BioFacts
Fueling a Stronger Economy

Global Warming and Biofuels Emissions

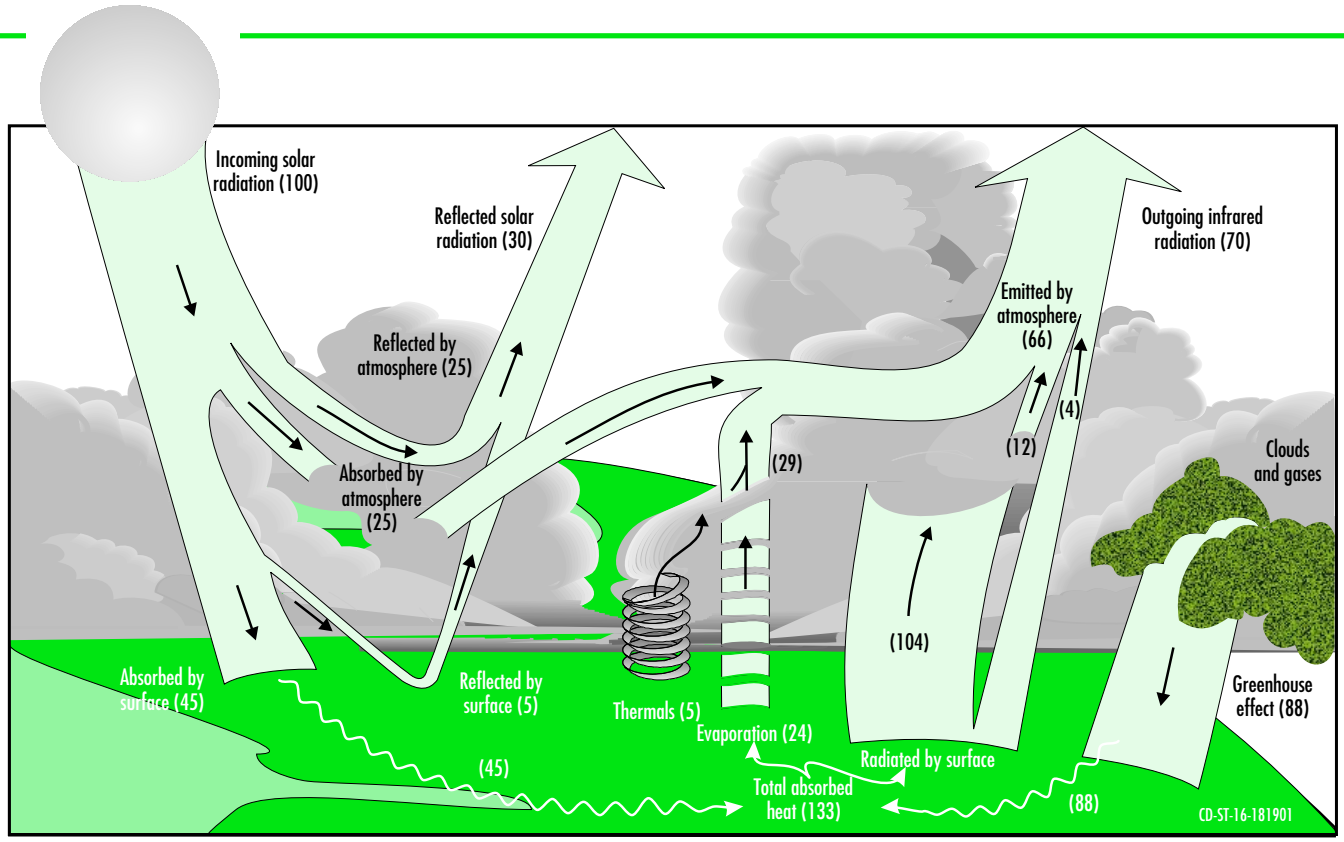
The focus of numerous federal and state regulations being proposed and approved today is the reduction of automobile emissions—particularly carbon dioxide (CO_2), which is the greenhouse gas considered most responsible for global warming. Studies conducted by the U.S. Department of Energy (DOE) through the National Renewable Energy Laboratory (NREL) indicate that the production and use of biofuels such as biodiesel, ethanol, and methanol could nearly eliminate the contribution of net CO_2 from automobiles. This fact sheet provides an overview of global warming, followed by a summary of NREL's study results.

What is Global Warming?

Although the terms greenhouse effect and global warming are often used interchangeably, they refer to two different atmospheric concepts.

The greenhouse effect is an actual process: it is the natural phenomenon by which Earth's atmosphere traps and holds warmth from the sun. The Earth's surface absorbs the solar radiation that reaches it and then radiates heat back into the atmosphere. Trace gases (CO_2, ozone, methane, oxides of nitrogen, and others) that exist in the Earth's atmosphere absorb and bounce back much of the planet's

The greenhouse effect is part of a complex web of natural phenomena that absorb and reflect radiation from the sun. The percentages shown indicate the amount of original solar radiation involved with each force.

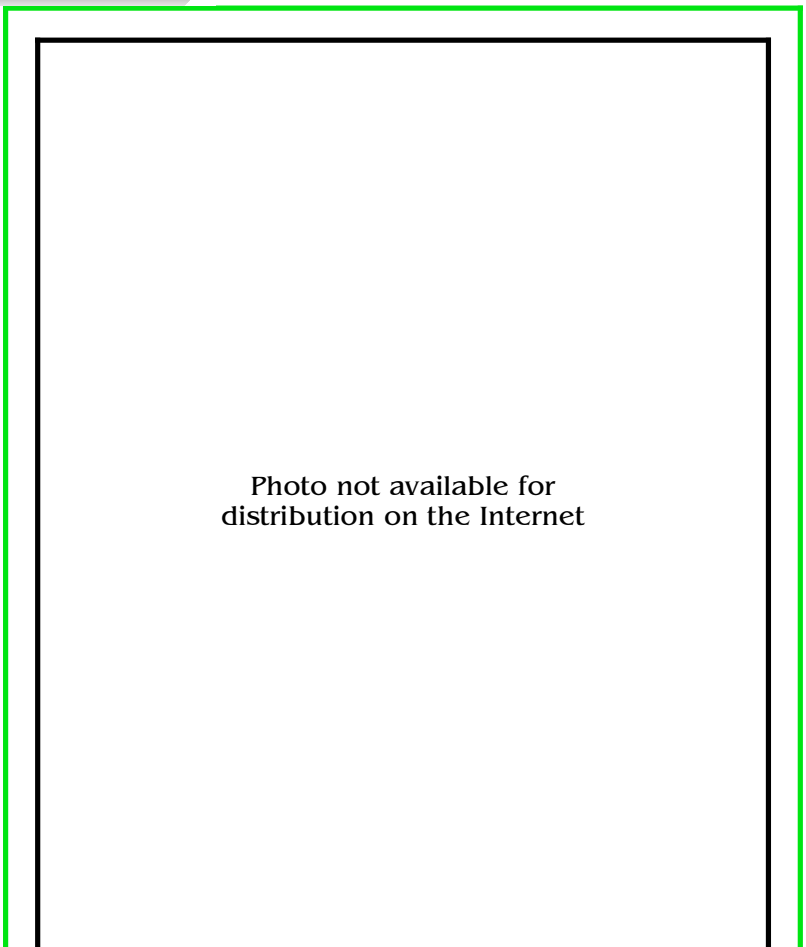


Adapted from NCAR* figure

radiated heat before it escapes into space. Because CO_2 exists in the atmosphere in far larger quantities than other trace gases, it is responsible for more than half the Earth's greenhouse effect. Without this process, the Earth's surface temperature would be 60°F (33°C) cooler and unable to support life as we know it.

Global warming refers to a theory: if the amount of CO_2 and other trace greenhouse gases in the atmosphere is increased, more heat will be trapped and the Earth's surface temperatures will rise. Supporters of this theory note that the atmosphere of Venus contains far higher concentrations of CO_2 than does that of Earth, which causes the 932°F (500°C) temperature at its surface. Conversely, the thin atmosphere of Mars contains very little CO_2, which makes its surface temperature as cold as Earth's polar winters.

One of the world's largest supercomputers, the CRAY-MP 8/864, is required for researchers at the National Center for Atmospheric Research to construct models that will simulate how the Earth's atmosphere could react to different atmospheric variables. Most debate surrounding global warming pertains to these simulations.



Debate Surrounds the Global Warming Theory

The global warming theory is widely accepted in principle. However, the validity of this theory has yet to be proven—largely because of the many, complex variables that affect the Earth's climate. Therefore, there is little agreement about how much warmer the Earth's atmosphere may become, the probable impacts that global warming could have, or how soon we might feel the effects.

Scientists can prove that the level of CO_2 found in the Earth's atmosphere was stable for most of human history. However, CO_2 has increased 25% since the start of the Industrial Revolution—a fact attributed to a combination of fossil fuel combustion and deforestation. The scientific community generally agrees that the Earth's temperature has increased between 0.54° and 1.3°F (0.3° and 0.7°C) during this same time frame; however, scientists cannot say whether the increase is caused by higher concentrations of greenhouse gases or the Earth's natural temperature fluctuations. According to many experts, the Earth's temperature rise would have to continue for 10–20 years before the theory of global warming could be proven.

Most of the debate surrounding global warming pertains to the scenarios devised by groups of scientists to assess and quantify the possible effects of global warming. Scientists create intricate mathematical models to simulate climatic conditions. They must make many assumptions and generalizations to compensate for conditions that are not fully understood and to scale such models down to a size that can be run on even the largest, most sophisticated computers available.

Because of the inexact nature of the models, numerous scenarios have been created that describe global and regional impacts that range from benign to nearly apocalyptic. The effects of global warming, as well as the implications of efforts to control it, could have significant ramifications, so the debate about global warming will likely continue for years to come.

Global Warming Policy Focuses on Transportation Fuels

The public has generally found the circumstantial evidence for global warming compelling. Many people find it prudent to begin activities to prevent or limit global warming as "insurance" against the impacts of possibly radical climate change. As a result, many countries, including the United States, are implementing policies and regulations to reduce CO_2 emissions.

With only 5% of the Earth's population, the United States contributes more than 20% of worldwide CO_2 emissions. About one-third of U.S. CO_2 emissions is generated by the production and consumption of transportation fuels—making them an obvious focus for emissions-control efforts.

Biofuels Reduce or Eliminate CO_2 Emissions

Biofuels are transportation fuels that are produced from biomass—energy crops such as trees, grasses, and microalgae as well as food-processing wastes, forestry and agricultural residues, and a significant percentage of municipal solid wastes. As they grow, plants absorb atmospheric CO_2 through a process called photosynthesis. This ability to absorb CO_2 is just one of a complex set of natural processes that form the Earth's carbon cycle, which circulates carbon through the Earth's atmosphere, plants, animals, oceans, soil, and rocks—primarily in the form of CO_2. Carbon is the key element in the chemical structure of plants, animals, and microorganisms. Fossil fuels, which play an important role in the carbon cycle, were formed from prehistoric plants and animals and have impounded CO_2 contained in these sources for more than 100 million years. The consumption of fossil fuels, therefore, releases carbon that had been locked away by nature without providing a rapid mechanism to reabsorb it. Conversely, biofuels work with the Earth's carbon cycle. Much or all of the CO_2 released when biomass is converted into a biofuel and burned in automobile engines is recaptured when new biomass is grown to produce more biofuels.

Several steps are required to grow and convert biomass into usable transportation fuels. Thus, NREL

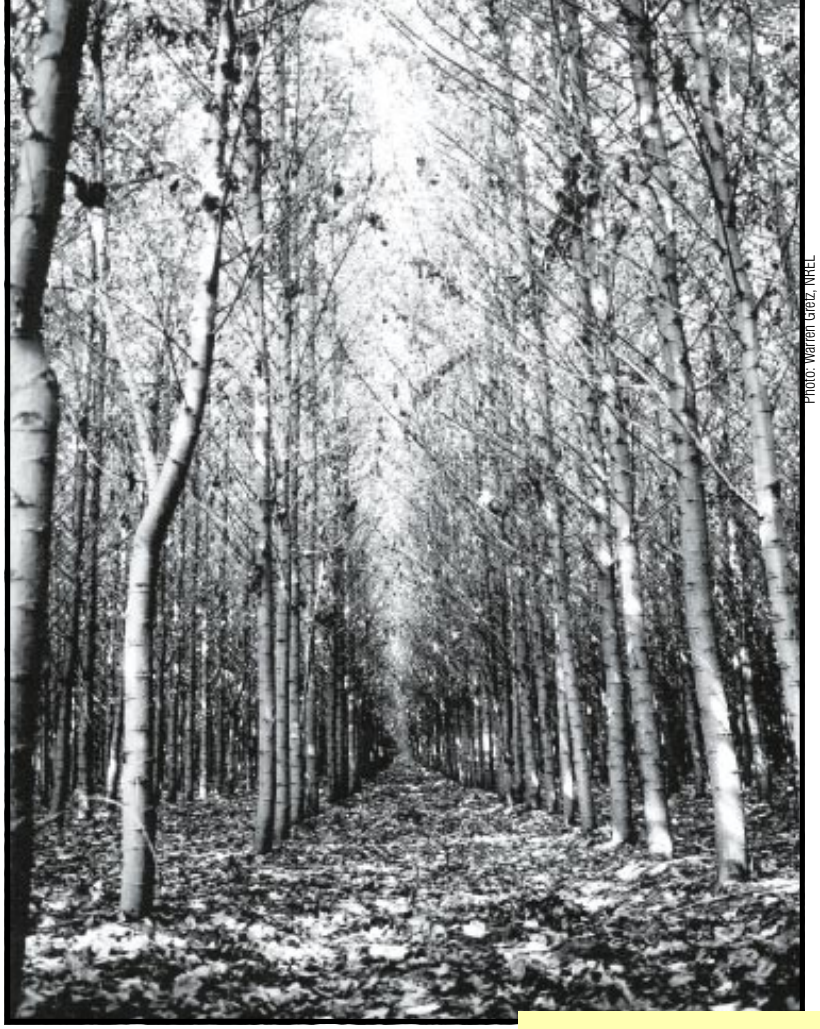
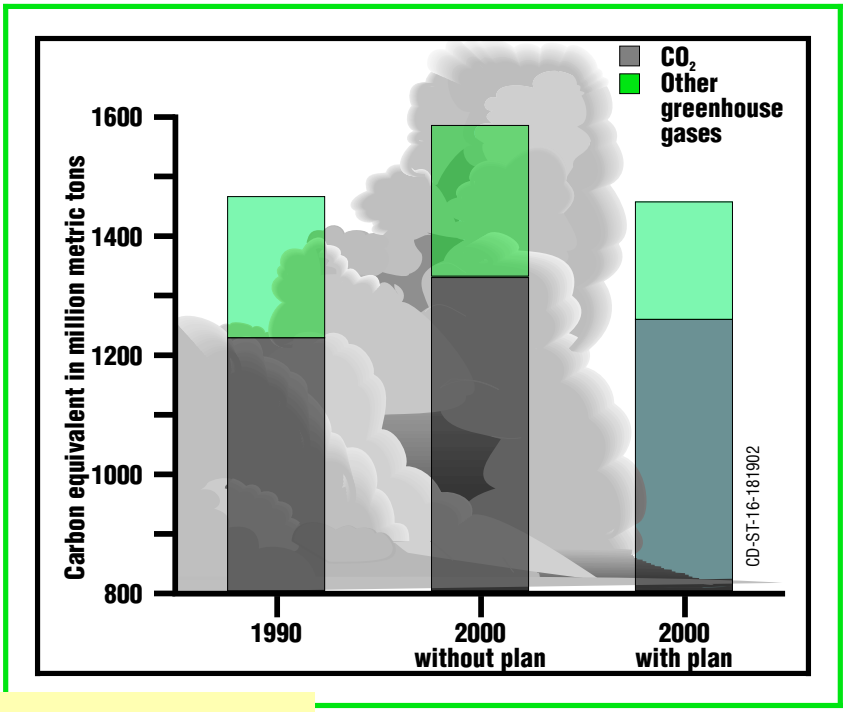


Photo: Warren Gretz, NREL

Biofuels are part of the Earth's carbon cycle. Most of the CO_2 released when biofuels are produced and used is recaptured when biomass, such as this short-rotation tree crop, is grown to produce more biofuels.



The increased demand expected for transportation services will fuel CO_2 emissions to over 8% above 1990 levels by 2000. The Climate Change Action Plan seeks to limit the growth of CO_2 emissions to 2% above 1990 levels. Biofuels can play a significant role in achieving this.

researchers have conducted studies that estimate all CO_2 emissions from the farming, conversion, distribution, and use of biofuels to evaluate and compare each fuel's environmental impact to that of conventional transportation fuels. The studies are based on analysis of net CO_2 emissions—they take into account CO_2 released, less CO_2 recaptured, during every step in the fuel acquisition, production, and use cycles.

NREL researchers recently evaluated a hypothetical industry in the year 2010 that produced ethanol from energy crops. The results of the analysis led researchers to conclude that ethanol manufactured from energy crops and containing 5% gasoline denaturant would generate 90% less net CO_2 emissions than reformulated gasoline.

Furthermore, when secondary emissions from the generation of electricity used in the process are considered, net CO_2 emissions are even less. This is because biomass is used to generate electricity for the ethanol production process. Unlike fossil-fuel refineries, which consume substantial amounts of electricity, the excess electricity produced from biomass can be sold to the local electric utility and offset electricity generated from fossil fuels—often coal. As a result, when electricity is factored into the analysis, ethanol contributes little or no net CO_2. More wide-scale use of renewables in the process would lower emissions even further.

It is clear that biofuels, when used in place of fossil fuels, could reduce or possibly eliminate net CO_2 emissions from transportation. For this reason, biofuels play an important role in U.S. efforts to create an "insurance policy" against global warming.

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*National Center for Atmospheric Research/ University Corporation for Atmospheric Research/National Science Foundation

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