

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

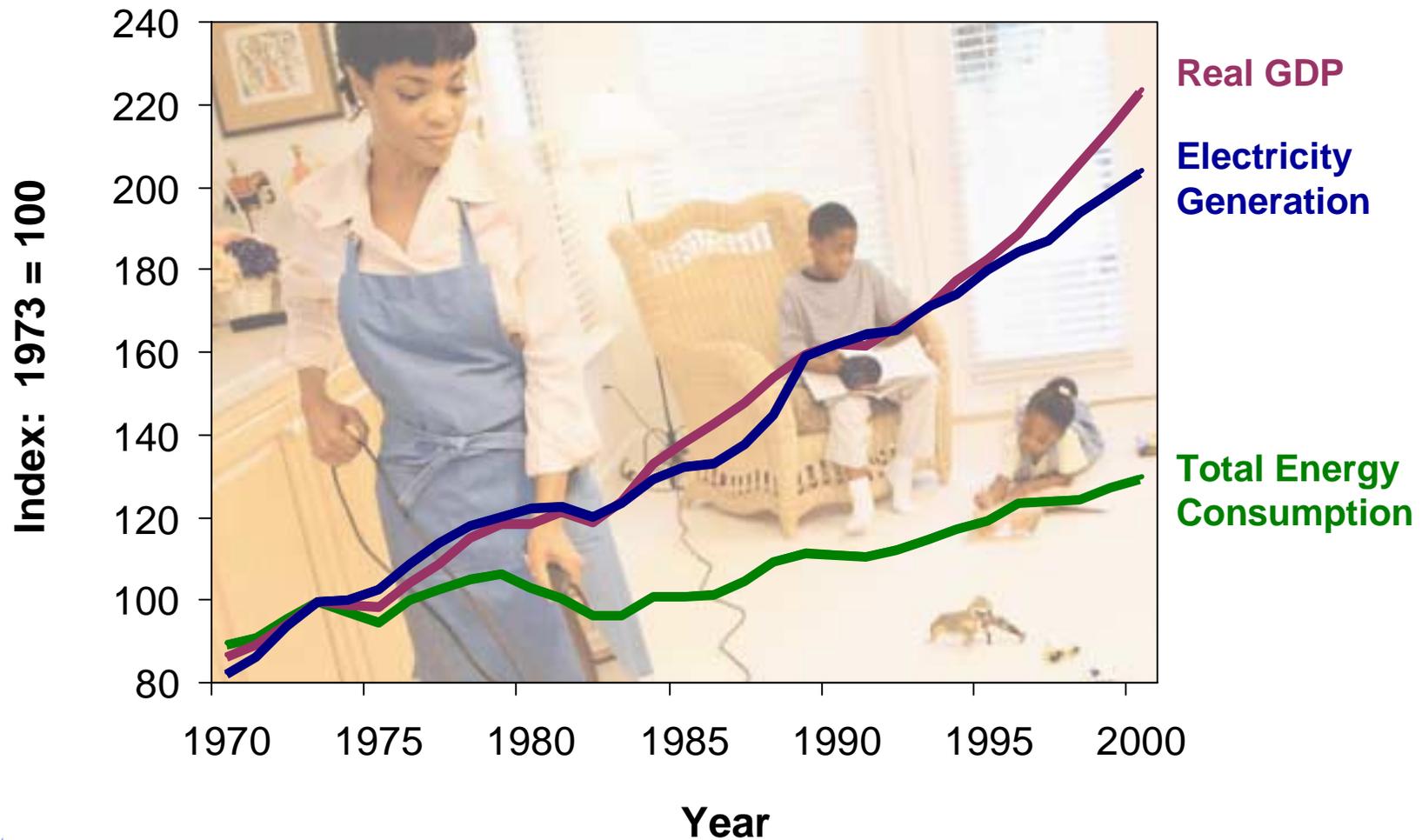
Michael L. Eastman, Product Manager
National Energy Technology Laboratory



www.netl.doe.gov



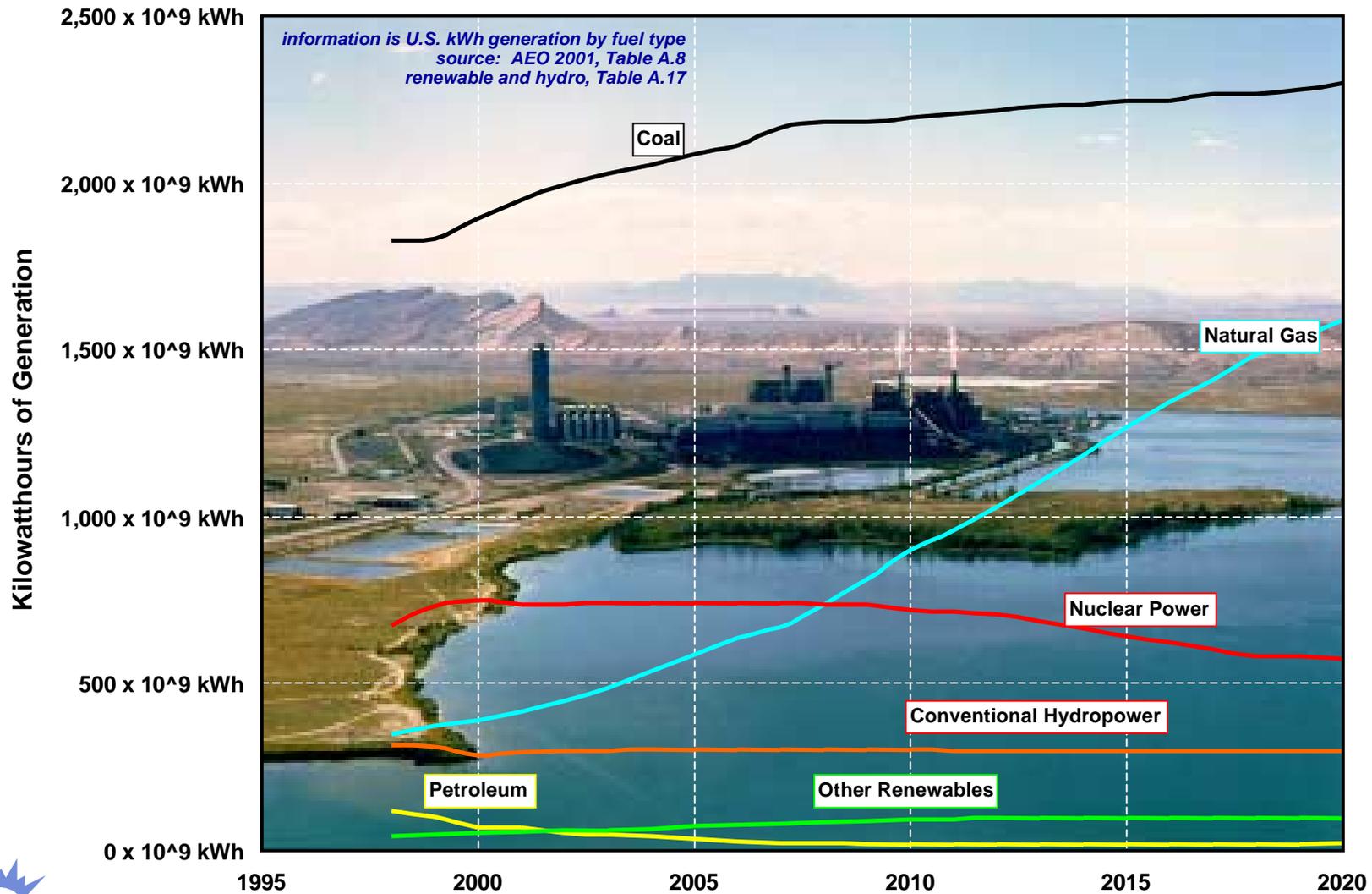
Economic Growth Linked to Electricity



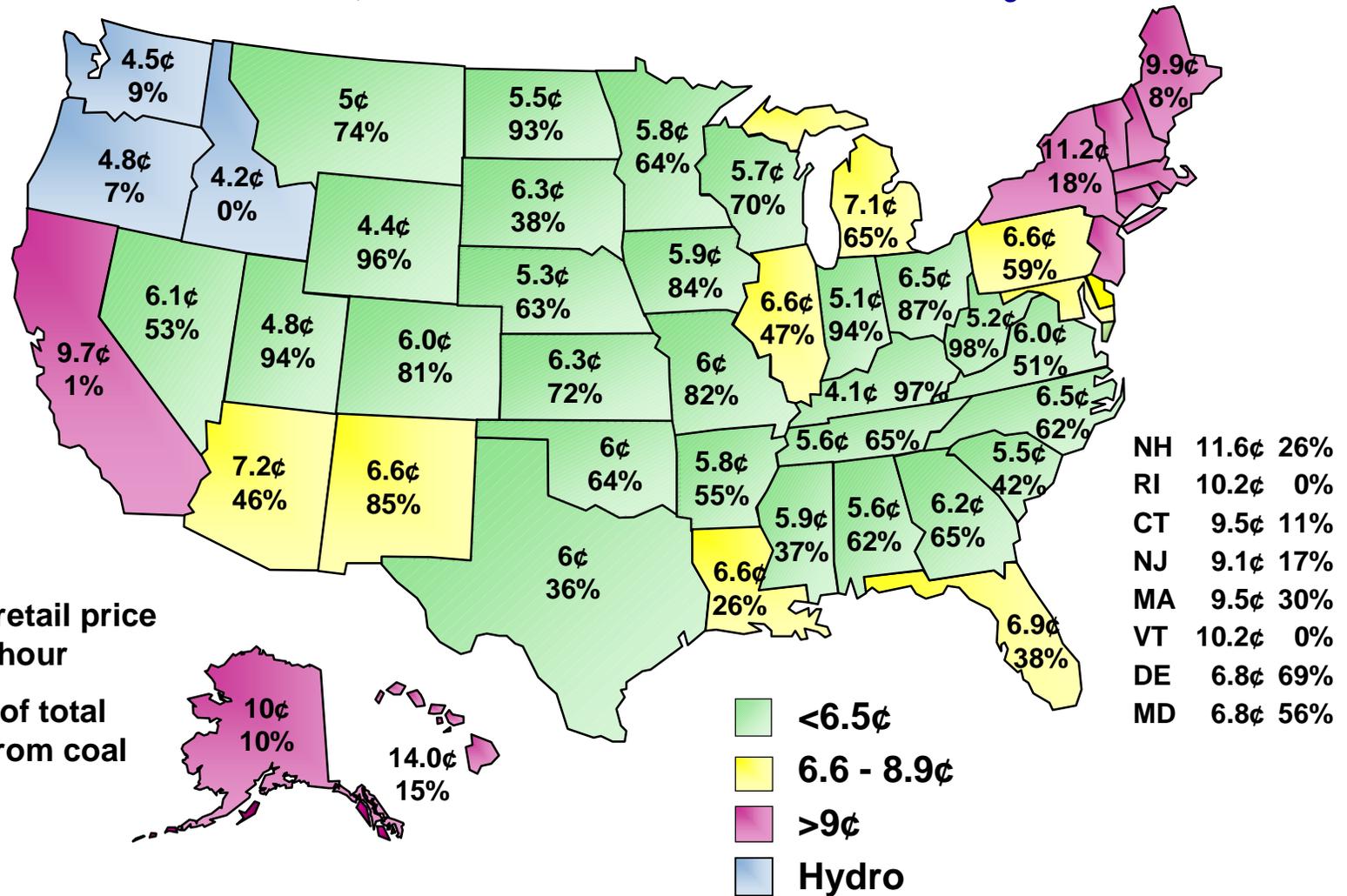
GDP: U.S. DOC, Bureau of Economic Analysis
Energy & Electricity: EIA, AER Interactive Data Query System

CTUAW Ohio 9/12/02

EIA Expectation Electric Generation kWh by Fuel Type



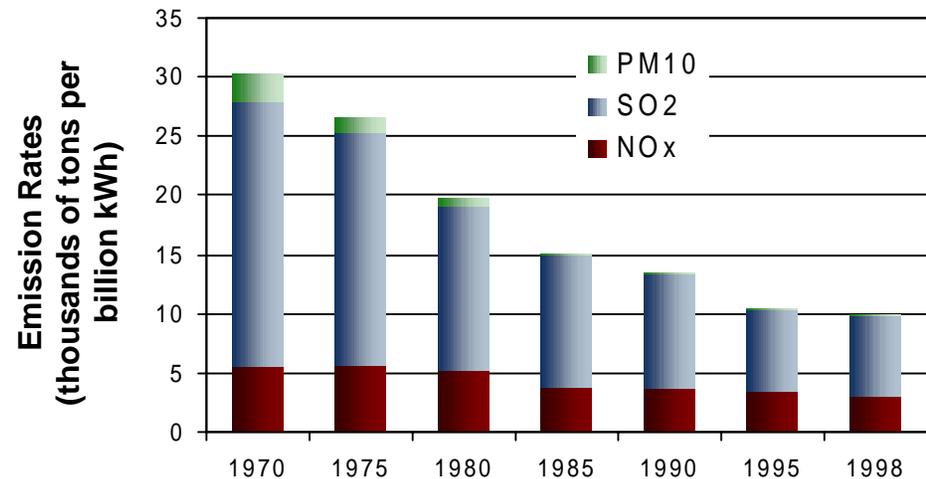
Coal Use Translates to Secure, Reliable, Affordable Electricity



Much Progress in Reducing Emissions Since 1970

- **National emissions down**
 - SO₂ emissions down 70%
 - NO_x emissions down 45%
 - All while coal use doubled

**Individual coal
plant emissions
down**



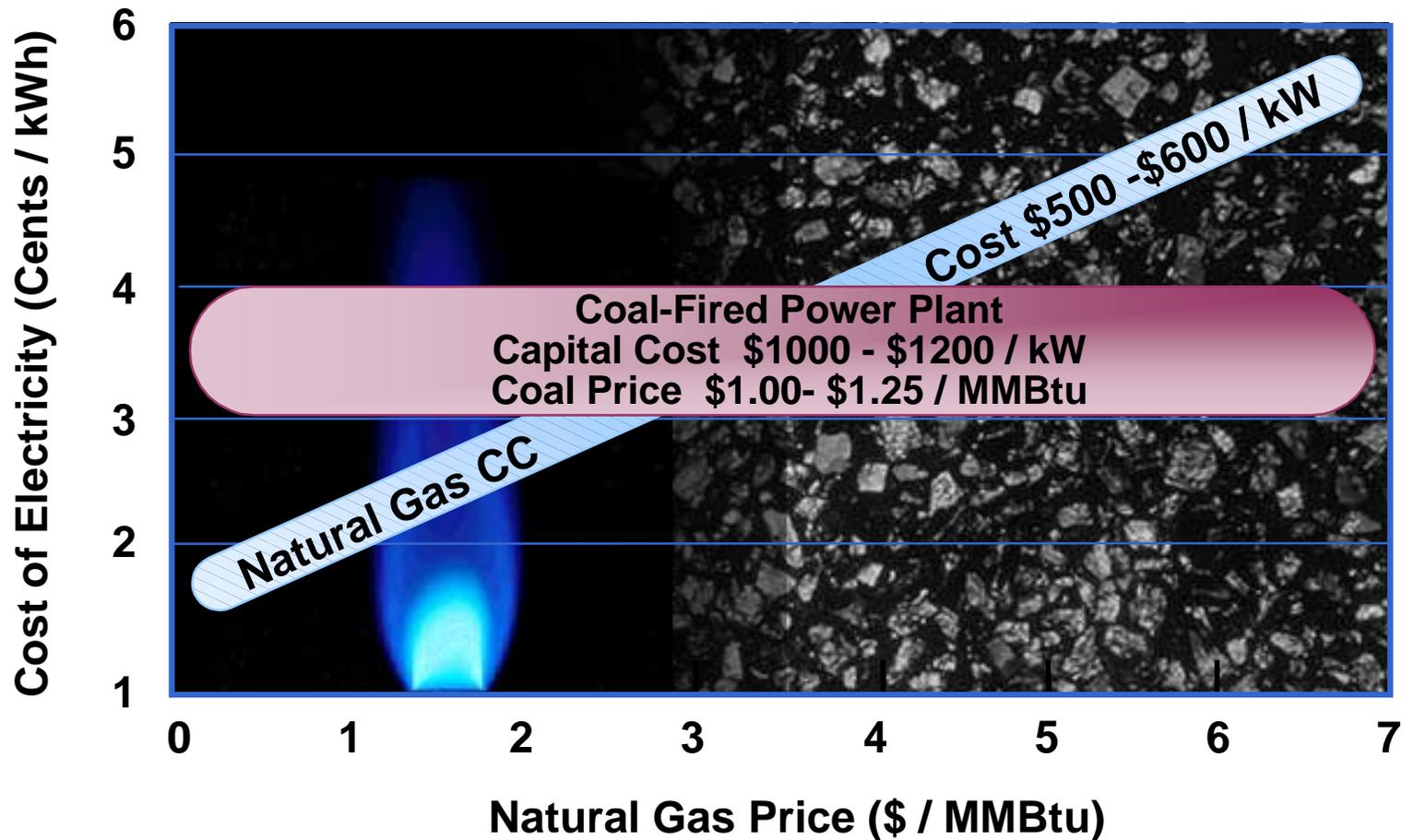
**But Pressure to Improve
Environmental Performance
Continues**



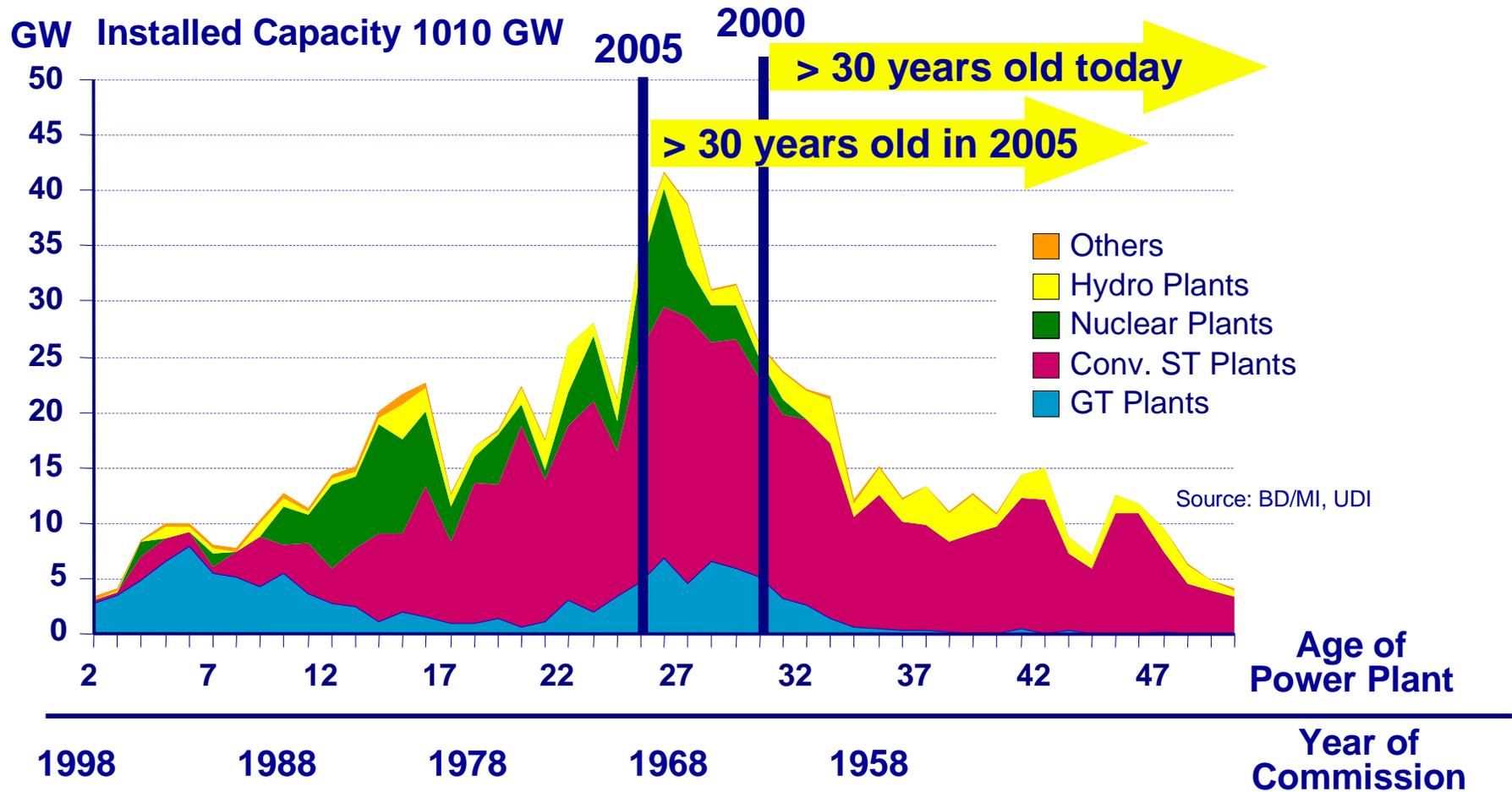
Emissions: *National Air Pollutant Emission Trends, 1990-1998*,
EPA 454/R-00-002, March 2000;
Generation: *EIA Annual Energy Review 1998*

CTUAW Ohio 9/12/02

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)

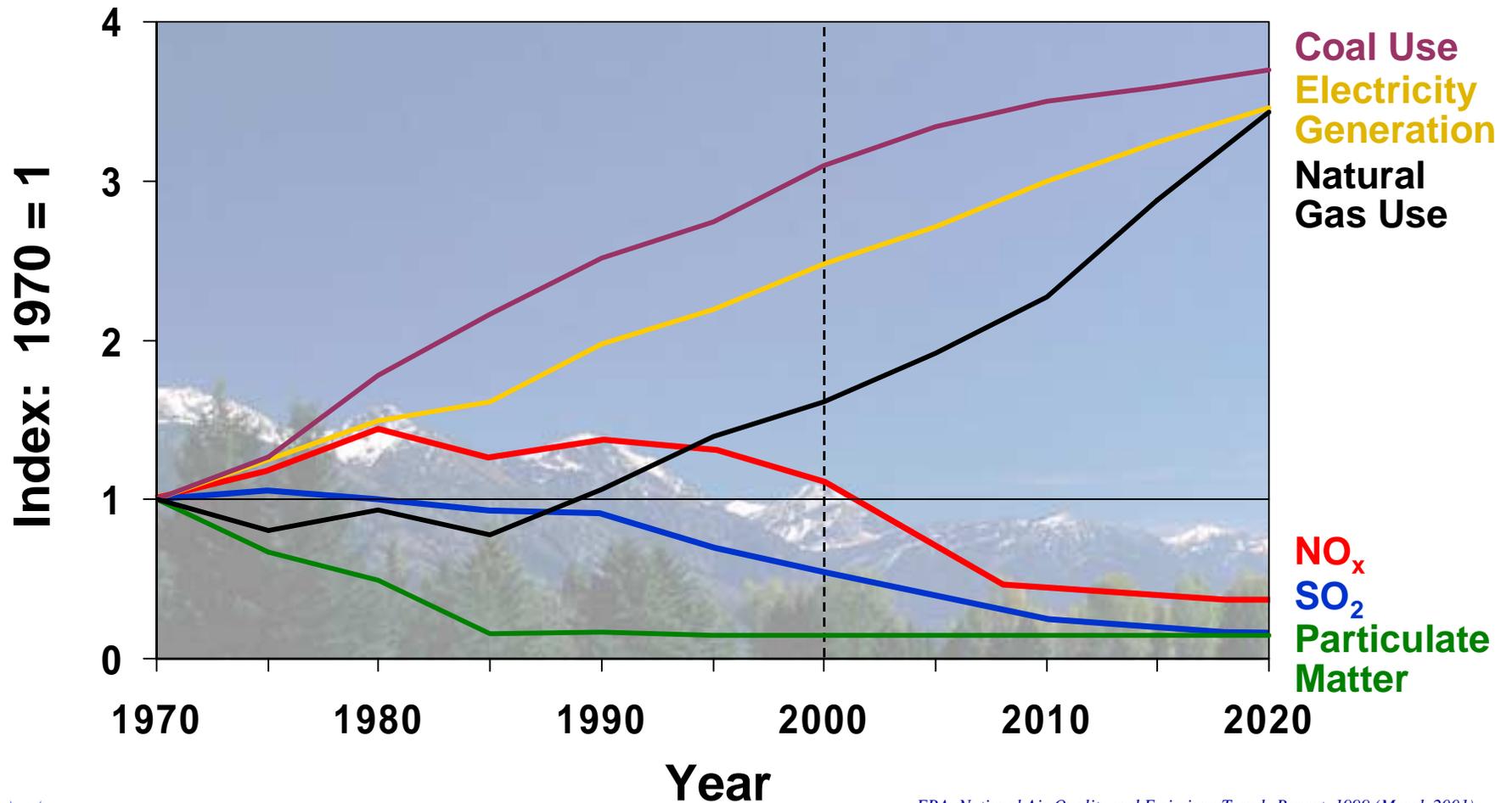


Current Status of Coal Plants

- **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 SO₂: Clear Skies Initiative

CTUAW Ohio 9/12/02

Proposed Emissions Reductions

Electric Power Plants

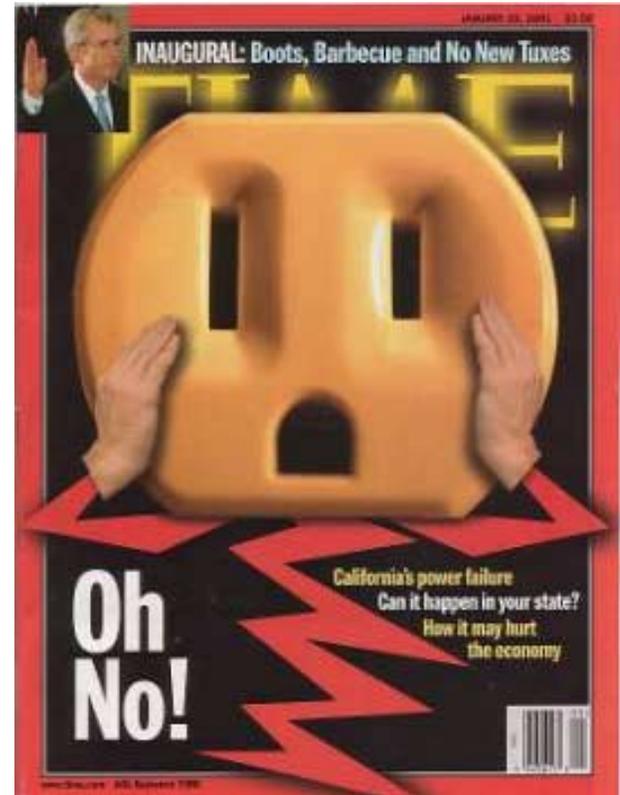
| <i>Emission</i> | <i>Actual 1999</i> | <i>Baseline</i> | Clear Skies | | Jeffords |
|-----------------------|------------------------|------------------|--------------------------|------------------|-------------------|
| | | | <i>2008/2010 Cap</i> | <i>2018 Cap</i> | <i>2007 Cap</i> |
| SO₂ | 12.0 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 |
| CO₂ | 2.19 B tons/yr | ? | None | None | 1.94 B tons/yr |



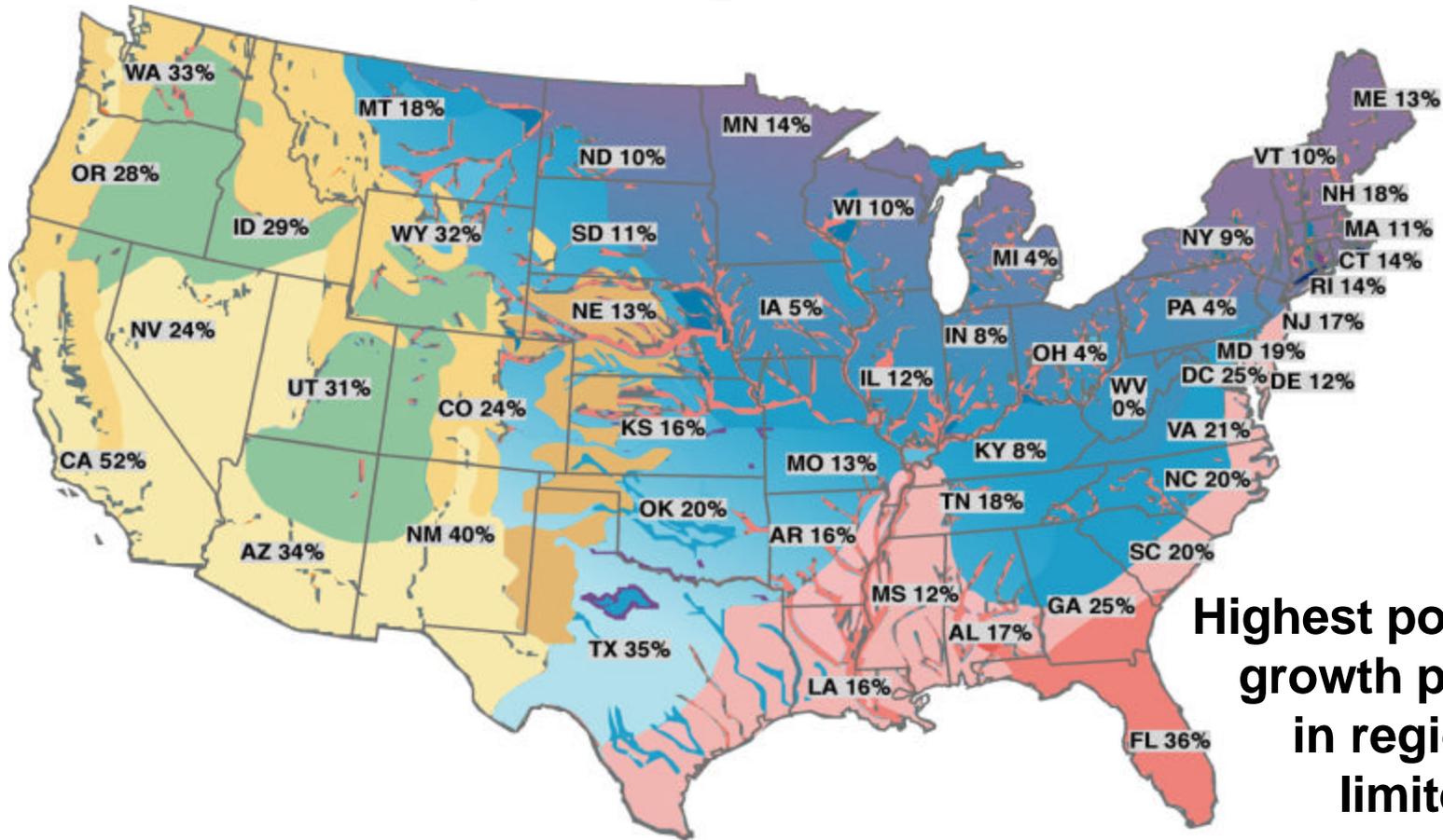
Electric Supply and Reliability

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**



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



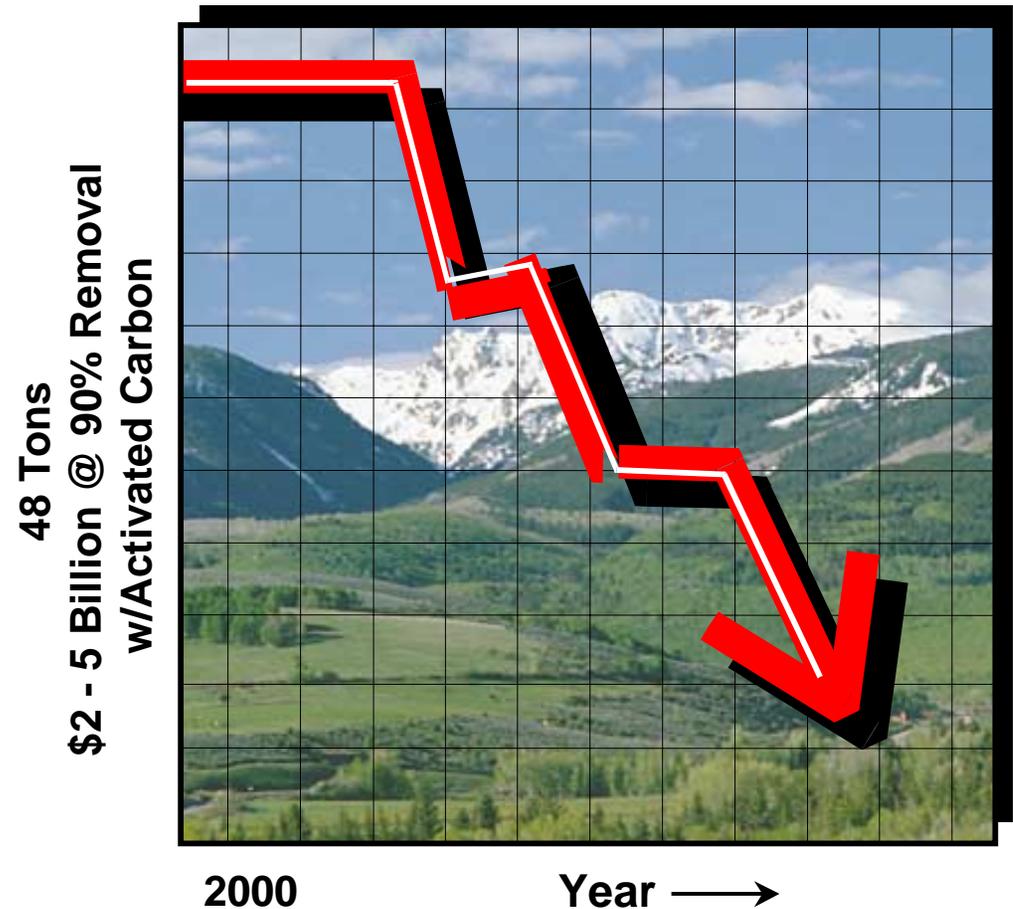
Fossil Energy Technology Development Strategy

- **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



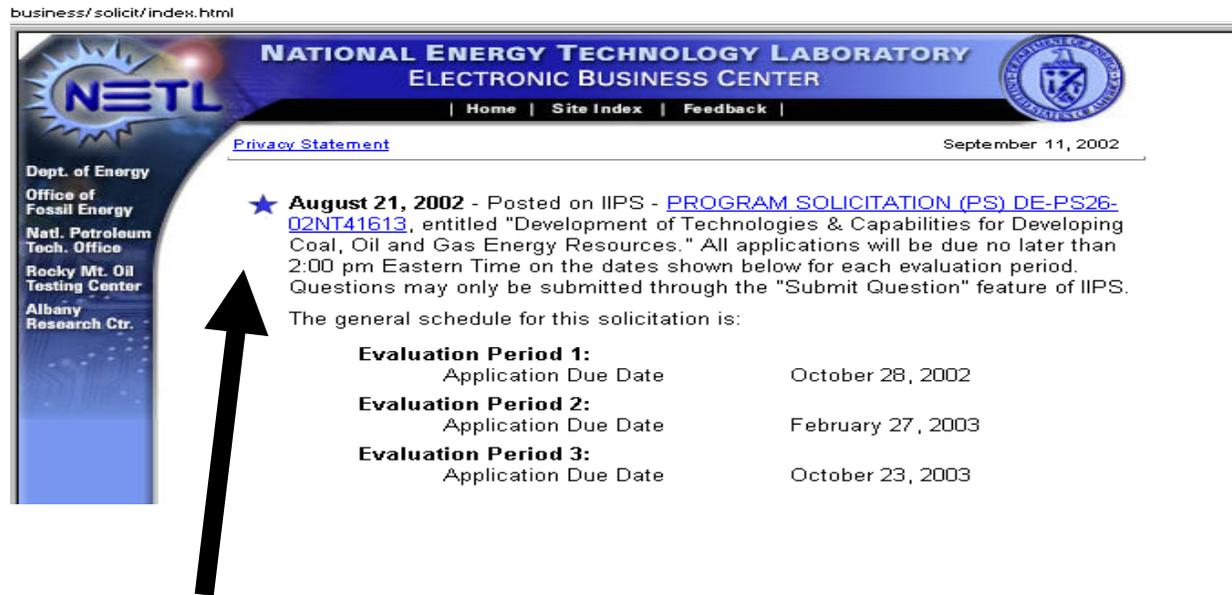
*Advanced Materials Consortium
Ultra-Supercritical Power Plants
CURC / EPRI / ORNL / NETL*



Coal R&D Opportunities

Solicitation is Open

business/solicit/index.html



The screenshot shows the top of the NETL website. The header includes the NETL logo, the text "NATIONAL ENERGY TECHNOLOGY LABORATORY ELECTRONIC BUSINESS CENTER", and navigation links for "Home", "Site Index", and "Feedback". A "Privacy Statement" link is also visible. The date "September 11, 2002" is shown in the top right. On the left, a sidebar lists various offices: "Dept. of Energy", "Office of Fossil Energy", "Nat. Petroleum Tech. Office", "Rocky Mt. Oil Testing Center", and "Albany Research Ctr.". The main content area features a star icon next to the announcement: "★ August 21, 2002 - Posted on IIPS - PROGRAM SOLICITATION (PS) DE-PS26-02NT41613, entitled 'Development of Technologies & Capabilities for Developing Coal, Oil and Gas Energy Resources.'" It states that applications are due no later than 2:00 pm Eastern Time on the dates shown below for each evaluation period. Questions may only be submitted through the "Submit Question" feature of IIPS. Below this, the general schedule for the solicitation is provided in a table format.

★ August 21, 2002 - Posted on IIPS - [PROGRAM SOLICITATION \(PS\) DE-PS26-02NT41613](#), entitled "Development of Technologies & Capabilities for Developing Coal, Oil and Gas Energy Resources." All applications will be due no later than 2:00 pm Eastern Time on the dates shown below for each evaluation period. Questions may only be submitted through the "Submit Question" feature of IIPS.

The general schedule for this solicitation is:

| | |
|-----------------------------|-------------------|
| Evaluation Period 1: | |
| Application Due Date | October 28, 2002 |
| Evaluation Period 2: | |
| Application Due Date | February 27, 2003 |
| Evaluation Period 3: | |
| Application Due Date | October 23, 2003 |

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
- O₂, H₂, CO₂ 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**

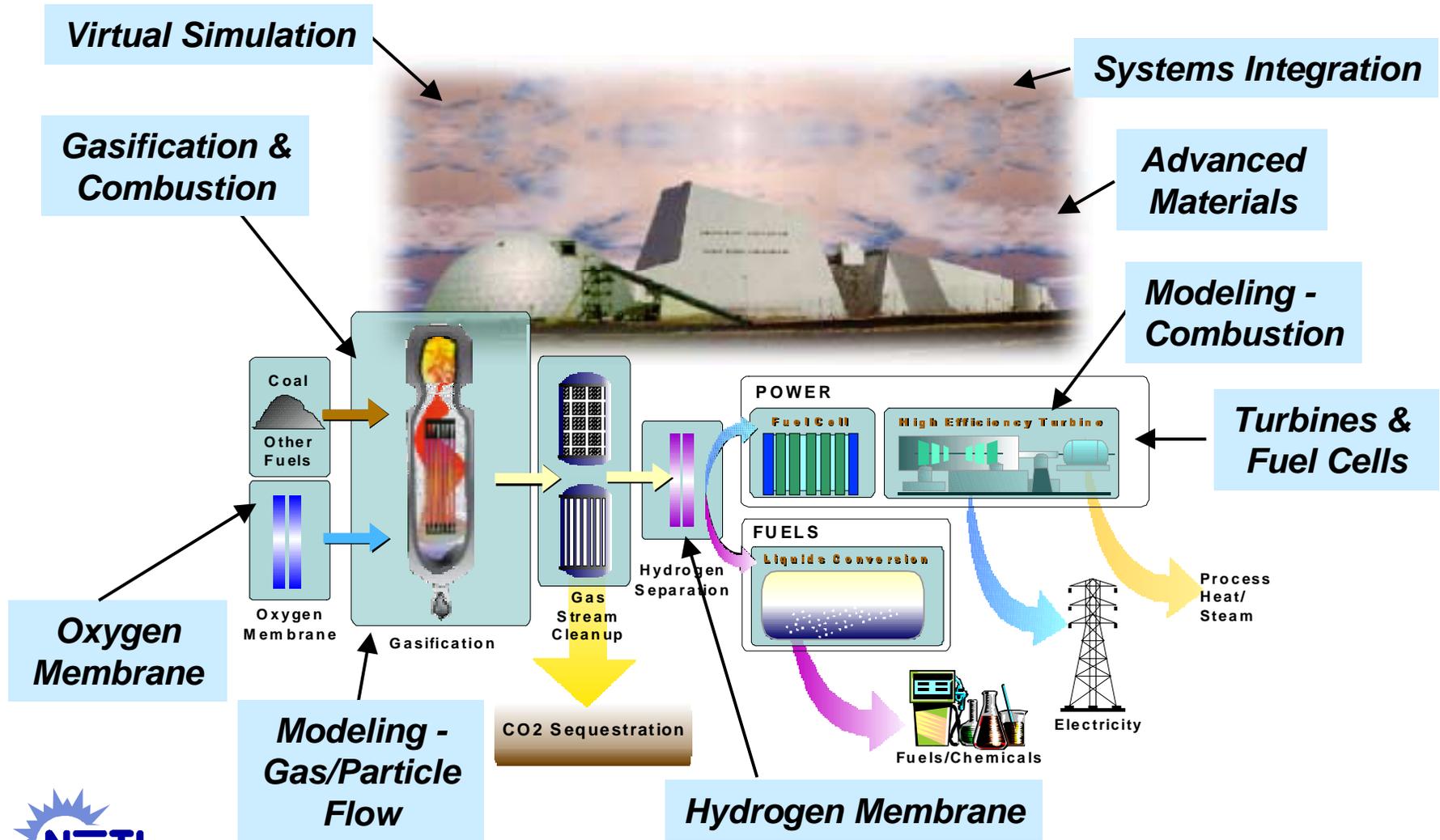


- Approach*
- **Maximize efficiency**
 - **Near-zero emissions**



Vision 21 Program

New Projects Contribute to Ultra-Clean Energy Plant



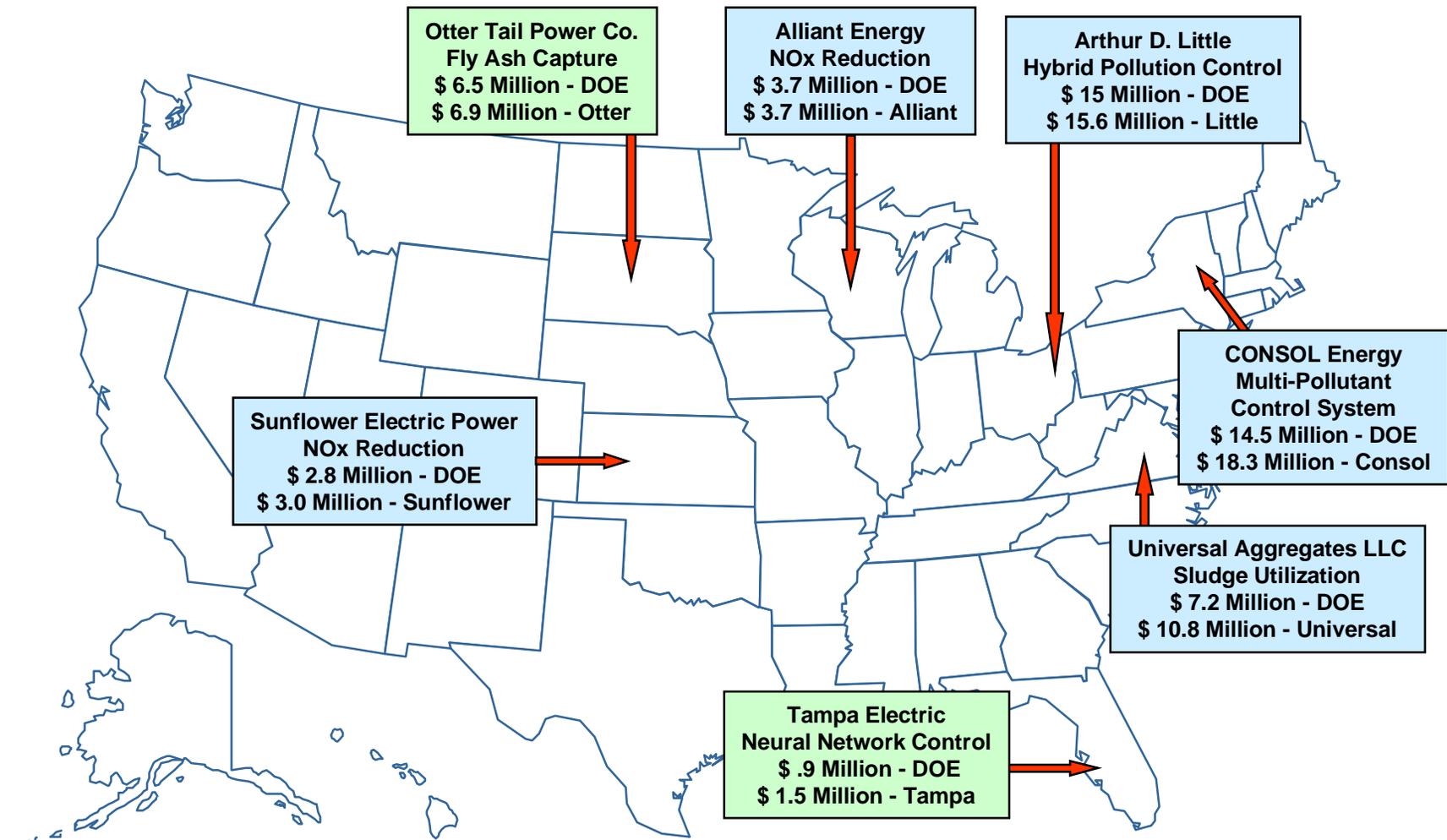
Power Plant Improvement Initiative (PPII)

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)



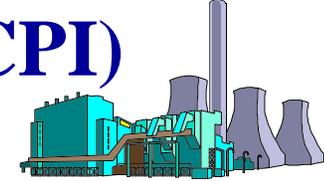
Power Plant Improvement Initiative (PPII)



 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

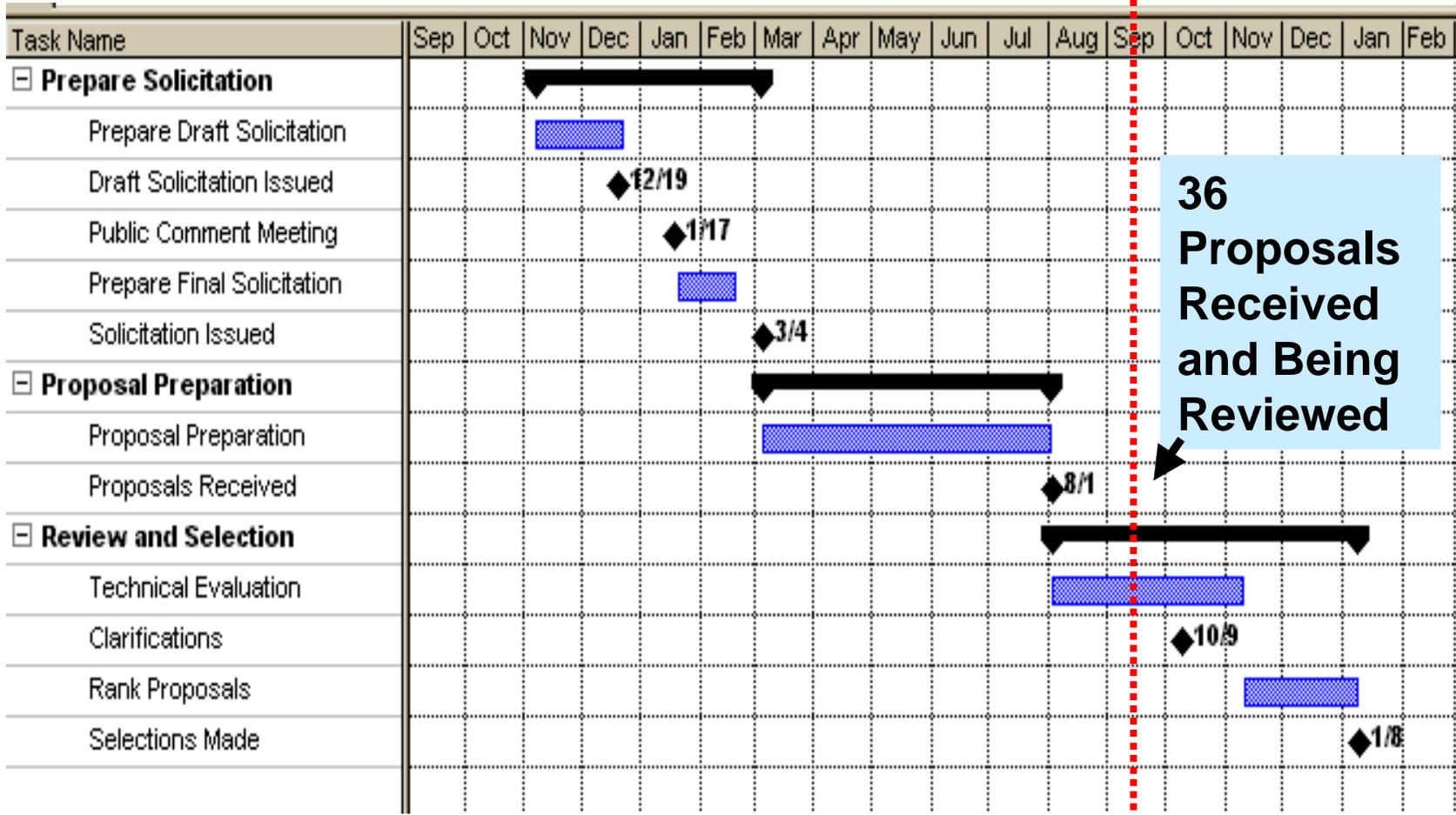
- **Technology Demonstration Opportunities**

- 3P control systems (SO₂, NO_x 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



**36
Proposals
Received
and Being
Reviewed**



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**



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

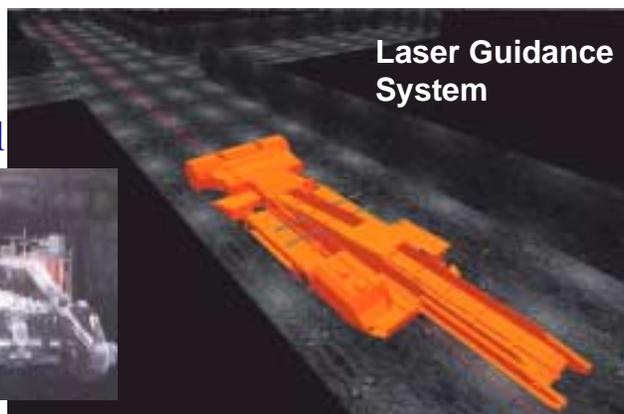
Mission

- 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

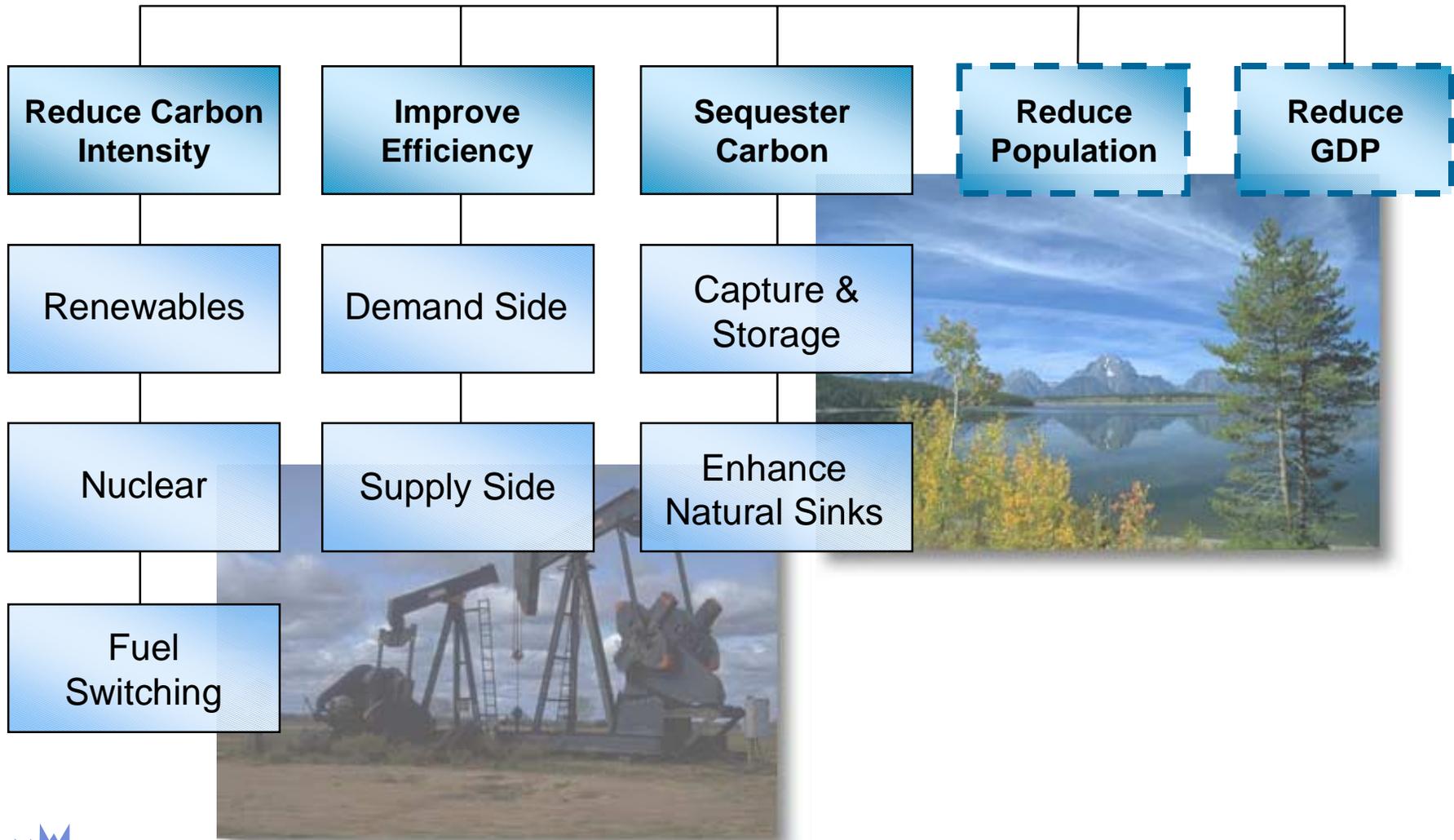
Program Activity

- 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

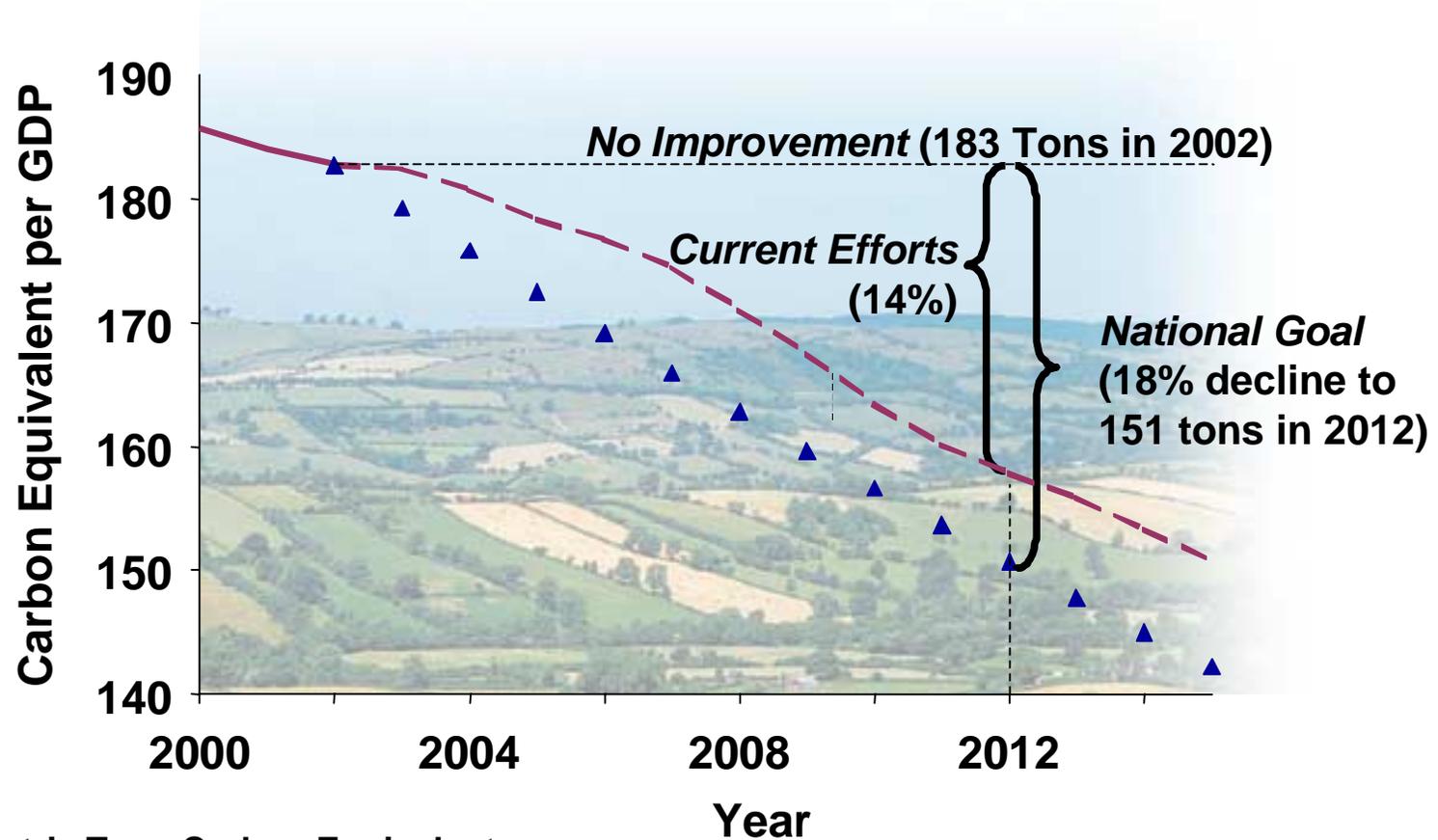
INEEL/CMU/Consol



CO₂ Mitigation Options



Reduce Greenhouse Gas Emission Intensity by 18% Over Next Decade



Metric Tons Carbon Equivalent per Million \$ GDP, 2001 Dollars

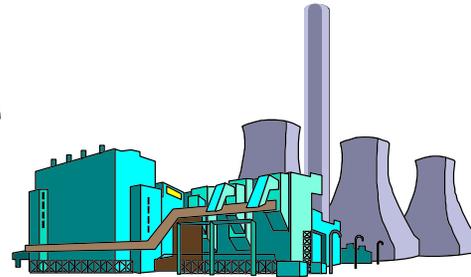


Carbon Sequestration

(Barrier Issues)

- **Separation and Capture**

- Large capital cost
- Large operating cost
- Large parasitic power load
- Low plant efficiencies

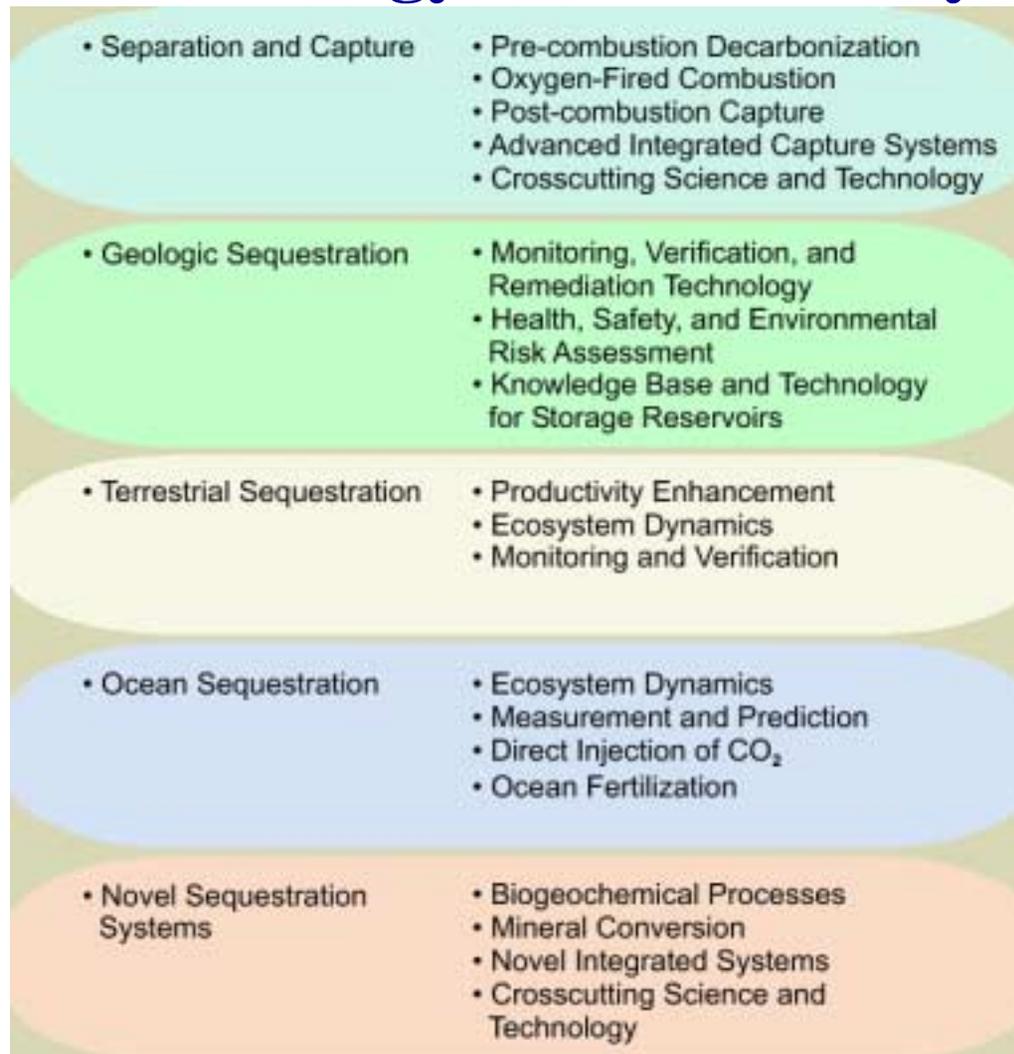


- **Geologic Sequestration**

- 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 sequester CO₂, 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

| <i>Technologist Speak</i> | <i>Lenders Hear</i> |
|-------------------------------|-------------------------|
| 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 CO₂ than commonly recognized**
- **Public seems to support some action now**
 - Early incremental action harms both coal and gas industries

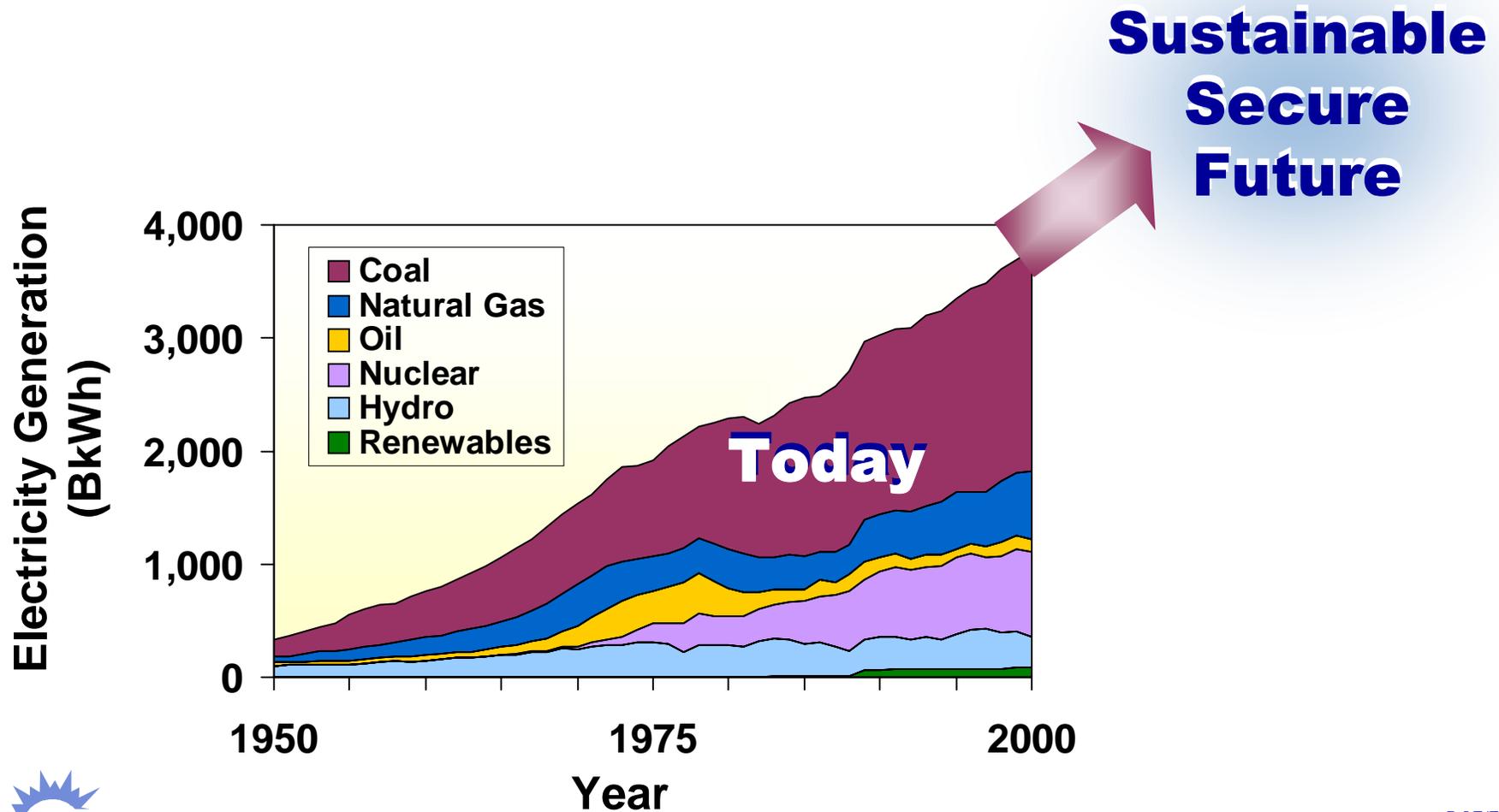


Closing Thoughts III

- **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 CO₂ 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



Visit Our NETL and...
www.netl.doe.gov

OCES/CCPI Websites
www.netl.doe.gov/coalpower/ccpi

NATIONAL ENERGY TECHNOLOGY LABORATORY
United States Department of Energy

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September 11, 2002

Industry Steps Up to Join President's Clean Coal Initiative
In the opening round of competition for federal co-funding in President Bush's clean coal initiative, technology developers and power companies have proposed more than \$5 billion of innovative projects. Energy Secretary Spencer Abraham calls the response "the most striking example yet of industry's willingness to invest in a new generation of clean coal technologies." [Read More](#)

BUSINESS SECTORS
Strategic Center for Natural Gas
Coal and Em. Systems
Climate Change Policy Support
National Petroleum Technology Office
Env. Technologies & Business Excellence

BUSINESS SECTORS

- Strategic Center for Natural Gas
- Electric Power Using Coal**
- Climate Change Policy Support
- Fuels
- Oil Supply
- Enviro. Mgt. & Defense Programs

NATIONAL ENERGY TECHNOLOGY LABORATORY
Clean Coal Power Initiative (CCPI)

Clean Coal Power Initiative Round 1
Project Proposal Summaries

| Proposer | Technology |
|--------------------------------|---------------------------------------|
| AAA Gas, Jackson, L.L.C. | Multi Fuel/Coal Lignite 2000 |
| AMCO | Adv. Combustion 2000 |
| American LLC | Multi Fuel/Coal Lignite 2000 |
| Clean Energy Systems | Gasification and Adv. Combustion 2000 |
| Colorado Springs Utilities | Adv. Combustion 2000 |
| Continental Resources Co. | Gasification 2000 |
| E.ON Energy Corp. | Multi Fuel/Coal Lignite 2000 |
| McKesson Technology, Inc. | Multi Fuel/Coal Lignite 2000 |
| ProCo, Inc. | Steam and Gasification 2000 |
| Wabco Fuel Assets, Corp. | Coal Upgrading 2000 |
| Yonkers Energy at Home, LLC | Gasification 2000 |
| A.V. Inc. Corp. | Coal Upgrading 2000 |
| Wabco Technology | Gasification/Coal Gas 2000 |
| Therco, Memphis, TN | Combustion Gasification 2000 |
| Johnson, Ron Power, LLC | Multi Fuel/Coal Lignite 2000 |
| Minnesota Energy Coal, Inc. | Coal Upgrading 2000 |
| Western Commercial Services | Gasification 2000 |
| Ohio Research Corp. | Steam and Gasification 2000 |
| MTI Group, Inc. | Multi Fuel/Coal Lignite 2000 |
| Lynco Energy, Inc. | Multi Fuel/Coal Lignite 2000 |
| Advanced Applications, LLC | Combustion By-products 2000 |
| Ohio Oil Refining/Adv. Lignite | Multi Fuel/Coal Lignite 2000 |
| Western Commercial Services | Adv. Combustion 2000 |
| Wabco Inc. Energy Co. | Multi Fuel/Coal Lignite 2000 |
| WMT, P.T.Y., LLC | Water Coal Conversion to Lignite 2000 |
| Living Energy, Inc. | Adv. Combustion 2000 |

The opening round of the Department of Energy's Clean Coal Power Initiative (CCPI) Solicitation... Roughly half of the projects proposed demonstrate advanced methods for reducing sulfur, nitrogen and mercury pollutants, either by cleaning the exhaust gases of coal burners or by gasifying the coal into a clean-burning gas. Other technologies being proposed include co-production concepts where the plant would produce electricity and clean liquid fuels or other useful products from coal, coal upgrading technologies that serve to improve the quality of the coal being fed to power plants thereby improving their environmental performance, approaches to use coal at sites by-products more productively and safely, improved instrumentation and control systems that offer to optimize the performance of existing and advanced energy systems. President Bush has pledged to invest \$2 billion over the next 50 years in new efforts to demonstrate advanced clean coal technologies. The Department of Energy plans to award approximately \$330 million in federal matching funds for this first round of proposals. Power sector proposals must agree to fund at least half the cost of any project selected by the department. The Department is reviewing these proposals now and plans to announce the selections in January 2003.

