All The Greenhouse Gases: Where Do They All Come From?

for presentation at the Global Change Education Program 2000

End-of-Summer Workshop, Oak Ridge, Tennessee, August 2000

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Research sponsored by the Environmental Sciences Division, Office of Biological and Environmental Research, U.S. Department of Energy, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

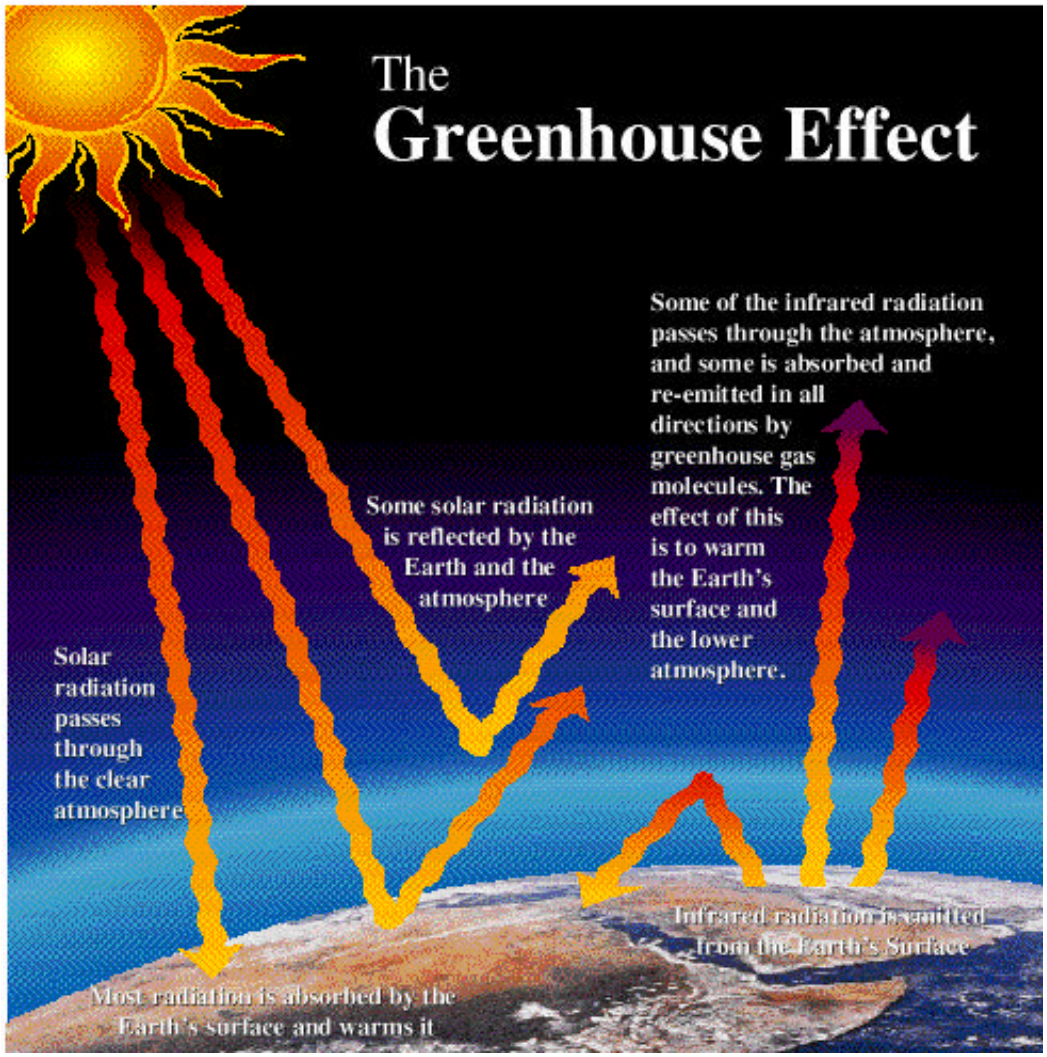
Introduction to CDIAC

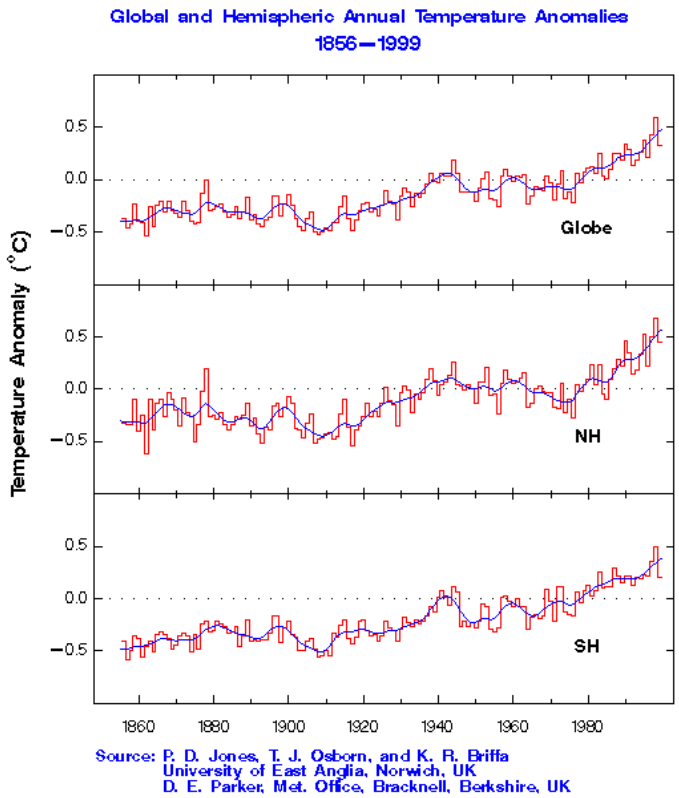
Providing a wide variety of data and information products to the global-change community since 1982, on behalf of the U.S. Department of Energy's Office of Biological and Environmental Research

- **Special emphasis**
  - **Quality assurance**
  - **Documentation**
  - **Derived, integrated products**
- **Focus areas**
  - **Ocean carbon surveys**
  - **Free-Air CO_2 Enrichment (FACE)**
  - **NARSTO**
  - **AmeriFlux**
- **World Data Center for Atmospheric Trace Gases**

  Since 1992, a component of the World Data Center System of the International Council of Scientific Unions
- **User community**

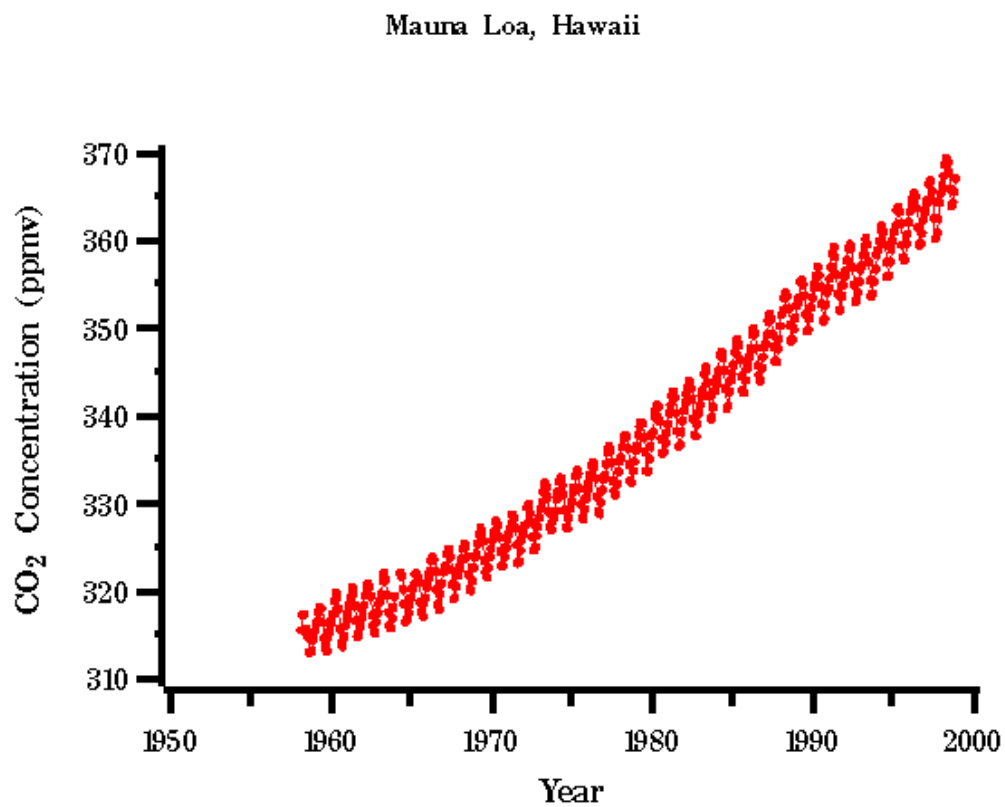
  Many thousands of individuals and institutions around the world


The
Greenhouse Effect
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere
Solar radiation passes through the clear atmosphere
Infrared radiation is emitted from the Earth's Surface
Most radiation is absorbed by the Earth's surface and warms it


Global and Hemispheric Annual Temperature Anomalies
1856—1999
Temperature Anomaly (°C)
0.5
0.0
−0.5
Globe
NH
SH
1860
1880
1900
1920
1940
1960
1980
Source: P. D. Jones, T. J. Osborn, and K. R. Briffa
University of East Anglia, Norwich, UK
D. E. Parker, Met. Office, Bracknell, Berkshire, UK

Greenhouse Gases

- CO_2
- CH_4
- N_2O
- HFCs
- PFCs
- SF_6
- CFCs



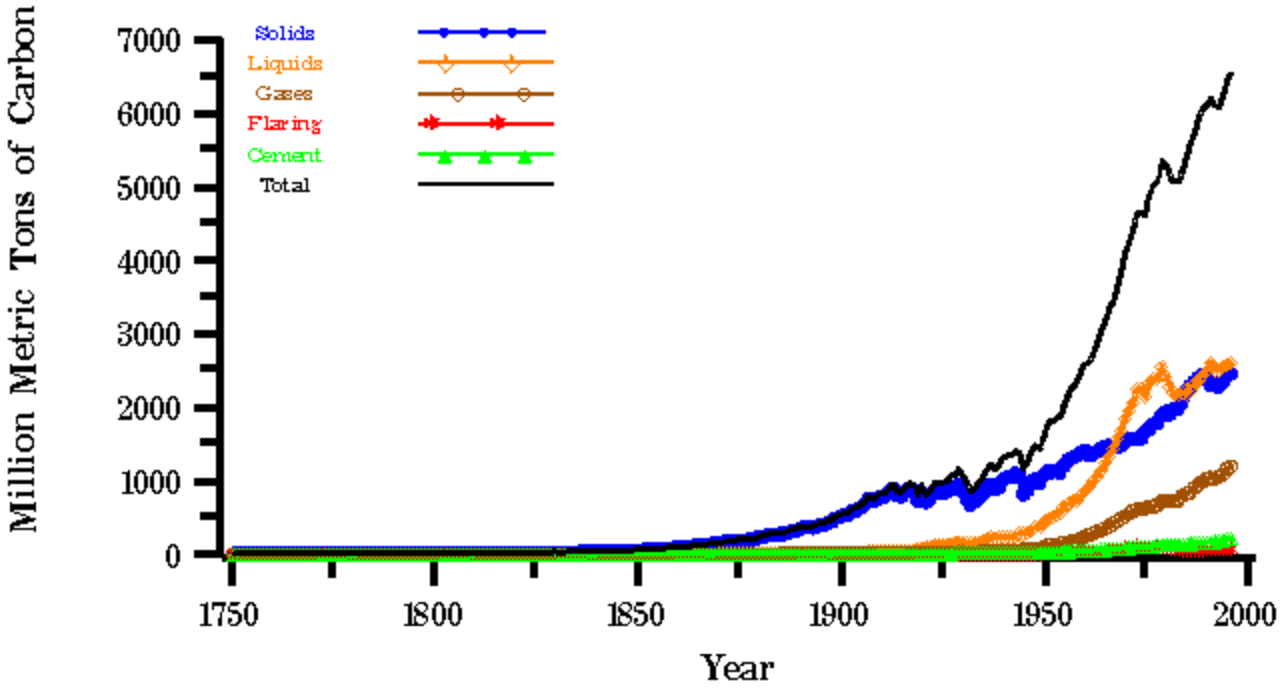
Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

(data from CDIAC NDP-001)

Sources of GHG Emissions

- **Energy**
  - fossil-fuel combustion, coal mining...
- **Agriculture**
  - fertilizer use, rice cultivation, livestock...
- **Industry**
  - cement, nylon, nitric acid...
- **Waste Management**
  - landfills, wastewater treatment...
- **Land-Use Change**
  - deforestation...

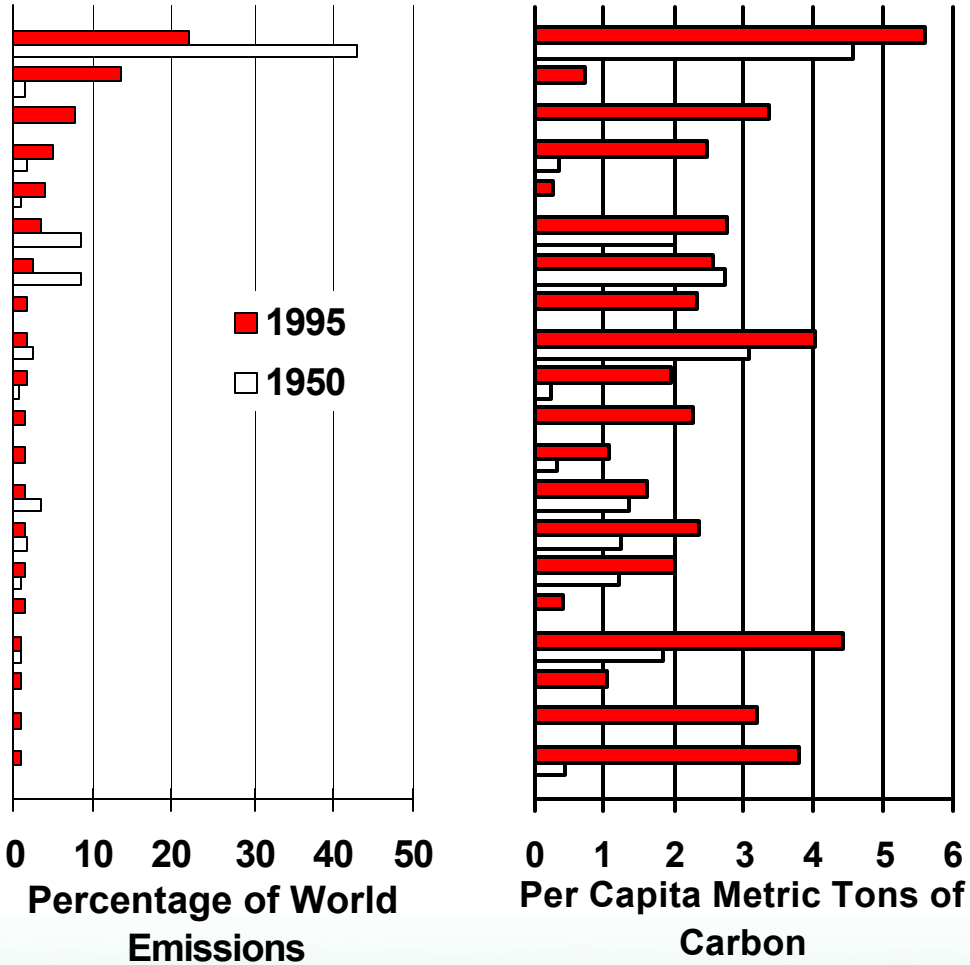
Fossil-Fuel & Cement CO_2 Emissions



(data from Marland et al., CDIAC NDP-030)

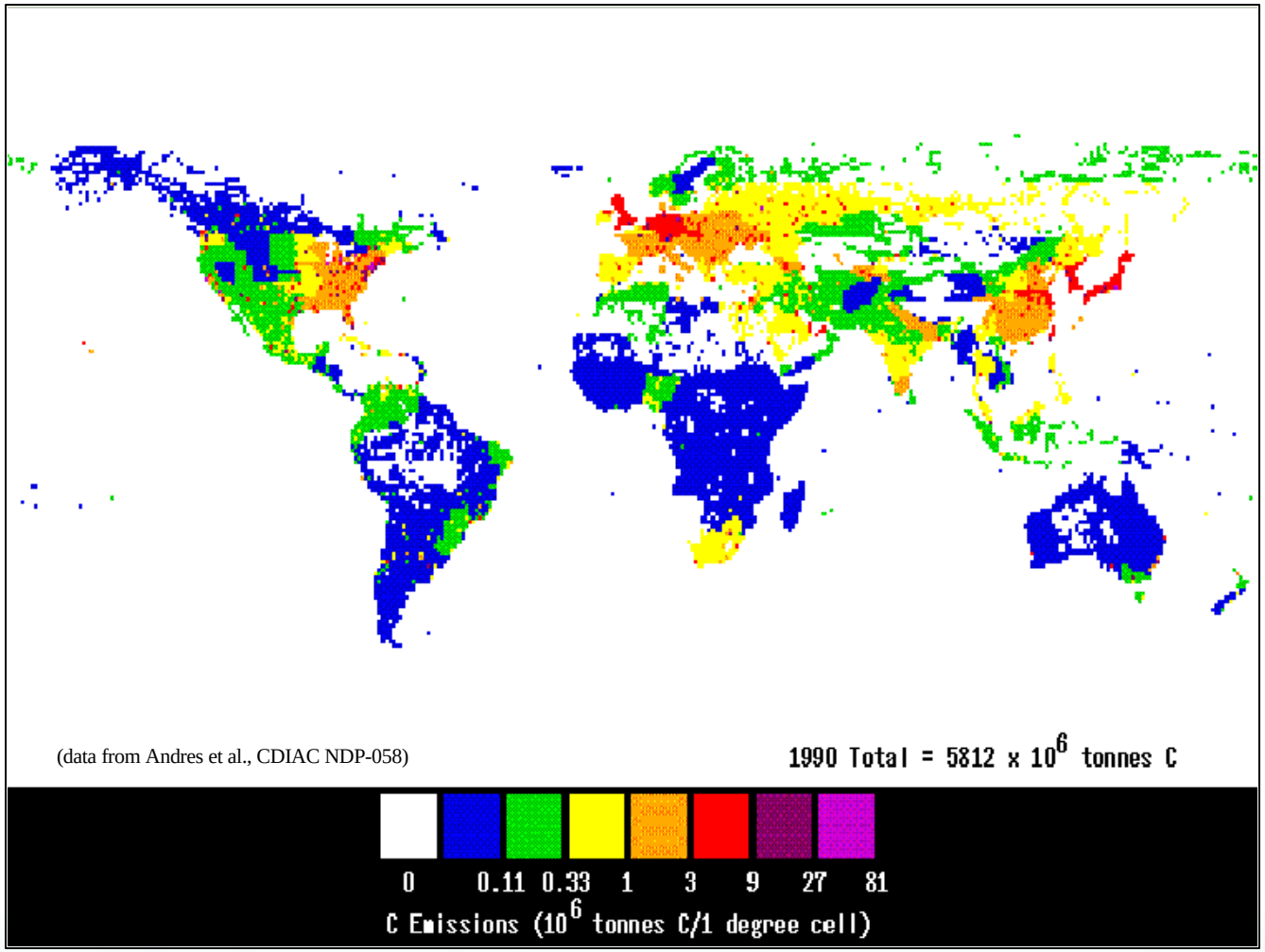
Top 20 (1995 Fossil-Fuel/Cement CO_2 Emissions)

1995 Rank	1950 Rank
(1) USA	(1)
(2) China	(10)
(3) Russia	(FSU=2)
(4) Japan	(9)
(5) India	(13)
(6) Germany	(3)
(7) UK	(4)
(8) Ukraine	(FSU=2)
(9) Canada	(7)
(10) Italy	(17)
(11) South Korea	(58)
(12) Mexico	(20)
(13) France	(5)
(14) Poland	(8)
(15) South Africa	(14)
(16) Indonesia	(31)
(17) Australia	(15)
(18) Iran	(164)
(19) North Korea	(73)
(20) Saudi Arabia	(47)

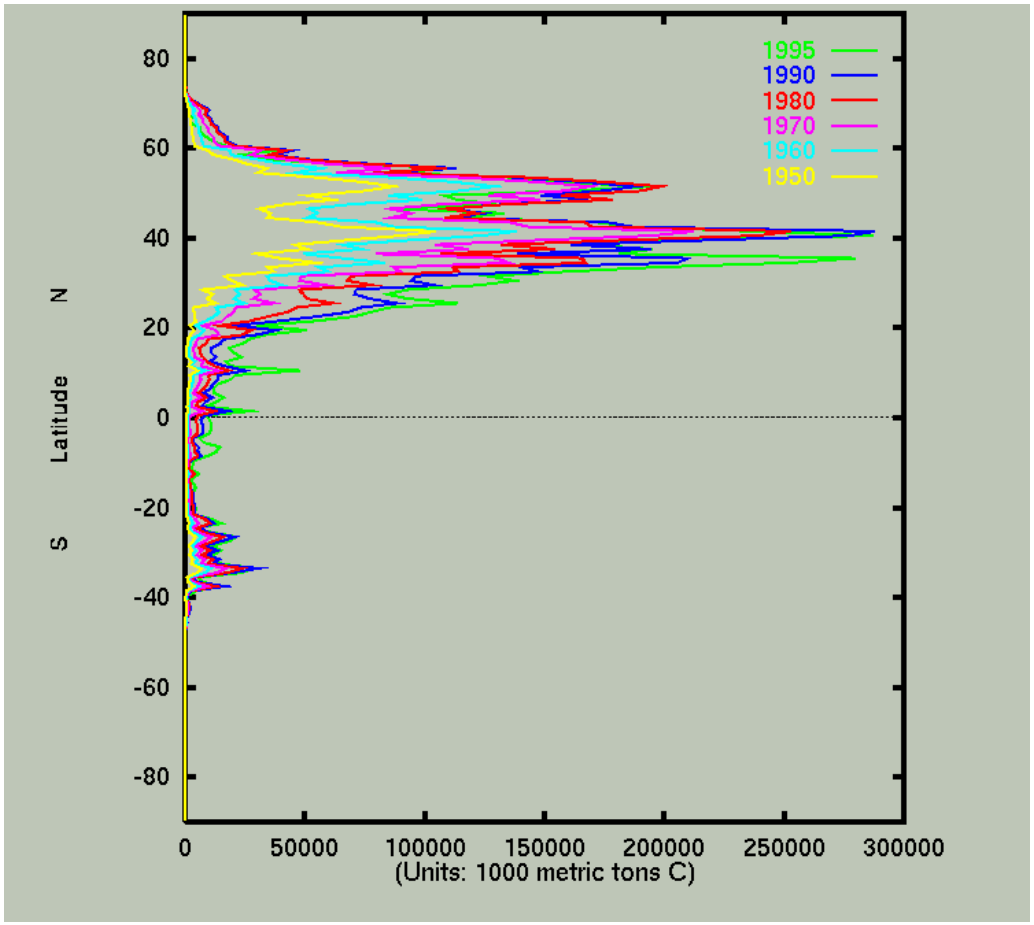


(data from Marland et al., CDIAC NDP-030)

Gridded 1990 Global CO_2 Emissions, Distributed per Population

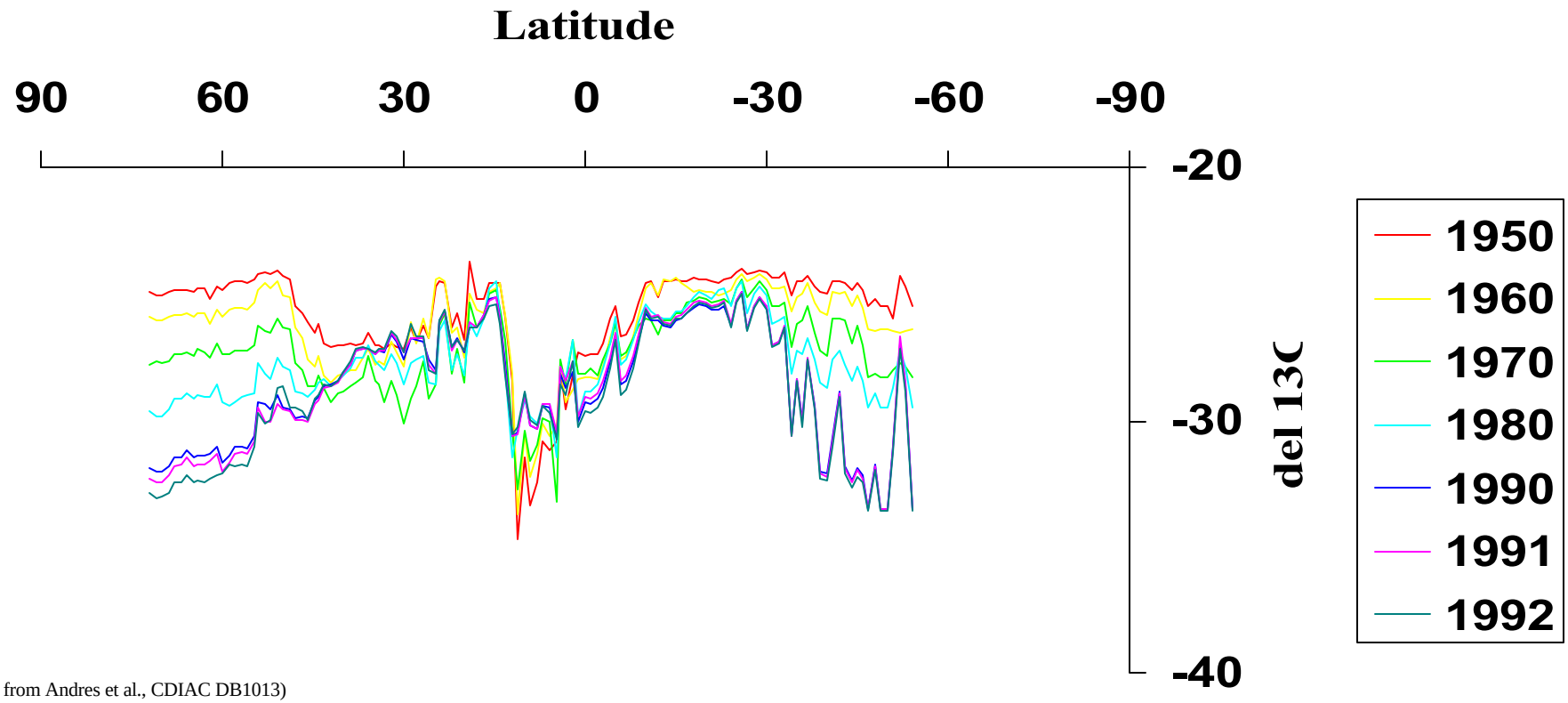


Latitudinal Distribution of CO_2 Emissions



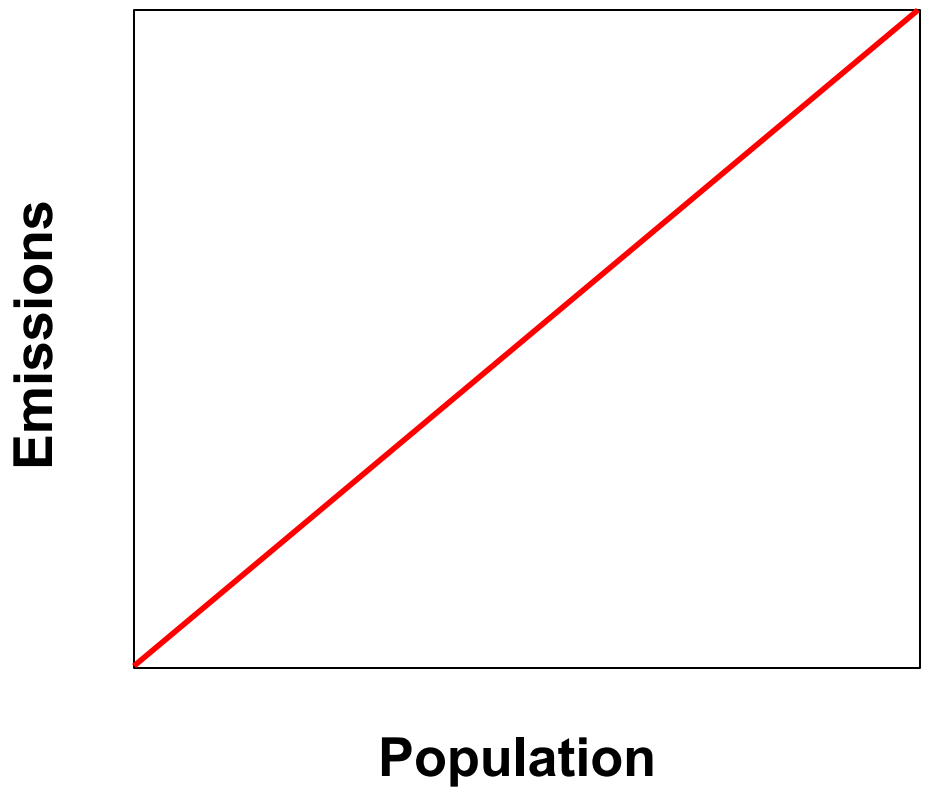
(data from Andres et al., CDIAC DB1013)

Isotopic Signature of Fossil-Fuel and Cement Manufacture Carbon Emissions



(data from Andres et al., CDIAC DB1013)

Ideal World

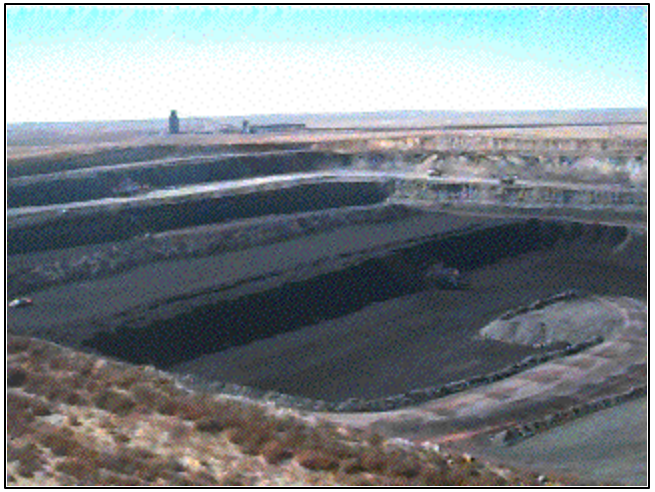


How well does population distribution predict the distribution of CO_2 emissions?

What other factors are important?

Validation of Population Proxy

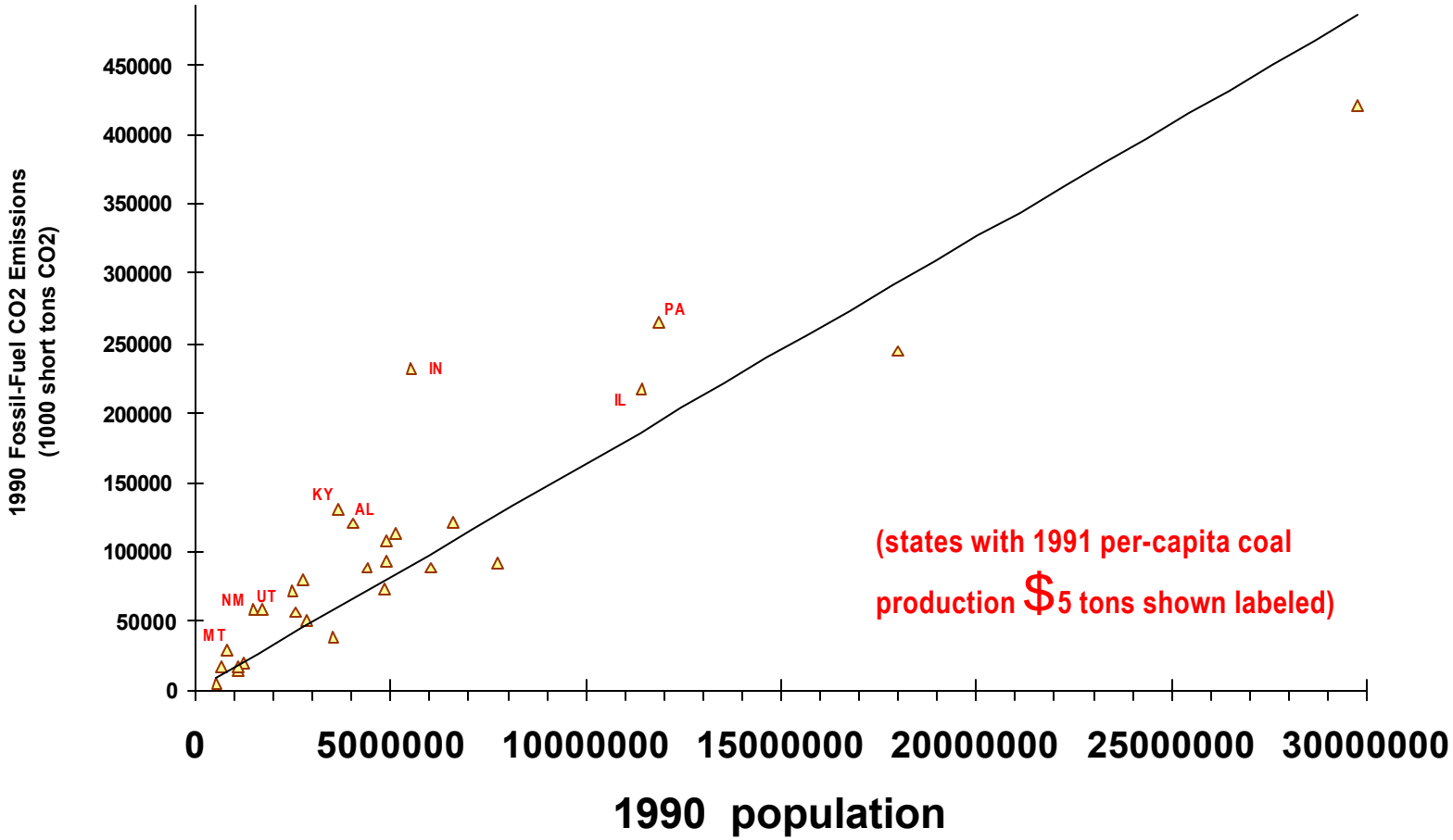
Hypothesis: Big Influence from Coal



- Coal is often combusted near the source (i.e., many mine-mouth power plants)
- Coal has the highest carbon/energy coefficient of the fossil fuels
  - coal: 25-26 kg C/10^6 Btu
  - petroleum: 17-21 kg C/10^6 Btu
  - natural gas: 14-15 kg C/10^6 Btu

ˆ states with major coal production should tend to have higher per-capita carbon emissions

State Fossil-Fuel Emissions & Population



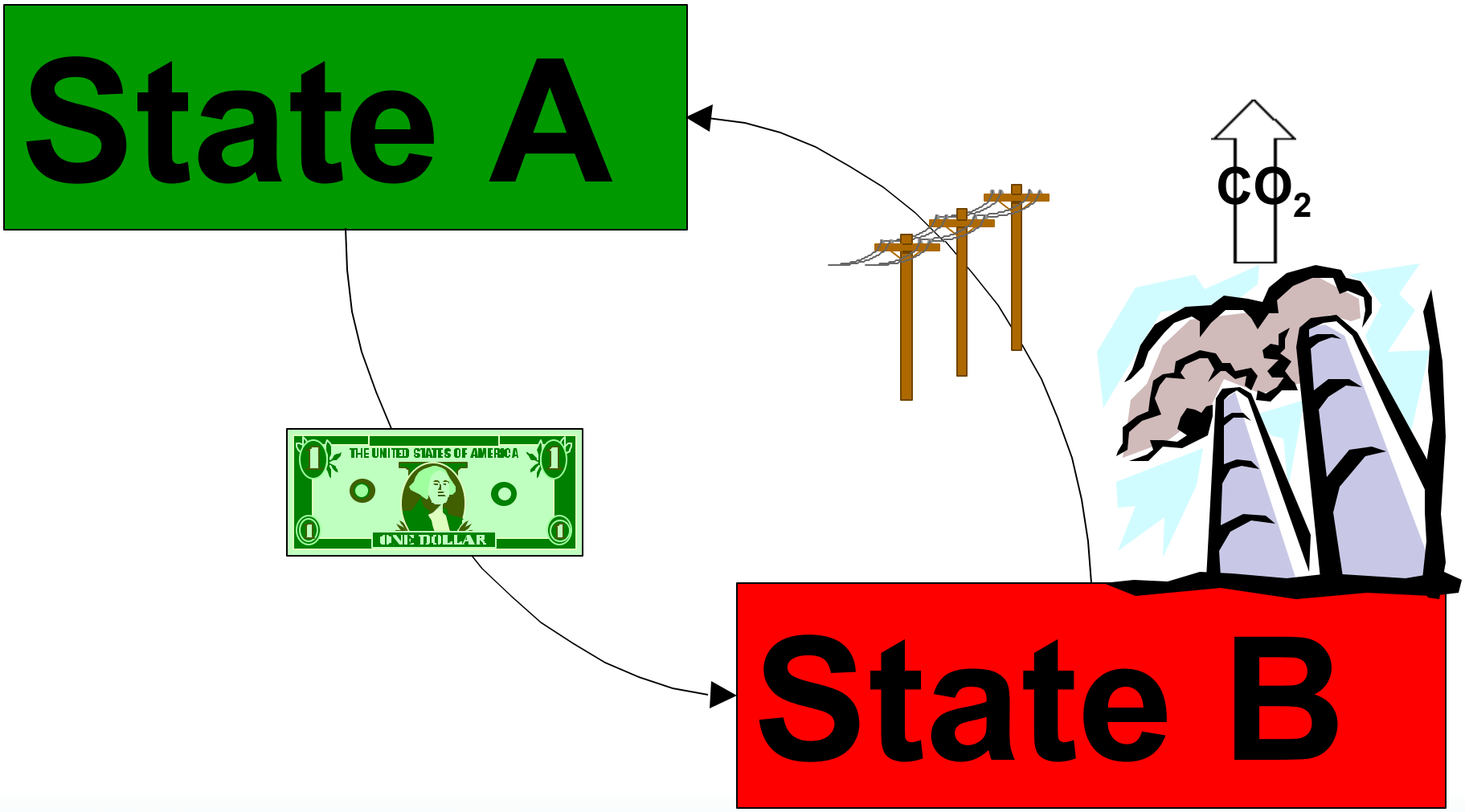
Other Factors

- Non-fossil energy sources
- Electrical imports

… would both tend to lower per-capita carbon emissions within a state

Non-Fossil Energy Sources

Electricity Imports



Results of Statistical Analyses

- Population explained 84-85% of variance in CO_2 emissions ($P<0.0001$)
- Contribution and significance of other variables depended on statistical model
  - Untransformed variables:
    - electricity imports ($P<0.006$) + coal production ($P<0.06$) together explained an additional 7% of variance
    - non-fossil energy explained <1% of variance ($P>0.16$)
  - Transformed variables:
    - coal production explained 9% of variance ($P<0.0001$)
    - electricity imports ($P>0.86$) and non-fossil energy ($P>0.23$) together explained <0.5% of variance

Factors Affecting Population-Emissions Relationship

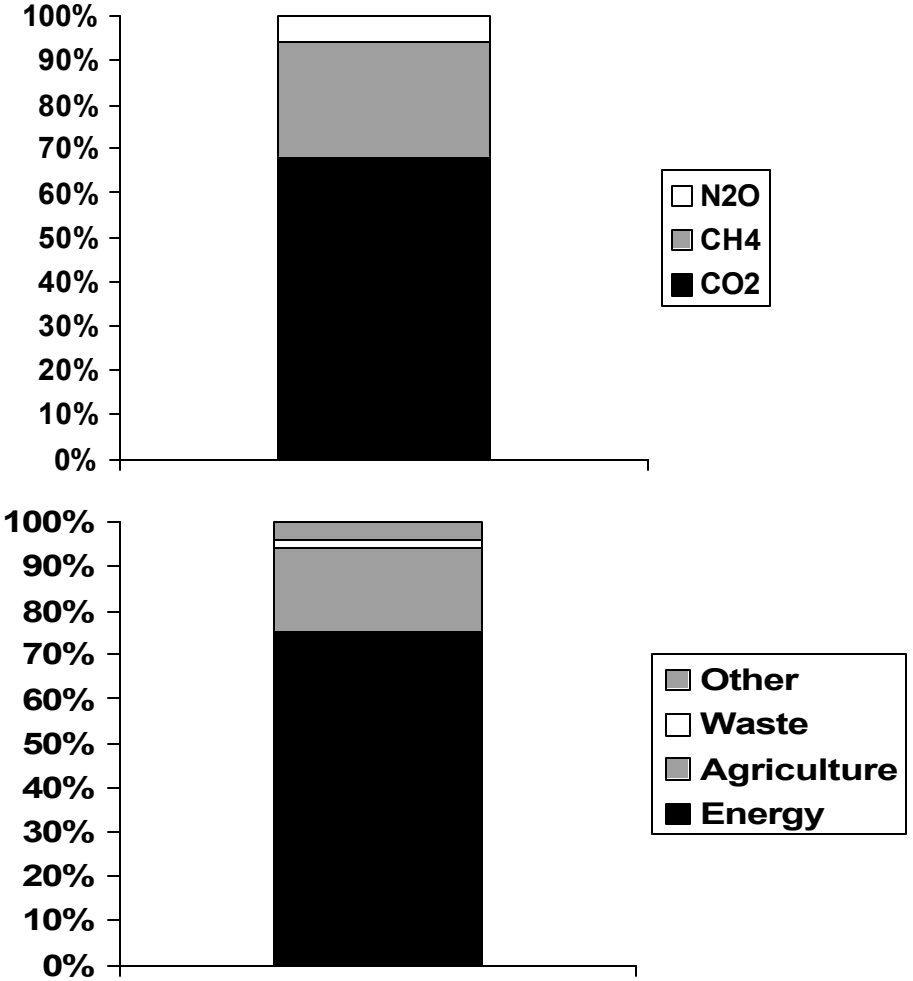
- Population distribution explains most – but not all – of the variance in state-level distribution of CO_2 emissions in U.S.
- Coal production an important secondary factor
- Additional source of variance from imports of electricity
- Contribution from non-fossil energy sources not statistically demonstrable

Comparison of Priorities

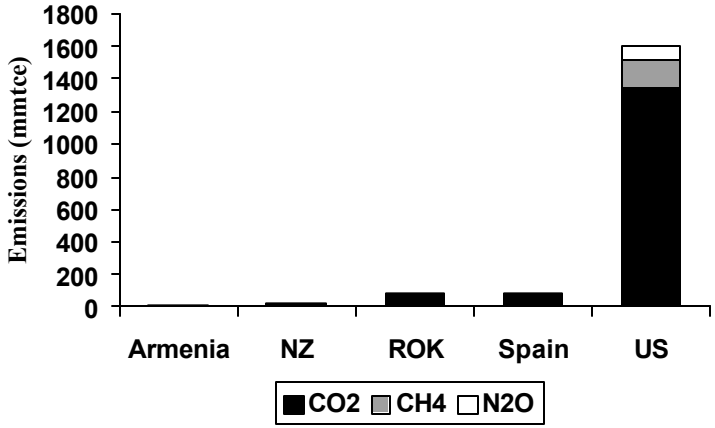
How do priorities (by gas, sector) vary as a result of scale?

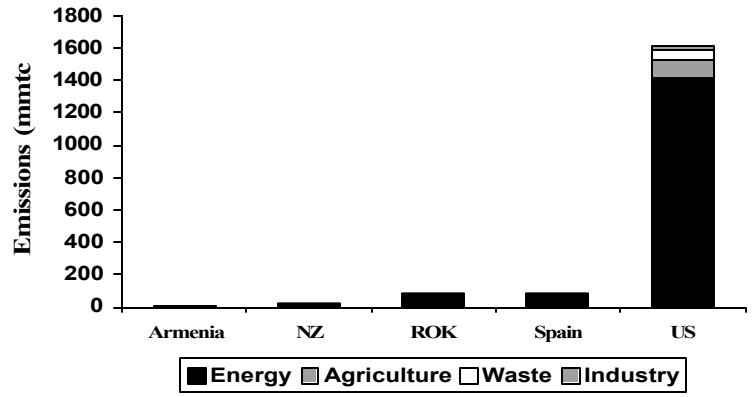
- **Global**
- **National**
- **Sub-National**

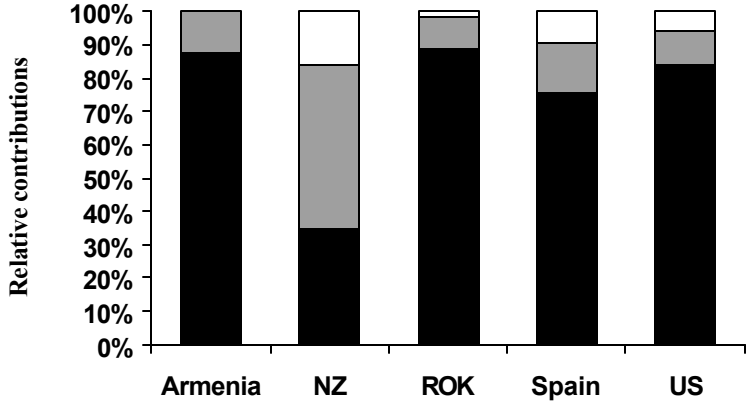
Comparison of Priorities: Global

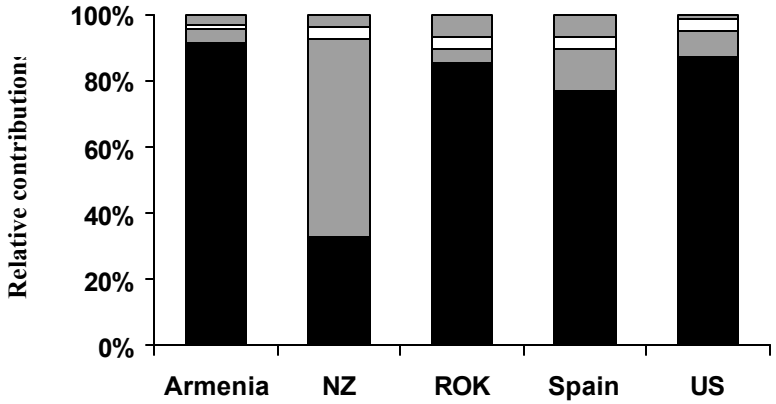


Comparison of Priorities: National

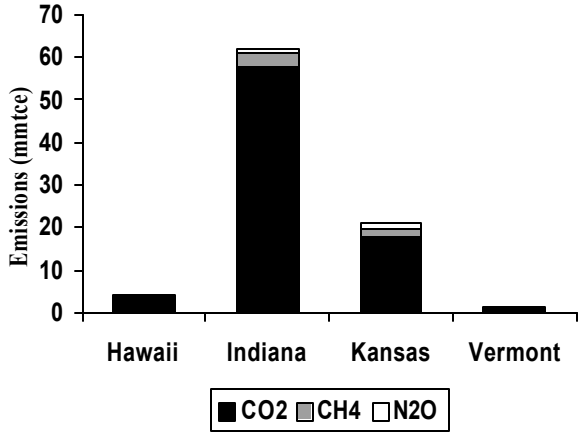


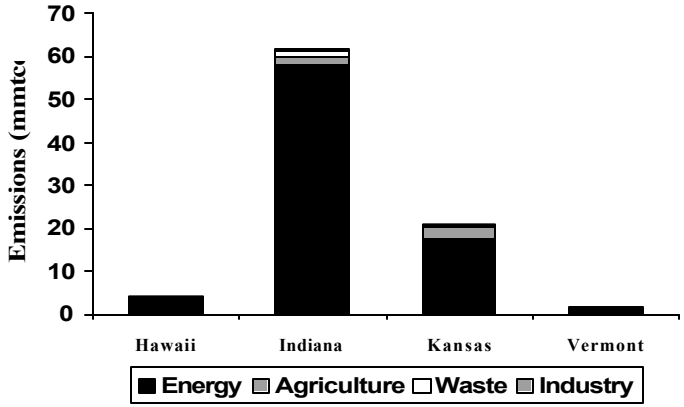


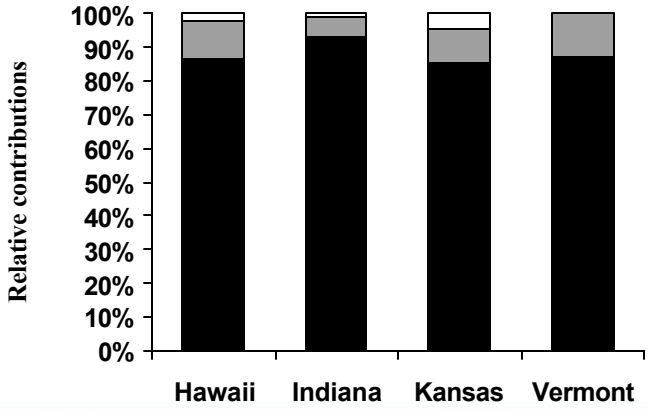


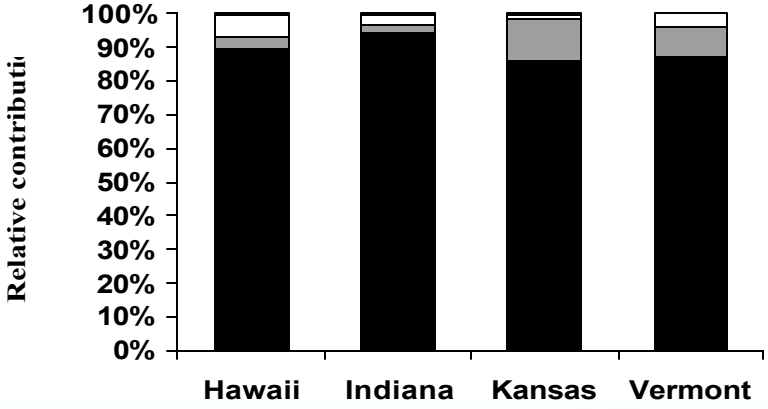


Comparison of Priorities: State









Priorities Vary...

- as a function of political scale
- between political units of the same scale

- Not to mention the complicating factors of economics, politics, social values...

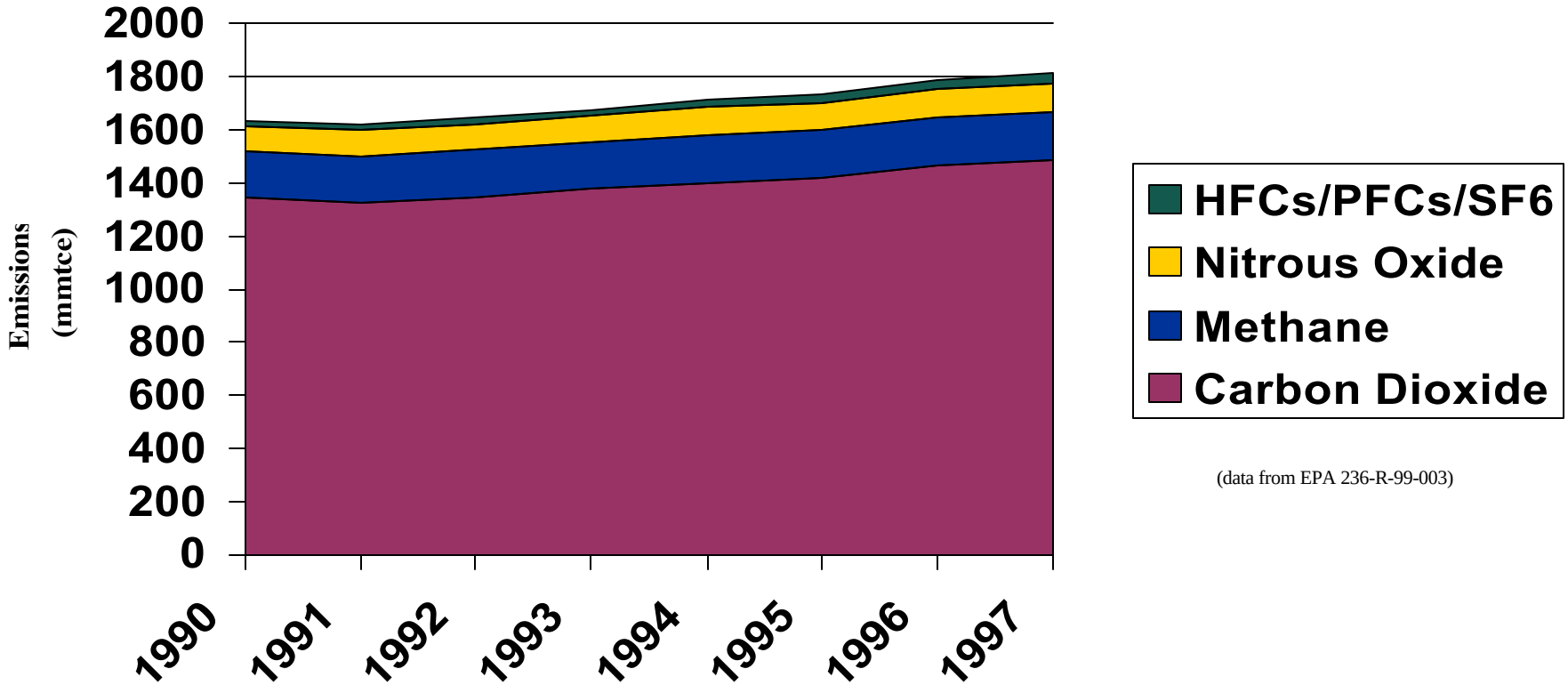
Additivity Issues

- Some similarities, some differences, concerning aggregating states to country, countries to globe
  - Bunkers
  - Double-counting
    - fossil-fuel import/exports
    - electricity imports/exports
    - waste imports/exports
  - Omissions

International Agreements to Control GHG Emissions

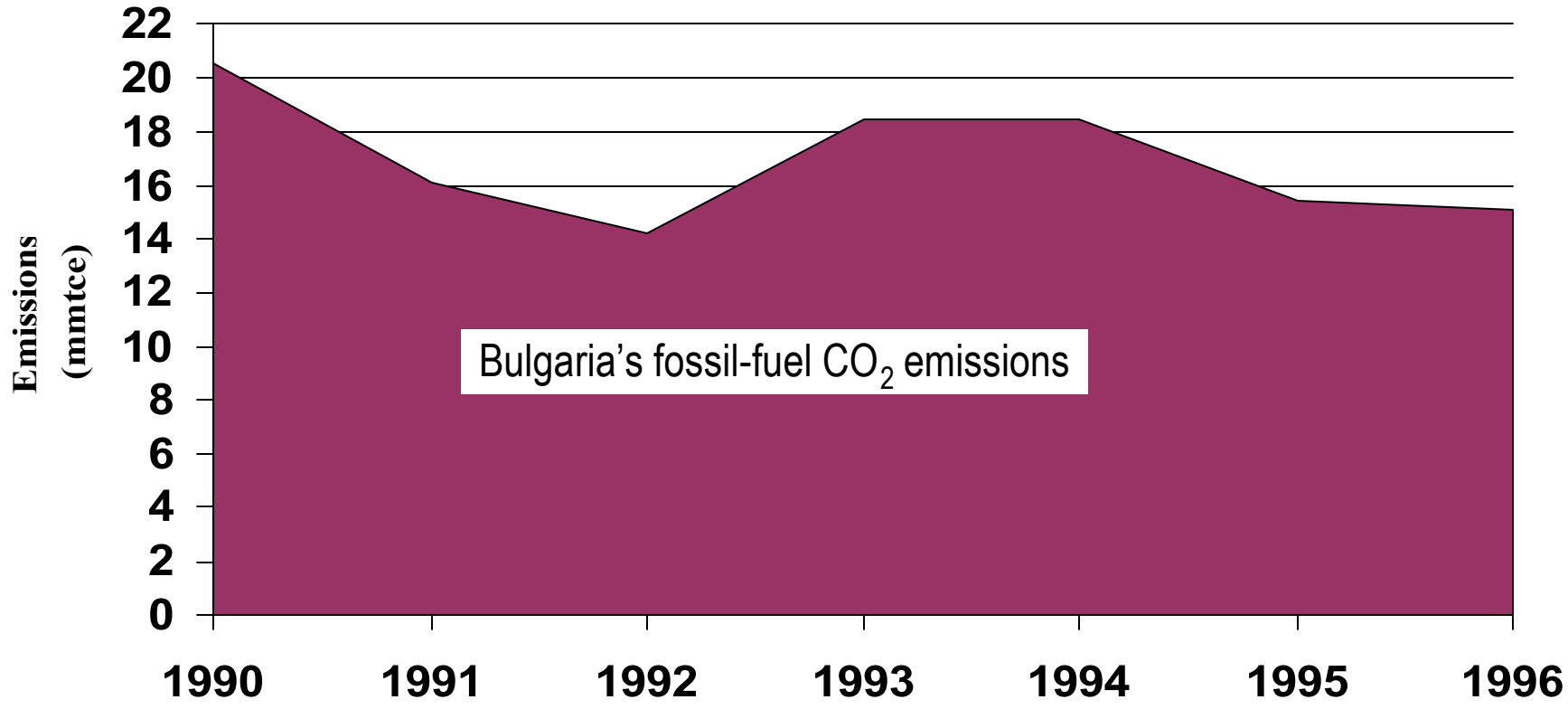
- 1992 (Rio): Return to 1990 emissions by 2000
- 1997 (Kyoto): Achieve country-specific reductions, relative to 1990, by circa 2010 (industrialized countries)
  - Japan 6%
  - United States 7%
  - European Union 8%
  - *but not yet ratified by enough countries to enter into force*

U.S. Greenhouse-Gas Emissions, 1990-1997



(data from EPA 236-R-99-003)

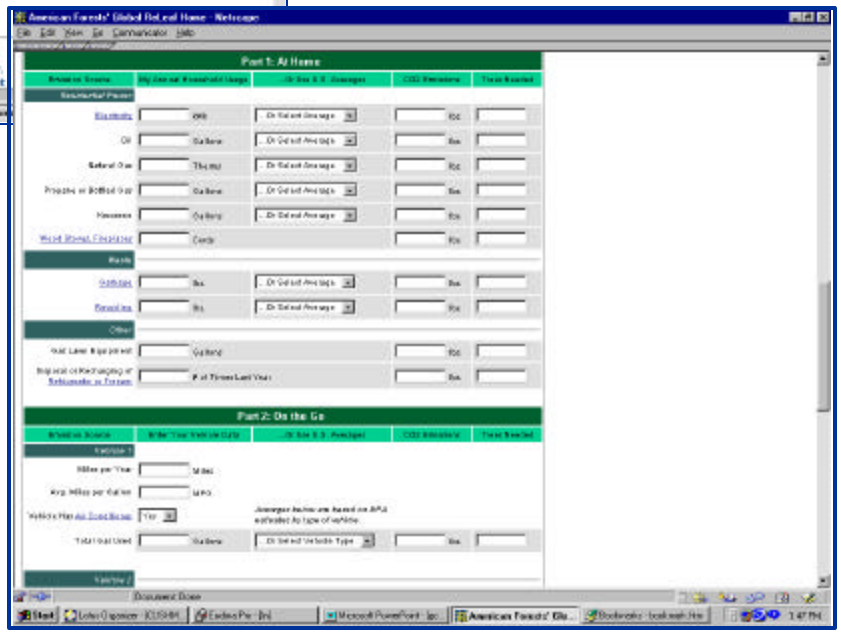
How *NOT* to Control GHG Emissions!



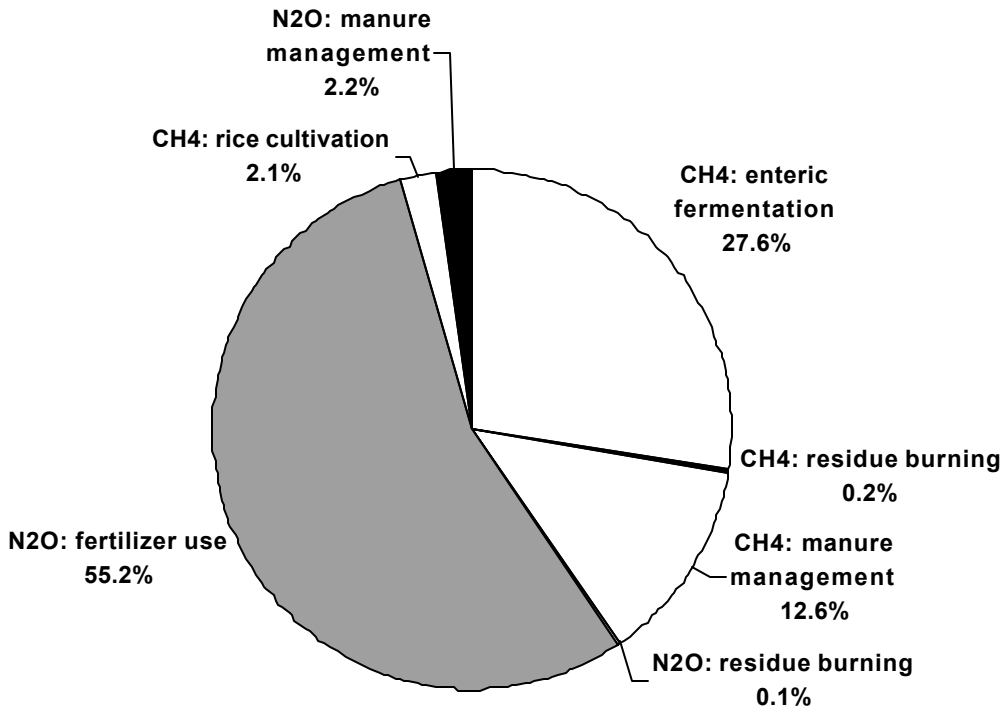
(data from CDIAC NDP-030)

CLIMATE CHANGE
The AMERICAN FORESTS Personal
Climate Change Calculator
Plant a tree... cool the globe.
Even if I were certain that the world would end tomorrow, I would plant a tree this very day.
– Martin Luther King, Jr.
CALCULATOR SHORTCUT
PLANT 30 TREES
The average American is responsible for about 19 tons of CO2 emissions each year. You can plant 30 Global ReLeaf trees right

HOT EARTH.net
Solutions
Top 10 things you can do to reduce global warming
10 - Plant two or more trees around your home.
9 - Put energy-saving lightbulbs in the three most used lights in your house.
8 - When you replace your refrigerator, buy a high-efficiency model.
7 - Buy food and other products with reusable or recyclable packaging.
6 - When you replace your washing machine, buy a low-energy, low-water use model.
5 - Install a solar thermal system to help provide your hot water.
4 - Recycle all of your home's newsprint, cardboard, glass, and metal.
3 - Leave your car at home two days a week.
2 - Insulate your home, tune up your furnace, and install efficient shower heads.

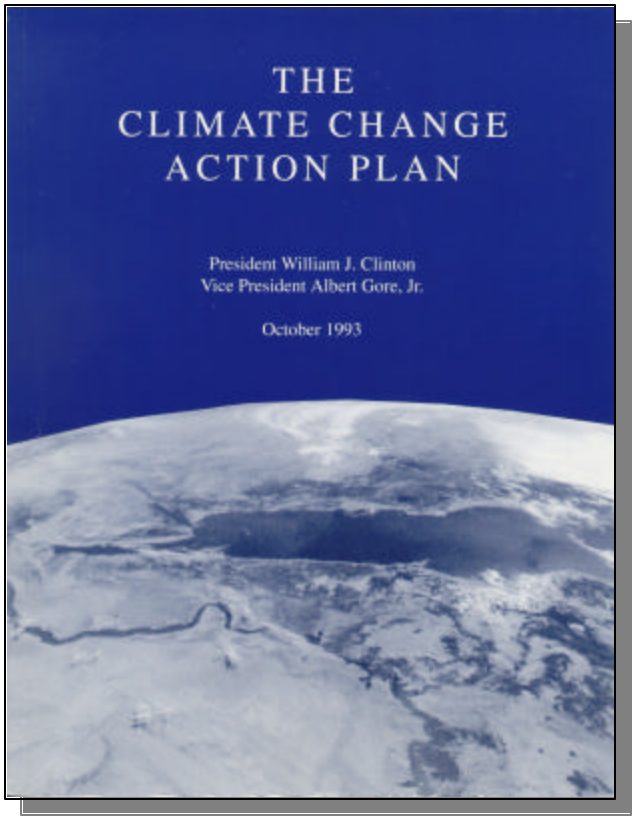
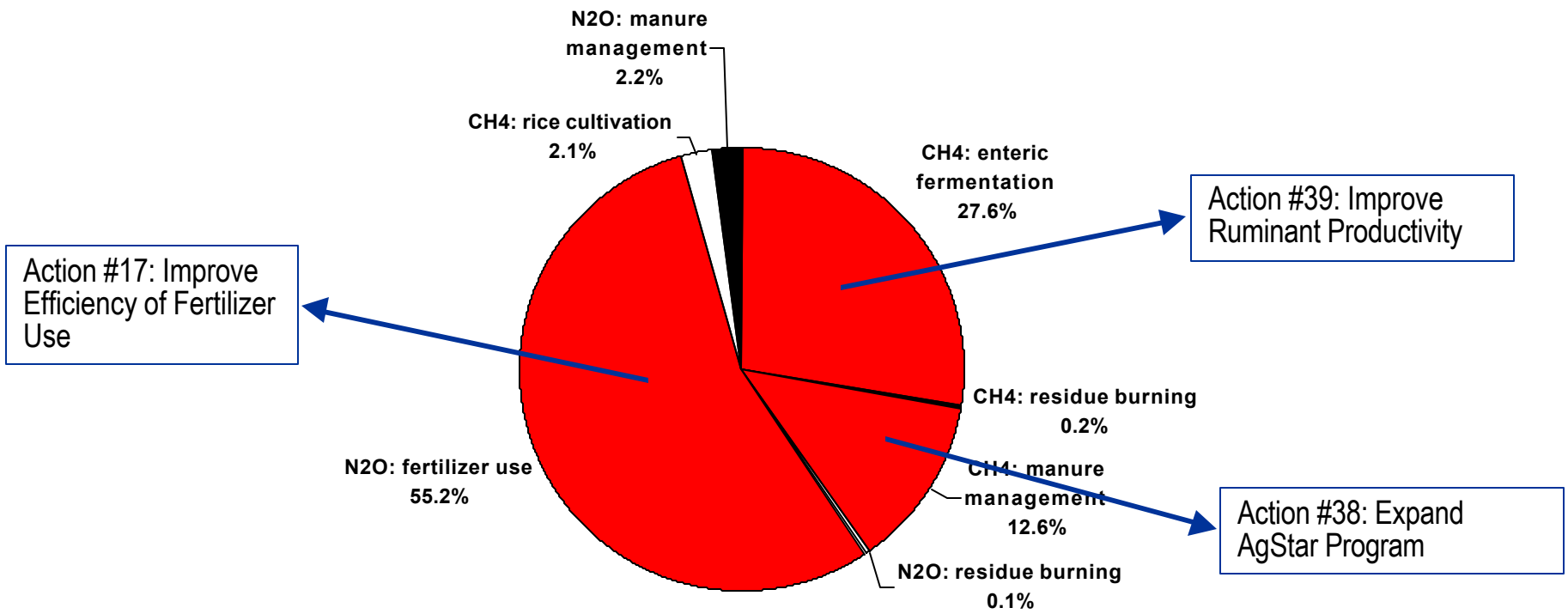

Part 1: At Home
Part 2: On the Go

U.S. Agricultural GHG Emissions, by Gas and Source



U.S. Climate Change Action Plan

- Published by the White House following the 1992 Earth Summit in Rio
- "returns U.S. greenhouse gas emissions to 1990 levels by the year 2000 with cost-effective domestic actions"
- "nearly 50 new and expanded initiatives"



Policies to Reduce Emissions: Hey, We Picked the Right Ones!