

The Chemistry of Coal and Its Environmental Challenges



The Value of Coal

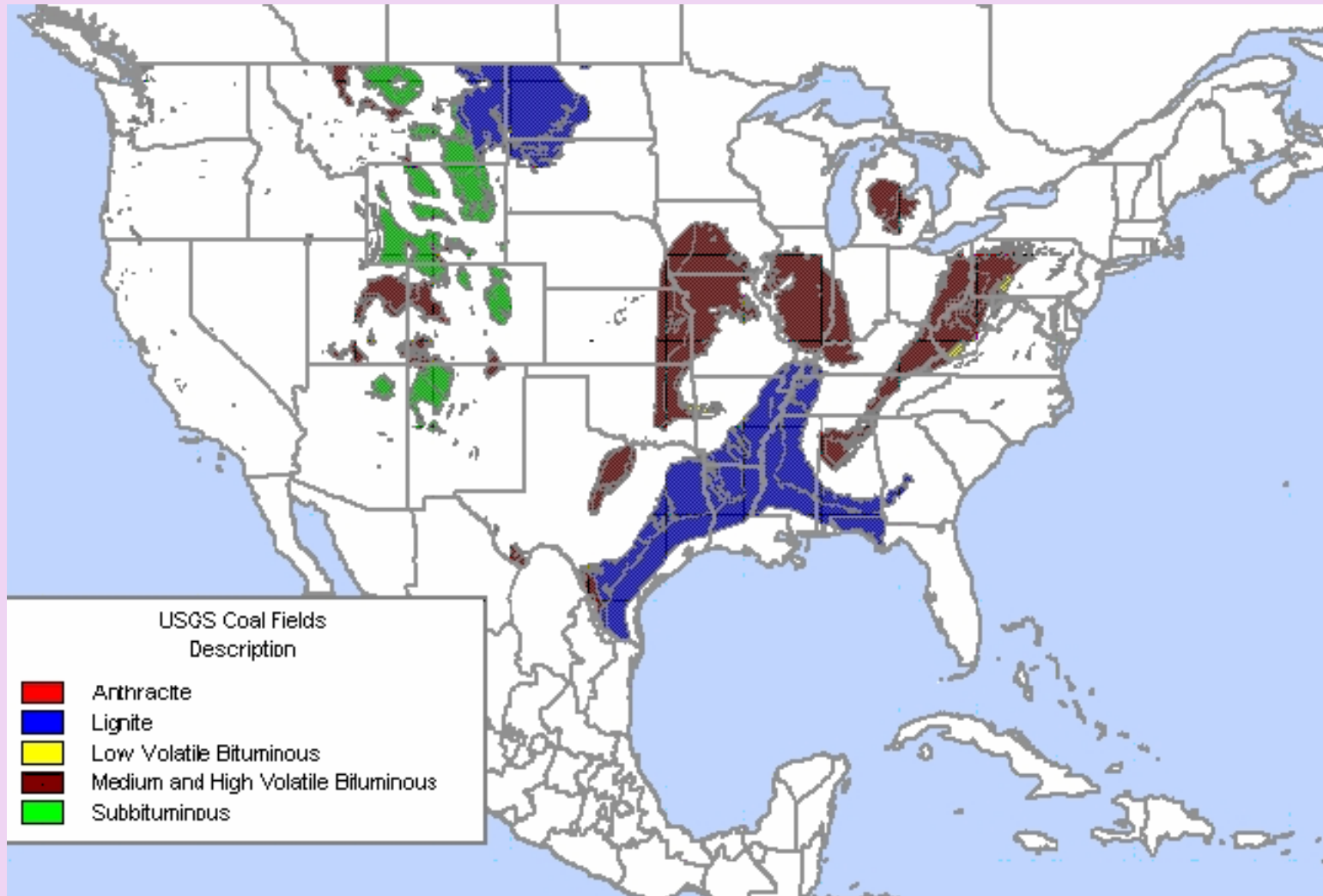
- The energy value of coal, or the fuel content, is the amount of potential energy in coal that can be converted into actual heating ability.
- The energy value can be calculated and compared with different grades of coal or with other energy sources (i.e. biomass).
- Coals of different grades will produce differing amounts of heat for a given mass.

What Is Coal Made of?

- Coal consists primarily of carbon, but this is usually mixed with various other elements, including water and mineral matter such as sand and clay.
- The amounts of these other elements affects the usefulness of the coal as a fuel. The quality of coal can be determined by its rank and grade.
- Energy content of coal is ranked in an ascending order of carbon content (from low to high):

Lignite → Subbituminous → Bituminous → Anthracite

Distribution of U.S. Coal Types



Source: Energy Velocity database

How Are Emissions Formed?

- **NO_x**
 - Oxides of Nitrogen (NO_x) are formed during the combustion process from nitrogen in the air and in the coal.
- **SO₂**
 - Mainly sulfur dioxide, produced from the combustion of sulfur present in many coals.
- **PM**
 - Particulate Matter emissions are produced as a result of the ash that remains in the flue gas after the coal is combusted or gasified.
- **Hg**
 - Mercury (Hg) is a trace element found in coal that is released during combustion
- **CO₂**
 - Carbon dioxide is formed when carbon, the dominant element in coal and all fossil fuels, is oxidized and combusted.

Technology Has Successfully Addressed Coal's Environmental Challenges and Launched a New Generation of Power Systems

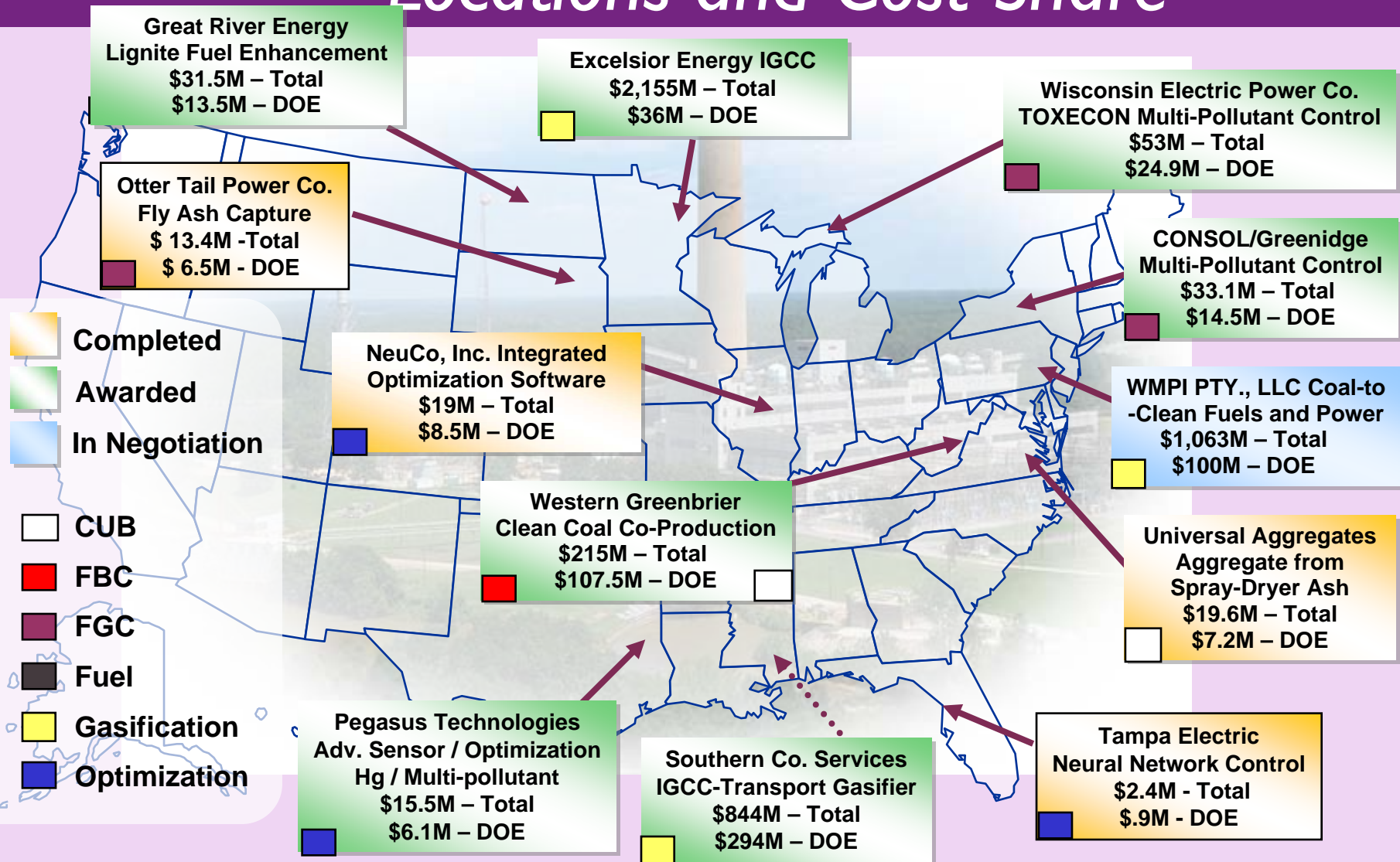
- The DOE clean coal technology demonstration (CCTDP) program is a cost-shared collaboration between the public and private sectors to develop advanced coal technologies to address national goals
- Program Successes:
 - 75% of existing coal-fired generating units retrofitted with low NO_x burners developed in CCTDP program
 - Suite of lower cost and higher performance emissions control systems:
 - FGD's for SO₂, SCR for NO_x, ACI for mercury
 - EPA projects about 1/2 of U.S. power generation will have scrubbers and SCRs by 2010, 2/3 by 2020. The rest will generally burn low sulfur coal and use low NO_x burners.
 - Two of the world's four coal-based IGCC power plants in operation
 - Since the CCTDP demonstrations, 29 units greater than 100 MW have been sold representing over 6,000 MW of capacity.

DOE Clean Coal Technology Demonstration Programs

- **Clean Coal Technology Demonstration Program (CCTDP)**
 - Program established in 1984 to address acid rain issues and enhance environmental and economic performance from coal fired power plants
 - Several emissions control systems and new advanced technologies demonstrated and deployed as a result of this program
 - Current IGCC systems in operation today a result of the CCTDP
- **Power Plant Improvement Initiative (PPII)**
 - Lapse between the last CCT program solicitation in 1992 and a new solicitation through the PPII program in 2000
 - Clinton Administration DOE Clean Coal Demonstration Program (2000)
 - One solicitation issued; four projects currently underway with a focus on more effective and lower cost emission controls, improving the by-product utilization, performance and reliability of power plants.
- **Clean Coal Power Initiative (CCPI)**
 - Bush Administration Clean Coal Technology Demonstration program at DOE
 - Two solicitations issued; third solicitation may be issued in the Fall of 2007
 - Several projects currently underway with a focus on mercury controls, advanced power generation (IGCC and Advanced PC)

Demonstration Projects

Locations and Cost Share



Benefits from CCTDP Investments In NO_x Controls

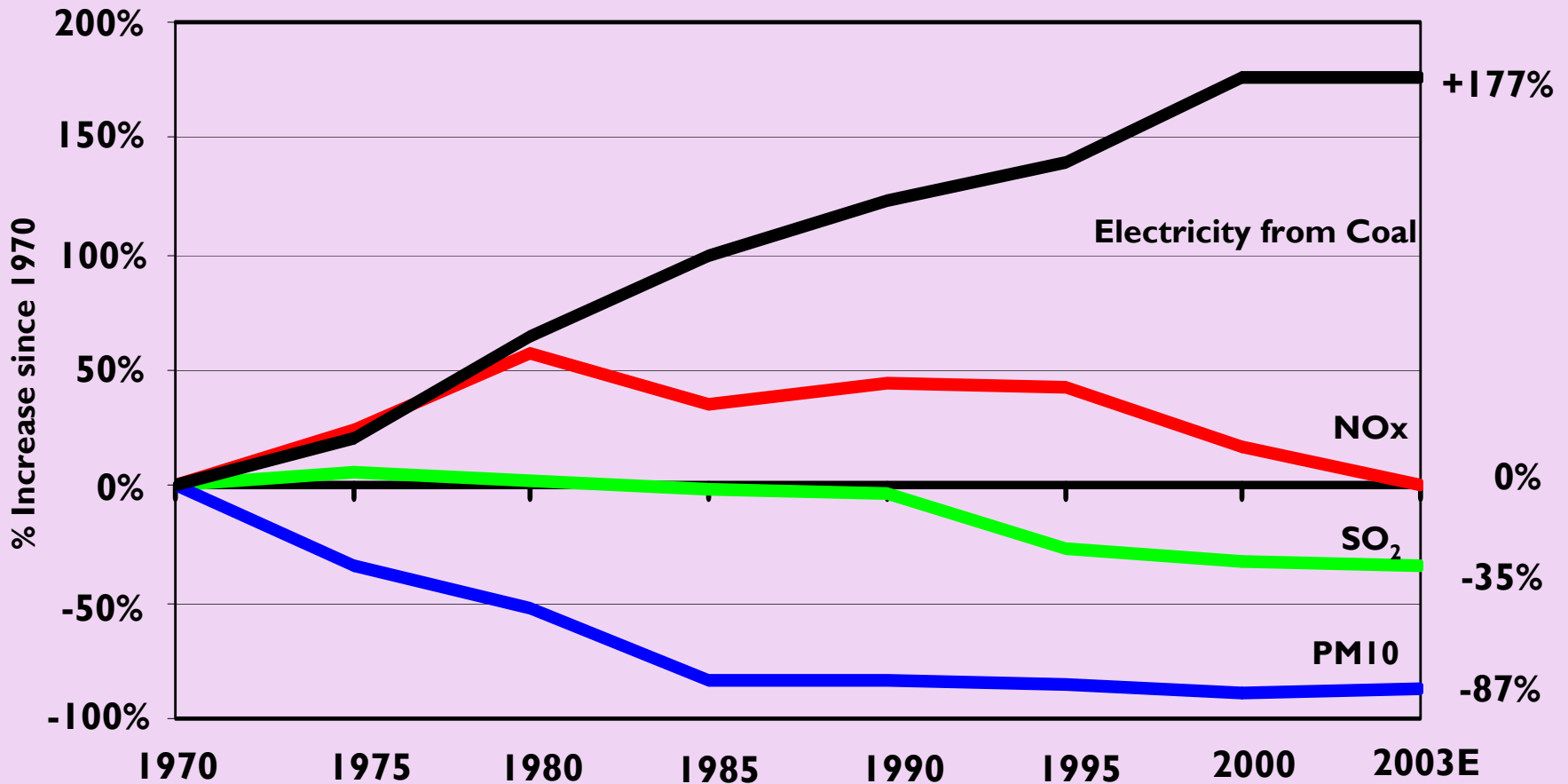
- Six of the seven NO_x control technology demonstrations have successfully completed demonstrations.
- Selective Catalytic Reduction (SCR), a technology developed from the CCTDP, has achieved NO_x reductions of 80 to 90+ percent.
- 75% of existing coal-fired generating units have been or are being retrofit with low NO_x burners, a technology developed under the CCT program.

Benefits from CCTDP Investments In SO₂ Controls

- All 5 SO₂ control technology demonstrations from the CCTDP have successfully completed operations and achieved SO₂ removal efficiencies of 70 to 95+ percent.
- The CCTDP redefined state-of-the-art flue gas desulfurization (FGD) capabilities and brought to the market scrubber technology that has nearly halved capital and operating costs and mitigated plant efficiency losses.
- There have been more than 400 commercial deployments of FGD systems as a result of the CCTDP.

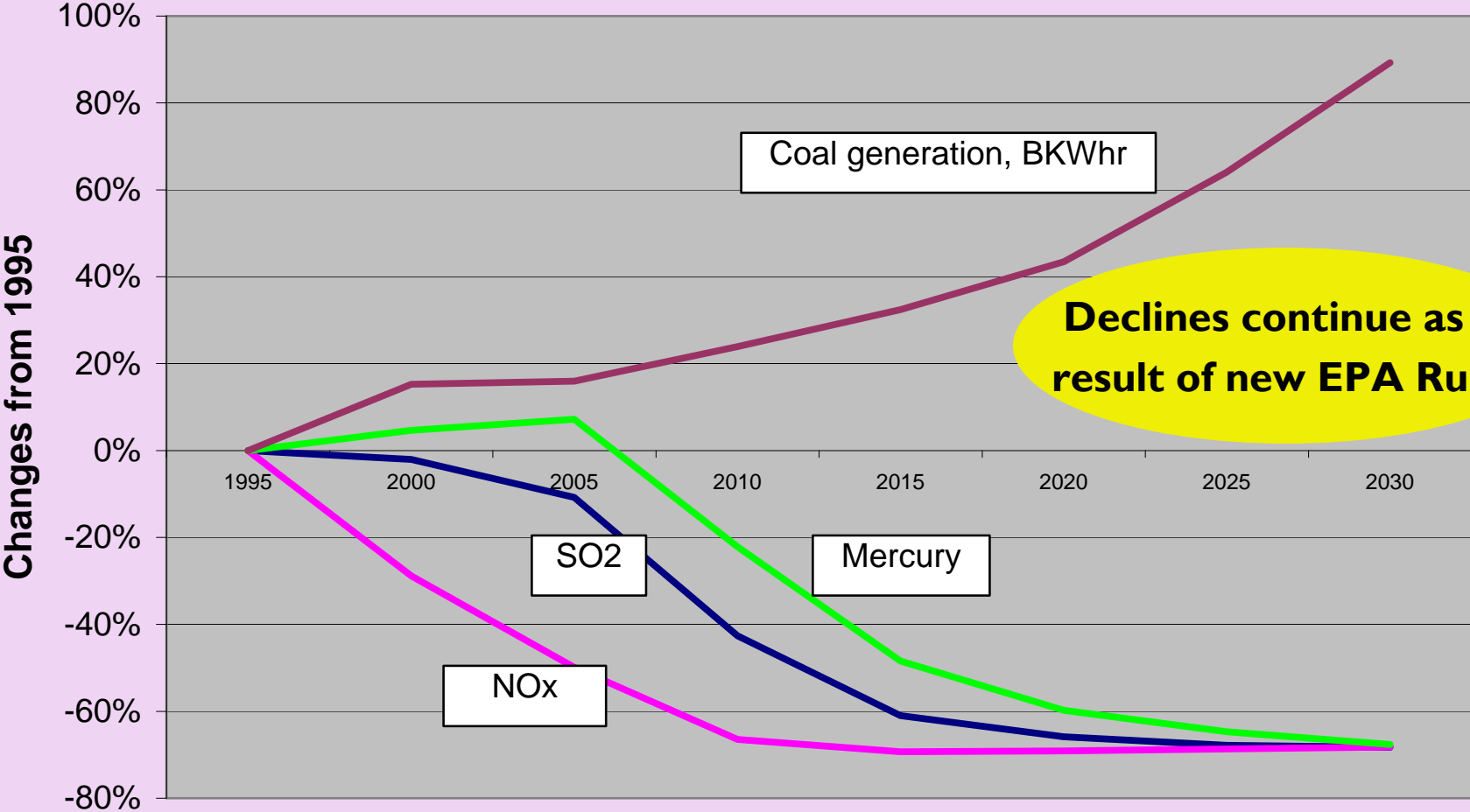
Coal - Increasingly Clean

Changes in Coal-Based Electricity & Emissions Since 1970



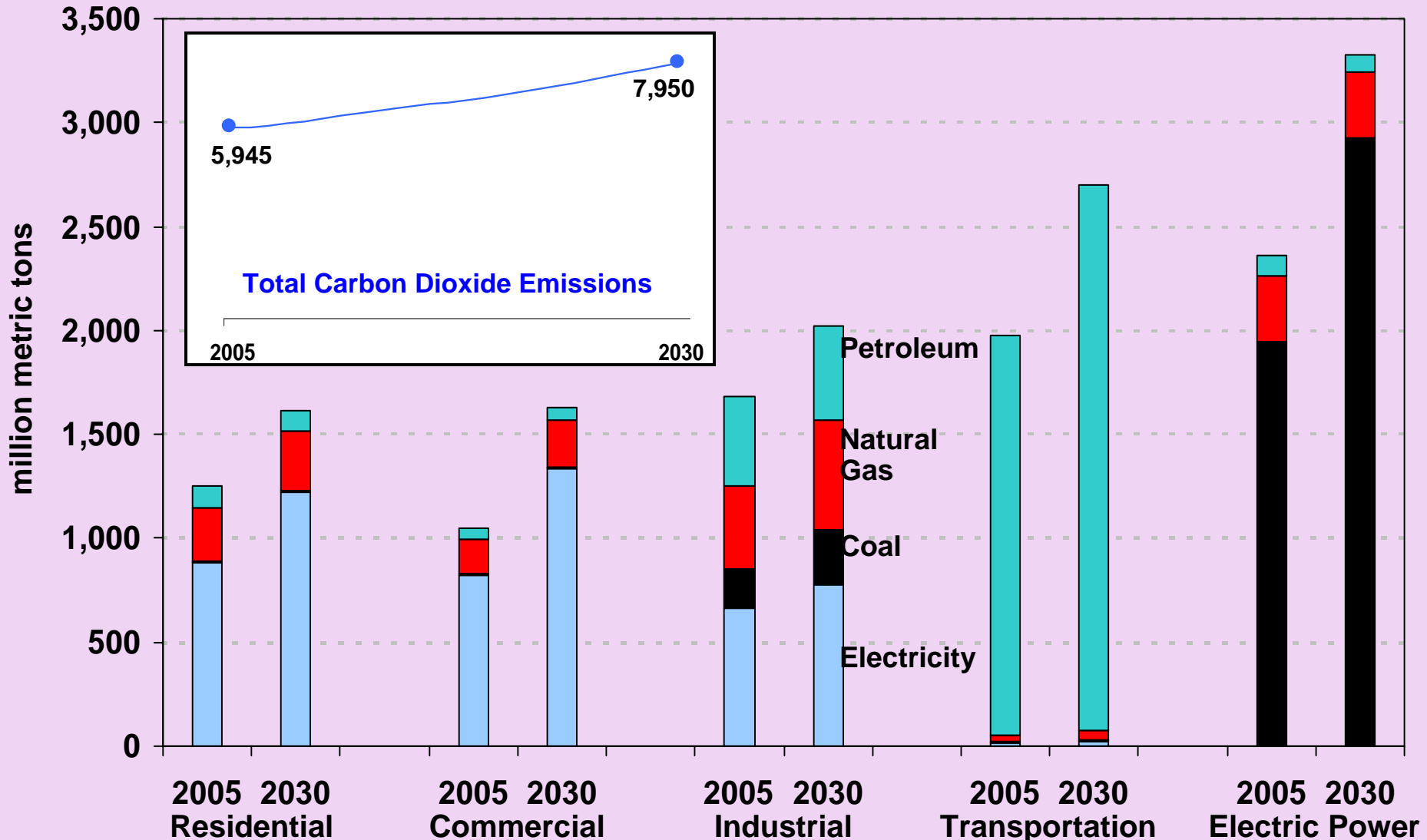
Source: EIA Annual Energy Review 2003 (Sept. 2004), EPA National Emissions Inventory Trends (Dec. 2004)

Emissions Will Continue to Decline While Generation Increases Through 2030



Declines continue as a result of new EPA Rules

U.S. CO₂ Emissions



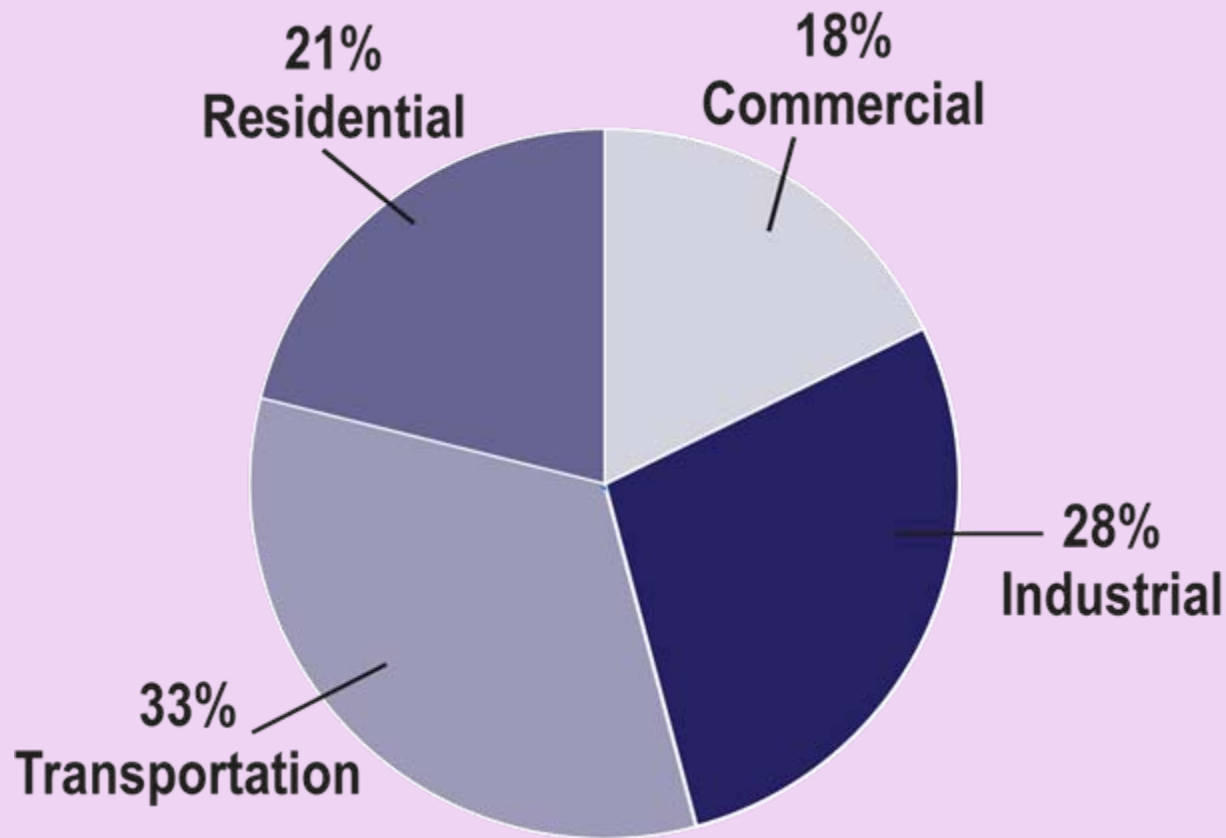
Source: U.S. Energy Information Administration, 2005 data

U.S. CO₂ Emissions

- This figure reflects EIA's comparison of 2005 and projected 2030 CO₂ emissions for the U.S., by sector.
- Each fuel is broken out by color, and electricity is treated as a separate fuel.
- Electricity CO₂ emissions are imbedded in each of the 4 economic sectors (residential, commercial, industrial, and transportation)
- The breakout of total electricity CO₂ emissions, by fossil fuel, is shown in the last 2 bars.

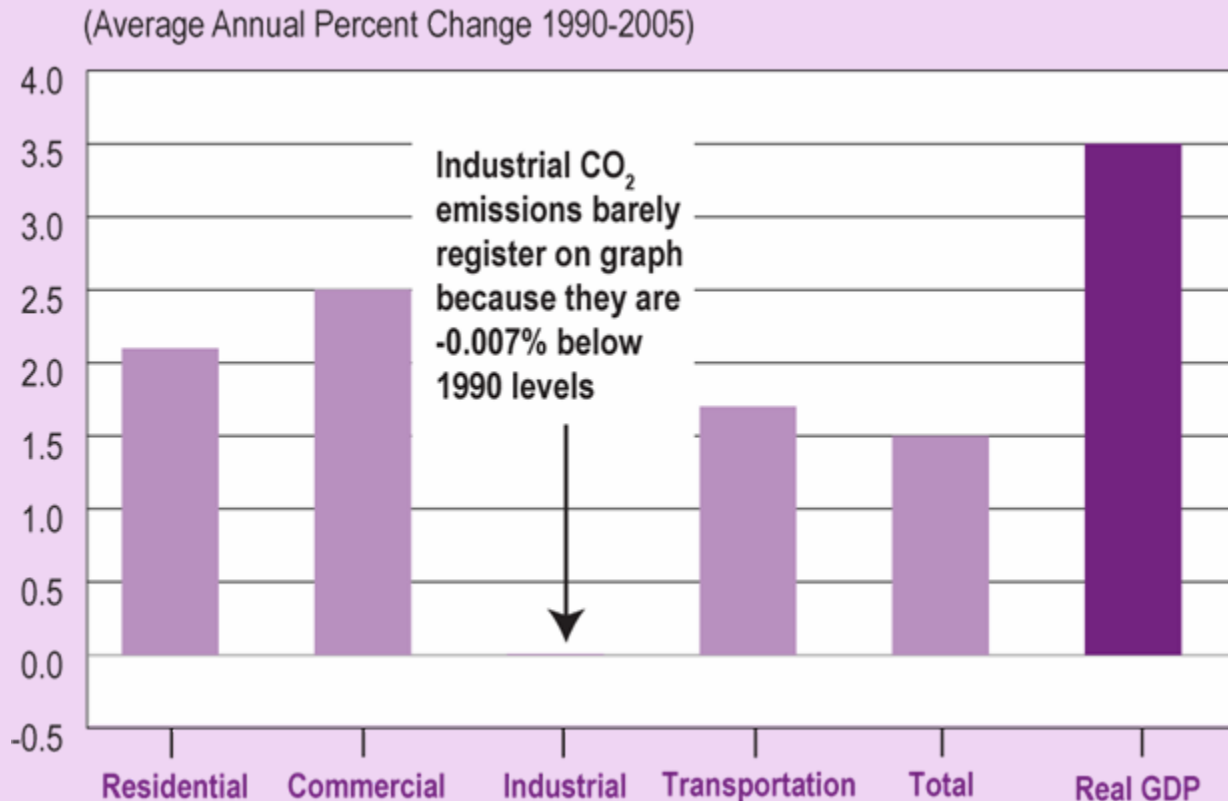
U.S. CO₂ Emissions by Sector

Total Energy Related CO₂ Emissions by Sector



Source: U.S. Energy Information Administration, 2005 data

With Results: CO₂ Emissions from Industry Are Below 1990 Levels



- CO₂ emissions are increasing in all sectors EXCEPT for Industrial (in large measure because industry has moved offshore)
- Growth in Residential, Commercial and Transport sectors due to
 - More people
 - More and bigger houses
 - Strong economy
 - More gasoline use

Benefits of Clean Coal Technology Development

- Greatly reduced emissions from power generation:
 - Sulfur dioxide, nitrogen oxides, mercury, particulate matter; less water consumption; less solid waste generation, or greater utilization as byproducts.
- Lower cost power, allowing coal to displace higher priced fuel like natural gas
- Gasification-based systems can also produce transportation fuels and other products
- In the future, the ability to cost-effectively capture and store CO₂