National Energy Technology Laboratory
U.S. Department of Energy

Renewable Energy From Organics Recycling

Analyzing the Global Impacts of Reuse Technologies

James Ekmann, Associate Director, Office of Systems and Policy Support.

Who is NETL?

What the NETL Is

- **One of DOE's 15 national laboratories**
- **Government owned and operated**
- **Sites in Oklahoma, Pennsylvania, West Virginia, and Alaska**
- **Over 1,000 federal and support contractor employees**

What the NETL Does

Shape, fund, and manage extramural RD&D

- 1,100 research activities in all 50 states and 26 countries
- Primarily funded through competitive procurements
- Regional development

Conduct on-site research

- Involves 1/3 of staff
- Research and development
- Science and technology

Support technology policy development

- Key issues in production and use of fossil fuels
- Climate change policy support
- International projects in 26 countries

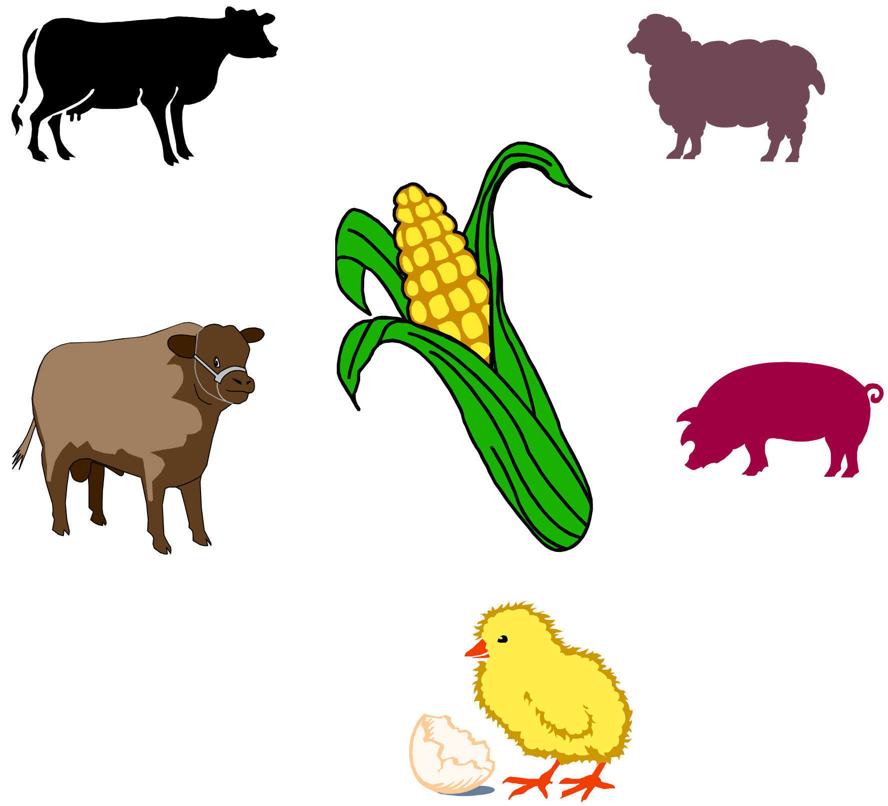
What is a “reuse” technology?

Reuse Energy Technologies

- **The definition of *"reuse"* as a recycling term: To use a product repeatedly in the same form (e.g.: glass bottles, cloth diapers)**
- **The definition of the term "*reuse technology*" from an Agri-Energy viewpoint can be: the use of energy conversion technologies that utilize the energy content of these agricultural by-products, fuel feed stocks and wastes.**
- **Energy conversion can produce heat, electricity, gas fuels and liquid fuels. Solid residues remaining can be applied or reused in other areas of the "farm" as value added products such as fertilizer or compost.**

Support for the Increased Use/Reuse of Biomass

- **Biomass is stored solar energy that can be converted to electricity or fuel.**
- **Increased use of biomass for energy would lead to reductions in greenhouse gas emissions, enhanced energy security, new opportunities to improve rural economies, and the potential for new <u>American</u> industries.**



Benefits of Producing Biomass

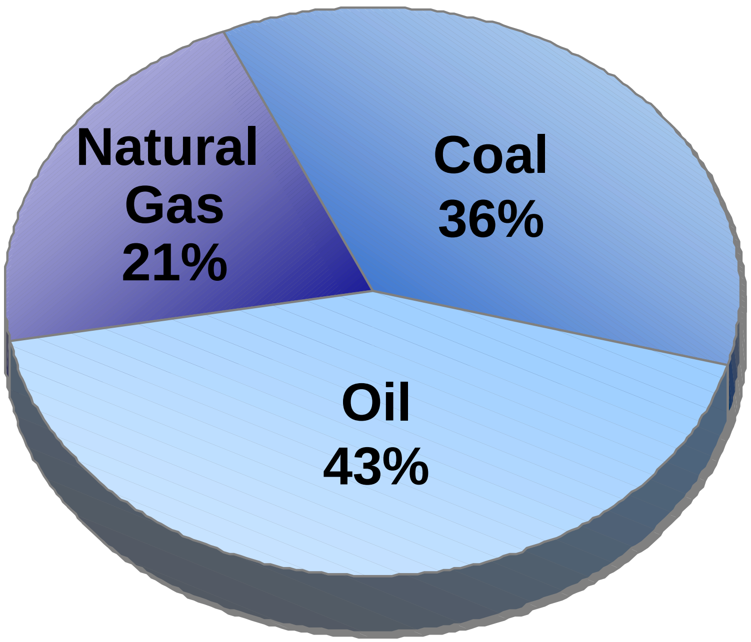
- **Biomass: Best potential of any renewable energy resource for base load electric power production.**
- **Biomass: Renewable resource with the most promise for producing economical and competitively priced liquid transportation fuels.**
- **The Electric Power Research Institute: Producing 5 quads of electricity from biomass grown on 50 million acres would increase farm income by $12 billion annually.**

Fossil Fuels remain dominant energy resource

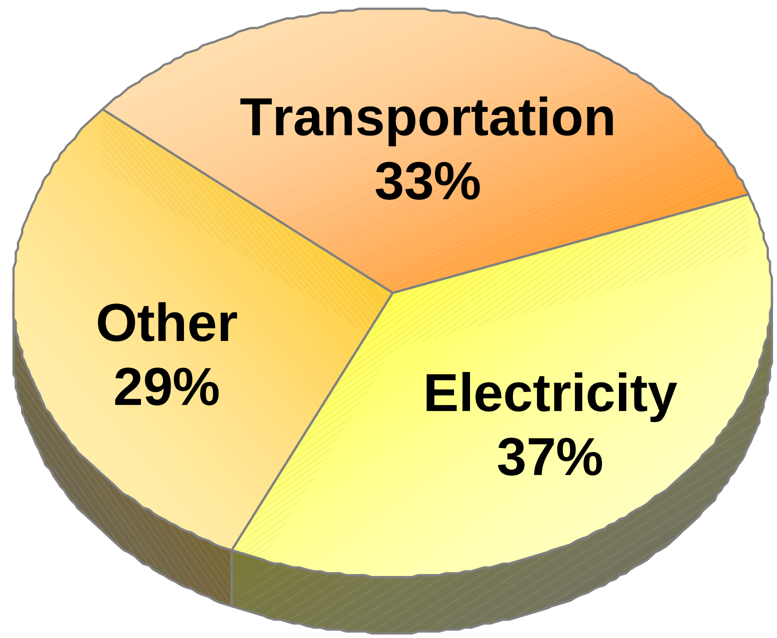
All Fossil-Based Sources and Uses Contribute

1999 U.S. CO_2 Emissions From Energy

Fuel Sources

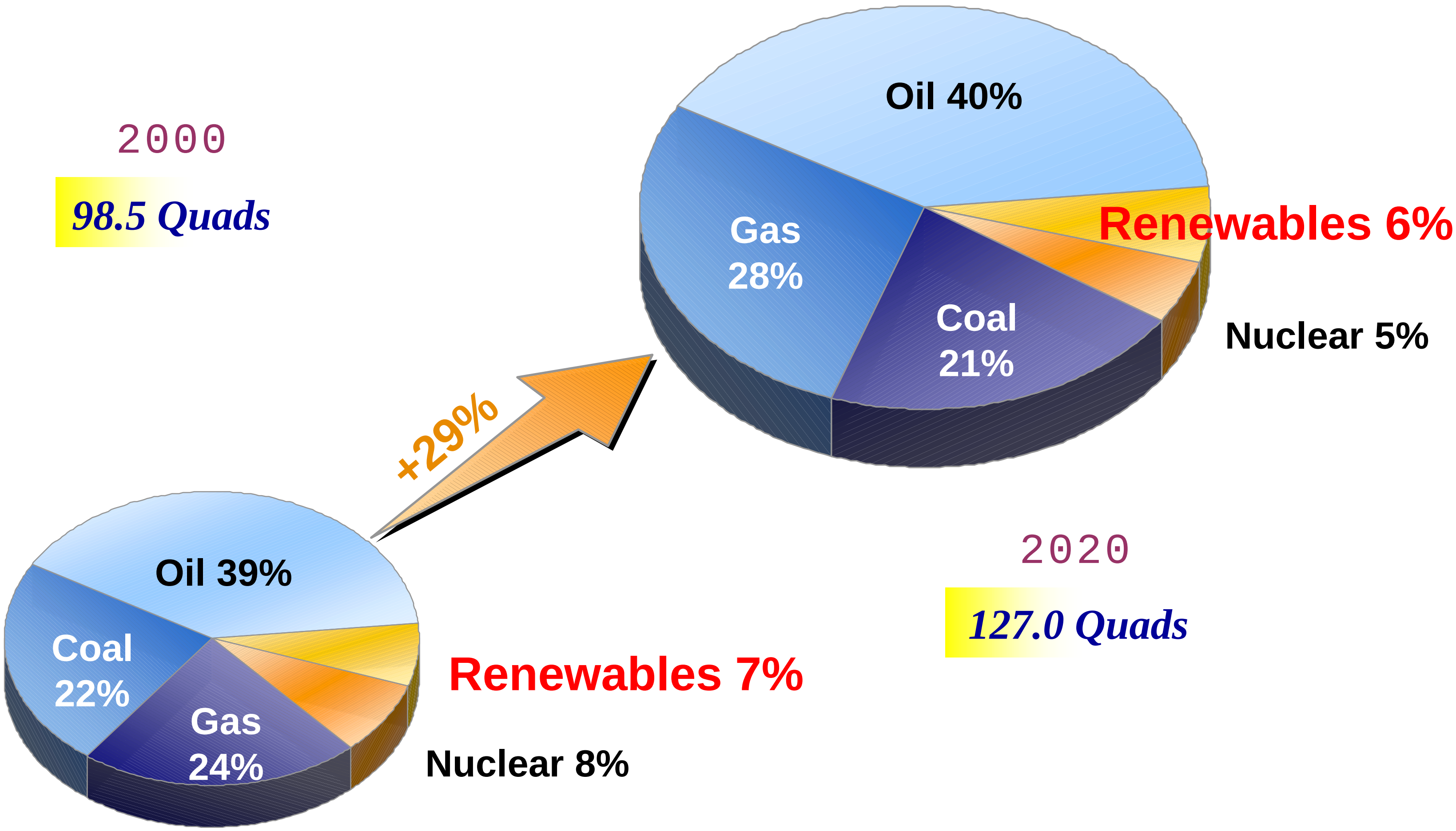


End Uses



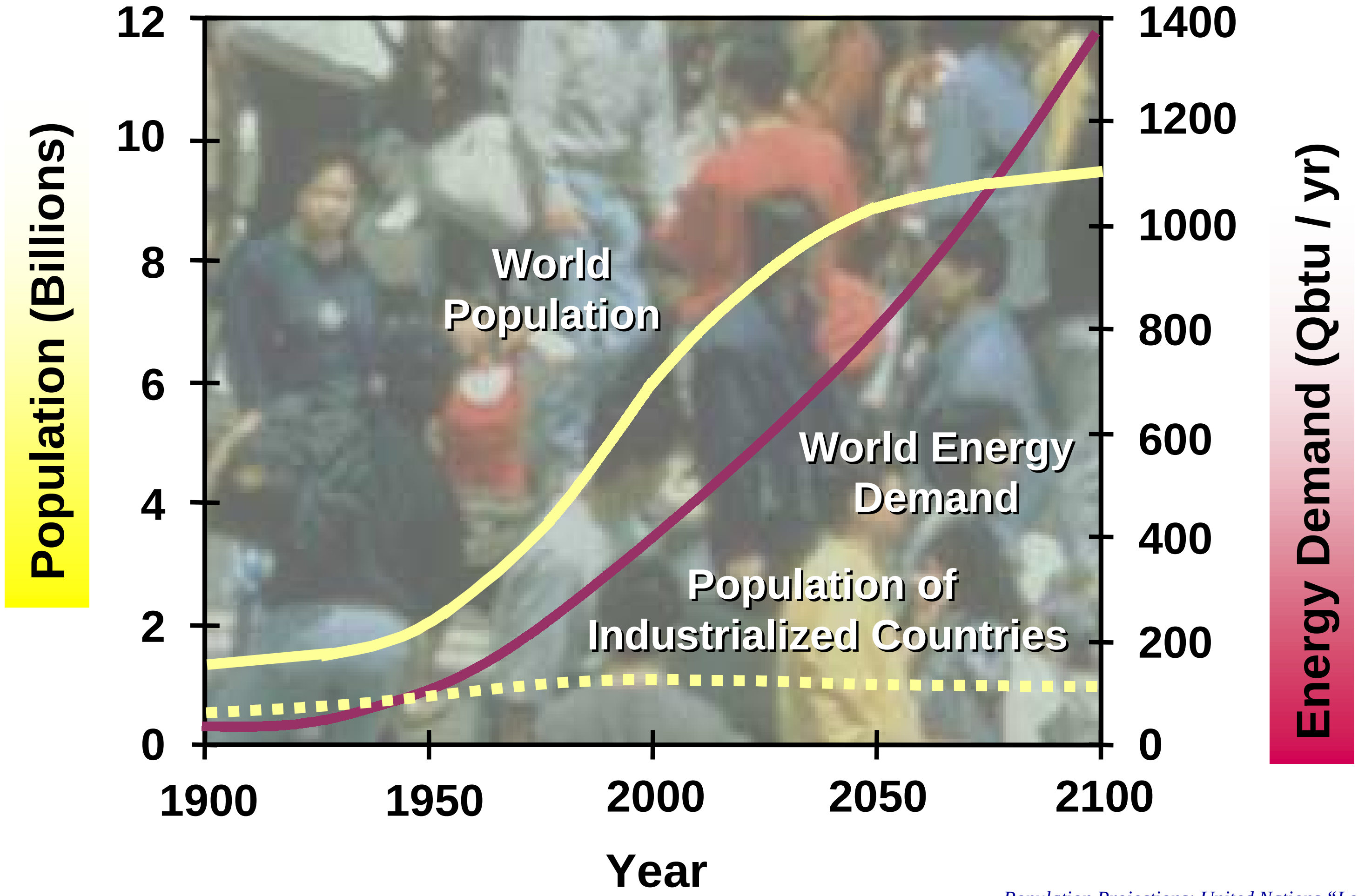
AEO 2001, Table A19

America's Energy Foundation



Source: DOE/EIA

Looking Further Ahead . . .



Population Projections: United Nations "Long-Range World Population Projections: Based on the 1998 Revision"

Energy Projections: "Global Energy Perspectives" ITASA / WEC

Fossil and Alternate Methane Fuel Resources Abundance

Proved Recoverable World Reserves

Natural Gas,
More Than 5,000Tcf

Coal
984 Billion tons

Oil
Just over I Trillion Barrels

Estimated World Resource

Methane Hydrates
Up to 270 Million Tcf

World Energy Council
1998 Survey of Energy Resources

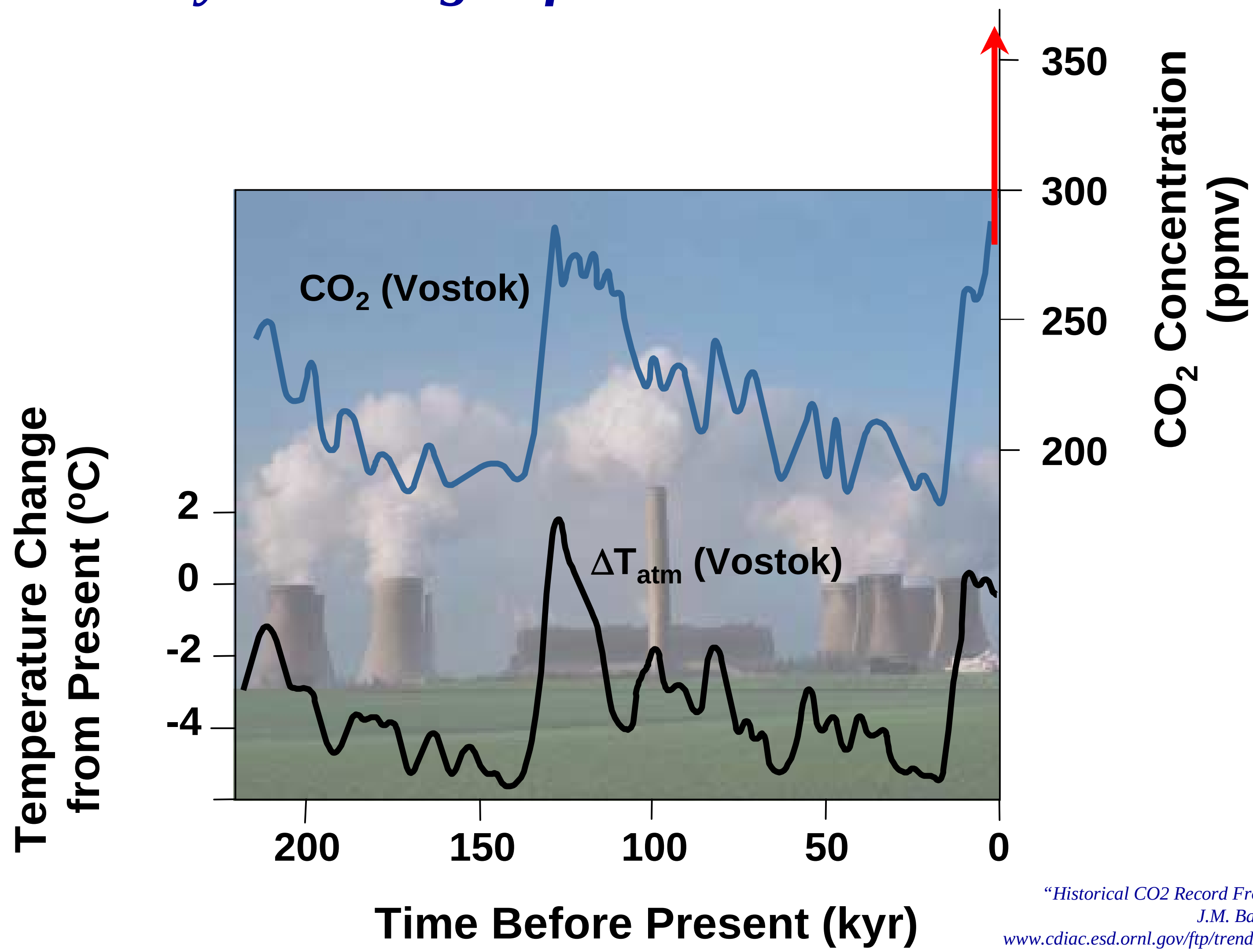
U.S. Anthropogenic Methane Resources

Landfills Methane 51.4 MMTCE

Agricultural Methane Emissions 53.6 MMTCE

But concerns over rising GHG emissions require us to look at all possible low carbon energy sources to assist in efforts to stabilizer atmospheric concentrations of GHGs.

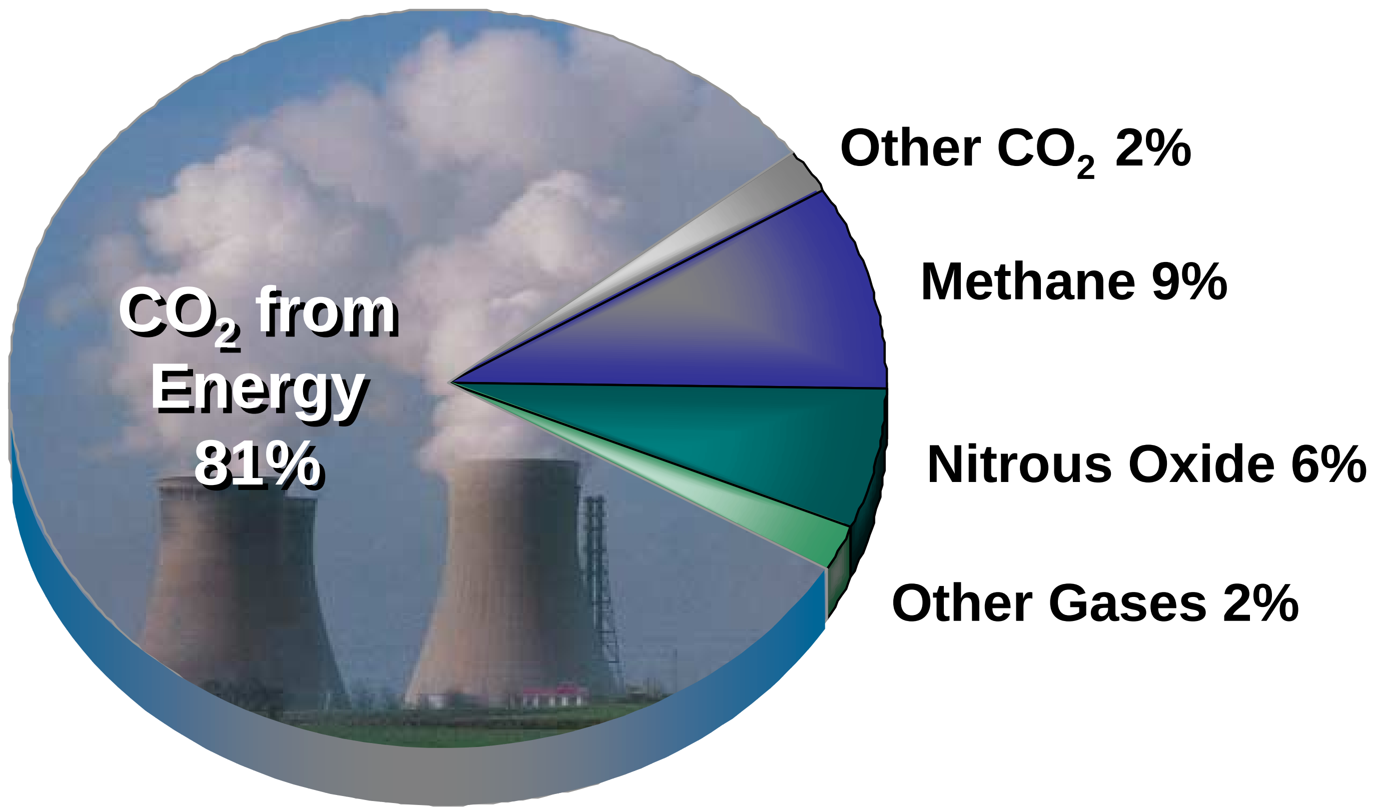
Global CO_2 Concentrations
Beyond Range of Natural Occurrence



"Historical CO2 Record From the Vostok Ice Core"
J.M. Barnolo et al, August 1999
www.cdiac.esd.ornl.gov/ftp/trends/co2/vostok.icecore.co2

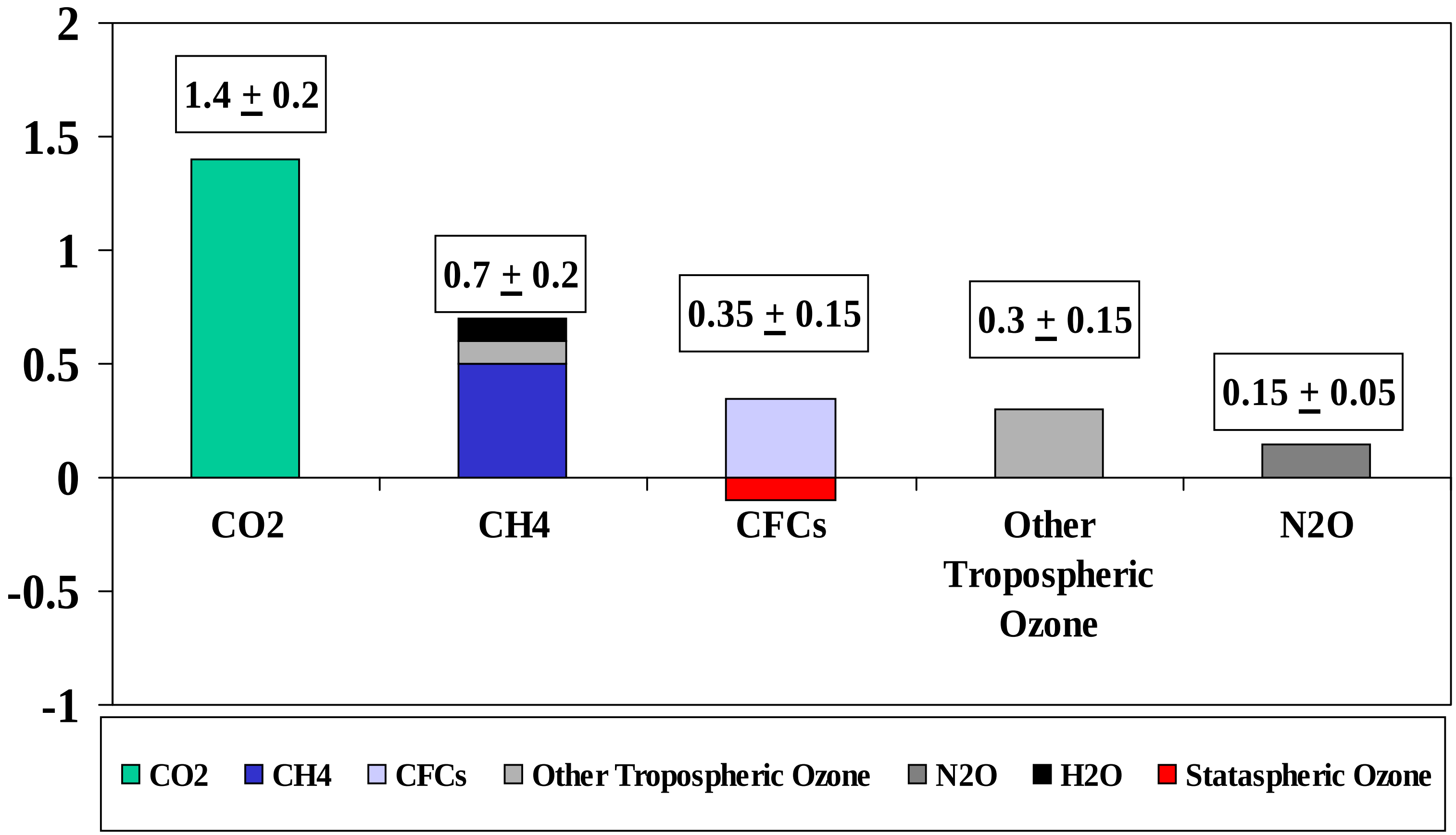
CO_2 From Energy Is Major Contributor

U.S. GHG Emissions Weighted by Global Warming Potential



Source: EIA Report #EIA/DOE-0573 (98)
"Emissions of Greenhouse Gases in the U.S.: 1998 Executive Summary" (Nov. 99)

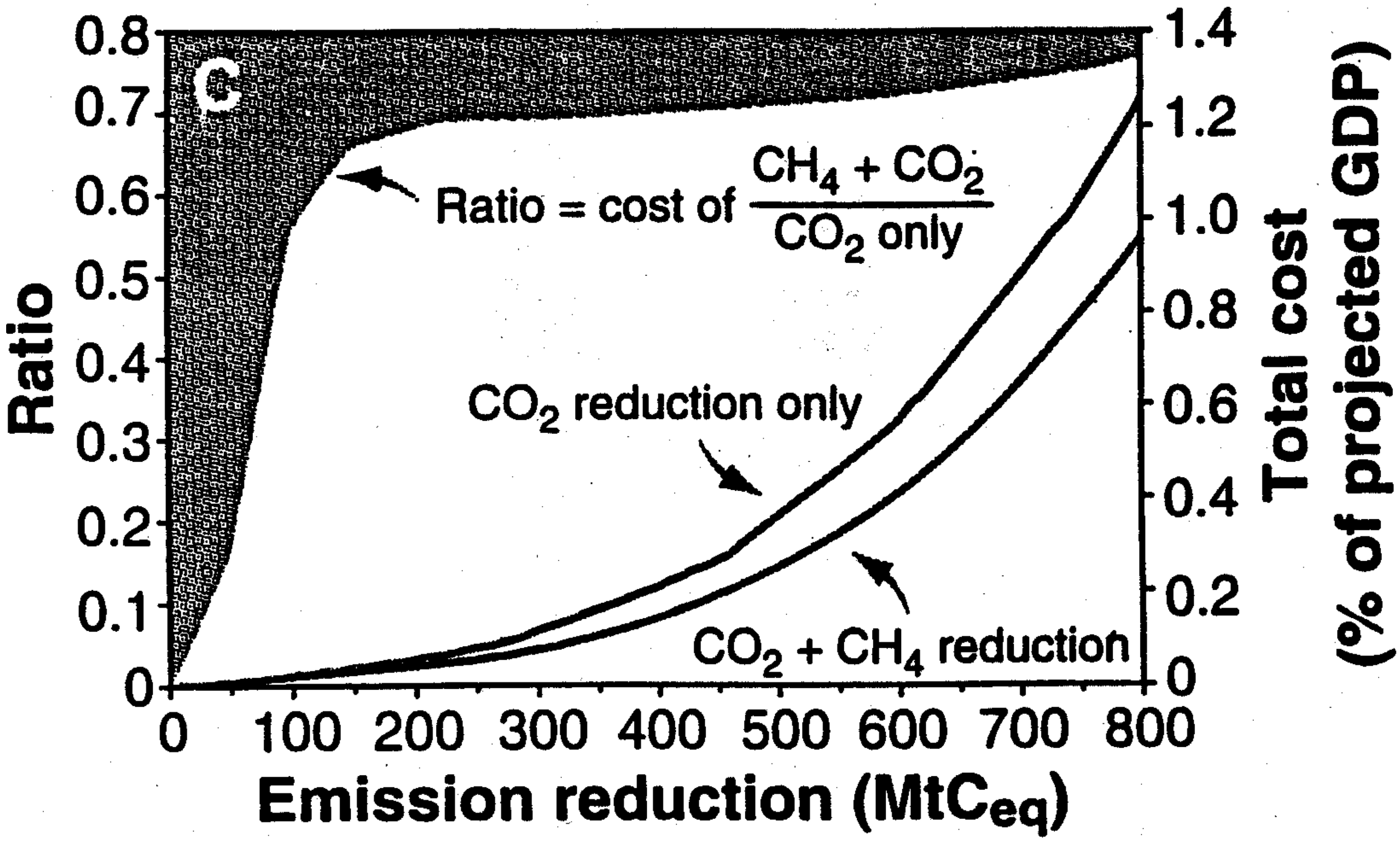
ESTIMATED RADIATIVE FORCINGS OF GHGs BETWEEN 1850 and 2000, W/m^2



Hansen, et al., 2000

COST EFFECTIVENESS OF CARBON REDUCTION

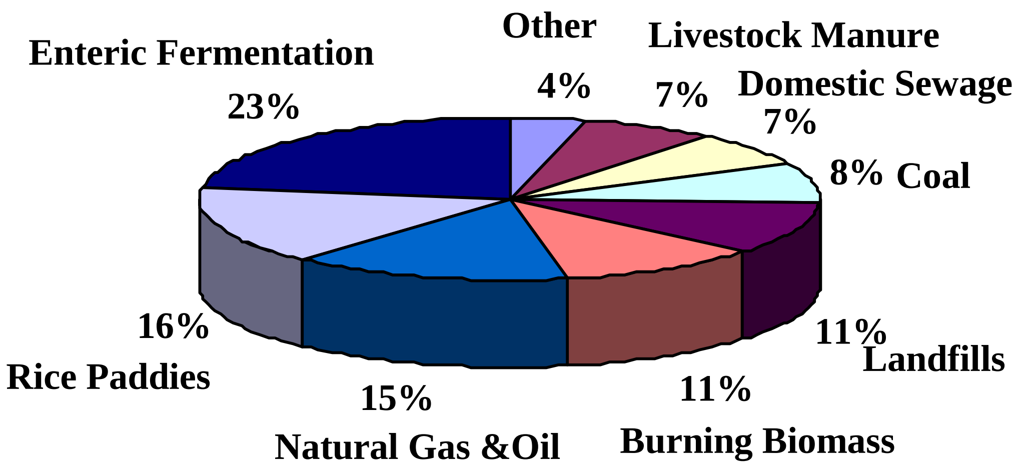
(Hayhoe, et al, Science, (286), 905-906, 1999)



GHG pluses and minuses from “organics recycling”

Methane Emissions

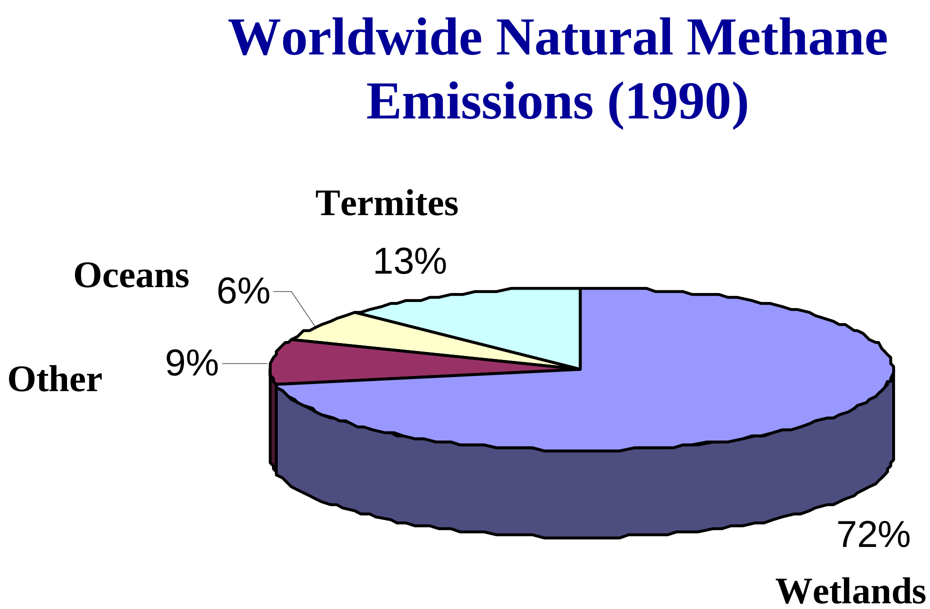
Worldwide Anthropogenic Methane Emissions (1990)



Total =2.,150 MMTCE

(IPCC, 1995-1996)

Methane Emissions

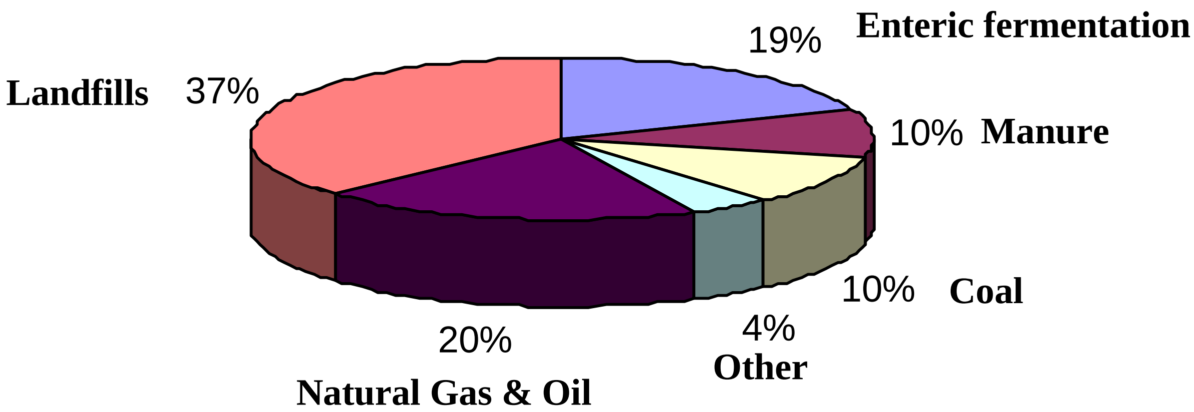


Total = 916MMTCE

(IPPC, 1995-1996)

U.S. Methane Emissions

Source Breakdown of 1997 U.S. Methane Emissions



Total = 179.6 MMTCE
(EPA, 1999)

Methane From Agricultural Activities

- Manure management
  - Quantity varies by animal type,
    - a 1400 pound cow produces about 110 pounds/per/day,
    - a 180 pound hog produces around 11 pounds /per/day

Methane Emissions From Livestock Manure MMTCE (EPA,1999)

Animal Type	1993	1994	1995	1996	1997
Dairy cattle	4.4	4.5	4.6	4.5	4.6
Beef cattle	1.2	1.2	1.3	1.3	1.3
Swine	8.6	9.1	9.2	8.9	9.3
Sheep	0.0	0.0	0.0	0.0	0.0
Goats	0.0	0.0	0.0	0.0	0.0
Poultry	1.6	1.7	1.7	1.7	1.8
Horses	0.2	0.2	0.2	0.2	0.2
Totals	*16.1*	*16.7*	*16.9*	*16.6*	*17.0*

Thorough analysis of the impact of reuse versus other use options and other fuels is key to making progress in achieving atmospheric stabilization

Sequestration is one of three elements in an effective greenhouse gas mitigation strategy.

DOE's Portfolio of Energy Technologies

Reliable & Diverse Energy Supply

- Enhancing domestic supplies
- Producing clean fuels

Clean & Affordable Power

- Advanced power systems
- Enhancing energy systems reliability

Efficient & Productive Energy Use

- Clean & efficient vehicles
- Efficient & affordable buildings
- Clean & productive industries

Hybrid Fossil and Renewable Systems

Hybrid systems provide power 24/7

NETL's Sequestration Program

Direct Sequestration

- CO_2 separation and capture
- Sequestration in geological structures
- Deep Ocean sequestration

Indirect Sequestration

- Integration of energy production systems with terrestrial sinks

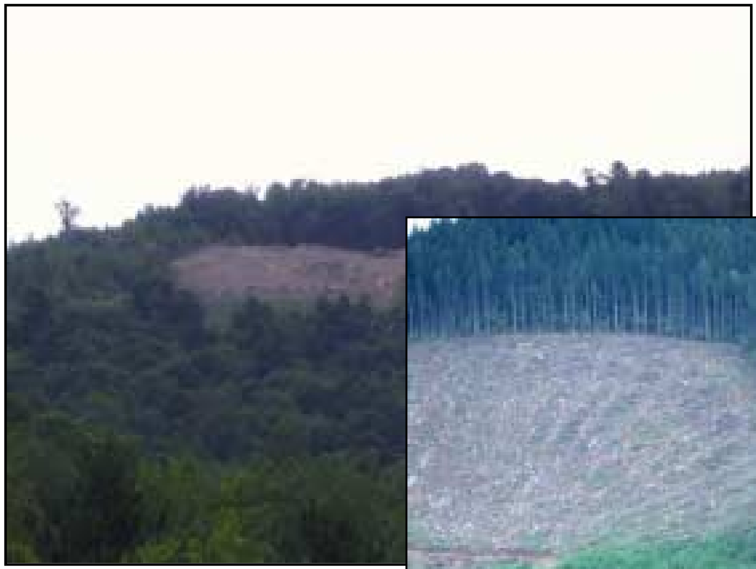
Crosscutting

- Advanced chemical and biological concepts
- Modeling and assessments

Terrestrial Sequestration

- **Stephen F. Austin State University**
  - Evaluate reclamation and reforestation of abandoned mine lands in the Appalachian region to sequester carbon and develop a CO_2 trading system.

- **Tennessee Valley Authority**
  - Evaluate the application of coal combustion byproducts as soil amendments for reclaiming abandoned mine lands for subsequent CO_2 storage.



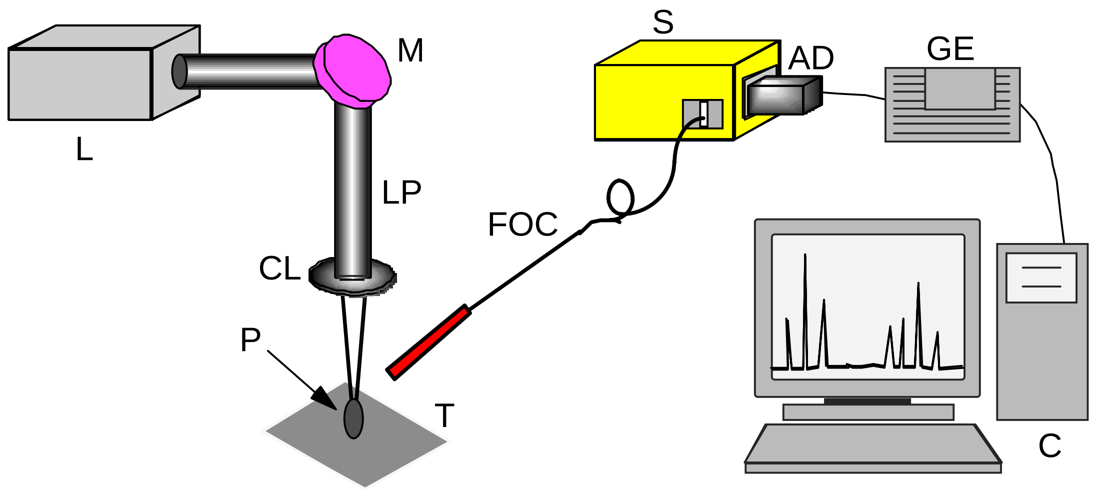
Enhancing Carbon Sequestration and Reclamation of Degraded Lands

- **Oak Ridge/Pacific Northwest National Laboratories**
  - Collaborate with The Ohio State University and Virginia Polytechnic Institute
  - A 2-year effort to investigate the use of soil amendments from coal plants, paper mills, and sewage treatment to improve CO_2 sequestration of degraded lands.

The LIBS Method

- laser pulses are fired on the target to form a plasma
- the plasma light is collected and spectrally resolved
- elements are identified by their spectral signatures

L=laser; M=mirror; LP=laser pulse; CL=converging lens; P=plasma; T=target; FOC= fiber optic cable; S=spectrograph; AD=array detector; GE=gating electronics; C=computer.



Emission Life Cycle Assessment

- Pollution prevention might not normally be adopted as a first choice of environmental management. Environmental costs of non-prevention approaches and the economic benefits of pollution prevention could have potential added cash savings from a project.
- Encourages and motivates the decision makers to understand the full spectrum of environmental costs, and integrates these costs into decision making.
- Adoption of environmental accounting techniques increases visibility of environmental costs
- Environmental accounting can provide the opportunity to:
  - significantly reduce or eliminate environmental costs,
  - improve environmental performance, and
  - gain competitive advantage.

Emission Life Cycle Assessment

- **GHG emissions can vary widely over different stages in the life cycle of most products and processes.**
- **Use of dedicated biomass or reuse of wastes should be compared to benefits of sequestration including enhancing soil quality.**
- **Accounting for GHG emissions from upstream and downstream activities along the life cycle of the product or process can add to an additional cash value to these emissions in a life cycle assessment**
- **At this time it is not possible to predict the exact pricing, accounting and reporting requirements of the future, as national regulatory issues concerning GHG emission trading are still evolving**

National and Regional Greenhouse Gas Emissions Trading

- **Project developers may target greenhouse gas emission reductions as a primary goal.**
- **Others pursue other goals (such as odor control or energy savings), and see greenhouse gas emissions reductions as collateral benefit.**
- **Quantification, documentation and reporting of emission reductions can provide flexibility to meet future obligations and opportunities.**
- **Measurement and reporting in today's pre-policy context is critical to provide market credibility, and to establish a record from which to make claims once policy is established.**

Technology Transfer For Carbon Mitigation: Driving Factors

- **Growing value of greenhouse gas emission (GHG) reduction credits**
  - **About 70 million metric tons carbon traded annually**
  - **Current volume expected to more than double over the next ten years - even in the absence of Kyoto Protocol**
  - **Trading range of US$0.25-$10 per metric ton carbon dioxide equivalent**
    - **mostly "forward" trades or options**
  - **German firm recently offered $5 per ton for up to 5 million tons of U.S. reductions**
  - **Early market participants include: Alcan, British Petroleum, Dupont, Trans Alta, Ontario Power Generation, Pechiney, Shell and Suncorp**

Growth in Biomass/ Renewable Produced Energy

•U.S. electricity generation from the renewable energy sources (geothermal, biomass, digester gas, landfill gas, and wind) projected to grow from 77 billion kilowatt hours in 1999 to 146 billion kilowatt hours in 2020.

•Biomass is projected to enjoy the largest increase among renewable energy sources, rising by 80 percent and reaching 65.7 billion kilowatt hours in 2020.

Worldwide, renewable energy use is expected to increase by 53 percent between 1999 and 2020, but the current 9-percent share of renewables - largely from hydroelectric facilities - in total energy consumption is projected to decline slightly, to 8 percent in 2020

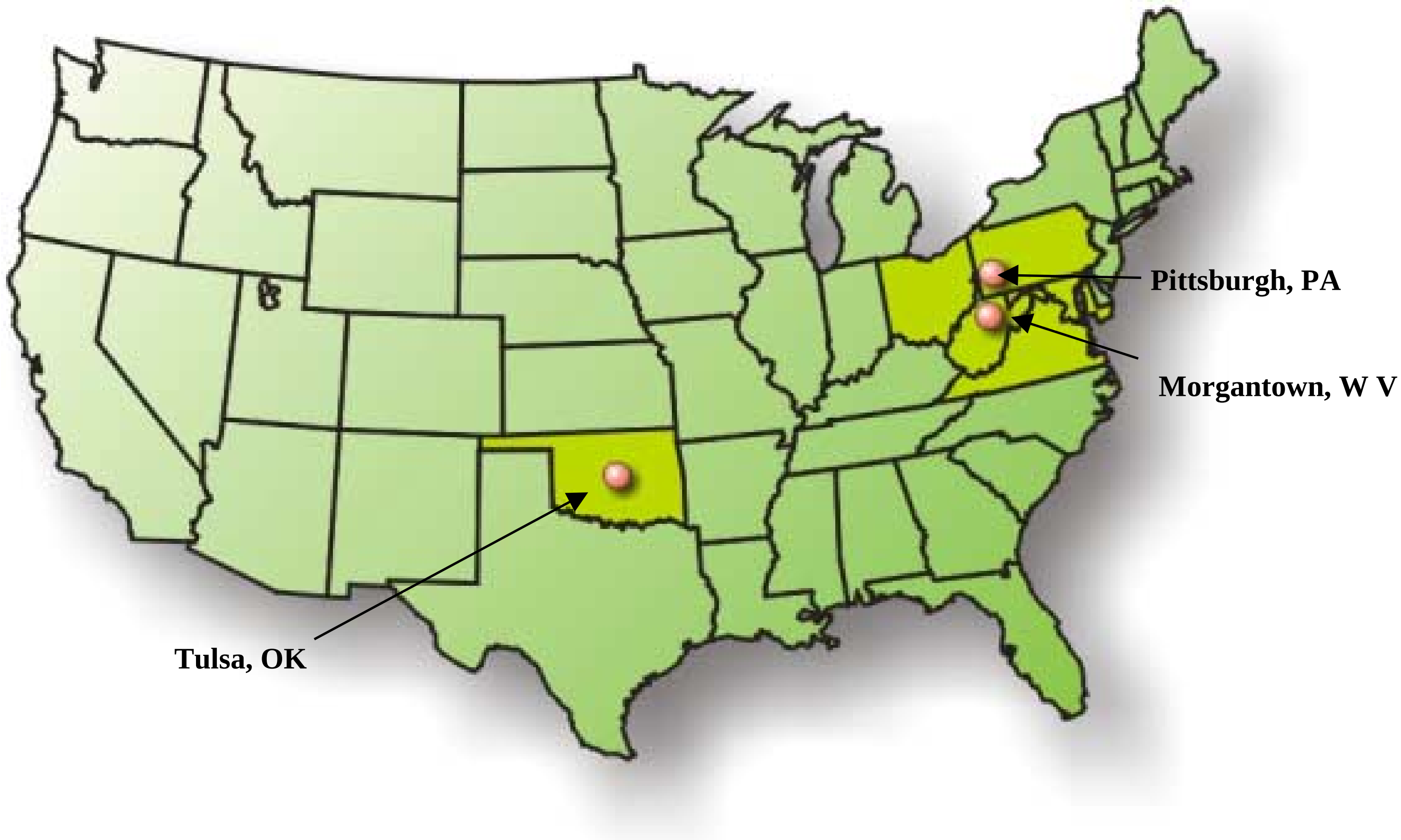
Advanced Technologies Will Play a Crucial Role in Addressing Environmental, Supply, and Reliability Constraints of Producing and Using The Nations Various Energy Resources

SUMMARY

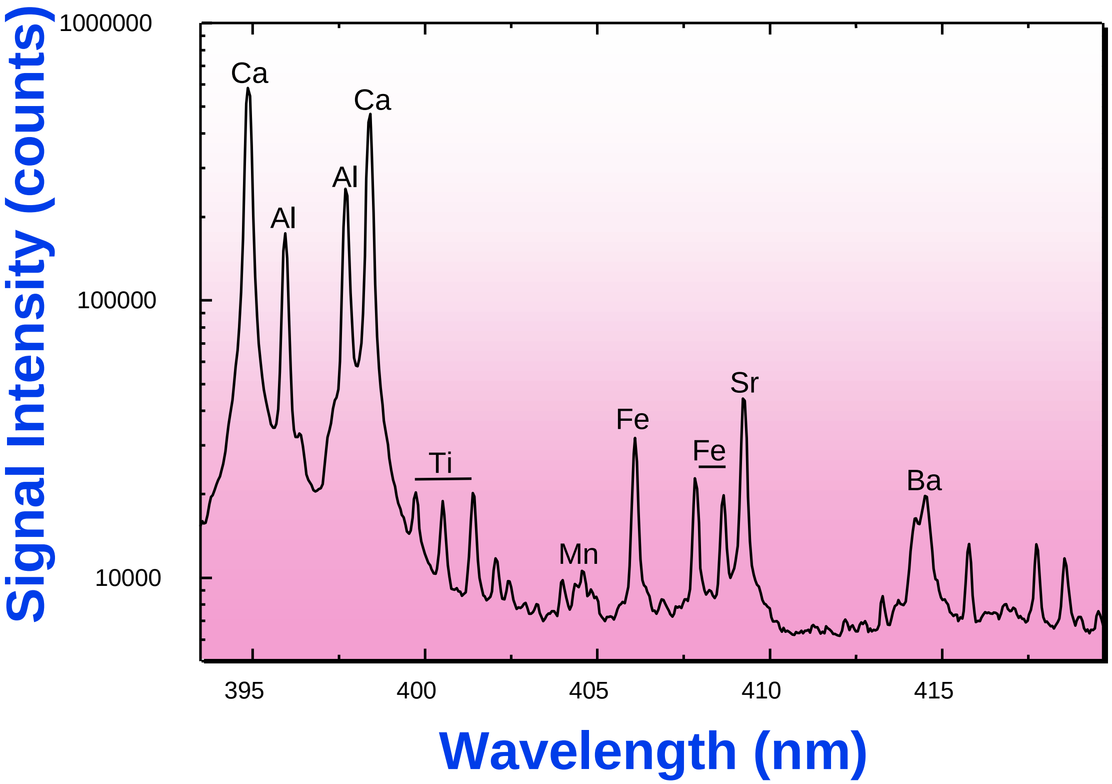
- Opportunities exist to generate energy from organic material recycling.
- This energy resource may find use in both conventional and emerging technologies.
- Analyses of options - reuse versus terrestrial sequestration for example - should examine environmental, economic, and social impacts.
- Life cycle analysis is useful tool for exploring impact and benefit.

Thank you!

National & Regional Development
Three Present Locations

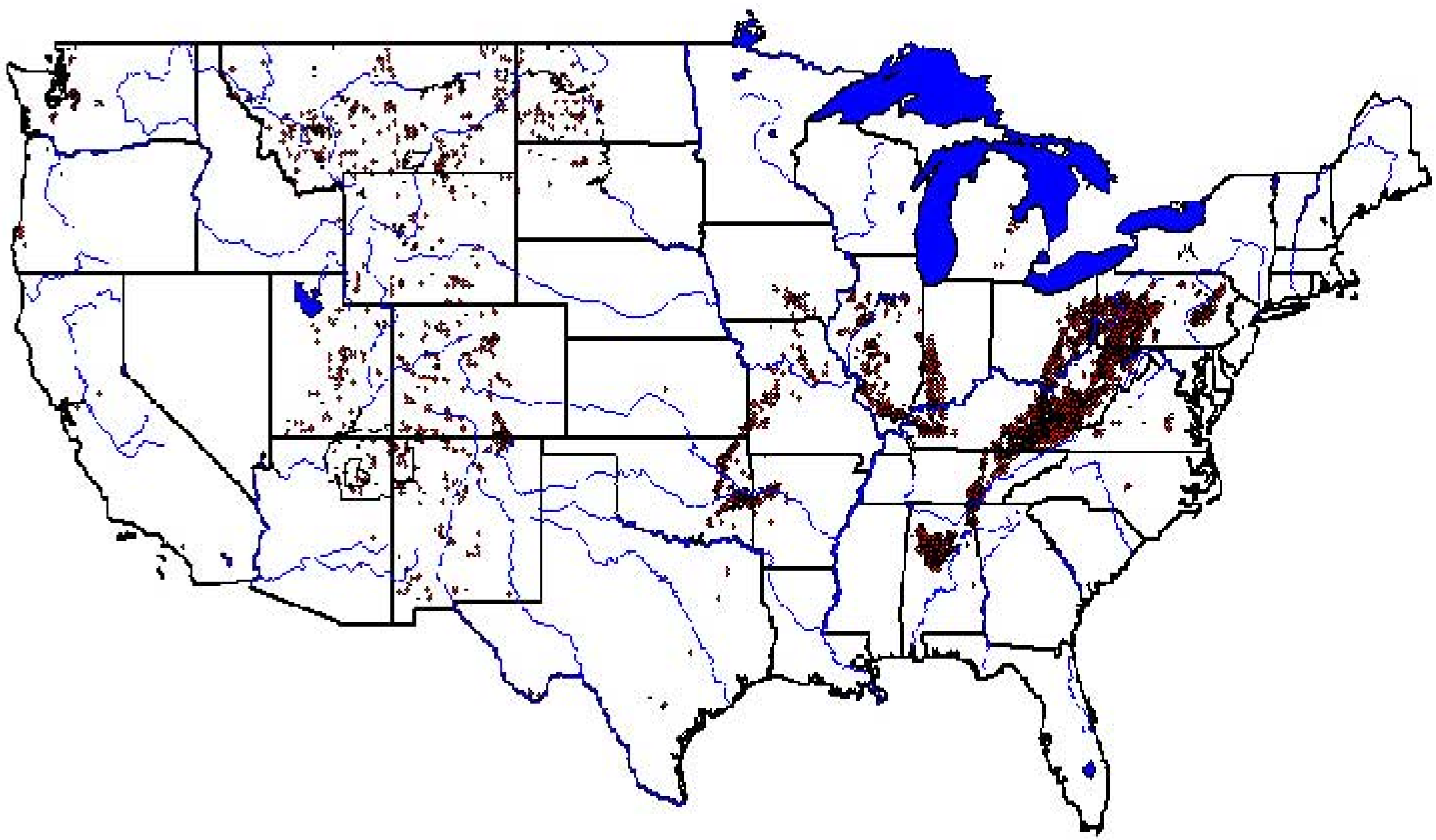


LIBS Spectrum of Soil



Note: Only the blue spectral region is shown here. Other regions can be monitored to determine other elements.

Locations of AML Problems Eligible for OSM Funding



Source: www.osmre.gov

Aerobic Wetland

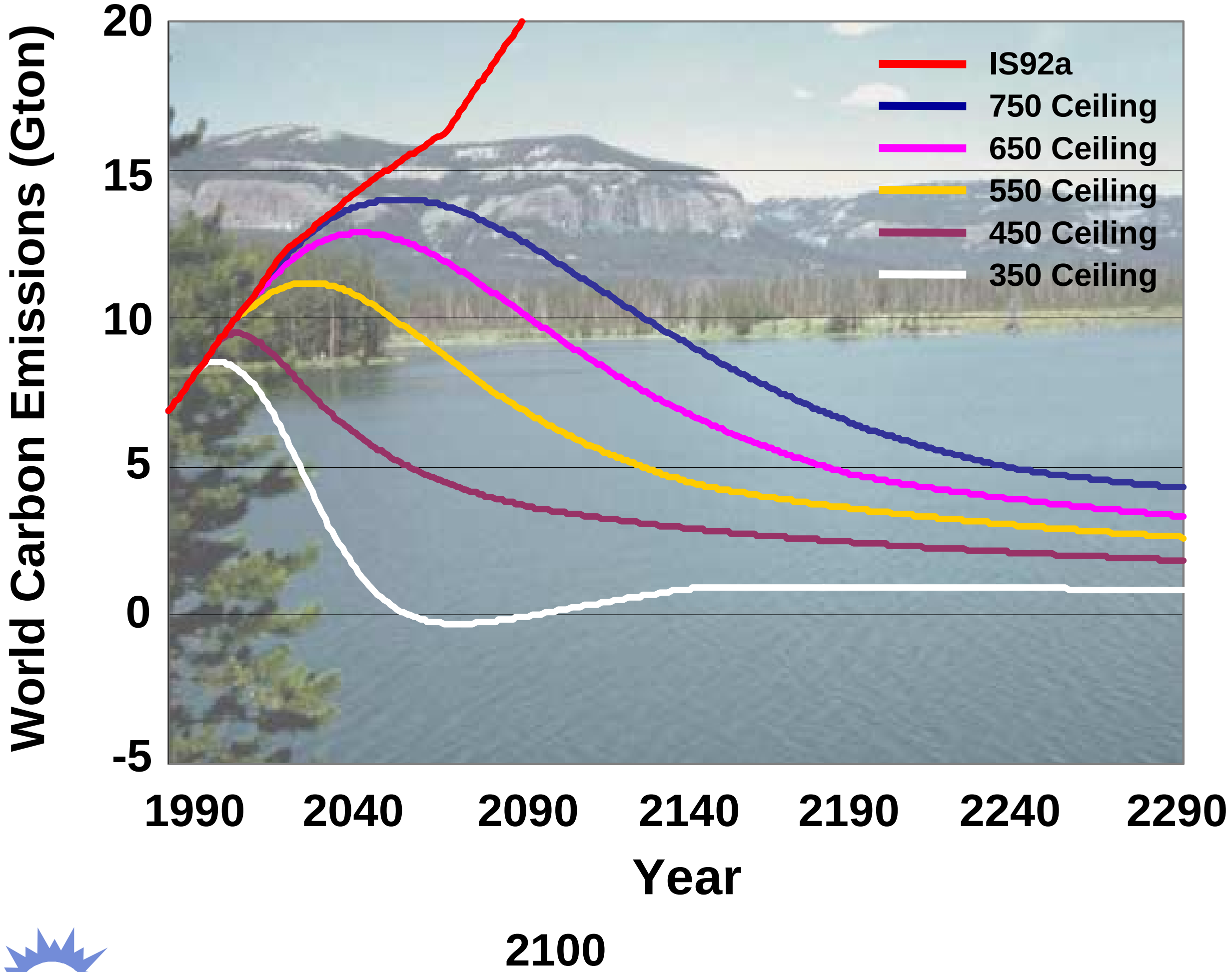
ESTIMATED GLOBAL WARMING POTENTIAL VALUES FOR 100 YEAR TIME HORIZON

GHG SPECIES	GWP VALUE
CO_2	1
CH_4	21
HFCs	140-11,700
SF_6	23,900
PFCs	6,500-9,200
N_2O	290

GLOBAL WARMING POTENTIAL - - A MEASURE OF RELATIVE GHG RADIATIVE EFFECTS

- **Global Warming Potential (GWP) Reflects Cumulative Radiative Forcing of a Species Over a Specified Time Horizon**
- **Kyoto Protocol Requires Use of 100-year Integration Time Horizon to Calculate GWP**
- **Uncertainty Associated with GWP Estimates:**
  - Estimation of Atmospheric Lifetimes of Gases
  - Dependence of Radiative forcing on Concentration in Atmosphere
  - Calculation of Indirect Effects of emitted gases and Subsequent Radiative Effects (e.g., Tropospheric Ozone)
  - Integration time Period
- **GWPs Difficult to Apply to Radiatively Important Species Unevenly Distributed in the Atmosphere (e.g. Tropospheric Ozone, Aerosols)**

Scenarios to Stabilize CO_2 Concentrations



550 ppmv pathway requires 60% reduction from 1990 levels at steady state

Wigley, T.M.L., Richels, R., and Edmonds, J.A. ***Nature 379****, 240-243 (1996)*

Technology Policy Support

Climate Change is a key issue for Fossil Fuels

- Understand tradeoffs to guide RD&D program development
- Policy support for co-control of GHGs and criteria pollutants
- Contribute to resolution of issues

International Projects: A Critical Element in Addressing Climate Change

- Projects in 26 countries
- Emphasis on developing economies particularly China, India, Latin America
- Promote use of advanced technology from NETL portfolio