ELEVATOR PITCH #2
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Uncertainty of Net-Zero Emissions Formulations

The way net-zero goals are defined has significant implications for the timing and achievability of global and national climate goals

Net-zero goals have become a commonly used climate policy pledge. Regardless of their popularity, there is no uniform definition of “net-zero”, leading to significant variability in how countries set their targets. The variation in these definitions can shift the timing of when net-zero is achieved by several decades, impacting the alignment of national targets with global climate objectives. Research from the ELEVATE project explores main factors that create this variability and what they mean for effective target setting.

Results show that:

- Some net-zero goals include only CO_2, others all greenhouse gases (GHGs). The difference is significant because achieving net-zero GHG is more ambitious than achieving net-zero CO_2 alone.
- Non-CO_2 emissions can be converted to CO_2 equivalents using the Global Warming Potential (GWP) metrics. Depending on the given time horizon, conversion may lead to a distortion of the distance between CO_2 and GHG targets.
- Delayed action and temperature overshoot determine the remaining carbon budget and negative emission requirements, influencing the timing of net-zero. Some countries rely heavily on negative emissions, but these technologies carry uncertainties and risks.
- For transparency and accuracy in formulating net-zero goals, countries should always disclose the emissions scope, the conversion metrics used, and the temperature goal it is contributing to.

ELEVATE supporting international climate policy

PBL Netherlands Environmental Assessment Agency

Various Net-Zero Formulations

Currently, there is no international agreement on how net-zero goals should be formulated. Without guidelines, countries use varying approaches[1], making direct comparison difficult. For instance, a key distinction is whether a target refers to net-zero CO_2 or net-zero greenhouse gas (GHG) emissions. Other factors influencing the timing of net-zero include conversion metrics, the temperature goal of the net-zero pledge, allowance for temperature overshoot, and reliance on negative emissions. Understanding these factors is critical to setting realistic and effective net-zero targets and policies[2].

Largest Influences on Net-Zero Timing

A major uncertainty in determining the alignment of the net-zero year with Paris Agreement goals is the range of temperature formulations. There are significant differences between scenarios that limit warming to well-below 2°C versus those limiting it to 1.5°C, and the possibility of overshoot plays a substantial role, as well. The IPCC scenarios in category C1 (limit warming to 1.5°C with low or limited overshoot), C2 (return warming to 1.5°C after overshoot), and C3 (limit warming to 2°C with a >67% chance) can all be consistent with the Paris Agreement. An ex-post analysis of net-zero goals considered different components: 1) emission scope, 2) conversion metrics, and 3) delayed action and net-negative emissions[2].

Emission Scope

The emission scope of net-zero goals specifies whether only CO_2 or all GHGs are included. Some countries exclude certain gases, while others do not have a clearly defined emissions scope. According to Wegh et al. (2023), including CH_4 and N_2O has significant impacts on the timing of net-zero GHG, while F-gases have a minor effect.

Figure 1 compares net-zero years for different temperature goals and emission scopes (CO_2 vs. GHG, excluding F-gases). The difference can be decades. For instance, in 1.5°C scenarios with low overshoot (C1), the difference between net-zero CO_2 and net-zero GHG is about 20 years. Therefore, comparing net-zero goals between countries requires accounting for these differences in scope.

Conversion Metrics

Conversion metrics, which compare GHGs by converting them into CO_2-equivalents (CO_2e), also strongly influence the timing of net-zero. Lower conversion values reduce the gap between net-zero GHG and net-zero CO_2, while higher values widen the gap, sometimes making net-zero GHG unachievable. Conversion metrics can also affect abatement costs if the price of non-CO_2 gases is linked to CO_2 prices[4].
Global Warming Potential (GWP) is the most

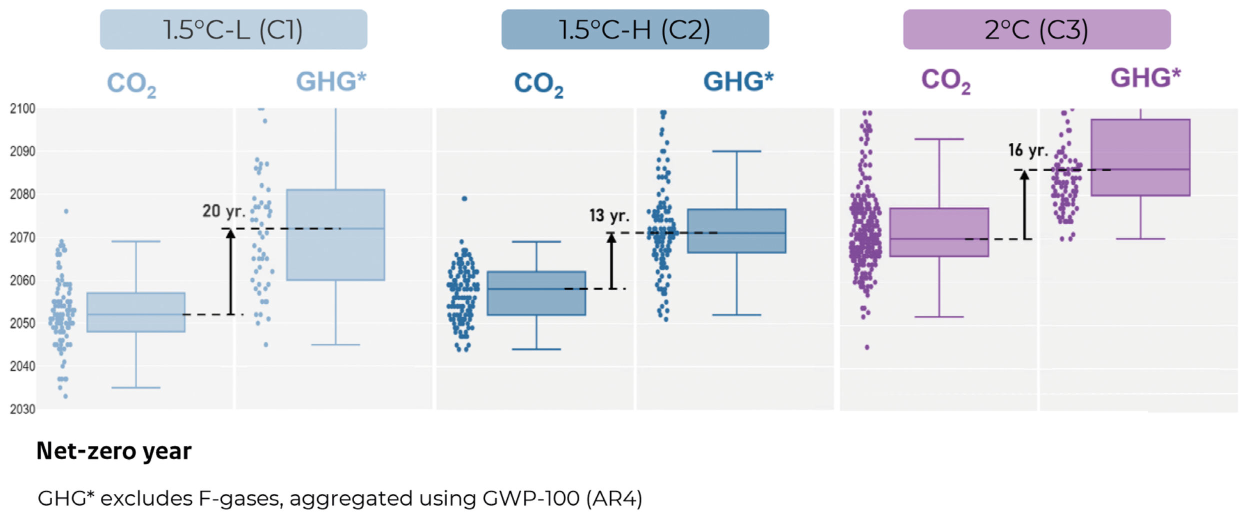

Figure 1: Net-zero CO_2 compared to net-zero GHG for scenarios with different temperature goals: C1 (1.5 °C-L), C2 (1.5 °C-H) and C3 (2 °C). Adapted from Wegh et al. (2023).

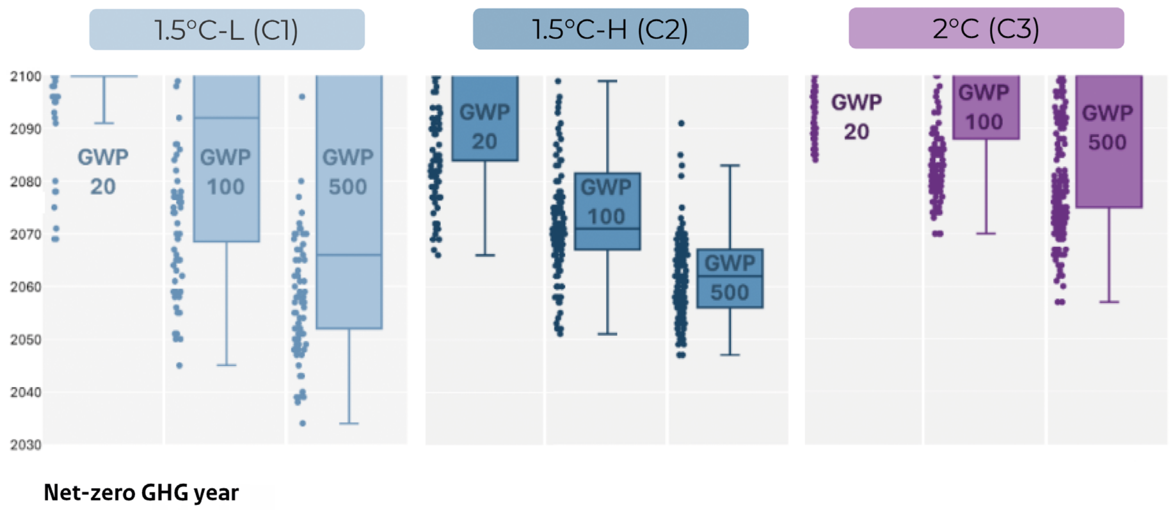

Figure 2: Timing of net-zero GHG for different GWPs (GWP-20, GWP-100 and GWP-500) for scenarios with different temperature goals: C1 (1.5 °C-L), C2 (1.5 °C-H) and C3 (2 °C). Adapted from Wegh et al. (2023).

commonly used conversion metric. Larger GWP values indicate a higher warming effect of a gas compared to CO_2 over a specific time period. Although many countries' net-zero goals do not specify which metric they use, GWPs from the IPCC's AR4 report are often applied[4]. Updated values from the IPCC's latest report differ only slightly. However, using GWPs over different timeframes (e.g., 20 years vs. 500 years) shows how these metrics affect net-zero. Shorter timeframes like GWP-20 emphasize short-lived gases, delaying net-zero GHG, while longer ones like GWP-500 prioritize long-term effects, advancing net-zero (Figure 2). GWP-100, a compromise, is most commonly used.

Delayed Action and Net-Negative Emissions

Delayed climate action can significantly impact the timing of net-zero. According to IPCC AR6[5], most 1.5°C and 2°C scenarios project emissions peaking between 2020 and 2025, followed by rapid and sustained transitions toward net-zero. CO_2 emissions need to drop by about 45% by 2030 (relative to 2010 levels) to have a likely chance of limiting warming to 1.5°C without overshoot. For 2°C, the reduction target is around 25%. Following current NDCs, emissions will need even faster reductions post-2030 to meet the Paris goals by 2100.

The relationship between net-negative emissions and net-zero year depends on temperature overshoot. If overshoot is limited, the timing of net-zero inversely correlates with the amount of net-negative emissions. Generally, delayed climate action means earlier net-zero emissions and more net-negative emissions are required for lower temperature goals.

Conclusion

The findings of this study are based on global-scale emissions, and the specific net-zero year will vary by country due to differing emissions profiles. However, these results provide guidance for formulating national net-zero goals and improving their transparency and accuracy by taking into account the outlined sensitivities.

References

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More information about the ELEVATE project: www.elevate-climate.org

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PBL Netherlands Environmental Assessment Agency

PBL Netherlands Environmental Assessment Agency is the national institute in the Netherlands for strategic policy analysis in the fields of environment, nature and spatial planning. PBL plays an important role in international assessment of global environmental change. The team involved in the Integrated Model to Assess the Global Environment (IMAGE) produces scenarios of climate policy and climate change in terms of energy and land use and emissions of greenhouse gases. The IMAGE team has been involved in several European research projects and plays a key role in the development of scenarios for climate change assessment. PBL researchers play an active role in various international assessments, including those of the Intergovernmental Panel on Climate Change (IPCC), UNEP's Global Environmental Outlook (GEO), and the Global Land Outlook. PBL is part of many relevant scientific networks, including the Integrated Assessment Modelling Consortium (IAMC), the Global Carbon Project (GCP) and the Energy Modelling Forum (EMF). The organisation has extensive experience on advising policymakers on climate policy, including the European Commission and the government of the Netherlands.