Global Climate Change: Myth or Reality? Mitigation or Adaptation?

Presented to

Chattanooga Engineers Club

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The global climate problem

Key Conclusions of the Intergovernmental Panel on Climate Change, 2001

The Earth's climate is changing

- Temperatures and sea level are increasing
- Glaciers are retreating
- Arctic sea ice is thinning
- El-Nino is becoming more frequent

Human activities are changing the atmospheric concentrations of greenhouse gases

There is new and stronger evidence that most of the observed warming of the past 50 years is attributable to human activities

The Earth's mean annual surface temperature is projected to increase by 1.4–5.8 °C between 1990 and 2100

Sea levels are projected to rise 3–35 inches by 2100

Potential climate change impacts

Health Impacts
- Weather-related mortality
- Infectious diseases
- Air quality - respiratory illnesses

Agriculture Impacts
- Crop yields
- Irrigation demands

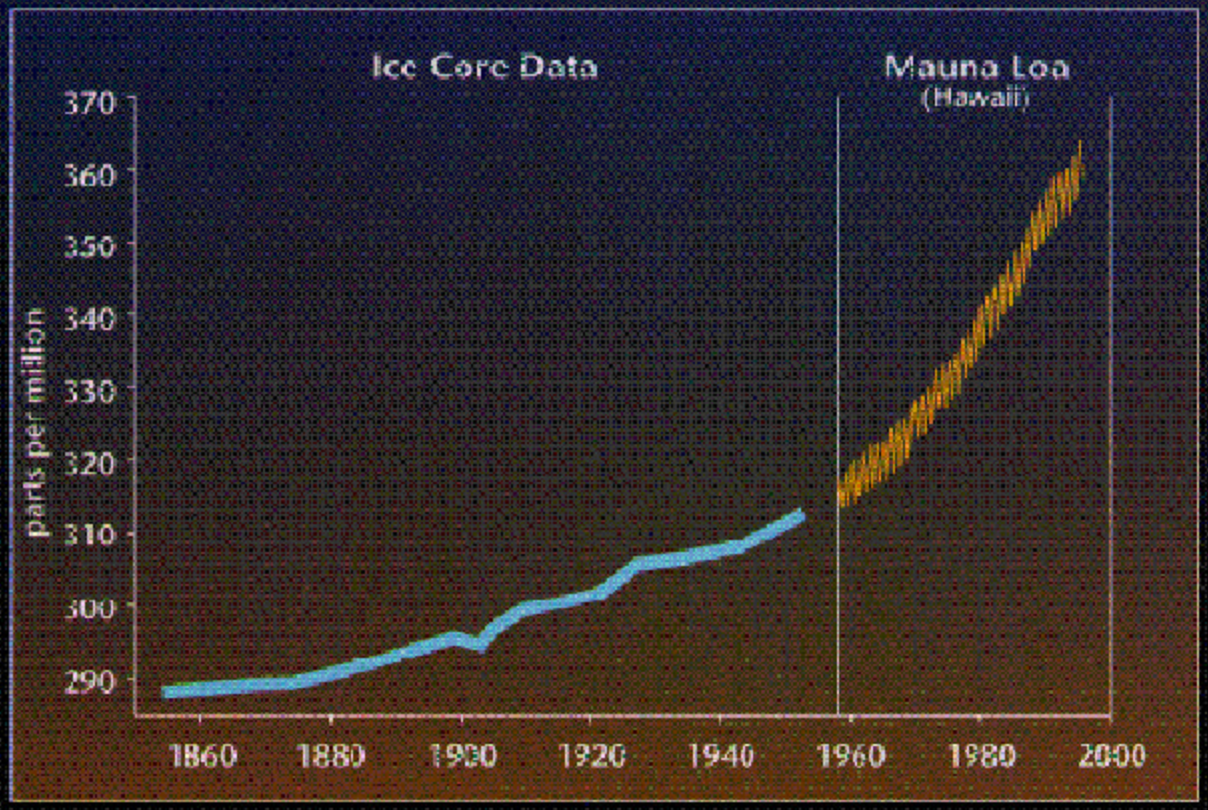
Forest Impacts
- Forest composition
- Geographic range of forest
- Forest health and productivity

Water Resource Impacts
- Water supply
- Water quality
- Competition for water

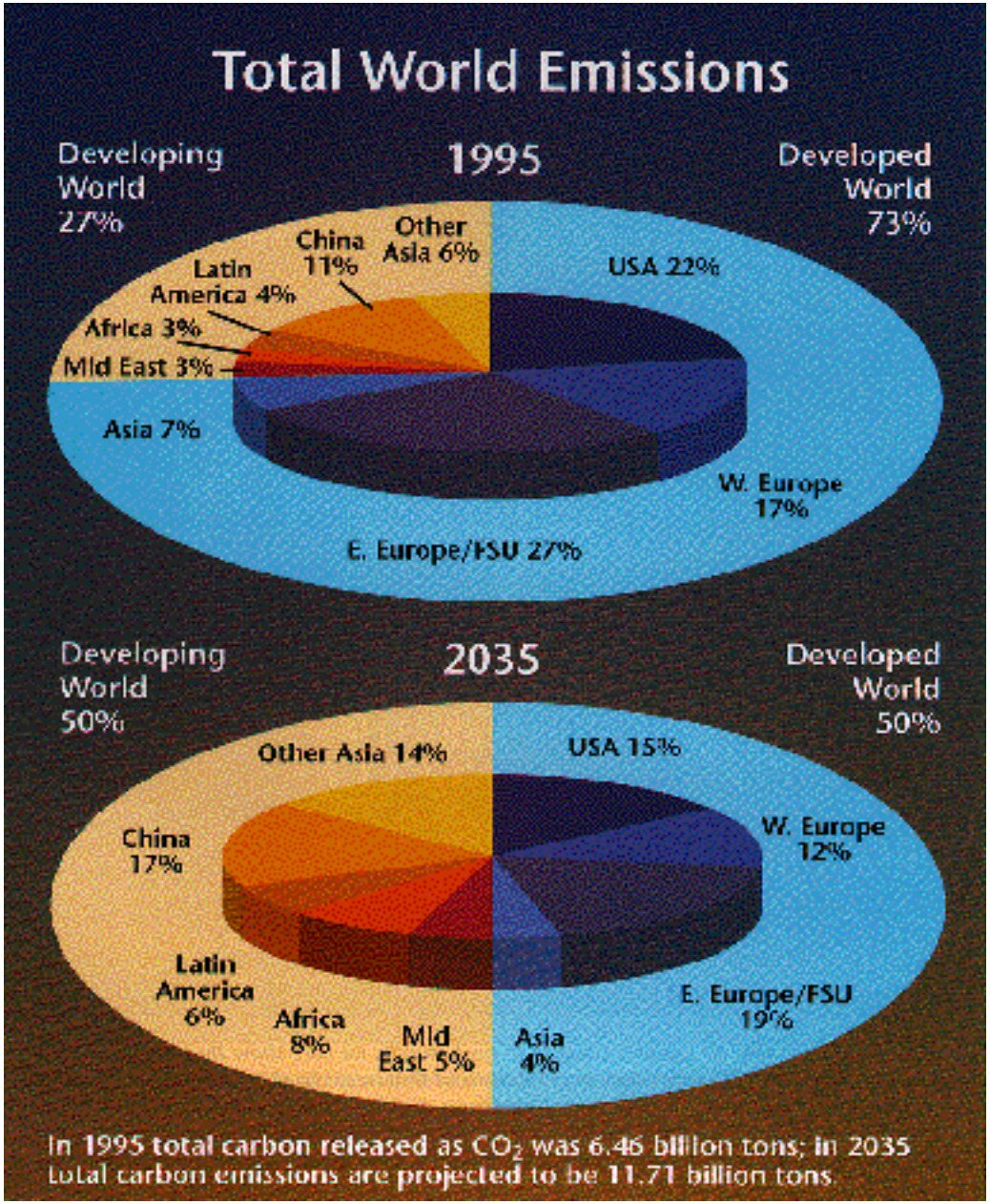
Impacts on Coastal Areas
- Erosion of beaches
- Inundation of coastal lands
- Additional costs to protect coastal communities

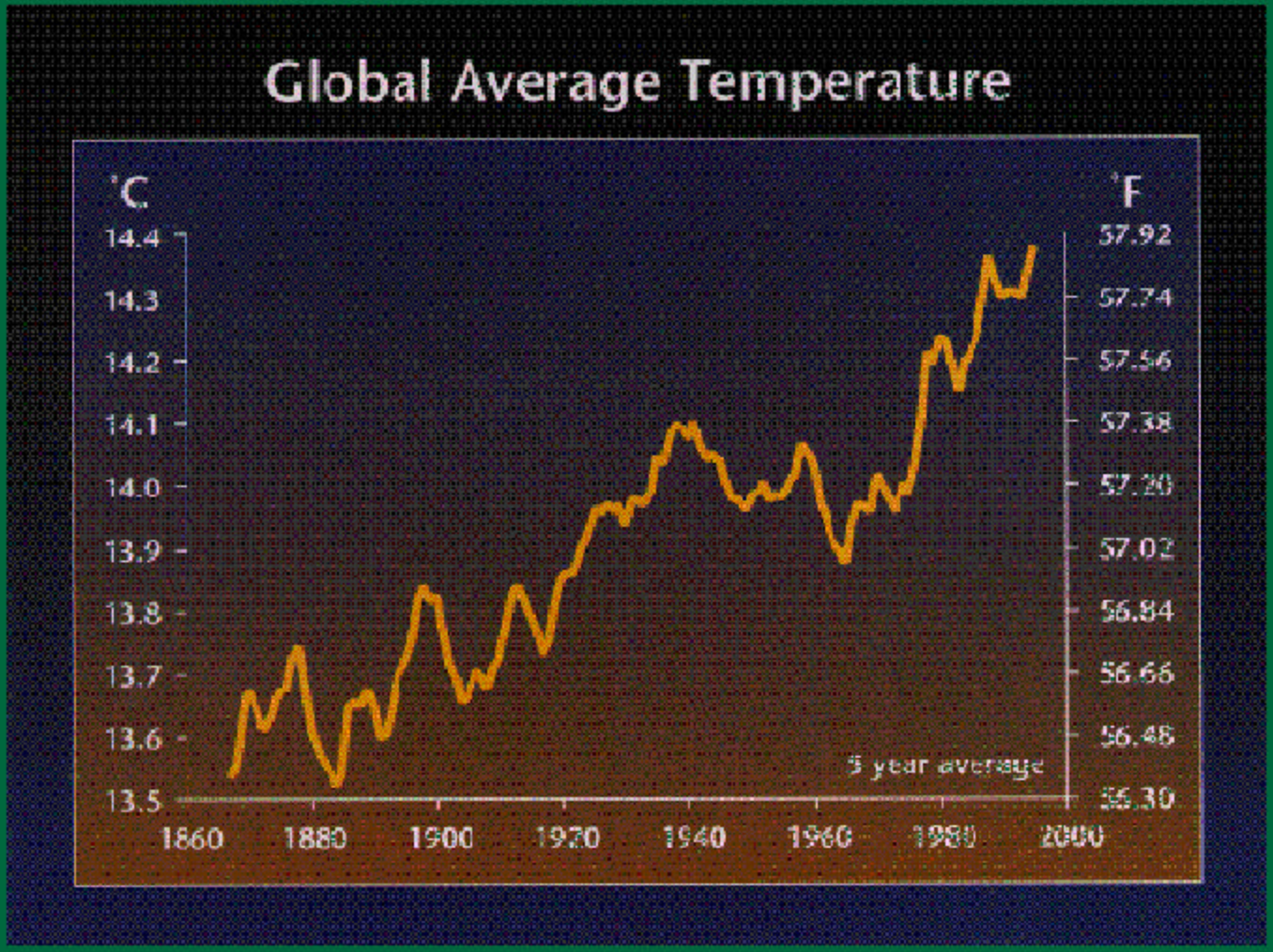
Impacts on Species and Natural Areas
- Loss of habitat and species

Carbon Dioxide Concentrations

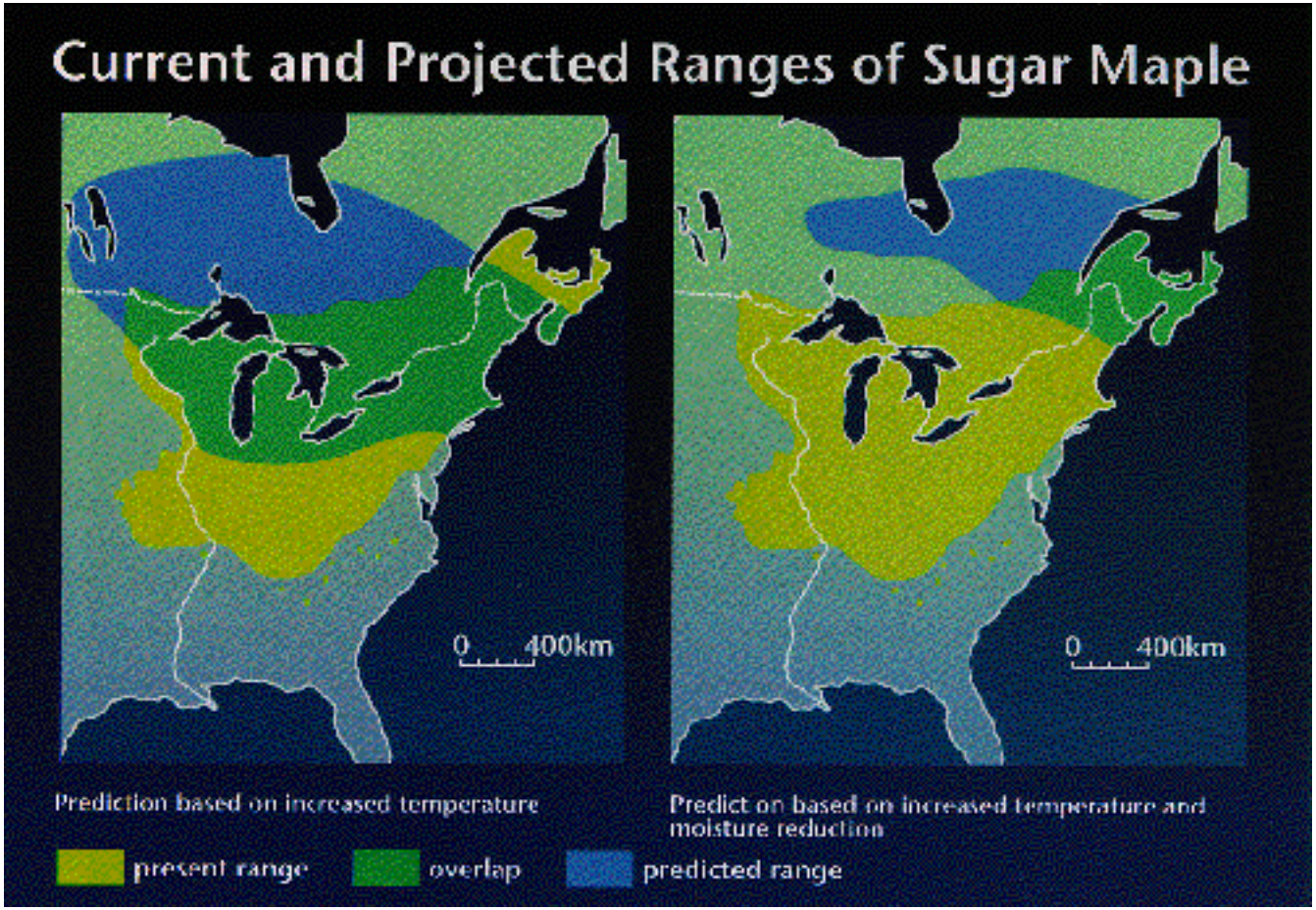


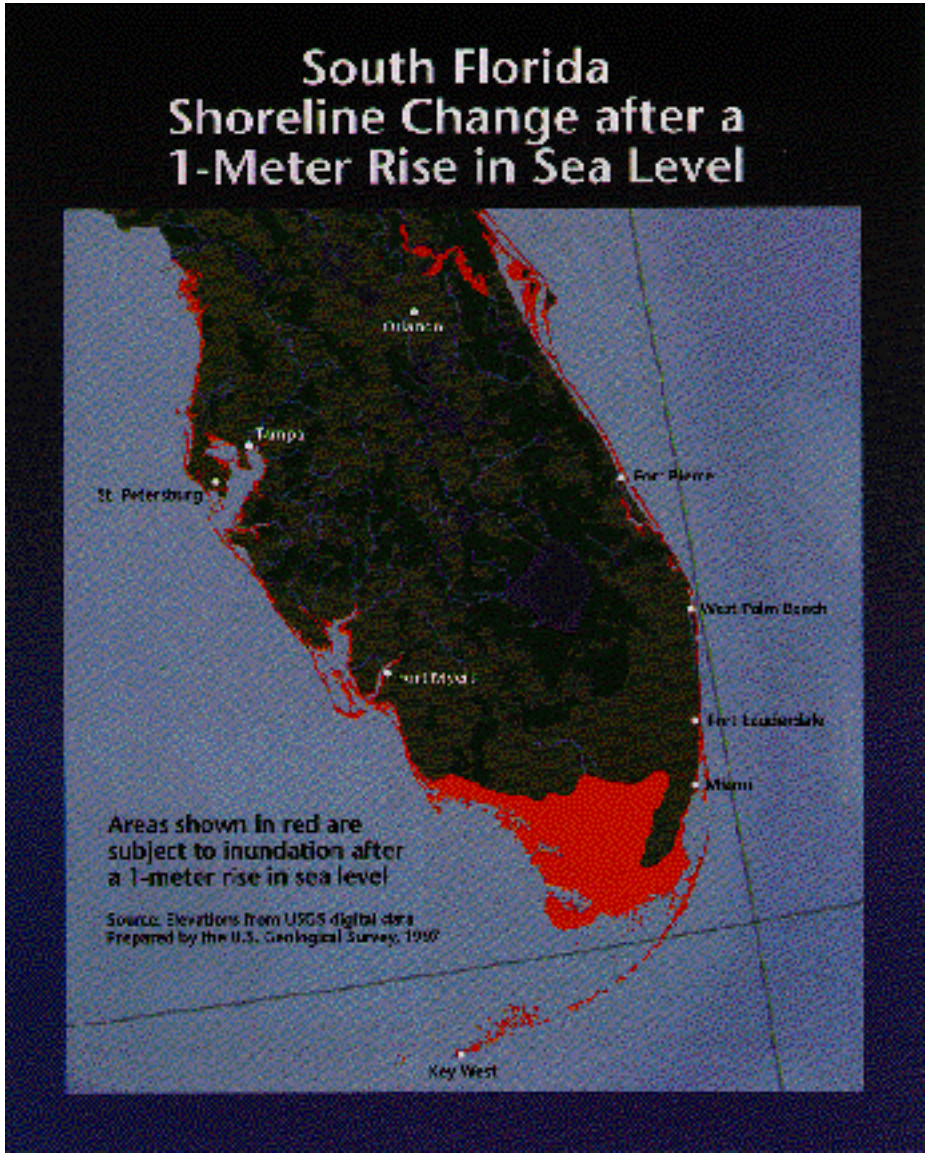
Since the beginning of the Industrial Revolution in the middle of the 19th century, the concentration of carbon dioxide (CO_2) in the atmosphere has steadily increased. Beginning in 1958, continual measurements of atmospheric CO_2 concentrations have been made by scientists at an observatory in Mauna Loa, Hawaii. The seasonal cycle of vegetation in Northern latitudes can be seen in this record: each spring the vegetation "inhales" and absorbs CO_2, and each autumn most of that CO_2 is released back to the atmosphere.


Total World Emissions
1995
Developing World 27%
Developed World 73%
China 11%
Other Asia 6%
Latin America 4%
Africa 3%
Mid East 3%
Asia 7%
USA 22%
W. Europe 17%
E. Europe/FSU 27%
2035
Developing World 50%
Developed World 50%
Other Asia 14%
China 17%
Latin America 6%
Africa 8%
Mid East 5%
Asia 4%
USA 15%
W. Europe 12%
E. Europe/FSU 19%
In 1995 total carbon released as CO_2 was 6.46 billion tons; in 2035 total carbon emissions are projected to be 11.71 billion tons.



The global average temperature has risen by approximately 1°F over the last century.


Current and Projected Ranges of Sugar Maple
0 400km
0 400km
Prediction based on increased temperature
Predict on based on increased temperature and moisture reduction
present range
overlap
predicted range


South Florida
Shoreline Change after a
1-Meter Rise in Sea Level
Tampa
St. Petersburg
West Palm Beach
Miami
Key West
Areas shown in red are
subject to inundation after
a 1-meter rise in sea level

"ADAPTATION" IS ONE WAY OF RESPONDING TO GLOBAL CLIMATE CHANGE

(1) Geoengineering to mitigate impacts of climate change

- **Accelerating the adaptation of natural biosystems, e.g., through species transplantation**
- **Establishing and maintaining gene banks to preserve biodiversity**

(2) Geoengineering to reduce climate change without reducing emissions

- **Orbiting reflecting panels**

(3) Strengthening physical infrastructures

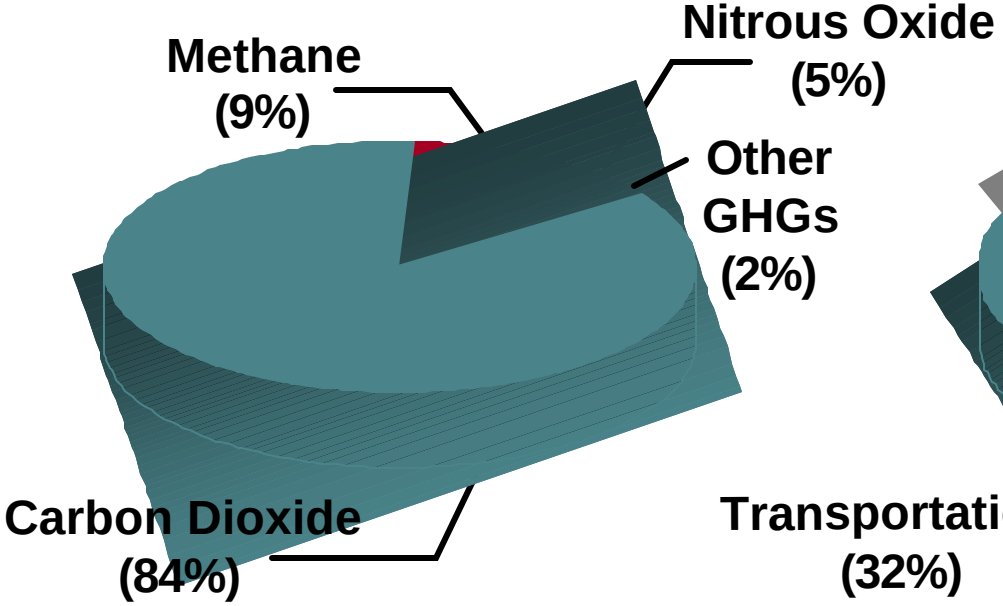
- **Hardening seacoast structures against sea-level rise, including seawalls**
- **Assuring the resilence of transportation, communication, and transmission infrastructures**
- **Climate-conditioning buildings**

ADAPTATION PATHWAYS (cont.)

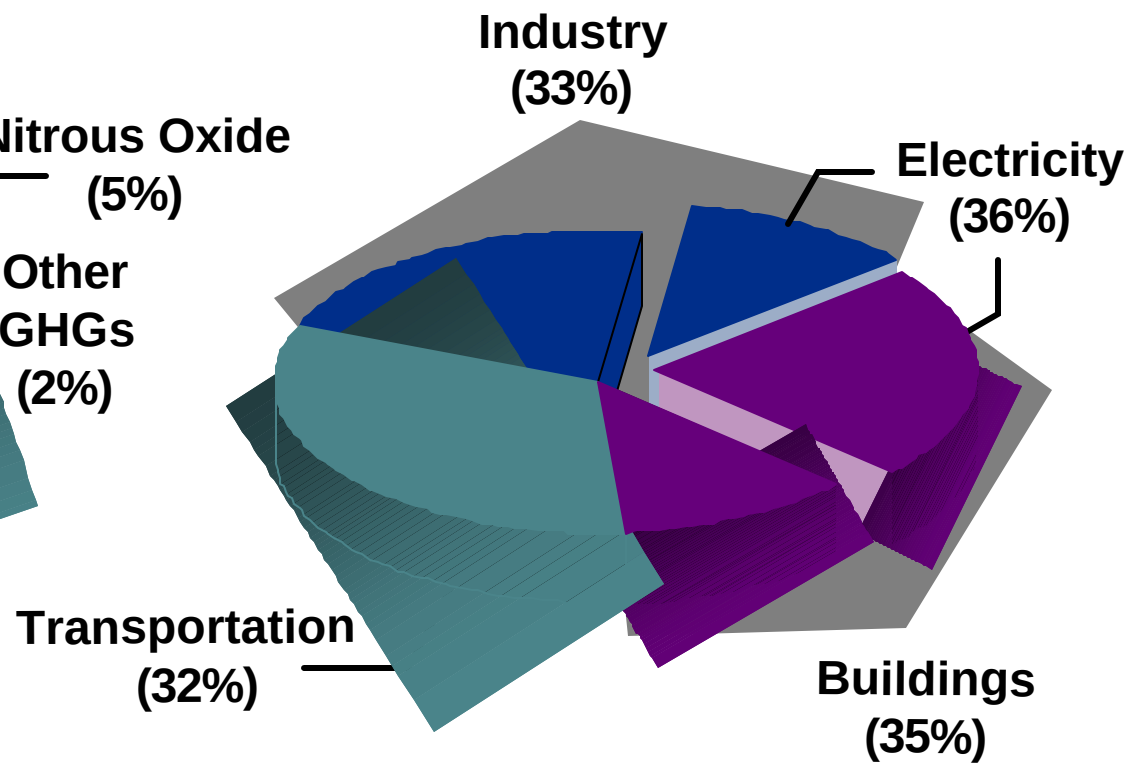
- **(4) Strengthening information infrastructures**
  - **Improving environmental monitoring, including detection of early warning signals**
  - **Improving climate prediction and weather forecasting**
  - **Improving early warning systems for floods and other natural disasters**
- **(5) Strengthening institutional infrastructures**
  - **Developing agricultural systems and practices better suited to climate variability and change**
  - **Land-use planning, e.g., limiting development in low-lying coastal, wetlan, and floodplain areas and other actions t limit precarious land uses**

"MITIGATION" IS ANOTHER RESPONSE--it is intimately tied to energy

U.S. GHG Emissions
88% are energy related

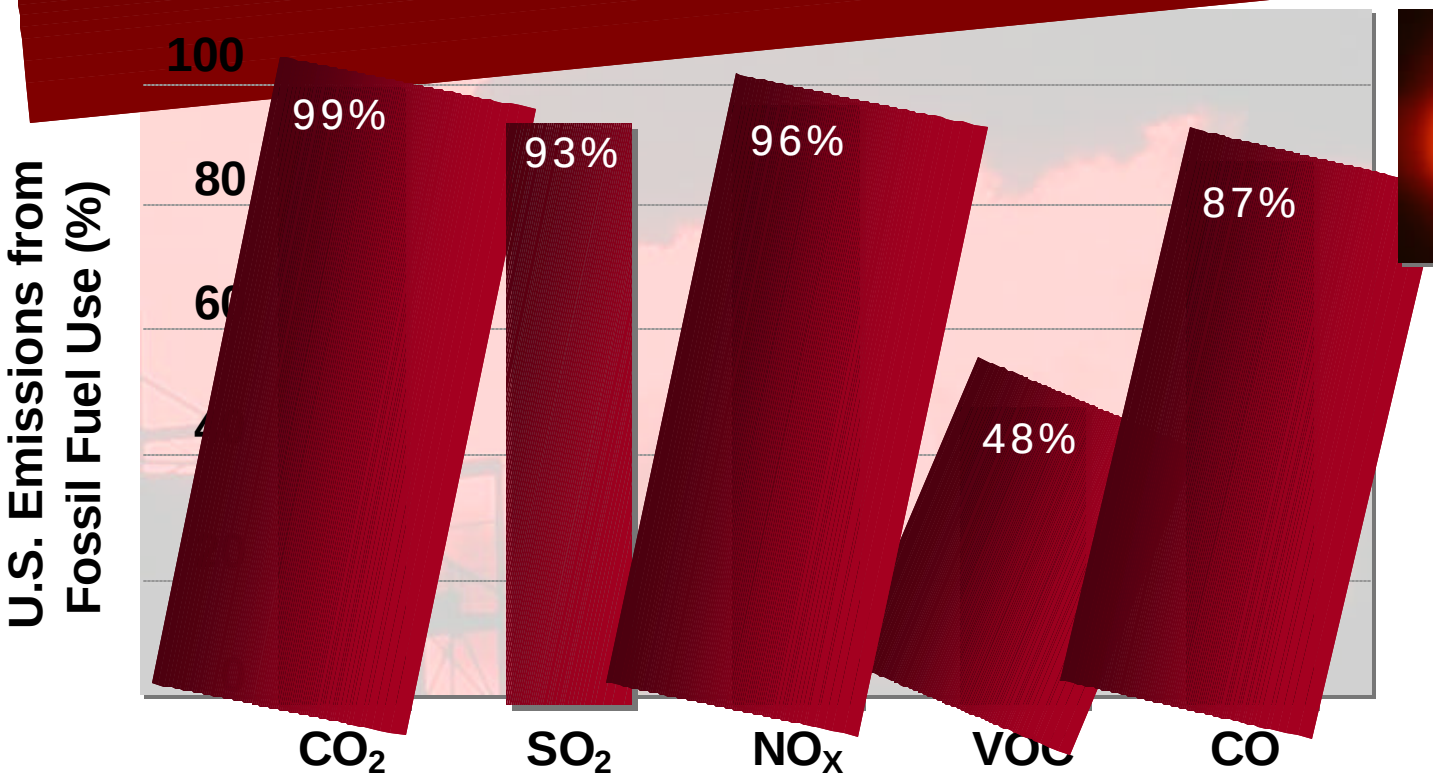


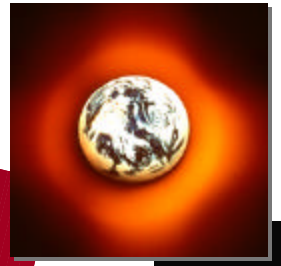
U.S. CO_2 Emissions
by Energy Sector



Reducing GHG emissions could also address the nation's air quality challenge

"Using energy in today's ways leads to more environmental damage than any other peaceful human activity" . . . ***The Economist***

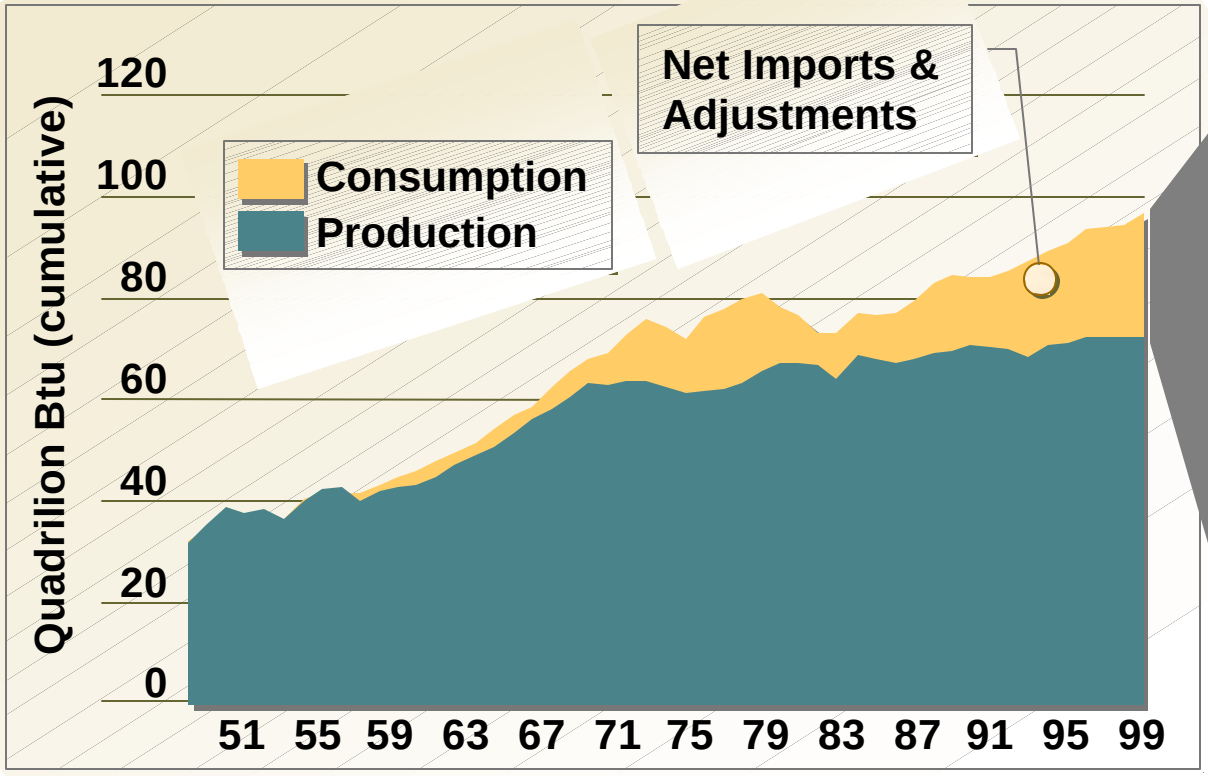




DISTINCTIONS BETWEEN MITIGATION AND ADAPTATION:

	Mitigation	*Adaptation*
Timing	**Costs now, benefits delayed**	**Costs whenever, benefits may be relatively soon after**
Temporal Incidence	**Costs now, benefits to later generations**	**Benefits more or less appropriable by those bearing costs**
Geographic Incidence	**Local costs, global benefits**	**Local costs, often relatively local benefits**
Sectoral Incidence	**Focus on emissions from energy consumption**	**Very heterogeneous**
Relation to Uncertainty	**Must act early despite greater uncertainty**	**May act later after reducing uncertainty**

There are Other Energy Challenges: America's margin of energy supply is at an all-time low



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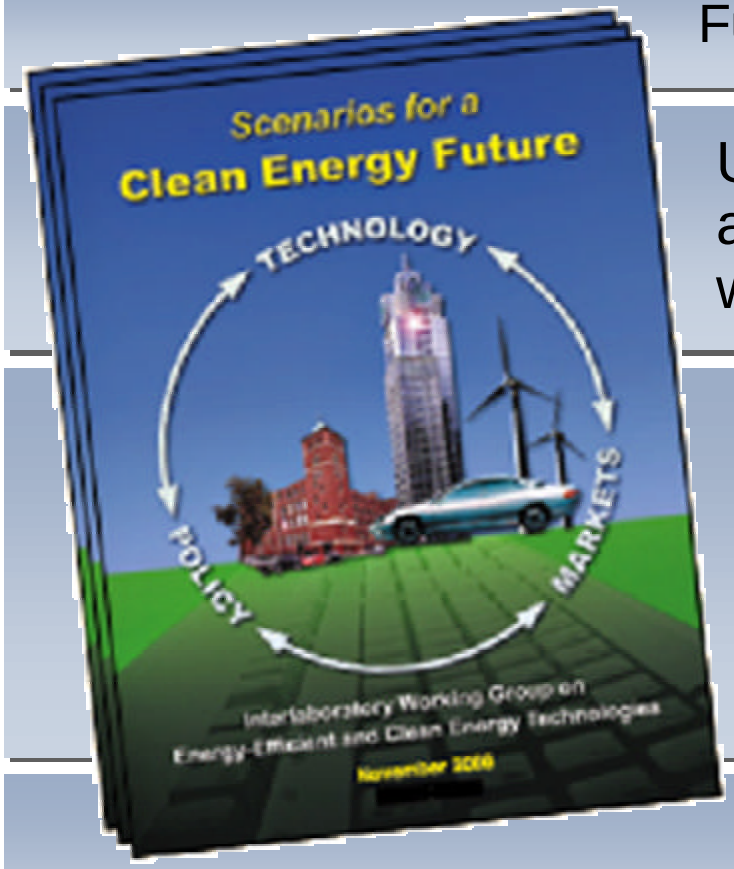
A balanced strategy is needed to meet the nation's energy challenges

Scenarios for a clean energy future



Funded by DOE and EPA

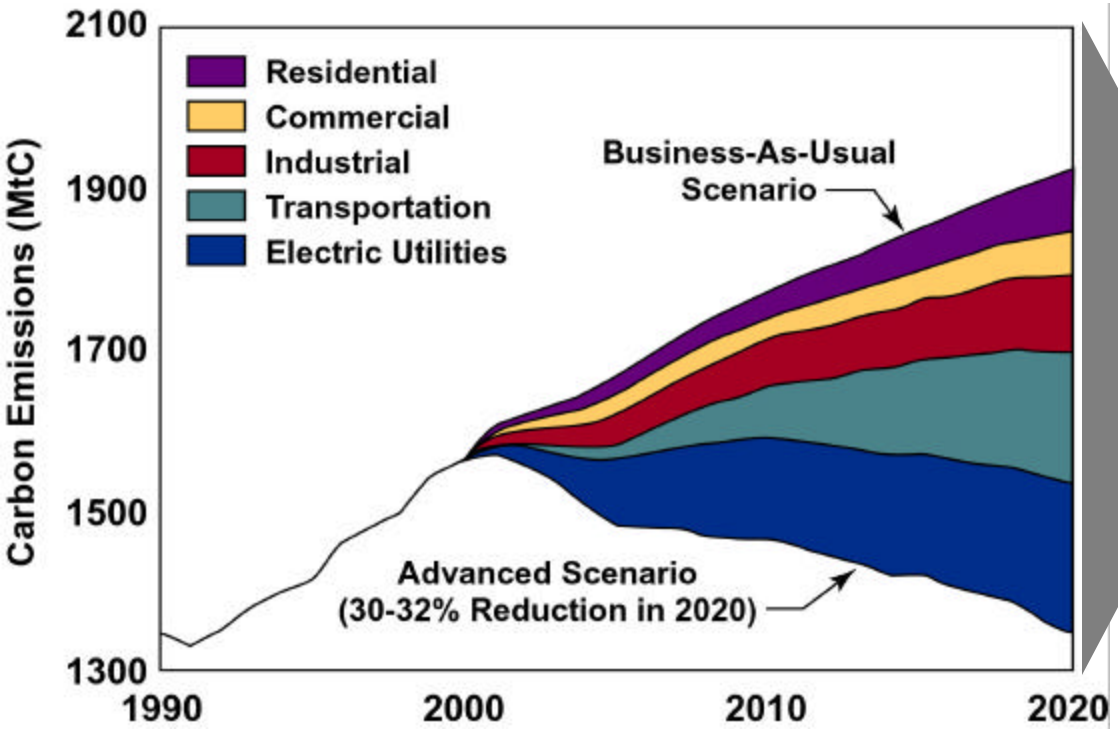
Undertaken by researchers at 5 DOE national laboratories with input from experts groups

Goal: to identify and analyze policies that promote efficient and clean energy technologies to reduce CO_2 emissions and improve energy security and air quality

Published in November 2000 (www.ornl.gov/EERE/CEF.htm)

The report documented a large potential for "no cost" and "low cost"

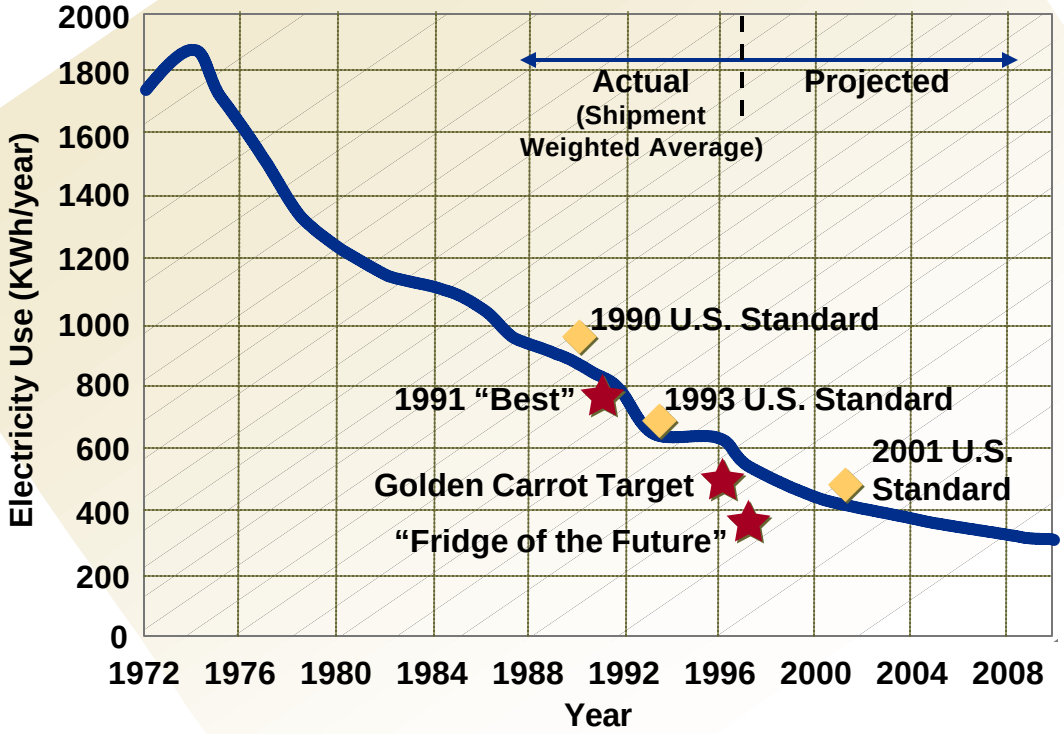
U.S. carbon reductions



1990 carbon emissions level was restored by 2020, with continued economic growth

Refrigerator energy efficiency improvement

- Refrigerators account for 12% of U.S. residential energy use ($14B/year)
- DOE investment of $5M from 1977–82 enabled improvements that saved consumers $9B in the 1980s
- ORNL roles:
  - Modeling and analysis
  - Technical support to subcontract with Columbus Products for improved compressor
  - Component development (motors, insulation, controls)
  - Testing and input to national standards
- Projected savings of 0.7 quad/year by 2010 based on research in the 1990s



SPONSOR:

U.S. DEPARTMENT OF ENERGY
OFFICE OF BUILDING TECHNOLOGY, STATE AND COMMUNITY PROGRAMS

PARTNERS:

Columbus Products Co., Appliance Research Consortium

AHAM association of home appliance manufacturers

UT-BATTELLE

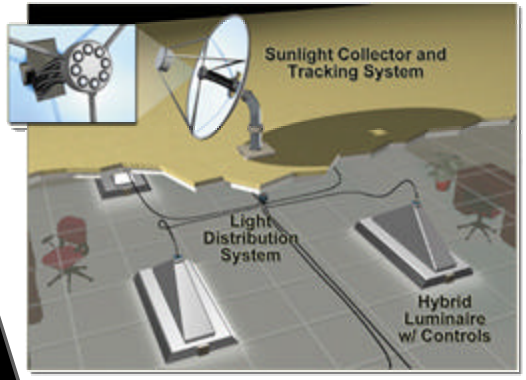
Hybrid Lighting: one part of a zero-energy building

Hybrid Lighting Uses

Full solar energy spectrum
Natural and electric light sources
Networks of optical fibers
Hybrid luminaires and control systems

Projected Benefits

- Payback estimated at 2–5 years after R&D
- Student/worker productivity shown to be much higher under natural lighting
- Significant public interest



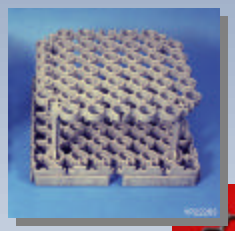
Hybrid Lighting Design Concept

Prototype Hybrid Luminaire

Advanced materials can cut energy use in energy-intensive industries

- **Nickel aluminide alloys improve energy efficiency in steel, heat treating industries**
  - **Energy efficiency improvements range from 5–25%**

- **New crack-resistant alloys for Kraft recovery boiler tubes**
  - **Five percent improvement in energy efficiency of boiler operations**



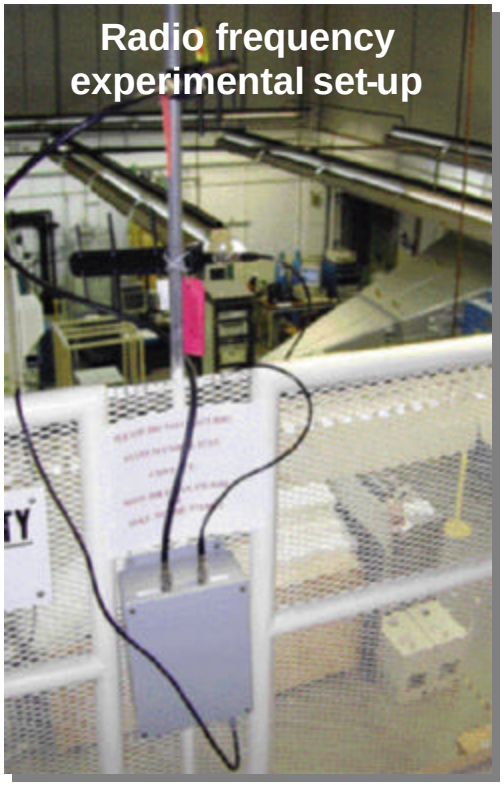
Advanced sensors and controls can optimize operations in harsh environments

Industrial wireless communication

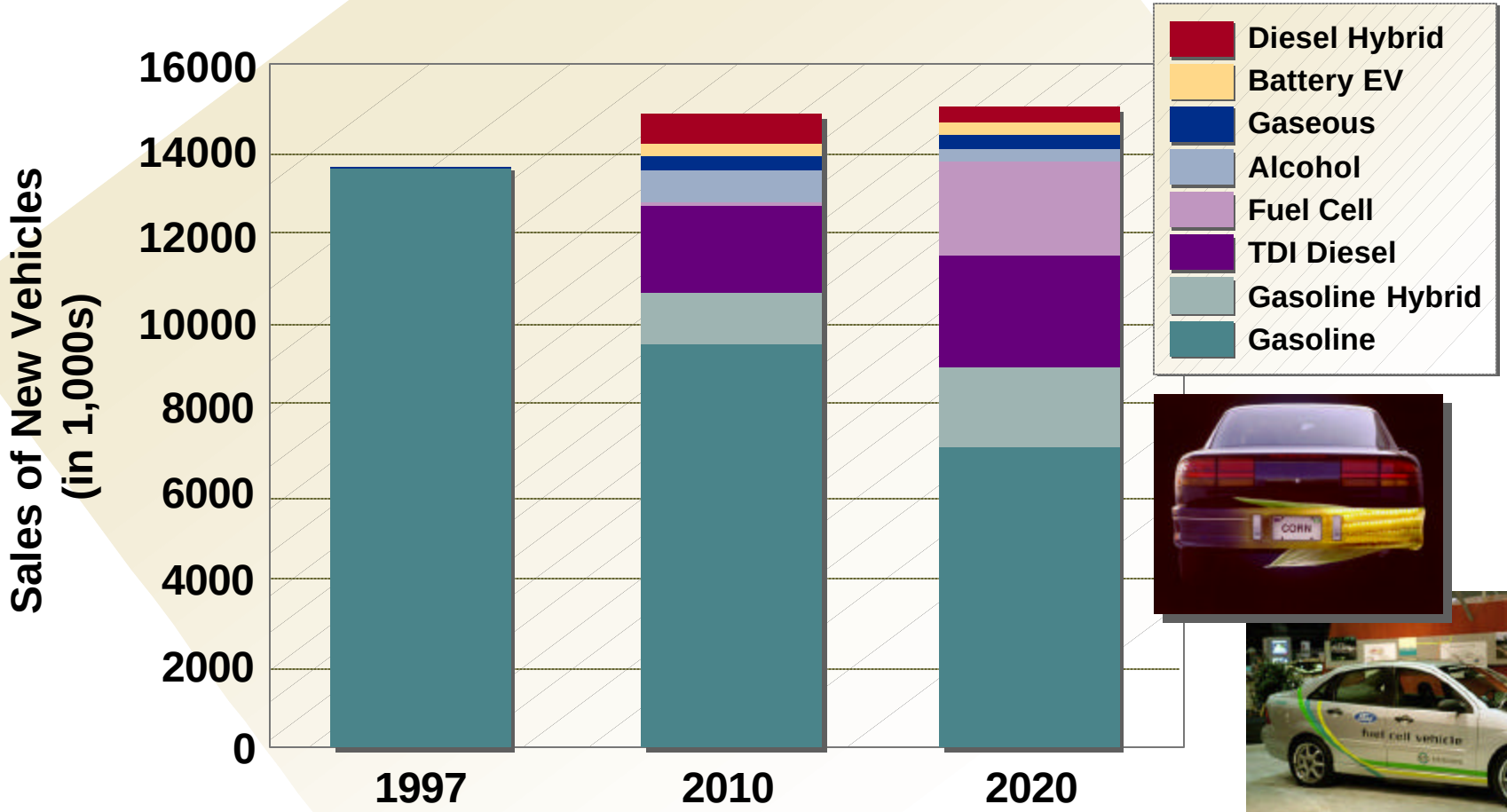
- Can work with little operator intervention

Sensor readings

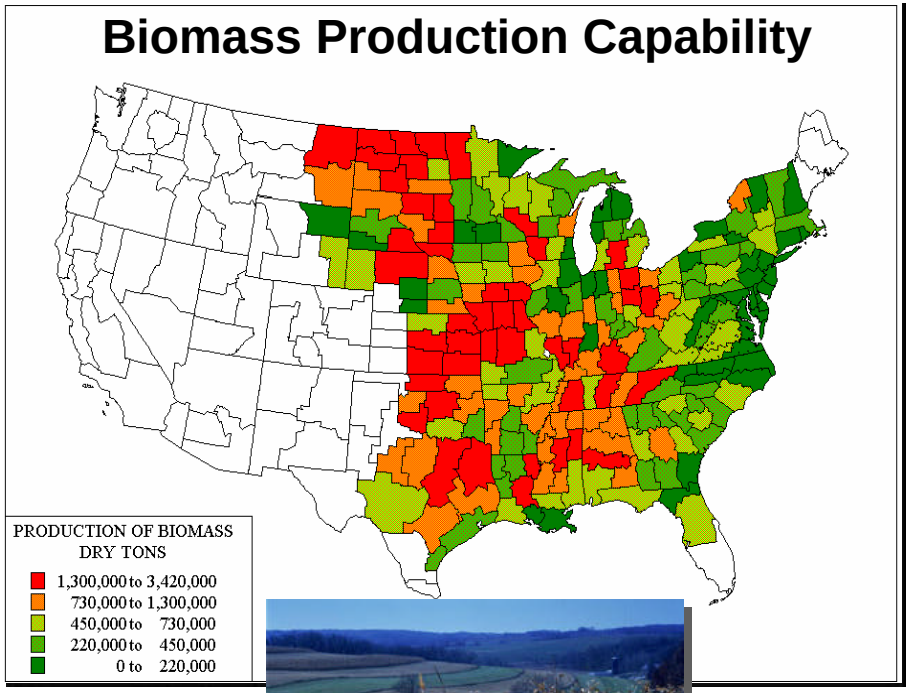
- Can currently be read at distances of >100
- Can be communicated over a radio link using spread-spectrum technology



By 2010, alternative fuels and propulsion systems could have a large share of new U.S. car sales

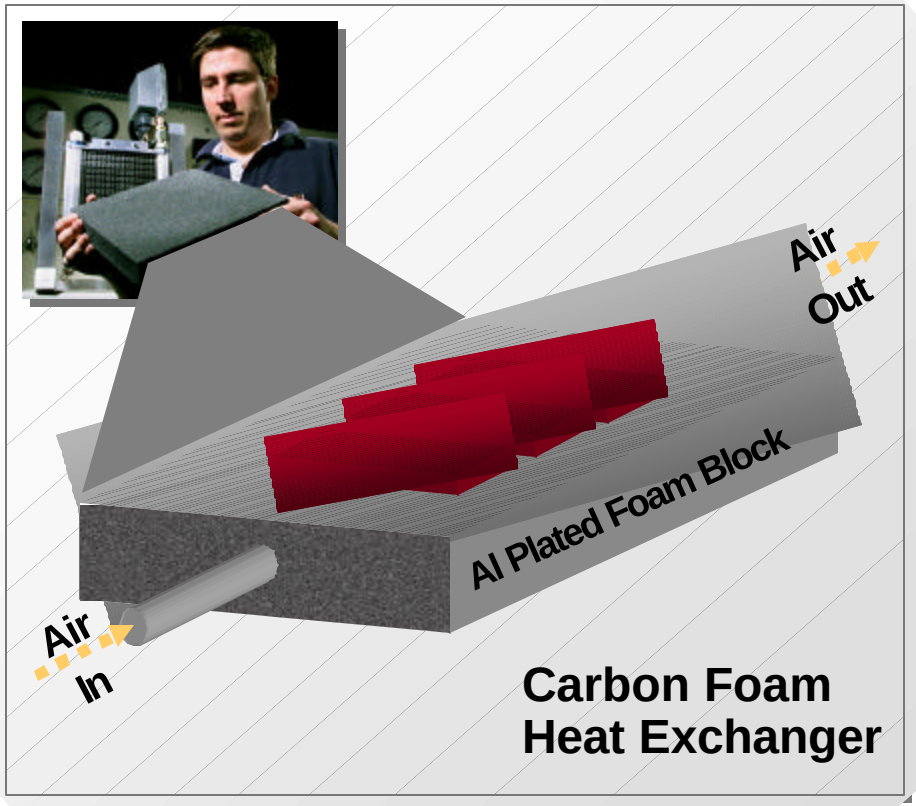


Clean products and energy from biomass



- Midwest ethanol production could increase farm income by 10% creating 70,000 jobs
- Ethanol could be produced from woody waste for $1.25/gal
- Biomass could be co-fired with coal to generate a significant portion of the nation's electricity
- Plants could replace oil to produce plastics, clothing, chemicals, car bumpers,nutritional supplements

Carbon foam could revolutionize thermal management systems



Carbon Foam Heat Exchanger is:

- One fifth the weight of aluminum
- Equivalent thermal conductivity
- Air cooled rather than water cooled

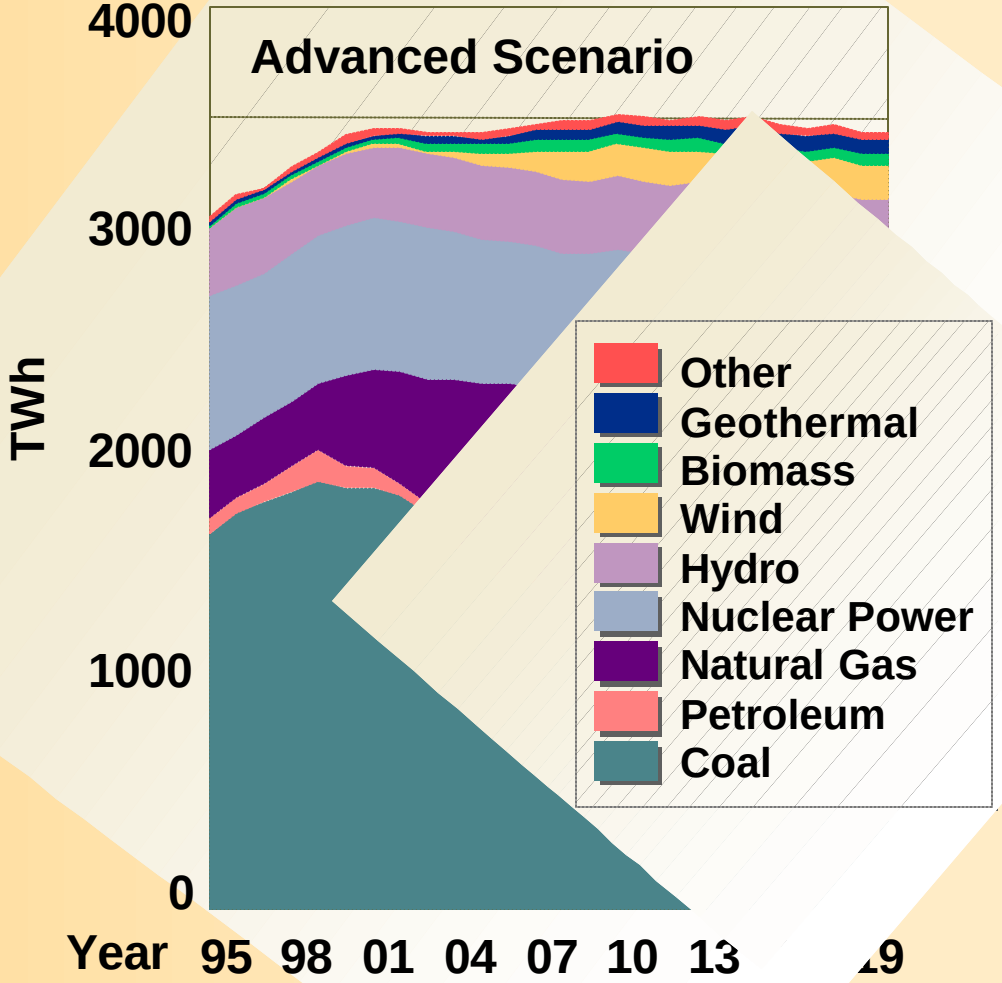
Applications include:

- Cars and trucks
- Fuel cell membranes

Photo courtesy of PNNL

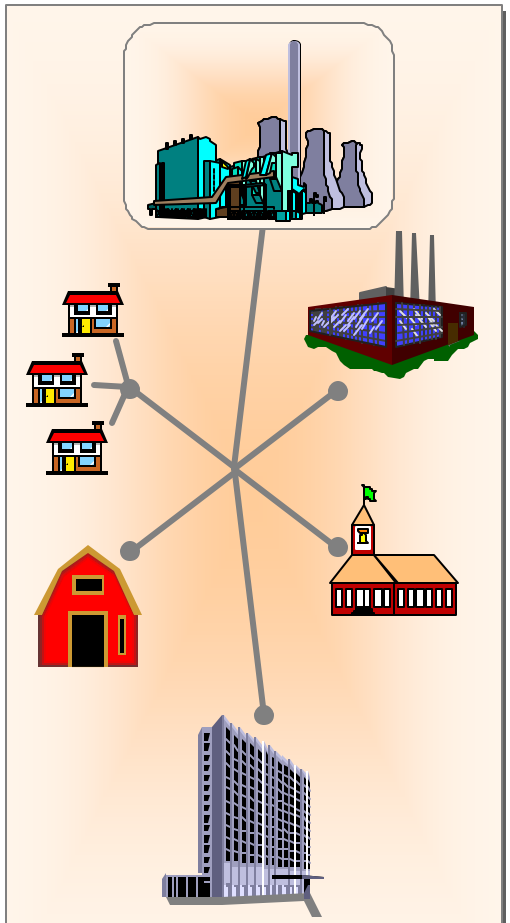
Photo courtesy of NREL

Renewable power resources play an increasing role in the "Advanced Scenario"



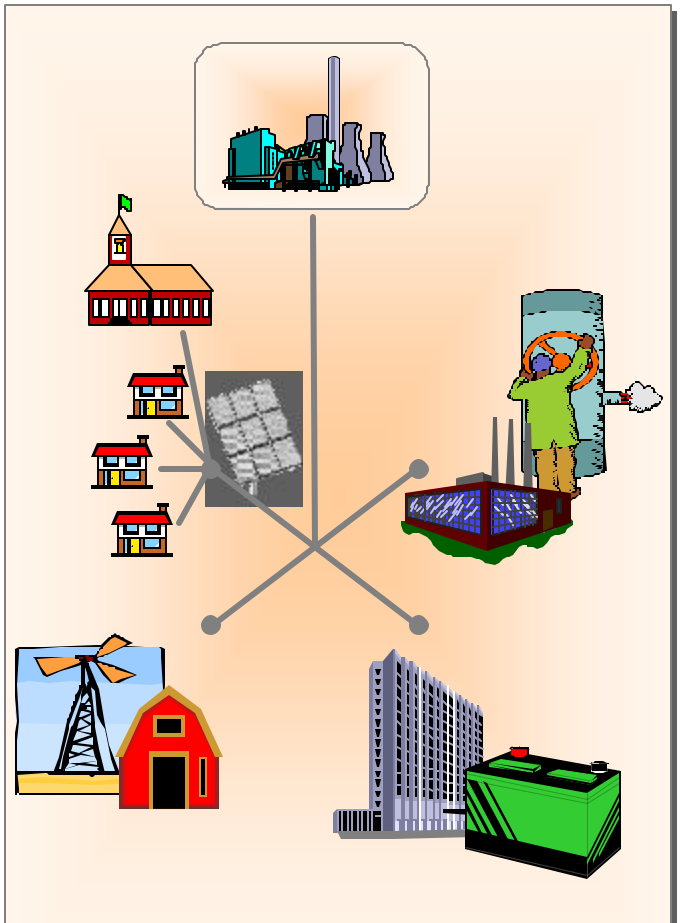
Distributed energy resources offer the prospect of improved efficiency, reliability, and security

Current Central Generation



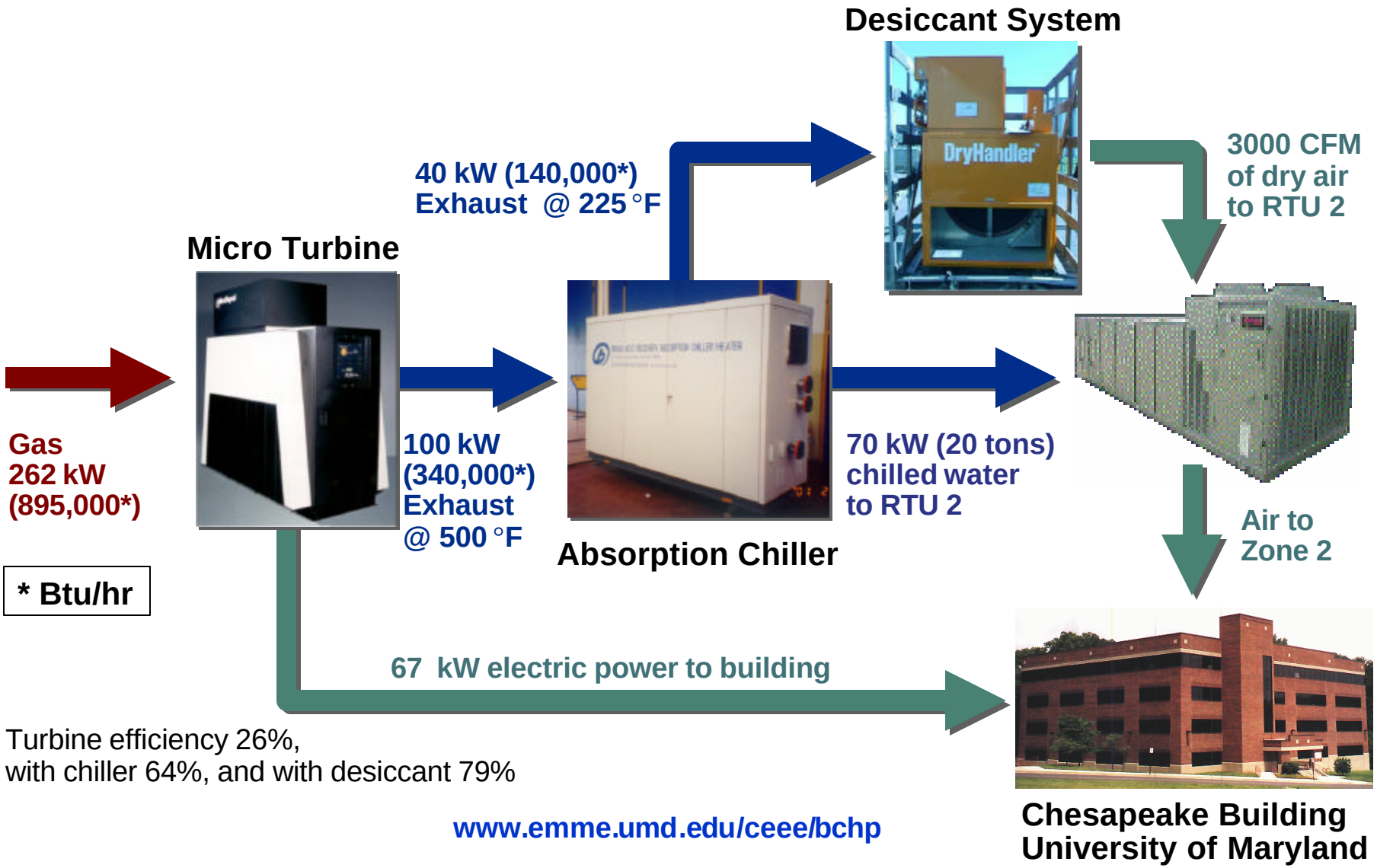
Losses: 50-65%

New Distributed Generation



Losses: 20-30%

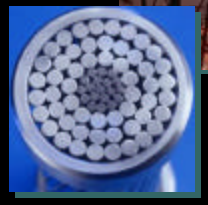
Integrating power with space conditioning is a key to cost-effectiveness



Turbine efficiency 26%,
with chiller 64%, and with desiccant 79%

www.emme.umd.edu/ceee/bchp

The grid can be “strengthened” by advanced powerline conductors



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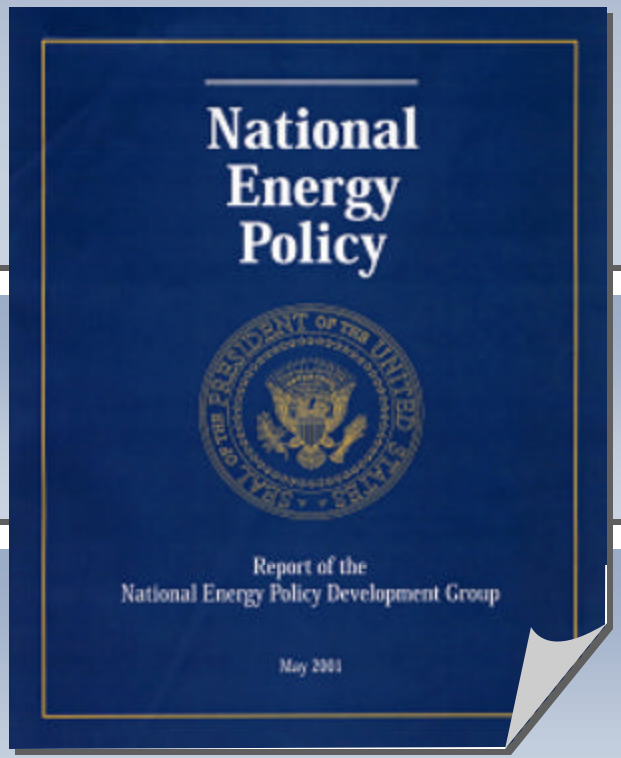
CONCLUSIONS

1. **An array of clean energy policies and emerging technologies exist that can help to sustain economic growth and**
   - **Reduce greenhouse gas emissions**
   - **Improve air quality**
   - **Strengthen energy security**

2. **Technology advances are an essential ingredient for success.**

3. **A balanced energy strategy must consider supply, demand, and distribution.**