Energy and Climate Change

CHAPTER

6

Fuel to Burn?

As explained in Chapter 4, there are at least hundreds, and perhaps thousands, of years' worth of fossil fuels still available on Earth. However, the issue of man-made (anthropogenic) global warming has raised an important question: What will happen to the environment if that fuel is actually burned?

As the name implies, hydrocarbon molecules are made up of strings of hydrogen and carbon atoms.[208] When these molecules are *oxidized* (burned), heat is released along with water (H_2O), carbon monoxide (CO), and carbon dioxide (CO_2). Because air is about 79 percent nitrogen, oxides of nitrogen (NO_x) are also produced, and if the fuel contains sulfur, then sulfates (compounds of sulfur and oxygen) will be formed as well.

Carbon dioxide and nitrous oxide (N_2O) are *greenhouse gases* that, in high enough atmospheric concentrations, will warm the Earth's climate if no natural or human-driven processes offset the effect. Some scientists worry that such climatic changes might cause extreme heat and drought, more violent storms, higher ocean levels (putting coastlines and cities at risk), and increase the spread of tropical diseases.

Are these concerns justified, and if so, what can be done? The short answers are (respectively)"maybe" and "quite a bit."

The Greenhouse Effect

Have you ever gotten into a car after it had been sitting in the sun and noticed how much hotter the air is inside the car than outside? This phenomenon is caused by the *greenhouse effect*. Sunlight passing through the car's windows is

[208]Coal is not a hydrocarbon. It is nearly all carbon and does not contain significant amounts of hydrogen (anthracite coal, for example, is 92 to 98 percent carbon).

absorbed by the interior, heating it and the air inside the car. Some of the heat passes back through the windows, but some is reflected off the windows back into the car. This trapped heat builds until the car's interior is warmer than the outside air.

The Earth's atmosphere acts like the car's windows, keeping heat from escaping back into space as infrared radiation. Greenhouse gases (such as carbon dioxide, methane, and water vapor) let incoming sunlight through, but block some of the infrared energy radiated upward by the sunlight-warmed Earth.[209] According to the EPA, "Without this natural greenhouse effect, temperatures would be much lower than they are now, and life as we know it would not be possible. Thanks to greenhouse gases, the Earth's average temperature is a hospitable 60°F,"[210] about 59°F warmer than it would be otherwise.[211]

But if the greenhouse effect becomes too strong, and if not enough radiated heat can escape from the atmosphere, then temperatures may rise too much.

Air pollution also has an impact on how much of the sun's energy penetrates the atmosphere and how much gets back out. Sulfates and particulates (e.g., smoke) may block the sun's incoming rays and therefore have a cooling effect.

When particulate emissions were much greater during the 1970s and 1980s, the possibility of global cooling was a concern.[212] Now that particulates are under better control, at least in western countries, global warming is the main worry.

Greenhouse Gases

As explained above, greenhouse gases are relatively transparent to visible light and relatively opaque to infrared radiation. They let sunlight enter the Earth's atmosphere, and, at the same time, keep radiated heat from escaping into space. The following sections provide brief descriptions of the most important of these gases.

Carbon Dioxide (CO_2)

By volume, carbon dioxide currently makes up 367 parts per million (0.0367 percent) of our atmosphere.[213] About 95 percent of this comes from natural

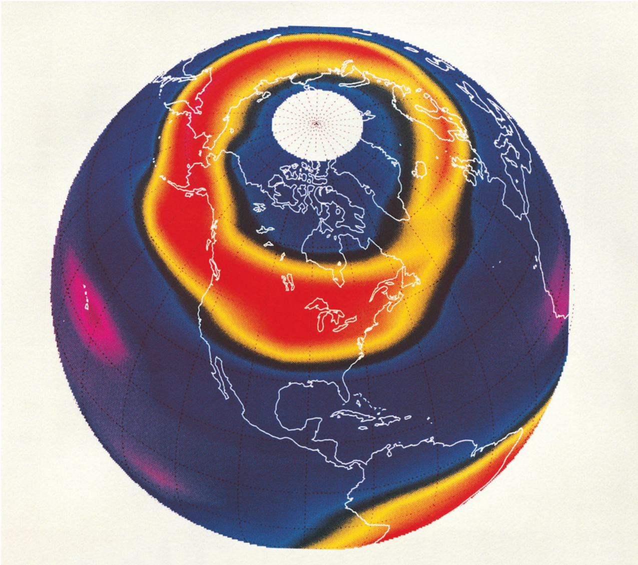
[209]Intergovernmental Panel on Climate Change, *Climate Change 2001: The Scientific Basis* (Cambridge, UK: Cambridge University Press, 2001), pp. 89–91.

[210]From the Environmental Protection Agency's web site: www.epa.gov/globalwarming/climate

[211]Patrick Michaels and Robert Balling, Jr., *The Satanic Gases: Clearing the Air About Global Warming* (Washington: Cato Institute, 2000), p. 25.

[212]James Fleming, *Historical Perspectives on Climate Change* (New York: Oxford University Press, 1998), pp. 131–36.

[213]IPCC, *Climate Change 2001: The Scientific Basis*, p. 185.



Digital Vision

sources (emissions from animal life, decaying plant matter, etc.) and the rest from human sources, mainly the burning of carbon-based fuels.[214]

While the human share of the total is relatively small, an estimated 3.5 percent to 5.4 percent, this additional contribution builds up over time because carbon dioxide is a very stable molecule and can last in the atmosphere for more than a hundred years. Since 1750, the atmospheric carbon dioxide concentration has increased by about 31 percent (from around 280 ppm) and is increasing at the rate of about 0.4 percent per year. It is estimated that carbon dioxide accounts for about 60 percent of the *anthropogenic* (or human caused) greenhouse change known as the *enhanced greenhouse effect*.[215]

If carbon fuels are of biologic origin, then sometime in the Earth's distant past there must have been far more CO_2 in the atmosphere than there is today. Over millions of years, much of it was removed by sea and land flora (plants). Most was returned to the air when the plant material decayed, but some of the carbon was locked up (or *sequestered*) in the form of wood, peat, coal, petroleum, and natural gas. Now that we are burning these fuels, the carbon is being released into the atmosphere once again.

[214]Ibid., p. 121.

[215]Ibid., p. 7, and Tom Wigley, "The Science of Climate Change," in Eileen Claussen, ed., *Climate Change: Science, Strategies, & Solutions* (Boston: Brill, 2001), p. 70.

Carbon dioxide is less soluble in warmer water than in cold, and as ocean surface layers warm, CO_2 could be driven out of solution and into the atmosphere, thus exacerbating the problem.[216]

There are benefits to increased CO_2 concentrations as well as potential problems. Plants need carbon dioxide; in fact, the optimal concentration for most plants is estimated to be between 800 and 1,200 ppm.[217] Some plants do best at even higher concentrations; the optimal range for rice is 1,500 to 2,000 ppm.[218] As the atmosphere becomes richer in CO_2, crops and other plants will grow more quickly and profusely. A doubling of carbon dioxide concentrations can be expected to increase global crop yields by 30 percent or more.[219]

Higher levels of CO_2 increase the efficiency of photosynthesis, and raise plants' water-use efficiency by closing the pores (stomates) through which they lose moisture. Carbon dioxide's effect is twice that for plants that receive inadequate water than for well-watered plants. In addition, higher CO_2 levels cause plants to increase their fine root mass, which improves their ability to take in water from the soil.[220] Higher water efficiency should allow plants to better cope with hotter climates.

Water Vapor (H_2O)

The most common greenhouse gas is *water vapor*, which accounts for about 94 percent of the natural greenhouse effect.[221] Its atmospheric concentration is ten times that of CO_2.

Water vapor's impact on the climate is complex and not well understood. It can both warm and cool the atmosphere. When water evaporates, it cools the surface from which it evaporates. In addition, heavy clouds block sunlight and reflect it back into space.

On the other hand, thin cirrus clouds may tend to let solar energy in while keeping radiated energy from escaping into space. Also, moist air retains more heat than does dry air, so a humid atmosphere should be warmer than a dry one. On balance, it is believed that water vapor has a net warming effect.

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[216] IPCC, *Climate Change* 2001: *The Scientific Basis*, p. 200.

[217] Sylvan Wittwer, *Food, Climate, and Carbon Dioxide: The Global Environment and World Food Production* (Boca Raton, FL: CRC Press, 1995), p. 101.

[218] Ibid., p. 113.

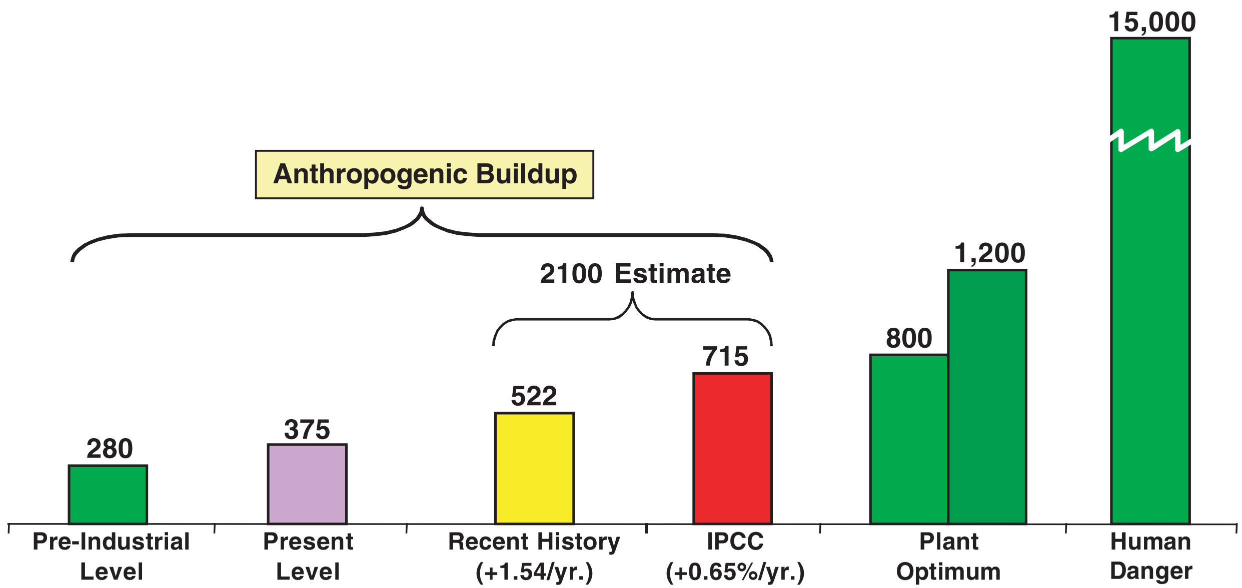
[219] Ibid., 86.

[220] Patrick Michaels and Robert Balling, Jr., *The Satanic Gases*, p. 184.

[221] Ibid., p. 25.

ATMOSPHERIC CO_2 & SOCIAL WELFARE (PARTS PER MILLION BY VOLUME)

The positive effects of carbon fertilization on crop yields lead some economists to suggest that the benefits of higher atmospheric CO_2 concentrations may outweigh the costs for decades to come. *Source: Climate Change 1995—The Science of Climate Change,* pp. 21–26 by John Houghton, ed.; *Food, Climate, and Carbon Dioxide* pp. 89–91 by Sylvan Wittwer; *In Defense of Carbon Dioxide,* p. 1 by New Hope Environmental Services.



The main concern about increased concentrations of atmospheric water vapor is the possibility of a strong *positive feedback effect*.[222] As the climate warms, more water will evaporate, increasing the amount of water in the air. The increased concentration will, in turn, further warm the climate leading to a still higher level of water vapor in the atmosphere. This iterative cycle, it is feared, could spiral out of control, resulting in damaging or even catastrophic temperature increases.

However, if the Earth's climate were that sensitive, it would probably have spun out of control long before now given that there have been periods in the distant past when temperatures and CO_2 were higher than they are today. This leads some scientists to suspect that there may be natural mechanisms working to keep the climate in balance.

Meteorologist Richard Lindzen has proposed one such mechanism, which he calls the Iris Effect.[223] Lindzen and his colleagues suggest that upper-level cirrus clouds, which tend to trap heat radiated from the Earth's surface, may open "as an iris (by analogy with the eye's iris)" in response to higher earth surface temperatures.[224] Lindzen's Iris Effect is only a hypothesis, but important scientific work is beginning to suggest that the water vapor feedback is not as strongly positive as indicated by some computer climate-models.

Methane (CH_4)

While methane is 25 times more powerful a warming agent than carbon dioxide, it has a much shorter life span and its atmospheric concentration is only about 17 ppm. Concentrations have more than doubled since 1850, though for reasons that are still unclear, they have leveled off since the 1980s.[225] Human activity accounts for about 60 percent of methane emissions, while the rest comes from natural sources such as wetlands. Human sources include leakage from pipelines, evaporation from petroleum recovery and refining operations,

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[222]The term "feedback effect" was borrowed from the name given to the loud screech that is produced when a microphone is placed near a speaker. Background noise, picked up by the microphone, is amplified and then fed to the speaker. The microphone picks up this amplified sound, sends it back to the amplifier, and so on until the noise becomes painfully loud. The word "positive" in the phrase, "positive feedback effect," is not meant to imply "good." Rather it means that the effect builds on itself, growing larger and larger. A *negative feedback effect* would be one that tends to dampen itself out.

[223]Lindzen is currently the Alfred Sloan Professor of Meteorology in the Department of Earth, Atmospheric, and Planetary Sciences at MIT. He is widely respected and highly credentialed (Lindzen was one of the youngest members ever elected to the National Academy of Sciences), but, while other scientists researching global warming consider him brilliant, they also see him as something of a maverick.

[224]Richard Lindzen, Ming-Dah Chou, and Arthur Hou, "Does the Earth Have an Adaptive Infrared Iris?," *Bulletin of the American Meteorological Society*, September 2001, p. 417.

[225]E. J. Dlugokencky, et al., "Atmospheric Methane Levels off: Temporary Pause or a New Steady-state?" *Geophysical Research Letters*, October 8, 2003, doi:10.1029/2003GL018126, 2003.

rice fields, coal mines, sanitary landfills, and wastes from domestic animals. About 20 percent of the total human greenhouse impact is due to methane.

Nitrous Oxide (N_2O)

Nitrous oxide's warming potential is some 300 times that of CO_2. It has an atmospheric concentration of about 0.32 ppm, up from 0.28 ppm in 1850. In the United States, 70 percent of man-made nitrous oxide emissions come from the use of nitrogen-containing agricultural fertilizers and automobile exhaust. Globally, fertilizers alone account for 70 percent of all emissions.

Catalytic converters, whose use on car exhaust systems was federally mandated in 1970 by the Clean Air Act, increase N_2O emissions, though to what extent is under debate. The EPA has calculated that production of nitrous oxide from vehicles rose by nearly 50 percent between 1990 and 1996 as older cars without converters were replaced with newer, converter-equipped models. Critics argue that the EPA's numbers are greatly exaggerated. In addition, they point out that converters reduce emissions of another greenhouse gas, ozone, as well as carbon monoxide and NO_x (which leads to smog).

CFCs

Chlorofluorocarbons, or CFCs, are powerful global warming gases that do not exist in nature but were invented by scientists at an American chemical company in the 1930s. They are used as propellants in aerosol sprays and as refrigerants. Freon, the most well-known CFC, was widely used in refrigerators and in home and auto air conditioning systems until it was banned in 1995.[226]

The fact that CFCs are chemically inert (that is, they do not react with other chemicals) makes them very useful in a wide variety of applications, but it also means that they last for a very long time in the atmosphere (perfluoromethane, for example, can persist for 50,000 years).

These gases affect the climate in different ways depending upon their location in the atmosphere. At lower altitudes, they trap heat like other greenhouse gases and have a much stronger warming effect than CO_2. In fact, some can trap as much as 10,000 times more heat per molecule than carbon dioxide. While CO_2 is measured in atmospheric concentrations of parts per million, CFCs are measured in parts per trillion. Despite their low concentrations, it is believed that these gases account for about 15 percent of the human greenhouse change.

[226]Freon's use was originally scheduled to be phased out by the year 2000 in accordance with the 1987 Montreal Protocol, but the timetable was advanced in response to pressure from environmentalists. Developing countries and Eastern-bloc nations did not sign the protocol, and still use the chemical. In addition, Freon is being smuggled into the United States because it generally costs less, works better, and is less toxic and corrosive than its replacements.

In the upper atmosphere, or stratosphere, chloroflourocarbons are broken down by sunlight. The chlorine that is released by this decomposition acts as a catalyst to break naturally occurring ozone (O_3) molecules into oxygen (O_2) molecules. Ozone helps block the sun's ultra-violet radiation, which can cause skin cancer after long-term exposure.

Worldwide CFC emissions have been steadily dropping, and it is expected that ozone depletion (the ozone hole), which reached its peak in the last decade, will drop to zero later this century.[227]

Is the Climate Warming?

We know that concentrations of carbon dioxide, methane, and nitrous oxide are increasing due to human activity, but is the climate getting warmer as a consequence? The evidence, while still not conclusive, suggests that it is. A number scientists point to ground measurements taken over a number of decades that indicate a noticeable temperature rise.

On the other hand, skeptics point out that the data are skewed toward urban areas where most measurements are taken. The problem, they argue, is that cities tend to be warmer than the surrounding countryside because of heat absorption by streets, parking lots, and dark roofs. While measurements are adjusted to compensate for this *urban heat island effect*, the critics claim that the adjustments are insufficient.

In addition, as Russia's economy worsened, the country stopped taking ground-based measurements in many areas. As a result, data from cooler regions of the globe have been significantly reduced.

Another criticism is that methodical, direct atmospheric temperature monitoring has only begun in recent decades. Estimates of past temperatures are based on observations of coral reefs and tree rings. Such indirect measurements are subject to uncertainty, and any trend analysis based on such data is open to question.

Furthermore, temperature readings from satellites and weather balloons are not detecting the *greenhouse signal* in the area where it should be strongest—the lower troposphere.[228] It is possible, though, that ozone depletion or other factors could be producing a downward bias in these readings.[229]

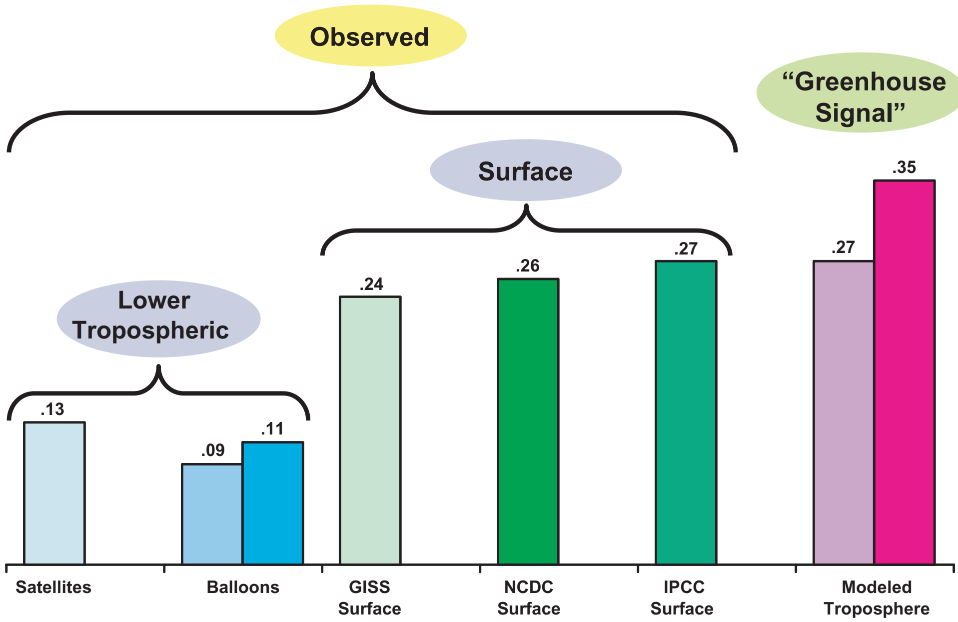
[227]U.S. Environmental Protection Agency, *Latest Findings on National Air Quality: 2001 Status and Trends* (Washington: EPA, 2002), p. 240.

[228]The troposphere is that part of the atmosphere that extends from the earth's surface to an altitude ranging from about five miles over the polar regions to eight miles over the equator.

[229]Robert Bradley, Jr., *Julian Simon and the Triumph of Energy Sustainability*, p. 98.

GLOBAL TEMPERATURE DISCREPANCIES

This graph compares the global average temperature increase (1979–2003 in F°/decade) over the last quarter century as measured by three sets of surface readings vs. the average temperature measured by satellites and balloons. The discrepancy between the two sets of measurements is currently an active area of research. The last set of bars indicates the temperature increase predicted by climate models. *Source:* Goddard Institute for Space Studies (NASA), National Climate Data Center, and Intergovernmental Panel on Climate Change.



At least some of the last century's warming is believed to be the result of increased solar activity (the sun's intensity rises and falls over time with 11-, 22-, and 88-year cycles). One study suggests that "the increase in direct solar irradiation over the last 30 years is responsible for about 40 percent of the observed global warming."[230] Changing ocean currents may have also produced a warm phase coming out of the little ice age in the mid-nineteenth century.

Nonetheless, according to the Intergovernmental Panel on Climate Change (IPCC), temperature readings at ground-based measuring stations reveal an average warming trend of about 1.1°F (0.6°C) since 1850 after adjusting for the urban heat island effect. About half of this warming has occurred since 1970, which, to many scientists, is proof of an emerging greenhouse signal.

[230]For a summary of solar/climate studies, see Bjørn Lomborg, *The Skeptical Environmentalist*, pp. 276–78.

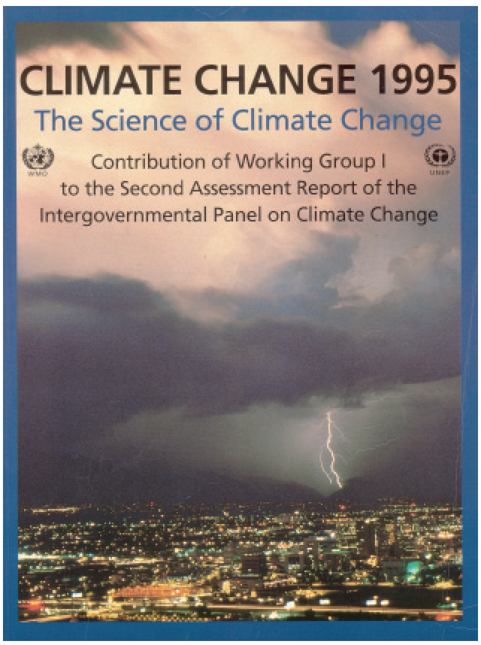
In 1988, the *Intergovernmental Panel on Climate Change* was created under joint sponsorship of the United Nations and the World Meteorological Organization (WMO). While the IPCC is not itself a scientific research organization, its three working groups—WG I Science, WG II Impacts and Adaptation, and WG III Mitigation—each issue a report every five years on the findings of the latest climate-change research. The First Assessment Report was completed in 1990, the second in 1995, and the third in 2001. The Fourth Assessment Report is scheduled for completion in 2005.

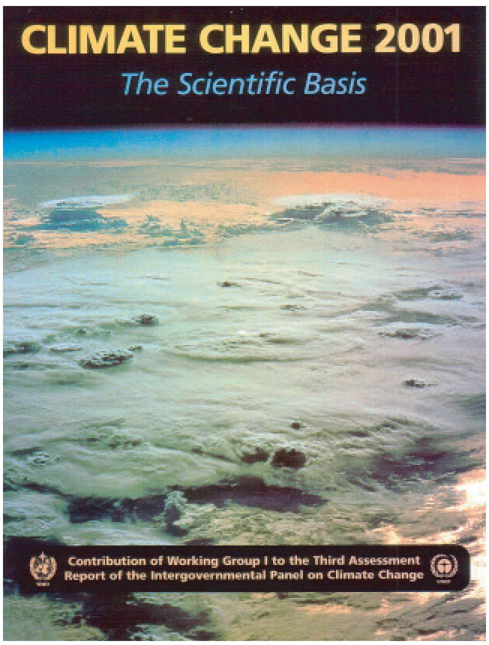
Along with the book-length reports produced by each of the three working groups, the IPCC issues a 20-page *Summary for Policymakers.* This summary is politically influential and is usually the only part of the report that gets read.

Though it is generally acknowledged that the IPCC reports present the best available science, critics argue that the executive summaries tend to be much more alarmist than the scientific portions of the reports warrant.[231]

COVERS OF IPCC SCIENCE REPORTS

The IPCC's second and third scientific assessments, released in 1995 and 2001, respectively, have provoked the greatest international debate on energy usage and policy in history. *Source:* IPCC.





[231]According to the National Research Council's report, *Climate Change Science, An Analysis of Some Key Questions* (Washington: National Research Council, 2001, p. 4), "The *Summary for Policymakers* reflects less emphasis on communicating the basis for uncertainty and a stronger emphasis on areas of major concern associated with human-induced climate change."

HAVE THERE BEEN OTHER CHANGES?

Along with higher temperatures, many scientists expect that anthropogenic global warming will mean a more active *water cycle* (increased evaporation and rainfall, for example) and higher sea levels (due to thermal expansion of the oceans' water and to melting ice sheets). Some scientists argue that more extreme weather events such as tornadoes, hurricanes, dust storms, and droughts could also occur.

At this time, there is not enough information to identify trends in these areas with much assurance. Data quality is poor, incomplete, and of limited duration. For example, measurements of ice sheet changes are contradictory, and we do not know whether they are growing or shrinking. While the melting of floating ice (such as that at the Arctic) will not cause sea levels to rise, the land-based ice masses in Greenland and Antarctica are of concern. However, the IPCC predicts that in the 21st century, increased water runoff in Greenland (from warming) will be offset by an ice buildup in Antarctica (from more precipitation).[232]

The best available research to-date indicates the following:[233]

- There is no firm evidence of a global increase in extreme weather events during the 20th century.
- There has been a slight increase in rainfall of about 1 percent in the Northern Hemisphere.
- Sea levels have risen over the past hundred years; estimates range from about 4 to 10 inches (10 cm to 25 cm).
- The temperature of the top 10,000 feet of the ocean has risen approximately 0.11°F (0.06°C) between 1955 and 1996.[234]
- Between 1955 and 1996 there was also an increase in the average temperature of the top 1,000 feet of the ocean. Strangely, however, this rise appears to have all occurred during the years 1976 and 1977. Climatologists call this phenomenon "the great Pacific climate shift," but have not been able to explain it.[235]

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[232]IPCC, *Climate Change* 2001: *The Scientific Basis*, pp. 650–52, 664–65, and 668–70.

[233]Unless otherwise noted, this information is taken from IPCC, *Climate Change* 2001: *The Scientific Basis*, pp. 4–5, 11, 15–16, 33, 73, 104, 641, and 699.

[234]Sidney Levitus et al., "Warming of the World Ocean," *Science*, March 2000, p. 2227.

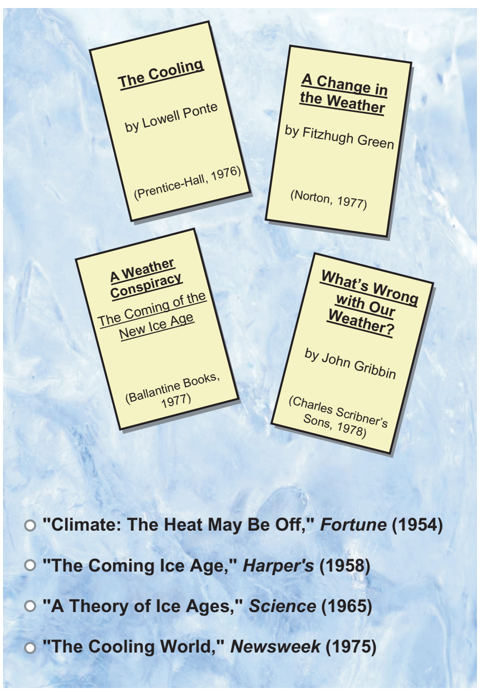
[235]The climate shift that some scientists believe occurred in 1976–1977 may not have been a natural phenomenon at all, but may have only been a shift in the data caused by the closing of Soviet monitoring stations.

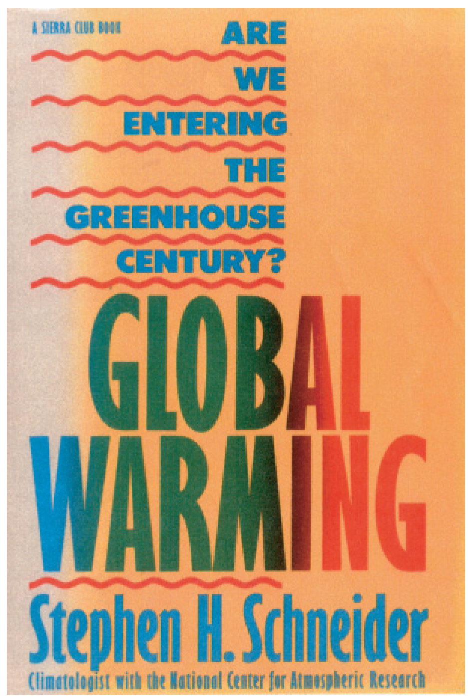
ARE PEOPLE CAUSING THESE CHANGES?

The human contribution to these trends is uncertain because there is so much natural climate variation. Not only are there solar activity cycles, but there is also a 100,000-year ice age cycle. Currently, we are enjoying one of the cycle's 10,000- to 30,000-year warming periods. As James Hansen pointed out, "Climate is always changing. Climate would fluctuate without any . . . [man-made] climate forcing. The chaotic aspect of climate is an innate characteristic."[236] In Richard Lindzen's opinion, "[W]e are not in a position to confidently attribute past climate change to carbon dioxide or to forecast what the climate will be in the future. . . . One reason for this uncertainty is that . . . the climate is always changing; change is the norm. Two centuries ago, much of the Northern Hemisphere was emerging from a little ice age. A millennium ago, during the

COOLING AND WARMING BOOK COVERS

Between the mid-1940s and mid-1970s, global surface temperature readings, indicating that the climate was cooling, sparked a fear that Earth was headed toward another little ice age. When the trend reversed soon thereafter, the concern became global warming. *Source:* (left) Illustration by Jean Spitzner (right) Cover design by Lawrence Ratzkin.





[236] James Hansen, "How Sensitive is the World's Climate?," *National Geographic Research & Exploration*, Vol. 9, No. 2 (1993), p. 143.

Middle Ages, the same region was in a warm period. Thirty years ago, we were concerned with global cooling."[237]

Despite the uncertainty, the IPCC's 1995 report concluded, "The balance of evidence suggests a discernible human influence on global climate." Its conclusion was based on mathematical analysis "reality checked" with available data. The IPCC hedged by stating: "Although these global mean results suggest that there is some *anthropogenic* (i.e., human-made) component in the observed temperature record, they cannot be considered as compelling evidence of a clear cause-and-effect link between anthropogenic forcing and changes in the Earth's surface temperature."[238]

The 2001 report concluded that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."[239]

Despite the IPCC's increasing confidence, Richard Kerr of *Science* pointed out that the range of uncertainty as reflected in the data and projections presented in the 2001 report actually *increased* in comparison with that presented in the earlier report.[240] The more we learn, the more we learn that there is more to learn.

COMPUTER MODELING

The temperature increase thus far detected is significantly less than the computer model predictions that have been the source of much of the concern over global warming. While these models are very sophisticated and run on extremely powerful machines, they have not yet been able to accurately mirror the immensely complex greenhouse that is Earth. Clearly, there are still many unknowns that must be resolved and much more data that must be collected before the models can be trusted.

Some of the unknowns are:

- The effect of the oceans, which may be acting as *heat sinks* absorbing some of the heat that would otherwise be raising atmospheric temperatures. If so, then the oceans' ability to absorb heat may drop as it gets warmer (heat transfer rate is proportional to temperature difference).
- The impact of plant life, both on land and in the sea. Higher carbon dioxide levels will lead to increased plant life and greater crop yields.

[237] Richard Lindzen, "Scientists' Report Doesn't Support the Kyoto Treaty," *Wall Street Journal*, June 11, 2001, p. A22.

[238] IPCC, *Climate Change 1995: The Science of Climate Change* (Cambridge, UK: Cambridge University Press, 1995), p. 4.

[239] *Climate Change 2001: The Scientific Basis*, p. ix.

[240] Richard Kerr, "Rising Temperature, Rising Uncertainty," *Science*, April 13, 2001, pp. 192–94.

More plants will mean more carbon removed from the atmosphere—though not enough to completely offset fossil fuel emissions.

- The water vapor feedback effect. Is it positive or negative, and what is its magnitude?
- The effect of clouds.
- The contribution of natural climate variability, including solar activity.
- The net impact of aerosols (i.e., suspended particles). Some of these particulates reflect light and tend to cool the atmosphere. Others absorb light and can have a warming effect. Most aerosols (about 90 percent) such as dust from soil, volcanic dust, and sea salt are of natural origin. Aerosols of human origin include soot and sulfates from burning carbon-based fuels.

Climate scientists are working to resolve the issues and collect needed data. However, as the technical summary of the IPCC's 2001 report states, "The climate system is a coupled nonlinear chaotic system, and therefore, the long-term prediction of future exact climate states is not possible."[241] (For a plain-English explanation of why this is so, refer to *Appendix* C—*The Butterfly Effect*.)

Critics of climate modeling point out that meteorologists cannot even accurately predict the weather more than three or four days in advance. How then, they ask, can modelers hope to predict the climate 50 or 100 years from now? While there is some merit to this argument, the fact is that predicting climate change is not the same as predicting the weather. It is both simpler and more complex.

It is simpler in that climate scientists do not have to determine specific future weather conditions (for example, if there will be a tornado in Wichita Falls, Texas, on June 6, 2050). Instead, they are trying to identify trends in the world's climate—a global "average" of local weather conditions. On the other hand (as explained in *Appendix* C), in any iterative, nonlinear system, small and immeasurable causes may have huge effects over long periods.

There are many pitfalls, and many opportunities for human error. As pointed out by climatologist Gerald North, climate modelers can be the victims of a "group think" bias. That is, scientists have a tendency to "calibrate" or adjust their models to agree with other models. Few researchers want to publish predictions that are either significantly higher or lower than the norm. Nor do agencies that fund this research want to pay for results that are outside the mainstream.[242]

The problems inherent with attempting to model Earth's atmospheric mechanisms make quantitative predictions suspect. Most likely we will only know what the climate will be like 50 years from now in 50 years.

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[241] IPCC, *Climate Change* 2001: *The Scientific Basis*, p. 78.

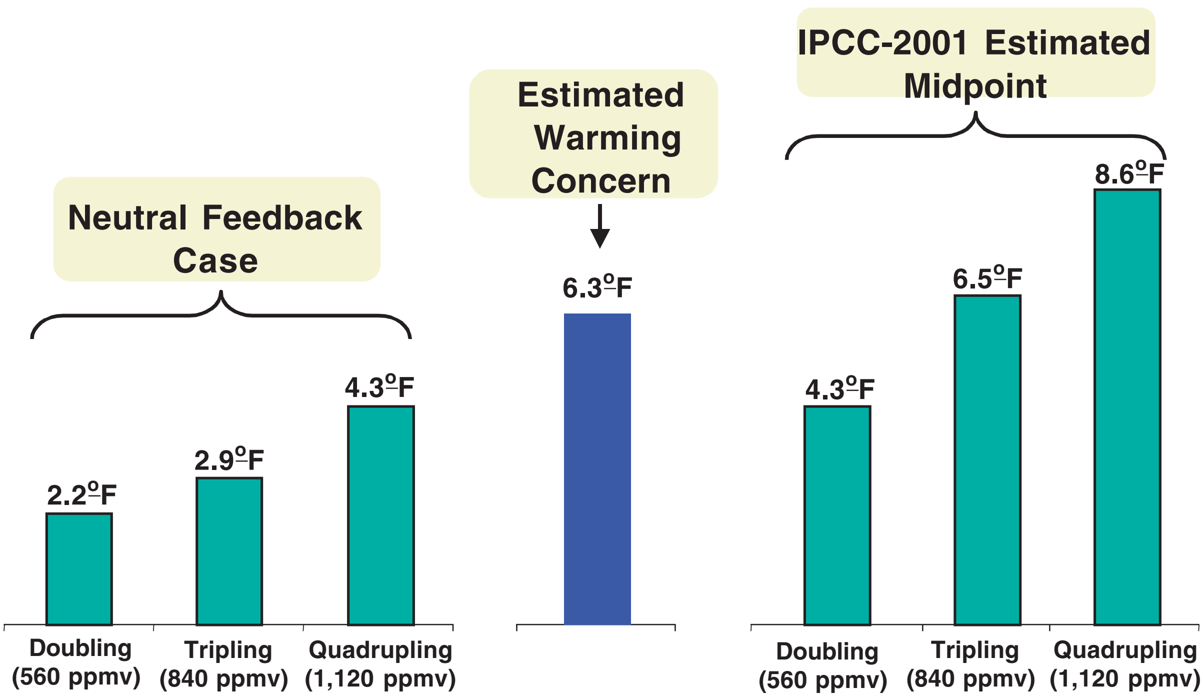
[242] Gerald North, book review, "L. Danny Harvey, *Global Warming: The Hard Science*," *Climate Change*, June 2001, pp. 293–97.

That said, the fact remains that all the models and the available data do point to a warming trend. The following diagram shows the projected increase in average climatic temperature if CO_2 concentrations in the atmosphere double, triple, or quadruple over the coming centuries. Two scenarios, one assuming neutral climate feedback effects and the other assuming strong positive feedback (which the IPCC models predict), are compared to an estimated "problematic" warming level.[243]

The importance of feedback effects on global warming is shown in this graph. In the neutral feedback case, the amount of projected warming is tolerable. However, given strong feedback effects, warming, as estimated by the IPCC, could reach a level of concern before the end of this century.

ATMOSPHERIC GHG BUILDUP & WARMING

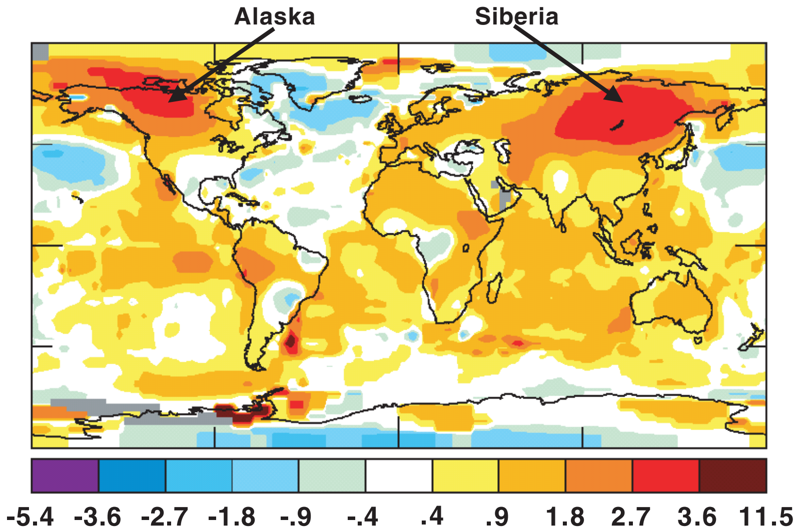
Scientists agree that temperatures will rise with increasing atmospheric concentrations of CO_2. The questions are, "how much?" and "how bad?" The range between the "best" and "worst" case scenarios (in comparison with the estimated level at which the net effect of warming will be negative) illustrate the uncertainty that currently surrounds the issue. *Source:* See footnote 243.



[243]IPCC, *Climate Change* 2001: *The Scientific Basis*, p. 577; Steve Schneider, "What Is 'Dangerous' Climate Change?" *Nature*, May 3, 2001, pp. 17–19.

ANTHROPOGENIC SURFACE WARMING

Data collected from 1951 through 1997 shows anthropogenic warming is greatest in the colder regions of the globe.[244] Warming is also skewed toward the coldest times of the year in these regions. *Source:* James Hansen et al., "A Closer Look at United States and Global Surface Temperature Change," *Journal of Geophysical Research,* volume 106, pp. 23, 947–53, 963.



WARMING DISTRIBUTION

Actual data and theoretical modeling indicate that this warming trend disproportionately affects lower temperatures and frigid regions during the coldest times of the year. Over the past 40 years, nights have warmed more than days, with minimum temperatures typically increasing twice as much as maximum temperatures. The above chart, created by NASA meteorologist James Hansen, shows that the areas of greatest warming are concentrated in Siberia and Alaska.

The fact that global warming is greatest in colder regions mitigates its effects somewhat. In fact, colder areas will likely benefit from a warmer climate. Economic impact studies suggest that North America, Europe, and the former Eastern-bloc countries may gain from moderate global warming—primarily due to longer growing seasons.[245]

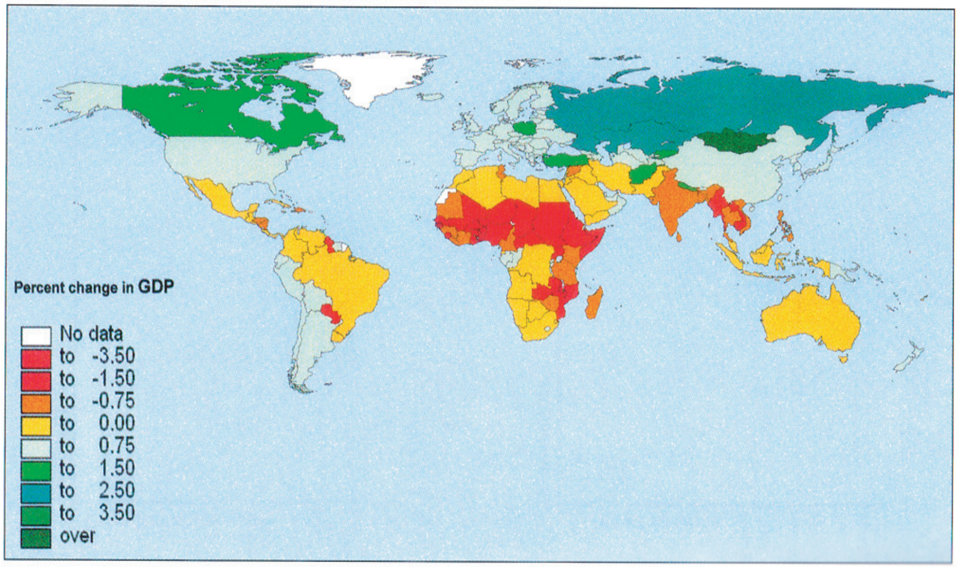
However, while warming may be concentrated in colder regions, it is not confined there. Areas that already have very warm climates such as Africa, India, Mexico, and Central America will likely suffer disproportionately from the trend. Similarly, while rising sea levels may be only a matter of inconvenience to some countries, they could pose a serious problem to island nations.

[244]Robert Balling, et al., "Analysis of Winter and Summer Warming Rates in Gridded Temperature Time Series," *Climate Research*, February 27, 1998, p. 178.

[245]Robert Mendelsohn, *The Greening of Global Warming* (Washington: American Enterprise Institute, 1999), p. 25. Mendelsohn's conclusions made in 1999 have not significantly changed as of 2004 (communication from Mendelsohn to authors, February 21, 2004).

ESTIMATED WARMING EFFECTS: YEAR 2100

Climate economist Robert Mendelsohn has estimated the economic impact of IPCC-predicted warming, precipitation, and sea level rise over the coming century for different regions of the world. The regions shown in green are expected to gain from climate change, while those in red will be hurt. These differences stem from each region's current climate and level of wealth. Areas that are currently the warmest will be hurt the most, and the poorest regions will be least able to adapt. Mendelsohn expects that globally, the costs and benefits will balance out. *Source:* Robert Mendelsohn. *The Greening of Global Warming,* p. 18. Reprinted by permission of Robert Mendelsohn.



Whatever the impact of global warming, wealthy nations will be better able to adapt than will poorer ones.

SOLUTIONS

A number of possible methods of dealing with climate change have been proposed. These fall into three main categories:

1. Prevention:
   - Reduce carbon dioxide emissions by producing and using energy more efficiently.[246]
   - Develop carbon-free energy sources such as nuclear power and renewables.

[246]Increased efficiency can be a "double-edged sword." As power generation efficiency increases, energy prices drop and consumption rises.

- Use zero-emission coal technology to extract hydrogen from water reacting with coal.[247] Capture and sequester any CO_2 produced in the process.[248]
- Remove carbon dioxide from plant flue gas emissions to make fertilizer, or to produce chemical products. The extracted CO_2 could also be injected into petroleum reservoirs to help increase oil production.
- Work to prevent soil erosion in order to keep carbon material sequestered.
- Switch to no-till agriculture, which can reduce soil erosion by as much as 98 percent.
- Change rice cultivation methods to reduce methane emissions.
- Reduce methane emissions by working to eliminate pipeline and drilling leaks.
- Use existing technology to prevent methane leaks from landfills.

2. Correction:
   - Expand *carbon sinks* (e.g., forests).
   - Remove CO_2 directly from the atmosphere.
   - Increase the amount of sulfates in the atmosphere (perhaps by adding sulfur to jet fuel in commercial airliners) to reflect sunlight.
3. Adaptation:
   - Increase world trade to improve the productivity and wealth of poorer nations so that they have the resources to deal with problems that may arise from a changing climate.
   - Build dikes and seawalls to block rising seawater.
   - Migrate from warmer to cooler climates.

People's self-interest will drive them toward solutions. For example, power companies are cutting costs by investing in new technologies and using natural gas instead of coal. Combined-cycle natural gas plants are more efficient than traditional oil- and coal-fired plants, and natural gas burns cleaner and produces less carbon dioxide (30 percent less than oil and 40 percent less than coal per unit of energy generated).

Between just the early eighties and nineties, the efficiency of new power plants increased by 50 percent. Government regulations could encourage, or at least not discourage, the construction of new plants. Consider, for instance, that 45 percent of the cost of New Mexico's San Juan coal-fired power plant

[247] Han-Joachim Ziock, Klaus Lackner, and Douglas Harrison, "Zero Emission Coal," E*nergy* 2000, pp. 268–274.

[248] Martin Hoffert, et al., "Advanced Technology Paths to Global Climate Stability," p. 983.

was spent in complying with environmental regulation.[249] Some economists have pointed out that less stringent regulations on the construction of new plants could actually result in a cleaner environment (and fewer CO_2 emissions) by making it more likely that older, dirtier, and less efficient plants get upgraded or replaced by newer (though less than perfectly clean) plants.

Refineries and other plants that are not normally in the power business can build *cogeneration* facilities that convert waste heat into electrical power. They can use this power themselves or sell it on the market.

Offices can cut power costs by using more efficient lighting (e.g., fluorescent rather than incandescent), and painting their buildings' roofs white to reflect heat (studies have shown that white roofs are significantly cooler than black ones, and can lower air conditioning costs by up to 40 percent).[250]

Some scientists and policy makers are urging the government to promote the use of nuclear power as a replacement for fossil fuels. Nuclear plants produce no carbon dioxide. In fact, it is estimated that the world's nuclear power plants save 550 million metric tons of carbon in the form of CO_2 from being released into the atmosphere each year.[251] As discussed in Chapter 2, however, atomic plants must confront serious waste disposal issues (both technical and political). Electric power from fusion may be a long-term solution, but it is probably decades away.[252]

Electricity can also be produced by such zero-or-low emission technologies as solar cells, wind turbines, tidal power, and geothermal generators, but each of these sources suffers from the limitations discussed in the second chapter.

Interest in using hydrogen as an automobile fuel has been growing. Hydrogen is very efficient and clean; burning it produces only water and some nitrogen oxides. However, hydrogen is very reactive and does not exist in a free state on Earth. Hydrogen is, therefore, not a primary energy source. It can be generated by water hydrolysis, a process that consumes a lot of electrical power. Hydrogen can also be extracted from hydrocarbon fuels. However, these processes generate less energy (in the form of hydrogen) and more CO_2 than would be produced by burning the hydrocarbons directly.[253] On the other hand, CO_2 produced at a central plant would be far more easily contained and sequestered than CO_2 emitted by thousands of individual gasoline-burning automobiles.

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[249]Christopher Flavin and Nicholas Lenssen, *Power Surge*, p. 67.

[250]John Emshwiller, "California's Shortages Rekindle its Efforts to Conserve Electricity," *The Wall Street Journal*, February 20, 2001, p. A1.

[251]*New Energy Technologies: A Policy Framework for Micronuclear Technology*, Baker Institute for Public Policy, Rice University, Houston, Texas, September 2001, p. 3.

[252]D. W. Ignat, "Nuclear Fusion" in John Zumerchik, ed., *Macmillan Encyclopedia of Energy*, vol. 2, p. 878.

[253]Martin Hoffert, et al., "Advanced Technology Paths to Global Climate Stability," p. 983.

Microbiologists are currently working with genetically engineered bacteria that can efficiently convert waste biomass into ethanol for fuel. From the standpoint of carbon dioxide emissions, there might appear to be little difference between burning alcohol and burning gasoline. However, burning gasoline releases new carbon dioxide into the atmosphere, while burning ethanol only puts back what was there before (that is, before it was removed from the atmosphere by the plants that produced the biomass products).

Telecommuting, or logging into work via computer rather than driving in by car, could reduce CO_2 emissions along with other pollutants. Computers can help in countless other ways as well, not least by enabling people to easily share information and ideas over the Internet.

An obvious way to help offset CO_2 emissions is to plant trees. One much debated paper has suggested that North America may already have enough trees to absorb all the carbon dioxide that the continent emits.[254] However, unless trees are harvested and their wood turned into relatively permanent objects (houses, furniture, etc.), the amount of carbon that our forests can absorb will reach equilibrium at some point. The CO_2 absorbed will be balanced by the amount given off by burning or decaying trees.

The 1990s policy of favoring wilderness areas over managed forests reduced the effectiveness of national parks in serving as carbon sinks. Managed forests can support many more trees per acre than can wildernesses, and trees in wilderness areas eventually decay or burn so that their carbon is ultimately returned to the atmosphere. The choice between the carbon sink capacity of managed forests and scenic, untouched wilderness is another difficult environmental trade-off.

The Kyoto Protocol is an attempt to limit CO_2 emissions through an international cap-and-trade scheme. Though finalized in 1997, not enough countries ratified the protocol to bring it into force. The agreement, which does not have the support of the United States, would obligate the 38 developed countries to reduce their aggregate GHG emissions by 5 percent from 1990 levels by 2008–2012. Under the agreement, the developing nations are not covered by mandatory, or even voluntary, measures.

The protocol got off to a slow start because it was perceived by many to be all pain and no gain. It has been calculated that if all the nations met their obligations under the protocol by 2050, the reduction in the amount of global warming would be 0.13°F (0.07°C), an amount impossible to detect given the

[254] S. Fan et al., "A Large Terrestrial Carbon Sink in North America Implied by Atmospheric and Oceanic Carbon Dioxide Data and Models," *Science*, October 16, 1998, p. 442.

natural temperature swings from year-to-year.[255] The cost of this insignificant gain would amount to trillions of dollars in resources.[256]

Even many of its supporters in the scientific community admit that the protocol would do little to halt global warming, but they still back the treaty as an important first step in the right direction. Critics point out, however, that adhering to the treaty would have a significant impact on many nations' economies. If the impact were severe enough, a second step could be politically impossible.

Worse, though, is the incalculable loss of those trillions of dollars worth of resources spent for so little benefit. If those resources were used instead to create real wealth, countries that are now poor would be better able to adapt to a changing climate. They could also be invested to develop technology capable of solving the problem far more cheaply and effectively.

Another danger of an international cap-and-trade plan like Kyoto is that it provides an incentive for dictators to retard the economic growth of their countries so that they can sell unused carbon emission credits to other nations. Money flowing from democracies to tyrannies in this manner would only serve to prop up corrupt and despotic regimes.

Often a country's motives in signing a treaty like Kyoto are not obvious. When the United States refused to ratify the Kyoto accord, Europeans expressed great moral outrage (despite the fact that only one European country, Romania, had ratified it at that time). However, Margaret Wallström, the environment commissioner of the European Union, tacitly admitted that one reason for the anger was that Europeans had hoped that the treaty would weaken American manufacturing.

"This is not a simple environmental issue," she stated. "This is about international relations, this is about [the] economy, about trying to create a level playing field for big businesses throughout the world. You have to understand what is at stake and why it is serious."[257]

Energy costs are much greater in Europe than in the United States largely because of substantially higher levels of taxation and regulation. As a result, American companies have a significant advantage over their European competitors. Kyoto would have disproportionately driven up energy costs in the United States and helped to reduce this advantage.[258]

When participants in such negotiations have "an ideological axe to grind or a financial stake in the outcome, or both,"[259] scientific objectivity is quickly lost. A solution that is politically acceptable may not be good for either the environment or the economy.

[255]T. M. L. Wigley, "The Kyoto Protocol: CO_2, CH_4 and Climate Implications, *Geophysical Research Letters*, July 1, 1998, pp. 2285–88.

[256]Bjørn Lomborg, *The Skeptical Environmentalist*, p. 304.

[257]Stephen Castle, "EU Sends Strong Warning to Bush Over Greenhouse Gas Emissions," *The Independent*, March 19, 2001, p. 14.

[258]Steven Hayward and Julie Majeres, *Index of Leading Environmental Indicators*, 6th ed. (San Francisco: Pacific Research Institute for Public Policy, 2001), p. 61.

[259]Brink Lindsey, *Against the Dead Hand*, p. 253.

Another proposed government-based solution is the imposition of a carbon tax. The purpose of such a tax would be three-fold:

1. Discourage the use of carbon-based fuels.
2. Encourage the use of alternative energy sources (both by raising the price of conventional fuels, and by providing government with the means to subsidize alternatives).
3. Provide funds for government energy research.

Some economists argue that a carbon tax would be more flexible and straightforward than Kyoto's cap-and-trade scheme. The main objections to such taxes are that they would drive consumers away from more efficient sources of fuel and towards less efficient (though government-approved) sources. Also, a tax of any kind shifts financial resources to the government and away from a private sector better equipped to develop new energy technology.

Most scientists have concentrated on controlling carbon dioxide as the solution to global warming. However, Richard Lindzen and James Hansen (two prominent scientists who are usually on opposite sides of the debate) have argued that a better approach, at least in the near term, may be to focus on more powerful, and more easily controlled, warming agents such as methane, soot, and chlorofluorocarbons.[260]

Carbon sequestration may also be a more viable method of reducing atmospheric CO_2 concentrations than reducing carbon emissions. A study published in *Science* found that large quantities of carbon could be captured at an estimated cost of $30 a ton, or about $13 per barrel of oil or $0.25 per gallon of gasoline. The author, Klaus Lackner, concluded, "Today's urgent need for substantive CO_2 emission reductions could be satisfied more cheaply by available sequestration technology than by an immediate transition to nuclear, wind, or solar energy. Further development of sequestration would assure plentiful, low-cost energy for the century, giving better alternatives ample time to mature."[261]

On the other hand, while the International Energy Agency agrees that "carbon sequestration and storage technologies hold out the long-term prospect of enabling fossil fuels to be burned without emitting carbon into the atmosphere," it cautions that "these technologies . . . are unlikely to be deployed on a large scale before 2030."[262]

The issue of population control often arises in discussions of global warming. By limiting the number of people, it is argued, resource consumption and

[260]Andrew Revkin, "Study Proposes New Strategy to Stem Global Warming," *New York Times*, August 19, 2000, p. A12; Richard Lindzen, "Scientists' Report Doesn't Support the Kyoto Treaty," *Wall Street Journal*, p. A22.

[261]Klaus Lackner, "A Guide to CO_2 Sequestration," *Science*, June 13, 2003, p. 1678.

[262]International Energy Agency, *World Energy Outlook*: 2002 (Paris: OECD/IEA, 2002), p. 31.

pollution will also be limited. It turns out, however, that population growth is already slowing for economic reasons. Contrary to what Thomas Malthus believed, people do not "breed like flies." Instead, in the case of procreation, as in other areas, people tend to act rationally given their circumstances.

In western countries, population growth has slowed or even halted because children are a net economic burden. In a high-tech society, children are not suitable as sources of labor but must be educated for many years before they become productive. By that time they are ready to leave home and start households of their own.

In developing countries, by contrast, little education is needed before children become proficient with the lower levels of technology available. Children in these countries are considered cheap labor and an economic asset. In addition, children provide for their elderly parents. Finally, child mortality rates are high in the Third World, and people tend to have additional children to ensure that at least some will survive to add to the family's income. Attempts by the West to reduce population growth in these countries are often resented by locals as attacks on their wealth.

As the Third World nations advance, however, people there will change their actions as incentives change. In fact, the world population growth rate has been declining since about 1970.[263]

Julian Simon's contrary view was that, "In the long run the most important economic effect of population size and growth is the contribution of additional people to our stock of useful knowledge. And this contribution is large enough in the long run to overcome all the costs of population growth."[264]

Whether a person is seen as a mind and pair of hands or as just another mouth to feed may depend on the society in which he or she lives. People in free-market societies are rewarded in proportion to what they produce, and, as a result, they produce far more than they consume. The guiding principle of socialism, on the other hand, is "from each according to his ability, to each according to his need." To the extent that this rule is actually followed, it creates incentives for people to demonstrate minimum ability and maximum need.

Some rather exotic methods of dealing with global warming have also been proposed. For example, the oceans near the equator could be fertilized with iron filings to promote the growth of plankton. When these billions of tiny plants die, they sink to the bottom of the ocean. There is little or no oxygen at the ocean floor, and plankton do not decay. The carbon that they took out of the atmosphere and incorporated in their bodies while they were alive remains locked up.

[263] Bureau of the Census, U.S. Department of Commerce, http://www.census.gov/ipc/www/worldpop.html

[264] Julian Simon, *The Ultimate Resource*, p. 196.

A problem with this idea is that mining and refining iron ore requires a lot of energy, and still more energy would be spent flying over the ocean to drop it. It is questionable whether the additional plankton engendered by this method would offset the CO_2 emitted in the production and delivery of the iron fertilizer.

When assessing the value of any proposal, it is important to look at the big picture (what economists call performing a *life-cycle analysis*). For instance, the federal government has proposed new efficiency standards for household appliances that could help reduce energy requirements (and therefore CO_2 emissions). This may seem to be a good idea at first glance. But will the energy savings over the life of an appliance offset the additional energy and resources needed to make it more efficient? Or even if there is a net benefit, could the resources expended on improving appliance efficiencies be spent to greater effect in other ways?

Scientists at Los Alamos National Laboratory have proposed what they claim is a cost-effective method for removing carbon dioxide directly from the atmosphere. Their process involves passing air over calcium oxide (quicklime), which combines with carbon dioxide in the air to form calcium carbonate (limestone). The limestone is then heated to yield pure CO_2 and quicklime. The quicklime is recycled back to the extractor, while the CO_2 can be injected into the ground.

"Geoengineering" techniques designed to block sunlight from entering the Earth's atmosphere may also offer a partial solution. As explained in an article in *Science*, such measures might include placing "layers of reflective sulfate aerosols in the upper atmosphere. . ., injecting sub-micrometer dust into the stratosphere. . ., increasing cloud cover by seeding," and placing huge (2000 km diameter) mirrors in space to block the sun's radiation. [265]

The possibility of such future technology leads to an important question: Should we attempt to mitigate global warming now or wait until we understand the potential problem more clearly and have better (and as yet unimagined) technology to handle it?

NASA has offered what is, perhaps, the most novel solution to global warming yet proposed—move the Earth to a higher orbit, farther from the sun. According to the plan's authors, Greg Laughlin, Don Korycansky, and Fred Adams of NASA's Ames Research Center, it is all basic physics. Simply locate a suitable asteroid, attach a rocket to it, fire the rocket at just the right time to alter its course, and sling it by the Earth so that its gravitational force drags our planet into a higher orbit.

[265] Martin Hoffert, et al., "Advanced Technology Paths to Global Climate Stability," p. 986.

There are several possible downsides to their plan, however. The first is that a miscalculation could send the asteroid crashing into the Earth. Another is that if the plan works, the moon could be left behind. Also, with the Earth at a higher orbit, a year (the time it takes the planet to travel around the sun) would be longer. The loss of the moon and a longer year would each have significant impacts on global climate.

Actually, the scientists proposed the plan as a solution to the ultimate global warming problem. Our sun is gradually brightening, and in about a billion years it will be hot enough to kill off all life on Earth if the planet stays in its current orbit.[266]

TRADE-OFFS

Normally, the most environmentally friendly technology is also the most efficient, and people will tend to move to such technologies of their own accord. Yet this is not always the case. While it is clearly much more efficient to strip mine coal by simply removing the overburden and digging out the coal, this technique leads to erosion that fills rivers and lakes in the area with silt and heavy metals. Government regulations, therefore, now require coal companies to scrape off and preserve the topsoil before the rest of the overburden is removed. After the coal has been extracted, the overburden is replaced and contoured. Next, the topsoil is restored and seeded to prevent erosion.

The benefit is that the land is preserved, as are lakes and rivers. At the same time, though, more resources must be expended to extract the same amount of coal. The result is an environmental trade off—one thing is given up to gain another.

Nowadays, coal ash need no longer be simply carted away and dumped. Instead it can be used in cement making. However, the ash can be used for this purpose only if its carbon content is very low; in other words, the coal must be thoroughly burned. Such complete burning requires higher temperatures, which increases power plant efficiency but also produces more nitrogen oxide emissions.

Such trade-offs can be wrenching. Many environmentalists have worked hard to save natural wetlands, yet wetlands are significant sources of methane, a greenhouse gas.

Similarly, support is growing for the practice of organic farming, which eliminates the use of pesticides and fertilizers. Banishing these chemicals from agriculture, however, would reduce the amount of food that can be grown on an acre of land. In order to switch to organic farming, then, more land must be put to the plow. This means cutting down forests that remove carbon from the atmosphere.

[266] Frederic Golden, "How Long Will We Be Around?," *Time*, June 25, 2001, p. 53.

European environmentalists generally suport the diesel engine as a viable alternative to the gasoline engine because of its greater efficiency and lower greenhouse gas emissions. Several diesel passenger-vehicle models already on the road get more than 60 miles per gallon. Moreover, the infrastructure needed to supply diesel fuel to consumers is already in place. Many environmentalists in America, however, oppose a switch to diesel engines because they emit more NO_x and soot particles than do gasoline engines. Soot in the atmosphere has a net warming effect, and may more than offset any gains from reduced CO_2 emissions.

What about Poorer Countries?

Some have suggested that, because the industrial nations produce most of the anthropogenic CO_2, they have a moral obligation to help the world's poorer countries cope with the impact of enhanced global warming. Others reject this notion because, they argue, Asian rice paddies produce massive amounts of methane, a more powerful greenhouse gas than carbon dioxide. Also, they point out that the large populations in China and India are going to produce a tremendous amount of CO_2 in the future as they become more technologically advanced and their energy needs increase.[267] Such finger pointing is one reason that treaty negotiations are so difficult.

In any event, if the West chooses to help the poorer nations, it must decide how best to do it. In the past, foreign aid has usually come in the form of government-to-government payments or loans. All too often, the money has disappeared into useless public works or into private, offshore bank accounts. Worse, the money may prop up corrupt and repressive regimes that destroy people's freedom and confiscate the products of their labor.

The wealthier people are, the more they will be able to command the resources needed to deal with a warmer climate and rising sea levels. History teaches that the freer a people are, the wealthier they are. Rather than strengthening repressive governments, then, perhaps private property rights and open markets should be strengthened.

Built-in Biases

Understandably, global warming has become a very emotional issue for many people, and these emotions can make the job of finding the truth difficult. Further clouding the facts are the built-in biases that everyone has. Sometimes

[267]The U.S. Energy Information Administration estimates that combined China/India emissions will exceed those of the U.S. by the year 2020 [EIA, *International Energy Outlook* 2002 (Washington: Department of Energy, 2001), Table A10.

these biases depend upon personality types such as whether an individual is generally an optimist or a pessimist.

People's livelihoods also influence their attitudes. Neither oil producers nor coal miners want their products banned or restricted, and they would prefer that the global warming issue simply went away. On the other hand, if it turns out that global warming is not a problem, then many researchers will lose their government funding. Professional environmentalists need hot issues to garner contributions and keep themselves relevant. Journalists welcome global warming as a front-page issue on slow news days. They like crisis reporting and the bold headlines that go with it; negative stories sell more newspapers than do positive ones. People in government tend to like crises as well. Governments increase their power by offering solutions to problems, both real and imagined. The bigger the problem, the more people look to government institutions for answers.

That is not to say that everyone with a stake in the issue will consciously try to hide the truth or skew the data. But people often emphasize facts that support their own positions and either ignore or minimize information to the contrary.

Whether it is decided that global warming is or is not a problem, the decision must be based on good science and economics, and not emotion. Actions must be well thought out; good intentions are not enough. Too many people can be hurt if bad policies are adopted. As even energy critic Paul Ehrlich said, "Taking action on the basis of worst-case prognoses would . . . be inappropriate and costly; suddenly imposing fuel rationing and high taxes on industrial activity with no tangible justification would cause economic disruption and most likely would backfire."[268]

> "*Action is most effective when it is driven by passion but directed by reason.*"
>
> ***The authors***

WHERE DOES ALL THIS LEAVE US?

Thus far, neither the computer models nor the actual data have provided a clear and definitive picture of the trends in the Earth's climate. Scientists are still arguing about how serious a problem enhanced global warming is and even if there is a *greenhouse signal* apart from natural variability. If the experts cannot agree, how are laymen to decide the truth? The fact is that we just do not know yet what the truth is, and much more research is needed before we can know.

In the meantime, some environmentalists argue that the *precautionary principle* requires that we act now even though we lack scientific certainty as to

[268]Paul Ehrlich and Anne Ehrlich, *Betrayal of Science and Reason*, p. 31.

whether, or to what degree, human activity has enhanced global warming, how much it will affect future climate, or, more importantly, what impact it will have.[269] The precautionary principle has been defined in a number of ways, ranging from Principle 15 of the United Nations' Rio Declaration (1992):

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

to the more radical Wingspread Declaration (1999):

> When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not established scientifically. In this context the proponent of the activity, rather than the public, should bear the burden of proof.

Critics point out that the principle must be applied in a balanced way; that is, it should be applied not only to the activity that environmentalists want regulated, but also to the regulations themselves. Government intervention can make a problem worse[270] or can create problems where none existed before. As pointed out in a study by the National Academy of Sciences, "Errors of doing too much can be as consequential as errors of doing too little; the error of trying to solve the wrong problem is as likely as the error of failing to act."[271]

Indur Goklany, an American representative to the IPCC and chief of the Technical Assessment Division of the National Commission on Air Quality, has proposed the following climate-change policies as being consistent with a balanced application of the precautionary principle.[272] Note that Goklany takes into consideration the impact on both public health and the environment.

1. Avoid government mandated greenhouse gas emission restrictions in the next few decades. In the absence of such mandates, individuals, businesses and other institutions would, in any case, undertake no-regret actions which, by definition, would pay for themselves even

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[269]Indur Goklany, "Potential Consequences of Increasing Atmospheric CO_2 Concentration Compared to Other Environmental Problems," *Technology*, vol. 7, Supplement (2000), pp. 189–213.

[270]Remember President Jimmy Carter's *Powerplant and Industrial Fuel Use Act of* 1978, which was intended to save natural gas, but resulted in increased coal power plant construction and with it more pollution and CO_2 emissions.

[271]National Academy of Sciences, et al., *Policy Implications of Greenhouse Warming*, p. 194.

[272]Indur Goklany, *The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment* (Washington: Cato Institute, 2001), pp. 86–88.

in the absence of any climate change. Mandating controls that would necessarily have to go beyond no-regret actions to be meaningful, will likely slow worldwide economic growth leading to more hunger, worse health, and higher mortality rates, especially in the Third World.

2. Avoid artificially raising oil and gas prices. Higher prices would slow the switch from dirtier fuels such as wood, coal, and animal dung. Higher energy costs would also increase the costs of food production and reduce crop yields. Lower crop yields would, in turn, lead to increased land conversion and loss of habitat, which, in turn, would only add to CO_2 emissions.
3. Work to solve problems, such as malaria and malnutrition, which are urgent today and may be aggravated by global warming.
4. Eliminate policies (such as subsidies for the exploitation of energy and other natural resources) that contribute to increased production of greenhouse gases.
5. Increase agricultural productivity to expand food production while at the same time reducing the amount of land under cultivation. This would increase natural habitat and decrease soil erosion and the associated loss of carbon sinks.
6. Increase people's ability to adapt to environmental change by promoting technological progress, trade, and economic growth through the institutions of free markets, secure property rights, and honest government.
7. Continue researching the science and economics of climate change. Such research should include preventative and corrective measures for dealing with greenhouse gases and global warming as well as ways to adapt to a changing climate in the event that there are problems.

Goklany's first point—the avoidance of near-term government-mandated emission reductions—is very important. As discussed, many ways of dealing with greenhouse gases have already been proposed. Many other methods will be developed in the future as we learn more. Money spent on ineffective solutions now cannot be spent on things that will actually make a difference. Worse, measures that harm the economy now will reduce the resources that will be available in the future when there will be a better understanding of the problem and of how to deal with it.

Unfortunately, most government initiatives have zeroed in on one very expensive and very ineffective solution—compulsory CO_2 emission reductions. The Kyoto Treaty and various U.S. House and Senate proposals would impose caps on CO_2 emissions at very high cost for virtually no benefit in terms of reductions in the impacts of climate change or in terms of advancing human or environmental welfare.[273]

If anthropogenic global warming proves to be a problem, then we must keep our eyes on the goal—the reduction or reversal of the effects of such warming. To achieve this goal efficiently and effectively in the long run, we should examine a combination of measures that would (a) reduce emissions to slow down temperature change, (b) remove greenhouse gases from the atmosphere, and (c) help societies cope with the negative impacts of climate change.

While establishing this goal may be a legitimate function of government, it will be counterproductive for government to dictate a one-size-fits-all solution. Reducing average global temperature will be a titanic undertaking, and, if it must be done, it must be done as efficiently as possible. Trying to handle such a vast challenge inefficiently will generate pollution, waste resources, perpetuate poverty, and engender public anger.

Only market forces can marshal the incredible creativity needed to tackle such an undertaking. The solutions may include planting trees, changing farming methods, managing forests differently, using alternative fuels, improving emissions controls, and employing technology that we cannot even imagine today. Whatever the answers, they can only come from unshackled, inventive minds and from a dynamic marketplace, free to employ resources to their best effect.

> “*Perhaps the most important aspect of [global warming] . . . is that we now have ever-increasing capacities to reverse such trends if necessary. And we can do so at costs that are manageable rather than being an insuperable constraint upon growth or an ultimate limit upon the increase of productive output or of population.*”[274]
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> ***Julian Simon—American professor of business administration***

[273]Goklany, *The Precautionary Principle*, p. 67.

[274]Julian Simon, “Introduction,” in Simon, ed., *The State of Humanity* (Cambridge, MA: Blackwell, 1995), p. 18.