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Carbon Output Must Near Zero To Avert Danger, New Studies Say

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The task of cutting greenhouse gas emissions enough to avert a dangerous rise in global temperatures may be far more difficult than previous research suggested, say scientists who have just published studies indicating that it would require the world to cease carbon emissions altogether within a matter of decades.

Their findings, published in separate journals over the past few weeks, suggest that both industrialized and developing nations must wean themselves off fossil fuels by as early as mid-century in order to prevent warming that could change precipitation patterns and dry up sources of water worldwide.

Using advanced computer models to factor in deep-sea warming and other aspects of the carbon cycle that naturally creates and removes carbon dioxide (CO₂), the scientists, from countries including the United States, [Canada](#) and [Germany](#), are delivering a simple message: The world must bring carbon emissions down to near zero to keep temperatures from rising further.

"The question is, what if we don't want the Earth to warm anymore?" asked Carnegie Institution senior scientist Ken Caldeira, co-author of a paper published last week in the journal *Geophysical Research Letters*. "The answer implies a much more radical change to our energy system than people are thinking about."

Although many nations have been pledging steps to curb emissions for nearly a decade, the world's output of carbon from human activities totals about 10 billion tons a year and has been steadily rising.

For now, at least, a goal of zero emissions appears well beyond the reach of politicians here and abroad. U.S. leaders are just beginning to grapple with setting any mandatory limit on greenhouse gases. The Senate is poised to vote in June on legislation that would reduce U.S. emissions by 70 percent by 2050; the two Democratic senators running for president, [Hillary Rodham Clinton](#) (N.Y.) and [Barack Obama](#) (Ill.), back an 80 percent cut. The Republican presidential nominee, [Sen. John McCain](#) (Ariz.), supports a 60 percent reduction by mid-century.

[Sen. Barbara Boxer](#) (D-Calif.), who is shepherding climate legislation through the Senate as chairman of



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the Environment and Public Works Committee, said the new findings "make it clear we must act now to address global warming."

"It won't be easy, given the makeup of the Senate, but the science is compelling," she said. "It is hard for me to see how my colleagues can duck this issue and live with themselves."

[James L. Connaughton](#), who chairs the White House Council on Environmental Quality, offered a more guarded reaction, saying the idea that "ultimately you need to get to net-zero emissions" is "something we've heard before." When it comes to tackling such a daunting environmental and technological problem, he added: "We've done this kind of thing before. We will do it again. It will just take a sufficient amount of time."

Until now, scientists and policymakers have generally described the problem in terms of halting the buildup of carbon in the atmosphere. The United Nations' Framework Convention on Climate Change framed the question that way two decades ago, and many experts talk of limiting CO₂ concentrations to 450 parts per million (ppm).

But Caldeira and [Oregon State University](#) professor Andreas Schmittner now argue that it makes more sense to focus on a temperature threshold as a better marker of when the planet will experience severe climate disruptions. The Earth has already warmed by 0.76 degrees Celsius (nearly 1.4 degrees Fahrenheit) above pre-industrial levels. Most scientists warn that a temperature rise of 2 degrees Celsius (3.6 degrees Fahrenheit) could have serious consequences.

Schmittner, lead author of a Feb. 14 article in the journal *Global Biogeochemical Cycles*, said his modeling indicates that if global emissions continue on a "business as usual" path for the rest of the century, the Earth will warm by 7.2 degrees Fahrenheit by 2100. If emissions do not drop to zero until 2300, he calculated, the temperature rise at that point would be more than 15 degrees Fahrenheit.

"This is tremendous," Schmittner said. "I was struck by the fact that the warming continues much longer even after emissions have declined. . . . Our actions right now will have consequences for many, many generations. Not just for a hundred years, but thousands of years."

While natural cycles remove roughly half of human-emitted carbon dioxide from the atmosphere within a hundred years, a significant portion persists for thousands of years. Some of this carbon triggers deep-sea warming, which keeps raising the global average temperature even after emissions halt.

Researchers have predicted for a long time that warming will persist even after the world's carbon emissions start to fall and that countries will have to dramatically curb their carbon output in order to avert severe climate change. Last year's report of the [U.N. Intergovernmental Panel on Climate Change](#) said industrialized nations would have to cut emissions 80 to 95 percent by 2050 to limit CO₂ concentrations to the 450 ppm goal, and the world as a whole would have to reduce emissions by 50 to 80 percent.

European Union Environment Commissioner Stavros Dimas, in Washington last week for meetings with administration officials, said he and his colleagues are operating on the assumption that developed nations must cut emissions 60 to 80 percent by mid-century, with an overall global reduction of 50 percent. "If that is not enough, common sense is that we would not let the planet be destroyed," he said.

The two new studies outline the challenge in greater detail, and on a longer time scale, than many earlier studies. Schmittner's study, for example, projects how the Earth will warm for the next 2,000 years.

But some climate researchers who back major greenhouse gas reductions said it is unrealistic to expect policymakers to think in terms of such vast time scales.

"People aren't reducing emissions at all, let alone debating whether 88 percent or 99 percent is sufficient," said Gavin A. Schmidt, of NASA's Goddard Institute for Space Studies. "It's like you're starting off on a road trip from New York to [California](#), and before you even start, you're arguing about where you're going to park at the end."

Brian O'Neill of the National Center for Atmospheric Research emphasized that some uncertainties surround the strength of the natural carbon cycle and the dynamics of ocean warming, which in turn would affect the accuracy of Caldeira's modeling. "Neither of these are known precisely," he said.

Although computer models used by scientists to project changes in the climate have become increasingly powerful, scientists acknowledge that no model is a perfect reflection of the complex dynamics involved and how they will evolve with time.

Still, O'Neill said the modeling "helps clarify thinking about long-term policy goals. If we want to reduce warming to a certain level, there's a fixed amount of carbon we can put into the atmosphere. After that, we can't emit any more, at all."

Caldeira and his colleague, H. Damon Matthews, a geography professor at Concordia University in Montreal, emphasized this point in their paper, concluding that "each unit of CO₂ emissions must be viewed as leading to quantifiable and essentially permanent climate change on centennial timescales."

Steve Gardiner, a philosophy professor at the [University of Washington](#) who studies climate change, said the studies highlight that the argument over global warming "is a classic inter-generational debate, where the short-term benefits of emitting carbon accrue mainly to us and where the dangers of them are largely put off until future generations."

When it comes to deciding how drastically to reduce greenhouse gas emissions, O'Neill said, "in the end, this is a value judgment, it's not a scientific question." The idea of shifting to a carbon-free society, he added, "appears to be technically feasible. The question is whether it's politically feasible or economically feasible."

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