Global Warming: A Response

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The Summer/Fall 1993 ILLINOIS REAL ESTATE LETTER carried Edward Krug's article "Global Warming: Could We Be So Lucky?" In the article, Dr. Krug (who does not believe the planet is undergoing man-made global warming) accepts, for argument's sake, opposing scientists' view that the world is getting warmer because of human activities, and he offers evidence that such warming would generally benefit mankind. The article has produced many comments from readers, and we have received materials both from supporters and from opponents of the Krug view. Among materials supporting Krug:

- *an article citing University of Alabama findings that greenhouse theories have predicted substantially greater temperature increases than have been observed;*
- *a published academic study concluding that high carbon dioxide readings in the polar ice caps (alleged evidence of global warming) reflect measurement errors;*
- *a report of evidence from Harvard-Smithsonian research that solar activity, rather than man-made gases, has been responsible for climate changes;*
- *a report of a study showing no climate-induced changes in the thickness of ice in the Arctic; and*
- *a news story on a U.S. Senate Energy and Natural Resources Committee hearing, at which a meteorologist from MIT testified that global warming models are based on assumptions that cannot be scientifically supported.*

University of Illinois climatologist Michael Schlesinger, however, expressed many reservations and concerns regarding Krug's work. ILLINOIS REAL ESTATE LETTER invited Dr. Schlesinger to refute specific statements offered in the earlier article, or to criticize the author's conclusions or any of the references on which those conclusions were based. Dr. Schlesinger suggested, as an alternative, the following article that offers his views on the global warming issue. The work is condensed from "Greenhouse Policy," written by Schlesinger for NATIONAL GEOGRAPHIC RESEARCH & EXPLORATION magazine (Spring 1993).

There is disagreement among scientists regarding global climate change. One camp urges a "precautionary" policy of immediate action to reduce emissions of carbon dioxide and other "greenhouse" gases, in order to prevent a concentration of these gases from inducing climate change. An opposing view urges a "wait-and-see" policy, based on the belief that the effect of greenhouse gases is uncertain while the economic consequences of reducing these gases would certainly be adverse. While I applaud the openness of the debate, I am troubled by the "all-or-nothing" responses. Accordingly, I have examined several issues to determine how quickly and intensively we must respond to the global warming threat.

The Greenhouse Effect

The one aspect of the global warming issue about which there is no doubt is that concentrations of greenhouse gases have increased, and continue to do so. At the time our country began fighting for its independence, 279 parts per million of the air that a person breathed consisted of carbon dioxide. A century later the concentration had increased to 290 parts per million, and 100 years later, by the early 1970s, it had risen to 326 parts per million. In the two most recent decades, the concentration has risen to 355 parts per million. The equivalent carbon dioxide concentration of all greenhouse gases (including chlorofluorocarbons) in the air rose from 279 to 404 parts per million between 1765 and 1990.

Higher greenhouse gas concentrations began in the middle of the 18th century, when industrial activity was fueled by coal and oil. Another cause has been deforestation. Projections of future greenhouse gas concentrations therefore rest on the degree to which the causal activities continue, and on expected population growth and per-capita energy use. If observed trends in these activities were to continue, the air could contain 1533 parts per million of equivalent carbon dioxide by the year 2100. Should we view this 0.15% of the earth's atmosphere as a non-negligible amount of greenhouse gases?

Our first step in answering this question is to note that the earth, with its current atmosphere, has an average surface temperature of approximately 59^{o} F. If the atmosphere consisted only of nitrogen and oxygen (which together constitute 99% of our current air), the average surface temperature would be approximately 0^{o} F, the level that would also prevail if there were no atmosphere at all. Thus, the two other components of the atmosphere, water vapor and carbon dioxide, hold the surface temperature at its 59^{o} average. A small amount of water and carbon dioxide can achieve this effect, while enormous amounts of nitrogen and oxygen cannot, because water (H_2O) and carbon dioxide (CO_2) have three atoms per molecule, while nitrogen (N_2) and oxygen (O_2) have only two atoms per molecule.

Molecular structure (along with some quantum mechanics) therefore explains why water vapor and carbon dioxide are greenhouse gases. They can absorb radiation emitted by the earth's surface, whereas nitrogen and oxygen cannot, and they reradiate this energy to outer space from a temperature colder than the earth's surface temperature. Hence, in order for there to be a balance between absorbed and reradiated radiation, the surface temperature must rise to a level higher than it would be if there were no greenhouse gases in the atmosphere.

Climate Modeling and Simulation

How much will the surface temperature increase for a particular increase in the concentration of greenhouse gases? To understand how scientists attempt to answer this question, we must understand climate modeling. Because climate is too complex to be miniaturized and studied under controlled laboratory conditions, climate changes have been estimated with computer models based on the fundamental laws of nature.

There are many types of climate models, but only the general circulation model (GCM) allows for the consider-

ation of temperature, wind, water vapor, clouds, precipitation, soil moisture, soil and water temperatures, evaporation, ocean currents, and ocean salinity. Because of the complexities of climate, we must make simplifying assumptions. (It has been estimated that a highly accurate simulation would require more than thirty years to compute, even on today's supercomputers!) For example, the earth's climate system is affected in important ways by physical processes that cover horizontal distances ranging from 40,000 kilometers down to one ten-billionth of a kilometer, but a GCM includes a physical process only if it covers a distance of at least 500 kilometers. Because the effects of processes involving smaller areas cannot be ignored, researchers must use a technique called *parameterization*, in which they treat such small-scale processes as cloud formation and precipitation using only the much larger-scale information that is available.

Climatologists have run GCM simulations to determine the equilibrium climate that the earth would attain under various atmospheric conditions. A key point of interest is the change in global mean surface-air temperature that would occur if the carbon dioxide concentration were to double from its current level. GCM results from a number of research organizations, including the University of Illinois, indicate that the global average temperature would rise by 2.7° to 8.1° F.

Projections of Global Warming Induced by Greenhouse Gases

Former student Xingjian Jiang and I used a model much simpler than a GCM to project global warming under different projections regarding mankind's use of fossil fuels. If we assume that future use will follow recent trends, we obtain estimates of increased average surface temperatures that range to almost 13° F, truly a catastrophic result. Curtailing our use of fossil fuels reduces the severity of any rise in average temperatures; the degree of abatement depends on the extent to which average temperature rises with increased carbon dioxide concentrations (a measure that we do not know with certainty).

Must we begin immediately to take measures to reduce global warming? Jiang and I investigated this question under three possible scenarios: an unchanged level of fossil fuel usage, a prompt transition (taking place over 20 years) away from fossil fuels, and a transition that would not begin for a decade. We concluded that, while movement away from fossil fuels is essential in reducing greenhouse gases, the additional temperature change incurred as a result of delaying the transition for ten years would be small.

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One issue of concern must be that of costs. We recognize that any change from current practices is costly, but such costs must be balanced against costs of climate damage. If the climate were not harmed by greenhouse gases, then it would be cost-effective to allow carbon dioxide emissions to continue unabated until well into the next century, when oil and gas reserves are depleted. Our own results and the findings of other researchers have led us to conclude, however, that an optimal policy would call for emissions growth to be slightly curtailed relative to the pattern that had been observed through 1990. An ecological policy of stabilizing climate would be prohibitive; one analyst has estimated the discounted cost at $30 trillion. Research substantiates the view that overall costs will be affected by the degree to which we can reduce fossil fuel use, the speed with which we convert to alternative fuels, and the magnitude of the average temperature increase that we are willing to accept.

Conclusions and Recommendations

From my analysis of available information, I have drawn the following conclusions. First, the question of whether to aggressively reduce fossil fuel use is less important than the question on the amount of damage that will likely result from climate change. Second, we will not make a once-and-for-all decision now about future greenhouse policy, but instead will make a sequence of increasingly informed future decisions. Third, if we learn that the damage cost of climate change is high, then the most cost-effective temperature change will be low, and global policies on reducing fossil fuel use will gain in importance. Finally, our ability to control the temperature increase will depend largely on our longer-term ability to switch to non-fossil fuels, particularly in the developing world.

What, in this light, should be done about the threat of global warming? First, we must conduct research to reduce the uncertainty regarding climate sensitivity and the damage costs of climate changes induced by greenhouse gases. We must also take advantage of the knowledge and technology that we do have in making more efficient use of fossil fuels. In addition, we must recognize that some nations have not yet begun to use fuel technologies that are already antiquated in the more developed world; we must assist developing areas in leap-frogging to more efficient methods, including renewable energy sources.

Finally, if continuing research shows that greenhouse gases will cause severe climate changes, then we may have to curtail fossil fuel use long before such action would be necessitated by depleted supplies. The attendant problems would be daunting; will our progeny have to rely heavily on nuclear energy and face the accompanying environmental and security side effects? We do not know the answers to these questions today. Consequently, rather than squabbling about near-term policies, the effects of whose differences are only minor, we should focus on long-term major issues of providing energy worldwide. ■

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