Environmental Science and Technology for Public Policy

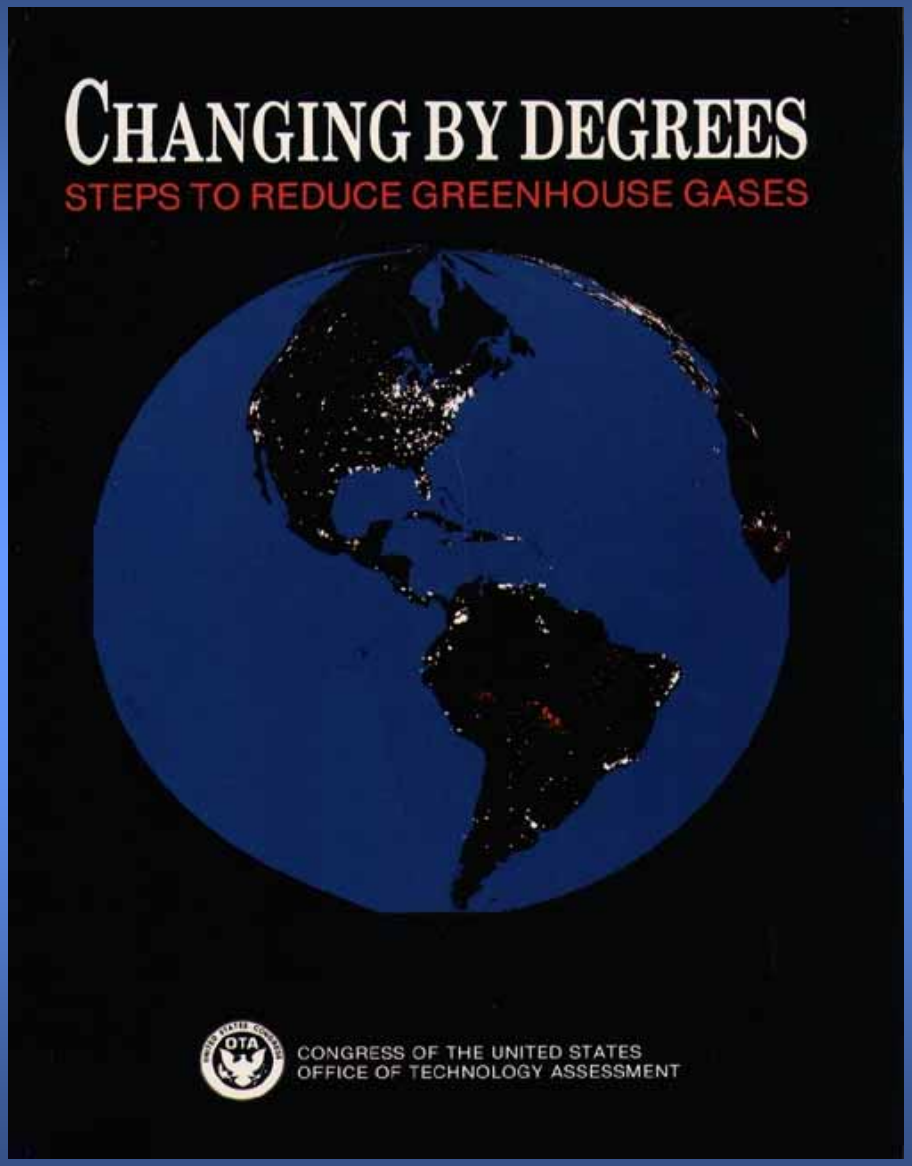
Symposium on Technology Innovation for Sustainable Prosperity:

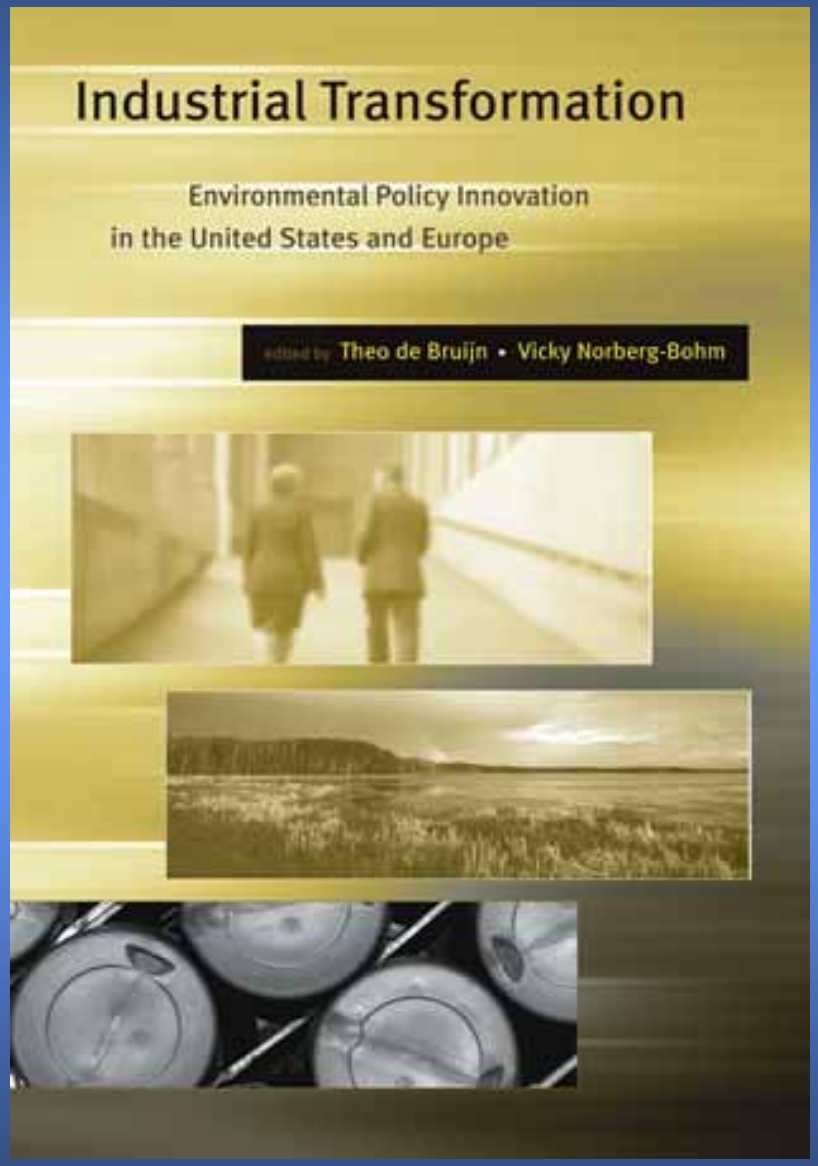
A memorial tribute to Vicki Norberg-Bohm

Rosina Bierbaum

Dean and Professor

September 23, 2005


CHANGING BY DEGREES
STEPS TO REDUCE GREENHOUSE GASES
CONGRESS OF THE UNITED STATES
OFFICE OF TECHNOLOGY ASSESSMENT


Industrial Transformation
Environmental Policy Innovation
in the United States and Europe
edited by Theo de Bruijn • Vicky Norberg-Bohm

LESSONS FROM WORKING AT THE SCIENCE/POLICY INTERFACE

- Science is not the loudest voice
- Timing is all
- An unsustainable trend is unsustainable
- All “missing” research can’t be done at once
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ACID RAIN

Sources Power Plants, Industry, Transportation, Natural

Atmospherics Meteorology, Deposition, Chemical Transform

Mediating Factors Biota, Nat. Acid., Soil Chem., Water

Resources Surf. Water, Forests, Crops, Groundwater, Materials

Societal Concerns Commerce, Eco Effects, Health, Energy, ...

Policy Energy, Pollution, Agric., Natural Res., Fed/State, Intern.

ACID RAIN

POLICY

- Energy
- Pollution
- Natural Resources
- Agriculture
- Fed/State
- International

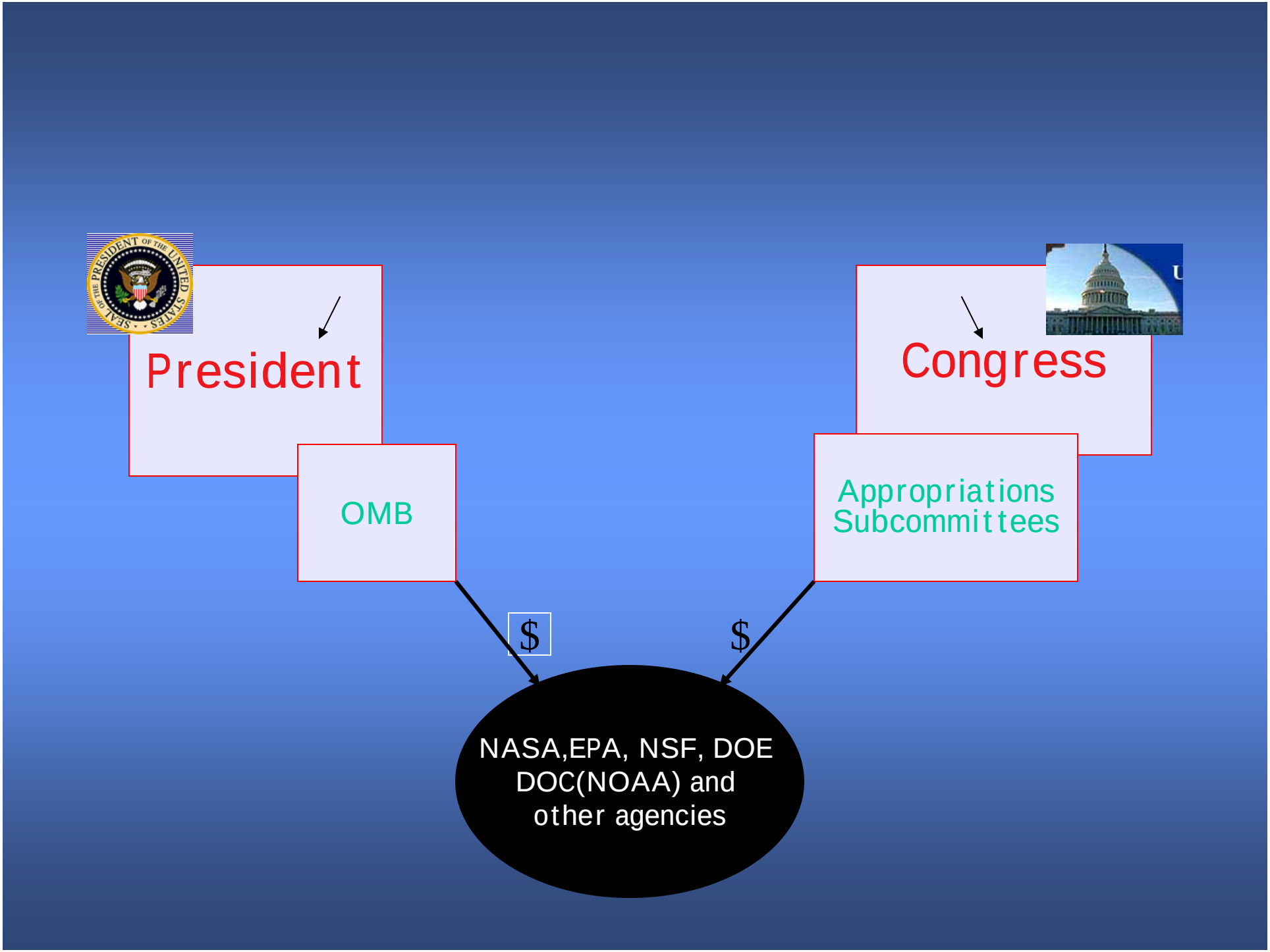
SOCIETAL CONCERNS

- Welfare
- Equity
- Energy Supply
- Health
- Ecosystems
- Materials
- Visibility
- Recreation

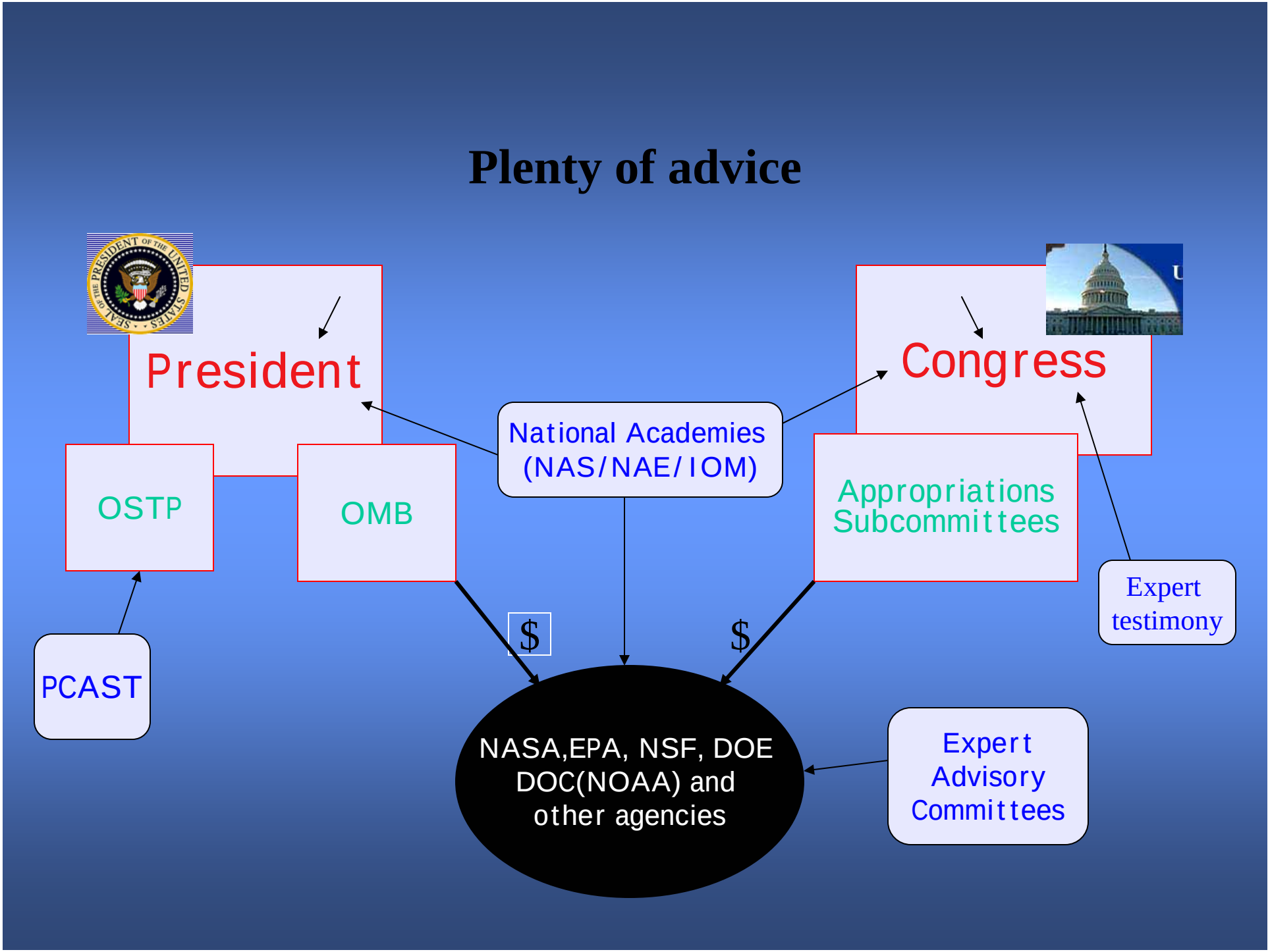
PROCESSES

- Sources
- Atmospherics
- Resources

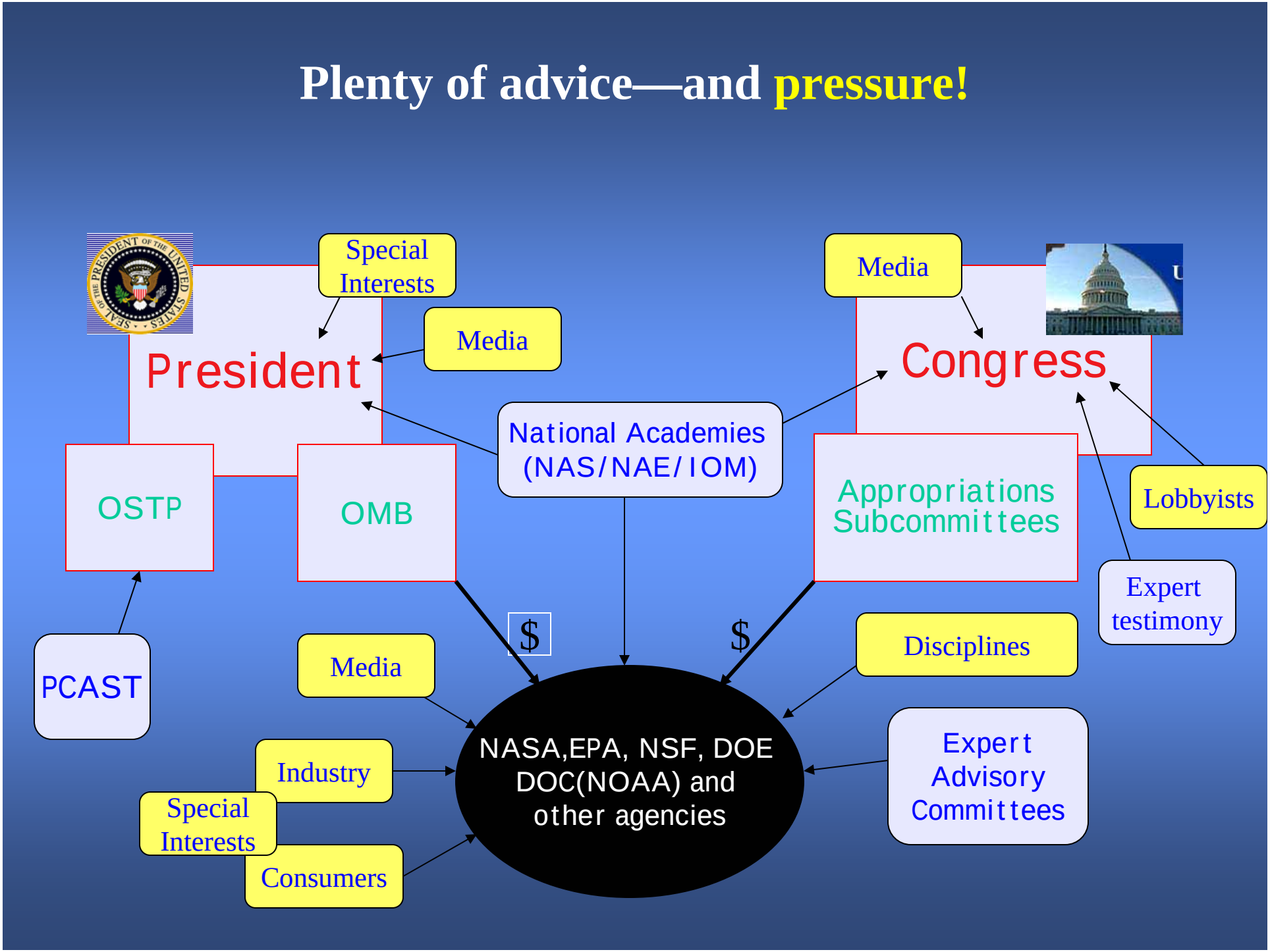
U.S. Congressional Office of Technology Assessment


President
OMB
Congress
Appropriations Subcommittees
$
$
NASA,EPA, NSF, DOE
DOC(NOAA) and
other agencies

Plenty of advice



Plenty of advice—and pressure!



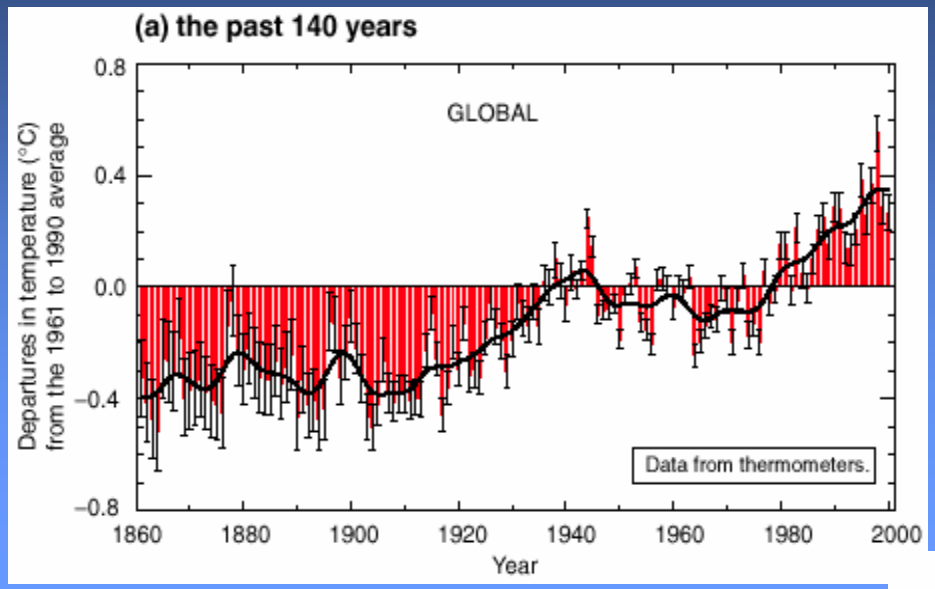
Increasing Confidence in the Science

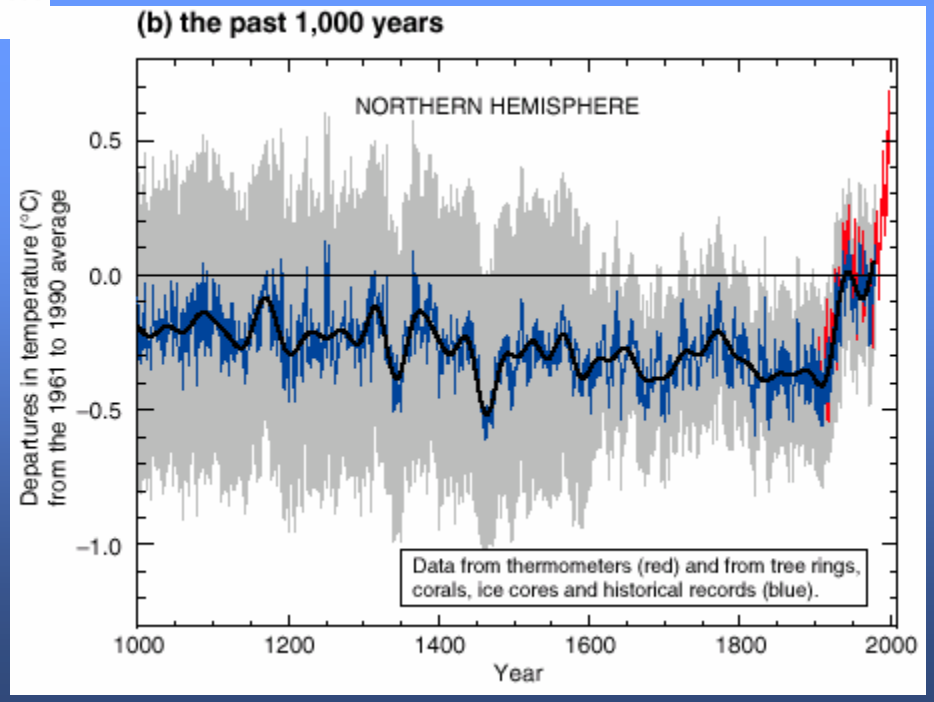
- **IPCC 1990: The observed increase [*in temperatures*] could be largely due to natural variability; alternatively this variability and other man-made factors could have offset a still larger man-made greenhouse warming.**

- **IPCC 1995: The balance of evidence suggests a discernible human influence on global climate.**

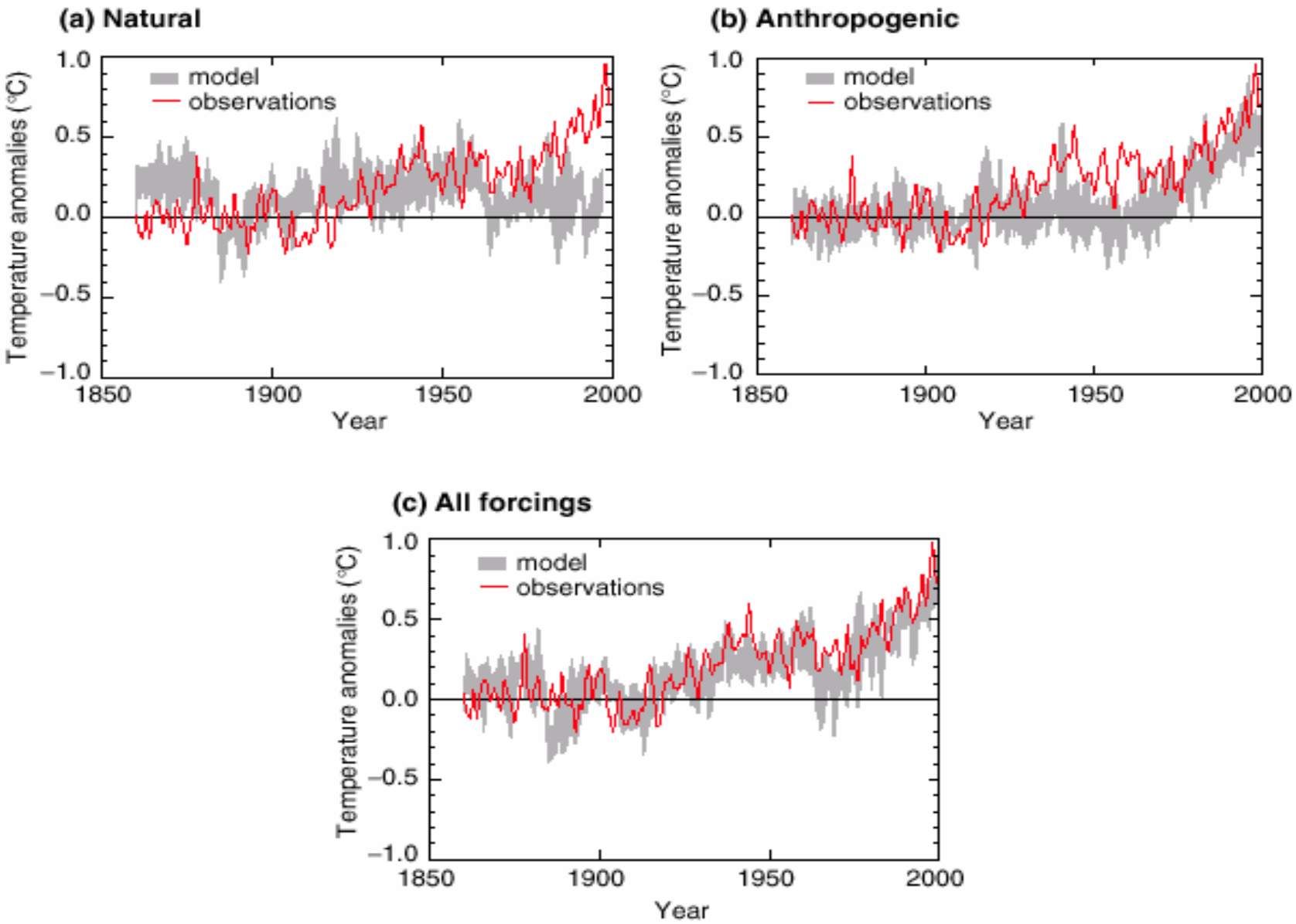
- **IPCC 2001: There is new and stronger evidence that most of the warming observed over the last 50 years is due to human activities.**

Variations of the Earth's Surface Temperature for:





Simulated annual global mean surface temperatures



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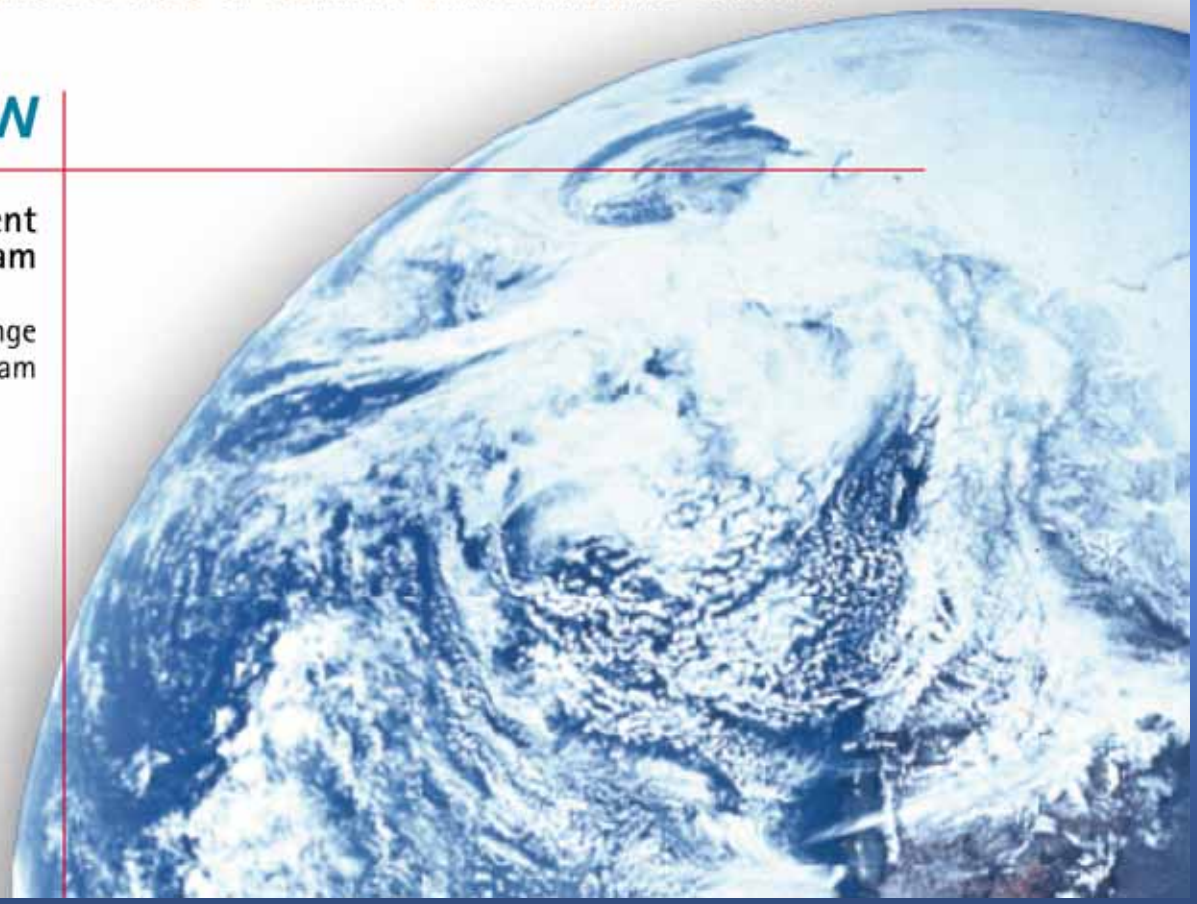
CLIMATE CHANGE IMPACTS ON THE UNITED STATES

THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE

Overview

National Assessment
Synthesis Team

US Global Change
Research Program



Development of International Climate Change Regime

1988	1992	1997	2005
IPCC established	Framework Convention (UNFCCC)	Kyoto Protocol	?????
Scientific assessment	Non-binding aim	Binding emissions target	

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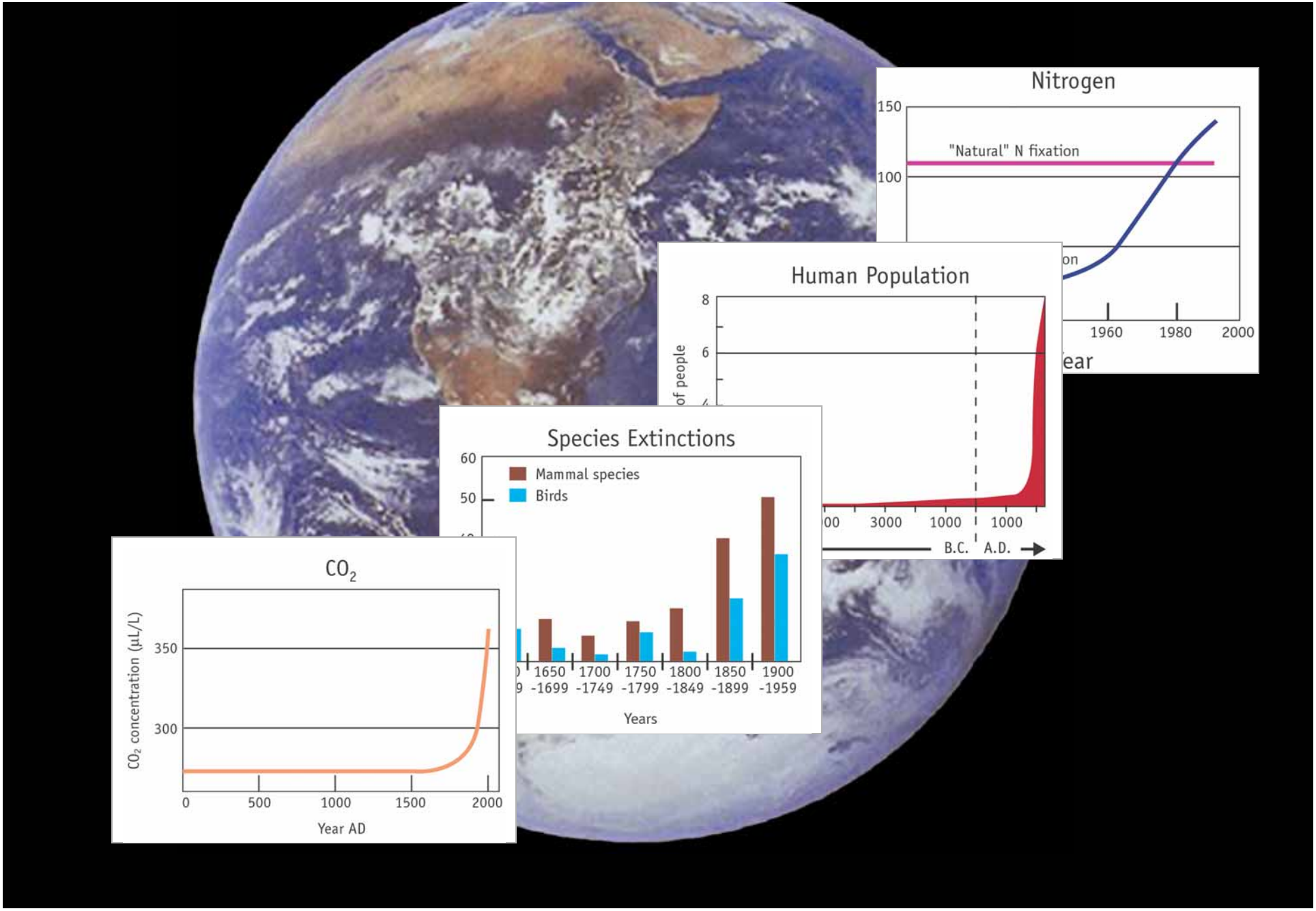
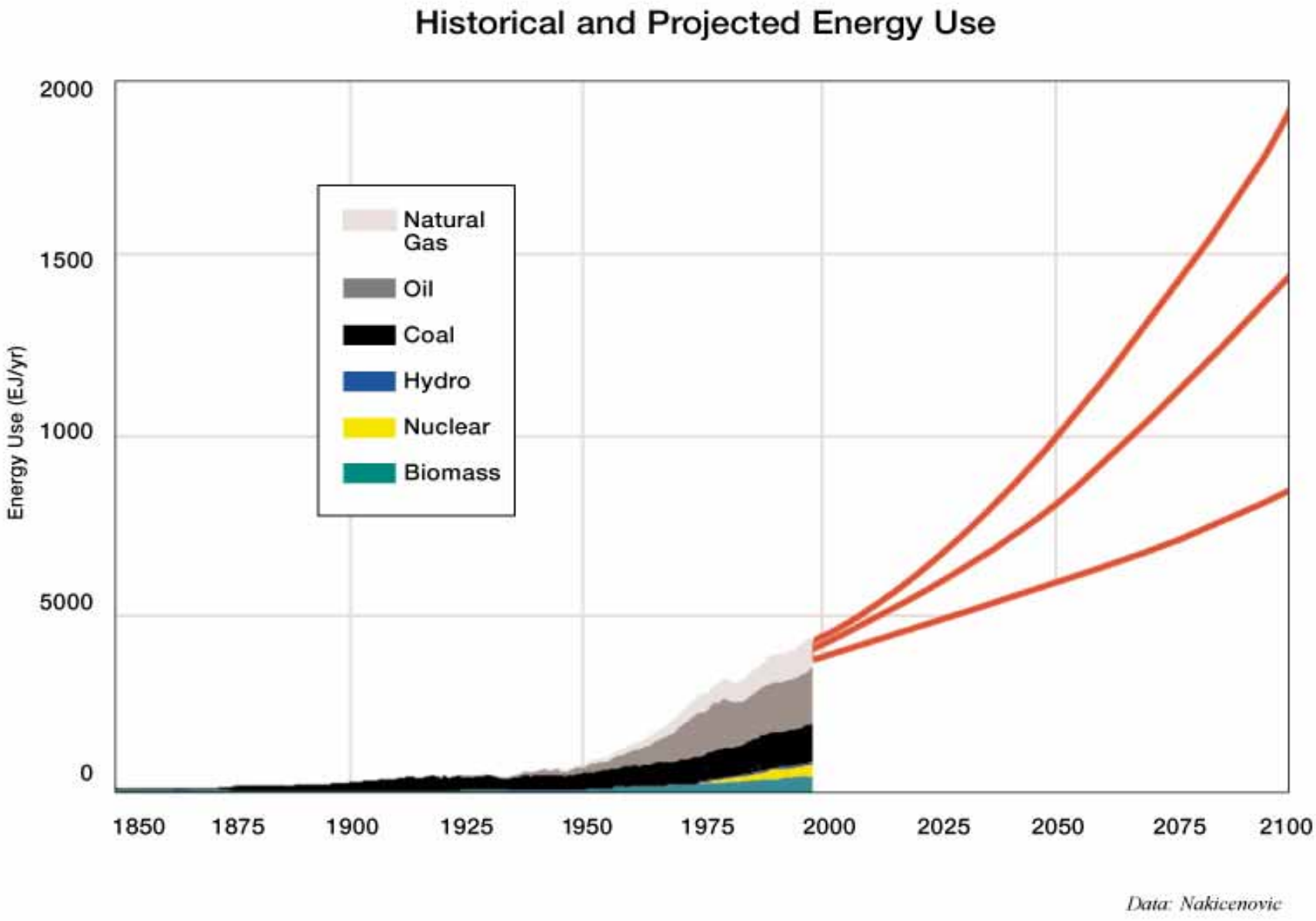
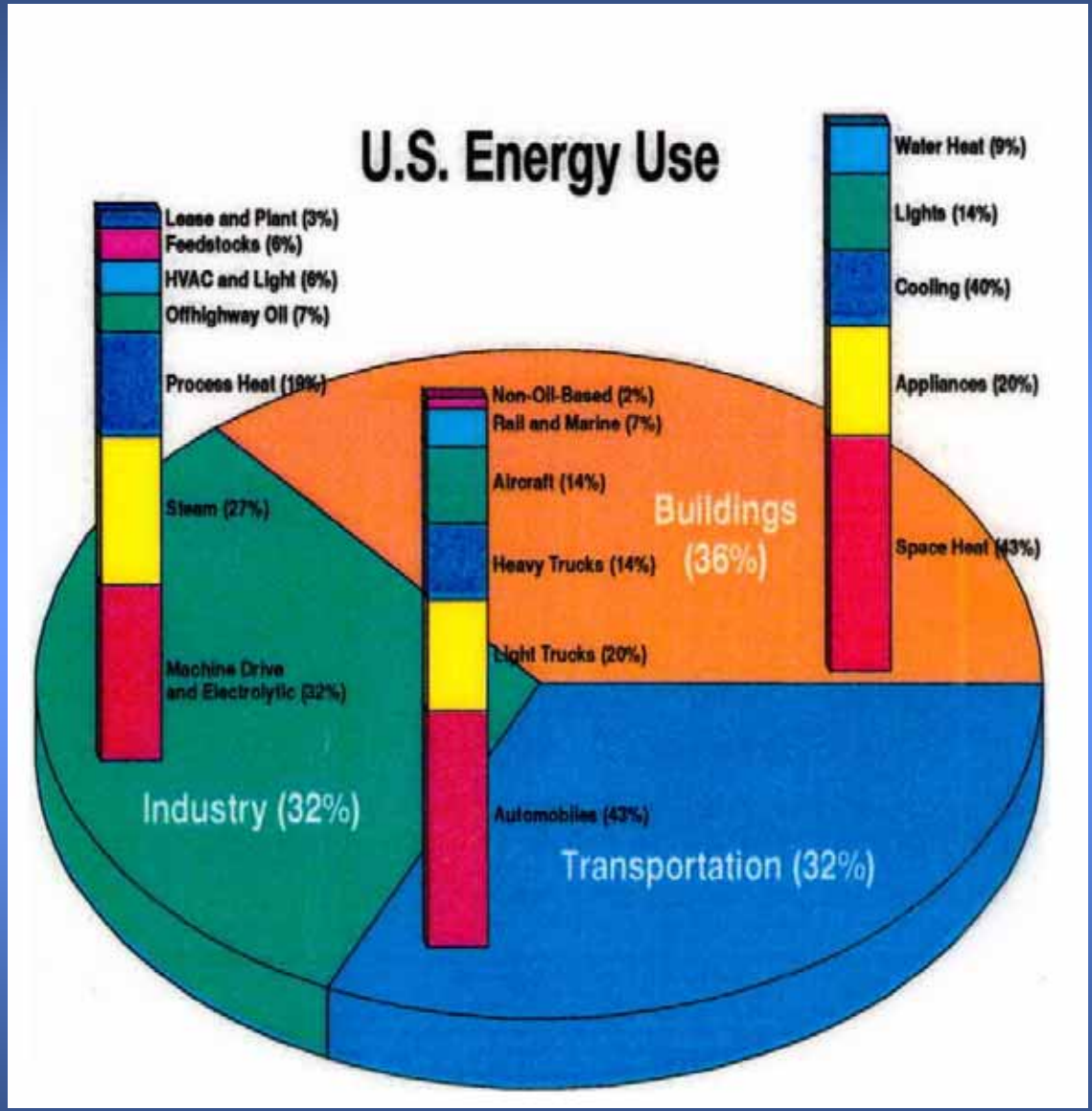
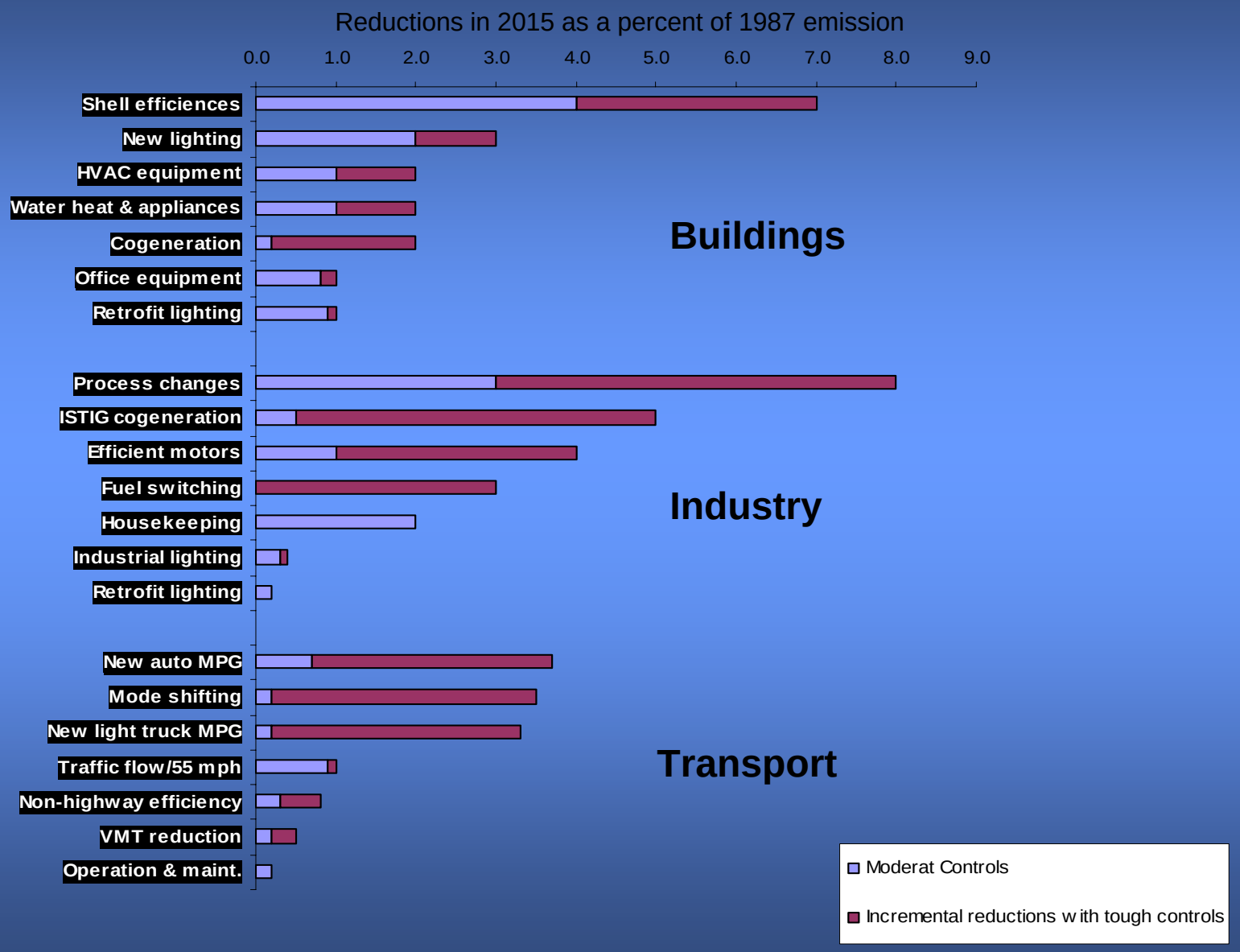


The Challenge: Sustainable Management of an Ever-Changing Planet

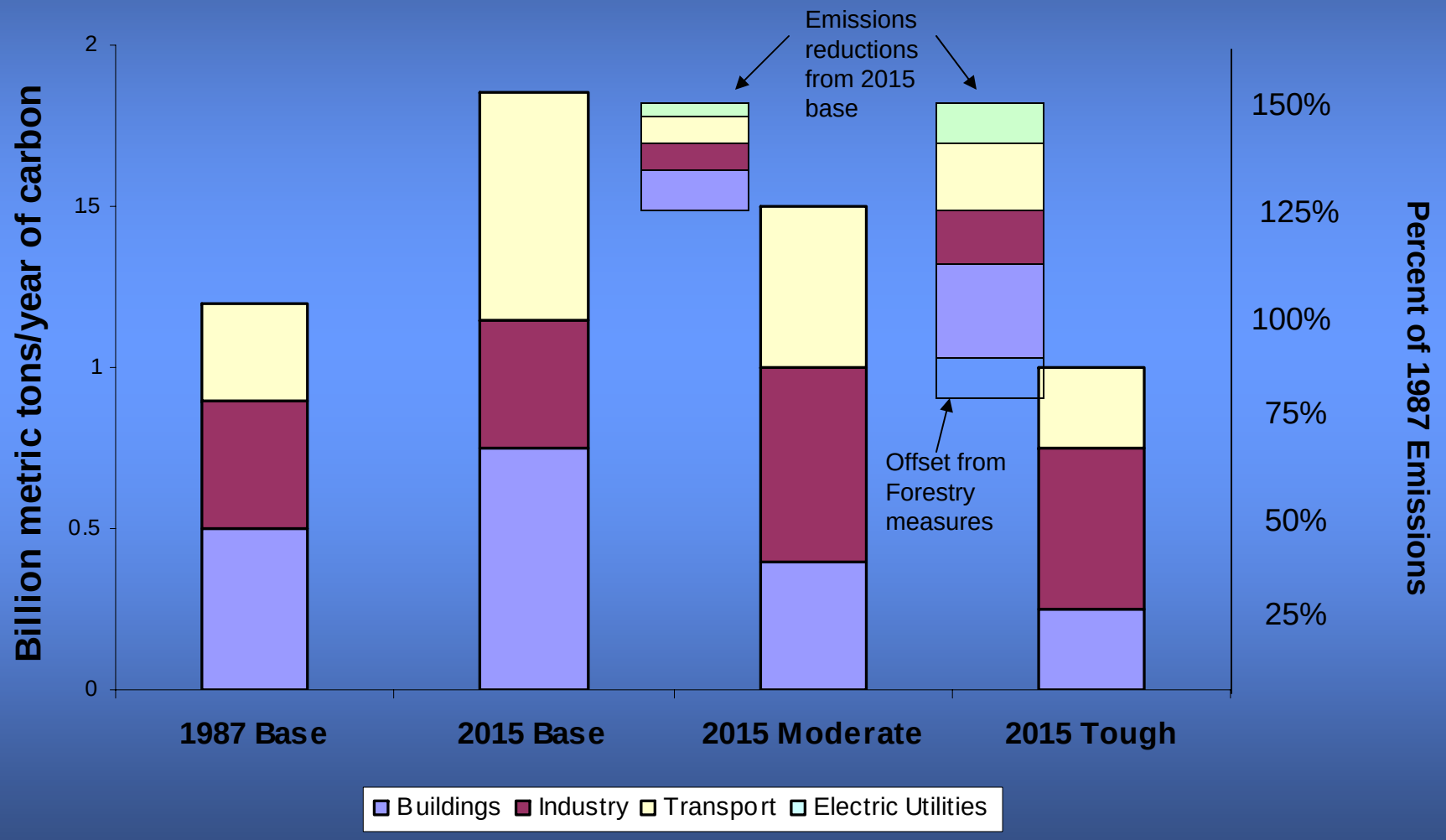

Historical and Projected Energy Use
Energy Use (EJ/yr)
2000
1500
1000
5000
0
1850
1875
1900
1925
1950
1975
2000
2025
2050
2075
2100
Natural Gas
Oil
Coal
Hydro
Nuclear
Biomass
Data: Nakicenovic


U.S. Energy Use
Lease and Plant (3%)
Feedstocks (6%)
HVAC and Light (6%)
Offhighway Oil (7%)
Process Heat (19%)
Steam (27%)
Machine Drive and Electrolytic (32%)
Industry (32%)
Non-Oil-Based (2%)
Rail and Marine (7%)
Aircraft (14%)
Heavy Trucks (14%)
Light Trucks (20%)
Automobiles (43%)
Transportation (32%)
Water Heat (9%)
Lights (14%)
Cooling (40%)
Appliances (20%)
Space Heat (43%)
Buildings (36%)

Demand Side Measures



Carbon Emissions Under the Base Case, Moderate, & Tough Scenarios



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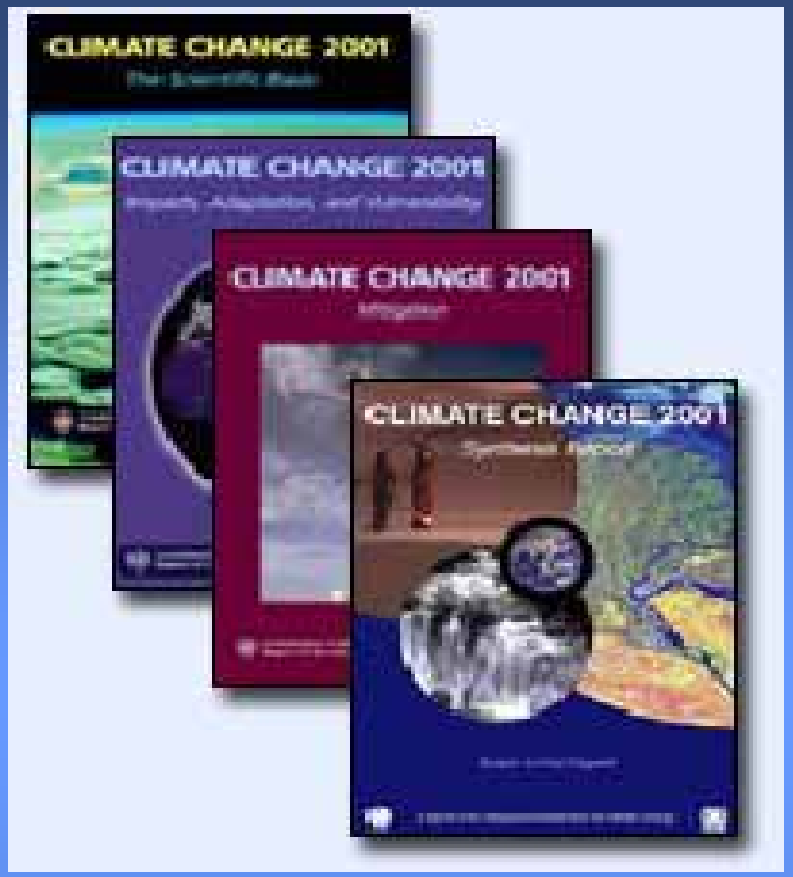
CLIMATE CHANGE 2001
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CLIMATE CHANGE IMPACTS ON THE UNITED STATES
THE POTENTIAL CONSEQUENCES OF CLIMATE VARIABILITY AND CHANGE
Overview
National Assessment Synthesis Team
US Global Change Research Program

Climate Change Research Needs

- **Regional impacts**

  --*What does it mean in my place?*

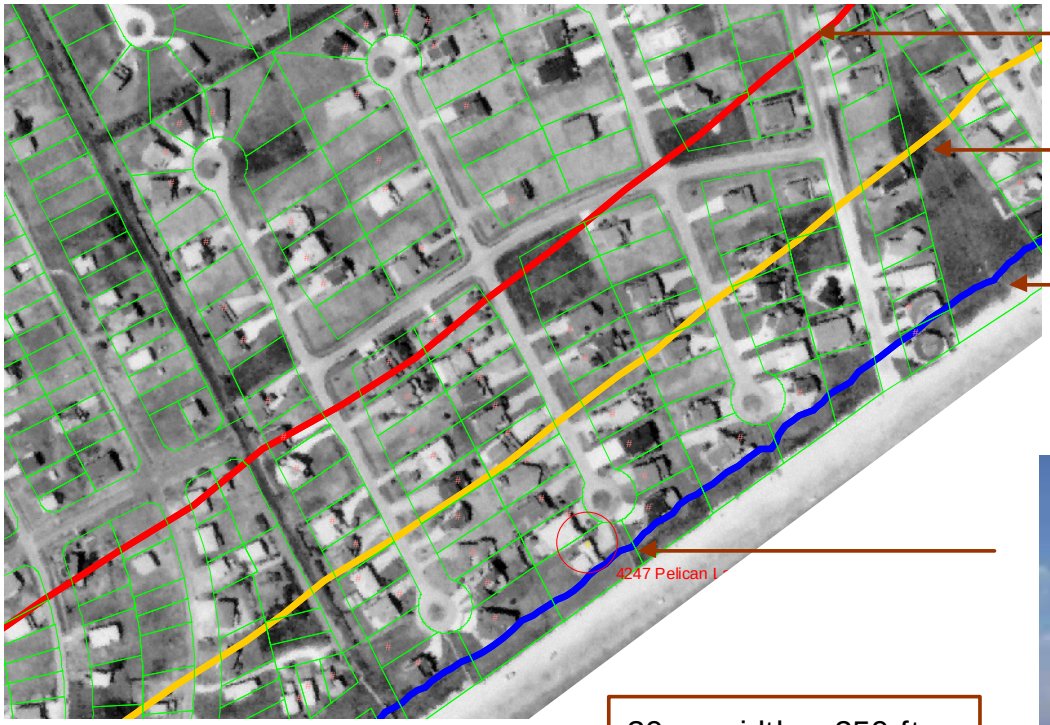
- **Interactions with other environmental stresses**

  --*so that "fixes" will not exacerbate other problems; worry about "tipping points"*

- **Extreme Events and their consequences**

  --*because they will increase in the future and we do not handle them well now*

Galveston, Texas



60-year ERF

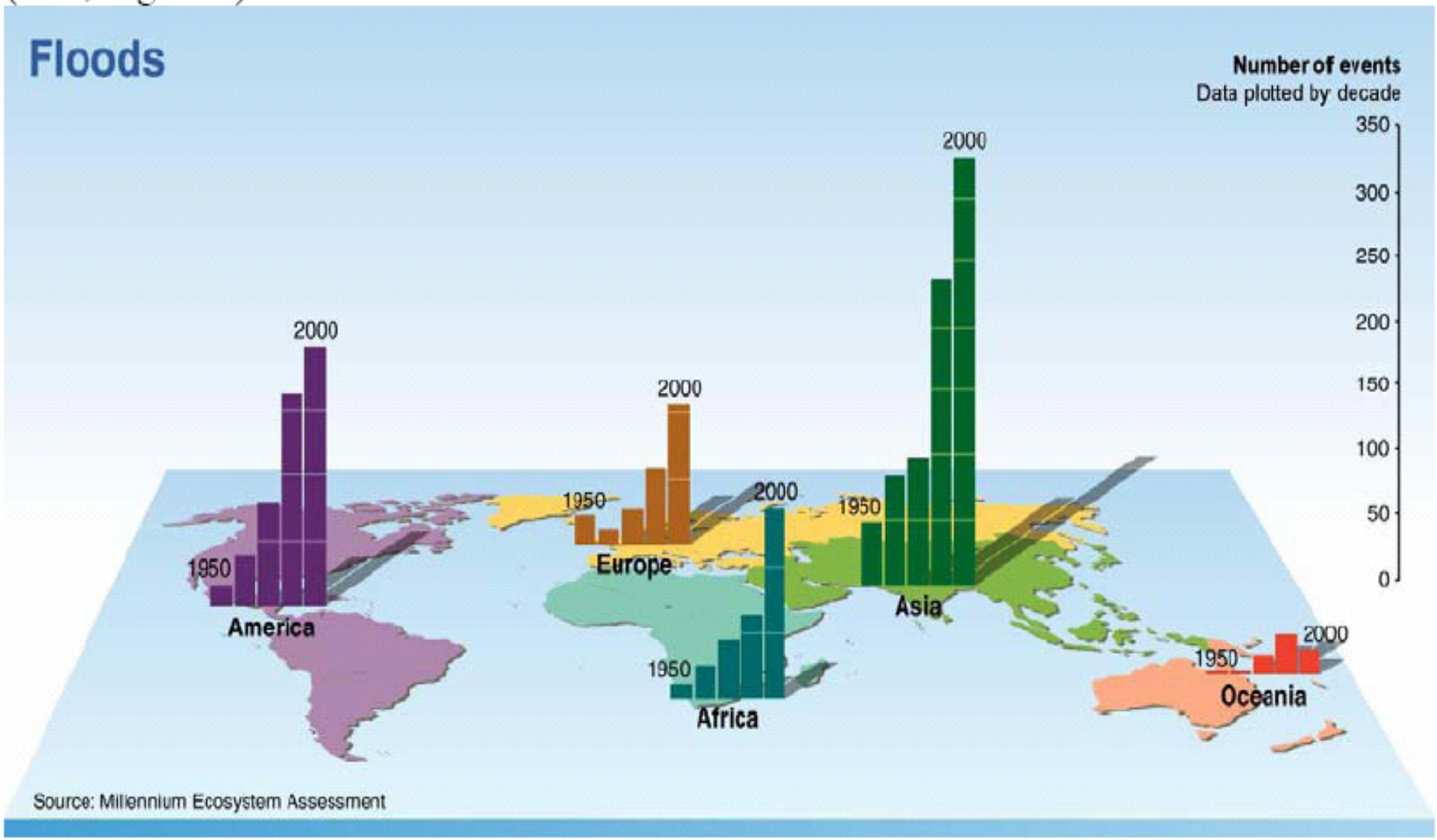
30-year ERF

Current ERF

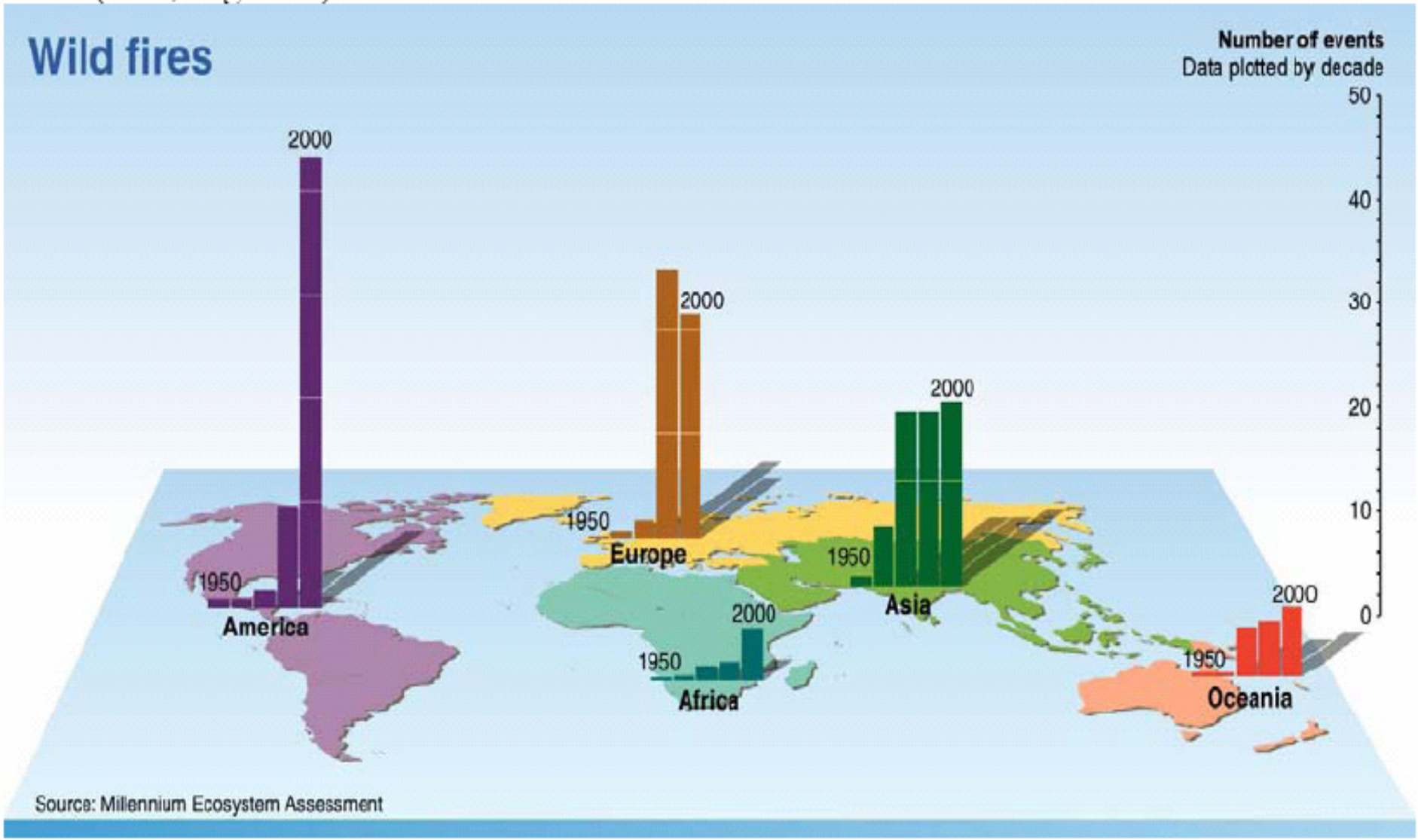
Key:
ERF = erosion reference feature
AAER = average annual erosion rate
BFE = base flood elevation

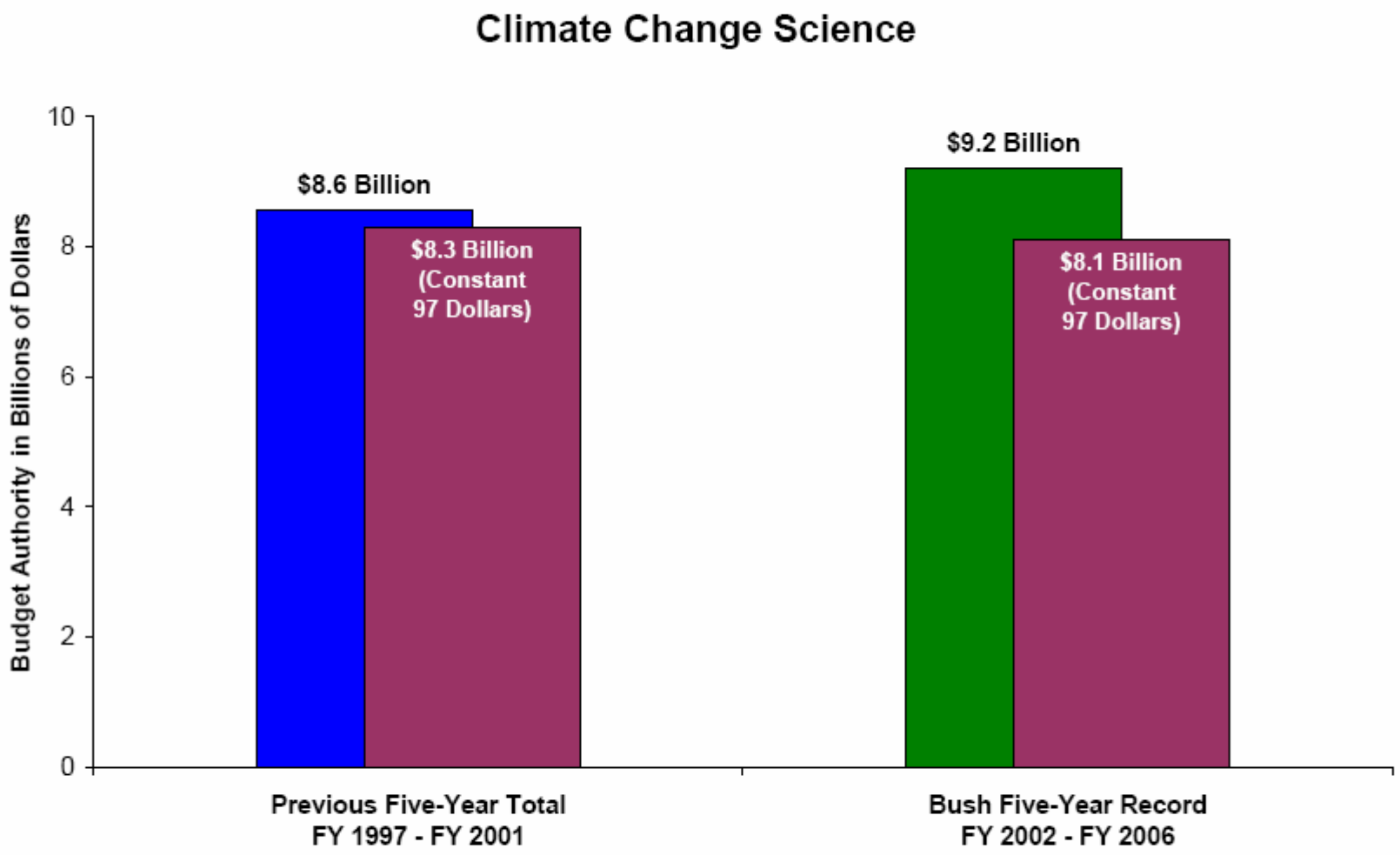
30-yr width = 250 ft
AAER = 8.5 ft/year
Zone = VE
BFE = 20

Appendix Figure A.7. Number of Flood Events by Continent and Decade Since 1950
(C16, Fig 16.6)



Appendix Figure A.8. Number of Major Wild Fires by Continent and Decade Since 1950 (C16, Fig 16.9)



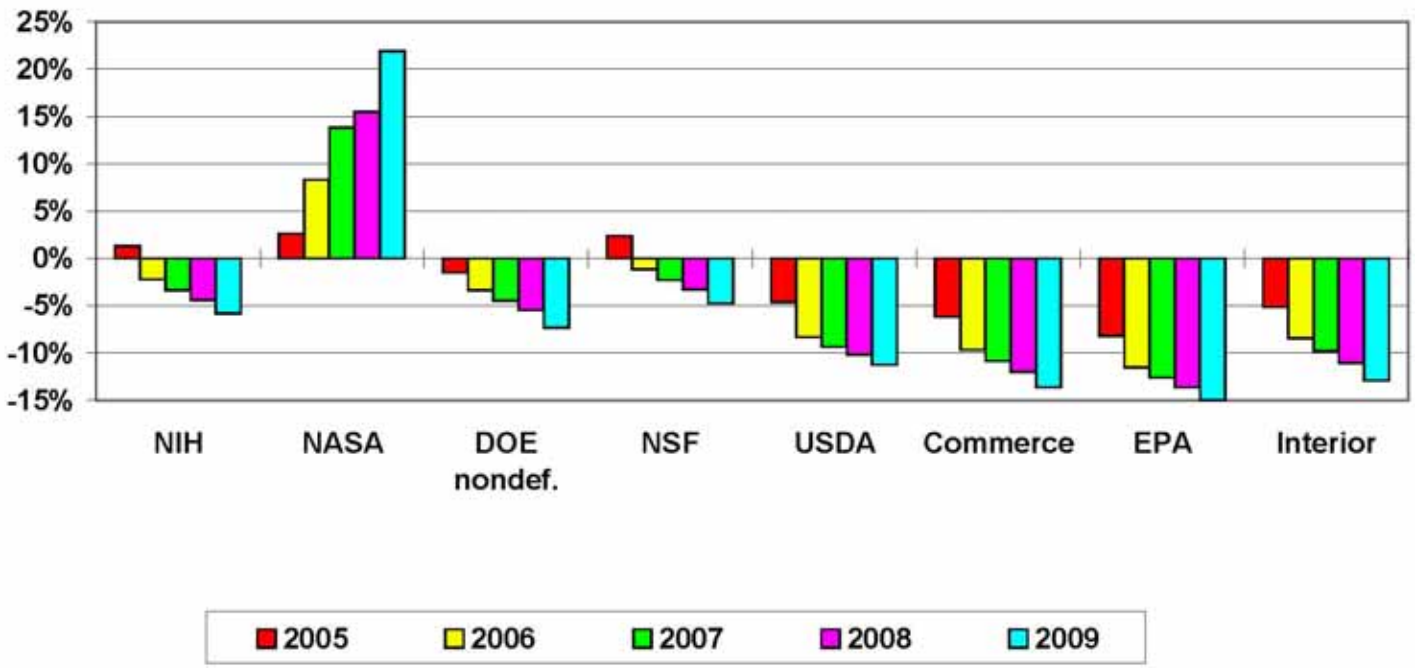


U.S. Global Change Research Program FY 1997 - 2001;
Climate Change Science Program FY 2002 - 2006

Research will get Squeezed in Future Budgets

Projected Nondefense R&D in the President's Budget, FY 2004-2009

% change from FY 2004 funding level in constant dollars



Source: AAAS analysis *Projected Effects of President's FY 2005 Budget on Nondefense R&D*

APRIL '04 © 2004 AAAS

AAAS

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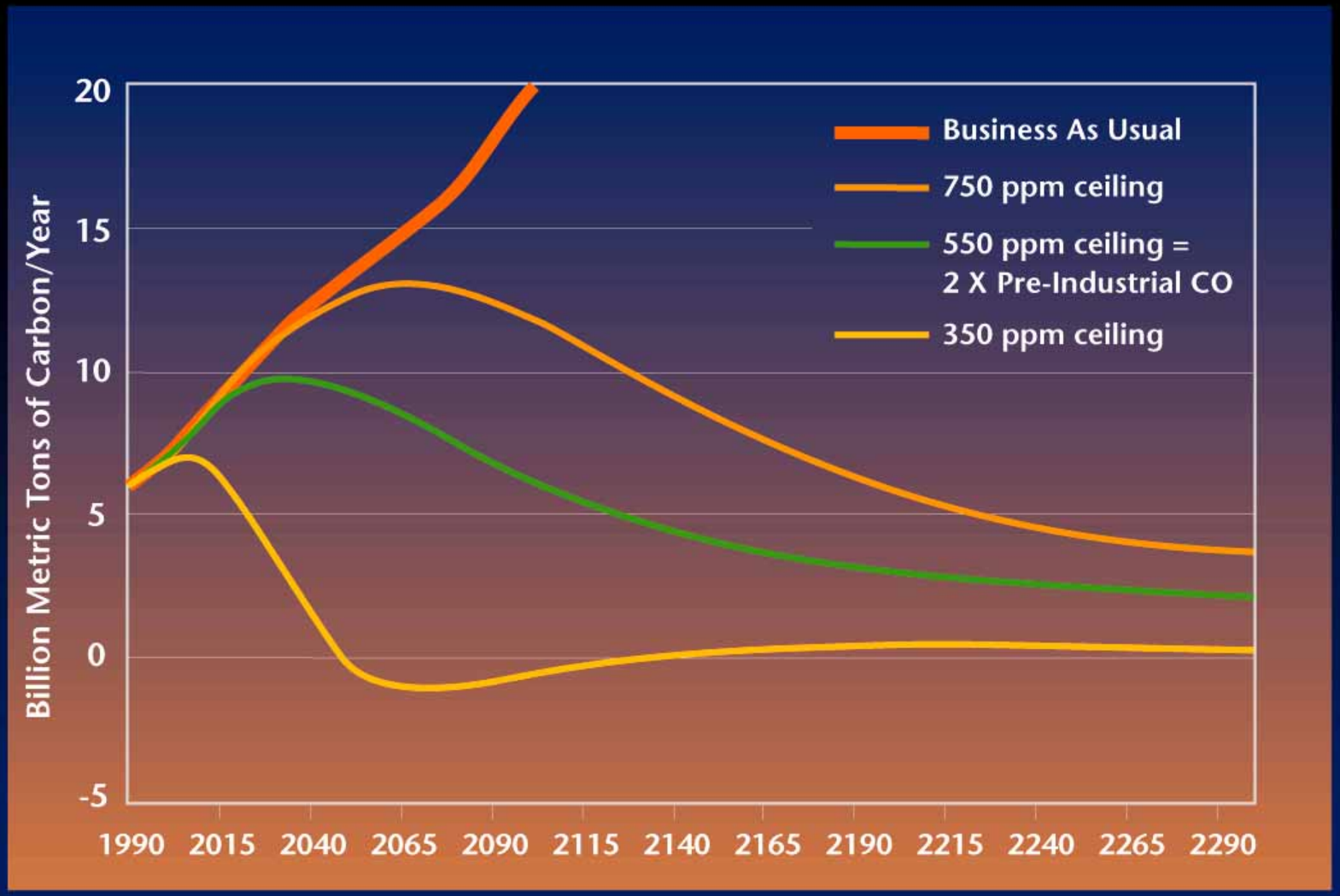
  The government must lead……

Atmospheric Stabilization Emissions Paths



Fifteen example wedges

CO_2 Capture & Storage (CCS)

CO_2 capture:

1. Introduce CCS at 800 GW coal or 1600 GW natural gas plants (1100 GW coal today)
2. Introduce CCS at plants producing 250 MtH_2/yr from coal or 500 MtH_2/yr from natural gas (40 MtH_2/yr today)
3. Introduce CCS at synfuels plants producing 30 mbd from coal (200x Sasol)

H_2 safety, infrastructure

Geologic storage:
Create 3500 Sleipners

Durable storage

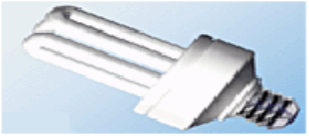
Wind and Solar

4. Add 2 million 1-MW-peak windmills (50 times current level) on 30 Mha, displacing coal electricity
5. Add 2000 GW-peak PV plants (700 times current level) on 2 Mha, displacing coal electricity

6. Add 4 million windmills or 4000 GW-peak PV plants generating 200 MtH_2/yr, displacing gasoline hybrid cars

Energy storage, H_2 safety, infrastructure
PV production cost

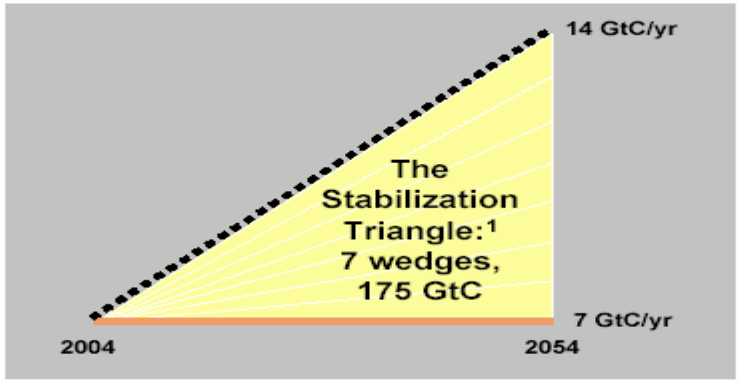
Energy Efficiency & Conservation



Increase economy-wide emissions/GDP reduction by additional 0.15%/yr (e.g. increase US goal of 1.96%/yr to 2.11%/yr):

8. Increase fuel economy for 2 billion cars from 30 to 60 mpg
9. Decrease car travel for 2 billion 30-mpg cars from 10,000 to 5,000 miles/yr
10. Cut carbon emissions in buildings/appliances by 1/4 over 2054 projection
11. Produce twice today's coal output at 60% efficiency instead of 40% (compare with 32% today)

Weak incentives, urban design, lifestyle changes



Forests & Soils

14. Decrease tropical deforestation to zero instead of 0.5 GtC/yr, and establish 300 Mha of new tree plantations (twice current level)
15. Implement conservation tillage on all cropland (10 times current level)

Competing land use, verification, reversibility

Biomass Fuel

7. Add 50 times current US and Brazil ethanol production on 250 Mha (1/6 world cropland)

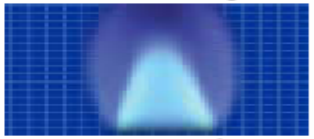
Biodiversity, competing land use

Nuclear Fission

13. Add 700 GW nuclear plants (compare with 350 GW today) replacing coal

Nuclear proliferation, terrorism, waste

Fuel Switching



12. Replace 1400 GW coal plants with natural gas plants (compare with 350 GW natural gas today)

Competing demands for natural gas

Beyond 2054

More wedges will be needed to maintain the trajectory established by the stabilization triangle, and scaling up the above technologies are unlikely to be enough to satisfy growing energy demand. Therefore, it is imperative that advanced technologies, including **artificial photosynthesis, satellite solar power, nuclear fusion,** and **geoengineering strategies** be developed now,[3] so that the second and subsequent "runners" have the necessary tools to do their jobs.

References

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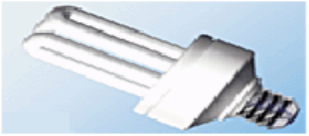

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Weak incentives, urban design, lifestyle changes

Renewables = 4 wedges

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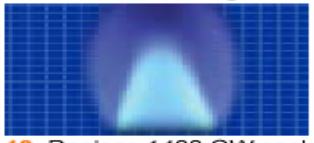

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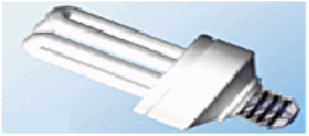

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Efficiency = 4 wedges

Forests & Soils

14. Decrease tropical deforestation to zero instead of 0.5 GtC/yr, and establish 300 Mha of new tree plantations (twice current level)
15. Implement conservation tillage on all cropland (10 times current level)

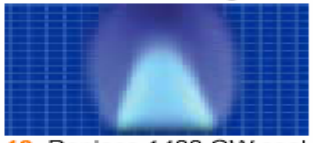
Competing land use, verification, reversibility

Nuclear Fission

13. Add 700 GW nuclear plants (compare with 350 GW today) replacing coal

Nuclear proliferation, terrorism, waste

Fuel Switching



12. Replace 1400 GW coal plants with natural gas plants (compare with 350 GW natural gas today)

Competing demands for natural gas

Biomass Fuel

7. Add 50 times current US and Brazil ethanol production on 250 Mha (1/6 world cropland)

Biodiversity, competing land use

Beyond 2054

More wedges will be needed to maintain the trajectory established by the stabilization triangle, and scaling up the above technologies are unlikely to be enough to satisfy growing energy demand. Therefore, it is imperative that advanced technologies, including **artificial photosynthesis, satellite solar power, nuclear fusion,** and **geoengineering strategies** be developed now,[3] so that the second and subsequent "runners" have the necessary tools to do their jobs.

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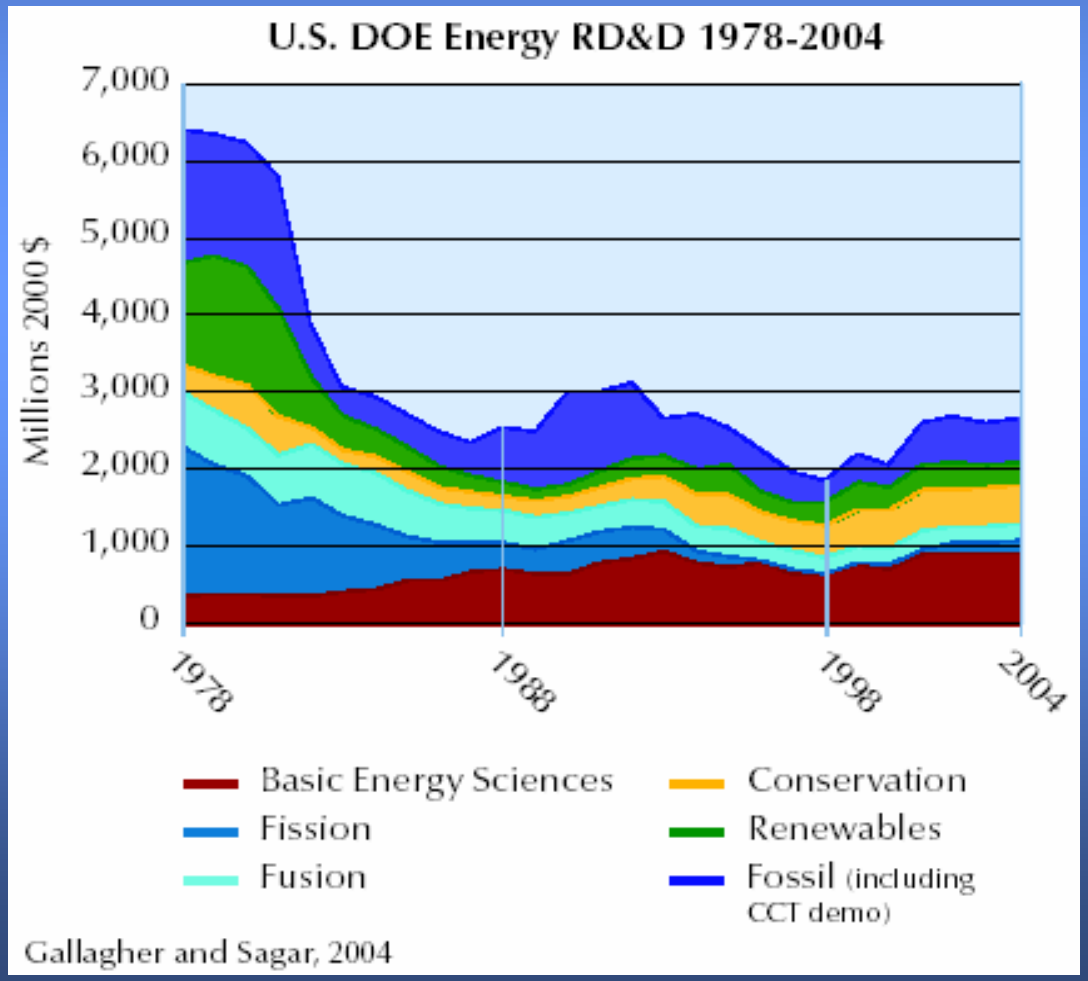
Technology Development

Federal energy R&D spending has declined over the past 25 years.



Changing Landscape

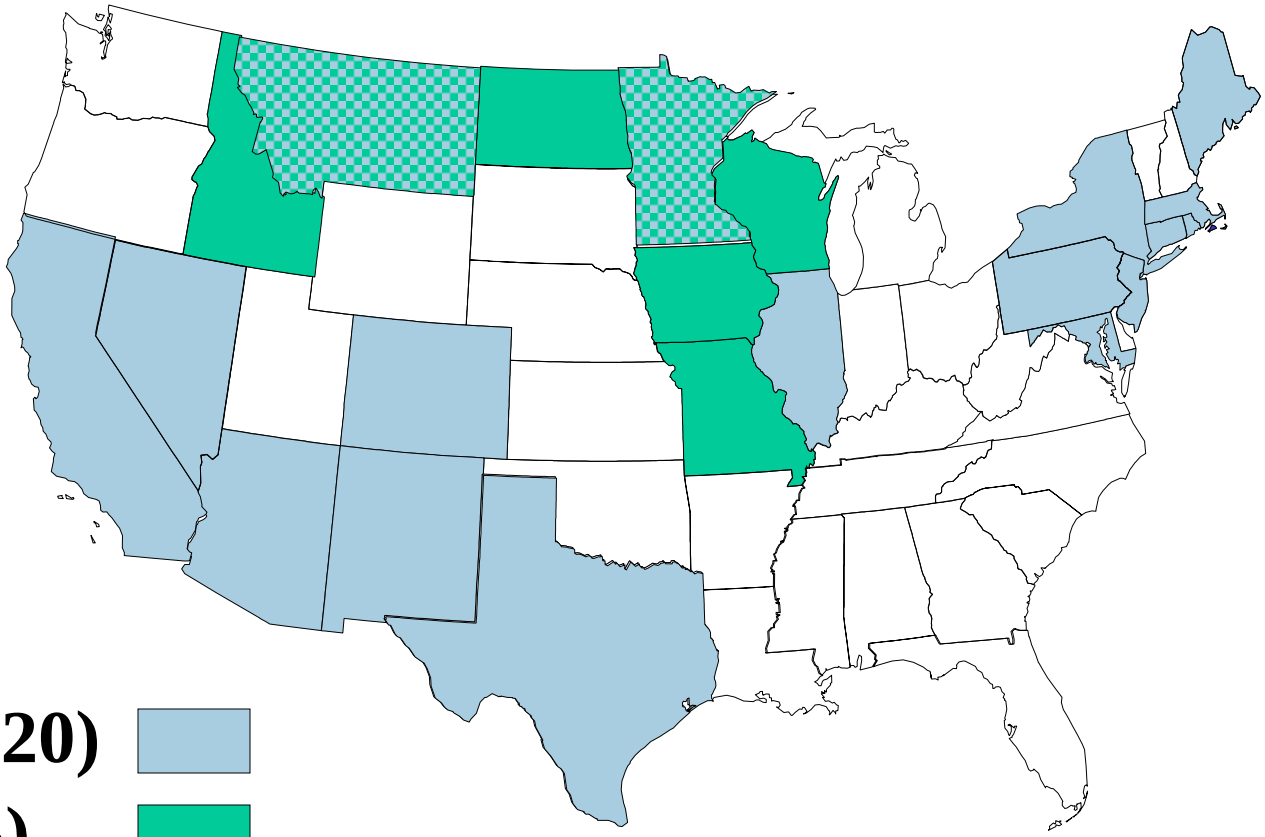
- G-8 Communique
- Sense of the Senate Resolution
- Senate Energy Bill—RPS, RFS
- Pressure coming from
  - Cities
  - States
  - Mainstream corporate America
  - International
  - Drumbeat of science
  - New voices: Evangelicals

National Commission on Energy Policy

Duke Energy

CINERGY the power of change

Renewable Power (RPS) and Fuels (RFS) Standards



Hawaii

Power (20)

Fuels (5)

Both (3)

Corporate Commitments and Results

10% reduction
$650 million saved

69% reduction
$2 billion saved

10% reduction
"It's made us more competitive"

5% reduction

Absolute cap

35% reduction
$200 million saved

19% reduction

10% reduction

72% reduction

25% reduction
$100 million saved

6% reduction

65% reduction
$791 million saved

9% reduction

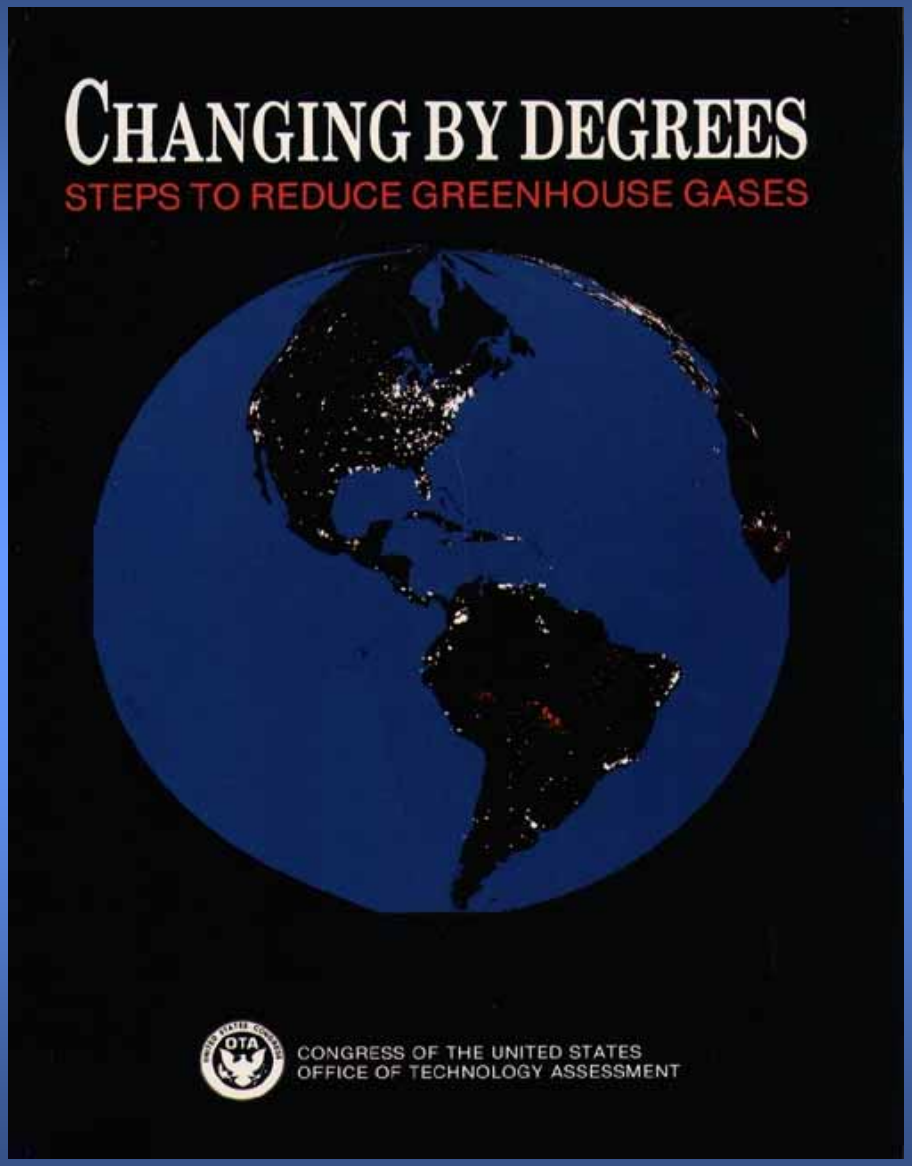
37% reduction

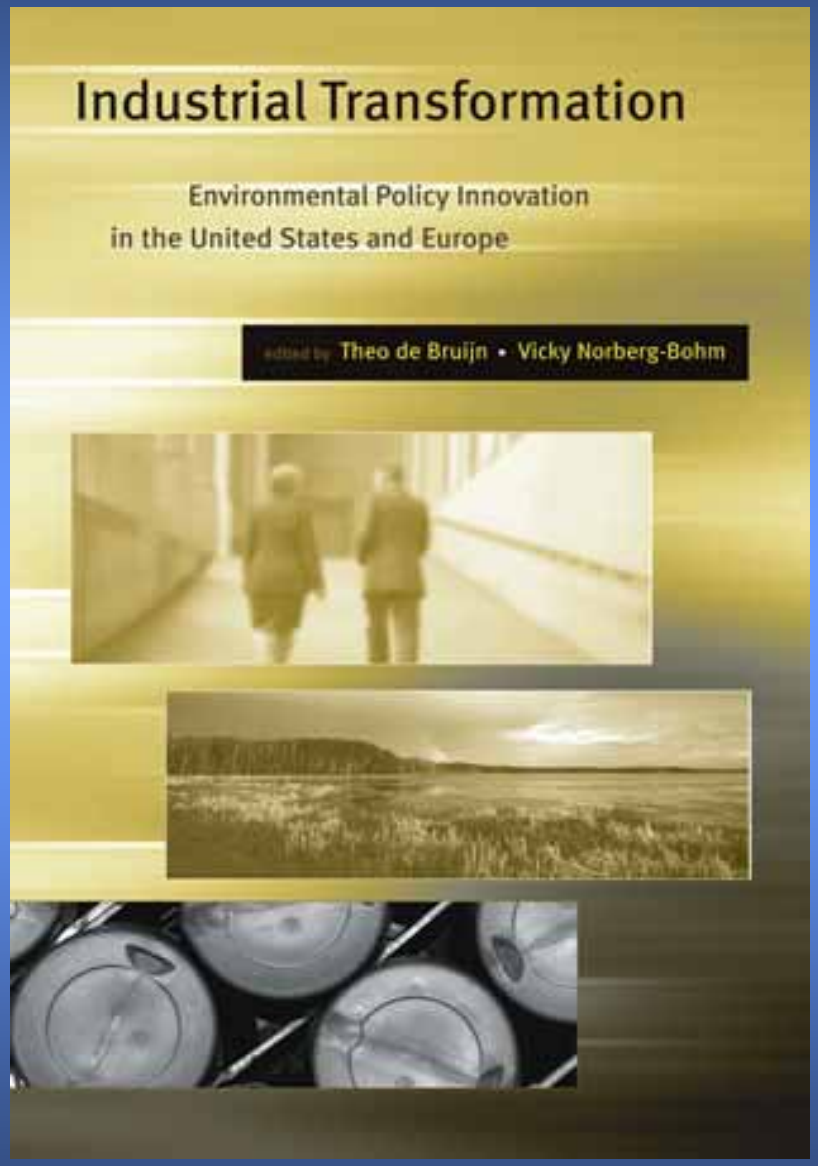
13% reduction

1% reduction
$1.5 billion clean tech R&D

17% reduction

25% reduction


CHANGING BY DEGREES
STEPS TO REDUCE GREENHOUSE GASES
CONGRESS OF THE UNITED STATES
OFFICE OF TECHNOLOGY ASSESSMENT


Industrial Transformation
Environmental Policy Innovation
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