Storing Carbon Dioxide (CO_2) Deep in the Earth

One of Many Technologies Needed to Slow Global Climate Change

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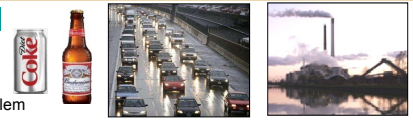
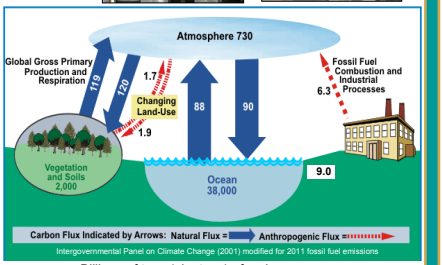
What and where is CO_2?

- The bubbles in soda and beer
- In the air we breathe (0.039%)
- We produce more when we burn things
- Burning large amounts of fossil fuels is the problem
  - Gasoline and diesel from cars and trucks
  - Coal or natural gas from power plants





Billions of tons (gigatons) of carbon per year.
To convert carbon to CO_2 multiply by 3.7

The Carbon Cycle is out of balance – We're making too much CO_2 and dumping it into the atmosphere

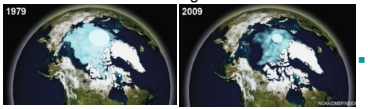
- Cars produce about 1 pound of CO_2 per mile
- 300 MW gas-fired power plant: 1.2 M tons/year
- 1,000 MW coal-fired plant: 8 million tons/year
- U.S. fossil fuel CO_2 emissions: 6 billion tons/yr
- Global fossil fuel CO_2: 26 billion tons/year

CO_2 is called a Greenhouse Gas (GHG) because it traps in heat and warms the Earth

- Glaciers are melting

Muir Glacier, Alaska — 53 years later

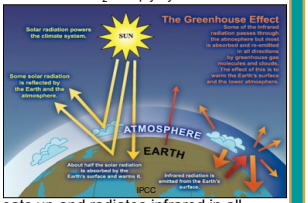
- Arctic sea ice is shrinking



National Oceanic and Atmospheric Administration

Greenhouse Effect

- High frequency sunlight passes through the atmosphere and heats the Earth
- Low frequency radiation (heat) from the Earth is trapped by GHGs in the atmosphere

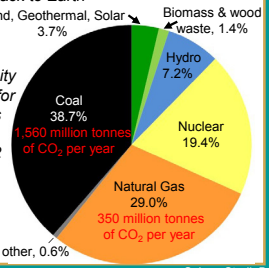


- The atmosphere heats up and radiates infrared in all directions, including back to Earth

What can we do to reduce CO_2 emissions?

- Efficiency (appliances, transmission lines, factories)
- Efficient building codes (insulation, windows, lighting)
- Electricity peak demand management
- Wind, solar, geothermal electricity generation
- Switch from coal to gas (half as much CO_2)
- Electric cars, better mileage

U.S. Electricity Generation for 12 months ending June 2012



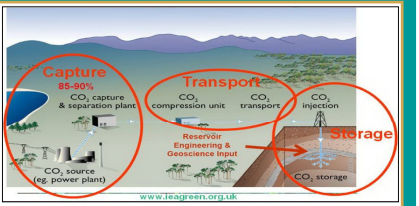
But … it will take many years to produce most of our electricity from renewable sources

- Wind, solar, and geothermal combined produced only 3.7% of our electricity over the past year

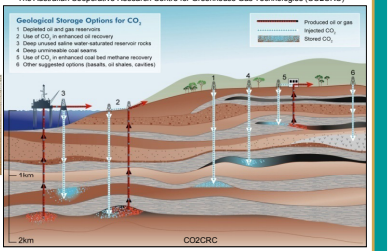
One solution – Capture CO_2 from industrial sources, then permanently store it deep underground (CO_2 sequestration)

- Industrial sources include power plants, refineries, coal gasification, and ethanol plants
- Capturing CO_2 from smokestacks can be done at industrial scale (but it's expensive)
- Transportation by pipeline is routine
- Geologic trapping is well understood

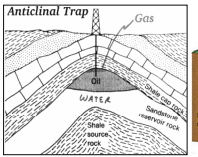
CO_2 pipeline

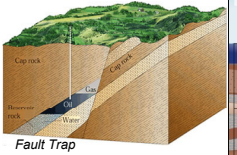


The Australian Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)



CO_2 can be trapped in geologic reservoirs the way oil and gas have been trapped for millions of years

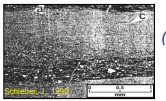




Fault Trap

How does a geologic trap work? Find geologic areas with …

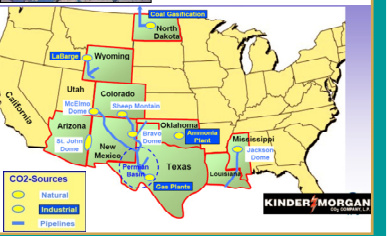
- An impermeable rock layer (like shale or salt) as a cap rock seal …
- Above a porous, permeable rock layer (like sandstone) as a reservoir rock
- Sandstone can have 10-20% open pore space, which is where oil, gas, or salty water are found
- This is how geologic reservoirs trap buoyant fluids like oil and natural gas (and CO_2)
- The natural pressure at depth keeps CO_2 compressed and liquid-like (2/3 as dense as water)



Cap rock seal (microscopic view of shale - fine grains and low permeability)

on top of

Porous reservoir rock (microscopic view of sandstone - large grains and high porosity/permeability)

CO_2 compression, transportation by pipeline, well drilling, and injection deep in the Earth *is not new*

- Started in 1972 for enhanced oil recovery (EOR)
- 50 million tons of CO_2 is injected every year in the US
- 3,300 miles of pipelines transport CO_2 to oil fields in Texas, New Mexico, Louisiana, Mississippi, Wyoming
- Most of this CO_2 comes from natural reservoirs that have trapped it underground for millions of years
- CO_2 EOR has produced a billion barrels of domestic oil
- Some of the CO_2 for EOR is recycled, but eventually all of it stays trapped in the Earth