Kentucky Association of Rural Electric Cooperatives

Future of Coal-Fired Power and CO_2 Sequestration

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November 17, 2008

Outline for the talk

I. IPCC and climate change

II. Fossil fuels the driver in climate change

III. CO_2 Sequestration, *the* answer or *an* answer, or *no* answer?

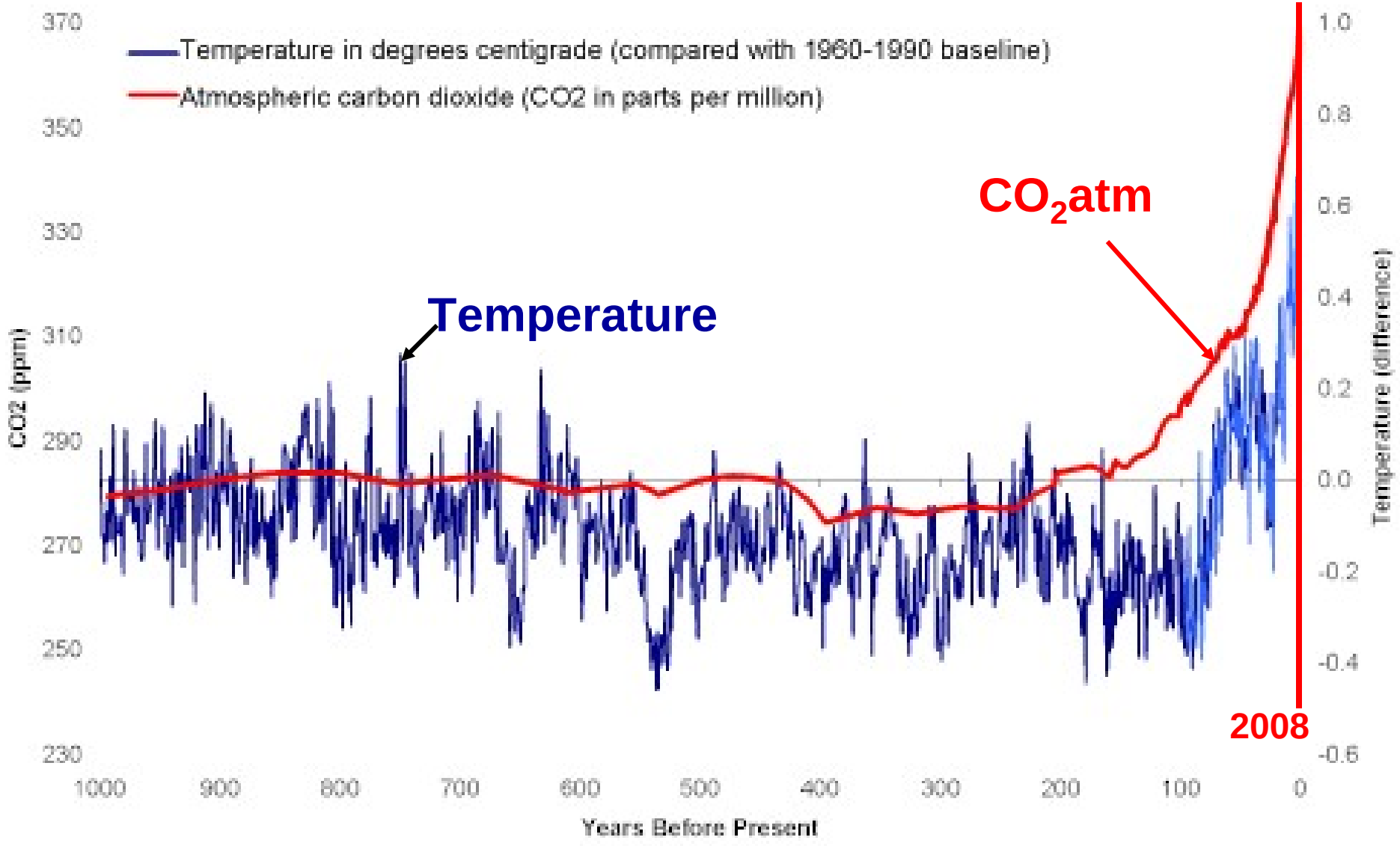
United Nations Intergovernmental Panel on Climate Change, 2008

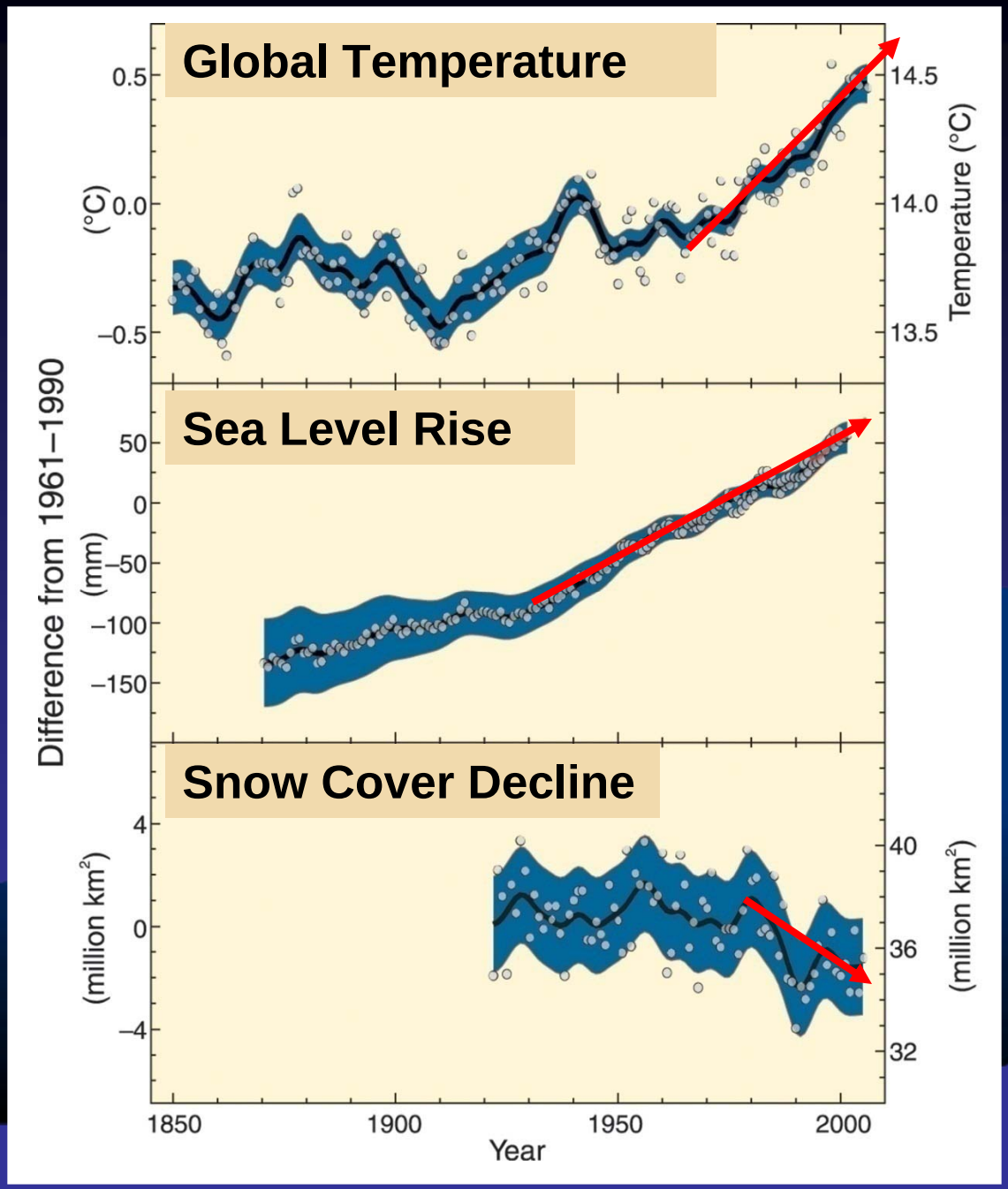
"The understanding (science) of anthropogenic (human) warming and cooling influences on climate has improved leading to *very high confidence* that the global average net effect of human activities since 1750 has been one of warming," UN IPCC, 2008

According to the IPCC

- Carbon dioxide is the most important anthropogenic greenhouse gas
- Concentration of carbon dioxide in the atmosphere exceeds the natural range over the last 650,000 years
- Fossil fuel use was the primary source of carbon dioxide with deforestation a significant but smaller contributor
- Annual carbon dioxide emissions increased from 23.5 GtCO2 per year in 1990 to 26.4 GtCO2 per year in 2005

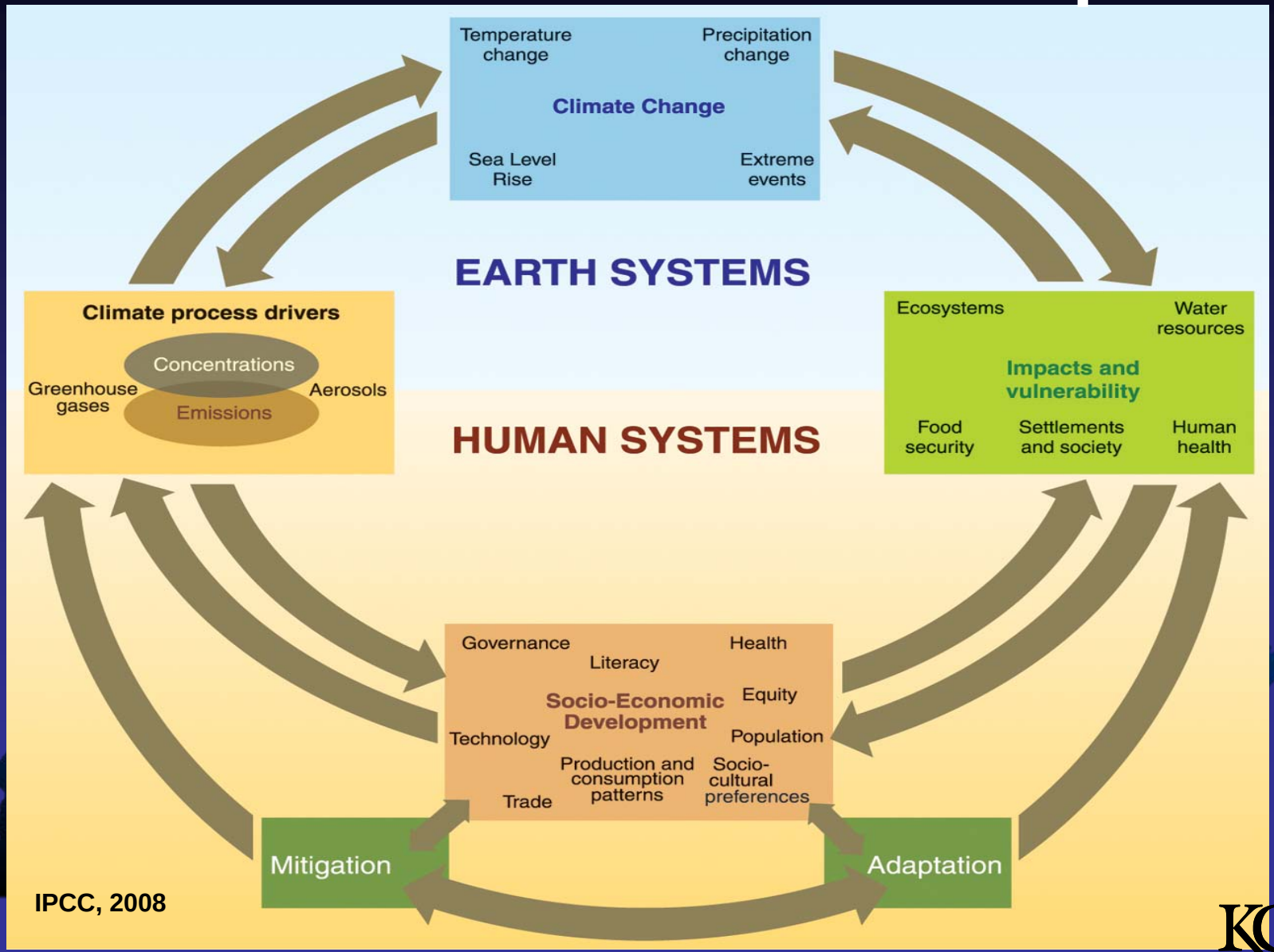
CO_2 and Temperature Trends for the Last 1,000 years




Global Temperature
Sea Level Rise
Snow Cover Decline
Difference from 1961–1990
(°C)
Temperature (°C)
(mm)
(million km²)
(million km²)
0.5
0.0
−0.5
14.5
14.0
13.5
50
0
−50
−100
−150
4
0
−4
40
36
32
1850
1900
1950
2000
Year

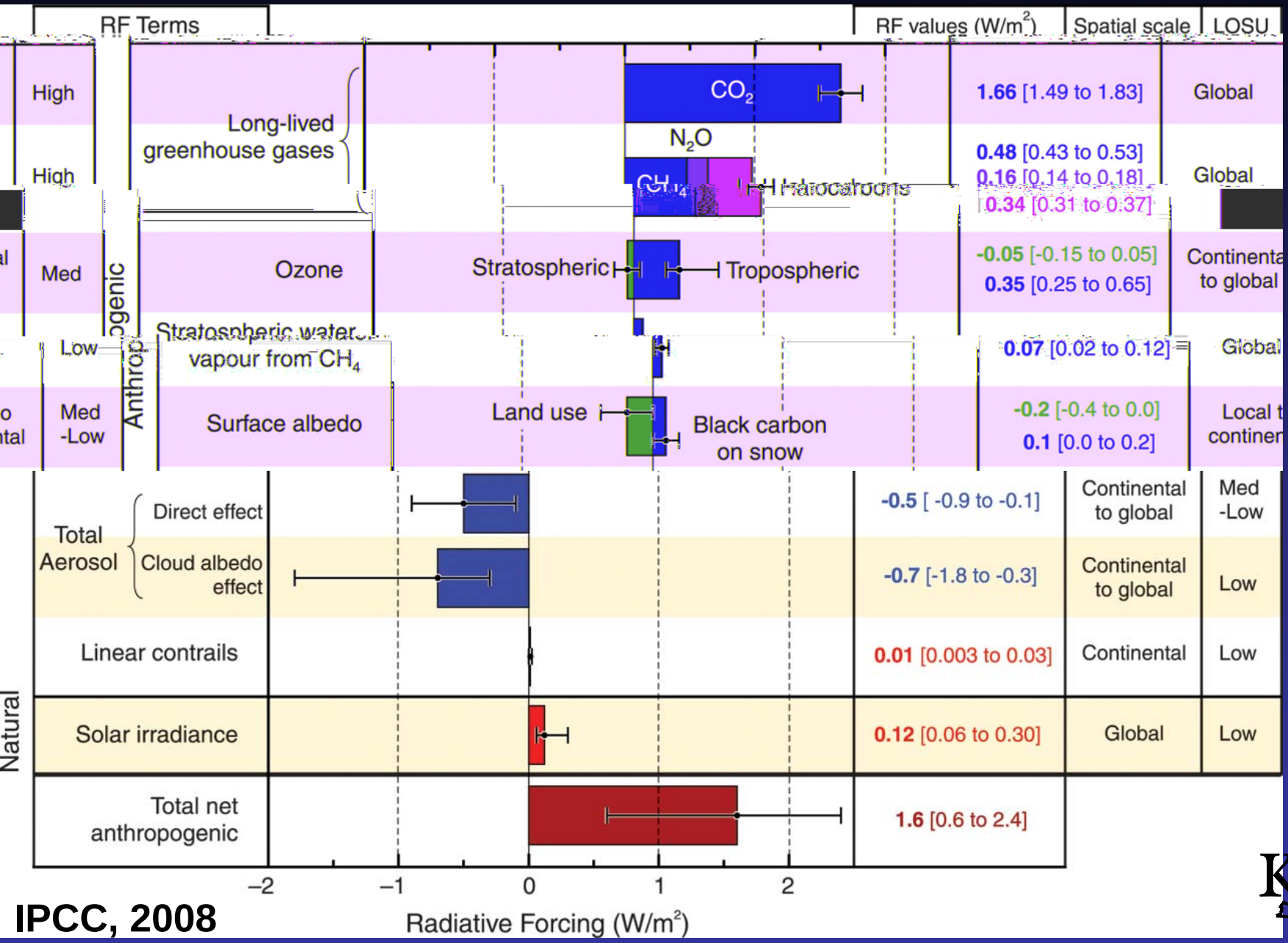
IPCC, 2008

Human Climate Effects and Responses



IPCC, 2008

Accounting for Warming



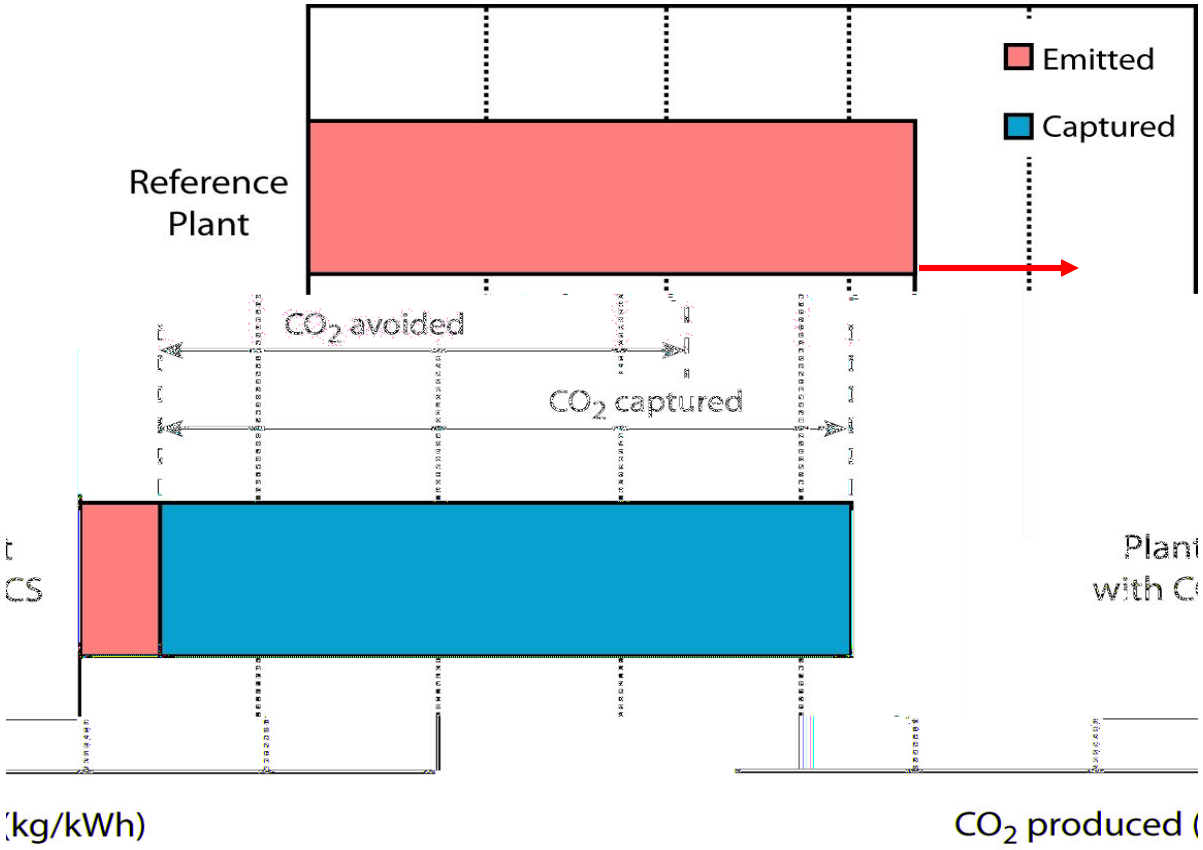
IPCC, 2008

If Fossil Fuels are Bad Why Pick on Coal

	Carbon Intensity g C/unit energy
Natural gas	15
Oil	20
Coal	26

Modified from Masters, G.M., 1998

Loss of overall power plant efficiency as a consequence of CO2 capture

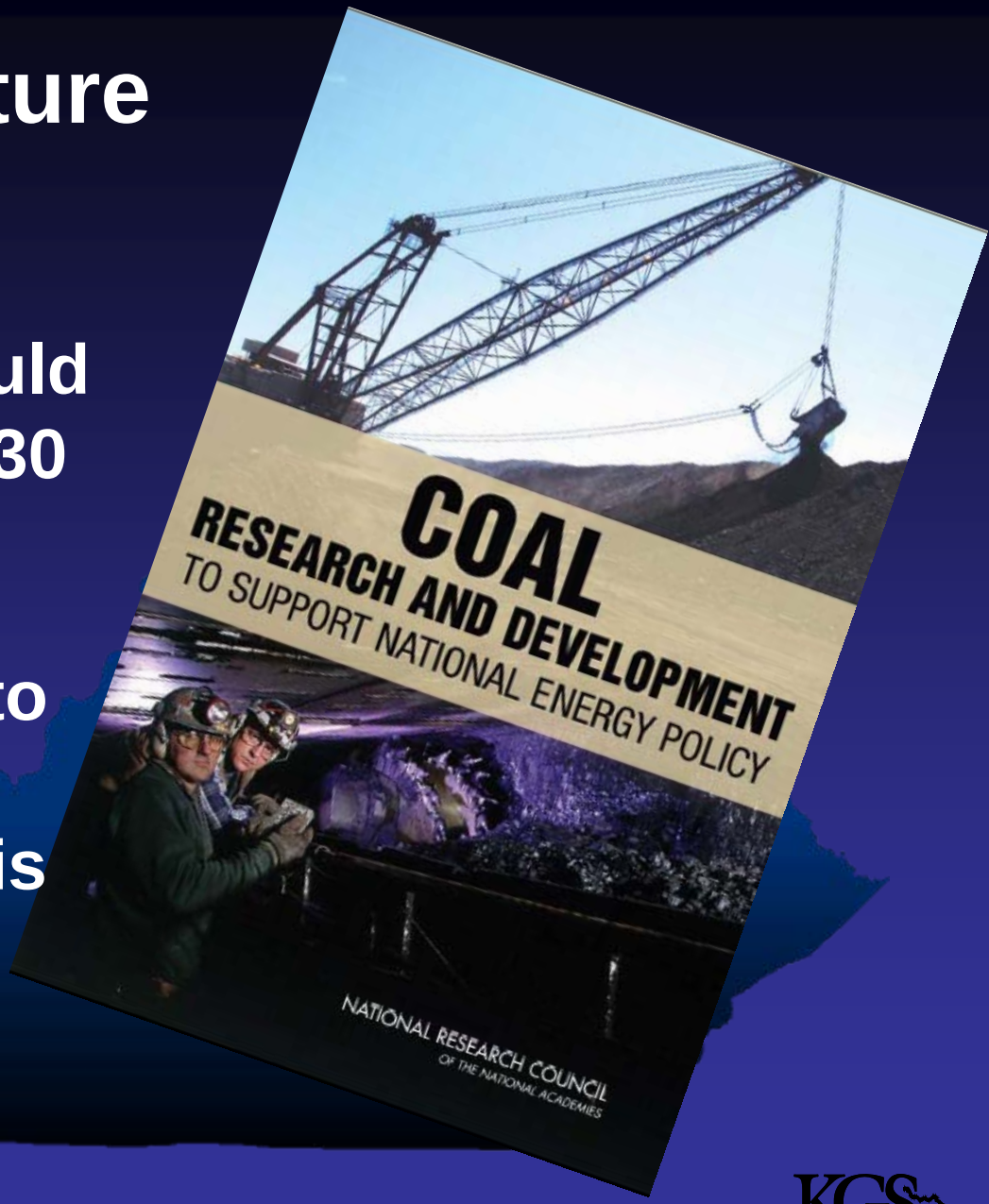


About 20% penalty in theory

SRCCS Figure TS-11

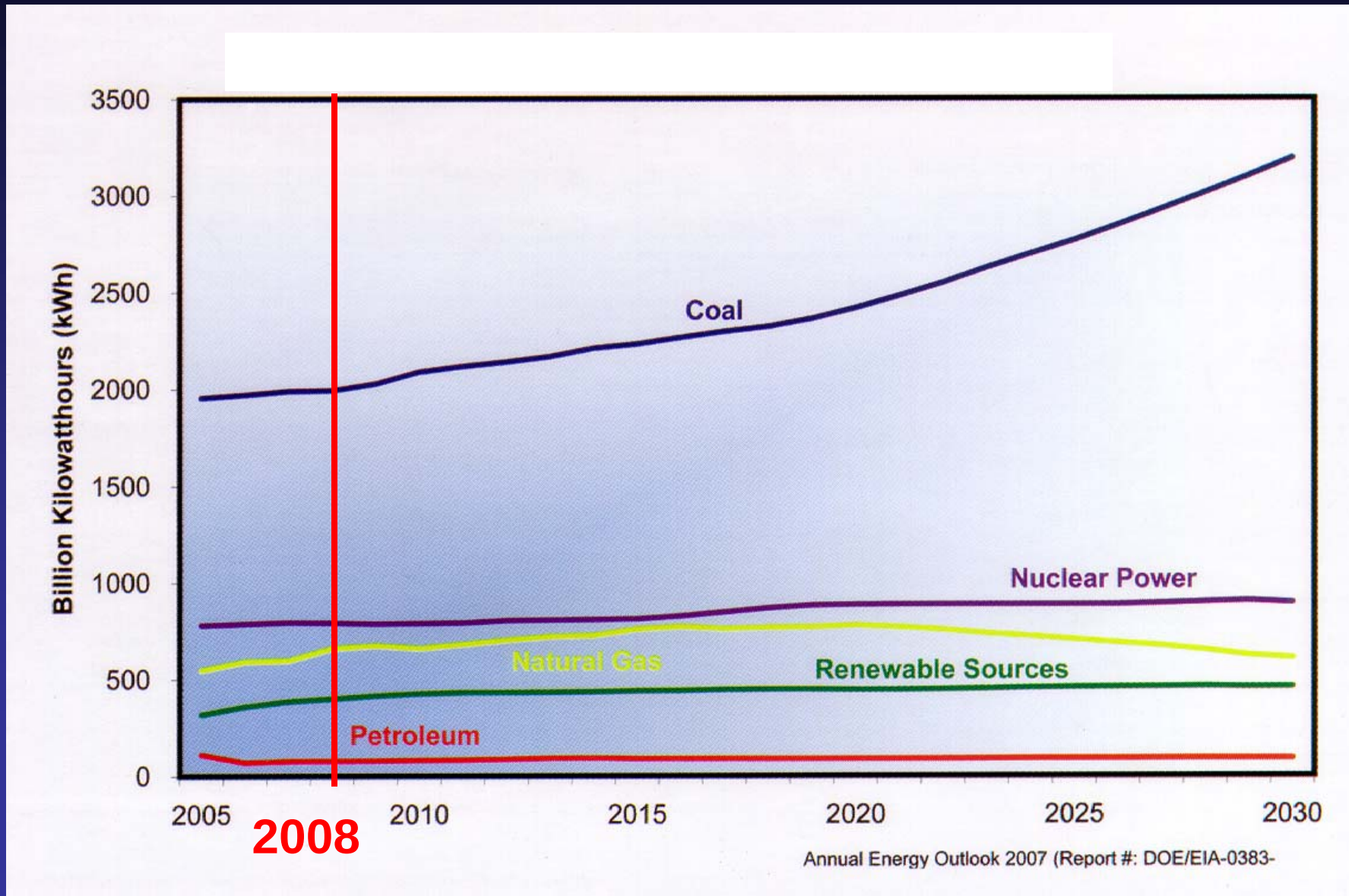
NRC Report on Future of Coal in U.S.

- Coal production could increase 70% by 2030
- U.S. has more than adequate reserves to accommodate this increase but R & D is needed

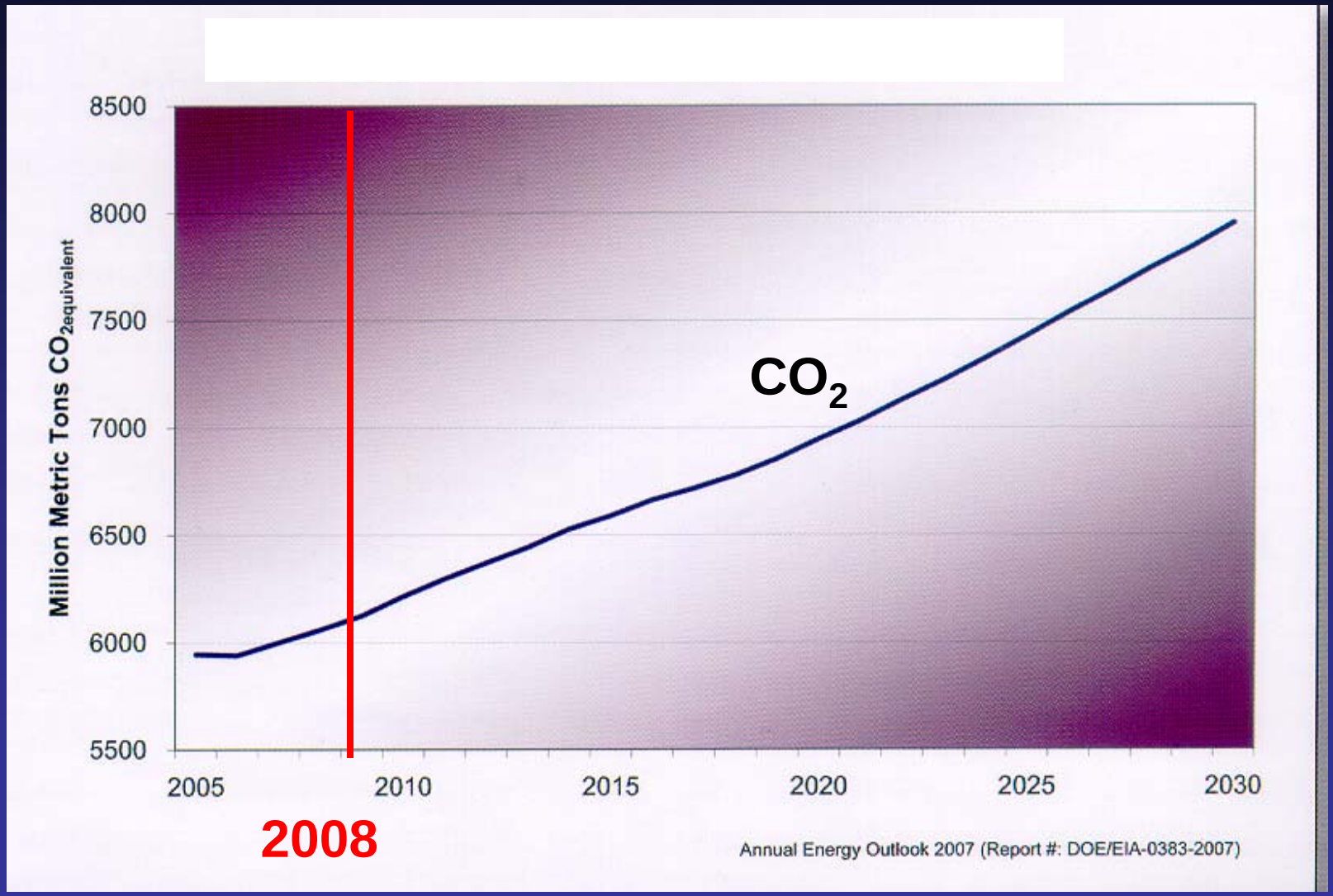


NRC, 2007

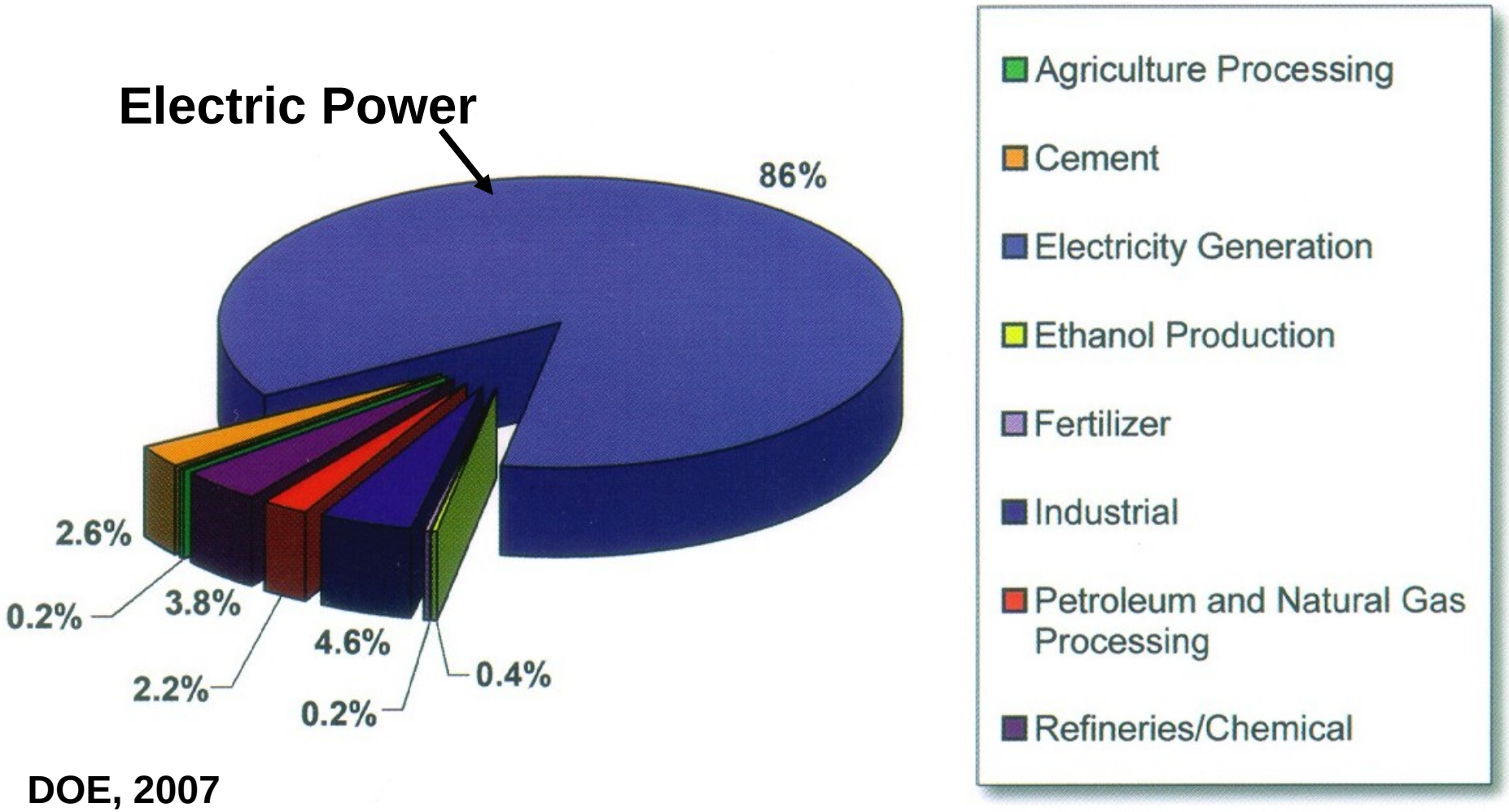
Projected U.S. Electric Power by Fuel Type



U.S. Projected CO_2 Emissions

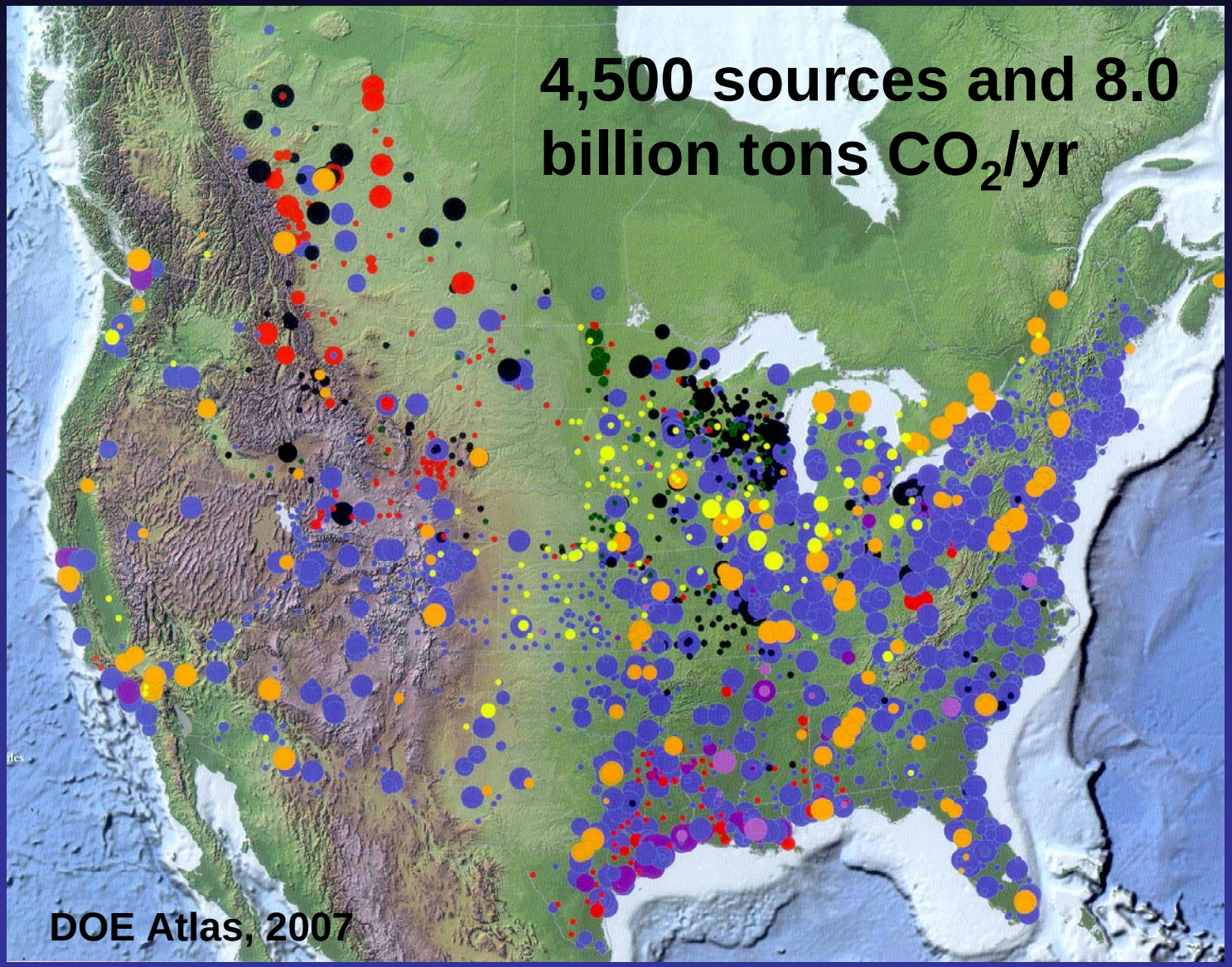


U.S. CO_2 Emissions from Stationary Sources by Category



DOE, 2007

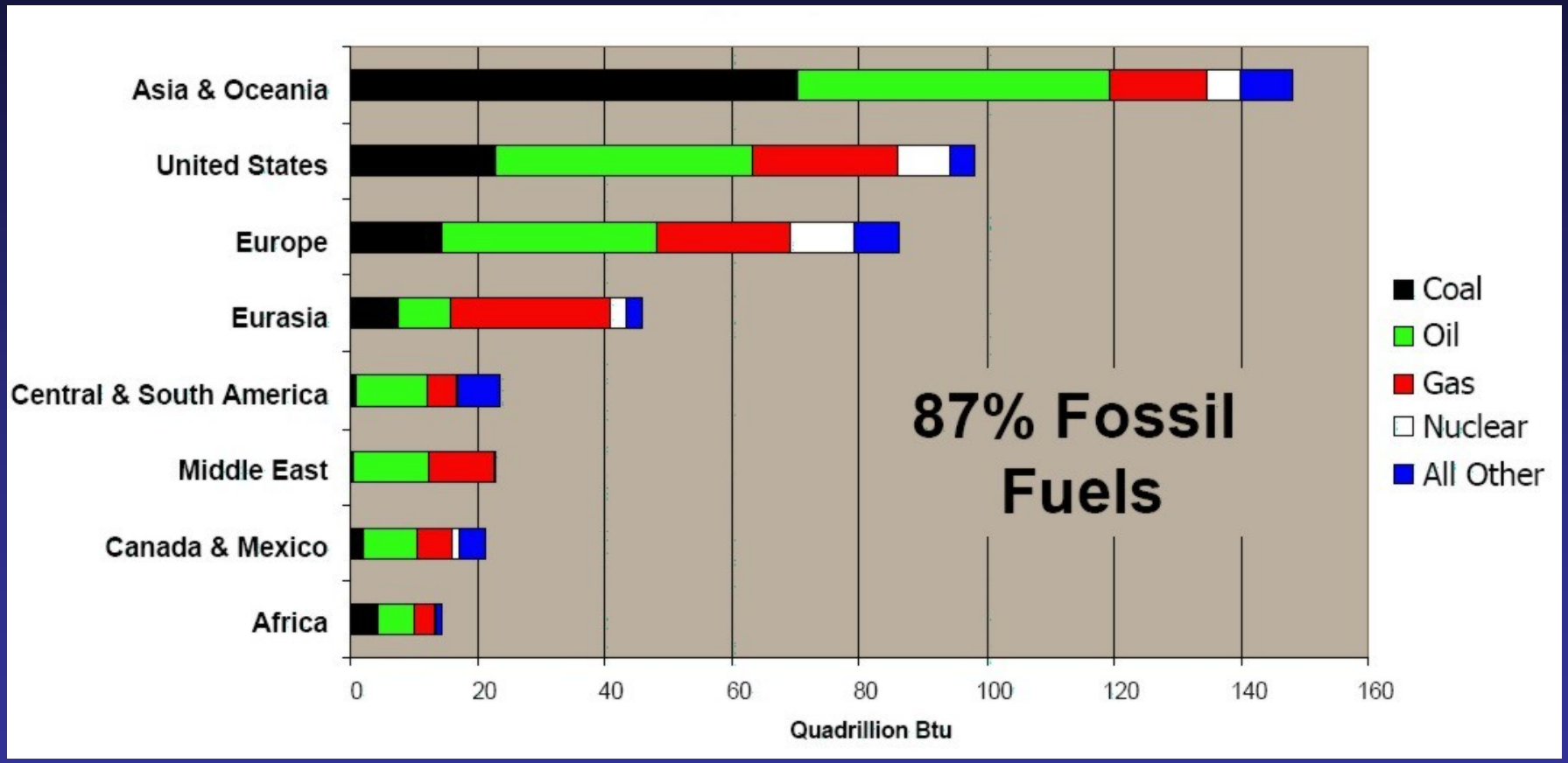
Stationary Sources of CO_2 in the U.S.



Energy in the World

Global Energy Use by Region

Energy Use (Quadrillion Btu)



Data: EIA, October 2007

Energy in Kentucky

KyHB-1 Funding Research for Economic Development

- In passing HB-1 (2007), Kentucky legislators signaled that the need for domestic energy and controls on CO_2 had penetrated into the state political scene, a bellwether event!
- Leveraged nearly $6.0 million in private industry funding and technical input.
- Motivated the creation of the Western Kentucky Carbon Storage Foundation [501 (c) (3)] foundation to match HB-1 funding.

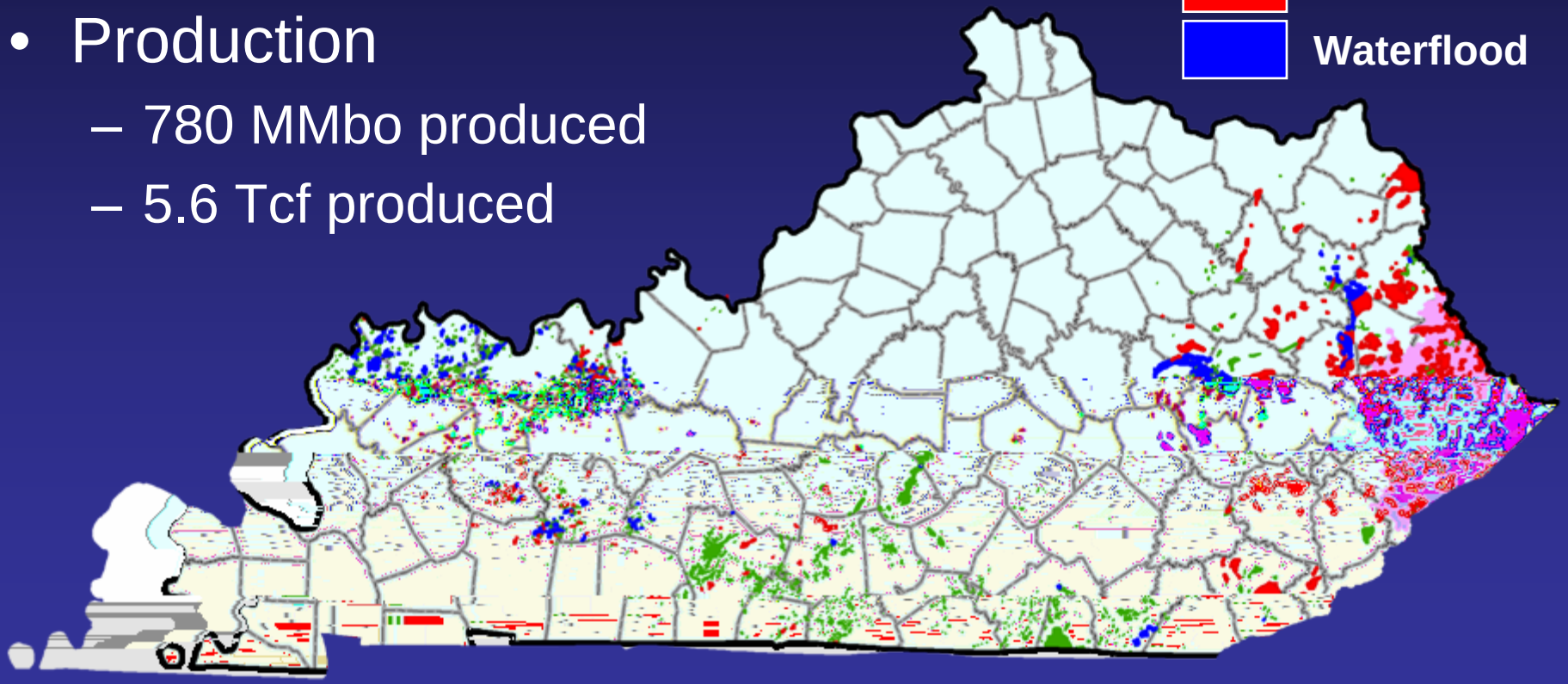
Budget for HB-1 Sequestration Research in millions $

Western KY Seq.	State*	Industry	Other	TOTAL
	$1.35	$5.69	$0.25	$ 7.29
Eastern KY Seq.	1.35	1.35	0.5	3.2
EOR	0.85	0.85	0.5	2.2
EGR	0.85	0.85	0.5	2.2
TOTALS	$4.40	$8.74	$1.75	$14.89

*UK is contributing $1.0 million

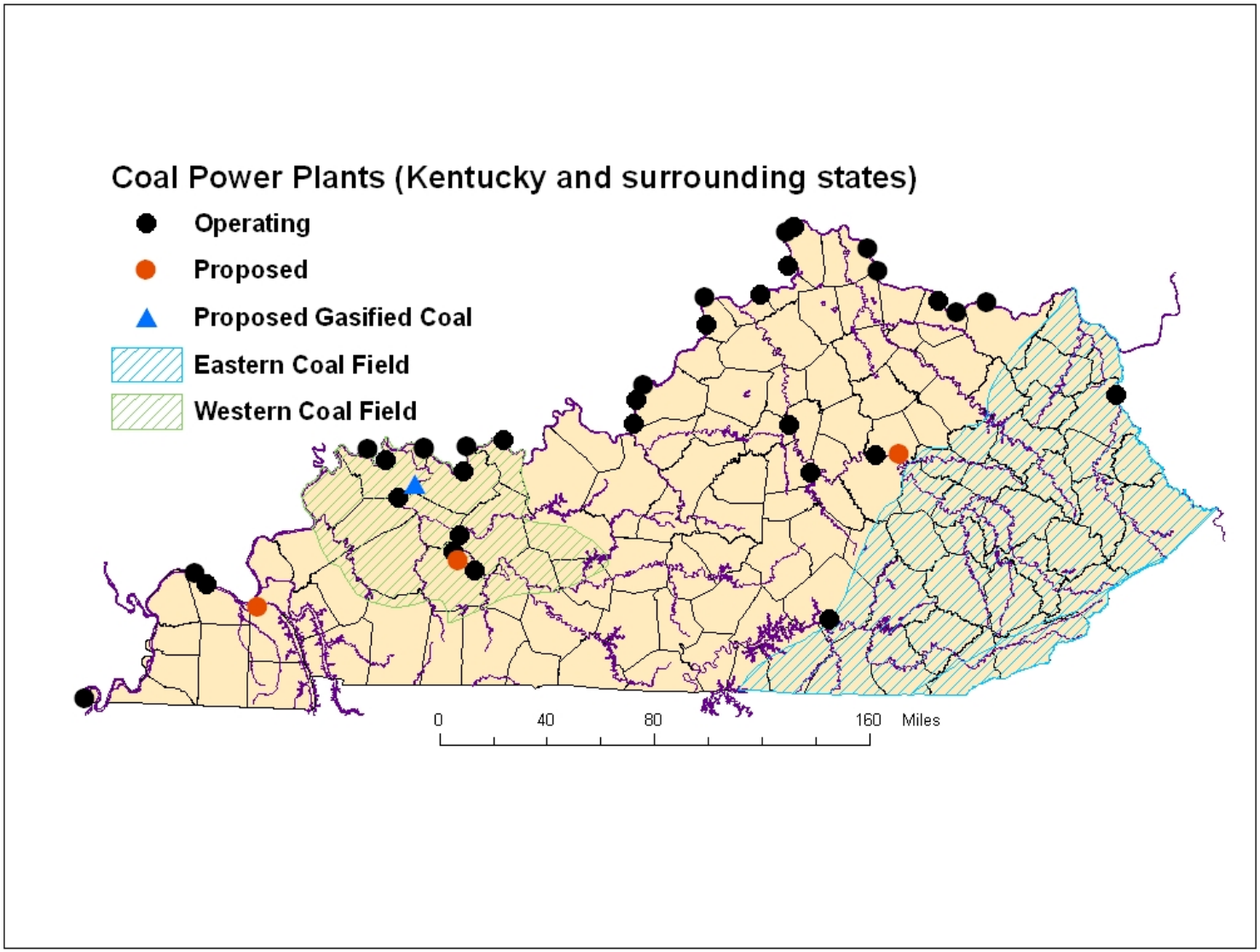
Oil and Gas Fields of Kentucky

- OOIP: 2.4 billion barrels*
- Gas resource: 125 Tcf
- Production
  - 780 MMbo produced
  - 5.6 Tcf produced



** Does not include 3.4 billion barrels tar sand in W. Ky.*

Coal-fired Electric Generation in and near Kentucky



Kentucky's Carbon Numbers

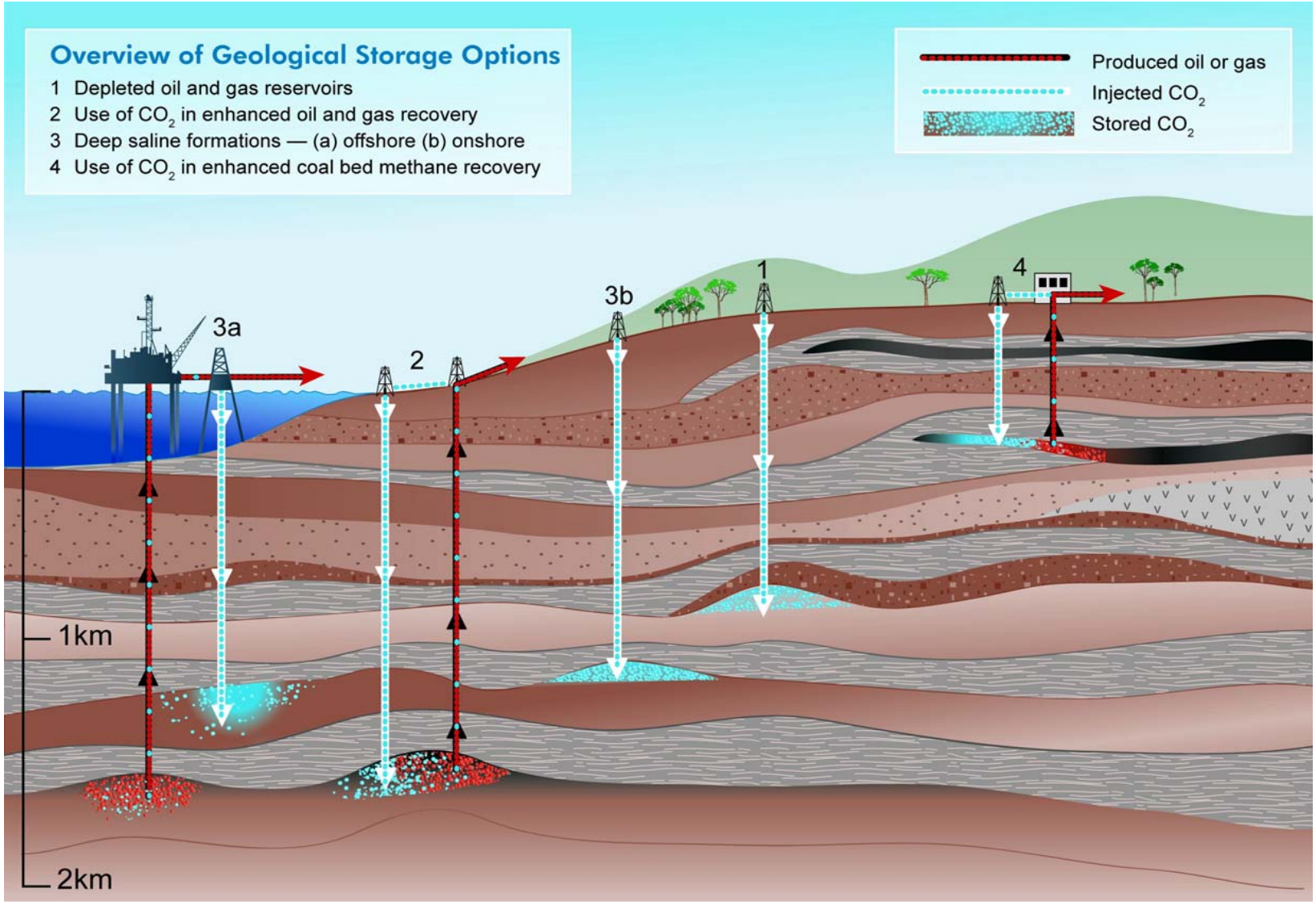
- Kentucky ranks 3rd nationally in annual coal production
- 10-15 billion short tons of recoverable coal reserves
- 92% of electrical generation is from coal-fired power plants
- 155 million metric tons CO_2/annually (all sources)
- Kentucky produces coal, natural gas, oil, tar sand, ethanol, and processes uranium at Paducah

CO_2 Sequestration
"the Basics"

What is carbon sequestration?

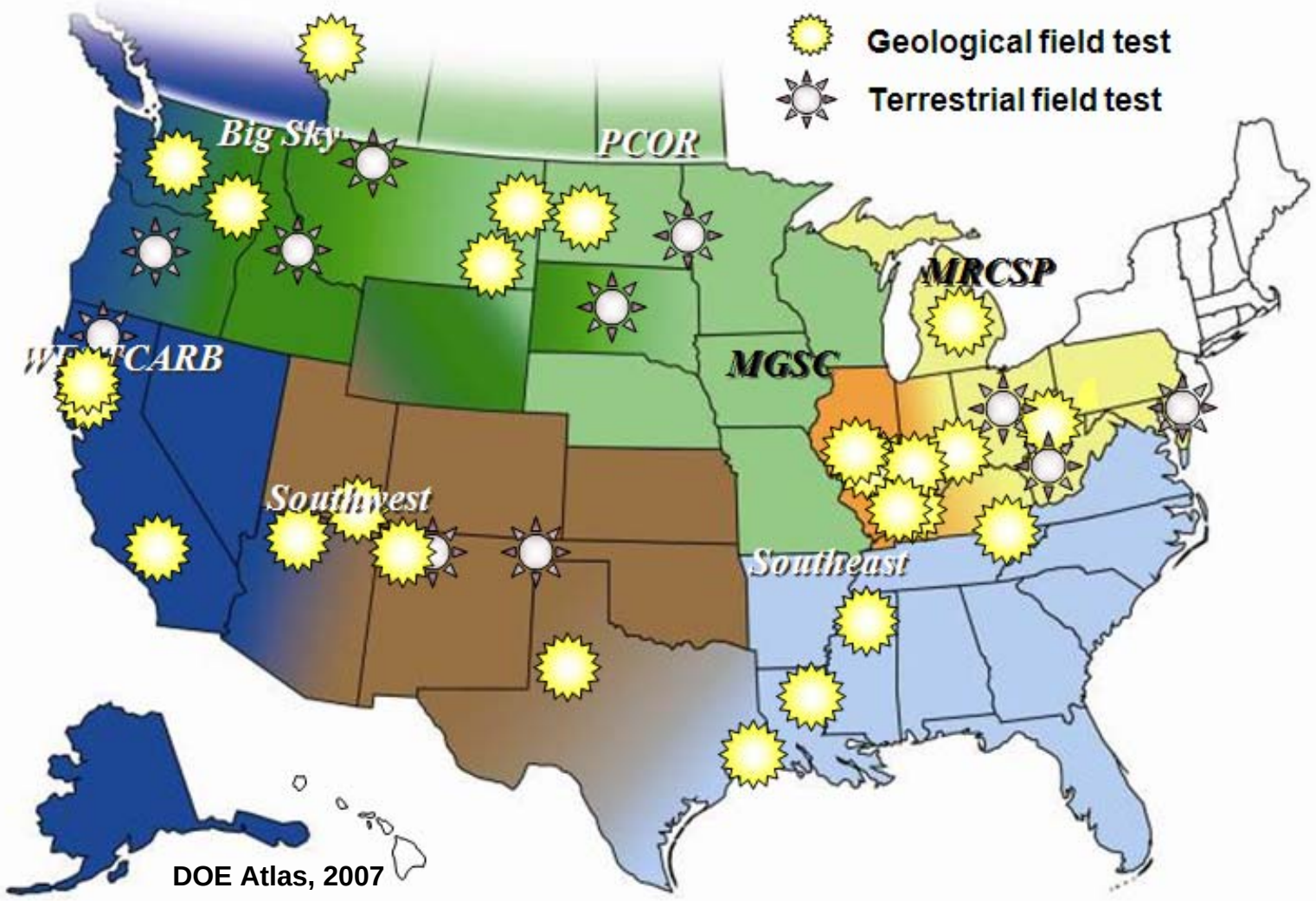
- Carbon is short for CO_2 or carbon dioxide
- Sequestration means removed or isolated from the atmosphere and stored away for a long time
- Sequestration is by injection into deeply buried rock formations, oil or gas fields, or coal seams
- CO_2 is to be confined for thousands of years
- This is experimental evolving technology

Methods for storing CO2 in deep underground geological formations

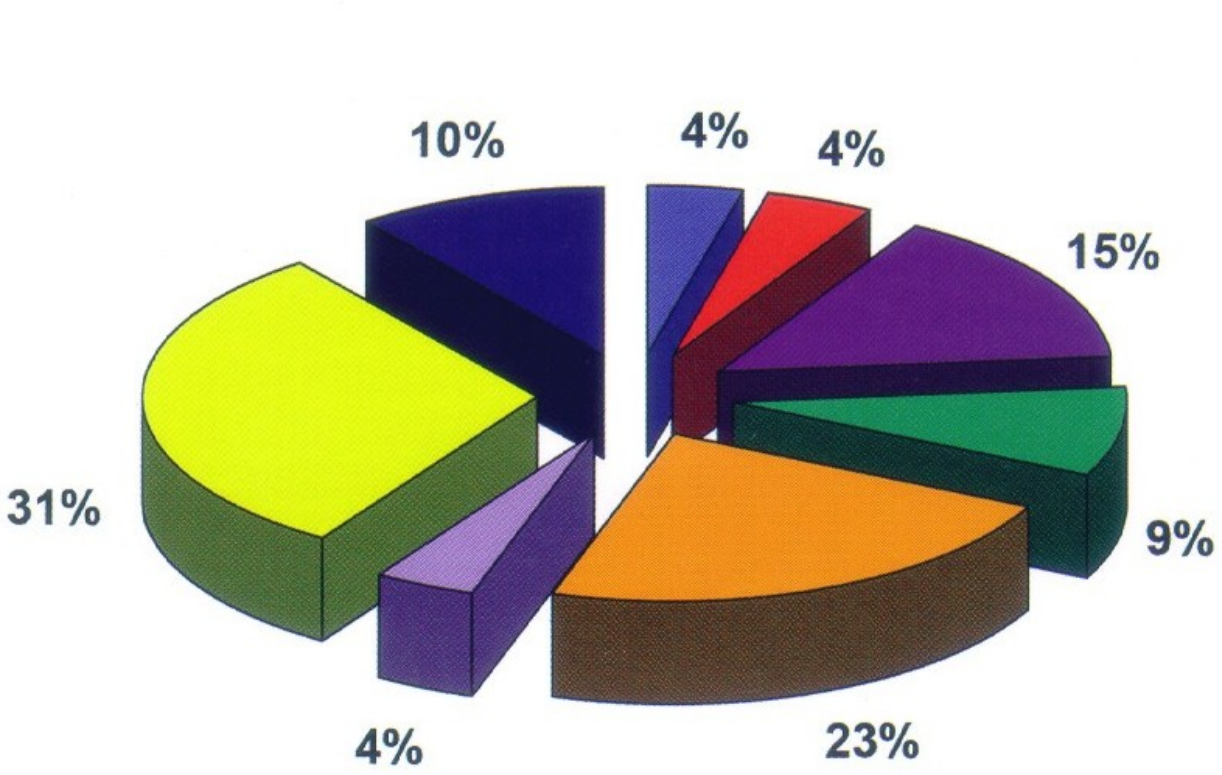


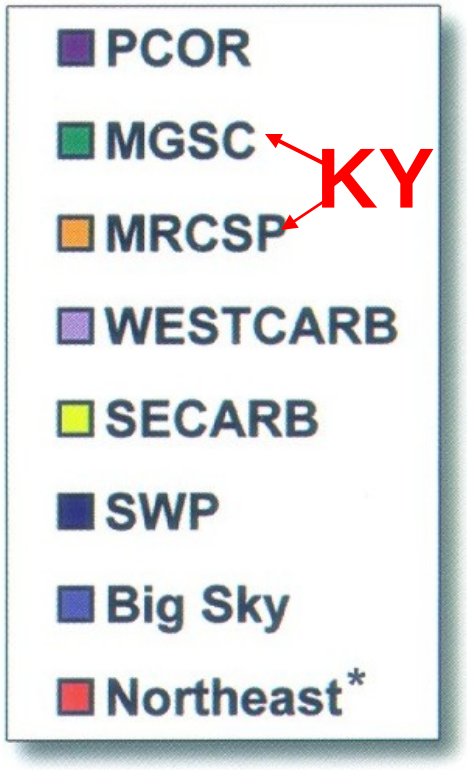
SRCCS Figure TS-7

DOE Sequestration Regional Partnerships



U.S. CO_2 Emissions by Region





* Northeast category includes states not covered by the RCSPs

DOE, 2007

Why Sequester CO_2?

- Political consensus manmade CO_2 is changing the climate, storing CO_2 away from the atmosphere will help moderate climate change
- CO_2 emissions are rising
- Concern about CO_2 emissions is high

Carbon Capture and Sequestration

- CCS is a three part process

  1) Capturing the CO_2 at the power plant

  2) Compressing and transporting CO_2 to storage site

  3) Injecting CO_2 into a deep geologic formation

Challenges to CCS Deployment

- EPA forming news regulations on deep well injection under UIC program
- No cap and trade or CO_2 credit system in place
- No state regulations on pore space management
- No private or public (state or federal) indemnification

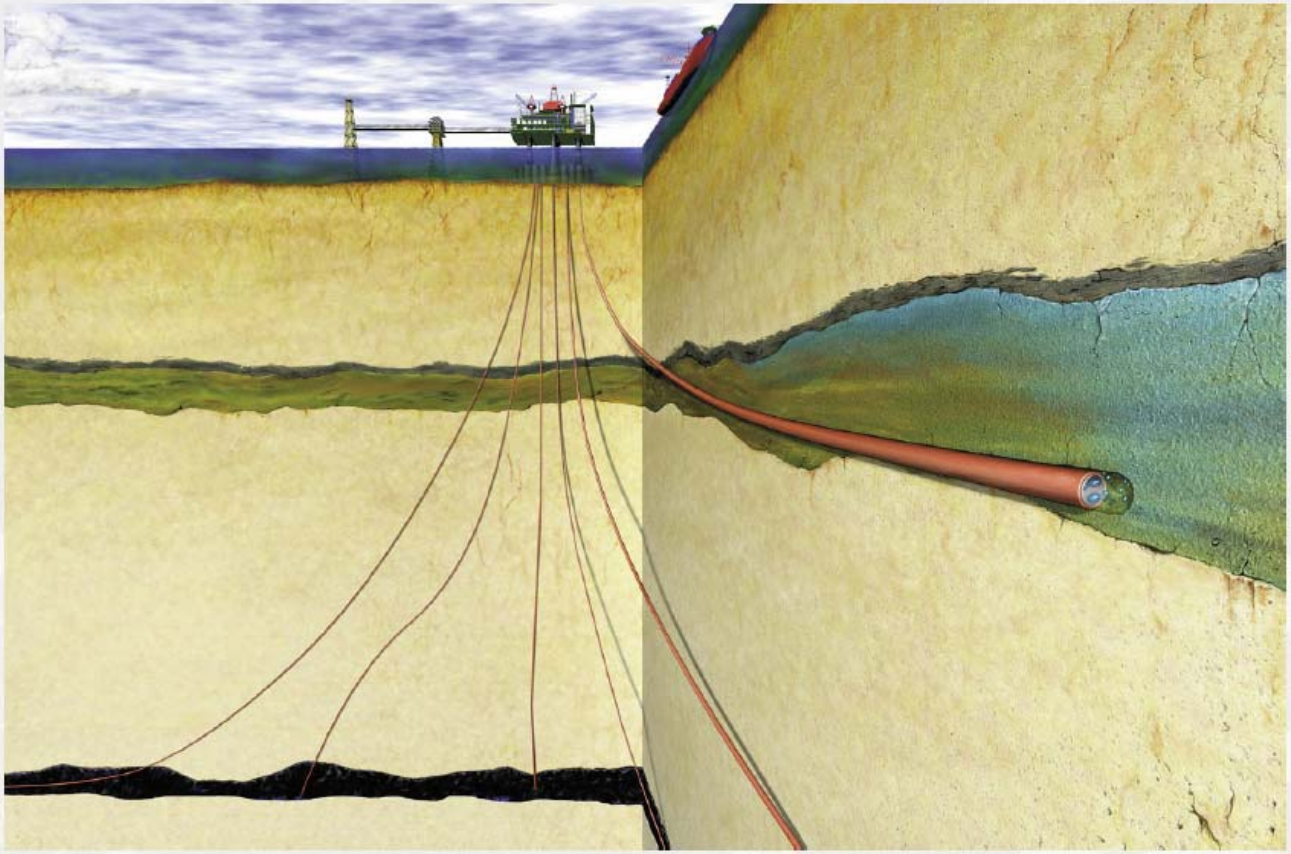
Challenges to CCS Deployment

- Scale of deployment is massive
- Public acceptance questionable
- Potential Benefits – Actual Costs = True Value
- Ultimate value – Will it make a difference in moderating climate change?

North Sea Sleipner Project

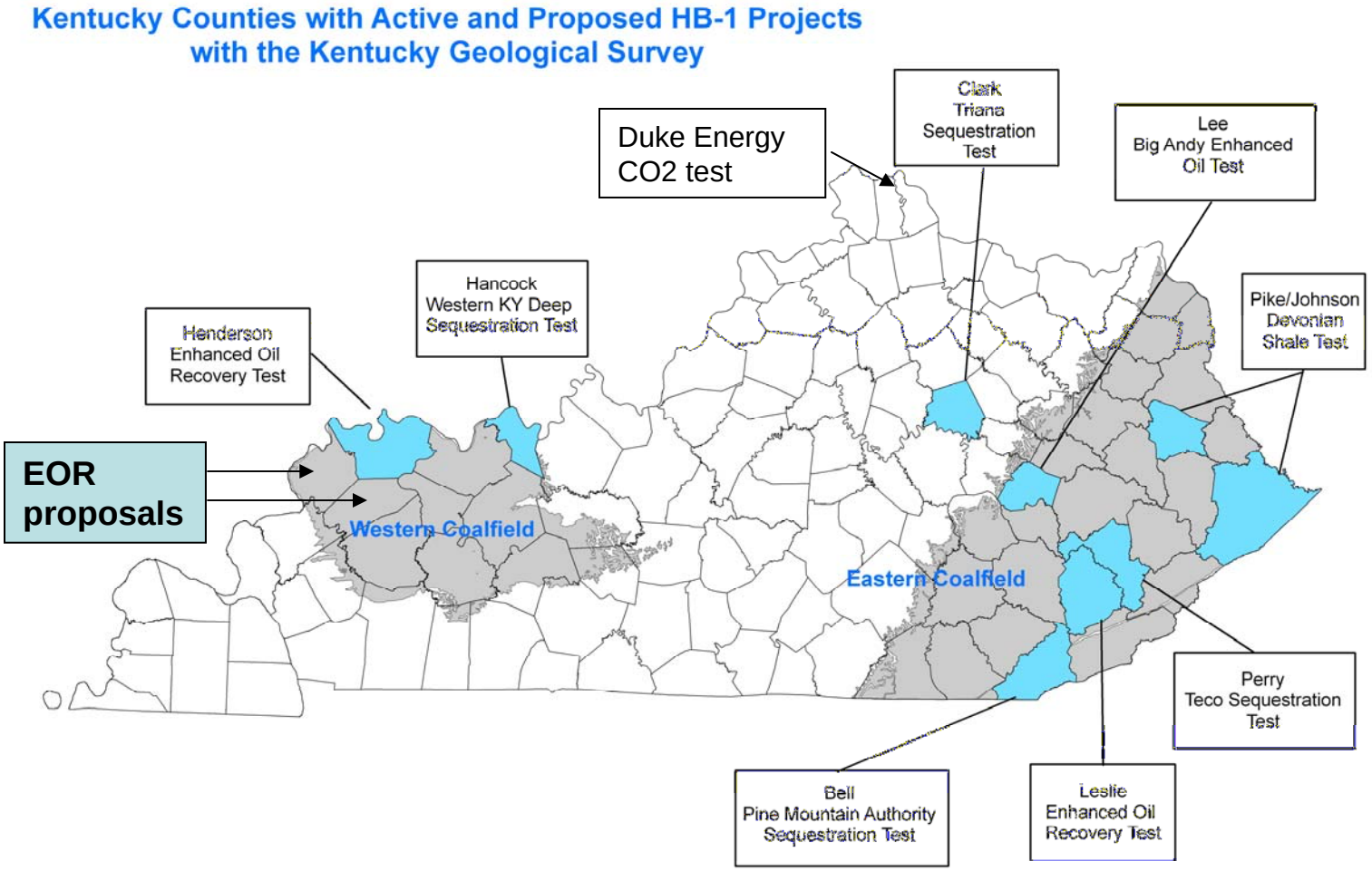
The Sleipner CO2-injection into the Utsira Formation at 1000 Meters Below Sea Bottom
- About 1 million tons/yr -

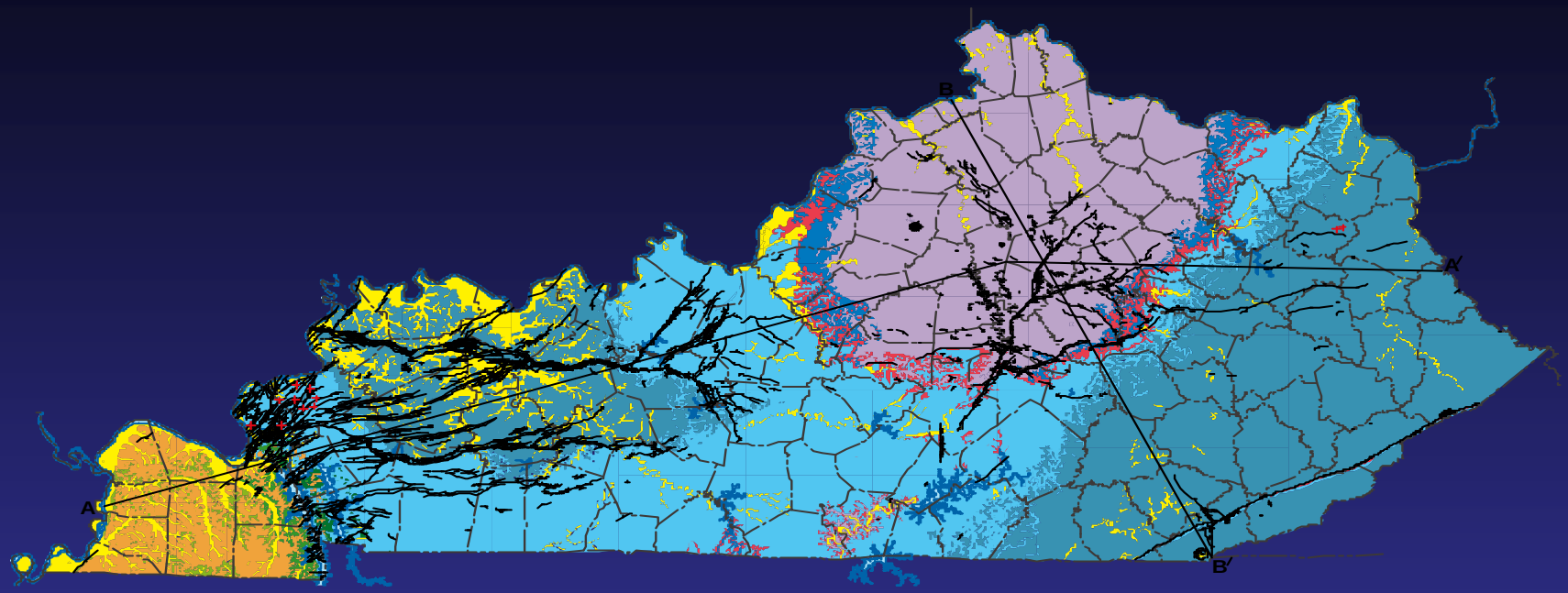
STATOIL



Sequestration Research in Kentucky

HB 1 Research Projects Planned or Proposed

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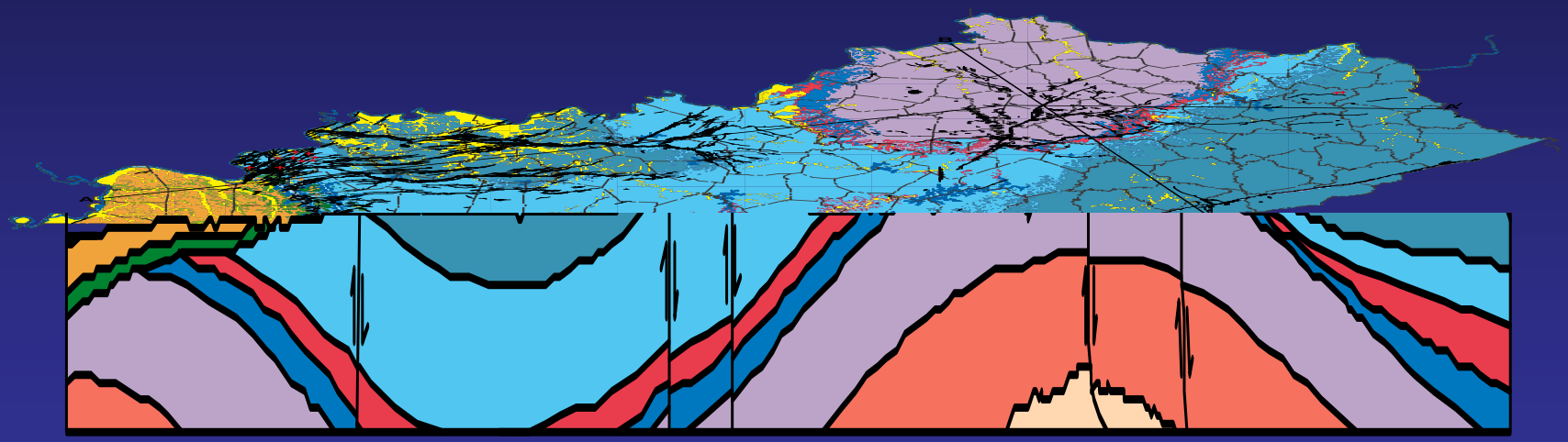
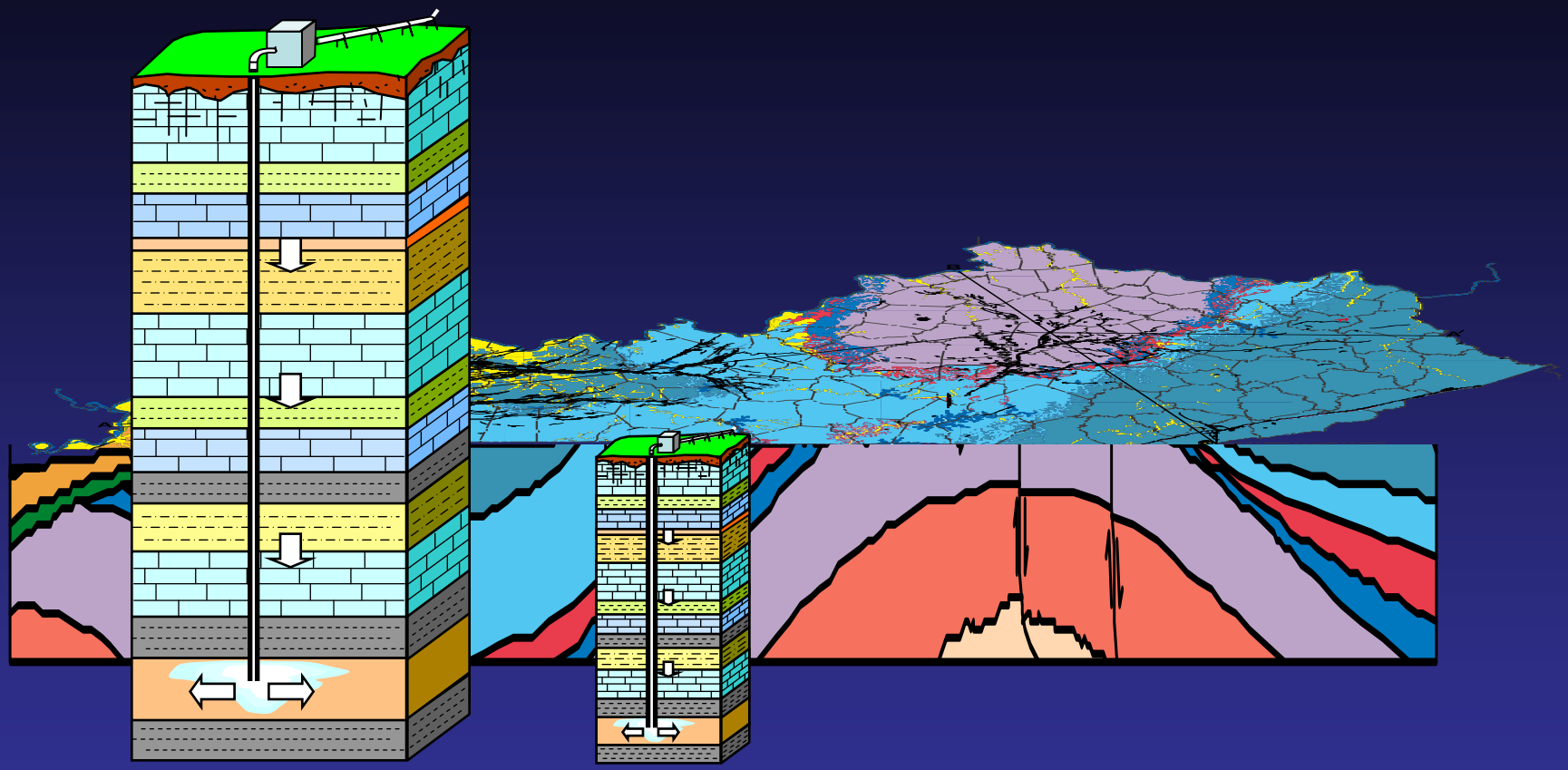
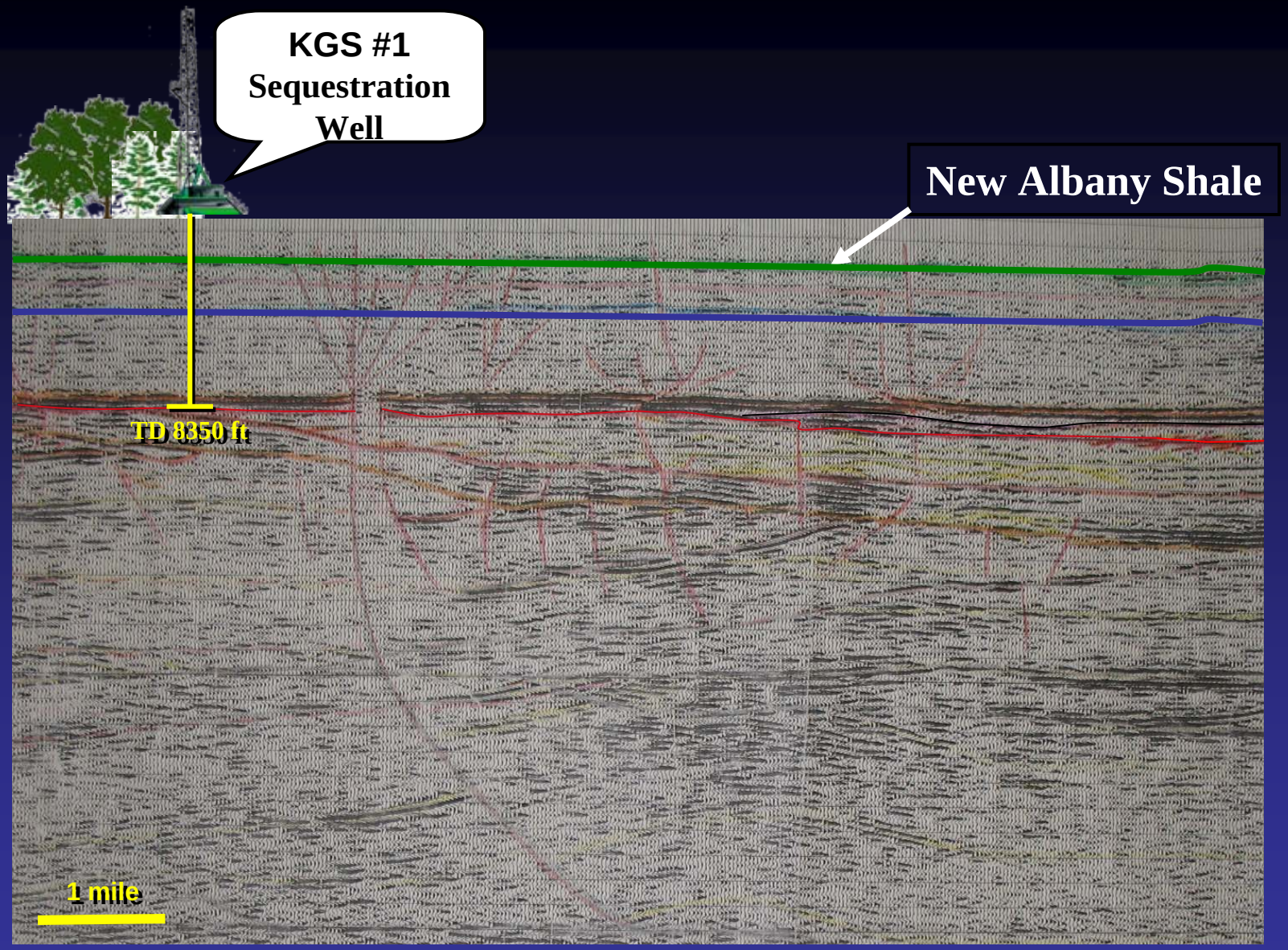






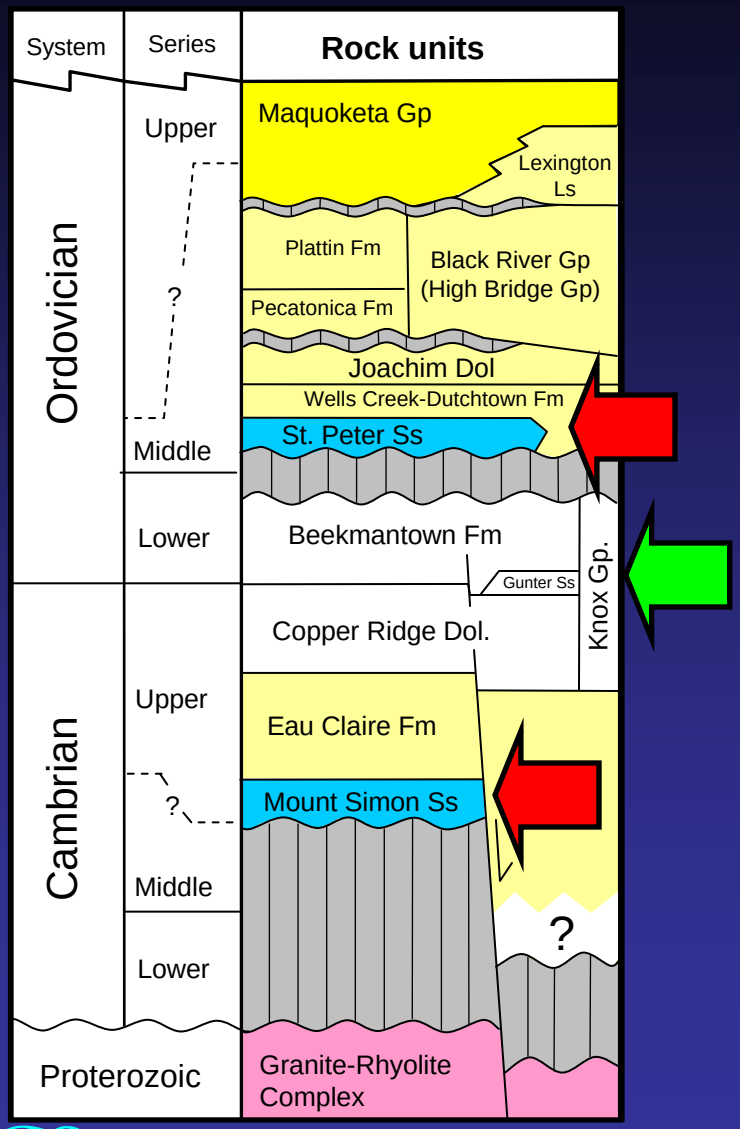
North-South Seismic Line Hancock County showing sequestration research in deep saline reservoirs

Project Goals

- Demonstrate CO_2 storage in deep saline reservoirs
- Demonstrate reservoir sealing strata for long-term CO_2 storage
- Demonstrate technologies for evaluation of CO_2 storage in Kentucky
- Publish the results
- Accomplish this project with consideration of the interests and concerns of landowners, industry, government agencies, and the citizens

KGS

Potential Reservoirs for CO2



Regional saline reservoirs:

- Mt. Simon Sandstone
- Knox Group dolomites
- St. Peter Sandstone

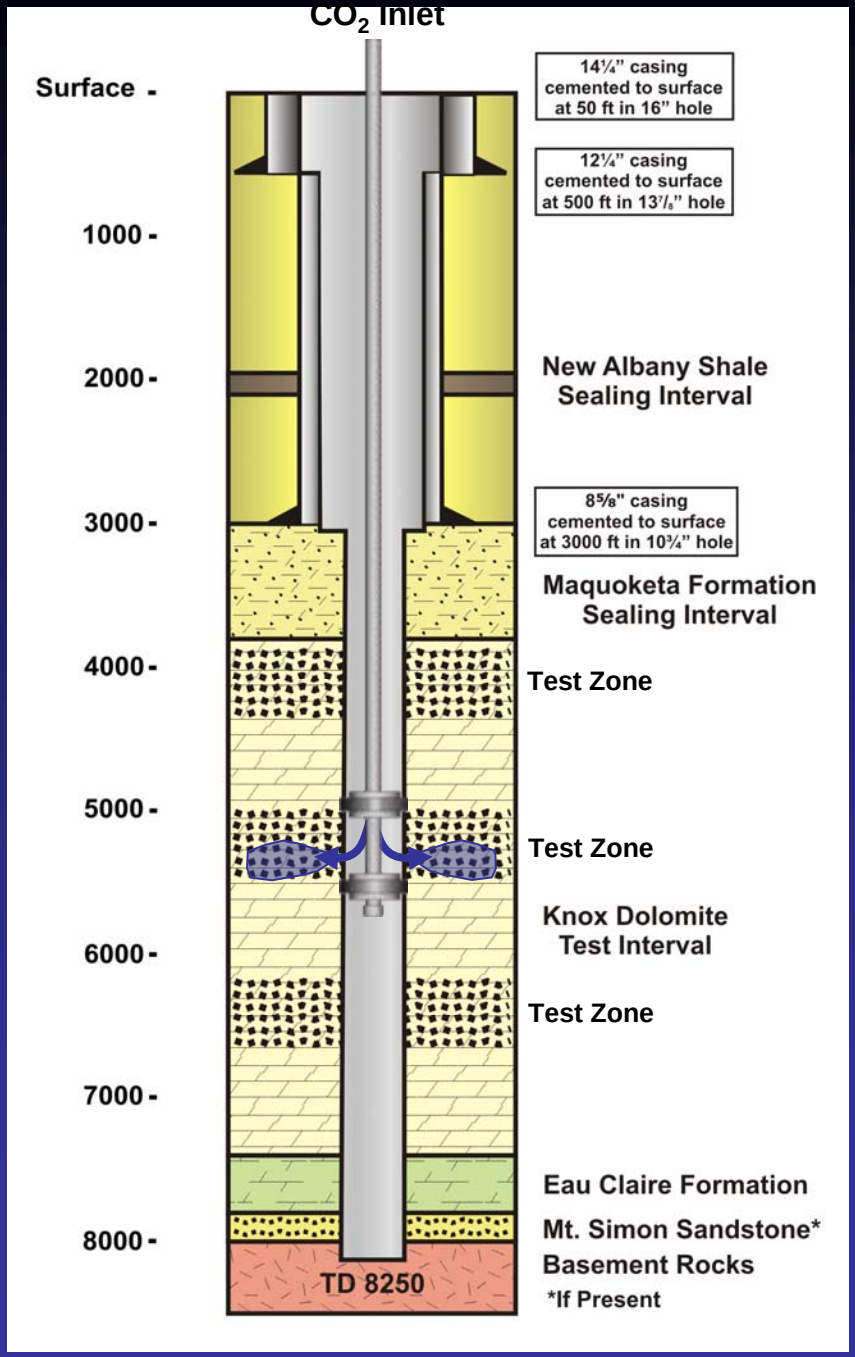
Potential CO_2 sinks/ reservoirs

Sealing interval

Missing section

Sink or seal (*depends on location*)

Metamorphic and igneous rocks (*mostly seal*)



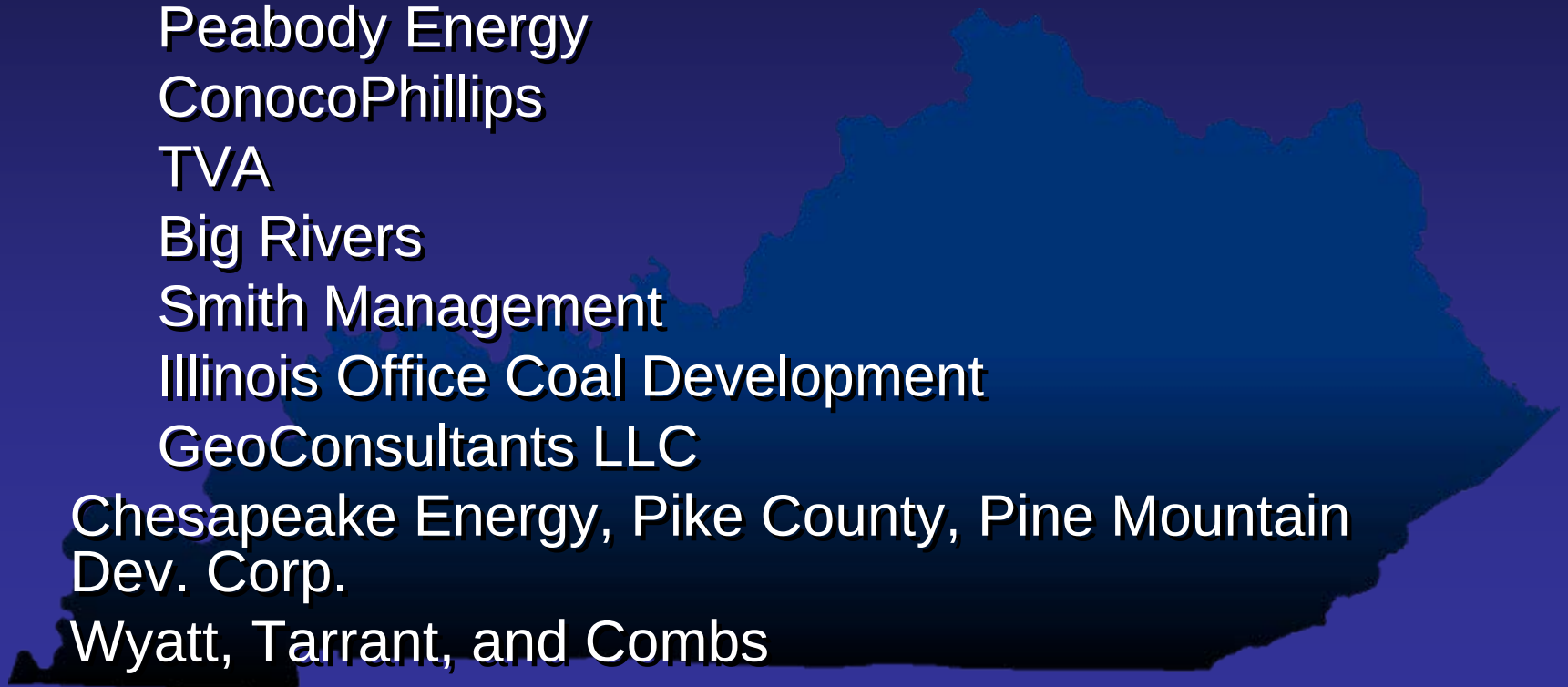
Testing Program

- Testing from the deepest formation up to casing
- Test intervals will be isolated by packers
- Units will be tested with brine injection
- Favorable units tested by injection of CO_2
- Well will be plugged and abandoned

KGS #1 Wellsite Construction Program

Partners in Kentucky Sequestration Research

- Energy and Environment Cabinet
- University of Kentucky
- Kentucky Geological Survey
- Western Kentucky Carbon Storage Foundation
  - E.ON U.S.
  - Peabody Energy
  - ConocoPhillips
  - TVA
  - Big Rivers
  - Smith Management
  - Illinois Office Coal Development
  - GeoConsultants LLC
- Chesapeake Energy, Pike County, Pine Mountain Dev. Corp.
- Wyatt, Tarrant, and Combs
- Hancock Co



Take away Message

I. Global climate change is a political reality

II. Legislation requiring CCS is likely

III. Affects on Kentucky will be large

IV. Geological sequestration is a possibility but unproven

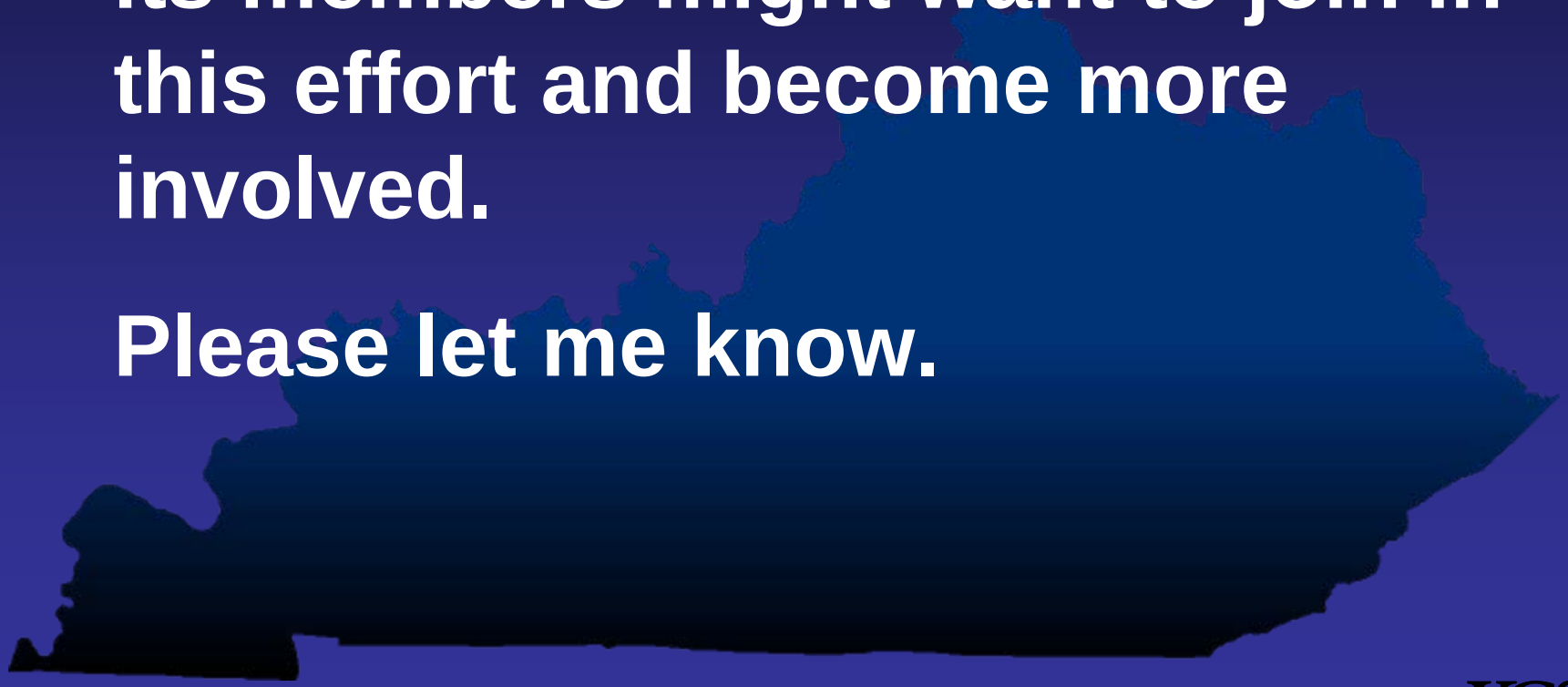
V. Costs for electric generation will go up

VI. Research is being done at CAER, KGS, etc.

VII. More should be done

The Kentucky Association of Rural Electric Cooperatives and its members might want to join in this effort and become more involved.

Please let me know.



Thank You