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Climate Change: What Are Net-Zero Emissions?

“Net-zero emissions” refers to a situation in which human-caused greenhouse gas (GHG) emissions from sources such as fossil fuel combustion and deforestation are fully balanced by carbon dioxide removal (CDR) from the atmosphere. Methods of removal include natural absorption and storage in forests and other ecosystems as well as technological removal and storage.

When emissions of carbon dioxide (CO₂) are balanced by and equal to the removal of CO₂, the net addition of CO₂ to the atmosphere is equal to zero. This balance is referred to as *net-zero CO₂*. CO₂ is not the only GHG. Human-caused emissions of other GHGs—including methane (CH₄), nitrous oxide (N₂O), and hydrofluorocarbons (HFCs)—also increase global temperatures. The influence of GHGs on global temperatures is the combined effect of CO₂ and the other non-CO₂ GHGs. The combined influence of all GHGs may be determined by normalizing the global warming potentials of the GHGs to the global warming potential of carbon dioxide (CO₂). This results in a metric of carbon dioxide equivalent (CO₂e) to compare across GHGs.

Net-zero GHG means that the combined net emissions of all GHGs must be zero, accounting for the different warming effects of the various GHGs. For example, methane is a 27–30 times stronger GHG than CO₂, over a 100-year time horizon.

No commercially available method for removing non-CO₂ GHGs from the atmosphere exists. This means that to balance emissions of non-CO₂ GHGs that cannot be abated, additional removals of CO₂, by the use of CDR, would be needed. These removals are sometimes known as *negative emissions*. Net-zero GHG is achieved when CO₂e emissions of all GHGs are equal to CO₂e removals from the atmosphere through removals of CO₂.

Application of the Net-Zero Concept

The concept of net-zero emissions has found application in international and domestic climate change policy. Human-caused CO₂ emissions increase the levels of CO₂ in the atmosphere. Higher levels of CO₂ result in increases in global average temperature and a corresponding increase in global net negative effects. The Intergovernmental Panel on Climate Change (IPCC) has estimated that human activity since the Industrial Revolution has resulted in 1.07°C of warming compared with a preindustrial baseline temperature. The U.S. Global Change Research Program (USGCRP) stated, “With every additional degree of warming, the United States is expected to see increasingly adverse consequences.” There is broad scientific consensus that if society does not halt the accumulation of CO₂ in the atmosphere, global warming will continue and the risk of more severe climate impacts will increase.

Temperature Stabilization and Net-Zero

Global temperatures are generally not expected to stabilize until after GHG emissions are at net-zero. The sooner net-zero is attained, the smaller the temperature rise and climate impacts are likely to be.

Climate goals for global temperature stabilization have been set by international agreement under the Paris Agreement (PA). The PA is the second major subsidiary to the United Nations Framework Convention on Climate Change (UNFCCC), which the United States ratified. The temperature aims of the PA are stated as

[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.

Climate scientists use climate models to project the behavior of the earth’s climate under a range of potential human-driven emissions scenarios. Using climate models, researchers have estimated when net-zero GHG would need to be reached to achieve these PA climate goals. The IPCC Sixth Assessment Report and the USGCRP Fifth National Climate Assessment state that achieving net-zero CO₂ by 2050 and net-zero GHG later in the 21st century are consistent with limiting the increase in global temperatures to 1.5°C above the pre-industrial level. As models, methods, and emissions scenarios vary, there is a degree of uncertainty in these estimates.

Carbon Dioxide Removal and Hard-to-Abate Emissions

Most climate scientists do not consider the elimination of all human-caused GHG emissions feasible, in part because of the difficulty of fully eliminating emissions from the global economy. For example, in some industries, such as steel and cement, CO₂ emissions are particularly challenging to abate because they are generated during the chemical reactions of production.

Some scenarios of the IPCC and the USGCRP combine projected large reductions in emissions with human-mediated, long-term carbon dioxide removal. CDR methods include enhanced CO₂ removal on land by forests, crops, and soils; ocean-based removal in coastal areas (i.e., blue carbon) and the open ocean (e.g., iron fertilization); and mechanical removal by direct air capture. In the scenarios described above, GHG emissions are reduced to levels that can be balanced by human-mediated CDR, such that the net addition of GHGs to the atmosphere is zero. The scenarios in these reports estimate that net-zero GHG could be reached if human-mediated CDR is used to remove process emissions from industrial sectors that are too difficult, too expensive, or not currently possible to eliminate.

Net-Zero in Federal Policy

The net-zero concept appears in both enacted legislation and executive branch actions. Provisions in recent legislation funded emissions reductions activities, in some cases citing achieving net-zero GHG emissions in specific contexts. Executive orders from the Biden Administration have established a climate policy goal of reaching net-zero GHG emissions by 2050 through both emissions reductions and CDR. While many federal activities support emissions reductions and CDR, this document focuses on those in which net-zero is the stated policy.

The Inflation Reduction Act

In 2022, Congress passed P.L. 117-169, commonly known as the Inflation Reduction Act (IRA), which has two provisions using net-zero criteria:

- Section 50161. Advanced Industrial Facilities Deployment Program.** This section appropriates approximately \$5.8 billion in financial assistance to industrial or manufacturing facilities to help them adopt “advanced industrial technology at an eligible facility.” One of the criteria for receiving the assistance is the level of emissions reductions from an industrial or manufacturing facility. Industrial technologies that accelerate progress to net-zero through GHG emissions reductions are supported. The industries eligible for assistance include the steel, cement, and chemical industries, as well as other energy-intensive processes.
- Section 70006. FEMA Building Materials Program.** This section authorizes the Administrator of the Federal Emergency Management Agency (FEMA) to provide financial incentives for “net-zero energy projects.” A January 2024 FEMA memorandum describes the implementation of IRA Section 70006. Financial assistance must be tied to disaster recovery or mitigation, and applicants are encouraged to include net-zero aspects in such projects. Net-zero energy projects are to be funded on the same cost-share basis as other FEMA projects. Funding is available for projects with buildings that meet the energy performance and renewable generation standards of the International Energy Conservation Code for new construction and the International Green Construction Code for existing buildings. The combination of energy efficiency and the use of renewable energy in these standards is considered compliant with the FEMA specifications for a net-zero energy project.

Executive Actions

Executive actions on climate of the Biden Administration, including the Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050 and some executive orders, have included net-zero GHG as a policy component.

A key aspiration of the Biden Administration Long-Term Strategy is to achieve a 50%-52% GHG emission reduction by 2030 (compared with 2005 levels) and net-zero GHG by

2050. These goals are consistent with the PA to reduce the risks and impacts of climate change. The Long-Term Strategy includes scenarios that achieve these goals through a combination of emissions reductions and CDR. CO₂ removal by CDR methods accounts for between 10% and 20% of total net-zero GHG emissions reduction.

Several recent analyses from groups in the private sector, academia, and the federal government estimated U.S. net GHG emissions reductions projected through 2030 and found that these estimated emissions reductions would likely not reach the 50%-52% reduction goal.

President Biden has issued two executive orders that include net-zero provisions, listed below:

- Executive Order 14082 of September 12, 2022, Implementation of the Energy and Infrastructure Provisions of the Inflation Reduction Act of 2022. The order’s stated purpose is to “effectively implement” the IRA. This executive order directs certain federal agencies to, among other things, prioritize a set of climate goals for the United States. These climate goals set out in Section 2 of the order include reducing GHG emissions 50%–52% below 2005 levels by 2030, achieving a carbon pollution-free electricity sector by 2035, and achieving net-zero GHG emissions by 2050.
- Executive Order 14057 of December 8, 2021, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. This executive order states a policy for the federal government of leading by example to achieve economy-wide net-zero emissions by 2050, through the use of its scale and procurement power. The order directs the federal government to achieve a portfolio of net-zero energy buildings by 2045 and to achieve net-zero emissions in federal procurement, including the use of construction materials with lower embodied emissions, without specifying a target date.

Considerations for Congress

The 117th Congress passed legislation with emissions reductions and CDR provisions, including the IRA and the Infrastructure Investment and Jobs Act (P.L. 117-58). This legislation provided supplemental appropriations and tax incentives that support emissions reductions and CDR, components of achieving net-zero emissions. Recent analyses have estimated U.S. emissions reductions and CDR and found that the United States may not be on track to reach 50%-52% emissions reduction by 2030.

These estimates may play a role in whether Members of Congress consider enhanced oversight of federal climate policy and whether to take additional legislative action with respect to the climate goals.

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