R E P R I N T E D F R O M

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The Enhanced Greenhouse Effect, Part II

by Robert Farmer, ©1998

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Last month I introduced you to the early history of our knowledge of the Enhanced Greenhouse Effect (EGE)—the underlying cause behind our concerns about global climate change. Unlike climate change, there is no uncertainty about EGE and this article will continue to develop the history of our knowledge of this atmospheric disease, a disease which, unchecked, threatens to overwhelm us all.

The Scientific Certainties

For 60 years the scientific community was unconcerned about EGE, believing that the oceans would absorb almost all carbon dioxide (CO2) emitted into the atmosphere. In 1957, Roger Revelle and Hans Suess of the Scripps Institute of Oceanography reported that the ocean had *not* absorbed as much CO2 as everyone had previously assumed. Significant amounts would remain in the atmosphere and could eventually warm the Earth. At that time they wrote that: "Human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in the sedimentary rocks over hundreds of millions of years."

Soon after, David Keeling invented an instrument to quantify these unexpected atmospheric CO2 levels. He installed it at the Mauna Loa Observatory in Hawaii, situated at 11,000 feet on a mountain top far away from any man-made sources of pollution. In the late 1950s, he found atmospheric concentration of CO2 to be 315 parts per million, and subsequent measurements have showed that this has been increasing annually.

Scientists tell us there are four lines of evidence that prove conclusively that the recent buildup of carbon dioxide arises largely from human activities.

The first line of evidence relates to a difference between the nuclei of carbon atoms emitted under natural conditions, and those emitted by burning fossil fuels. Carbon dioxide emitted from natural sources on the Earth's surface has a measurable radioactive signature. But the nuclei of carbon atoms in CO2 emitted by fossil fuels were formed deep underground tens of millions of years ago, and the fraction of their nuclei that were once radioactive have long ago decayed into non-radioactive carbon. Over time this CO2 emitted through fossil fuel combustion has diluted the radioactive fraction of natural carbon in the atmosphere. Scientists have measured this dilution by showing that the fraction of radioactive carbon-14 captured in tree rings has steadily decreased each year for the 150 years between 1800 and 1950.

The second line of evidence is the worldwide measurement of total atmospheric CO2, following David Keeling's lead. The data collected through worldwide monitoring shows convincingly that the total concentration of CO2 in the atmosphere has increased each year, and is continuing to do so. By 1994 the concentrations at Mauna Loa had reached 365 ppm, a 30-percent increase above the pre-industrial level of 280 ppm.

The third line of evidence comes from the geographic pattern of carbon dioxide distribution. Observations show that there is slightly more CO2 in the northern hemisphere than in the southern hemisphere. This difference arises because most of the human industrial activities that produce CO2 are in the north.

The fourth line of evidence has been added since 1980. Ice buried below the surface of the Greenland and Antarctic ice caps contains bubbles of air that were trapped as the ice was formed. These samples of fossil air, some of them over 200,000 years old, have been retrieved by drilling deep into the ice. More recent ice formations, containing air from only a few decades ago, have nearly identical CO2 concentrations as those measured by David Keeling's instruments in the

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corresponding time period. But the older parts of the cores show that for the 10,000 years prior to the Industrial Revolution, CO2 concentrations remained constant, and were about 25% lower than today.

Carbon dioxide and water vapor are not the only gases with global warming potential, although they are the major contributors. In the 1980s, methane, tropospheric ozone, nitrous oxide, CFCs, HFCs and PFCs were also identified and demonstrated to be heat-trapping greenhouse gases.

These, then, are the scientific certainties about the enhanced greenhouse effect—all greenhouse gases absorb selective wavelengths of infrared radiation re-emitted by the Earth. And, the atmospheric concentration of human-made greenhouse gases has been rising every year since the Industrial Revolution.

The inescapable conclusion is that, no matter how much we might like to think that global climate change might be due to natural variability, the EGE will continue to make our planet warmer. And, because CO2 lives in the atmosphere for centuries, its buildup threatens to bring about irreversible feedback loops (warmer oceans, more water vapor, more heat-trapping gases) which may well be the bane of us all.

Has anyone noticed how much bigger and wetter tropical cyclones seem to be of late? This summer National Hurricane Center advisories informed us not to focus on the location of the centers of these storms because "damaging winds extend for hundreds of miles". In 1996 Fran was huge, but in 1998 Bonnie was reported to be the size of Texas! And where did Georges get all that water vapor?

Prudent risk management suggests that we should all be actively working on solutions to reduce the Enhanced Greenhouse Effect today.

Next month: Climate change mitigation or adaptation? Whatever the approach there is a fundamental role for engineers, and especially energy engineers, in the solutions.

Robert Farmer is an energy planning engineer and energy policy specialist. A comprehensive resource on technologies, issues, and policies, he offers clients strategies, briefings, and presentations on planning a sustainable energy future.

His technical expertise includes large scale to small scale power generation, combined heat and power (CHP), marine and surface transportation, and alternative fuel applications.

A Florida resident since 1984, Robert was a member of the Energy Advisory Committee of Governor Chiles' Commission for a Sustainable South Florida.

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