FLORIDA SOLAR ENERGY CENTER®

The Greenhouse Effect

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The greenhouse effect

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Introduction

During the last decade, Florida's robust economy and burgeoning growth have been fueled by plentiful, inexpensive energy supplies.

The state's economic vitality depends primarily on tourism; so cheap, abundant supplies of transportation fuels have helped to feed "the tourist machine."

Florida is also an "electrified" region, with a huge demand for air conditioning energy. Relatively inexpensive electrically powered cooling has made this warm, humid state an extremely attractive location for almost any kind of development.

Unfortunately, the very energy boon that has supported Florida's growth and economy is also a part of the energy bane that is threatening the habitability of the planet.

Use of conventional energy sources — in Florida and throughout the world — has produced a global problem known as "the greenhouse effect." While the scientific community does not always agree on the greenhouse effect's potential impacts on the planet, and while policy makers do not always agree on methods to ameliorate or adapt to it, most concur on at least a few points:

- The greenhouse effect does indeed exist and is primarily a result of our use of carbon-based energy supplies.
- The greenhouse effect is changing the planet's climate.
- The greenhouse effect presents circumstances unique in human history — a global problem of unprecedented proportion and complexity.

This Energy Note presents a definition of the greenhouse effect, its causes, its potential impacts, and possible responses.

Definition

When any carbon-based material is burned, it releases usable energy. The combustion process also emits gases into the atmosphere — principally carbon dioxide. During the last 200 years, carbon fuel combustion has emitted much more carbon dioxide gas than the earth and its atmosphere can effectively absorb and dissipate.

Like the glass cover on a solar collector, carbon dioxide in the atmosphere readily allows the sun's short-wave energy to reach the earth. However, it does not allow much of the long-wave, infrared heat energy radiated back by the earth to escape (see Fig. 1). As a result, the increased concentration of atmospheric carbon dioxide has created an invisible solar energy collector around the planet — in effect, constructing a global greenhouse.

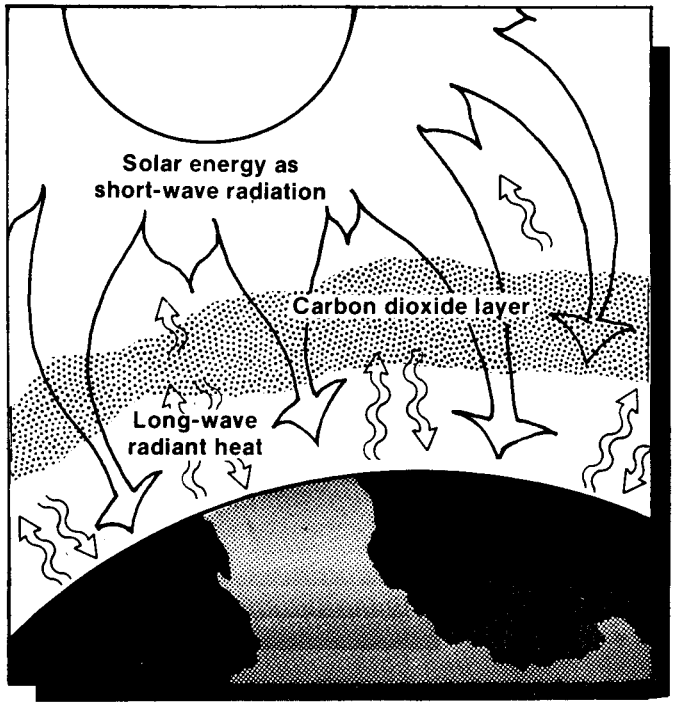

Figure 1. The global greenhouse effect.

Causes

Use of carbon-based energy supplies is the driving mechanism behind the greenhouse effect.

Carbon dioxide is produced any time coal, oil, natural gas or biomass is burned for energy production. The more carbon contained in a material, the more carbon dioxide it releases during combustion. For each million British thermal units of energy it provides, coal produces 225 pounds of carbon dioxide, oil produces about 160 pounds, and natural gas produces about 125 pounds.

Fuels derived from biomass (organic materials) also release carbon dioxide. However, their emissions do not add much to the net carbon dioxide buildup.

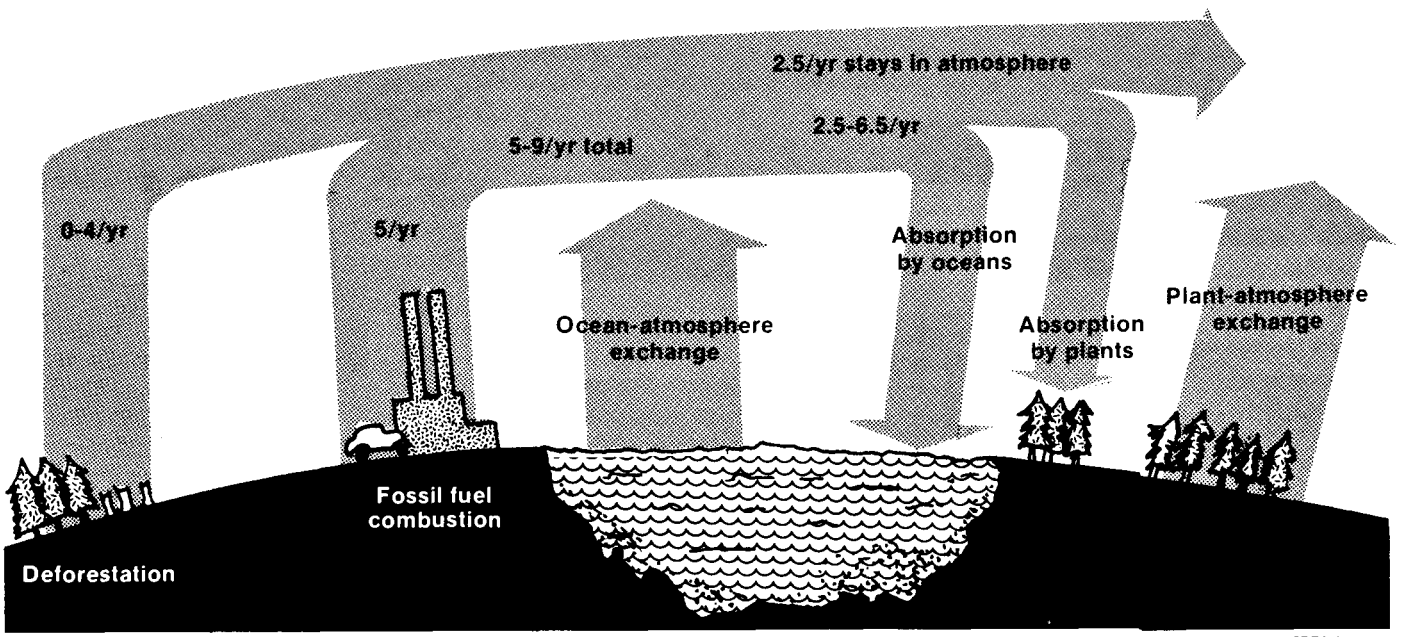

Figure 2. Earth's carbon cycle (quantities in 10^9 tons).

Essentially, such fuels simply recycle the carbon dioxide consumed during growth of the plant material that made up the fuel's feedstock.

On the other hand, fossil fuels have stored their carbon content for millions of years. The earth's natural carbon dioxide "sinks" — principally oceans and forests — cannot readily absorb such vast, long-stored emissions. Instead, these emissions accumulate in the atmosphere (Fig. 2). Other industrial, agricultural and energy practices are exacerbating the greenhouse problem. First, they produce more of the following trace gases that, even in small concentrations, have the potential to compound the greenhouse effect:

- Nitrous oxide, produced by combustion in power generation, automobiles, and by fertilizers
- Ground-level ozone, which results when fuel exhaust is exposed to sunlight
- Methane, produced by decomposition of organic matter (significant sources include rice paddies, wetlands, landfills, livestock and termites)
- Chlorofluorocarbons (CFCs), manmade chemicals released in refrigeration (air conditioning) processes, and in the manufacture of insulating and packing foams.

Second, development practices have diminished one of the planet's best carbon dioxide sinks — trees. As tropical rain forests are stripped to make way for agriculture and industry in developing countries, the earth's carbon dioxide equilibrium is thrown further out of balance.

Third, even though industrialized countries such as the U.S. have attempted to become more energy conserving, global energy use continues to increase. Rising world population, energy-intensive lifestyles being adopted in developing countries, and human persistence in burning fossil fuels, all continue to reinforce the global greenhouse (Fig. 3).

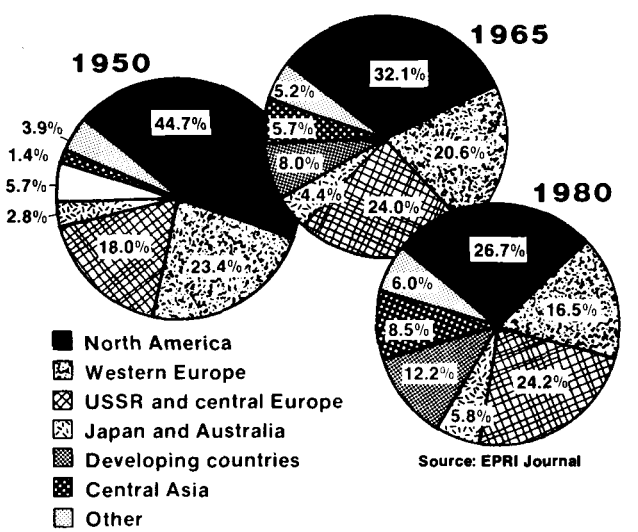

Figure 3. Sources of worldwide carbon dioxide production, 1950-1980.

The greenhouse effect is the net result of all these human activities and practices, but combustion of fossil fuels remains the major culprit.

Results

Scientists agree that the principal result of the greenhouse effect will be a warming of the world's climate with consequent changes in local, regional and global weather patterns. When and where these changes will occur,

how they will manifest themselves, and how they will affect human society are all matters of scientific discussion, research and controversy. However, the following measured phenomena suggest that the greenhouse effect has already begun to impose change:

- The concentration of carbon dioxide in the atmosphere has doubled in the last 100 years, and its rate of increase continues to rise (Fig. 4).
- During this century, the average global temperature has increased about one degree Fahrenheit.
- The 6 warmest years in the last century have occurred in the last 10 years.
- The world ocean, which expands as it warms, has demonstrated a sea-level rise of 6 inches in modern times.

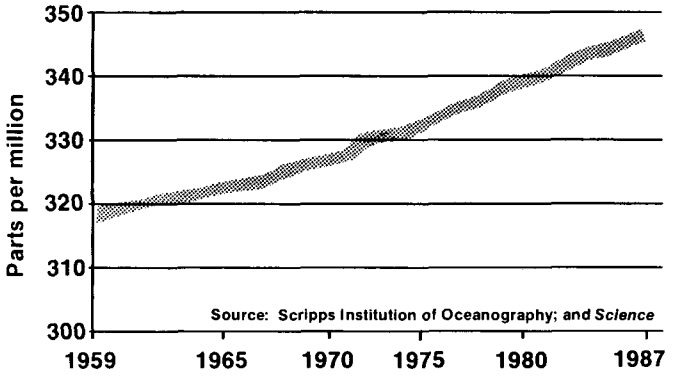

Figure 4. Atmospheric concentration of carbon dioxide, 1959-1987.

Because there is no precedent to the greenhouse effect, scientists have no validated model to use in predicting its results. Uncertainties are compounded by complex physical, chemical and energy interactions involving the atmosphere, the oceans, the continental land surface, and the planet's snow, ice, organic and cloud cover.

Even with limited data, the most reliable existing computer models predict that the world will experience the following phenomena within the next 50 years:

- Carbon dioxide concentrations will further increase by 30 percent.
- Carbon dioxide's greenhouse effect will be doubled by the effects of other greenhouse gases.
- The global climate will warm further by 3 to 8 degrees Fahrenheit.
- Regional weather patterns will change, with shorter, wetter winters and longer, drier summers probable in northern latitudes; less rain in subtropical regions; and more rain in the tropics.
- Severe weather occurrences will become more frequent and even harder to predict and prepare for.
- Rising sea levels will result in large coastal land losses and lead to severe flooding.
- Ecological, agricultural, economic and population patterns will be unpredictably stressed.

Response

Because the greenhouse effect is such a potentially devastating global problem, it demands a global response. Although experts differ on which should take priority, most scientists and policy makers agree that the world community should take three courses of action:

- Provide greater support for research on the greenhouse effect and its climate impacts.
- Develop and promote the use of technologies that will reduce carbon dioxide and trace gas emissions.
- Prepare to adapt to climate change.

The imperatives facing the world community are first, to slow the impending change as much as possible through energy conservation; and second, to develop alternative energy resources and technologies.

The rationale for these imperatives is obvious: carbon dioxide from burning of fossil fuels comprises 50 percent of the greenhouse problem, and as the world becomes more energy intensive, carbon dioxide emissions increase. Worldwide emissions more than tripled between 1950 and 1980 (Fig. 5). In 1980 alone, more than 5.1 billion tons of carbon dioxide were added to the atmospheric morass.

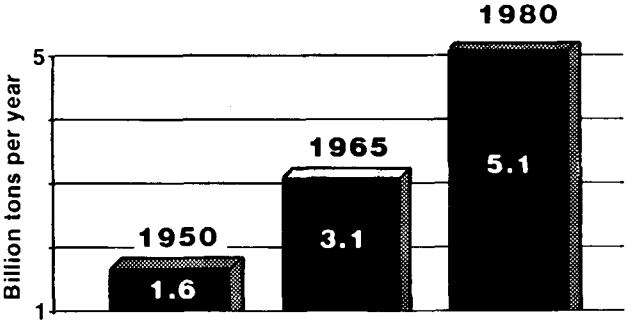

Figure 5. Increase in worldwide carbon emissions, 1950-1980.

The fact that the problem is global in scope should not impede the U.S. from taking immediate action, since this country is responsible for one quarter of total carbon dioxide emissions. About 29 percent of that portion is produced by industrial energy activity; 28 percent results from electrical energy generation; 27 percent is produced by transportation; and the remaining 16 percent results from energy use in homes and businesses.

Some alternative energy technologies already have the potential to quickly reach a stage of development where their effective application could significantly offset use of fossil fuels. Two examples include photovoltaics and hydrogen fuel. The principal factors that have impeded their widespread use are these: 1) what appears to be high initial costs for these technologies does not take into account their environmental benefit and 2) adopting these new technologies will require changes in deeply embedded technical, economic and social infrastructures.

Worldwide recognition and concern about the greenhouse effect has the potential to remove these impediments. Many organizations are already involved in responding to the greenhouse issue.

In Florida, the Florida Solar Energy Center (FSEC) plays an active role. Since 1975, FSEC has been conducting research to develop solar and other alternative energy technologies that can help to ameliorate the greenhouse effect.

Relevant FSEC research programs focus on the following energy alternatives:

- Photovoltaic systems, which convert sunlight directly to electricity without producing harmful emissions. Such systems have great potential for use in utility electrical generation as well as residential and commercial power applications.
- Production of hydrogen fuel from renewable resources. When used, hydrogen gives off no harmful emissions; it can be produced by a variety of solar driven processes such as photovoltaic electrolysis of water or photochemical reaction in biomass.
- Innovations in building design and operation, and mechanical systems, with the goal of displacing 50 to 70 percent of the energy required for cooling in hot, humid climates.
- Direct use of solar energy for low and medium temperature water heating.

Conclusion

Physicist-mathematician Jean-Baptiste Fourier pointed out the greenhouse effect as early as 1827; he also suggested that human activity can modify climate. The last 150 years have proved him right.

We now know that consumption of fossil energy supplies has inadvertently made our world a universal experiment on the results of human activity. The earth itself has become a giant laboratory, and the experiment involves complex interactions among atmospheric chemistry, radiation, thermodynamics and dynamics.

While we may watch, study and prepare for the changes that will result from this experiment, only one course of action will change its result: developing and implementing solar and other alternative energy supplies that do not hold the potential for irrevocably harming the planet.

What can you do?

The greenhouse effect seems to be an overwhelming problem. But Florida's 12 million citizens can make a difference by practicing energy conservation:

- Make high MPG ratings a must in your next car.
- Purchase only energy-efficient appliances.
- "Go solar" for water and pool heating.
- Offset air conditioning use with fans and windows.
- Set thermostats down in winter, up in summer.
- "Weatherize" your present house.
- Demand energy efficiency in your next house or apartment.
- Practice recycling; reprocessing materials takes much less energy than manufacturing new materials.
- Encourage conservation at work as well as at home.
- Teach children to conserve, too.
- Stay informed, let your Legislators know you're concerned, and support energy alternatives.

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