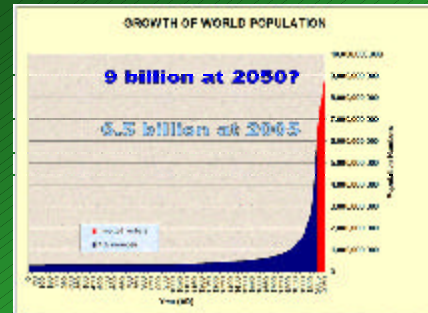


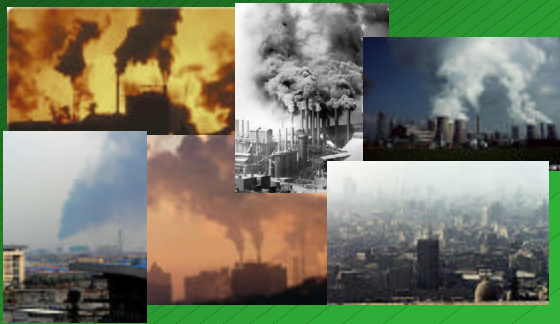
Global Warming

The Impact on Engineering

Have We Had an Impact?



Have We Had an Impact?



Have We Had an Impact?



Thickness of Earth's Atmosphere



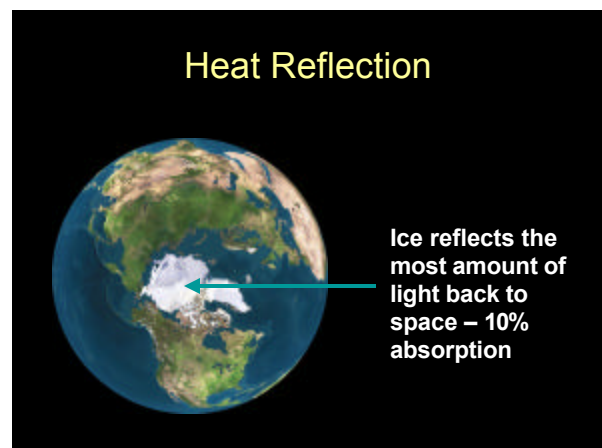
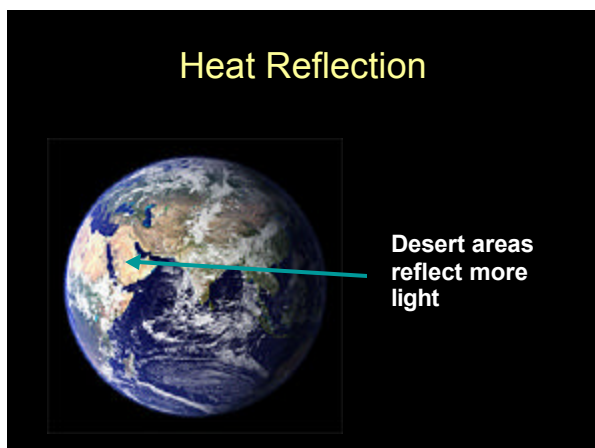
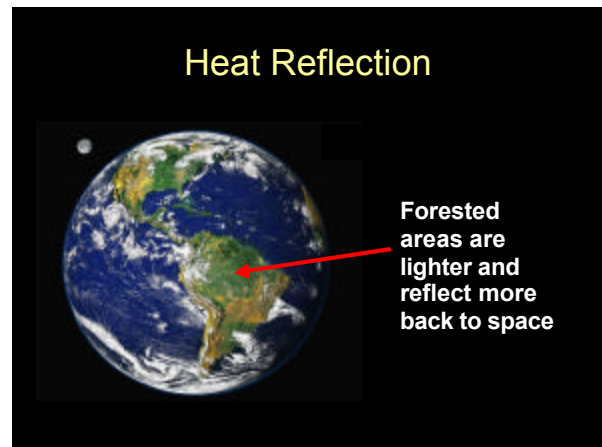
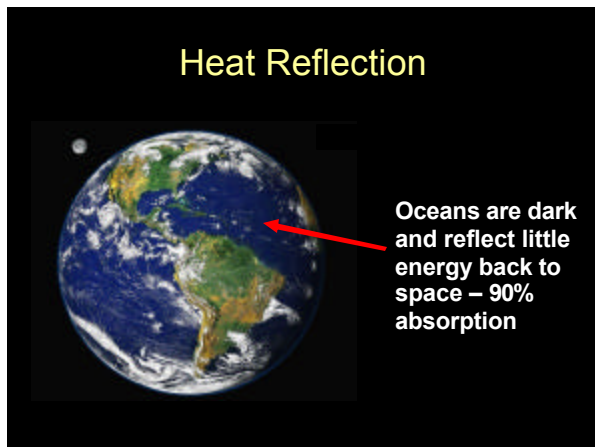
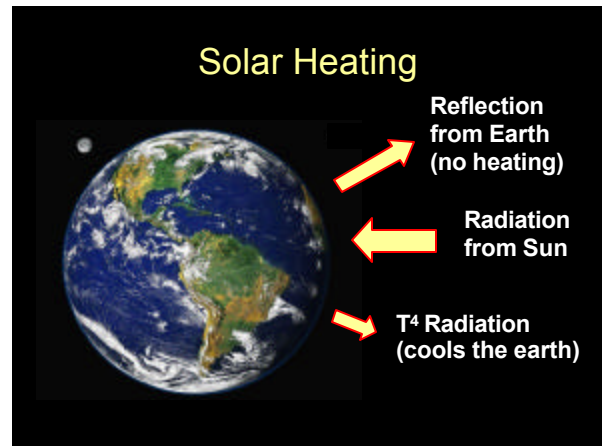
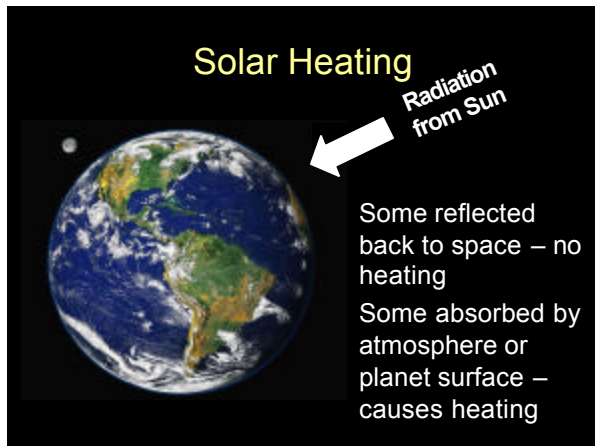
The Earth's atmosphere is very thin. At 7 miles high you are above 75% of the atmosphere

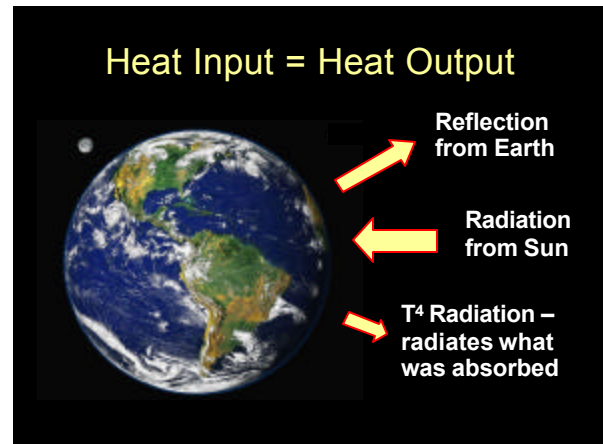
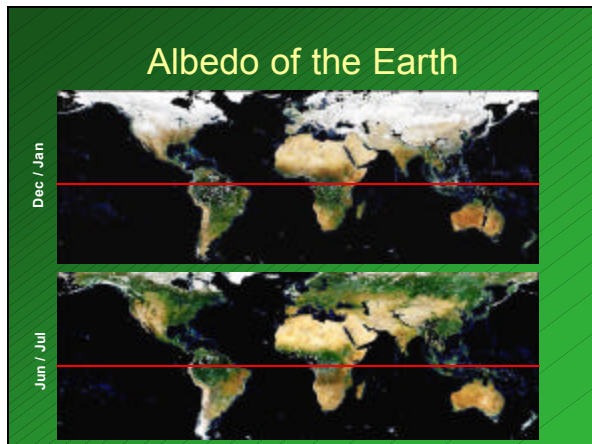
3 Forms of Heat Transfer

- Conduction
- Convection
- Radiation

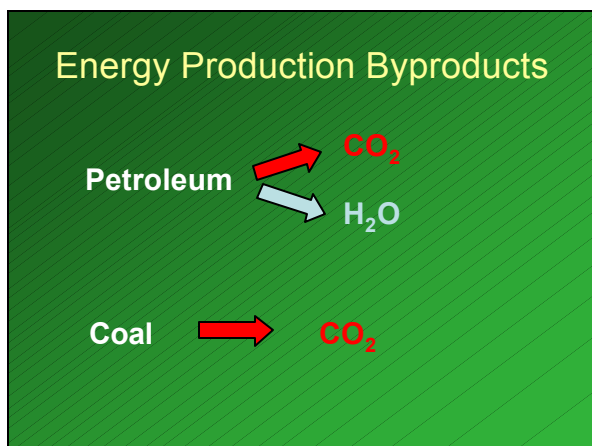
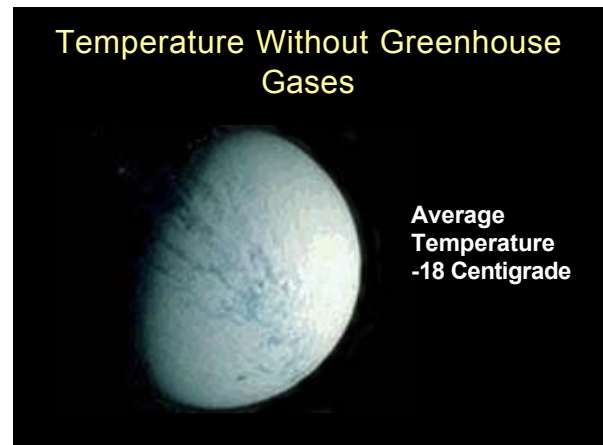
Space is a vacuum. The earth can only gain or loose heat through radiation.





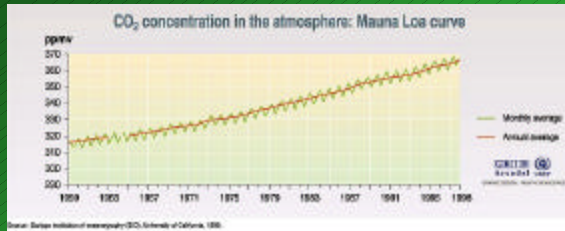


- ### Atmosphere Absorbs Sun's Energy
- Nitrogen – 78% (not a green house gas)
 - Oxygen – 21 % (not a green house gas)
 - H_2O – Up to 4% (green house gas)
 - CO_2 – trace – (green house gas)
 - Methane – trace – (green house gas)



- ### Measuring CO_2 in Air
- 1958 International Geophysical Year
 - Charles David Keeling
 - Mauna Loa – Hawaii
 - High altitude – clean air
 - Far away from industrial output

CO₂ Concentrations Mauna Loa



Ice Coring at Vostok Antarctica

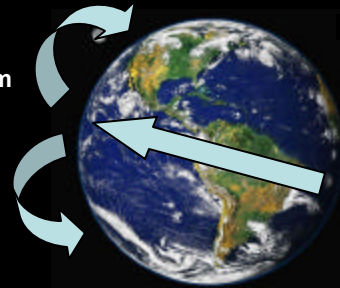


Measure CO₂ and Temperature

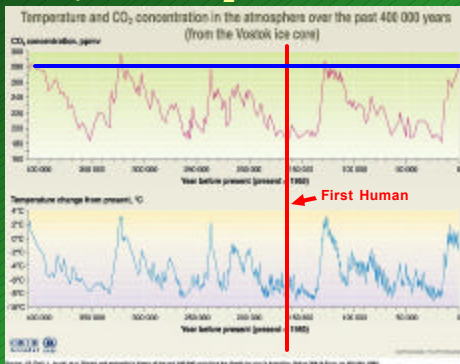
- Measure CO₂ in small bubbles
- Measure isotope of Oxygen – O₁₈
 - Heavier than normal Oxygen – O₁₆
 - Water with O₁₈ heavier than normal water

O₁₈ Content

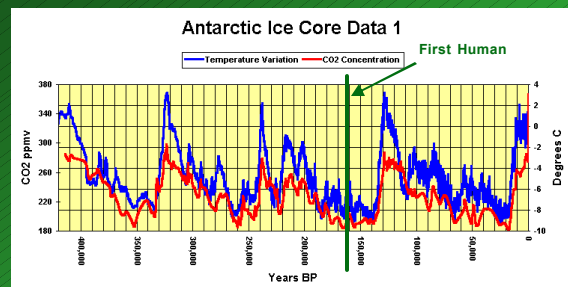
Movement of
Moisture from
equator to
higher
latitudes

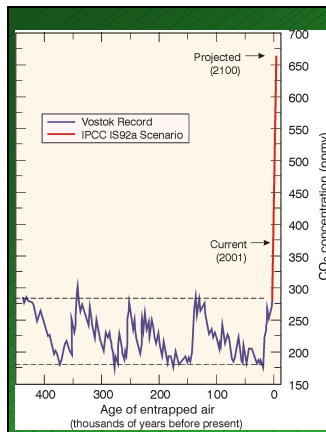


Atmospheric CO₂ Concentrations



Temperature and CO₂



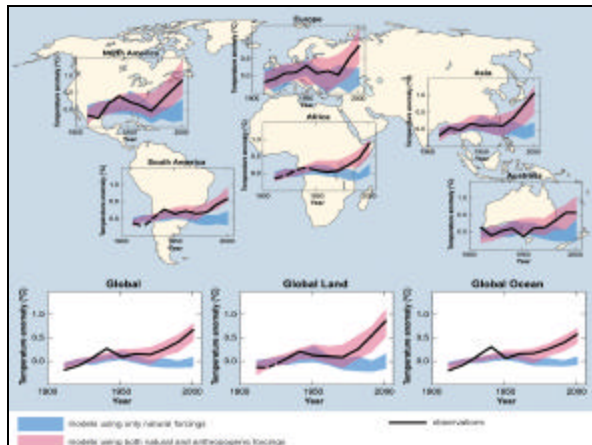


Current and Projected CO₂ Concentration

IPCC
Intergovernmental
Panel on Climate
Change

IPCC – Report 4

- 2500 Scientific expert reviewers
- 600 contributing authors
- 450 lead authors
- 113 countries
- 6 years of work



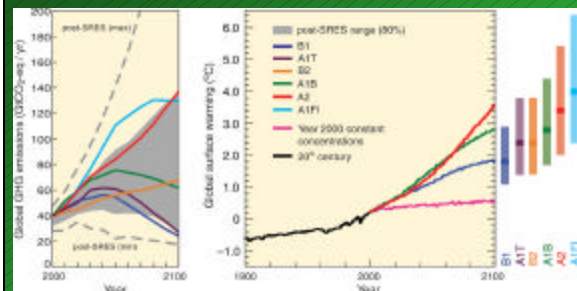
What Is the Future?

- IPCC IS92a – business as normal – 1% increase in CO₂ per year
- A1F1 – The future is heavily dependent upon fossil fuels
- A1T – Most energy comes from non fossil sources
- A1B – A balanced approach with fossil and non fossil fuels

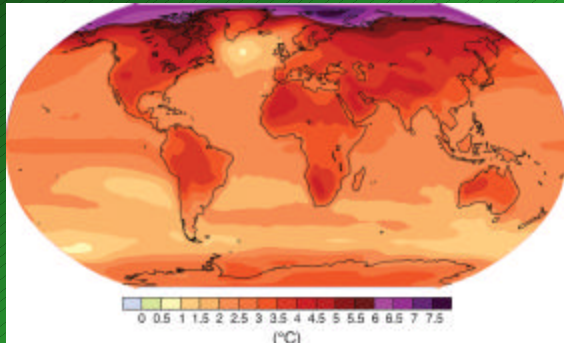
More Scenarios

- A2 – World remains culturally divided and population in underdeveloped countries continues to grow
- B1 – World cultures converge and population peaks at mid century
- B2 – Emphasis on local solution to problems – population continue to grow but not as fast as A2

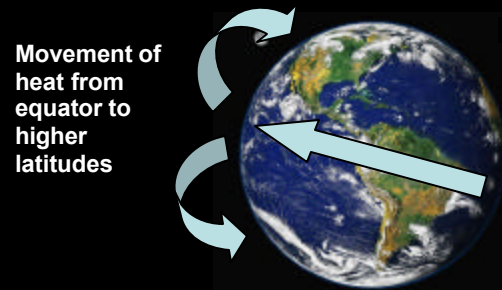
Projected Global Temperatures



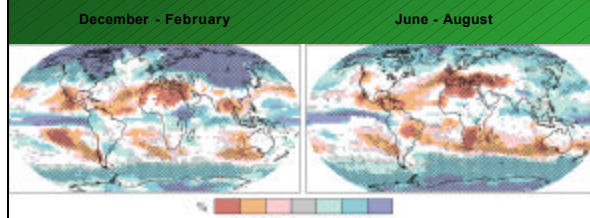
A1B – Moderate Scenario



Movement Of Heat



Change in Precipitation



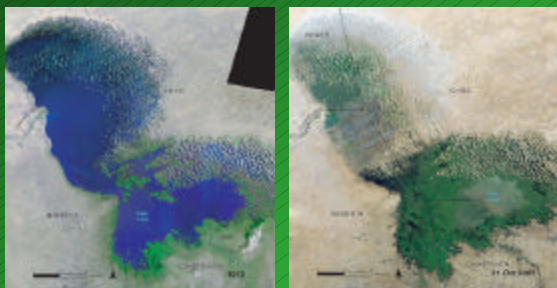
Amazon Drought - 2005



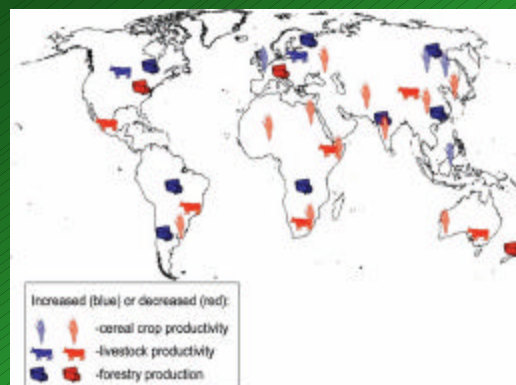
Lake Chad – Africa's Largest Lake

1972

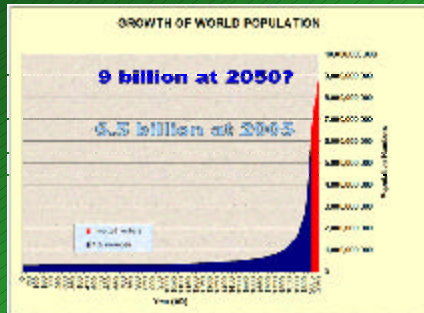
2001



Food Production 2050



How Will We Feed Them?



Current Food Shortages

- Price of food increasing
- Rice tripled in price
- Army guards rice fields in Viet Nam
- Corn going to bio fuel not food
- Food riots in poorer countries
- World Bank spending money directly on food – no time for economic development

Decreased Water Supply

Melting Glaciers

Glacier National Park



1932

1988

Pedersen Glacier

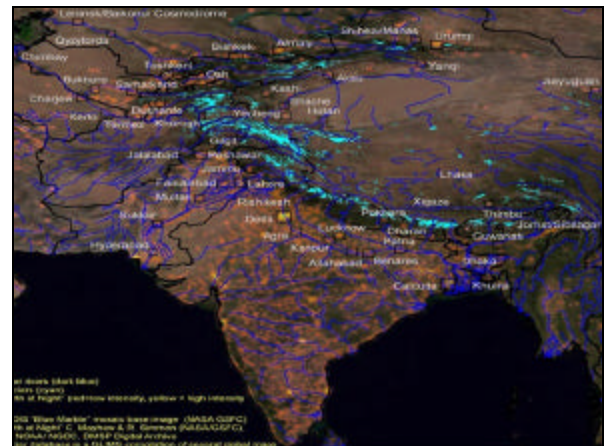


**Pedersen
Glacier
Alaska**

Muir and Riggs Glaciers

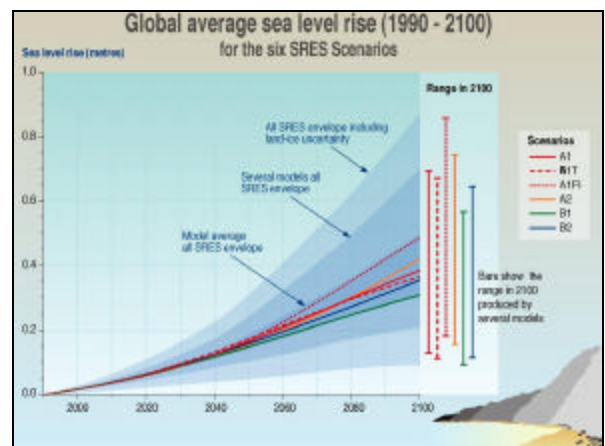
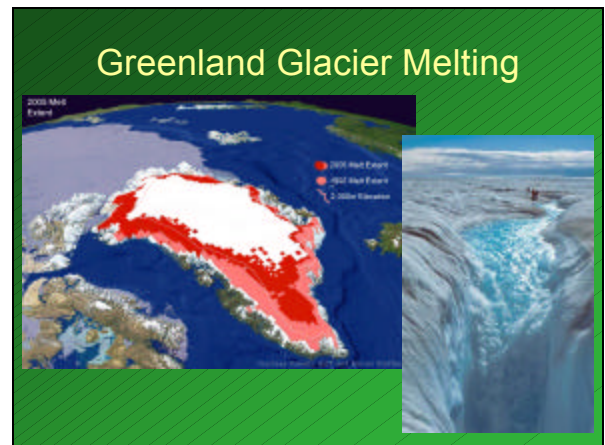


Alaska



Sea Level Rise

- Estimated to be 1 – 2 feet by 2100
- Estimate based on thermal expansion of oceans
- Includes some melting from glaciers, Greenland, and Antarctica
- Greenland and Antarctica melting at the 1993 – 2003 rate



Sea Level Rise

- Small increase places people around the world in danger from storm surges
- Rise could be several meters if Greenland and Antarctica melt faster than estimated
- Many coastal areas would be flooded

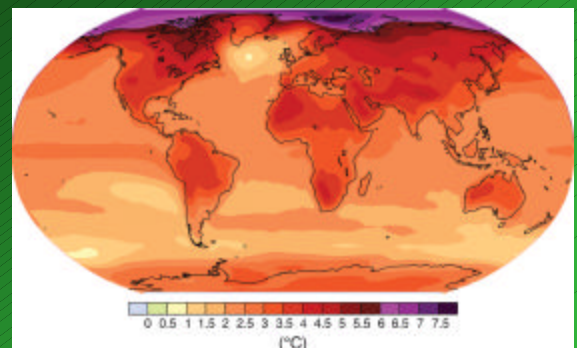
Positive Feedback Loop

- Warming causes something that caused further warming
- Arctic Melting
- Ice reflects 90% of sunlight
- Water absorbs 90% of sunlight
- Ice melts – water absorbs more sunlight – melts more ice

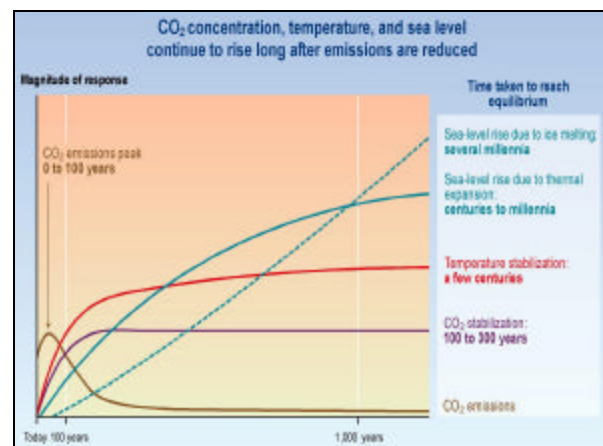
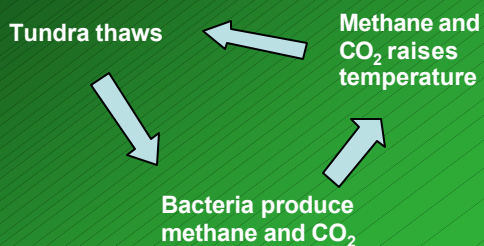
Melting Tundra



A1B – Moderate Scenario



Increased Methane CO₂ Production (positive feedback loop)



Loss of Species



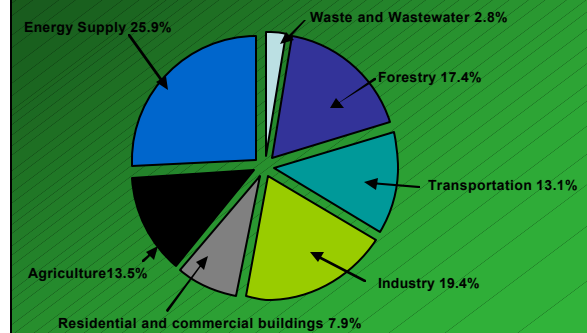
Bleaching Coral



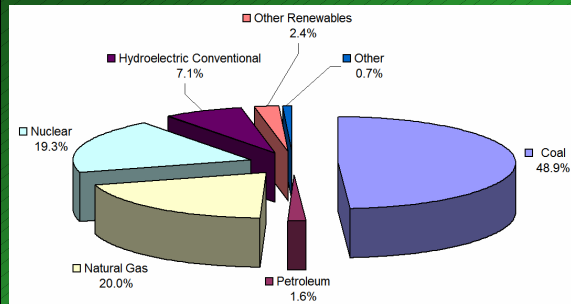
What Can We do?

- Stop using fossil fuels?
- Carbon sequestration?
- Hydrogen?
- Solar Power?
- Wind Power?
- Nuclear Power?
- Geothermal Power?

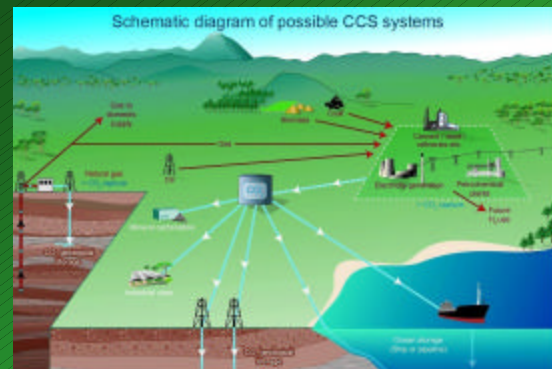
Sources of GHG



Electrical Energy Generation



Carbon Sequestration



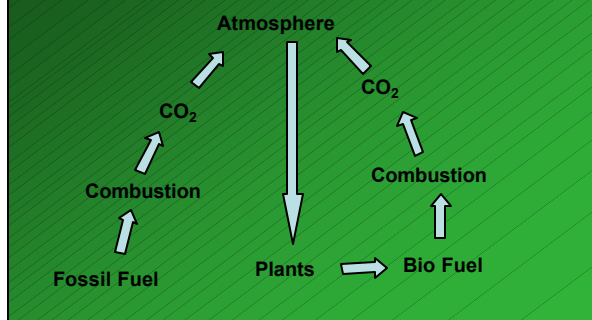
Nuclear Power

- IV Generators much more efficient
- Still produce radioactive waste – where do you put it
- Still produces plutonium – how do you keep it from being used in bombs

Transportation

- Bio Fuels – Do they produce CO₂ also?
- Ethanol – burning in existing engines
- Hydrogen – fuel cell
- Electric – using battery technology

Bio Fuel Carbon Cycle



Ethanol

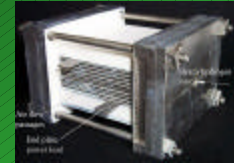
- Can burn in existing engines
- 34% less energy than gasoline
- Run much higher compression ratios to increase efficiency
- Largely produced by corn in US
- If all corn grown in US were converted to ethanol it would make up 12% of our gasoline needs

More Corn Based Ethanol

- It would take 75% of all cultivated land on the earth to make enough ethanol to replace US gasoline consumption
- It takes 1 unit of fossil fuel to produce 1.3 units of ethanol
- The corn required to produce 25 gallons of ethanol would feed a person for a year.
- New technology using cellulose technology is more efficient

Hydrogen

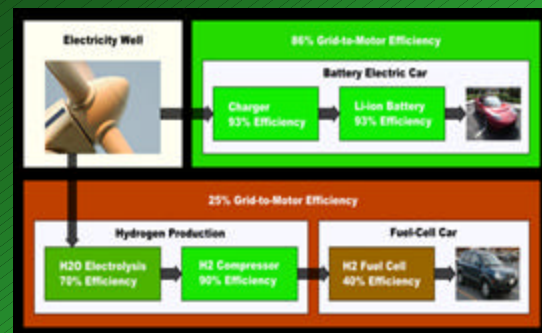
- Where does it come from?
- Can we create it without creating CO₂
- Is waiting for hydrogen technology just another way to stall?



Current Hydrogen Production

- **48% from Natural Gas**
- **30% from oil**
- **18% from coal**
- 4% from electrolysis – poor efficiency
- High temperature electrolysis – 50% more efficient
- Up to 30% of energy used for compression

Hydrogen Fuel Cell vs. Battery



Your Challenge

- Engineers determine the shape of the future
- You cannot dream your father's dream
 - Different problems
 - Different solutions
- Don't be afraid to see a different future

Questions