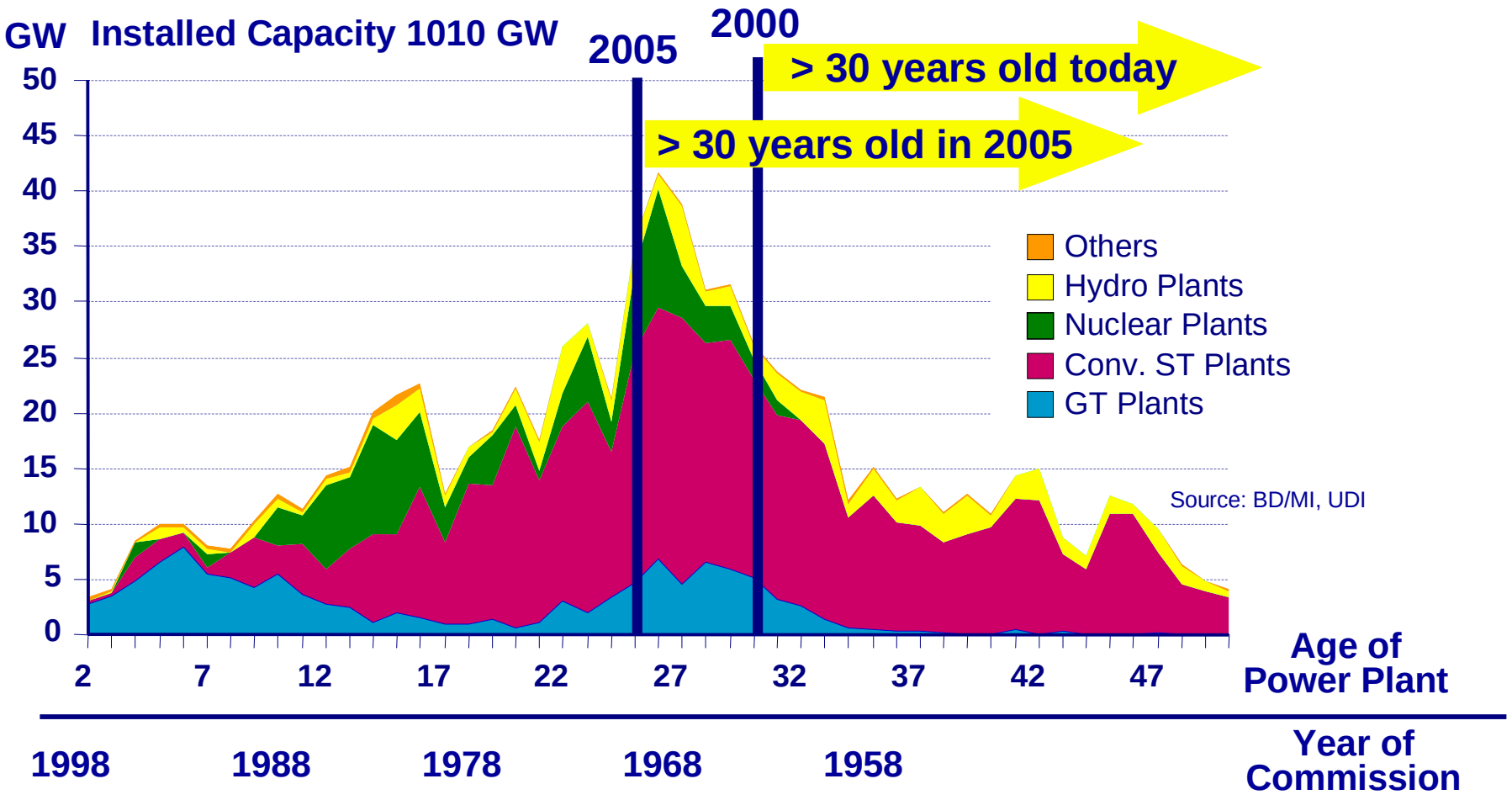
But Pressure to Improve Environmental Performance Continues

Emissions: *National Air Pollutant Emission Trends, 1990-1998,* EPA 454/R-00-002, March 2000;
Generation: *EIA Annual Energy Review 1998*

Coal Technologies are Cost Competitive



USA Power Plant Service & Retrofit

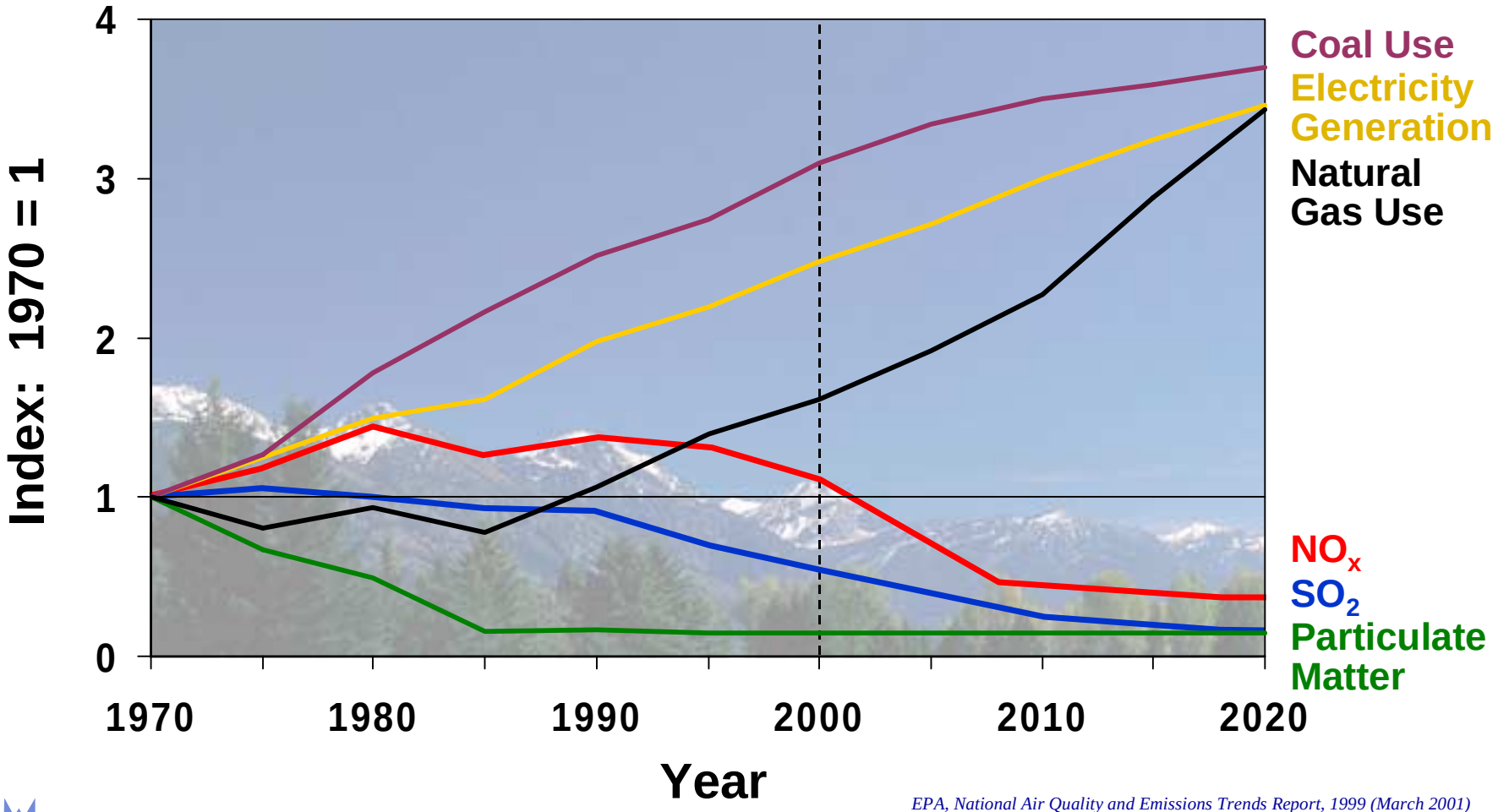


Notes:- 4.3GW missing due to unknown commission year, 90% Conventional ST Plants
- 25.2 GW older than 50 years (~60% Hydro, ~35% Conv. Steam Plants)

Current Status of Coal Plants

- **Most new coal plants:**
  - Use conventional boiler technology with advanced Clean Coal pollution control systems
  - Add new capacity
- **Old coal plants will continue to operate because of:**
  - Cost benefit (e.g., using and upgrading existing assets is cost effective)
  - Regulatory uncertainties (e.g., pollution control limits and permitting requirements are not well defined)
  - Existing knowledge (e.g., plant engineers and operators know how to operate this technology)
  - Investment requirements (e.g., short ROI's - 1 to 3 years)

Proposed Clear Skies Initiative Would Make Criteria Pollutants Essentially a Non-Issue



EPA, National Air Quality and Emissions Trends Report, 1999 (March 2001)
DOE, EIA Annual Energy Review
Projections for NO_x and SO_2: Clear Skies Initiative

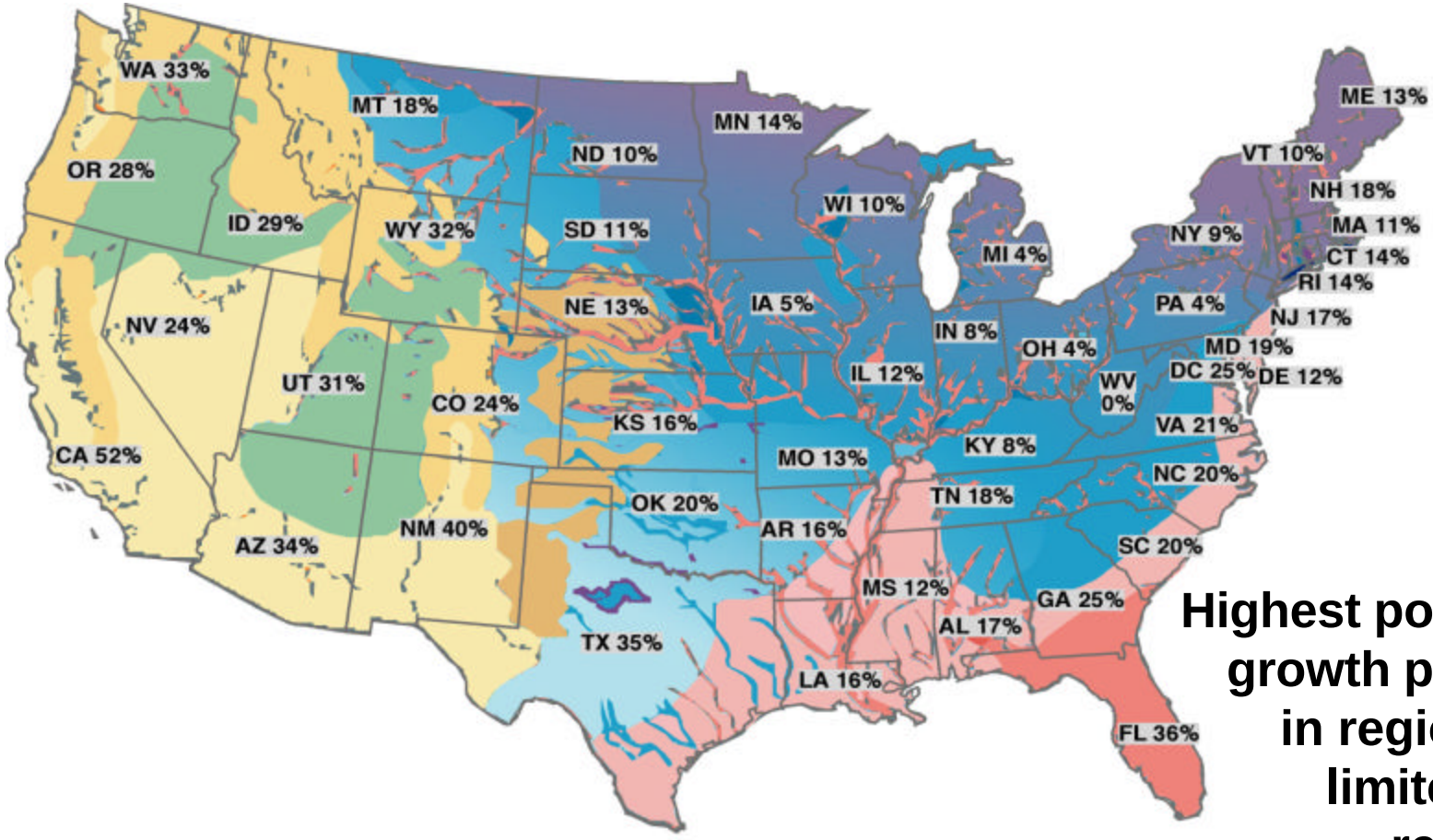
Proposed Emissions Reductions
Electric Power Plants

			Clear Skies		Jeffords
Emission	*Actual 1999*	*Baseline*	*2008/2010 Cap*	*2018 Cap*	*2007 Cap*
SO_2	12.0 M tons/yr	8.9 M tons/yr	4.5 M tons/yr	3.0 M tons/yr	2.2 M tons/yr
NO_x	7.1 M tons/yr	4.0 M tons/yr	2.1 M tons/yr	1.7 M tons/yr	1.5 M tons/yr
Mercury	48 tons/yr	48 tons/yr	26 tons/yr	15 tons/yr	4.8 tons/yr
CO_2	2.19 B tons/yr	?	None	None	1.94 B tons/yr

Electric Supply and Reliability
Becoming a National Problem

- **Demand outstripping supply**
  - Added only 5% plants to inventory in 1990's vs 20+% demand growth
- **T&D capacity strained**
  - Annual investment in T&D 1/3 of 1982
- **Increasing dependence on natural gas**
  - 95% of planned plants are gas-fired

Relative Water Availability and Projected Change in Population (2000-2020)



Highest population growth projected in regions with limited water resources

Less Water — More Water

Emerging Water Issues

- Power plants are second largest user of water in United States
- Current and future regulations could impact existing plant costs and efficiency
- Water restrictions affecting siting and permitting of new plants

Edison Electric Institute, 1996

What kind of research is needed?

- **NSF Definitions:**
  - "The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study, without specific applications in mind."
  - "Applied research is aimed at gaining the knowledge or understanding to meet a specific, recognized need."
- **Recognizing needs is exhausting work**
  - Anticipating and shaping requirements
  - Devising and implementing successful pathways

Fossil Energy Technology Development Strategy

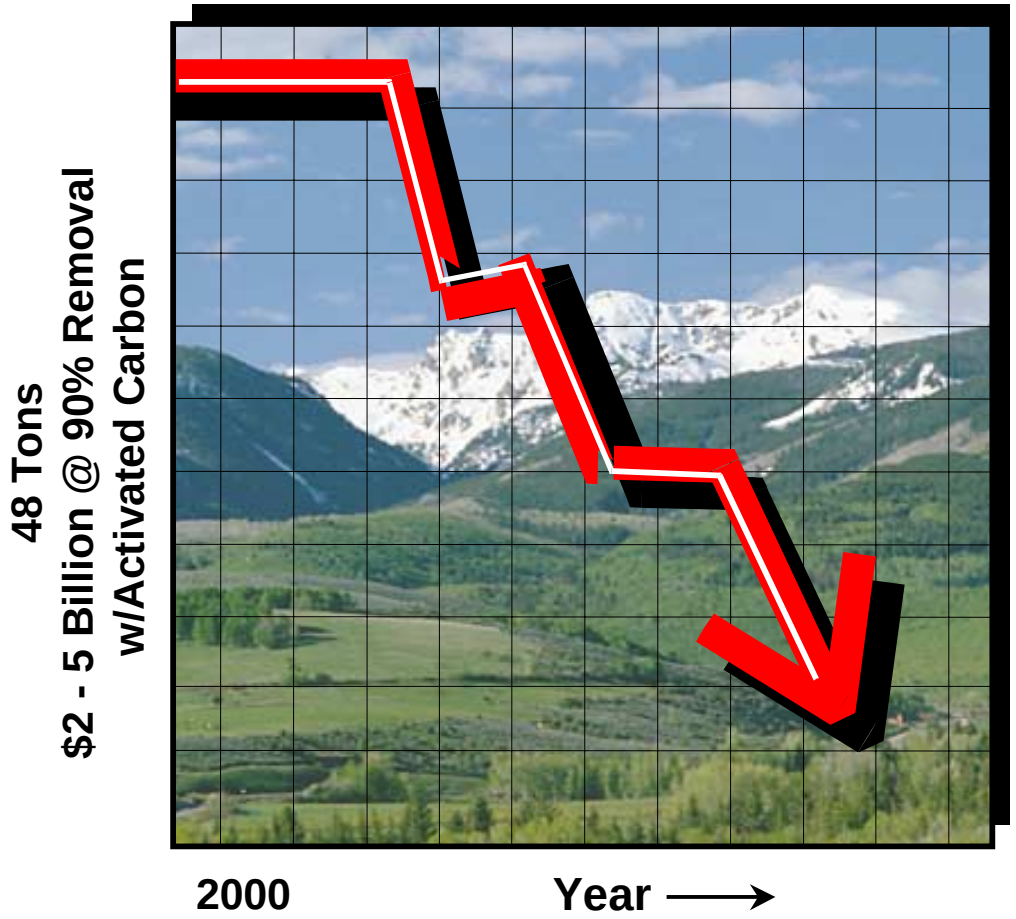
- **Foster complementary, integrated programs**
  - R&D, demonstrations, deployment incentives
  - Build from a foundation of successes

- **Leverage funds and accelerate technology transfer via government / industry partnerships**
  - Focus on technology needs not met by private sector, and providing a substantial public good

- **Continually re-assess market situation, external technology drivers, technology progress – and adjust RD&D program**
  - Work with regulatory agencies to ensure regulations are science-based and exploit emerging technologies

Mercury Control

- **Developing technologies ready for commercial demonstration:**
  - By 2002, reduce emissions 50-70%
  - By 2010, reduce emissions by 90%
  - Cost 25-50% less than current estimates



Baseline costs: $30,000 - $70,000 per lb. Hg removed

R&D in Mercury Control

An NETL Response to Clear Skies Initiative

- **Phase I field testing at six power plants**
  - 50-70% Hg removal
    - ADA-ES
    - B&W / MTI
- **Six pilot-scale projects**
  - > 90% Hg removal
- **Phase II field testing to be initiated in FY03**

ADA-ES Sorbent Injection
Alabama Power's
Gaston Station

Combustion Systems

Improved combustion systems for today's and tomorrow's plants

- Cost
- Efficiency
- Environmental performance
- Reliability

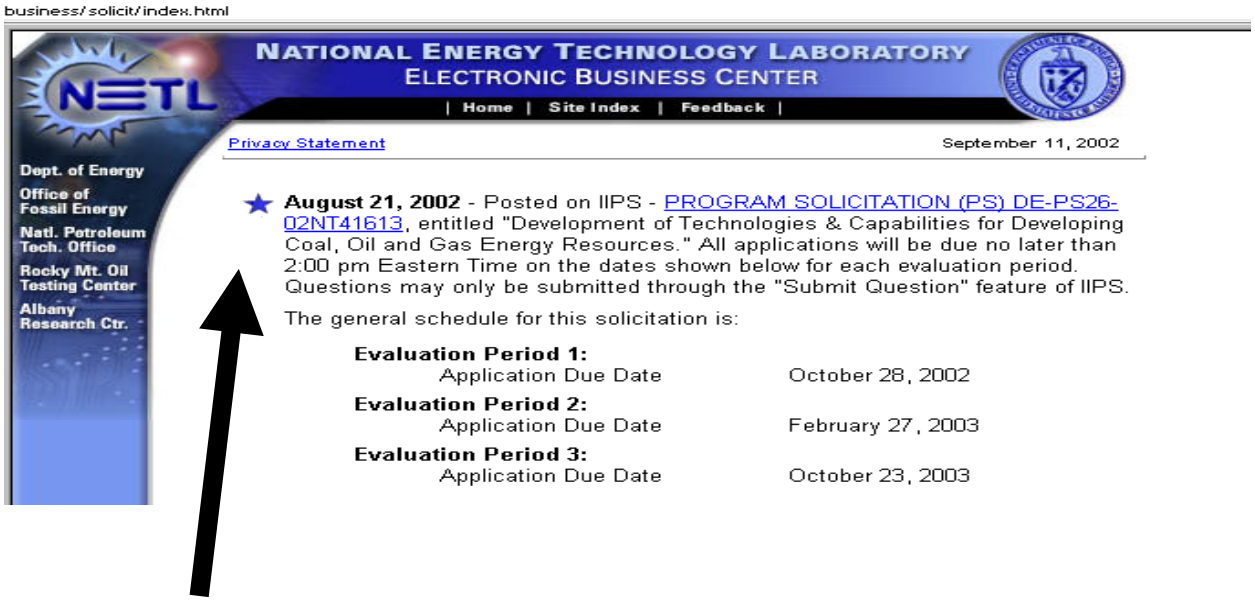
Activities

- PSDF
- HT particulate filters
- LEBS 80-MW demo
- Capitol Power Plant design

Advanced Materials Consortium
Ultra-Supercritical Power Plants
CURC / EPRI / ORNL / NETL

Coal R&D Opportunities

Solicitation is Open



Development of Technologies and Capabilities for Developing Coal, Oil and Gas Energy Resources

http://www.netl.doe.gov/business/solicit/index.html

Combustion Systems R&D Topics

- Advanced Filtration
- Rankine Cycle Improvements
- Improved Reliability and Cost Reductions
- Catalytic Combustion
- Advanced Combustion System Analysis

Gasification Systems

Improved Gasification and Cleanup Processes

- Efficiency
- Cost
- Sequestration compatibility

Activities

- PSDF
- O_2, H_2, CO_2 separation
- Improved refractory
- Co-production design optimization

Tampa Electric Co. IGCC
Polk Power Station

Vision 21
Ultra-Clean Energy Plant of Future

Energy Plants for Post-2015

- Coal and other fuels
- Electricity and possible co-products

Goal

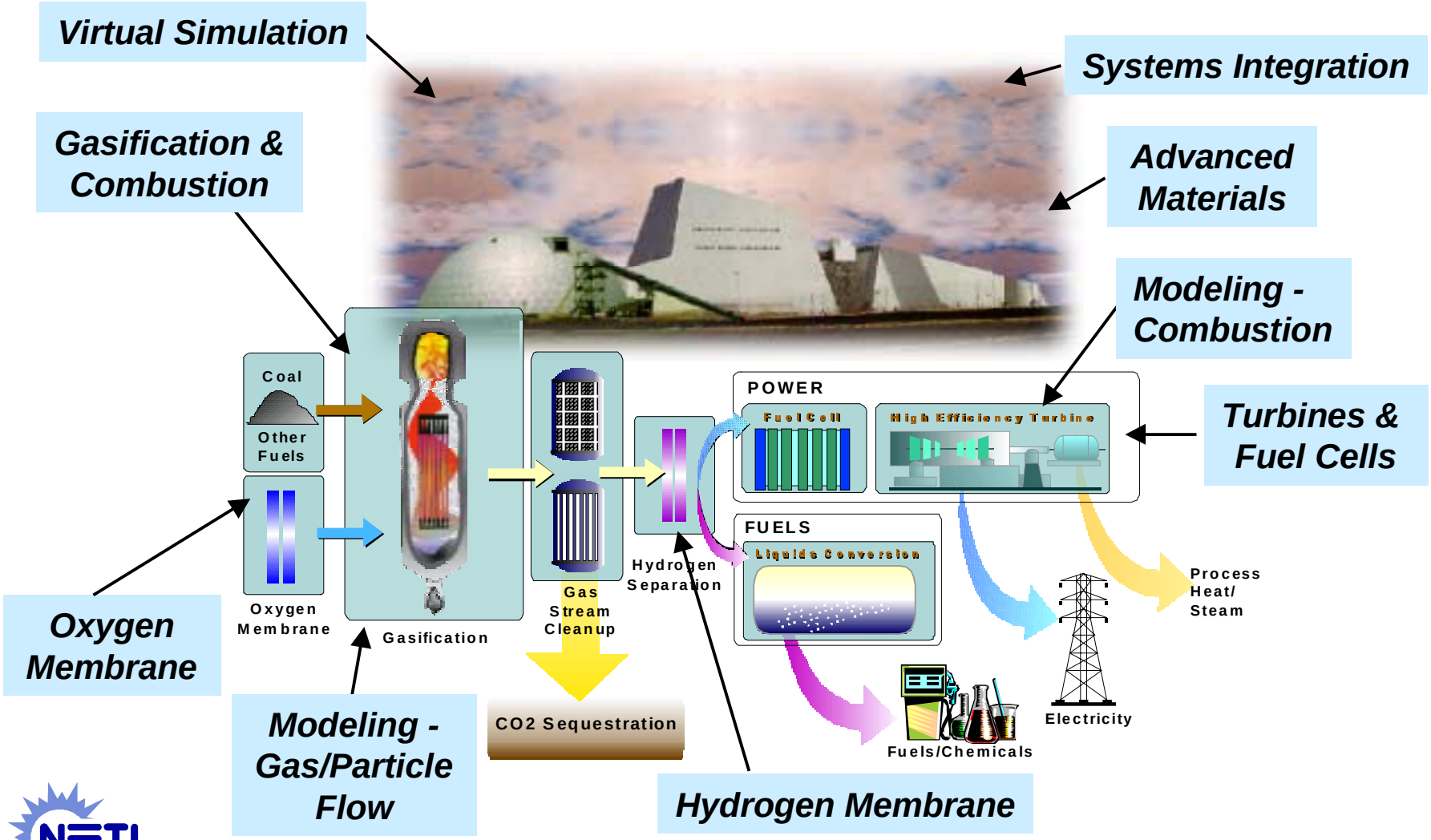
Eliminate Environmental Concerns from Use of Fossil Energy

Approach

- Maximize efficiency
- Near-zero emissions

Vision 21 Program

New Projects Contribute to Ultra-Clean Energy Plant

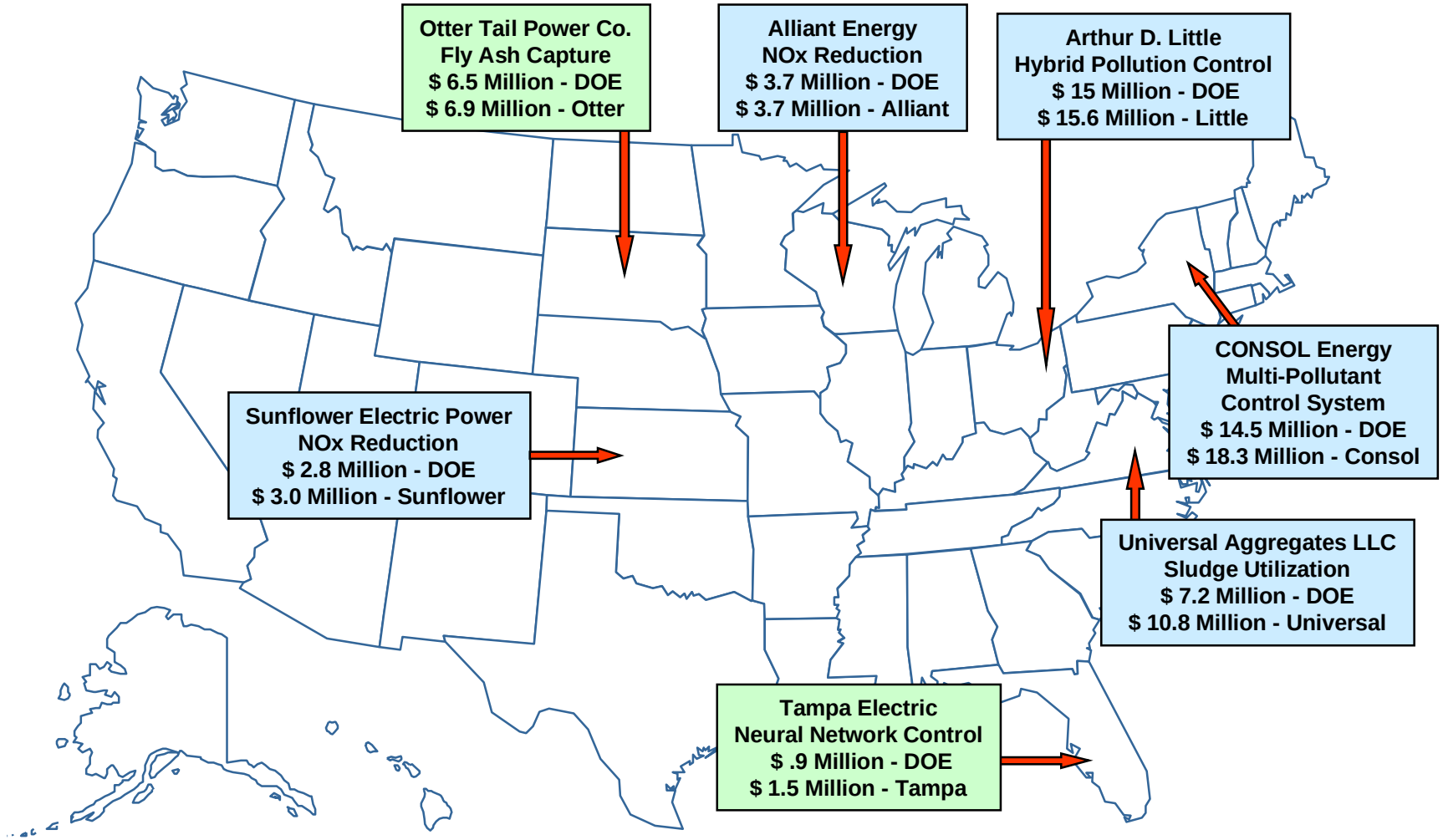


Power Plant Improvement Initiative (PPII)

Near-term technologies for coal-fired electric power generation

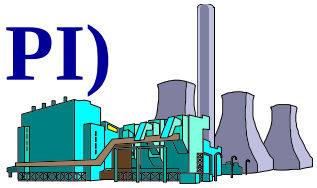
- **Congressionally mandated redirection of $95 Million in FY 2001**
- **24 Proposals Received; 8 Proposals Selected- 1 Withdrawn > $110 Million**
  - **Emissions control strategies - 4 projects**
  - **Advanced control schemes - 2 projects**
  - **Waste handling/reduction - 1 project**
- **Pre-award Activities Continue**
  - Good progress on 6 of 7 (2 have been awarded recently)

Power Plant Improvement Initiative (PPII)



Cooperative Agreements Awarded to Date

Clean Coal Power Initiative (CCPI)

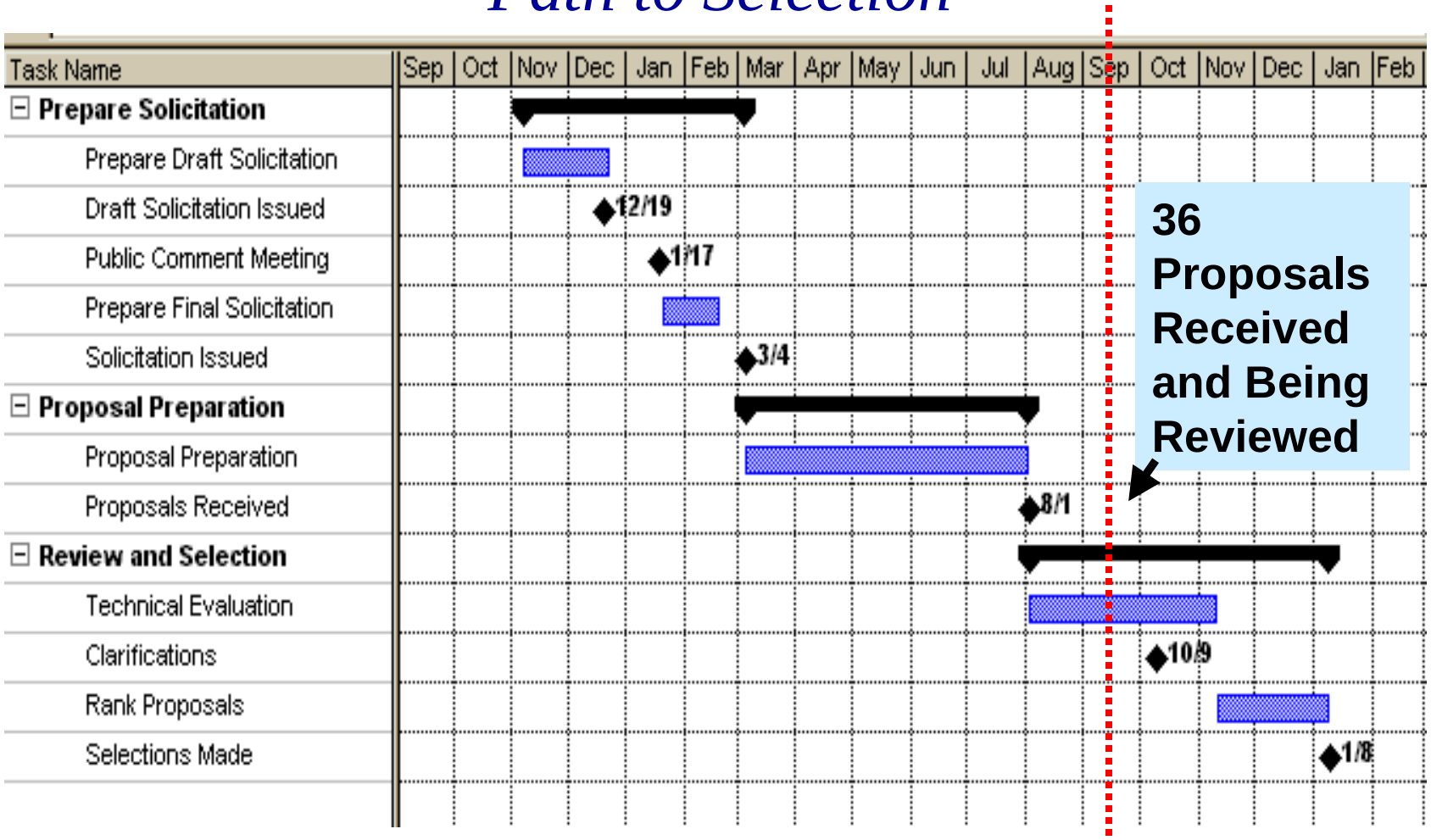


Clean, Reliable & Affordable Electricity
for America's Future

- **Additional Drivers**
  - Clear Skies Initiative
  - Reduced carbon intensity
  - Zero emissions technology goals
  - Energy/economic security
- **Technology Demonstration Opportunities**
  - 3P control systems (SO_2, NOx and Mercury)
  - High-efficiency electric power generation
    - Gasification
    - Advanced combustion
    - Fuel Cells and Turbines
  - Retrofit, Repowering and new Merchant Plants

CCPI Program Schedule

Path to Selection



CCPI Status

- **36 Proposals received on August 1, 2002**
- **Press Release and proposal Abstracts available** http://www.netl.doe.gov/coalpower/ccpi/index.html
- **Preliminary and Comprehensive Reviews underway**
  - Some proposals will fail to pass preliminary review- and will be notified by DOE; but no public announcement
- **DOE Review Teams are active**
  - Employing federal and private sector experts
- **On schedule for selection in January 2003**
  - Dependent on FY 2003 Appropriations

CCPI Proposal Summary

- **Solid Technology/Market Mix of Proposals**
  - 9 Multi- Pollutant Control($770M @ 45%DOE)
  - 6 Gasification Systems ($2,320M @ 25%DOE)
  - 7 Advanced Combustion ($1,480M @ 20%DOE)
  - 6 Coal Conversion/Upgrading ($723M @ 21%DOE)
  - 3 Sensors and Controls ($21M @ 46%DOE)
  - 5 Misc. -By-Products/Co-firing… ($46M @ 44%DOE)

- **Total of 36 Proposals ($5,360M @ 26%DOE)**
  - Industry steps up -- ready to participate in CCPI

Substantial Potential for Coal Retrofit & Repowering

Coal Nameplate Capacity
321 GW
44% of Total

240 GW (75%) of Fleet Capacity Is Prime Target For Increased Capacity Retrofit (40 GW potential in 3 years!)

80 GW (25%) of Fleet Capacity Is Prime Target For Repowering With Cleaner, Higher Efficiency Coal Technologies

Sources: National Coal Council

Power Reliability Improvement and Emission Reduction (PRIER) Program

Getting more out of the Fleet

- **National Coal Council - existing fleet could generate additional 40GW**
- **NETL believes could be 80GW**
- **PRIER designed to**
  - Develop and ready technologies for commercial use
  - Provide validated technologies, knowledge and retrofit/repowering strategies-compendium

photo courtesy of CP

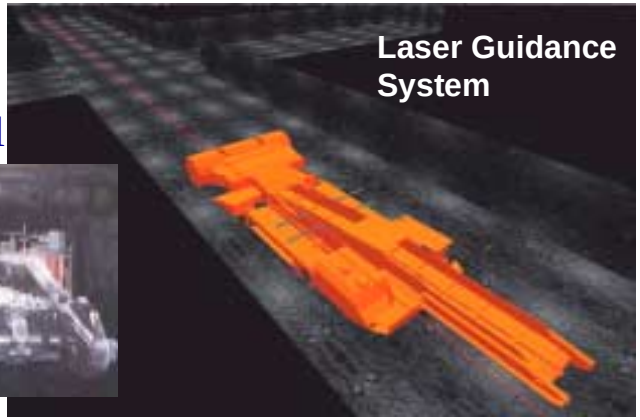
- **National benefits**
  - Energy security, environmental, capacity increase and reduced cost of electricity

DOE Mining Industry of the Future

Everything Begins with Mining

Mission

- Mining is part of EE/OIT Industries of the Future Program- Goal; energy efficiency improvement in key US industries
- Encompass hard rock and coal mining sectors (NMA is sponsor)
- Couple research capabilities at National Labs with Industry needs and partners



INEEL/CMU/Consol

Program Activity

- 28 on-going Industry and National Lab led “cross-cutting technology” projects
- New solicitation for Industry Led “mineral processing technologies”--17 proposals being reviewed
- $5.1 million appropriated in FY 2002
- NETL supports EE/OIT in program implementation
- Some commercial successes emerging

CO_2 Mitigation Options

Reduce Carbon Intensity

- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency

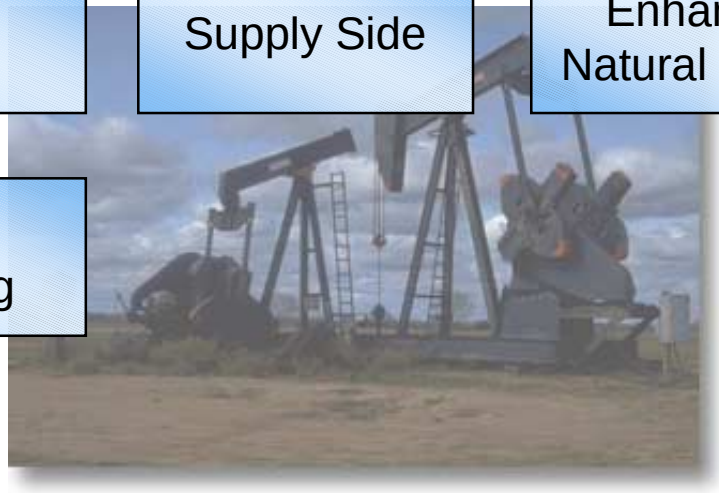
- Demand Side
- Supply Side

Sequester Carbon

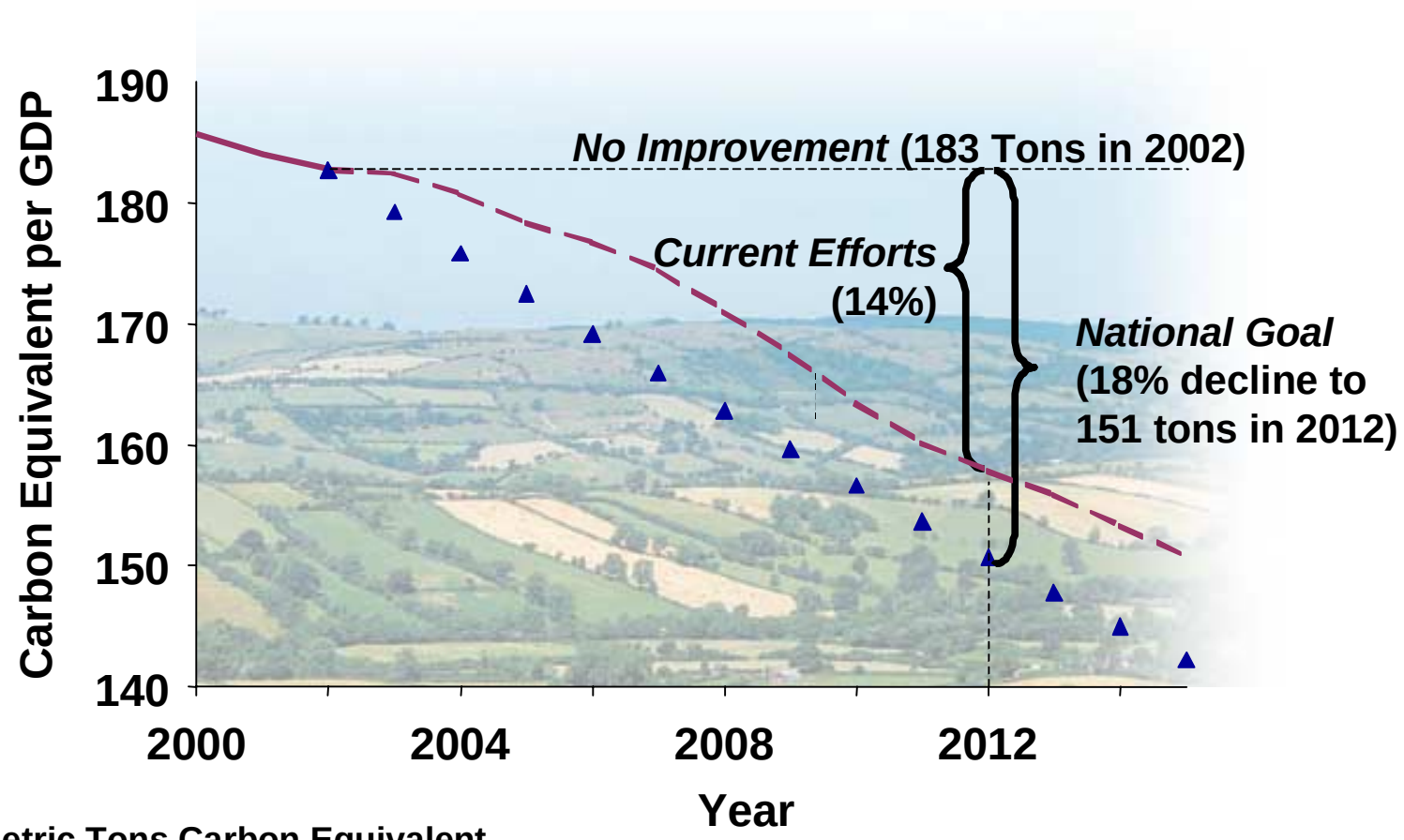
- Capture & Storage
- Enhance Natural Sinks

Reduce Population

Reduce GDP

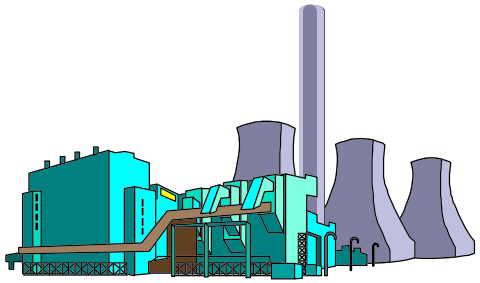


Reduce Greenhouse Gas Emission Intensity by 18% Over Next Decade

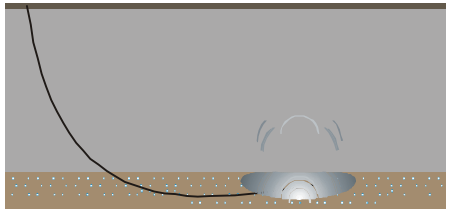


Metric Tons Carbon Equivalent per Million $ GDP, 2001 Dollars

Carbon Sequestration
(Barrier Issues)

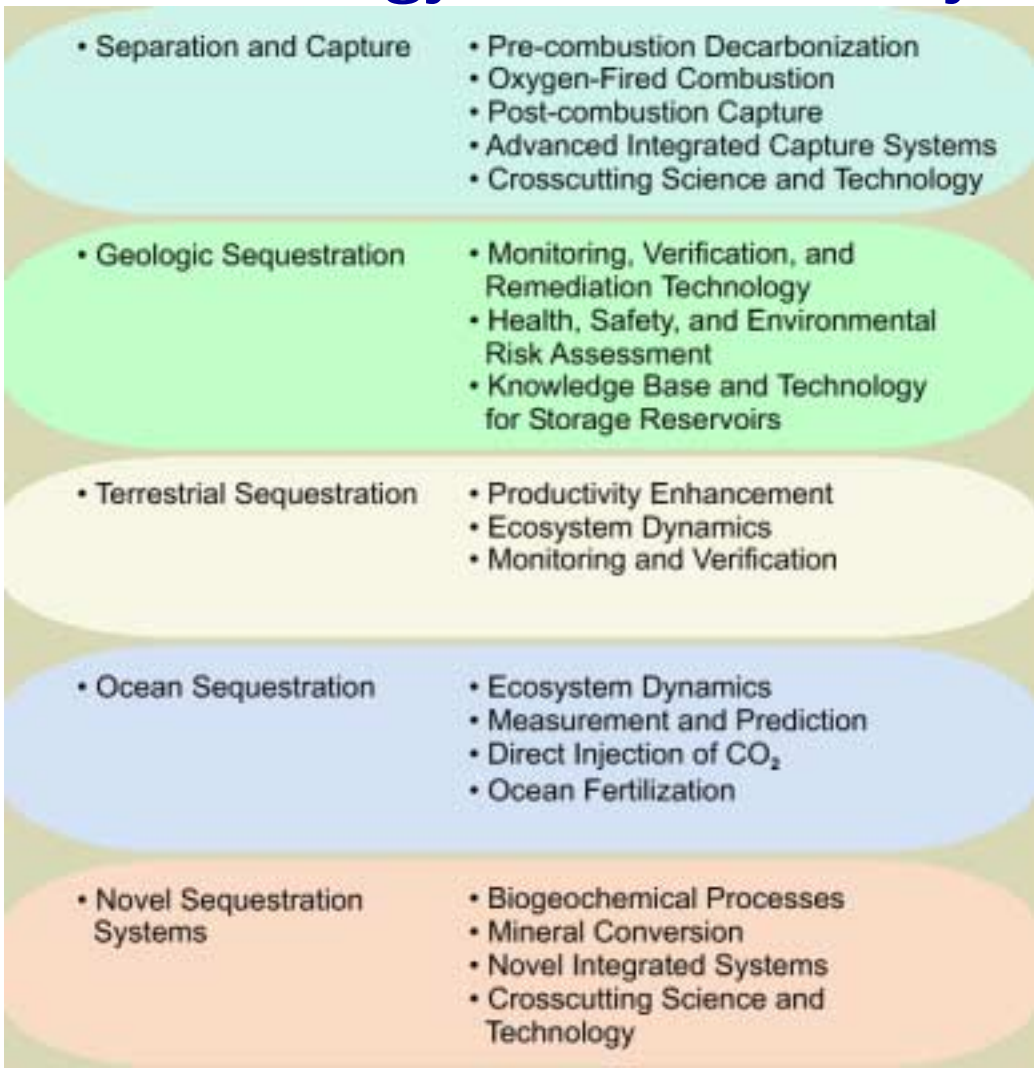


- **Separation and Capture**
  - Large capital cost
  - Large operating cost
  - Large parasitic power load
  - Low plant efficiencies



- **Geologic Sequestration**
  - Identification of amenable storage locations
  - Protocols for monitoring & verification
  - Health, safety and environmental risk assessment
  - Large scale verification
  - Capacity evaluation

Carbon Management Technology R&D Pathways



Obstacles to New Coal Plants
Regulatory-Technology Uncertainty

- **Will new plants need to be designed to control mercury emissions, and if so, to what level? 50% removal? 90% removal?**
- **Will new plants need to be designed to capture and sequestor CO_2, and if so, to what level of removal?**
- **In both cases, commercially-available technology does not exist.**

Obstacles to New Coal Plants
Financing

- **Lenders hear the words "risk" and "uncertainty" when being asked to finance new technology**

Technologist Speak	*Lenders Hear*
State-of-the-art	New
Innovative	Untested/experimental
New	Risky

Obstacles to New Coal Plants

Emerging Energy - Water Issues

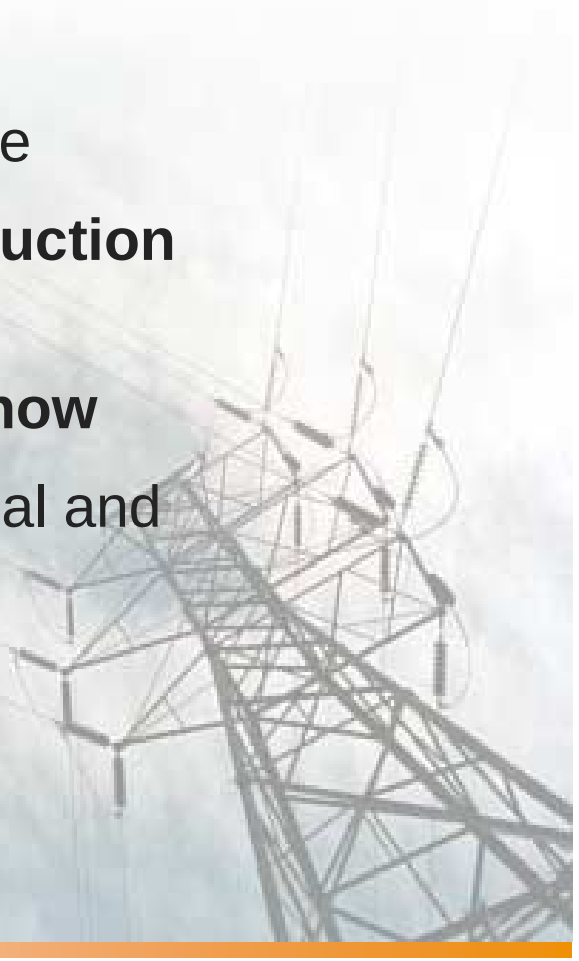
- **Restrictions on use of water in power generation to protect aquatic organisms could drive up cost of electricity**
- **Insufficient supplies of electricity could impact cost and availability of water**
- **Interdependency between water, carbon cycles, and climate change could lead to shifts in water distribution**

Closing Thoughts I

- **Maintaining low-cost-electricity requires flexibility in both fuels and generation technology**
  - Need to continue to use coal to produce electricity
- **Even with aggressive DSM, U.S. electric demand will continue to increase**
- **Need new power plants for demand growth and replacement capacity (including 3-P induced)**
- **Most planned new plants are natural gas**
  - Gas price risk
  - Natural gas most direct substitute for oil in transportation sector

Closing Thoughts II

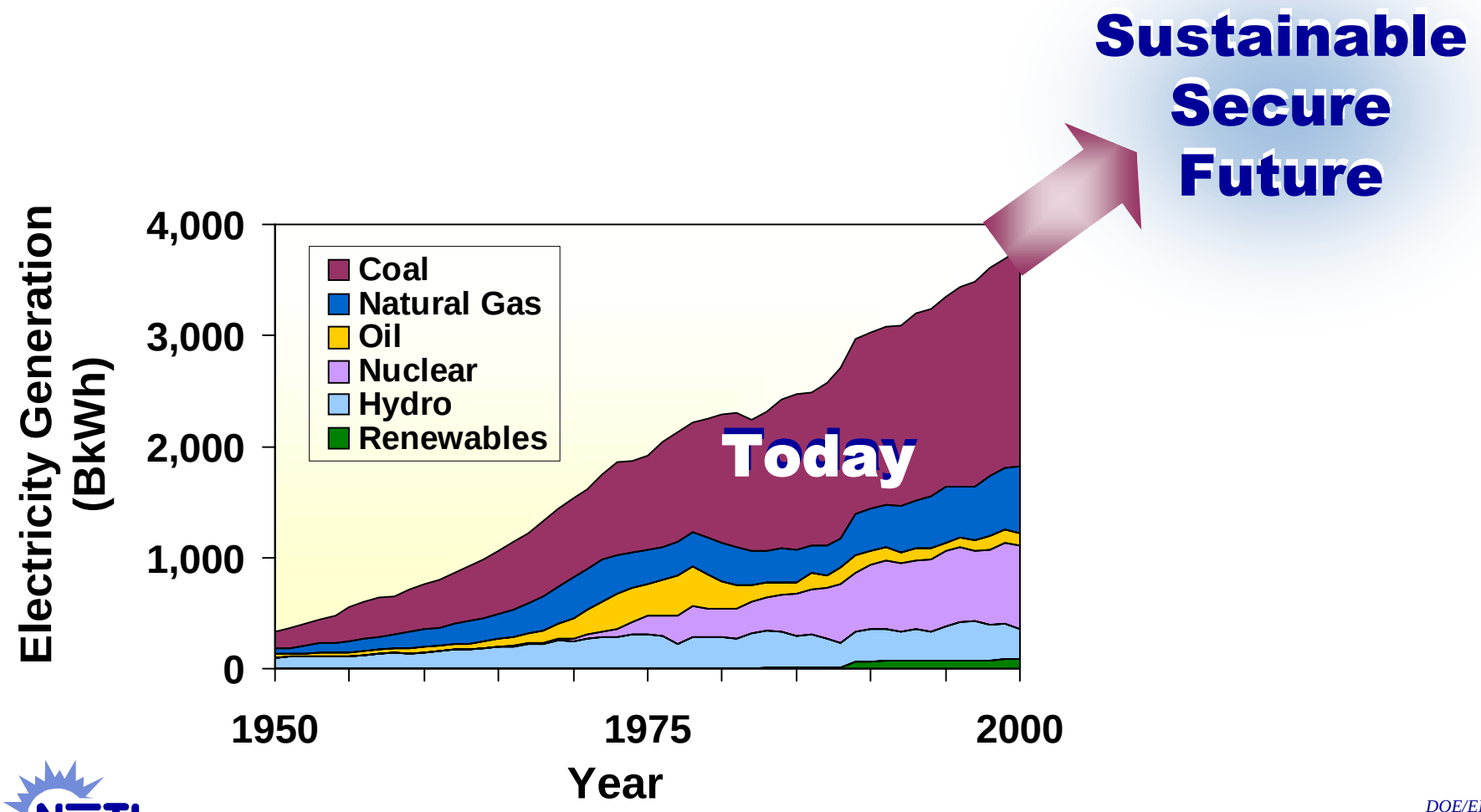
- **Electric industry reluctant to invest in new coal plants until clear path forward on carbon control**
  - Capital assets have 50-100 year lifetime
- **Climate change will require deeper reduction in CO_2 than commonly recognized**
- **Public seems to support some action now**
  - Early incremental action harms both coal and gas industries



Closing Thoughts III

- **Government policy may evolve to provide incentives to transition to high efficiency, low emission modes of power generation**
  - New coal plants – incentives for high-efficiency technologies that can be cost effectively sequestered
  - New gas CC plants – incentives for capability to retrofit with coal gas and sequestration
- **In future, if evidence for climate change becomes definitive and universally accepted, Government could mandate CO_2 caps**
- **Need focused RD&D and incentives program to have low emission options ready for possible future carbon constrained world**

The Challenge:
Defining a Pathway To U.S. Electricity Future



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