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Assessing the rapidly-emerging landscape of net zero targets

Thomas Hale [a], Stephen M. Smith [b], Richard Black [c], Kate Cullen[a], Byron Fay[a], John Lang[c] and Saba Mahmood[a]

[a]Blavatnik School of Government, University of Oxford, Oxford, UK; [b]Smith School of Enterprise and the Environment, University of Oxford, Oxford, UK; [c]Energy and Climate Intelligence Unit, London, UK

ABSTRACT

In the five years since the Paris Agreement, achieving net zero emissions has become a defining frame for climate action. We review over 4000 countries, companies, and subnational governments, which together make up the preponderance of global emissions. We find 769 of these entities have net zero targets, but only 152 meet minimum criteria for robustness, including timing, status, coverage, use of offsets, and governance. Though net zero is now widespread as a concept, its operationalization is still in its infancy. Making net zero targets robust should now be a priority for policymakers in order to deliver Paris-consistent action, as well as securing more ambitious targets.

Key policy insights:

- Net zero targets now cover two-thirds of the global economy, but robust net zero targets only cover around five percent.
- Strengthening targets and their implementation is particularly needed in the following areas: target status (including setting targets into law); coveraneuge of activities; limits to and transparency regarding the use of offsets; and publication of plans and of progress reports.
- Policymakers should aim to strengthen net zero targets by setting standards for robust net zero targets; building the capacity of entities, particularly those in the global South, to meet the technical and resource challenges required to effectively operationalize net zero emission targets.

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Net zero; Paris Agreement; climate neutrality; standards; carbon offsetting; transparency

Introduction

In a strikingly short time period, the concept of 'net zero emissions' has moved from a topic of scientific discussion to an organizing principle for international, national and subnational, and corporate efforts to address climate change. But as net zero targets have spread, so too have concerns about their credibility. In this article, we provide a global assessment of the net zero targets to date, showing that though the concept has spread far, targets remain very heterogenous in terms of their timing, bindingness, coverage, use of offsets, governance arrangements, and other desiderata. As a tool for policy, the net zero concept is still in its infancy.

Scientific discussion of net zero emerged in the late 2000s, as scientists turned increasing attention to the near-linear relationship between cumulative anthropogenic CO_2 emissions and global temperature change (Allen et al., 2009; Matthews & Caldeira, 2008; Zickfeld et al., 2009). In 2014, the Intergovernmental Panel on Climate Change (IPCC) highlighted this finding, along with the implication that limiting global temperature change to any given level requires a point at which net additions of CO_2 into the atmosphere reach zero (Pachauri et al., 2014). This became the basis for a long-term goal of the 2015 Paris Agreement: 'to achieve a

CONTACT Thomas Hale thomas.hale@bsg.ox.ac.uk
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balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century'. Notably, the Paris Agreement goal expands the net zero concept to greenhouse gases rather than CO_2 only, which is the main framing advanced by the IPCC.[1] Notably in 2018, the IPCC specified that limiting temperature rise to 1.5°C implies reaching net zero emissions of CO_2 by mid-century along with deep reductions in non-CO_2 emissions (Masson-Delmotte et al., 2018).

The conceptual simplicity of net zero makes it politically appealing as a framework for target-setting (Morseletto et al., 2017), given that it gives an entity a clear end-date for ending greenhouse gas emissions. The concept is intrinsically connected to approaches that emphasize temperature goals (reaching global net zero sooner results in lower warming) or carbon budgets (which specify the cumulative quantity of emissions before net zero is reached) (Geden, 2016; Randalls, 2010). The number of national governments, subnational authorities and private sector entities expressing a commitment to net zero has grown rapidly in recent years and is growing still. Mobilizing more commitments is the objective of the United Nation's Race to Zero Campaign (UNFCCC, 2021a).

At the same time, many are questioning the rigour and value of net zero targets, with activists like Greta Thunberg calling for 'real zero' instead of net zero (Stabinsky, 2021). These critiques tend to focus on two areas. First, critics fear that the 'net' part of net zero may sap effort away from emission reductions by allowing extensive reliance on carbon offset credits and/or carbon removal. Offset credit markets face criticism for lack of additionality and robust governance (Schneider & Theuer, 2019), while carbon removal is widely assumed in global pathways to meet the Paris Agreement but is currently untested at scale (Anderson & Peters, 2016). Second, critics worry that long-term net zero targets may give the illusion of aligning to the goals of the Paris Agreement, while actually diverting attention from the urgent, immediate action needed to achieve those goals.

Now that net zero has become a widespread concept there is a critical need to monitor the prevalence of targets and also to appraise them. One early study found a wide range of interpretations and lack of transparency among net zero targets set by cities, regions, and companies (Day et al., 2020). Here we systematically assess all entities in defined populations that account for the bulk of global emissions.[2] Specifically, we review 203 countries (including some self-governing territories), 806 states and regions of the world's 25 largest emitters, all 1170 cities with populations above 500,000, and 2000 largest publicly-traded companies by sales. Our approach relies on a team of 53 trained data collectors and utilizes publicly available sources in multiple languages obtained through systematic internet searches to categorize net zero targets against a standardized set of characteristics.

After reviewing these more-than-4000 entities individually, we calculate the fraction of emissions, population and economic value covered by targets, and scrutinize the robustness of these targets. To operationalize 'robustness', we draw on criteria identified for participation in the UN's Race to Zero Campaign, a global effort to mobilize net zero targets from sub- and non-state actors (UNFCCC, 2021b). These criteria were developed through dialogue with practitioners, and share themes common with many other widely-used best practice guides for setting emission reduction targets (C40, 2019; Carrillo Pineda et al., 2020; Dugast, 2020; ECIU, 2020; Levin et al., 2020; Natural Capital Partners, 2020; Rogelj et al., 2015; Rogelj et al., 2021). Overall, this analysis provides a global assessment not only of the uptake of net zero targets amongst the most crucial sources of global emissions but also of the quality of operationalization of net zero targets.

Methods

To generate comparable information on a meaningful set of net zero targets, we rely on a labour-intensive, comprehensive process of individually reviewing and coding information across a large number of entities through a common data collection protocol. We define the study population as follows.

Countries. All UN-recognized countries and a number of self-governing territories and dependencies are analysed, comprising 203 entities in total. We do not include the EU as a separate entity. Country codes and names were sourced from the International Organization for Standardization (ISO) 3166-1 Alpha standard. Country populations in 2019 were sourced from the United Nations (UN DESA, 2019a); Gross Domestic Product (GDP), measured in purchasing power parity terms in constant 2017 international US dollars from the World Bank (World Bank, 2019); and greenhouse gas (GHG) emissions from CAIT (WRI, 2018). We did not obtain

comparable GDP data for states and regions or cities, nor comparable GHG data for all sub- or non-state entities. We therefore restrict analysis of GDP and GHG coverage to nation states.

States and regions. We analyse the states, regions, and provinces (or other equivalent entities) of the top 25 emitting countries, which together account for over 80% of global greenhouse gas emissions. Specifically, this group comprises 806 states and regions from the United States, Australia, Canada, India, Russia, Japan, Germany, Iran, Saudi Arabia, South Korea, Mexico, Indonesia, Brazil, South Africa, France, Turkey, Italy, Thailand, Poland, Kazakhstan, United Kingdom, Spain, Taiwan, China, and Malaysia. As there are no global datasets for names and population, we compile them from a range of governmental and open-source repositories.

Cities. All cities with populations over 500,000 are analysed, comprising 1170 cities in total. City populations and names in 2018 were sourced from the UN (UN DESA, 2019b).

Companies. We analyse all 2000 publicly-traded companies included in the Forbes Global 2000 list (Forbes, 2020). Company sales, names, industry, and location of headquarters are sourced from Forbes.

To collect information on these entities, a team of trained student data collectors, supervised by the paper authors, systematically looked at each entity to ascertain whether it had a net zero target; and if so, what characteristics that target exhibited. We rely on publicly available sources such as entities' websites or published documentation, press releases, or news articles. Searches for information to complete the relevant template for each entity (see appendix) were undertaken using the following process:

(1). Cross checking entity name against the Race to Zero member master list (access provided by the UNFCCC Secretariat), and the Energy & Climate Intelligence Unit (ECIU) Net Zero Tracker master list (access to data provided by ECIU);
(2). Using Google Search to conduct the following Internet searches in English and the entity's main language (if not English):
   a. [entity name] net zero climate target,
   b. [entity name] climate neutral,
   c. [entity name] carbon neutral,
   d. [entity name] zero emissions;
(3). Reviewing relevant web pages relating to the entity's climate target; and
(4). Using Google Search to conduct follow-on Internet searches as necessary.

Coders were instructed to focus on primary materials where possible, but to complement and verify through secondary sources to the extent needed. All original source materials are recorded in the accompanying database.

The data acquisition activities were undertaken between August and December 2020 by the paper authors and a team of volunteer undergraduate and graduate coders studying relevant fields at the University of Oxford. A team of 53 students, together fluent in 26 languages and hailing from five continents, were recruited through an open-call to relevant academic departments. Before coding, volunteers were given training material and a coding manual, and participated in an hour-long induction and orientation. Members of the author team supervised the coders throughout the data collection process, providing guidance on how to apply the coding template and interpret the coding manual, and adjudicating any coding ambiguities.

Once the data acquisition for all entities was complete, ten percent of all entities in each category were randomly selected for 'double coding' to verify data accuracy. In other words, every tenth entity from an alphabetical list was selected. The data acquisition process outlined above was repeated for these entities, using different coders from those who had undertaken the process the first time around, and the results of both acquisitions compared. Through this method, we found identical data acquisition results in 94% of cases. This high intercoder reliability rate builds confidence in the accuracy of the coding process. Spot checks were additionally undertaken to verify the accuracy of data entries for specific major entities, for example, 'Los Angeles' (in cities) or 'Amazon' (in companies). The purpose of spot-checking was to confirm that any subsequent, important updates pertaining to net zero targets had been accounted for and, furthermore, to ensure entities with an outsized impact on our final results were triple-checked. Alongside this, Google News searches were conducted for new net zero announcements until the data acquisition process was complete to ensure

new announcements from entities that had been coded early in the data acquisition period were captured. Acquisition was completed on 23 November 2020, so the results should be considered accurate as of that point in time.

The data collection focused on net zero targets, widely defined. Our analysis encompasses both commitments for CO_2 only or multiple greenhouse gases, and those that refer to net zero emissions or to other related concepts that are widely used to denote net zero or net negative emissions. These terms are sometimes used interchangeably despite implying different climate outcomes (see appendix for full list). We use 'net zero' as shorthand for this heterogeneous array of targets. We do not, however, include other mitigation targets, such as commitments to reduce emissions by some percentage less than 100, 100 percent renewable energy targets, or similar.

To measure target robustness, we record a common set of characteristics that refer to the UN Race to Zero campaign criteria. The latter outline four procedural requirements for net zero targets and two substantive requirements:[3]

(1). Pledge: Pledge at the head-of-organization level to reach net zero in the 2040s or sooner, or by mid-century at the latest, in line with global efforts to limit warming to 1.5°C.
(2). Plan: In advance of COP26, explain what steps will be taken toward achieving net zero, especially in the short- to medium-term. Set an interim target to achieve in the next decade that reflects a fair share of the rough halving of global CO_2 emissions by 2030 relative to 2010 levels, identified by the IPCC as consistent with pathways that have limited or no overshoot of 1.5°C.
(3). Proceed: Take immediate action toward achieving net zero, consistent with delivering interim targets specified.
(4). Publish: Commit to report progress at least annually, including via, to the extent possible, platforms that feed into the UNFCCC Global Climate Action Portal.
(5). Scope: Cover all emissions, including scope 3 for businesses and investors where they are material to total emissions and where data availability allows them to be reliably measured, and all territorial emissions for cities and regions.
(6). Offsetting: Prioritize immediate mitigation measures directly within scope, and limit use of any externally-generated carbon credits ('offsets') to neutralize 'residual' emissions. Offset portfolios should transition to permanent removals by the time net zero is achieved. Ensure that all offsets meet robust standards for additionality, permanence, accounting, etc.

We do not seek to directly measure 'compliance' with Race to Zero, since the criteria above are operationalized in distinct ways by the various networks and initiatives that make up the campaign (and Race to Zero does not include nations). Rather, we seek to record characteristics of net zero targets that speak to the core elements of the Race to Zero criteria, as follows (see appendix for further details).

Timing. We record the year by which an entity aims to reach net zero. This, along with the path of emissions to that point, determines its contribution to warming. While global pathways consistent with 1.5°C show net emissions of CO_2 reaching zero around 2050, individual sectors and regions may reach net zero at different times, or not at all, based on considerations of techno-economic efficiency (Huppmann et al., 2018) and equity (Robiou du Pont et al., 2017; van Soest et al., 2021).

Status. Commitments vary in their level of organizational endorsement and the extent to which citizens or shareholders can hold entities to account, which affects how binding we can expect them to be. National targets may be announced by government, published in an official policy document such as a Nationally Determined Contribution (NDC), in draft legislation, or in law. Furthermore, some countries have already achieved net zero in the sense that their latest NDC indicates: (1) their annual territory-wide emissions as a net carbon sink, net negative, or similar language, and (2) an intent to maintain this emissions status, conditional or unconditional on international support, and with or without land-use changes. We define the status of such countries, which tend to be least developed countries with significant forest cover, as 'achieved' based on their claims rather than on independent verification of their GHG inventories. The same applies to cities, states and regions, although many do not have power to draft legislation. Corporate

targets range from simple proposals, through aspirational targets and inclusion in corporate strategies, to achievement.

Coverage. Not all commitments cover the full range of activities and greenhouse gases. National reporting follows well-established IPCC guidance covering all sources and sinks of a basket of gases (CO_2, N_2O, CH_4, and F-gases) within national territories. Nevertheless, national targets show differences in coverage of gases and activities; for example some cover international aviation and shipping, and some do not. Targets set by subnational and private sector entities show much greater variation in coverage across activities generally categorized as scope 1 (covering sources and sinks directly managed by an entity), scope 2 (indirect emissions from energy use) or scope 3 (all other indirect emissions across the entity's value chain).

Offsetting. The difficulty of reducing all emissions to zero means that offsets – credits gained through funding emission reduction or removal projects elsewhere – feature in many net zero commitments. Existing markets have struggled to provide consistently high quality, truly additional abatement (Cames et al., 2016; Cullenward and Victor, 2020). While immediate efforts to protect and restore natural carbon sinks are needed to achieve global mitigation outcomes, corporate contributions cannot substitute for or delay the decarbonization that is also needed (Allen et al., 2020). For this reason, initiatives like Science Based Targets do not allow for offsetting to substitute for emissions reductions, even as they encourage contributions to nature conservation on top of decarbonization efforts (SBTI, 2021). Further, few existing approaches to offsetting are aligned to the requirements of net zero, which ultimately requires that any residual emissions be fully neutralized by permanent removals (Allen et al., 2020; Kreibich & Hermwille, 2021; Michaelowa et al., 2021; Schneider & Theuer, 2019). For example, while avoiding emissions (e.g. by protecting forests that would otherwise be cut down) can contribute to reducing global emissions on the path to net zero, they cannot balance out ongoing emissions once a state of net zero has been reached because they do not remove emissions from the atmosphere. At the same time, to maintain a 'balance between sources and sinks' removals must ultimately persist over a timescale commensurate to the permanence of carbon in the atmosphere, potentially through techniques such as mineralization (Allen et al., 2020).

Governance. Poor governance increases the risk that targets are missed. We characterize governance using four features: a published plan for achieving the target, interim targets on timescales of planning cycles to assure accountability, reporting of progress, and consideration of equity. For the latter, we do not seek to assess whether an entity's target is adequate vis-à-vis a set definition of equity, but simply record whether or not an entity discusses equity in the context of its target setting. This is a limitation due in part to a lack of estimates in the literature for equitable timing of net zero targets at the level of companies and regions. However, even when estimates are available (such as they are for countries (Robiou du Pont et al., 2017)) multiple interpretations of equity exist. These interpretations lead to wide ranges and fundamentally contestable normative choices when making any such assessment.

Our dataset is limited by several factors. First, we consider only defined populations of entities. While we have included all countries in our analysis, we limited ourselves to states, regions, and provinces of the top 25 emitting countries; cities with a population over 500,000; and the 2000 largest publicly-traded companies by sales in 2020 which are publicly listed. These boundaries were imposed to maximize the quantity of global emissions we were able to cover within feasible resource constraints. Private companies are therefore excluded entirely, as are regions in lower-emitting countries, smaller cities and smaller public companies. Despite these exclusions, the data captures a globally significant range of entities that account for the vast bulk of global emissions. Second, we only include data in the public domain. This may not reflect the most complete and current information held by individual entities. Third, there are potential gaps in our analysis of net zero targets in some languages resulting from limits to translation. We mitigated this risk by assigning the coding for non-English entities to fluent speakers where possible, and then by translating non-English documents. For some languages, however, we were unable to enlist fluent speakers (specifically Thai, Turkish, Persian and Russian). Key concepts that are used to describe net zero commitments (e.g. 'offsetting' and 'coverage') may not be discussed by non-English speakers in the same way or using the same terminology.

Results

In total, we find that 124 countries, 155 cities, 73 states and regions, and 417 companies in our sample have some form of commitment to net zero. Countries with net zero targets together represent 61% of global emissions, 68% of global GDP (in purchasing power parity terms) and 52% of the global population (Supplementary Material, Table 1). Cities and regions whose net zero targets are not subsumed by a higher level of government add a further 4% to population; we were unable to obtain comprehensive and consistent data on GDP and emissions for non-state entities. Companies with net zero commitments together represent sales of nearly $14 trillion – 33% of total sales across the top 2,000 public companies, and approximately the size of China's GDP – with wide variations across sectors (Supplementary Figure 1). The majority of targets across entities are for 2050; however, a significant proportion of companies, states and regions are aiming for earlier years, particularly 2030. China alone makes up the large proportion of emissions covered by a post-2050 national target.

Assessing these commitments against the other criteria highlights stark differences in robustness and many instances of unavailable or unclear data. Below we focus on the subset of entities that have some kind of commitment to net zero.

Status

Commitments to achieve net zero come with varying degrees of robustness. We observe a stark contrast between countries and cities, where many targets remain aspirational; and states and regions and companies, where targets tend to be recorded in policy or, more rarely, in law. Sweden and the UK present promising examples where net zero laws help hold successive governments to a common course of action. Moreover, 21 countries, 1 state, and 44 companies already claim to have achieved net zero (Figure 1).

Coverage

A significant fraction of targets (14% by number) do not specify clearly whether they cover CO_2 or a wider basket of greenhouse gases. Where it is clear, a majority of country, city, and state and region targets are for CO_2 only. Only five countries include a share of international aviation and only four include shipping. For companies, only around 20 percent of emissions of companies with net zero targets include all scopes, though the majority include some degree of scope 3 (Figure 2).

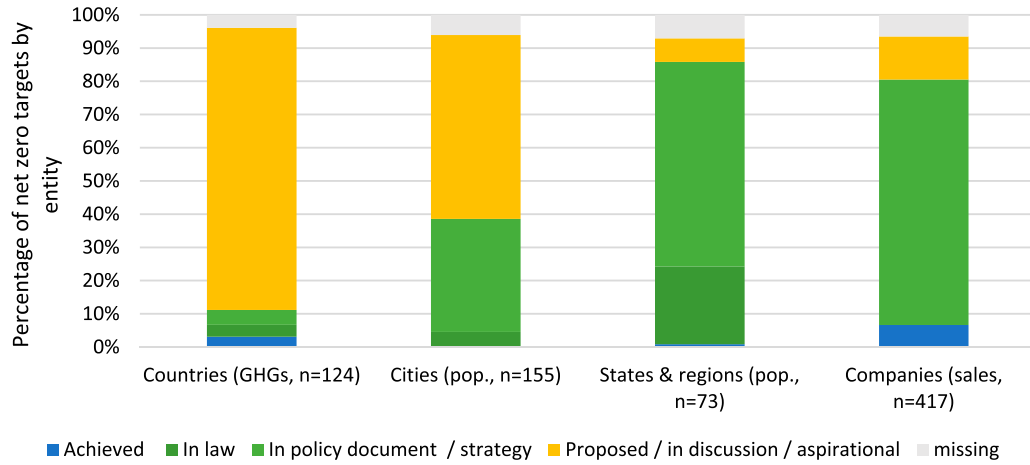


Figure 1. Status of net zero commitments by entity type. Notes: Each bar records the percentage of targets, weighted by the metric stated in each column, that exhibit a certain level of status for each type of entity.

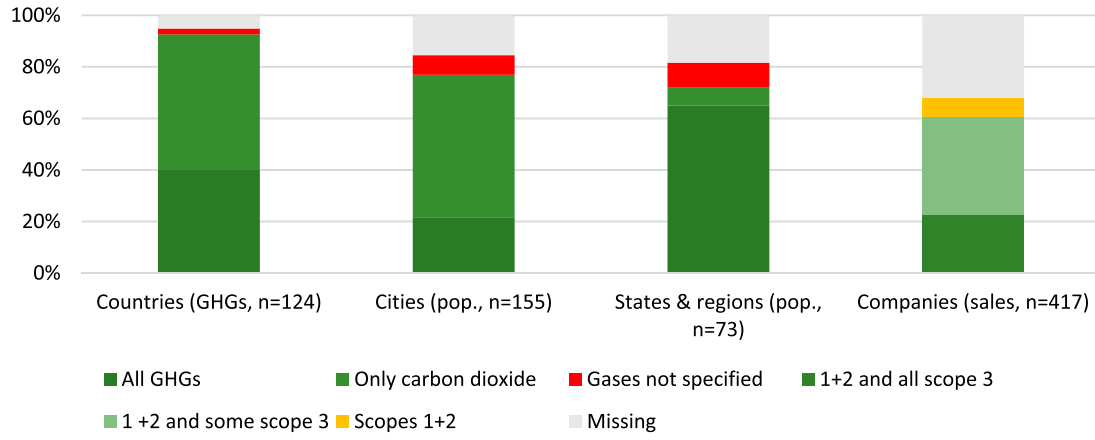


Figure 2. Coverage of net zero commitments by entity type. Notes: Each bar records the percentage of targets, weighted by the metric stated in each column, that exhibit a certain degree of coverage for each type of entity.

Offsetting

For all types of entity, the majority of commitments are unclear on the use of carbon offsets. This makes it very difficult to assess the robustness of an entity's net zero target. Where commitments are clear, more entities intend to use offsets than not in each category of entity. Only a few set conditions on their use: 9 countries, 32 cities, 11 regions, and 87 companies. For example, Microsoft has stated it will use carbon removal technologies to go beyond neutralizing its ongoing emissions and also remove its historical emissions as well (Figure 3).

Governance

Governance benchmarks vary significantly across entities. Regular reporting of progress is widespread for national targets following the Paris Agreement; however, reporting mechanisms are given by just 34 states and regions, 47 cities, and 263 companies. Published action plans are found for 25 countries (though these



Figure 3. Use of offsetting for net zero commitments by entity type. Notes: Each bar records the percentage of targets, weighted by the metric stated in each column, that take the specified approach to offsetting for each type of entity. 'Not specified' means the entity did not provide any public information on their approach to offsetting, while 'missing' means the data collector was not able to determine whether or not offsetting information was provided.

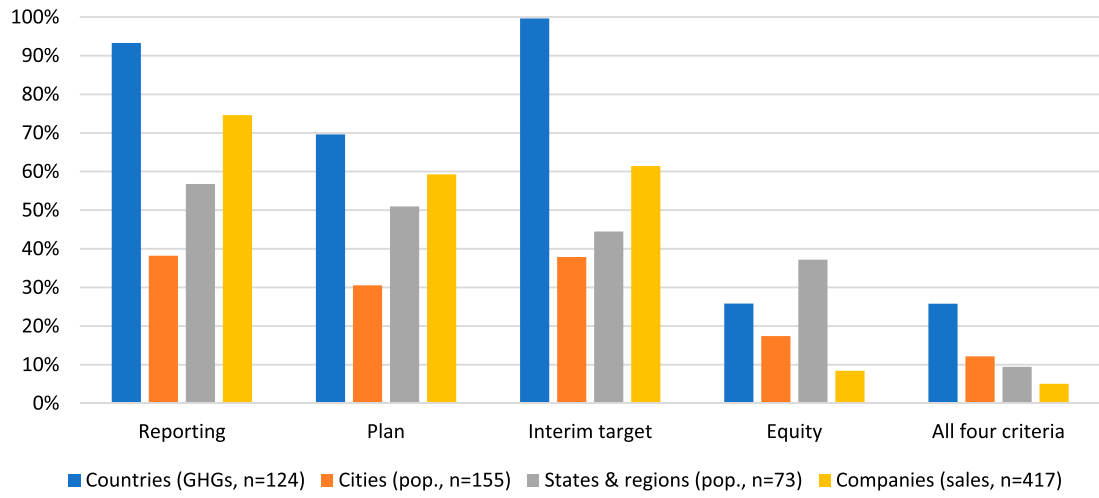


Figure 4. Governance net zero commitments by entity type. Notes: Each bar records the percentage of targets, weighted by the metric stated for each entity, which includes the four criteria of governance: annual reporting of progress, a published plan, interim targets, and consideration of equity.

account for nearly 70% of emissions), 65 cities, 41 regions, and 210 companies. Countries nearly all have interim targets, given that all parties to the UNFCCC have NDCs, but only about half of local governments and two-thirds of companies do. Few entities of any type refer to equity; perhaps most strikingly, only a small percentage meet all four governance criteria (Figure 4).

Overall robustness

Looking across the characteristics above, we find very few net zero targets meet all of the desiderata for robustness. We operationalize the Race to Zero procedural criteria as:

- Timing: target year 2050 or earlier
- Status: in law or in policy document (not proposed, in discussion, or aspirational); and
- Governance: annual reporting, plan, interim target.

We find that the proportion of net zero targets meeting all these criteria is: for countries, 12% by number (5% by emissions, approximately the emissions of Russia); for states and regions, 19% by number (85 million people, approximately the population of Germany); for cities, 8% by number (61 million people, approximately the population of the United Kingdom); for companies, 26% by number ($2.15 trillion by sales, approximately the GDP of Italy). If we further consider the two substantive criteria on scope and offsetting, only a handful of entities clear this higher bar: 5 countries, 4 cities, 4 states and regions, and 11 companies, though we note these numbers are rapidly changing as entities grapple with the net zero challenge (see more information in Supplementary Material).

Discussion

The results reveal the extraordinary expansion of net zero across all entity types, as well as the need for further deepening of commitments. The wide global coverage of net zero targets can give the impression that the world is further toward achieving the goals of the Paris Agreement than may actually be the case. In reality, net zero is perhaps unsurprisingly still in its initial stages as an organizing principle for climate action. Further work to is needed to operationalize this concept effectively in policy and practice for all entities.

Our findings show that strengthening of targets and related commitments and practice is particularly needed in the following areas: target status (particularly setting targets in law for countries); coverage of activities; limits to and transparency regarding the use of offsets; and publication of plans and of progress reports. One of the most significant findings is the lack of information provided by entities around approaches to offsetting, a key area where further research and, ultimately, regulatory standards will be needed. Without strong rules around offsetting that ensure each ton of carbon is only counted once, and purchased credits entail reductions that are truly additional to what would have happened anyway, overall emissions will not fall.

Robustness gaps for net zero targets can stem from multiple sources. Some may be driven, as critics fear, by 'greenwashing' strategies, in which companies aim to appear to be acting on climate change, without actually taking concrete steps to deliver on their promises. But gaps may also arise from, inter alia, lack of knowledge and capacity by actors to effectively operationalize complex concepts like net zero, or a lack of clear guidance from governments to sub- and non-state entities, or from international organizations to governments on what makes net zero targets robust. Developing credible net zero plans, securing necessary agreement from stakeholders, and taking steps to implement them are non-trivial tasks, and so it is natural to expect top-level pledges to come first, with follow through taking longer. That said, it will be important to see progression in the robustness of net zero targets over time. For countries, the regular NDC improvement cycle outlined in the Paris Agreement creates regular opportunities for raising robustness. For companies, robust targets, such as those verified by the Science Based Targets Initiative or other partners of the UN Race to Zero Campaign, can help companies get ahead of future regulatory changes around net zero. For cities, states, and regions, better clarity on how to approach net zero is key for mobilizing both popular and financial support. Networks like Cities Race to Zero and Net Zero Futures are helping to provide such guidance.

The results presented here create a baseline for assessing the further development of net zero targets. Future research should continue to track these and other criteria for robustness, and also delve more deeply into questions beyond the scope of this study, such as what factors lead certain entities to set more or less robust targets.

Conclusions

The growth of net zero emission targets illustrates a significant advance in ambition since the Paris Agreement. But meeting climate goals requires that these targets increase not just in quantity but also in quality and ultimately in implementation. Just as NDCs are intended to ratchet up over time, all entities should work to make their long-term targets increasingly transparent, binding, complete, and otherwise robust, alongside near-term targets and actions that follow a credible pathway to long-term goals.

Going forward, policymakers should prioritize strengthening the robustness and implementation of existing net zero commitments alongside securing more and more robust targets from entities that do not yet have them. This task can be advanced in several ways.

First, standards for robust net zero targets could help clarify for actors what is required of them. As noted above, researchers have already proposed a wide range of benchmarks for net zero targets, and the UN Race to Zero has sought to institutionalize these in a set of evolving 'meta-criteria'. While no formal set of standards exists for national governments, many networks of cities, businesses, and financial entities are devising specific ways to operationalize these types of benchmark for their members. And some national governments are beginning to set standards for entities within their jurisdictions; for example, the UK has stated that all companies bidding for large government contracts will need to have net zero targets (BEIS, 2021). Internationally, ISO, the global standard-setting body, is in the process of developing global rules for carbon neutrality and related concepts (ISO, 2021).

Second, entities' ability to set and implement robust net zero targets is a function not just of what is required of them, but also of their knowledge and capacity to effectively translate global climate science into their own policies and operations. Many cities, states and regions, and companies do not have personnel, expertise, or resources to carry out emissions inventories, model future scenarios, or design and implement complex transition policies. Local governments in the global South may face particular barriers in this regard. It is therefore imperative to increase entities' capacity to successfully set and implement robust, net zero targets.

Third, researchers and civil society groups should continue to assess entities' net zero targets and their progression across both interim and long-term targets. Transparency on what targets an entity has, how it has operationalized these targets, and how it is implementing them are critical for ensuring credibility and accountability. Critics of net zero should aim to distinguish between more and less robust targets, empowered by greater transparency from entities themselves and sound analysis from the research community.

Climate change is a decades-long challenge. Long-term planning and target-setting, based on science, is therefore critical for an effective policy response. In this sense, the widespread uptake of net zero targets is of significant value. At the same time, all entities setting net zero targets must ensure that such targets are well-designed, transparent, and, perhaps above all, paired with the immediate action these ambitious goals imply.

Notes

1. As we show below, the term 'net zero targets' has been applied to CO_2 and to greenhouse gases interchangeably and ambiguously, despite them entailing different climate outcomes. While net zero CO_2 emissions would result in stabilized global temperature, net zero greenhouse gas emissions achieved by balancing residual non-CO2 emissions with net negative CO2 emissions would result in decreasing temperature.
2. Some selected early findings were presented in a spring 2021 policy report (Black et al., 2021) and an updated dataset is maintained by the Net Zero Tracker consortium (Hale et al., 2021).
3. These refer to the 2020 criteria. The Race to Zero criteria are updated annually. An update occurred in June 2021

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ORCID

Thomas Hale http://orcid.org/0000-0002-8871-3376
Stephen M. Smith http://orcid.org/0000-0002-5737-0155
Richard Black http://orcid.org/0000-0002-8003-2605

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