

Reconciling Paris Agreement goals for temperature, emissions—study finds two targets don't always go hand in hand

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As society faces the challenge of limiting warming to no more than 2 degrees Celsius, new research finds an apparent contradiction: Achieving that goal doesn't necessarily require cutting greenhouse gas emissions to zero, as called for in the Paris Agreement. But under certain conditions, even zero emissions might not be enough.

The Paris Agreement, a global effort to respond to the threats of human-caused climate change, stipulates that warming be limited to between 1.5 degrees C (2.7 degrees Fahrenheit) and 2 degrees C (3.6 degrees F). It also stipulates that countries achieve net-zero [greenhouse gas emissions](#) in the second half of this century. But the relationship between the two—is the emissions goal sufficient or even necessary to meet the [temperature](#) goal?—has not been well understood.

In a new study published in the journal *Nature Climate Change*, scientists used a computer model to analyze a variety of possible future scenarios to better understand how emissions reductions and temperature targets are connected. The study, published March 26, was led by Katsumasa Tanaka at the National Institute for Environmental Studies in Japan and co-authored by Brian O'Neill at the U.S. National Center for Atmospheric Research.

"What we found is that the two goals do not always go hand in hand," Tanaka said. "If we meet temperature targets without first overshooting them, we don't have to reduce greenhouse gas emissions to zero. But if we do reduce emissions to zero, we still might not meet the temperature targets if we don't reduce emissions quickly enough."

The team also found that whether temperatures overshoot the [target](#) temporarily has a critical impact on the scale of emissions reductions needed.

"If we overshoot the temperature target, we do have to reduce emissions to zero. But that won't be enough," Tanaka said. "We'll have to go further and make emissions significantly negative to bring temperatures back down to the target by the end of the century."

The research was supported by the Environment Research and Technology Development Fund (2-1702) of the Environmental

Restoration and Conservation Agency in Japan and by the U.S. National Science Foundation, NCAR's sponsor.

Drafted in 2015, the Paris Agreement has been ratified by more than 170 countries. President Donald Trump announced last year the intention to withdraw the United States from the agreement.

Modeling the problem from both sides

For the study, the researchers used a simplified integrated assessment model that takes into account the physical connections between greenhouse gases and global mean temperature in the climate as well as the economic costs of emissions reductions.

"We investigated the consistency between the Paris targets in two ways. First we asked, what happens if you just meet the temperature target in a least-cost way? What would emissions look like?" said O'Neill, an NCAR senior scientist. "Then we said, let's just meet the emissions goal and see what kind of temperatures you get."

The team generated 10 different scenarios. They found that Earth's warming could be stabilized at 1.5 or 2 degrees C—without overshooting the goal—by drastically cutting emissions in the short term. For example, total greenhouse gas emissions would need to be slashed by about 80 percent by 2033 to hit the 1.5-degree target or by about two-thirds by 2060 to meet the 2-degree target. In both these cases, emissions could then flatten out without ever falling to zero.

Due to the difficulty of making such steep cuts, the scientists also looked at scenarios in which the temperature was allowed to temporarily overshoot the targets, returning to 1.5 or 2 degrees by the end of the century. In the 1.5-degree overshoot scenario, emissions fall to zero by 2070 and then stay negative for the rest of the century. (Negative

emissions require activities that draw down carbon dioxide from the atmosphere.) For the 2-degree temporary overshoot scenario, emissions fall to zero in 2085 and also become negative, but for a shorter period of time.

On the flip side, the scientists also looked at scenarios where they set the emissions levels instead of the temperature. In those cases, they analyzed what would happen if emissions were reduced to zero around mid-century (2060) or at the end of the century (2100). In the first case, the global temperature peaked around the 2-degree target and then declined. But in the second case, the temperature rose above 2 degrees around 2043 and stayed there for a century or more.

"The timing of when emissions are reduced really matters," O'Neill said. "We could meet the goal set out in the Paris Agreement of reducing emissions to zero in the second half of the century and still wildly miss the temperature targets in the same agreement if we wait to take action."

The new study is part of a growing body of research that seeks to better understand and define what it will take to comply with the Paris Agreement. For example, another recent study—led by Tom Wigley, a climate scientist at the University of Adelaide who holds an honorary appointment at NCAR—also looks at the quantity and timing of emissions cuts needed to stabilize global temperature rise at 1.5 or 2 degrees above preindustrial levels. This work focuses in particular on implications for emissions of carbon dioxide, the main component of the broader greenhouse gas emissions category that makes up the Paris emissions target.

O'Neill and Tanaka believe their work might be useful as countries begin to report the progress they've made reducing their emissions and adjust their goals. These periods of reporting and readjusting, known as global stocktakes, are formalized as part of the Paris Agreement and occur

every five years.

"Our study and others may help provide countries with a clearer understanding of what work needs to be done to meet the goals laid out in the [agreement](#). We believe that the Paris Agreement needs this level of scientific interpretation," Tanaka said.

More information: The Paris Agreement zero-emissions goal is not always consistent with the 1.5 °C and 2 °C temperature targets, *Nature Climate Change* (2018).

[nature.com/articles/doi:10.1038/s41558-018-0097-x](https://doi.org/10.1038/s41558-018-0097-x)

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