

<https://doi.org/10.1038/s43247-024-01535-z>

Science-based targets miss the mark

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Achieving the long-term temperature goal of the Paris Agreement relies on every actor maximising their effort to reduce emissions. Generic targets claiming a basis in science have been used to justify inequitable efforts that insufficiently stretch the ambition of the best-resourced countries and companies.

Science-based targets are proliferating not only in the corporate world, but national targets also often claim to reflect what science says is needed to limit warming to 1.5 °C. Such claims often rely on condensing diverse and complex scientific findings into simple and easily communicated benchmarks for corporate or national action towards global goals, such as reaching net-zero emissions by 2050. Typically, they cite the Intergovernmental Panel on Climate Change (IPCC) as the authoritative scientific source. Assertions of a basis in science aim to assure stakeholders, shareholders and the public that the level of ambition expressed by such targets is not the result of political contestation and moral judgements but is derived from objective scientific methods.

We argue that such a narrow conceptualisation of science to guide and justify targets for individual companies or countries is misleading. Simplistic use of global averages taken from IPCC reports, used out of context and generically applied to a broad diversity of individual actors, leads to inefficiency and inequity, higher emissions and more warming than intended. Indeed, such a generic approach is the very opposite of using science to inform actions consistent with the objectives of the Paris Agreement.

To address the multiple dimensions of equity associated with climate mitigation targets for individual actors such as companies or countries, social sciences and humanities need to become a core part of the science that informs target setting, including economics, political science, socio-technical transition theory and ethics. This requires embracing the wide range of actions that can contribute to the mitigation goals of the Paris Agreement, as opposed to hobbling acceptable actions by narrow and arbitrary decision-making rules.

Successive IPCC reports make clear that limiting global warming to well below 2 °C, let alone 1.5 °C, is possible only if each individual actor maximises their contribution towards reducing greenhouse gas emissions, wherever and in whichever way possible, with a secondary focus on removing carbon dioxide¹. Scientific studies offer a diverse and nuanced picture of how different companies and countries can do this, differentiated by sector, geography, history and capability. Shoehorning this diversity into a few generic methodologies may make target claims easier to quantify and communicate. However, targets derived from such approaches will not provide sufficient incentives to those with the highest capacity and responsibility to act.

We argue that the simple rules and benchmarks embedded in science-based targets must be opened up to allow and encourage more nuanced options and more diverse paths for action. We acknowledge that this carries

risks that each actor will pick the rules and justifications that minimise their individual obligations. However, we consider our proposed approach preferable to a rule-set that is stacked from the outset to underachieve the collective goal.

Three issues with current claims for science-based targets

The issues around current, allegedly science-based, targets can be summarised in three broad categories: basic misrepresentations of the global emission reductions of different greenhouse gases needed to limit warming to 1.5 °C; narrow, non-transparent and arbitrary rules to set benchmarks for emission reductions and rules for eligible offsets in corporate targets; and the reliance on global, regional and sectoral averages while excluding input from social science (apart from least-cost economics) and humanities to inform and justify emission targets of individual entities.

Basic misrepresentation. Our first concern is the surprisingly widespread confusion between net-zero emissions of *carbon dioxide* (CO₂) and net-zero emissions of the *full basket of greenhouse gases* covered under the Paris Agreement. The IPCC is clear that limiting warming to 1.5 °C by 2100 with no or a limited, temporary overshoot requires global human-caused CO₂ emissions to reach net zero around the early 2050 s, along with deep and sustained reductions in other greenhouse gases¹. Even in the most ambitious mitigation pathways, net zero greenhouse gas emissions (aggregated using the GWP100 metric) are not reached before about 2070, and some pathways that limit warming to 1.5 °C by 2100 do not reach net zero greenhouse gas emissions at all¹. Yet even the United-Nations-backed global campaign Race to Zero claims a need to “reach net zero greenhouse gases as soon as possible, and by 2050 at the latest, in line with the scientific consensus on the global effort needed to limit warming to 1.5 °C with no or limited overshoot”².

Referring to 2050 as the universal benchmark for net-zero emissions of all greenhouse gases rather than just carbon dioxide could be dismissed as a forgivable mistake that, after all, should further accelerate global emission reductions. However, the error points to deeper problems. One is that by adopting a simplistic catchphrase (“net zero by 2050!”) that is not grounded in global emission pathways, we make it much harder to use insights from those pathways to inform near-term emission reduction milestones or targets for individual entities with widely differing emission profiles. For sectors and countries where CO₂ emissions dominate and/or deep reductions of non-CO₂ emissions are technically feasible, such as energy supply and transport, the difference between CO₂ and greenhouse gas targets matters little. But in other sectors such as agriculture, and in countries where such sectors occupy a significant share of emissions, the difference in time and effort required to reach net zero for CO₂ only, or for all greenhouse gases, can be vast.

Using “net-zero” as the generic, allegedly science-based, requirement that is applied to each individual entity can thus result in highly uneven burdens that will preclude engagement for some entities or the setting of unrealistic targets without a credible path to achieve them. It can also provide motivation for some emitters to use new emission metrics that would allow them to claim “climate neutrality” even while their methane

emissions continue at high levels³. These responses risk creating a warmer world than if each emitter were to maximise their emission reductions and removals across all gases.

A further problem is that reaching global net-zero CO₂ emissions by 2050 is only consistent with 1.5 °C if followed by a long period of globally net negative CO₂ emissions, as virtually all of even the most ambitious modelled pathways assessed by the IPCC exceed the remaining carbon budget and temporarily overshoot the 1.5 °C limit. Current nationally determined contributions imply higher near-term emissions and hence an even greater need for globally net negative CO₂ and potentially even net negative greenhouse gas emissions in the long term to eventually return to 1.5 °C¹. Presenting “net zero” as a scientifically self-evident target misrepresents as destination what can only be a milestone in a much longer journey⁴.

Narrow and arbitrary benchmarks. The available body of research shows a wide spread of possible actions and emission reductions for individual companies and countries that would all be consistent with a global goal of limiting warming to 1.5 °C, dependent on actions taken in other sectors and parts of the world. Most initiatives that translate those global pathways into corporate targets compress these diverse pathways and interconnected assumptions into single time-bound numbers and rules^{5,6}.

The methodologies of the influential Science-Based Targets initiative (SBTi)⁷, as an example, rest on three key design choices and resulting current rules: a required (generic or sector-specific) annual rate of reduction; the exclusion of offsets in the near term and (with some exceptions) of carbon-dioxide removal (CDR) within the value chain; and a requirement that only CDR-based offsets regarded as permanent by SBTi are used to achieve net-zero status once the mandated reduction in gross emissions has been achieved. Other initiatives are less restrictive in the use of offsets and within-boundary CDR in the near term, but also often restrict eligible CDR activities.

Such simple rules respond to well-founded concerns about offsets with low integrity, and about monetary transfers substituting for transformational changes in wealthy and high-emitting companies and countries. However, the simpler such rules, the greater the trade-offs. Offsets are a key mechanism to enable and support climate action and help protect and restore carbon stocks in regions and sectors with less intrinsic capacity and responsibility to act. Excluding all offsetting in the near term limits climate finance and thus slows emission reductions by those unable to take on SBTi targets⁸. Ironically, those higher emissions result in a greater global reliance on CDR to meet global temperature goals.

A lack of near-term investment in carbon dioxide removal by companies outside of the forestry, land and agriculture sector also limits global incentives to restore carbon in sensitive ecosystems. Land-based carbon storage is inherently non-permanent but in aggregate can make a vital contribution towards achieving global emission goals; excluding it from near-term action throttles monitoring and accountability mechanisms that could help manage permanence risks. Overall, we are concerned that restrictive approaches to offsets and CDR withhold climate finance from much-needed energy transformation and increase future reliance on energy-intensive, expensive CDR methods such as direct air carbon capture and storage (DACCS), but without generating near-term financial flows that could make this method a reality. Those subjective and contested⁹ rule-sets thus increase both the overall quantity and cost to achieve the cumulative CDR volumes that will be needed globally to limit warming and return to 1.5 °C.

Unequal effort-sharing in an uneven world. Our third and perhaps most fundamental concern is that most allegedly science-based targets rely on modelled global or regional average rates of emission reductions to set

near-term company-level targets. Following this approach, any company or country that has higher-than-average emissions at present will be granted higher-than-average emissions in future until the common point of net-zero emissions is reached. This approach, known as grandfathering, is a distributional choice that in other policy contexts is often contentious and needs to be justified on a case-by-case basis. Science-based methodologies transform this distributional choice into a universal burden-sharing principle. This deeply embedded value judgement makes so-called science-based targets a highly attractive proposition to companies with high current emissions and/or high capacity to act, who would need to reduce their emissions far more rapidly than the global average under any other equity-based approach to global burden-sharing^{10,11}.

Even where sectoral or regional differentiation is used, methodologies that take modelled least-cost mitigation pathways as the starting point for sectoral, regional and entity-level targets confuse the locus of cost-effective abatement with the responsibility and capacity for making this abatement happen. Unsurprisingly, almost 90% of companies with 1.5 °C-aligned Science-Based Targets are located in advanced economies (North America, Europe and Pacific OECD), and less than 1% in Africa (see Fig. 1).

Similar biases operate in country targets, where “net zero” or “climate neutrality” by 2050 has become a near-universally adopted long-term target for developed countries. Notwithstanding debates about equity in the United Nations Framework Convention on Climate Change (UNFCCC), many national “net zero by 2050” targets are motivated by or explicitly refer to IPCC findings regarding the global emission reductions needed to limit warming to 1.5 °C. Reaching net zero greenhouse gas (rather than only CO₂) emissions by 2050 is arguably ahead of what is needed globally, but few countries explicitly apply equity criteria to assess whether such targets are *far enough* ahead, let alone where they might need to go after net zero to support the global temperature goal.

Taking a central estimate across many pathways might be seen as scientifically robust, but we do not live in a homogenous average world. Individual emitters, both corporate and national, occupy very different niches and have different opportunities to act. If companies and countries with the highest responsibility for current emissions, historical contributions to warming and capacity to act only go as far as, or slightly further than, the allegedly science-based global, regional or sectoral average, then global aggregate emission reductions will fall short of what is needed, given the lack of capacity to achieve similar reductions at the other end of the spectrum of development and opportunity.

Reaching global net-zero CO₂ emissions by 2050 would rely on most advanced economies, and companies with high technological and financial capacity, to have entered and sustain deeply net negative CO₂ emissions by that time. The current narrow and restrictive use of so-called science-based net-zero targets thus fails to tap vital mitigation and climate finance potential among the most powerful companies and governments, while potentially leaving those with less or different capacity to act with the blame for not having followed the science.

Putting science back into science-based targets

The most robust and durable scientific guidance from IPCC reports is that limiting warming to anywhere near 1.5 °C will only be possible if every actor maximises their contribution towards global mitigation actions. This will require actors to prioritise emissions reduction and protect carbon pools over enhancing carbon dioxide removals, but at the same time they will need to grow the capacity for sustained net negative CO₂ emissions in the longer term. The diversity of actors necessitates a diversity of actions that stretch the capacity of each actor to their maximum. Generic rules based on global, sectoral or regional averages ignore and constrain this diversity and, given

Number of Companies with SBTi Approved 1.5°C Targets

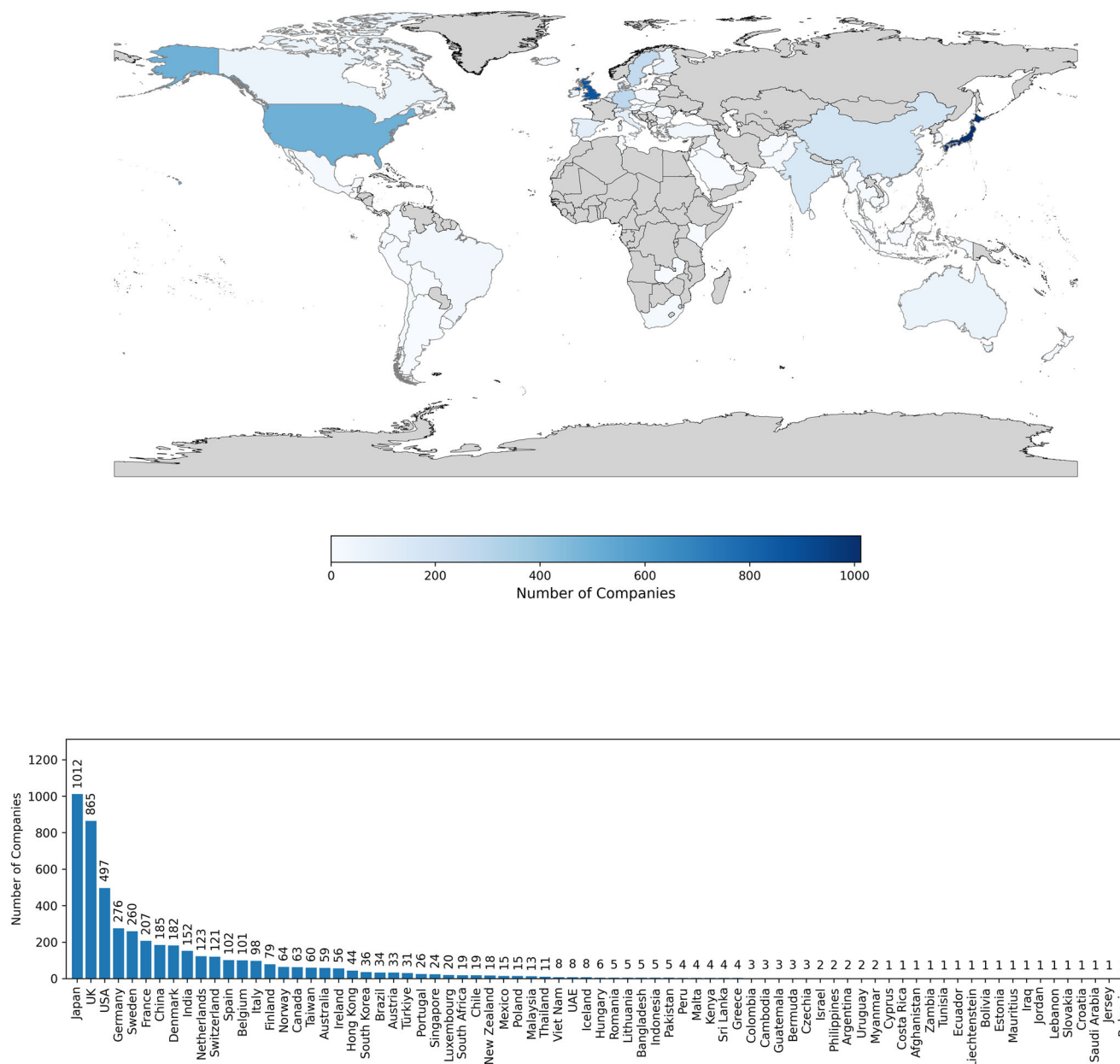


Fig. 1 | Uneven ambitions. Companies with climate mitigation targets that are aligned with the 1.5 °C-goal according to the Science-Based Targets initiative (SBTi)⁷ are overwhelmingly located in advanced economies, based on the SBTi “Companies Taking Action” dashboard¹⁶, retrieved 6 June 2024.

the voluntary nature of corporate science-based targets, result in a pseudo-club that inadequately challenges its self-selected members while setting prohibitive expectations for those with less than average capacity¹²⁻¹⁴.

Nevertheless, we recognise the benefit of having universal rules and easily communicated benchmarks that make it harder for individual entities to engage in special pleading when they present their maximum contribution to a shaky and evolving global effort.

There is no simple recipe for how to put science back into science-based targets without destroying their role and value. First and foremost, it is

necessary to recognise the deep and systemic problem that an appeal to science presents when setting climate targets at company or country level. Below we set out a direction of travel, but developing and implementing actual solutions will need a much bigger collective effort.

The solution to our first concern, basic misinterpretation of science, is simple – don’t do it. There is no excuse for expert bodies to confuse CO₂ with total greenhouse gas emissions, and to misrepresent the timing when the respective emissions reach net zero in global pathways that limit warming to 1.5 °C. If we want science to help guide or inform actions at entity level, we

need to actively resist overly simplistic catchphrases like “net zero by 2050” that effectively disable the available science from providing further decision-support. While our solution is simple on paper, this will rely on significant capacity building at the advisory and consultancy level.

Addressing our second concern, the narrow, non-transparent and arbitrary rules used to set benchmarks for emission reductions, offsets and carbon dioxide removal for corporate science-based targets, builds on the first solution. Narrow rules fulfil two laudable functions: one is to avoid each company having to understand and navigate the full range of socio-economic scenarios and mitigation options as prerequisite to setting and justifying its own climate target; the second is to stop companies from cherry-picking an incoherent and self-interested set of targets and actions from the full range of options. Regaining the richness of options without opening the door to greenwashing will be challenging but necessary if we want to maximise the actions that each individual company can take.

To enable this, methodologies for corporate science-based targets would need to shift from universal narrow rule-sets to a wider but transparent menu of options, along with mandatory disclosure and justification of the strategy adopted by each company, based on its own circumstances. This will need to involve regular, collective reviews to ensure targets remain appropriate given the rapidly shrinking remaining carbon budget and increasing maturity of technologies to address some hard-to-abate emissions. We recognise that this is not a ready-made solution, as it would rely on companies being able to access sufficiently trained advisory and consultancy services, and building capacity to engage in voluntary target setting that is more nuanced and yet drives ambition. This more diverse approach would make it harder to compare actions and ambition between companies. However, using the same rigid and arbitrary yardstick for everybody, despite the different niches and opportunities that companies occupy, does not provide for a level playing field either.

This leads us to our third concern, the near total exclusion of social science approaches (apart from least-cost economics) to inform and justify emission targets of individual entities. Literature on equity and burden sharing has been developed and used mostly at country level but few countries proactively and formally draw on this. An undeniable insight from almost all scientific studies that considered equity-based burden sharing is that most countries in the developed world would need to bring their net zero targets forward and start planning for deeply net negative CO₂ emissions by 2050, sustained for at least the remainder of the 21st century, if the global goal of limiting warming to 1.5 °C is to be kept in reach^{14,15}.

Equity principles cannot necessarily be applied in the same way to companies, but core considerations are the same: given the sum of actions needed to achieve a global goal, and taking into consideration the diversity of actors and their capacities, histories and needs, companies need to decide and demonstrate what contribution might be considered consistent with the global challenge. Based on their geographic location (see Fig. 1), we deduce that most companies that currently adopt science-based targets have substantially higher than average financial, technological and human resources and capacity to deploy them, and market reach. An equity-based approach suggests that for these companies, the global average rate of reduction in emissions or even best-in-class emissions intensity is an indicator of what reduction is insufficient, rather than what they should aim for.

Turning this insight into action would require developing methodologies that include equity principles that can be applied at company level, along with disclosure rules that allow each company to explore and explain its unique position, with institutionalised scrutiny to avoid this exploration turning into exploitation of special circumstances.

We recognise the importance of simple concepts such as net-zero emissions to act as a focal point for global action, both at government and corporate levels. However, those concepts cannot serve as substitute for science. Those engaged in supporting the formulation, monitoring and implementation of long-term emission targets at corporate and country level need to re-balance the use of overly simplistic, eye-catching numerical targets with the considerations needed to increase the ambition of all actors. For many companies and countries, this means stretching far beyond the global average and aiming for net-negative emissions (at a minimum for long-lived, but potentially for the sum of all greenhouse gases) to establish ambitious, science-informed target-setting at individual level.

Data availability

The code, data and plot for Fig. 1 are publicly available on GitHub: https://github.com/AlKhourdajie/SBTi_map.

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Received: 13 May 2024; Accepted: 3 July 2024;

Published online: 23 July 2024

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Acknowledgements

Alaa Al Khourdajie was supported by the Engineering and Physical Sciences Research Council, United Kingdom, grant/award no. EP/P022820/1, and the European Union's Horizon Europe research and innovation programme under grant agreement no. 101056306 (IAM COMPACT).

Author contributions

AR, ALC, OG and AAK equally conceived and wrote this article. AAK collected data and produced Fig. 1.

Competing interests

The authors declare no competing interests.

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