THE GREENHOUSE EFFECT AND YOUR FAMILY’S CONTRIBUTION TO IT

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November 9, 2005

The Greenhouse Effect

Solar radiation passes through the clear atmosphere.

Some solar radiation is reflected by the Earth and the atmosphere.

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.

Most radiation is absorbed by the Earth's surface and warms it.

Infrared radiation is emitted from the Earth's surface.
THE GREENHOUSE EFFECT

THE EARTH’S ENERGY BUDGET: A DELICATE BALANCE

- Sunlight heats the Earth.
- The warm Earth radiates energy (in the form of infrared radiation, or heat) back out to space.
- Some of this infrared radiation is trapped in the atmosphere, giving Earth its temperate climate.

This is the greenhouse effect. Without it, the Earth’s climate would be like the moon’s, harsh and severe.
GLOBAL ENERGY BALANCE

Global and annual average energy fluxes in watts per square meter

\[ \frac{1}{4} S_0 (1 - \alpha) = \sigma T^4 \]

\[ 69\% = 1 - \alpha \]

\[ \alpha = 31\% \]

\[ 106 \quad 237 \quad \approx 254K \]

\[ 343 \]

\[ 237 \]

\[ 390 \quad \approx 288K \]

\[ 327 \]

\[ 68 \]

\[ 169 \]

\[ 169 \]

\[ 90 \]

\[ 16 \]

\[ \text{H}_2\text{O}, \text{CO}_2, \text{CH}_4 \ldots \]

\[ \text{Atmosphere} \]

\[ \text{Shortwave} \quad \text{Longwave} \]

Schwartz, 1996, modified from Ramanathan, 1987
ATMOSPHERIC RADIATION

Energy per area per time

Power per area

Unit: Watt per square meter
W m$^{-2}$
GEOGRAPHICAL VARIATION OF ATMOSPHERIC RADIATION

Annual average radiative flux at top of atmosphere, W m$^{-2}$

Emitted thermal infrared

Reflected shortwave

CERES (Clouds and Earth’s Radiant Energy System satellite, March, 2000 - May, 2001)
Everybody talks about the weather —
But nobody does anything about it.
– Mark Twain

Now with the greenhouse effect,
we ARE doing something about it.
What are we doing?
ATMOSPHERIC CARBON DIOXIDE IS INCREASING

Global carbon dioxide concentration and infrared radiative forcing over the last thousand years
Northern Hemisphere temperature trend (1000-1998), from tree-ring, coral, and ice-core proxy records. As calibrated by instrumental measurements. 

Mann et al., Geophysical Research Letters, 1999
GLOBAL TEMPERATURE TREND OVER THE INDUSTRIAL PERIOD

Temperature Anomaly, K

-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8


GISS
East Anglia
INDICATIONS OF SYSTEMATIC WARMING IN RECENT YEARS

The 1990s were the *warmest decade* in the instrumental record.

The *warmest two years* of the entire instrumental record have been 1998 and 2002.

The *nine warmest years* globally have now occurred in the 1990s and 2000s.
RETREAT OF MID-LATITUDE GLACIERS

South Cascade Glacier, Washington

1928

2000
THE “BIBLE” OF CLIMATE CHANGE RESEARCH

CLIMATE CHANGE 2001
The Scientific Basis

Cambridge University Press, 2001

http://www.grida.no/climate/ipcc_tar/wg1/
FUTURE CLIMATE IS HIGHLY UNCERTAIN

Contributors to uncertainty include emissions, concentrations, and Earth's climate sensitivity.
WHERE IS ALL THIS CO₂ COMING FROM?

WHO IS RESPONSIBLE?
HOW MUCH CARBON IS IN A GALLON OF GASOLINE?

1 lb? 2 lbs? 3 lbs!? 5 lbs!??

All of this carbon goes into the atmosphere as carbon dioxide when you burn the gasoline in your car.
THE MOST EFFECTIVE WAY TO DOUBLE THE FUEL ECONOMY OF A CAR . . .

IS TO PUT TWO PEOPLE IN IT!
WHERE DOES YOUR ELECTRIC ENERGY COME FROM?

SOURCES OF ELECTRIC ENERGY IN THE UNITED STATES

Annual Total 3.71 Trillion KWH

On Long Island most electric energy derives from combustion of oil.
YOUR FAMILY’S CONTRIBUTION TO THE GREENHOUSE EFFECT

CARBON DIOXIDE EMISSIONS FROM ELECTRIC ENERGY PRODUCTION (1990's Technology)

Suffolk County 2001 Legislation

A typical household using 1000 kilowatt hours of electricity per month is responsible for emission of 3 tons of carbon a year in the form of carbon dioxide.
How much does your household contribute?
At half a pound of carbon per KWH, the average household is responsible for emission of 500 pounds of carbon a month.
WHAT COUNTRY USES THE MOST ELECTRIC POWER?
WHAT COUNTRY USES THE MOST ELECTRIC POWER?

ANNUAL ENERGY CONSUMPTION

Total Global Consumption 382 Quadrillion BTU

Selected Countries

No surprise. It's the United States.
WHAT COUNTRY USES THE MOST ELECTRIC POWER **PER CAPITA**?
WHAT COUNTRY USES THE MOST ELECTRIC POWER **PER CAPITA**?

No surprise. It's the United States again.
WHERE IS THIS CARBON DIOXIDE COMING FROM?

WE ARE ALL RESPONSIBLE.

Burning a gallon of gasoline in your car puts 5 pounds of carbon in the atmosphere as carbon dioxide ($\text{CO}_2$), and it will stay there for decades — maybe a century!

Other sources are home heating and electric power production.
Global Atmosphere, Global Warming

Questions about Global Warming

- Is it real?
- Is it important?
- What is it due to?
- How much more can we expect?
- Are we seeing just the tip of the iceberg?

Research at Brookhaven National Laboratory is helping to answer these questions.