



# DESIGNING AND COMMUNICATING NET-ZERO TARGETS

KELLY LEVIN, DAVID RICH, KATIE ROSS, TARYN FRANSEN, AND CYNTHIA ELLIOTT

## EXECUTIVE SUMMARY

### Highlights

- To limit warming to well below 1.5°C (2.7°F), global greenhouse gas (GHG) emissions must be slashed in half during the next decade and reach net zero early in the second half of the century.
- Given this need, several countries have adopted net-zero emissions targets, and many more have net-zero targets under consideration.
- Achieving net-zero targets is both a massive challenge—as countries will need to transform their economies—and an opportunity to advance development and sustainable economic growth while avoiding the worst climate change impacts.
- This paper aims to support countries in designing and communicating their net-zero targets to ensure they fully contribute to the achievement of the Paris Agreement’s goals.
- Net-zero targets must also inform the design of near- and midterm targets and policies, including nationally determined contributions (NDCs), development plans, policies, investments, and long-term low-emissions development strategies to support just transitions.

## CONTENTS

Executive Summary .....	1
1. Introduction.....	3
2. Why Net Zero?.....	4
3. Defining Net Zero .....	6
4. Situating the Net-Zero Target in the Policy Process.....	7
5. Designing a Net-Zero Target .....	10
6. Using the Target to Inform Action .....	18
7. Communicating Net-Zero Targets.....	19
8. Conclusion and Recommendations .....	20
Appendices.....	21
Abbreviations .....	25
Endnotes.....	26
References .....	29
Acknowledgments.....	30
About the Authors .....	30

*Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback, and to influence ongoing debate on emerging issues. Working papers may eventually be published in another form and their content may be revised.*

**Suggested Citation:** Levin, K., D. Rich, K. Ross, T. Fransen, and C. Elliott. 2020. “Designing and Communicating Net-Zero Targets.” Working Paper. Washington, DC: World Resources Institute. Available online at [www.wri.org/design-net-zero](http://www.wri.org/design-net-zero).

---

## Context

**The latest science from the Intergovernmental Panel on Climate Change (2018) suggests that to meet the Paris Agreement’s temperature goals, the world will need to reach net-zero GHG emissions early in the second half of the century.**

Under the Paris Agreement, countries agreed to limit average global temperature rise to well below 2°C and pursue efforts towards limiting warming to 1.5°C above preindustrial levels. At the global level, achieving net-zero emissions means balancing anthropogenic (human-caused) emissions and removals of GHGs in a given time period. In practice, achieving net-zero emissions means reducing anthropogenic emissions—like those from fossil-fueled vehicles and factories—as close to zero as possible while ramping up carbon removal—for example, by restoring forests or through direct air capture and storage technology—to balance out any remaining emissions.

**To date, 19 countries and the European Union have adopted net-zero targets, and more than 100 others are considering doing so.** As countries design their targets, they will doubtless encounter questions about which GHGs and sectors to include, the timeline for achieving net-zero emissions, the role of carbon removal, and the role of internationally transferred GHG mitigation (emissions reductions or removal enhancements), among others. These design choices can have significant implications for how well a net-zero target incentivizes economy-wide actions to reduce emissions and enhance carbon removals, and they set a country on a plausible pathway to achieving net-zero emissions.

### About This Working Paper

**This paper is a resource for countries that are considering, designing, and communicating net-zero targets.** It summarizes how countries have designed net-zero targets to date and discusses the pros and cons of different design choices. It recommends options for designing net-zero targets and communicating with domestic and international constituencies in accordance with the most recent climate science and the Paris Agreement’s long-term temperature goals.

**National policymakers charged with designing net-zero targets are the primary audience for this paper.** It may also be useful for those interested in participating in the design process or seeking to understand and evaluate net-zero targets. While the paper focuses on setting national net-zero targets, it may also be relevant to regions, states, cities, and businesses, many of which are also setting net-zero targets. Given their different emissions boundaries, some considerations relevant to subnational jurisdictions and businesses are noted in Appendix C.

### Recommendations

**Achieving net-zero emissions will require fundamental shifts in how society operates.**

While there are significant opportunities associated with a zero-carbon future, there will be winners, losers, and trade-offs along the way to achieving this vision. Robust stakeholder processes can play a critical role in surfacing and managing trade-offs, promoting societal buy-in, and helping to ensure a just transition. Securing high-level political support and engaging relevant ministries, parliaments, experts, and the public can also enhance a net-zero target’s prospects for withstanding future government changes. Independent expert bodies can help provide accountability and review design and implementation choices.

**Net-zero targets should be comprehensive.** They should cover all GHGs and all sectors.

**Governments should establish specific time frames for achieving targets.** The specific year or multiyear time frame should be as early as feasible and should account for global scenarios compatible with limiting warming to 1.5°C or 2°C, equity principles, and pathways and options for emissions and removals.

**Countries with the highest emissions and greatest responsibility and capability should adopt the most ambitious target time frames.** Major emitters should adopt a time frame that is at least as early as the global time frame to achieve the Paris Agreement goals, and it should be earlier still if they have high historical and per capita emissions. Countries with a high capacity for reducing GHG emissions and removing carbon should supplement net-zero targets with plans to achieve net-negative emissions after achieving net-zero emissions.

**Separate targets should be set for GHG emissions reductions and net-zero or net-negative emissions.** Distinct targets provide a clear road map for decarbonization, scaling carbon removals, and achieving net-zero or net-negative emissions.

**Governments should prioritize reducing GHG emissions and enhancing GHG removals within the country's territory rather than relying on international transfers of GHG mitigation to achieve net-zero targets.** If international transfers of GHG mitigation are used to meet the target, countries should ensure that only surplus mitigation from other countries is transferred and should consider limiting the portion of the net-zero target that may be met through international GHG mitigation, as much as is feasible.

**Countries should transparently communicate their net-zero targets.** They should clearly provide information on the parameters of the net-zero target, including the GHG and sector coverage, the time frame, the decarbonization targets, and the use of international transfers and any limits. Countries may also consider communicating supplemental information in order to strengthen the transparency of their targets.

**Countries should ensure that net-zero targets inform near- and midterm climate action,** including targets and policies, NDCs, development plans, policies, investments, and long-term low-emissions development strategies to support just transitions.

## 1. INTRODUCTION

To avoid the worst impacts of climate change, global greenhouse gas (GHG) emissions will need to drop by half during the next 10 years and reach net-zero around midcentury (IPCC 2018a). Nineteen countries and the European Union have already adopted net-zero targets,<sup>1</sup> and more than 100 others are considering doing so.<sup>2</sup> While these are positive developments, the fraction of global emissions covered by some form of a nationally adopted net-zero target still hovers around 10 percent.

If we are to achieve the global goal of net-zero emissions established in Article 4 of the Paris Agreement,<sup>3</sup> each country that has signed and ratified the agreement must consider how to contribute to the goal at the national level. This requires a broad range of policies and measures, including net-zero targets. For example, framework legislation and strategies (e.g., climate laws and long-term strategies); economic instruments (e.g., carbon taxes, subsidy reform, trade policy, and tax incentives); regulatory instruments (e.g., emissions, technology, and product standards); and other approaches, such as information policies, procurement policies, voluntary agreements, and evaluation and accountability mechanisms, can play important roles in the broader climate policy package.

As countries design their net-zero targets, they face decisions such as how to define net-zero emissions, how to set the time frame for reaching net-zero emissions, which sectors and GHGs to include in a net-zero target, and the role of carbon removal and international transfers in achieving net zero emissions, among others.

Critically, countries now considering such targets are doing so against the devastating backdrop of the COVID-19 outbreak. The pandemic and its associated recovery efforts intersect with climate action in general and with the transition to net-zero emissions in particular. Broadly speaking, the pandemic has underscored the need to address many of the same weaknesses in global socioeconomic structures that make people vulnerable to climate change. There are also synergies among the interventions that will help economies recover from the pandemic and those that will mitigate climate change (Hepburn et al. 2020). Appropriately, many countries have indicated that their recoveries must be sustainable and inclusive, aligning economic, social, and environmental objectives. Climate action—including the design of net-zero targets and their implementing policies, actions, and enabling environments—therefore remains imperative.

But the transformative nature of the net-zero transition, combined with the large-scale disruption of the pandemic, is worth particular focus. Achieving net-zero emissions requires overcoming technological, institutional, and behavioral forms of carbon lock-in. The literature on carbon lock-in highlights the role of exogenous shocks in pushing countries onto different development pathways (Unruh 2000). The pandemic constitutes a major exogenous shock, with the potential to catalyze large-scale actions, such as major public investments and policy shifts, that would be politically infeasible in normal times. How countries respond to this shock—and, in particular, how “green” they make their recovery efforts—will have major implications for their ability to achieve net-zero emissions.

This paper aims to inform the design and communication of net-zero targets, and it brings to the fore some of the issues that policymakers grapple with when designing net-zero targets. For those countries that have made a political commitment to net-zero emissions, this paper may help translate this commitment into a more tangible goal. It primarily focuses on net-zero target setting at the national level, but it may also be relevant to regions, states, cities, and businesses. Appendix C outlines additional issues for cities and businesses, given their emissions boundaries.

## 2. WHY NET ZERO?

### 2.1. Only Net Zero Will Stop Warming

The world has already warmed, on average, by just over 1°C since preindustrial times (IPCC 2018a). Limiting further warming to well below 2°C or even 1.5°C, as set by the Paris Agreement (UNFCCC 2015), will require that global emissions reach net zero, as outlined below.

Different GHGs play different roles in warming the planet. Cumulative carbon dioxide (CO<sub>2</sub>) emissions will be the primary determinant of temperature change in this century; the relationship between cumulative emissions and projected global temperature change is almost linear (IPCC 2014). As long as net CO<sub>2</sub> emissions are above zero, CO<sub>2</sub>

will continue to accumulate in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), “Limiting global mean temperature increase at any level requires global CO<sub>2</sub> emissions to become net zero at some point in the future” (IPCC 2018a; emphasis added). Although shorter-lived GHGs such as methane (CH<sub>4</sub>) and hydrofluorocarbons (HFCs) do not accumulate in the atmosphere for a long time, they are nevertheless strong climate forcers and play a critical role in determining the level of warming we experience.

The IPCC presents scenarios that show the temperature increases associated with different emissions trajectories for CO<sub>2</sub> only and for the Kyoto GHGs<sup>4</sup> collectively. By considering a wide range of scenarios from various integrated assessment models, scientists can identify the trajectories that emissions generally follow under different temperature outcomes. For example, in scenarios that limit warming to below 1.5°C during the entire 21st century, the median year in which CO<sub>2</sub> emissions reach net zero is 2044, and the median year in which all Kyoto GHGs reach net zero is 2066. Crucially, emissions do not stop declining at net zero—they ultimately become net negative. Nearly all IPCC pathways consistent with 1.5°C show net-negative CO<sub>2</sub> emissions this century, making up for residual emissions of other gases and/or drawing down accumulated CO<sub>2</sub> (IPCC 2018a). Table 1 shows the years in which CO<sub>2</sub> and Kyoto GHGs reach net zero in scenarios associated with various temperature outcomes.

The timeline for achieving net zero will vary significantly among countries. This is underscored by the fact that whereas some countries currently have net-negative emissions, others aim to reach net zero in 2050. If warming is to be limited to below 1.5°C, however, any country that still has net-positive CO<sub>2</sub> emissions in 2044 or net-positive GHG emissions in 2066 will need to be matched by negative emissions in other countries. Beyond those years, when net-negative emissions are required, remaining emissions will need to be not only matched but also exceeded. Section 5.2 discusses net-zero target time frames at the country level.

Table 1 | **Timeline for Net-Zero Emissions of CO<sub>2</sub> and Kyoto GHGs under Various Temperature Scenarios**

SCENARIO CLASS	MEDIAN (25TH AND 75TH PERCENTILE) NET-ZERO YEAR	
	CO <sub>2</sub>	KYOTO GHGS
Pathways limiting peak warming to below 1.5°C during the entire 21st century, with 50–66% likelihood	2044 (2037–54)	2066 (2044 to post-2100)
Pathways limiting median warming to below 1.5°C in 2100, with a 50–67% probability of temporarily overshooting 1.5°C earlier in the century	2050 (2047–55)	2068 (2061–80)
Pathways limiting peak warming to below 2°C during the entire 21st century, with greater than 66% likelihood	2070 (2063–79)	post-2100 (2090 to post-2100)

Note: CO<sub>2</sub> = carbon dioxide; GHG = greenhouse gas.

Source: IPCC 2018a.

## 2.2. The Rationale for a Net-Zero Target

The pursuit of a net-zero target is perhaps the most ambitious collective undertaking in human history. It will require a worldwide transformation of economies and societies. Countries that have chosen to adopt net-zero targets have been motivated by a variety of factors. Some broad motivations are described below; a more detailed list of reasons for adopting net-zero targets cited by countries themselves is presented in Appendix A.

**Align policy with science.** The majority of countries acknowledge the scientific necessity of reaching net-zero emissions to avoid the most dangerous impacts of climate change.

**Guide policy and decision-making.** At a national level, net-zero targets herald a major shift in systems of economic production. The adoption of a net-zero target acknowledges that widespread transformation is needed and can influence the climate actions of nations, regions, and cities accordingly. See Section 6 for further details.

**Send signals for climate action.** At the international level, formally setting a net-zero target sends a clear signal to the world that a country is committed to achieving the temperature goals set in the Paris Agreement (Levin et al. 2018). This signal provides greater certainty and direction to businesses and investors as well as to other countries.

### **Strengthen social and economic development.**

Countries may design a long-term development pathway that is socially and economically beneficial and sustainable and, secondarily, may align with the Paris Agreement. Decarbonization associated with a net-zero target can complement efforts to achieve long-term social, environmental, and economic priorities, including cleaner air, improved energy security and energy access, and fairer income distribution, among others (DDPP 2015). Strong net-zero targets can shift investment to avoid locked-in and stranded assets. In addition, they can help anticipate technology and innovation trends so that policies can be designed in ways that allow them to take full advantage of economic opportunities (Levin et al. 2018).

**Leverage international finance.** A clear net-zero target may create opportunities to access international finance for national development. For example, as a result of Costa Rica's strong National Decarbonization Plan, the government has received a policy-based loan from the Inter-American Development Bank and the Agence Française de Développement. The funds received will be used to tackle the constraints of the COVID-19 pandemic (IDB 2020).



### 3. DEFINING NET ZERO

The Paris Agreement calls for the world to achieve “a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.”<sup>5</sup> The concept of balancing emissions and removals is akin to reaching net-zero emissions.

At the global level, the term *net-zero emissions* means achieving a balance between anthropogenic emissions and removals of GHGs in a given time period (typically a year). At the country level, the basic definition of *net-zero emissions* (excluding international transfers of GHG mitigation) is as follows: GHG emissions released to the atmosphere from sources within the country’s territory in the target year do not exceed GHGs removed from the atmosphere by sinks within the country’s territory in the target year.

Some countries include international transfers of GHG mitigation in the definition of net-zero emissions. The following definition is a variation that includes international transfers of GHG mitigation: GHG emissions released to the atmosphere from sources within the country’s territory in the target year (minus GHG mitigation acquired from other countries) do not exceed GHGs removed from the atmosphere by sinks within the country’s territory in the target year (minus GHG mitigation transferred to other countries).

These definitions refer to anthropogenic GHG emissions and removals in units of CO<sub>2</sub> equivalent. Countries can further specify the proportion of the target being met through emissions reductions versus removals (in either definition) or the proportion of domestic GHG mitigation versus international transfers of GHG mitigation (in the second definition). These issues are discussed further in Section 5. Box 1 provides definitions of key terms.

Within a given time period, a country might have net-zero emissions, net-positive emissions, or net-negative emissions; these terms are defined in Table 2. Likewise, countries can set a net-zero target, a net-negative target, or a target that results in net-positive emissions for a given time period.

#### Box 1 | Definitions of Key Terms

**Net-zero emissions at the global level:** A balance between anthropogenic emissions and removals of greenhouse gases (GHGs) in a given time period (typically a year).

**Net-zero emissions at the country level (excluding international transfers of GHG mitigation):** GHG emissions released to the atmosphere from sources within the country’s territory in the target year do not exceed GHGs removed from the atmosphere by sinks within the country’s territory in the target year.

**Net-zero emissions at the country level (including international transfers of GHG mitigation):** GHG emissions released to the atmosphere from sources within the country’s territory in the target year (minus GHG mitigation acquired from other countries) do not exceed GHGs removed from the atmosphere by sinks within the country’s territory in the target year (minus GHG mitigation transferred to other countries).

**Greenhouse gases:** These include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>), and nitrogen trifluoride (NF<sub>3</sub>).

**Emission:** The release of a GHG to the atmosphere by a source.

**Removal:** The transfer of a GHG (primarily CO<sub>2</sub>) from the atmosphere by a sink to long-term storage within a pool, such as trees, soil, or geologic reservoirs.

**Source:** A physical unit or process that releases a GHG into the atmosphere (such as fuel combustion, cement production, livestock management, and waste disposal).

**Sink:** A physical unit or process that removes and stores a GHG from the atmosphere (such as photosynthesis and direct air capture).

Governments have used different terminology to describe their targets, such as carbon neutrality, climate neutrality, net-zero emissions, phaseout, and/or net-CO<sub>2</sub> removal. Some have used different terms intentionally to refer to different forms of targets (e.g., coverage of gases), whereas others have used them interchangeably.

Table 2 | Definitions of Net-Zero, Net-Positive, and Net-Negative Emissions

LEVEL OF NET EMISSIONS	DEFINITION
<b>Net-zero emissions</b>	Annual GHG emissions within a country's territory in year $X$ = Annual GHG removals within a country's territory in year $X$
<b>Net-positive emissions</b>	Annual GHG emissions within a country's territory in year $X$ > Annual GHG removals within a country's territory in year $X$
<b>Net-negative emissions</b>	Annual GHG emissions within a country's territory in year $X$ < Annual GHG removals within a country's territory in year $X$

Notes: GHG = greenhouse gas. These definitions exclude international transfers of GHG mitigation.

Source: Authors.

Countries also have interpreted net-zero targets in different ways. Variations in net-zero targets that countries have adopted or proposed include the following:

- **Net-zero or net-negative targets:** Whether to aim to reach only net-zero emissions or to also aim to reach net-negative emissions after achieving net-zero emissions.
- **Target boundary:** Comprehensive or partial coverage of sectors and GHGs.
- **Target time frame:** The year or range of years in which the target will be achieved.
- **Role of emissions reductions versus removal enhancements:** Whether to specify the relative role of emissions reductions and removal enhancements in meeting the net-zero target, or whether any proportion of emissions reductions and removal enhancements meets the definition.
- **International transfers of GHG mitigation:** Whether the term *net zero* applies to territorial emissions and removals or whether GHG emissions reductions or removal enhancements occurring outside of the country's territory are counted towards the country's net-zero target; for example, through the transfer of credits.

## 4. SITUATING THE NET-ZERO TARGET IN THE POLICY PROCESS

### 4.1. The Policy Setting

Net-zero targets have taken a number of different forms, in different policy instruments, and differ widely regarding the binding nature of the commitment. The strength of the policy setting for the net-zero target will likely affect the extent to which it compels a country to take near-term action towards achieving the target. An examination of net-zero targets reveals various policy settings. The initial choice of policy is influenced by country-specific factors, and it can change over time as a country strengthens and clarifies its net-zero target and pathway:

- **Law.** Several countries have adopted formal legislation. In 2017, Sweden passed the Climate Act and Climate Policy Framework to be carbon neutral by 2045 (Swedish Environmental Protection Agency 2019). In 2019, the United Kingdom passed an amendment to its existing climate change law to bring all GHG emissions from an 80 percent reduction from 1990 levels to net zero by 2050 (BEIS 2019). France also voted a net-zero target into law in 2019. Scotland adopted the Climate Change (Emissions Reduction Targets) Act in 2019 (Government of Scotland 2019), which aims to reduce emissions to net zero by 2045. Denmark adopted the Climate Change Act in 2019, which commits to reach net-zero emissions by 2050 at the latest (State of Green 2019). New Zealand also adopted legislation in 2019 that sets goals to achieve

net-zero emissions by 2050. The European Council agreed to the objective of achieving climate neutrality by 2050 in December 2019, and the European Commission proposed on March 4, 2020, the first European Climate Law, which would enshrine the 2050 climate-neutrality target in law (European Commission, n.d.). A law or similar binding policy document may be the best vehicle to send long-term policy signals, persist through political cycles, and drive changes in near-term decision-making. Climate laws often include governance arrangements that support tracking progress, further facilitating its implementation.

- **Parliament or cabinet decision.** Following the adoption of the Paris Agreement, Norway’s parliament motioned to achieve net-zero GHG emissions by 2030 with international offsets (Norway Energy and Environment Committee 2016). In 2019, Japan’s cabinet adopted a plan to reduce GHG emissions to zero in the second half of the 21st century, “as close as possible to 2050” (MOE 2020). Parliament and cabinet decisions may send clear signals and support administrative efforts and policymaking, but they may be more difficult to maintain during political change.
- **Nationally determined contribution (NDC).** Countries may declare their aspirations to achieve net-zero through their NDCs or other national reports or strategies communicated to the United Nations Framework Convention on Climate Change (UNFCCC). For example, Bhutan reaffirmed its 2009 commitment to remain carbon neutral in its intended NDC (NEC 2015). Several other countries have similarly indicated net-zero aims in their NDCs, including Costa Rica, the Marshall Islands, and Norway (ClimateWatch 2020). NDCs allow countries to implement their net-zero target in a progressive fashion and to adjust medium-term climate commitments.
- **Long-term strategy.** Countries may also communicate net-zero targets in their long-term strategies under the Paris Agreement,<sup>6</sup> the only international process relating to long-term targets. For example, as its official long-term strategy, Costa Rica submitted its National Decarbonization Plan, which aims to decarbonize its economy and reach net-zero emissions in 2050. Other countries that include net-zero targets in their long-term strategies include

Fiji, France, Japan, the Marshall Islands, Portugal, and the European Union (ClimateWatch 2020).

- **Collective commitment.** Countries may choose to collectively express their aspirations to achieve net zero at some point in the future. For example, the Carbon Neutrality Coalition is a cooperative initiative whereby 29 country governments agree to “develop long-term low-greenhouse gases emission climate-resilient development strategies, in line with the agreed long-term temperature increase limit” (Carbon Neutrality Coalition, n.d.). Because limiting global temperature increase to well below 2°C and pursuing efforts to limit it to 1.5°C above preindustrial levels will require net-zero emissions, the international community has been interpreting such a commitment as an intent to adopt a net-zero target (Prensa Presidencia 2019). Similarly, the Climate Ambition Alliance is an initiative of countries as well as cities, regions, businesses, and investors committed to achieving net-zero CO<sub>2</sub> emissions by 2050.<sup>7</sup> Under both initiatives, some countries do not yet have binding national targets.
- **Policy position.** Many countries state net-zero targets as a policy position but have not enacted formal laws. Targets may be expressed through policy positions put forward by the president or prime minister or by other branches of government. For example, in August 2019 the Federal Council of Switzerland announced a target to reduce net emissions to zero by 2050. The Federal Office for the Environment will draw up a 2050 climate strategy to be finalized by the Federal Council in 2020 (Federal Council of Switzerland 2019). Other countries with public policy positions supporting net zero include Canada, Finland, Iceland, and Ireland.

## 4.2. Institutional Arrangements, Public Engagement, and Data and Analysis Needs for Net-Zero Target Design

Regardless of the policy setting, a net-zero target signals a country’s political commitment to transform its economy to a zero-carbon future, which will require leadership, support, and buy-in. The form of the net-zero target will dictate some of the preparatory steps—many of which will be the same as for other climate-related commitments. However, designing a net-zero target may be a fundamentally different exercise for some countries.



Well-designed net-zero targets imply transformative change, with impacts felt by all economic sectors and all people, in contrast to the more incremental change that is often implied by near- and midterm policies, including most NDCs. These high stakes magnify the importance of a design process that is participatory, transparent, and has high-level support from elected officials and the public.

#### 4.2.1. Institutional Arrangements

It can be helpful to designate a lead institution to manage the design process. The closer the lead institution is to the highest level of government (e.g., the prime minister's or president's office), the more buy-in will be maintained (Levin et al. 2018). The head of state may designate an institution to lead the development process. For example, the Costa Rican president made a direct request to the minister of environment and energy to undertake the process to design the long-term climate strategy, including a net-zero target (Elliott et al. 2019). Additional broader support from other ministries, the legislature, and, importantly, those who are most impacted will be critical for enhancing the target's durability and increasing its prospects for withstanding future government changes. A whole-of-government and whole-of-society approach can help foster greater coherence and coordination, looking across the entire economy for mitigation opportunities (Levin et al. 2018). For example, the United Kingdom is engaging different branches of government and nongovernmental actors to work with the treasury on ways to fund efforts—including an equitable balance of contributions—to meet its net-zero target (HMT 2019). The United Kingdom is also supporting business through the Industrial Energy Transformation Fund, which aims to help energy-intensive industries reduce their emissions (BEIS 2020). The United Kingdom and several other countries have established independent bodies (e.g., the United Kingdom's Committee on Climate Change) that are sheltered from the political process and can advise on the design of the target.

The lead institution will play an important coordination role within government: raising awareness of net-zero target setting, seeking input into the design process, and ensuring alignment with other policymaking processes. Coordination will be required across government institutions—including sectoral and other planning ministries, the finance ministry (to integrate and align efforts with budgetary decisions and support implementation), and parliament, as applicable—as well as among technical experts.

In addition to coordination, a governance framework will be necessary to facilitate and independently evaluate progress towards the net-zero target. In Sweden, for example, the Climate Policy Council, an independent interdisciplinary expert body, submits a progress report to the government (Swedish Environmental Protection Agency 2019). In France, the High Council on Climate tracks progress on the net-zero target and provides recommendations to the government on how to adjust policies accordingly. The establishment of short-term carbon budgets, as in France, New Zealand, and the United Kingdom, facilitates coherence between shorter- and longer-term policymaking.

#### 4.2.2. Engaging Stakeholders

Experience with policymaking related to decarbonization suggests that designing a net-zero target will require a national dialogue on climate action, particularly in priority abatement sectors. Focused dialogue can support just transitions for businesses and workers in high-emissions sectors (Levin et al. 2018). Engaging stakeholders beyond national government, including the general public, the private sector, civil society organizations, and subnational governments, can strengthen the quality of the net-zero target, its legitimacy, and its durability. In Japan, before the national long-term strategy was adopted, the government and major Japanese car companies collaborated to develop a long-term strategic road map for the car manufacturing industry. The process helped to ensure this critical stakeholder group supported the objective of achieving zero emissions in the sector (METI 2018). Likewise, Norway has invited industry to provide input into sectoral road maps, identifying opportunities and barriers and informing the vision (Ministry of Climate and Environment 2018).

Engagement can occur via stakeholder consultation groups and online comment platforms and by sharing drafts of the target design. Some countries, such as the United Kingdom, have established citizens' assemblies to inform the pathway to net-zero emissions (Batha 2020). In New Zealand, the Climate Leaders Coalition promotes domestic business leadership and collective action on climate change and aligns with the government's ambitions in the Zero Carbon Bill.<sup>8</sup> Some countries have chosen to rely on existing engagement processes for other climate decision-making, such as those related to domestic climate laws, the NDC, and/or the long-term strategy.

### 4.2.3. The Need for Data and Analysis

When preparing for net-zero target design, governments may choose to update their national inventory to understand current emissions levels and identify high-emitting sectors and priority GHGs. They may also improve land-sector estimates, given the role that land-based removals could play in achieving net-zero emissions.<sup>9</sup>

Quantitative scenarios examining different pathways to achieving net-zero emissions are central to understanding options for reaching the target and help inform discussions with stakeholders concerning the implications in terms of trade-offs and opportunities that will arise. Scenarios also allow exploration of interactions between sectors. Mitigation assessments can be conducted to help identify mitigation options, including policies, actions, and technologies that contribute to plausible decarbonization rates, and assess the implications of various net-zero emissions trajectories. Some countries may choose to estimate their future sinks in an effort to understand the implications for the decarbonizing effort required of other sectors to reach the overall target of net-zero emissions.

## 5. DESIGNING A NET-ZERO TARGET

### 5.1. Defining the Target Boundary

The target boundary refers to the GHGs and economic sectors that are included in the net-zero target. The choice of target boundary can significantly affect the impacts of the net-zero target on emissions as well as the choice of mitigation opportunities to be prioritized and incentivized.

#### 5.1.1. Greenhouse Gases

To meet the long-term temperature goals of the Paris Agreement, all GHG emissions<sup>10</sup> must be reduced substantially. Both CO<sub>2</sub> and non-CO<sub>2</sub> emissions can be reduced by broad mitigation measures in the energy, buildings, industry, and transport sectors. In addition, targeted non-CO<sub>2</sub> mitigation measures can reduce nitrous oxide (N<sub>2</sub>O) and CH<sub>4</sub> emissions from agriculture, CH<sub>4</sub> emissions from the waste sector, some sources of black carbon, and HFCs (IPCC 2018a). The net-zero goal cannot be met without a significant contribution from forests and, therefore, the global land sector will need to become increasingly net negative.

As described in Section 2.1, GHGs have different life spans in the atmosphere and different global warming potentials, which can impact how countries set net-zero targets. For example, New Zealand's net-zero target excludes biogenic CH<sub>4</sub>, which accounts for nearly half of the country's total GHG emissions (ClimateWatch 2020). Both CO<sub>2</sub> and N<sub>2</sub>O are "long-lived" GHGs, meaning they exist in the atmosphere for hundreds of years and accumulate. "Short-lived" GHGs, such as CH<sub>4</sub> and most HFCs, exist in the atmosphere for a shorter period (e.g., 12 years in the case of CH<sub>4</sub>) but typically have higher global warming potential than CO<sub>2</sub> (IPCC 2014).

There is a growing argument that long-lived gases need to be reduced to net zero, but short-lived gases need only to be stabilized in the atmosphere or gradually reduced.<sup>11</sup> Reducing emissions of CO<sub>2</sub> to net zero is essential because it is the predominant long-lived GHG. Historic and current emissions accumulate in the atmosphere over centuries. Yet short-lived GHGs also have a powerful impact on near-term global temperature rise because these gases exist in the atmosphere for a relatively short time span and have higher global warming potential than CO<sub>2</sub>. Accordingly, the effect of reducing emissions of short-lived climate pollutants on limiting global temperature rise can be almost immediate. Therefore, we argue that aggressive actions to reduce all GHGs are essential to keep temperature rise below 1.5°C while also limiting significant overshoot of this temperature threshold in the near term. Additionally, early action on some short-lived gases and pollutants, such as CH<sub>4</sub> and black carbon, may have considerable social and economic cobenefits, including reduced air pollution and improved public health (Shindell et al. 2017).

It is against this backdrop that most countries have set net-zero targets that cover the full basket of UNFCCC GHGs (see Appendix B). There are good reasons for doing so:

- It sends strong political signals about the legitimacy and efficacy of the target, both internationally and domestically.
- It clearly demonstrates that no GHGs require special treatment.
- A net-zero target that covers all GHGs is better aligned with Article 4 of the Paris Agreement, which requires a balance between sources and sinks of GHGs in the second half of the century.

To illustrate the last point, no mitigation options currently exist to eliminate all sources of short-lived GHGs such as N<sub>2</sub>O and biogenic CH<sub>4</sub>, which are primarily produced by agricultural processes like fertilizer use and enteric fermentation, respectively. These short-lived emissions must be reduced as much as possible, but reaching total net-zero GHGs will require removals (or net-negative emissions) of CO<sub>2</sub> from the atmosphere to compensate for these residual emissions. These removals can come from natural carbon sinks (for example, trees and soils, which absorb CO<sub>2</sub>) or technological innovations like direct air capture and storage (see Section 5.3).

### 5.1.2. Sectors

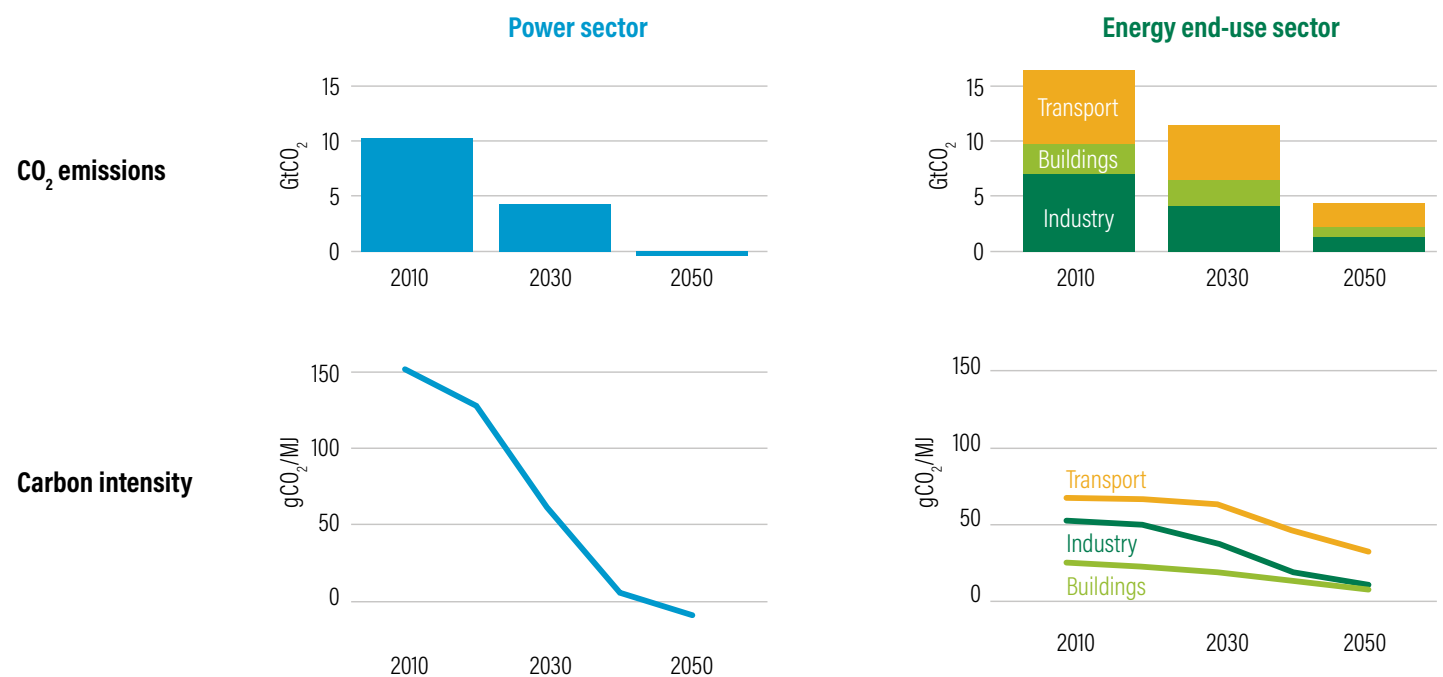
To meet the long-term temperature goals of the Paris Agreement, GHG emissions from all sectors must be reduced substantially. According to the 2018 IPCC *Special Report on the Impacts of Global Warming of 1.5°C*, “Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure

(including transport and buildings), and industrial systems. . . . These systems transitions are unprecedented in terms of scale . . . and imply deep emissions reductions in all sectors” (IPCC 2018b).

Decarbonization trajectories vary by sector. As Figure 1 illustrates, the power sector is decarbonized by 2050 in the 2°C scenario and before 2050 in the 1.5°C scenario. The energy end-use sectors, on the other hand, are still net emitters in 2050.

Land-use transitions pose significant challenges due to competing demands for land, food, and climate mitigation (IPCC 2018b) as well as technological difficulties. Some policy instruments are currently available to reduce emissions in agriculture (Searchinger et al. 2019), but many are still under development or are too expensive to implement (Kuramochi et al. 2018). Therefore, emissions from agriculture will likely need to be balanced by removals from other sectors, at least in the near term. But agriculture should not be excluded from a net-zero target; it can also contribute to achieving the target through carbon storage in soils.

Figure 1 | CO<sub>2</sub> and Carbon Intensity of Power and Energy End-Use Sectors in Low-1.5°C Scenarios



Note: GtCO<sub>2</sub> = gigatonne of carbon dioxide; gCO<sub>2</sub>/MJ = grams of carbon dioxide released per megajoule of energy  
 Source: Adapted from IPCC 2018a.

Countries setting net-zero targets may be guided by their current and future sectoral emissions profiles. In most countries, the energy sector, which involves production (generation) and use (e.g., in buildings, industry, and transport), is the largest emitting sector. But for 24 countries, the agriculture sector is the top source of emissions (primarily CH<sub>4</sub> and N<sub>2</sub>O) (Arcipowska et al. 2019). In such countries, the inclusion of all sectors in a net-zero target would be important to ensure that all major emissions sources are covered by the target. National removal profiles also vary, with some extensively forested countries having substantially more removals as a “starting point” than other countries.

Including all sectors in a net-zero target offers similar benefits to those outlined above for including all GHGs. In addition, including all sectors supports a least-cost-mitigation pathway, where technologies can be employed first in easier-to-abate sectors. Residual emissions in one sector can be balanced by removals in other sectors. And since removals are such a critical component of reaching a net-zero target, the inclusion of the agriculture, forestry, and other land use (AFOLU) sector is particularly important because it is the only sector that offers nature-based removals.

An important decision in designing a net-zero target is whether to include international aviation and shipping since these emissions fall outside of national boundaries (out of jurisdiction). The United Kingdom has established a net-zero target that includes international aviation and shipping (CCC 2019b), but Norway and Sweden have explicitly excluded international aviation and shipping from their net-zero targets. When setting net-zero targets, countries should consider including all international aviation and shipping as a means of reflecting the highest possible ambition, or they may opt for partial inclusion (Levin et al. 2014).

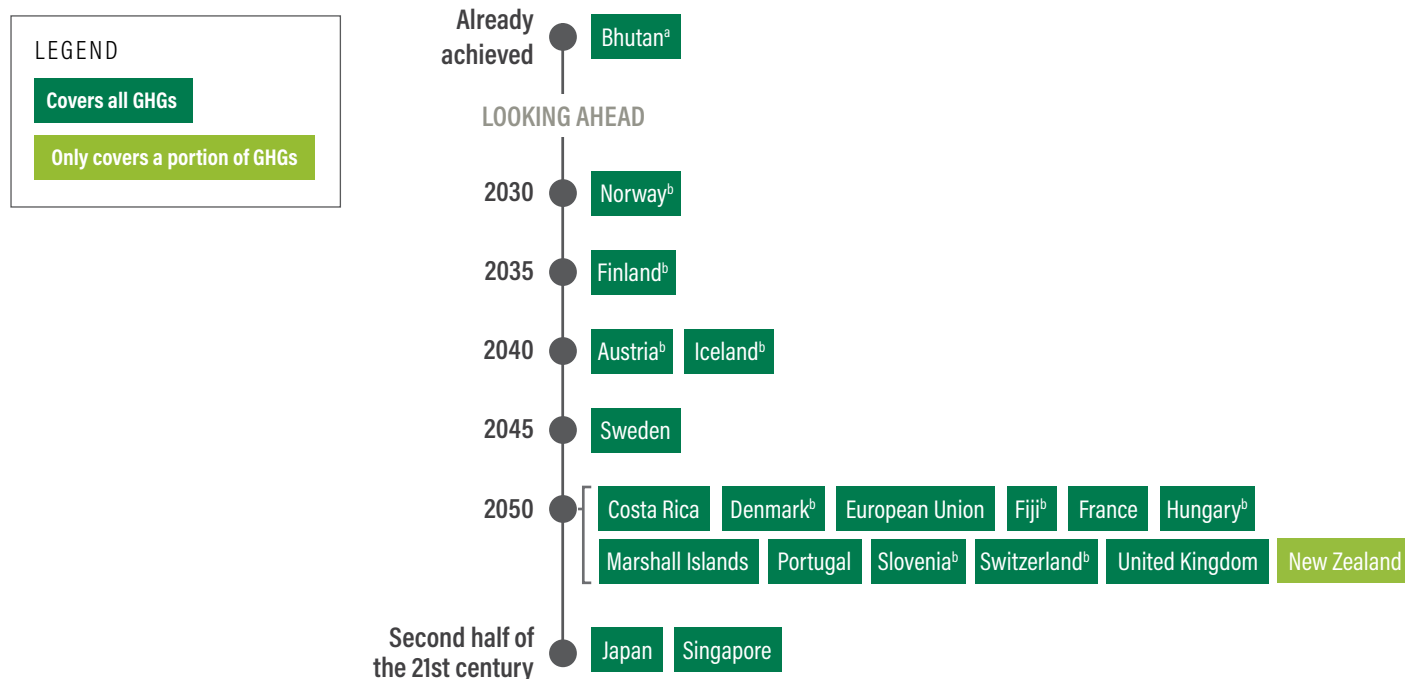
## 5.2. Country-Specific Net-Zero Target Time Frames

Like other GHG targets, net-zero targets are characterized by a year or a range of years in which the specified reduction will be achieved. Countries have established net-zero target time frames ranging from specific years between 2030 and 2050 to more general references to the second half of the century (Figure 2).

Countries should aim to achieve their net-zero target as early as feasible, taking into consideration the following factors:

- **Global scenarios compatible with limiting warming to 1.5°C or well below 2°C.** As outlined in Table 1, scenarios aligned with keeping warming below 1.5°C reach net-zero CO<sub>2</sub> emissions around 2044 and net-zero GHG emissions around 2066. Countries that plan to reach net-zero emissions after these dates implicitly count on their ongoing emissions being offset by other countries achieving stronger net-negative emissions. This is a particularly important consideration for countries with high net emissions. The more emissions that remain after the global net-zero date, the less likely it is that sequestration/removal capacity in the rest of the world will be able to absorb these remaining emissions, compromising the likelihood of reaching global net zero by that year. Therefore, all countries, and especially major emitters, should make every effort to set their net-zero target for a time frame at least as early as the global benchmarks for limiting warming to 1.5°C.
- **The current national inventory of emissions and removals.** Information relevant to setting a target time frame includes how close the country is currently to net-zero emissions, recent trends (are net emissions growing or shrinking, and how fast?), and which sectors and sources are responsible for significant emissions and removals. Countries that are already relatively close to net zero should consider earlier target time frames, particularly if their trends are pointing in the right direction. A small number of countries<sup>12</sup> have already achieved net-zero or net-negative emissions thanks to significant forest carbon removals combined with relatively low emissions from other sectors. Such countries should consider how to maintain net-zero emissions while achieving development objectives. This might involve planning to maintain or enhance natural sinks while setting specific targets for other sectors. The vast majority of countries, however, are still net emitters. They should identify the primary sectors and gases in their inventory and consider the global benchmarks for those sectors (Figure 1) and gases (Table 1) in setting their net-zero time frames.

Figure 2 | The Timing of Countries' Net-Zero Emissions Targets



Notes: GHG = greenhouse gas. Additional countries and regions have proposed adopting net-zero targets, including Ireland, the Netherlands, and Spain; some, such as Chile, are far along in the policymaking process.

a. Bhutan's commitment is to maintain its carbon neutrality.

b. For these countries, we assume complete coverage of GHGs, since no exclusions have been noted explicitly, and means of target achievement include all sectors.

Source: Adapted from Levin and Davis 2020, as adapted from the Energy & Climate Intelligence Unit.

■ **Pathways and options for emissions and removals.** Options for reducing emissions and increasing removals—and their relative costs, benefits, and levels of viability—vary across regions and countries (Griscom et al. 2020; IPCC 2014). Countries with relatively more cost-effective options should set earlier net-zero target dates. That being said, the lack of current abatement options should not deter countries from setting net-zero goals around midcentury. Part of the purpose of long-term planning and goal setting is to identify where further innovation is needed and to direct resources accordingly to facilitate achievement of ambitious goals.

■ **Equity.** The Paris Agreement establishes that Parties should achieve net-zero emissions “on the basis of equity” (Article 4.1). While the agreement itself does not define *equity*, the literature points to various principles associated with equity and its related concept of “effort sharing.” These include the following:

- Responsibility, including historical emissions (Höhne et al. 2014)
- Capability, including human development; resilience to climate impacts; and economic, governance, technical, and innovation capacity (Klinsky et al. 2017)
- Equality, including annual emissions per capita and cumulative emissions per capita (Höhne et al. 2014)



Many studies also consider the cost-effectiveness of abatement options as an effort-sharing principle, although this is typically not considered an equity principle (Höhne et al. 2014).

If countries were to agree on these factors and how to weight them, they could provide a basis for reallocating the remaining carbon budget, and time frames for achieving net zero could be established accordingly. Because such agreement has not been reached, however, countries should instead consider the full range of equity-related principles, emphasizing those that require more rather than less ambitious time frames. Countries should also bear in mind that if all countries selectively apply those principles requiring less ambitious time frames, the Paris Agreement goals will not be met.

Countries will also need to make the following decisions regarding their net-zero target time frames:

- **Whether to establish a target time frame for all gases collectively or to establish different target time frames for CO<sub>2</sub> and non-CO<sub>2</sub> gases.** A collective target offers simplicity in design and flexibility in implementation. For example, if one gas turns out to be easier to abate and another proves more difficult, policymakers can switch the order of gas phaseout without compromising target achievement. This flexibility helps deal with the uncertainty surrounding how technologies and their costs will evolve. However, the benefits of flexibility can be overstated given the need for rapid reduction of all gases. For most countries, CO<sub>2</sub> emissions will need to reach net zero far earlier than other gases. It is important, therefore, not to detract from a sense of urgency on the part of decision-makers in CO<sub>2</sub>-dominant sectors. Countries should establish a collective net-zero time frame, while also outlining sector-specific near- and midterm milestones, either as part of an initial net-zero target announcement or as part of a subsequent implementation plan.
- **Whether to establish a target for a single year or for a multiyear period.** Most countries with net-zero targets have pegged them to a specific year rather than to a multiyear period or an unspecified

time frame. At a minimum, countries should identify a specific year or multiyear period (for example, a five-year period). Choosing a multiyear period rather than a single year affords the possibility of averaging out fluctuations in highly variable sources and sinks. However, it may be more difficult to communicate to stakeholders. Declaring that the country will achieve net zero without mentioning a time frame, or specifying a time frame that is very broad (e.g., “in the second half of the century” or “after year X”), falls short for two reasons. Imprecise targets limit or eliminate accountability for their achievement, and they prevent quantification of the country’s future impact on global emissions.

In sum, countries should establish a net-zero time frame with reference to a specific year or range of years to be reached as early as possible, taking into consideration global scenarios compatible with the Paris Agreement goals, equity principles, and pathways and options for emissions and removals. Major emitters should ensure that their net-zero time frames are at least as early as the global Paris-aligned time frames, and within that group, countries with higher historical and per capita emissions and/or higher capabilities should aim for earlier still. While it is appropriate to specify separate time frames for individual sectors and gases in a net-zero implementation plan, countries should set a single net-zero goal with a single time frame that covers all sectors and gases.

### 5.3. Setting a GHG Emissions Reduction Target

Countries should specify separate targets and pathways for reducing GHG emissions and for achieving net-zero targets that reflect the balance of emissions and removals.

If a net-zero target does not also specify the GHG emissions reductions needed, meeting a net-zero target could rely on overly high rates of annual GHG removals to balance high rates of emissions, which carries significant risks. There is a large degree of uncertainty about the scale and availability of future carbon removals from both land-based carbon sinks and emerging carbon-removal technologies. There are also ongoing risks of reversals and losses from carbon stored in land-based and geologic pools that could negate the climate benefit of carbon removals.

Setting and achieving ambitious emissions reduction targets is therefore critical if the world is to decarbonize sufficiently to reach midcentury climate targets and to avoid the risks and uncertainties of relying on unproven levels of carbon removal. For example, countries should set targets to reduce GHG emissions in line with 1.5°C pathways and enhance carbon sinks to balance any residual emissions to reach net-zero or net-negative emissions. Setting transparent, separate GHG reduction targets and net-zero targets can more effectively inform policy planning and public and private sector investments in GHG reduction and GHG removal practices and technologies at the necessary scale (McLaren et al. 2019).

Countries should therefore work simultaneously to achieve GHG emission reduction targets and net-zero targets, using two complementary GHG targets (Equations 1 and 2):

#### Equation 1. Net-Zero Target (without International Transfers)

ACHIEVED IF:

$$\text{Emissions} - \text{Removals} \leq 0$$

WHERE:

*Emissions* = annual GHG emissions within a country's territory in target year (tonnes of CO<sub>2</sub> equivalent, or tCO<sub>2</sub>e)

*Removals* = annual GHG removals within a country's territory in target year (tCO<sub>2</sub>e)

#### Equation 2. Emissions Reduction Target (without International Transfers)

ACHIEVED IF:

$$\text{Emissions}_{\text{target year}} \leq \text{Emissions}_{\text{base year}} \times (1 - \text{Target Level})$$

WHERE:

*Emissions*<sub>target year</sub> = annual GHG emissions within a country's territory in target year (tCO<sub>2</sub>e)

*Emissions*<sub>base year</sub> = annual GHG emissions within a country's territory in base year (tCO<sub>2</sub>e)

*Target Level* = GHG reduction target level (percent; e.g., 80 percent for a target to reduce emissions by 80 percent below base year levels)

As an example, Sweden has set a goal to achieve net-zero GHG emissions by 2045 and reach net-negative GHG emissions thereafter. Sweden has also set a target for emissions from activities within the country in 2045 to be at least 85 percent below 1990 levels. This implies that up to 15 percent of the 2045 target can be met through CO<sub>2</sub> removal within Sweden or investments in GHG mitigation in other countries. Specific measures may include “increased uptake of carbon dioxide by forests as the result of additional measures; verified emissions reductions carried out outside the Swedish borders; and carbon capture and storage based on the combustion of biomass, known as bio-CCS [carbon capture and storage]” (Swedish Environmental Protection Agency 2019).

## 5.4. The Role of GHG Removal

To meet net-zero targets, countries will likely need to enhance GHG removals to balance residual GHG emissions arising within their borders. Residual emissions are the emissions remaining after a country has significantly reduced its GHG emissions, ideally in line with a 1.5°C emissions reduction pathway.

GHG removal, primarily CO<sub>2</sub> removal, can take the form of biogenic removals (i.e., photosynthesis) or technological removals. A removal is the transfer of a GHG from the atmosphere to storage within a pool, such as trees, soil, or geologic reservoirs. Emerging technologies that can remove CO<sub>2</sub> include direct air capture, in which CO<sub>2</sub> is extracted directly from the ambient air, and enhanced weathering, which speeds up weathering rates in reactive materials to sequester CO<sub>2</sub>. Emerging approaches, such as bioenergy with carbon capture and storage, involve both biogenic and technological elements.

For removals to effectively counterbalance the climate impact of CO<sub>2</sub> emissions accumulating in the atmosphere, carbon removed from the atmosphere must be securely and, to the extent possible, permanently stored, without leakage of emissions to other countries. For example, CO<sub>2</sub> removed through direct air capture (as well as CO<sub>2</sub> captured from point sources of emissions, which is an emissions reduction rather than a CO<sub>2</sub> removal technology) must be securely stored in geologic reservoirs that maximize permanent storage. Measures to remove CO<sub>2</sub> from the atmosphere through biogenic or technological processes must be coupled with requirements to permanently store the removed carbon, including requirements and incentives for long-term monitoring and verification to avoid or compensate for any leakage or reversals.

### 5.4.1. Biogenic Removals

Terrestrial carbon stocks (such as forests) must be maintained and enhanced over time. Maintenance of a stable land-based carbon stock does not itself constitute a removal, unless carbon stocks are growing. Increasing the carbon stock over time (e.g., through afforestation, reforestation, or restoration) constitutes a removal. Conversely, failure to maintain an existing land-based carbon stock (e.g., through deforestation or forest degradation) constitutes an emission.

In most countries, removals by the land sector are small relative to total emissions, meaning that steep reductions in GHG emissions will be needed to meet net-zero targets. Many countries also have AFOLU activities that generate net emissions rather than net removals and will need to be reduced or counterbalanced by removals.

Countries with significant current or future potential removals (e.g., heavily forested countries) should aim to reach net-zero or net-negative emissions by an earlier date due to their increased capacity to remove CO<sub>2</sub> compared to countries with less significant carbon sinks. Changes in carbon stocks (emissions and removals) on all lands should be regularly monitored and reported.

### 5.4.2. Technological Removals

The climate benefit of CO<sub>2</sub> removal technologies depends on how they are used. For example, direct air capture with carbon storage can have net-negative emissions by removing CO<sub>2</sub> from the atmosphere and storing it in geologic reservoirs without rereleasing it. The ability of direct air capture and utilization in CO<sub>2</sub>-based products to remove and store CO<sub>2</sub> depends on whether the carbon is rereleased during product use or is stored for the long term in long-lived products. (The GHG impact in both cases depends on using zero- or low-carbon energy sources in the direct air capture process and other life cycle emissions.)

Carbon capture and storage involves capturing CO<sub>2</sub> emissions from fossil fuels at the point of combustion and sequestering the gas in geological formations. The technique avoids an increase in emissions but does not lead to net-negative emissions because it does not involve removing CO<sub>2</sub> from the atmosphere. More information on carbon removal is available in other World Resources Institute publications.<sup>13</sup>

## 5.5. International Transfers of GHG Mitigation

Some countries have adopted net-zero targets that reflect the balance of GHG emissions and removals occurring within their national borders. The European Union and France, for example, have specified that they will not use international GHG mitigation to help reach their net-zero targets.

Other countries envision meeting net-zero targets in part through investments in or payments for emissions reductions or removal enhancements occurring outside their territory. Sweden and Switzerland, for example, have indicated that they plan to use a limited amount of international GHG mitigation to reach their net-zero targets for 2045 and 2050, respectively. Appendix B summarizes which countries' net-zero targets include or exclude international GHG mitigation.

To limit warming to 1.5°C, global CO<sub>2</sub> emissions need to reach net zero on average by 2044 (in scenarios with low or no overshoot), and total GHG emissions need to reach net zero on average by 2066 (IPCC 2018a). Reaching global net-zero CO<sub>2</sub> emissions in 2044, therefore, requires that either:

- each country's territorial CO<sub>2</sub> emissions are lower than its territorial CO<sub>2</sub> removals by 2044 (and 2066 for all GHGs); or
- some countries reach net-negative emissions by 2044 to counterbalance others having net-positive emissions at this point in time.

Some countries have greater domestic opportunities to reduce emissions or enhance removals (such as large-scale potential for biogenic or technological carbon removal and storage) and therefore may reach net-negative emissions sooner than other countries, which can be used to compensate for the net-positive emissions of countries with fewer domestic opportunities.

As global emissions approach net zero, countries using international GHG mitigation should purchase from countries that have net-negative emissions and therefore have a surplus of removals which could be used to counterbalance residual emissions in countries that have fewer domestic mitigation opportunities. Unless countries selling GHG mitigation have net-negative emissions, countries that plan to purchase international GHG mitigation make it more difficult for host countries to reach net-zero emissions themselves (because transfers to other countries are deducted from their net-zero target

accounting, as shown in Equation 3). To complement this approach, access to finance should be provided to developing countries to achieve their own GHG reduction, GHG removal, and net-zero or net-negative goals.

Countries should prioritize reducing domestic GHG emissions and enhancing domestic GHG removals rather than relying on purchases of GHG mitigation as a primary means of meeting a net-zero target. If international transfers of GHG mitigation are used to meet the target, countries should consider limiting the portion of the net-zero target that may be met through international GHG mitigation. A limit will maintain clear signals for domestic mitigation and investment and avoid locking in long-lived carbon-intensive infrastructure. While the quantity of international GHG mitigation used to achieve the net-zero target in the target year should be limited, countries can separately invest in GHG mitigation in other countries as a near-term strategy on the pathway to reaching net zero.

Countries intending to purchase international GHG mitigation to meet their targets should also consider increasing their overall target ambition. Purchasing international GHG mitigation can enable countries to achieve a higher level of overall GHG mitigation, which can take the form of achieving a net-negative rather than net-zero target, or achieving net-zero emissions (with purchased transfers included) significantly earlier than the global average.

Opportunities to transfer emissions reductions between countries are expected to be limited as the global emissions budget declines significantly by midcentury.

Opportunities to transfer removals between countries could remain, for example if technologies such as direct air capture and storage are developed and deployed on a global scale.

A system that includes international transfers of GHG mitigation between countries requires amending Equations 1 and 2 to reflect purchases and sales of GHG mitigation. The following equations (Equations 3 and 4) would be used to define net-zero emissions, using two complementary GHG targets, taking into account transfers between countries.

Alternatively, countries could set a net-zero target that includes international transfers (Equation 3) while setting an emissions reduction target that excludes international transfers and is based on domestic emissions only (Equation 2). This is the approach used by Sweden, as described above.

### Equation 3. Net-Zero Target (with International Transfers)

ACHIEVED IF:

$$Emissions - Removals - Purchases + Sales \leq 0$$

WHERE:

*Emissions* = annual GHG emissions within a country's territory in target year (tCO<sub>2</sub>e)

*Removals* = annual GHG removals within a country's territory in target year (tCO<sub>2</sub>e)

*Purchases* = international GHG mitigation purchased or acquired (tCO<sub>2</sub>e)

*Sales* = international GHG mitigation sold or transferred (tCO<sub>2</sub>e)

### Equation 4. Emissions Reduction Target (with International Transfers)

ACHIEVED IF:

$$Emissions_{target\ year} - Purchases + Sales \leq Emissions_{base\ year} \times (1 - Target\ Level)$$

WHERE:

*Emissions<sub>target year</sub>* = annual GHG emissions within a country's territory in target year (tCO<sub>2</sub>e)

*Purchases* = international GHG mitigation purchased or acquired (tCO<sub>2</sub>e)

*Sales* = international GHG mitigation sold or transferred (tCO<sub>2</sub>e)

*Emissions<sub>base year</sub>* = annual GHG emissions within a country's territory in base year (tCO<sub>2</sub>e)

*Target Level* = GHG reduction target level (percent; e.g., 80 percent for a target to reduce emissions 80 percent below base year levels)

Countries that use international GHG mitigation to meet their target should ensure that only surplus mitigation is transferred and that systems are in place to avoid double counting GHG emissions reductions or removals between countries.

Countries should also consider potential negative impacts outside national borders. Leakage can arise when efforts to reduce emissions or enhance removals within a country's borders lead to increased emissions or reduced removals in other countries. Countries should consider potential leakage impacts when designing strategies to reduce domestic emissions and implement measures to minimize leakage occurring in other countries.



## 6. USING THE TARGET TO INFORM ACTION

As outlined in Section 2, net-zero targets are envisioned as a core element of a broader, comprehensive climate policy package. Other elements will do the “heavy lifting” of implementing the transformative change needed to drive net emissions down to zero. Like any other emissions target in climate policy, net-zero targets are primarily useful insofar as they are integrated into these other elements of the policy package.

Interim targets are one element of such a package, and they set periodic milestones against which to measure GHG emissions and/or other indicators en route to achieving net-zero emissions. Alignment of near- and midterm milestones with the overall trajectory towards net-zero emissions is important in light of path dependence (Sachs et al. 2016; Unruh 2000). However, because the transitions that deliver long-term GHG reductions in complex sectors like the energy sector are nonlinear (Iyer et al. 2017), interim emissions milestones should not necessarily be based on a linear trajectory from current emissions to net-zero emissions. Rather, such milestones can be informed by more detailed modeling of pathways that reflect the characteristics of the transition in a particular country. These pathways, in turn, can be used to establish interim GHG and non-GHG targets (e.g., targets pertaining to the energy mix, vehicle technologies, or building standards) and to identify the implementing measures to support them.

Such a policy package also includes a broad suite of implementation policies and measures that will achieve the net-zero target and associated milestones. Implementing measures may include framework legislation and strategies, economic policy instruments, regulatory instruments, and other approaches, such as information policies, procurement policies, and voluntary agreements (Somanathan et al. 2014). Such policies can address not only the technological transitions needed in each sector but also the alignment of governance arrangements and financial flows to support the transition. They should also include plans to support workers and communities that may otherwise be negatively affected by economic and social change. Implementing policies and measures should also be selected with regard to the synergies and trade-offs between climate change mitigation and the Sustainable Development Goals (IPCC 2018a). Article 4.1 of the Paris Agreement establishes that Parties should achieve net-

zero emissions “in the context of sustainable development and efforts to eradicate poverty.”

Finally, the aspirational nature of net-zero targets means that they may be set before cost-effective abatement options are available for all sources of a country’s emissions. When developing policy packages to achieve net-zero targets, countries can be transparent about where such gaps exist. For instance, the United Kingdom has developed scenarios around three categories of options: core options (low-cost, no-regrets measures), further ambition options (available but more expensive options), and speculative options (characterized by low levels of technological readiness) (CCC 2019a). This approach can help countries target research and development spending, identify roles for international cooperation, and, for developing countries, make explicit their needs for international finance, technology, and capacity building.

In translating a net-zero target into action, countries should take the following steps<sup>14</sup> while engaging stakeholders, as discussed in Section 4.2.2:

- Model scenarios and pathways to achieve net-zero emissions.
- Identify sector-specific technologies, infrastructure, investments, and behavioral changes that underpin the pathways, particularly those that are robust across multiple scenarios.
- Use the pathways to inform the establishment of near- and midterm GHG and non-GHG targets in NDCs and domestic framework legislation, strategies, and sectoral plans.
- Consider synergies and trade-offs with Sustainable Development Goals.
- Identify implementing policies and measures to support the transitions identified by the pathways and work to advance them in national and subnational governments and with other stakeholders, including the private sector and civil society.
- Identify finance, technology, and capacity needs associated with achieving net-zero targets.
- Monitor progress towards the target—as well as the assumptions underlying the pathways—on an ongoing basis, adjusting policies as needed.



## 7. COMMUNICATING NET-ZERO TARGETS

Clearly communicating a net-zero target to domestic and international stakeholders is essential if a genuine commitment to transform economic systems is not to be perceived as political greenwashing. If a net-zero target is not clearly articulated, it can send mixed signals to domestic stakeholders and other countries. It will also be difficult for people to understand whether the target is in fact aiming to achieve a balance between emissions and removals. Clear communication will facilitate effective governance and policymaking to support the required transformation.

Several formats exist for communicating net-zero targets, and there are no reporting requirements to follow. The Greenhouse Gas Protocol Mitigation Goal Standard includes a list of information that should be communicated when committing to GHG targets to provide sufficient transparency (Levin et al. 2014).

Box 2 provides a summary of recommendations for relevant information to communicate regarding net-zero target details.

### Box 2 | Communicating Net-Zero Targets

Governments can help to ensure broad understanding of their net-zero targets by providing the following information:

- The greenhouse gas (GHG) coverage of the target and justification for any GHGs excluded from the target.
- The sector coverage of the target and justification for any sectors excluded from the target, including whether and how a country's existing forest carbon sink is included in the target and whether international aviation and shipping is included/excluded from the net-zero target.
- The specific year or multiyear time frame for achieving net-zero emissions.
- Justification for the chosen time frame in view of global scenarios compatible with limiting warming to 1.5°C or well below 2°C, equity principles, and pathways and options for emissions and removals.
- Separate targets for GHG emissions reduction (i.e., the target level of gross GHG emissions in the target year) in addition to net-zero or net-negative targets.
- Whether the target will be achieved by balancing GHG emissions and GHG removals within the country's territory or through some use of international transfers of GHG mitigation (emissions reductions or removal enhancements) occurring in other countries.

- If international GHG mitigation is used, a description of any limit on the portion of the net-zero target being met through international GHG mitigation; in addition, approaches to ensure that only surplus mitigation is transferred, double counting is avoided, and the environmental integrity of transferred GHG emissions reductions or removal enhancements is ensured between countries.

Supplemental information could include the following:

- Cross-references to any policy documents in which the target is included (e.g., domestic legislation, a long-term, low-emissions development strategy under the Paris Agreement, political announcement, or other international or domestic policy documents).
- Historical and projected levels of GHG emissions and GHG removals.
- An explanation of how the target will be accounted for, to the extent known (such as the data sources and accounting methodology, in particular for the agriculture, forestry, and other land-use sector).
- If scenarios were used, underlying assumptions regarding technology costs and development, behavioral patterns, and socio-economic parameters related to associated net-zero scenarios.

- The types (and, if relevant, quantities) of carbon removals expected to be used to meet the target.
- Policies to ensure secure storage of carbon dioxide in terrestrial and geologic reservoirs, including requirements and/or incentives for ongoing monitoring and verification to avoid or compensate for any leakage or reversals.
- Information on how the net-zero target will inform action, including:
  - scenarios and pathways for achieving the target;
  - sector-specific technologies, investments, and behavioral changes needed to achieve the target;
  - interim GHG and non-GHG targets and milestones, including clarity as to the relationship between the nationally determined contribution and the net-zero target;
  - implementing policies and measures (including, if relevant, alignment of financial flows as well as just transition plans); and
  - the remaining needs for innovation, finance, technology, and capacity building.
- Any plans to monitor and report on progress.

---

## 8. CONCLUSION AND RECOMMENDATIONS

The science is clear that not only do emissions need to peak in the very near future and steeply decline thereafter, but net emissions also must be phased out altogether if we are to meet the Paris Agreement's temperature goals and avoid the worst impacts of climate change (IPCC 2018a). It is encouraging that many countries are embracing the goals of the Paris Agreement at the national level and adopting net-zero targets. The COVID-19 pandemic presents a tremendous challenge as countries address an unprecedented health crisis, job losses, poverty, and inequity. At the same time, it also presents a once-in-a-lifetime opportunity to reshape investments in a net-zero, equitable, and just future.

Decision-makers face several choices when designing net-zero targets. This paper argues that to maximize the contribution of net-zero targets to drive decarbonization in line with climate science, countries should consider the following recommendations.

**Achieving net-zero emissions will require fundamental shifts in how society operates.** While there are significant opportunities associated with a zero-carbon future, there will be winners, losers, and trade-offs along the way to achieving this vision. Robust stakeholder processes can play a critical role in surfacing and managing trade-offs, promoting societal buy-in, and helping to ensure a just transition. Participation can facilitate more effective, inclusive decision-making and ultimately greater support for climate action. Importantly, participatory processes help translate net-zero targets into other decision-making processes, guiding the design of near- and midterm targets, policies and measures, and investments to support necessary transitions. Securing high-level political support and engaging relevant ministries, parliaments, experts, and the public can also enhance a net-zero target's prospects for withstanding future government changes. Independent expert bodies can help provide accountability and review design and implementation choices. Governments should also consider the most effective legal status of the target. Depending on the national context, a law or other binding policy may be the best instrument to send long-term policy signals and drive changes in near-term decision-making. Legal commitment will help ensure that net-zero targets are not just aspirational visions that fail to have any bearing on today's decisions; rather, these targets will become transformative instruments that drive action towards realizing the goals of the Paris Agreement.

**Net-zero targets should be comprehensive.**

They should cover all GHGs and all sectors.

**Governments should establish specific time frames for achieving targets.** The specific year or multiyear time frame should be as early as feasible and should take account of global scenarios compatible with limiting warming to 1.5°C or 2°C, equity principles, and pathways and options for emissions and removals.

**Countries with the highest emissions and greatest responsibility and capability should adopt the most ambitious target time frames.** Major emitters should adopt a time frame that is at least as early as the global time frame to achieve the Paris Agreement goals, and earlier still if they have high historical and per capita emissions. Countries with high capacity for GHG emissions reduction and carbon removal should supplement net-zero targets with targets and plans to achieve net-negative emissions after achieving net-zero emissions.

**Separate targets should be set for GHG emissions reductions and net-zero or net-negative emissions.** Distinct targets provide a clear road map for both decarbonization, scaling carbon removals, and achieving net-zero or net-negative emissions.

**Governments should prioritize reducing GHG emissions and enhancing GHG removals within the country's territory rather than relying on international transfers of GHG mitigation to achieve net-zero targets.** If international transfers of GHG mitigation are used to meet the target, countries should ensure that only surplus mitigation from other countries is transferred and should consider limiting the portion of the net-zero target that may be met through international GHG mitigation, as much as is feasible.

**Countries should transparently communicate their net-zero targets.** They should clearly provide information on the parameters of the net-zero target, including the GHG and sector coverage, the time frame, decarbonization targets, and the use of international transfers and any limits. Countries may also consider communicating supplemental information in order to strengthen the transparency of their targets.

**Countries should ensure that net-zero targets inform near- and midterm climate action,** including targets and policies, including NDCs, development plans, policies, investments, and long-term low-emissions development strategies to support just transitions.

## APPENDIX A: REASONS CITED BY COUNTRIES/REGIONS FOR PURSUING NET-ZERO TARGETS

This list does not include all countries or all reasons for choosing net-zero targets.

COUNTRY	CITED REASONS FOR PURSUING NET-ZERO TARGETS
<b>Bhutan</b>	Bhutan is already carbon negative and has reaffirmed in its NDC the intention to remain carbon neutral by ensuring that GHG emissions will not exceed the sink capacity of its forests. In its NDC, Bhutan notes, "This commitment was made with the view that there is no need greater, or more important, than keeping the planet safe for life to continue" (NEC 2015).
<b>Costa Rica</b>	President Carlos Alvarado Quesada has mentioned that the adoption of the National Decarbonization Plan was based on the notion of being "consistent with action" and the legacy of welfare taken up from previous generations with the abolishment of the army in 1984. That was a key political decision that has defined the development model of Costa Rica and allowed investments to be directed into a strong public health system, education, and nature conservation. Decarbonization (net-zero emissions) is the current focus that will define the development model of the country for the next 30 years ( <i>Time</i> 2019).
<b>Denmark</b>	When adopting the national Climate Act in 2019, the Danish minister of climate, energy and utilities, Dan Jørgensen, recognized science as a driving factor, noting, "We have heeded the call of science. We have decided not to aim for what we know to be possible, but what we know to be necessary" (Danish Ministry of Climate, Energy and Utilities 2019).
<b>Fiji</b>	The government of Fiji includes a net-zero target in its low-emissions development strategy. The document highlights the critical need for urgent global action in order to limit global temperature rise to 1.5°C and notes that not doing so would be disastrous and irreversible for future generations (Ministry of Economy 2018). The document also highlights Fiji's extreme vulnerability to climate change impacts, including sea-level rise, intense cyclones, and flooding, and the need therefore to rapidly reduce global GHG emissions. Fiji also strongly encourages other countries to aim to achieve net-zero emissions by 2050.
<b>Finland</b>	Finland recognizes its role in limiting the global mean temperature increase to 1.5°C. The government notes that "achieving the goals of the Agreement will require long-term climate measures designed to achieve carbon neutrality in the European Union before 2050" (Government of Finland 2019).
<b>France</b>	Prior to adopting the carbon-neutrality target in the energy-climate bill, the High Council on Climate issued a report that highlighted that France was already failing to meet current climate targets and supported the carbon-neutrality target, noting it is consistent with the Paris Agreement (HCC 2019). The president of the High Council on Climate noted that "the urgency imposed by the climate crisis requires acting quickly and in depth" and expressed the need for measures to reduce emissions to "be at the core of the decisions of public and private actors."
<b>Japan</b>	Japan notes several purposes in its long-term low-emissions development strategy, which outlines its decarbonization target. Japan highlights that the strategy is at the request of the Paris Agreement and allows Japan to share ideas and efforts with the world. It contributes to the achievement of the long-term targets of the Paris Agreement, including limiting the temperature increase to 1.5°C above preindustrial levels, and also supports leading international discussions (Government of Japan 2019b).
<b>New Zealand</b>	New Zealand adopted a zero-carbon bill in 2019 that aims to help New Zealand deliver on its Paris commitment, address the potential impacts of climate change, be held accountable by the Climate Change Commission, and safeguard the future of young people and their children (New Zealand Parliament 2019).
<b>Scotland</b>	Scotland adopted a net-zero target with a timeline five years earlier than that of the United Kingdom at the advice of the Committee on Climate Change (CCC). Scotland suggests it has a greater ability to adopt a more ambitious timeline because it has more potential sites for carbon capture and a greater landmass for tree planting (CCC 2019c). Scotland's environment secretary, Roseanna Cunningham, set a 2045 net-zero target based on independent expert advice from the CCC that higher targets are now possible and also due to the urgency required on this issue (Government of Scotland 2019).
<b>Sweden</b>	According to the government, "The net zero target forms part of Sweden's climate policy framework. . . . The framework aims to create a clear and coherent climate policy to ensure long-term signals to the market and other actors. It is a key component of Sweden's efforts to comply with the Paris Agreement" (Swedish Environmental Protection Agency 2019).
<b>United Kingdom</b>	The United Kingdom's 2050 net-zero target was adopted at the recommendation of the independent climate advisory body the CCC. The Energy and Clean Growth Minister, Chris Skidmore, noted the relevance of the United Kingdom adopting this target because it was also responsible for kick-starting the Industrial Revolution, which drove increasing emissions (BEIS 2019).

## APPENDIX B: COMPARISON OF ADOPTED NET ZERO TARGETS

COUNTRY	COVERAGE OF GHGS	COVERAGE OF DOMESTIC SECTORS	INCLUDING INTERNATIONAL AVIATION AND SHIPPING?	TARGET YEAR FOR ACHIEVING NET-ZERO EMISSIONS	SEPARATE TARGETS FOR GHG EMISSIONS REDUCTIONS AND NET-ZERO IN THE TARGET YEAR?	TARGET INCLUDES USE OF INTERNATIONAL GHG MITIGATION?	LEGAL STATUS OF NET-ZERO TARGETS (ECIU 2020)	SOURCE
<b>Austria</b>	All GHGs <sup>a</sup>	All sectors <sup>a</sup>	Not stated	2040	No	Not stated	Government pledge of the Conservative-Green coalition government	Farand 2020
<b>Bhutan</b>	All GHGs <sup>b</sup>	All sectors <sup>b</sup>	Not stated	Already net zero	No	No	In policy document (the NDC)	NEC 2015
<b>Costa Rica</b>	All GHGs <sup>c</sup>	All sectors <sup>c</sup>	Not stated	2050	No	Not stated	In policy document (the long-term strategy)	Government of Costa Rica 2019
<b>Denmark</b>	All GHGs <sup>d</sup>	All sectors <sup>d</sup>	No	2050	No	Not stated	In law (the Climate Act)	Danish Ministry of Climate, Energy and Utilities 2019
<b>European Union (EU)</b>	All GHGs	All sectors	Not stated	2050	No	Not stated	In policy document (the long-term strategy); European Green Deal and Resolution 2019/2956(RSP)	European Commission, n.d.
<b>Fiji</b>	All GHGs	All sectors	Not stated	2050	No	Not stated	In policy document (the long-term strategy)	Government of the Republic of Fiji 2018
<b>Finland</b>	All GHGs <sup>e</sup>	All sectors <sup>e</sup>	Not stated	2035 and net negative thereafter	No	Not stated, although the plan will be revisited in 2025, "along with the possibility of adopting international flexibility in meeting the targets"	Government pledge of the Coalition government	Government of Finland 2019
<b>France</b>	All GHGs	All sectors	No	2050	No	No	In law (Law no. 2019-1147 on Energy and the Climate)	French Ministry of Ecology, Sustainable Development and Energy 2015; French Senate 2019
<b>Hungary</b>	All GHGs	All sectors	Not stated	2050	No	Not stated	In law (Law on Climate Protection)	Darby 2020
<b>Iceland</b>	All GHGs <sup>f</sup>	All sectors <sup>f</sup>	Not stated	2040	No	Not stated	In policy document (Climate Action Plan)	Government of Iceland 2020
<b>Japan</b>	All GHGs	All sectors	Not stated, although "Japan will seek to contribute to the GHG reduction targets of the international shipping as agreed globally at the IMO"	Second half of the 21st century, "as close as possible to 2050"	No	Not stated, although Japan will "lead international rule-making and creating appropriate framework for using market-based mechanisms"	In policy document (the long-term strategy)	Government of Japan 2019b

COUNTRY	COVERAGE OF GHGS	COVERAGE OF DOMESTIC SECTORS	INCLUDING INTERNATIONAL AVIATION AND SHIPPING?	TARGET YEAR FOR ACHIEVING NET-ZERO EMISSIONS	SEPARATE TARGETS FOR GHG EMISSIONS REDUCTIONS AND NET-ZERO IN THE TARGET YEAR?	TARGET INCLUDES USE OF INTERNATIONAL GHG MITIGATION?	LEGAL STATUS OF NET-ZERO TARGETS (ECIU 2020)	SOURCE
<b>Marshall Islands</b>	All GHGs	All sectors	Not stated	2050	No	Not stated	In policy document (the long-term strategy); Resolution 83	Republic of the Marshall Islands 2018
<b>New Zealand</b>	All GHGs except for biogenic methane	All sectors	Not stated	2050	No	Yes	In law (Climate Change Response (Zero Carbon) Amendment Act)	New Zealand Parliament 2019
<b>Norway</b>	All GHGs <sup>a</sup>	All sectors <sup>a</sup>	No	2030	No	Yes	In parliamentary decision	Norway Energy and Environment Committee 2016
<b>Portugal</b>	All GHGs	All sectors	No	2050	No	No	In policy document (the long-term strategy); Resolution no.107/2019 of the Council of Ministers	Portuguese Republic 2019
<b>Singapore</b>	All GHGs	All sectors	No	Second half of the 21st century	No	No	In policy document (the long-term strategy)	NCCS 2020
<b>Slovenia</b>	All GHGs	All sectors	No	2050	No	No	In policy document (the National Energy and Climate Plan)	Republic of Slovenia 2020
<b>Sweden</b>	All GHGs	All sectors	No	2045 and net negative thereafter	Sweden has a target for emissions from activities on Swedish territory in 2045 to be at least 85% below 1990 emissions levels	Yes (with limits, as Sweden has separate emissions reduction target)	In law (the Climate Act)	Swedish Environmental Protection Agency 2019
<b>Switzerland</b>	All GHGs	All sectors <sup>h</sup>	No	2050	No	Yes <sup>i</sup>	Pledge of the Federal Council	Federal Council of Switzerland 2019
<b>United Kingdom</b>	All GHGs	All sectors	Yes	2050	No	Possible as contingency <sup>j</sup>	In law (Climate Change Act)	CCC 2019b

## Notes:

- a. Austria's aim of reaching "climate neutrality" by 2050 is assumed to cover all GHGs and sectors since the means of achievement includes all sectors.
- b. Bhutan's commitment, as outlined in the NDC, is to maintain its carbon neutrality. The NDC goes on to state that "emission of greenhouse gases will not exceed carbon sequestration by our forests." Accordingly, the target is assumed to cover all GHGs and sectors.
- c. Costa Rica's long-term strategy, which details the means of achieving the net-zero target, covers all GHGs and all sectors.
- d. Denmark's aim of reaching "climate neutrality" by 2050 is assumed to cover all GHGs and sectors since the means of achievement includes all sectors.
- e. Finland's aim of reaching "carbon neutrality" by 2035 is assumed to cover all GHGs and sectors since the means of achievement includes all sectors.
- f. Iceland's commitment is for "carbon neutrality." This is assumed to cover all GHGs and sectors.
- g. Norway's commitment is assumed to cover all GHGs and sectors because Norway's "Recommendation from the Energy and Environment Committee" (which includes the 2030 carbon neutrality goal) includes the means of achievement by all sectors.
- h. Switzerland's 2050 strategy refers to all sectors as the means of achieving the net-zero target.
- i. The plan states that it "leaves open the possibility of allowing for measures outside the country" (Federal Council of Switzerland 2020).
- j. According to the net-zero report from the UK CCC, "The aim should be to meet the net-zero GHG target without international carbon units, the UK should take steps to develop markets for carbon units as a potentially useful mechanism to mobilize finance and to support increased effort internationally, and as a contingency mechanism for meeting UK targets."



---

## APPENDIX C: CONSIDERATIONS FOR DESIGNING AND COMMUNICATING NET-ZERO TARGETS IN SUBNATIONAL JURISDICTIONS AND COMPANIES

Subnational jurisdictions—cities, states, and regions—and companies around the world are also starting to set net-zero targets. These targets can serve as a multiplier effect because they influence other net-zero targets, facilitate the adoption of national net-zero targets, and also help share the burden of implementing a national net-zero target.

### Designing Net-Zero Targets in Subnational Jurisdictions

Subnational jurisdictions play a critical role in enabling the transition to a zero-carbon future, and in several countries, cities, states, and regions, they are leading on establishing net-zero targets well before their national governments do so. For example, according to the Energy & Climate Intelligence Unit, as of March 2020, at least 21 cities had adopted a net-zero target by 2050 or earlier, and another 50 cities had committed to set a net-zero target by 2050 given their involvement in the Deadline 2020 initiative by C40 (ECIU 2020). In early June 2020, C40 and others joined the Race to Zero campaign as well.

Many of the choices related to designing and communicating a net-zero target in a subnational jurisdiction will be similar to those for national jurisdictions. However, a subnational jurisdiction will face additional considerations regarding the choice of the target boundary. Whereas national targets will typically cover emissions and removals within a national boundary defined by the national GHG inventory, setting a subnational level target boundary is somewhat more complex. More activities taking place within the jurisdiction's boundary may result in emissions from sources outside of the jurisdiction's boundary. For example, a city's electricity use may rely upon purchased electricity generated outside of that city's boundaries. As a result, a city establishing its target boundary will need to consider whether to include out-of-jurisdiction emissions, covering all emissions resulting from their city's activities, even those from sources outside of the city's boundaries. Subnational jurisdictions should consider covering all significant out-of-jurisdiction emissions for maximizing comprehensiveness and minimizing leakage, especially if a large proportion of emissions occur outside the city's boundary. If they choose to do so, they should transparently communicate the inclusion of out-of-jurisdiction emissions so that cities can identify goal overlap, as one city's out-of-jurisdiction emissions may be another city's in-jurisdiction emissions. Ideally, subnational target boundaries also align with inventory boundaries. Accounting and target design should be guided by globally recognized protocols, such as the Global Protocol on Community—Scale GHG Emissions Inventories.

### Designing Corporate Net-Zero Targets

In addition to countries and cities, companies are also setting net-zero targets. While many design choices and communication needs are similar to those that countries and cities face, companies may encounter additional considerations. Like cities, the target boundary will be defined differently than countries. Companies will need to choose the scope of emissions included in the target boundary (i.e., scope 1, 2, and 3<sup>15</sup>) and whether to have separate emissions targets by scope.

Additionally, depending on the company's sector, companies may find it challenging to achieve net-zero emissions within their operations and value chains. While this is true of certain jurisdictions as well—for example, due to their limited access to enhanced removals depending on the nature of their land sink—this issue is likely to be more acute for companies because they have a more limited emissions boundary (i.e., their operations and value chain). First and foremost, companies should set emissions reductions targets in line with 1.5°C before considering the use of offsets to go beyond that pathway to reach net zero or net negative.<sup>16</sup> There have been many risks identified with offsets, including additionality; leakage; failure to represent real emissions reductions; permanence; and monitoring, reporting, and verification limitations, among others (Broekhoff et al. 2019). In addition, a reliance upon offsets may not provide adequate signals for companies to reduce their own emissions.

The Science Based Targets initiative is developing guidance for companies seeking to achieve net-zero emissions. For more information about this resource, "Foundations for Science-based Net Zero Target Setting in the Corporate Sector" (forthcoming).

In addition to subnational jurisdictions and corporations, it is worth mentioning that some investors are also adopting net-zero targets. For example, the United Nations has convened a net-zero asset owner alliance that includes 25 institutional investors committed to transitioning their investment portfolios to net-zero emissions by 2050. A number of questions remain about the methodology, including what the scope of emissions will be for these targets (Rust 2020).

## ABBREVIATIONS

<b>AFOLU</b>	agriculture, forestry, and other land use
<b>CCC</b>	Committee on Climate Change
<b>CH<sub>4</sub></b>	methane
<b>CO<sub>2</sub></b>	carbon dioxide
<b>CCS</b>	carbon capture and storage
<b>EU</b>	European Union
<b>GHG</b>	greenhouse gas
<b>HFC</b>	hydrofluorocarbon
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>NDC</b>	nationally determined contribution
<b>NF<sub>3</sub></b>	nitrogen trifluoride
<b>N<sub>2</sub>O</b>	nitrous oxide
<b>PFC</b>	perfluorocarbon
<b>SF<sub>6</sub></b>	sulfur hexafluoride
<b>tCO<sub>2</sub>e</b>	tonne of carbon dioxide equivalent
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change

---

## ENDNOTES

1. Austria, Bhutan, Costa Rica, Denmark, Fiji, Finland, France, Hungary, Iceland, Japan, the Marshall Islands, New Zealand, Norway, Portugal, Singapore, Slovenia, Sweden, Switzerland, and the United Kingdom.
2. Data from this section are from the Net Zero Tracker (database), Energy & Climate Intelligence Unit, London, <https://eciu.net/netzerotracker>, accessed June 8, 2020. Our assessment does not include any net-zero targets that have not been formally adopted by government.
3. Article 4, paragraph 1, of the Paris Agreement states: "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."
4. The Kyoto GHGs are the basket of gases that are covered under the Kyoto Protocol: CO<sub>2</sub>, methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), HFCs, perfluorocarbons (PFCs), sulfur hexafluoride (SF<sub>6</sub>), and nitrogen trifluoride (NF<sub>3</sub>). The models show CO<sub>2</sub> reaching net zero earlier than the Kyoto GHGs due to a lack of mitigation options sufficient to entirely eliminate non-CO<sub>2</sub> emissions from livestock production and fertilizer use.
5. Paris Agreement, Article 4, paragraph 1.
6. Article 4, paragraph 19, of the Paris Agreement states that all parties should strive to formulate and communicate long-term low-emissions development strategies.
7. For more information, see the Climate Ambition Alliance: <https://cop25.mma.gob.cl/en/climate-ambition-alliance/>.
8. For more information, see the Climate Leaders Coalition, <https://www.climateleaderscoalition.org.nz/>.
9. If land-based removals are to be brought into policy options, this requires accurate estimates of land-sector emissions and removals and improved monitoring across land uses.
10. GHGs are defined here as the seven Kyoto GHGs: CO<sub>2</sub>, N<sub>2</sub>O, CH<sub>4</sub>, HFCs, PFCs, SF<sub>6</sub>, and NF<sub>3</sub>.
11. See, for example, Allen et al. (2018).
12. These countries are Bhutan, Gabon, Latvia, and Romania. Of them, only Bhutan has yet established a net-zero target. For more information, see ClimateWatch, <https://www.climatewatchdata.org>.
13. See, for example, Mulligan et al. (2018a, 2018b, 2020a, 2020b).
14. Some countries may have taken these steps in the course of deciding to establish a net-zero target; in that case, they may draw on these earlier exercises in order to translate the target into action.
15. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions. See the Greenhouse Gas Protocol for more information: <https://ghgprotocol.org>.
16. For more information, see Science Based Targets: <https://sciencebasedtargets.org/>.

## REFERENCES

- Allen, M.R., K.P. Shine, J.S. Fuglestedt, R.J. Millar, M. Cain, D.J. Frame, and A.H. Macey. 2018. "A Solution to the Misrepresentations of CO<sub>2</sub>-Equivalent Emissions of Short-Lived Climate Pollutants under Ambitious Mitigation." *Climate and Atmospheric Science* 1 (16). <https://doi.org/10.1038/s41612-018-0026-8>.
- Arcipowska, A., E. Mangan, Y. Lyu, and R. Waite. 2019. "5 Questions About Agricultural Emissions, Answered." *Insights* (blog), July 29. <https://www.wri.org/blog/2019/07/5-questions-about-agricultural-emissions-answered>.
- Batha, E. 2020. "UK Citizens' Assembly to Discuss How to Meet 2050 Climate Target." Reuters, January 21. <https://www.reuters.com/article/us-britain-climatechange-parliament-trfn/uk-citizens-assembly-to-discuss-how-to-meet-2050-climate-target-idUSKBN1ZL00W>.
- BEIS (Department for Business, Energy and Industrial Strategy). 2019. "UK Becomes First Major Economy to Pass Net Zero Emissions Law." June 27. <https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law>.
- BEIS. 2020. "Industrial Energy Transformation Fund: Finalising the Design." June 29. <https://www.gov.uk/government/consultations/industrial-energy-transformation-fund-finalising-the-design>.
- Broekhoff, D., M. Gillenwater, T. Colbert-Sangree, and P. Cage. 2019. *Securing Climate Benefit: A Guide to Using Carbon Offsets*. Stockholm: Stockholm Environment Institute & Greenhouse Gas Management Institute. [http://www.offsetguide.org/wp-content/uploads/2020/03/Carbon-Offset-Guide\\_3122020.pdf](http://www.offsetguide.org/wp-content/uploads/2020/03/Carbon-Offset-Guide_3122020.pdf).
- Carbon Neutrality Coalition. n.d. "The Declaration of the Carbon Neutrality Coalition." <https://www.carbon-neutrality.global/the-declaration/>. Accessed February 19, 2020.
- CCC (Committee on Climate Change). 2019a. *Net Zero—Technical Report*. London: CCC. <https://www.theccc.org.uk/publication/net-zero-technical-report/>.
- CCC. 2019b. *Net Zero: The UK's Contribution to Stopping Global Warming*. London: CCC. <https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/>.
- CCC. 2019c. *Reducing Emissions in Scotland—2019 Progress Report to Parliament*. London: CCC. <https://www.theccc.org.uk/publication/reducing-emissions-in-scotland-2019-progress-report-to-parliament/>.
- ClimateWatch. 2020. "NDC Content." <https://www.climatewatchdata.org/ndcs-content>.
- Danish Ministry of Climate, Energy and Utilities. 2019. "Key Elements of the Danish Climate Act." Copenhagen: Danish Ministry of Climate, Energy and Utilities. [https://en.kefm.dk/media/12969/climate-act\\_fact-sheet.pdf](https://en.kefm.dk/media/12969/climate-act_fact-sheet.pdf).
- Darby, M. 2020. "Hungary Sets 2050 Climate Neutrality Goal in Law, Issues Green Bond." Climate Home News, June 4. <https://www.climatechangenews.com/2020/06/04/hungary-sets-2050-climate-neutrality-goal-law-issues-green-bond/#:~:text=Hungary%2520has%2520set%2520a%2520climate,an%2520opposition%2520lawmaker%2520last%2520August>.
- DDPP (Deep Decarbonization Pathways Project). 2015. *Pathways to Deep Decarbonization*. New York: Sustainable Development Solutions Network; Paris: Institute for Sustainable Development and International Relations. [http://deepdecarbonization.org/wp-content/uploads/2016/03/DDPP\\_2015\\_REPORT.pdf](http://deepdecarbonization.org/wp-content/uploads/2016/03/DDPP_2015_REPORT.pdf).
- ECIU (Energy & Climate Intelligence Unit). 2020. "Net Zero: The Scorecard." May 5. <https://eciu.net/analysis/briefings/net-zero/net-zero-the-scorecard>.
- Elliott, C., J. Worker, K. Levin, and K. Ross. 2019. "Good Governance for Long-Term Low-Emissions Development Strategies." Working Paper. Washington, DC: World Resources Institute. <http://www.wri.org/publication/good-governance-low-emissions>.
- European Commission. 2018. *A Clean Planet for All. A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy*. Brussels: European Commission. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773&from=EN>.
- European Commission. n.d. "2050 Long-Term Strategy." [https://ec.europa.eu/clima/policies/strategies/2050\\_en](https://ec.europa.eu/clima/policies/strategies/2050_en). Accessed June 30, 2020.
- Farand, C. 2020. "Austria Swears In Coalition Government with Strengthened Climate Plan." Climate Home News, January 7. <https://www.climatechangenews.com/2020/01/07/austria-swears-coalition-government-strengthened-climate-plan/#:~:text=Austria%20swears%20in%20coalition%20government%20with%20strengthened%20climate%20plan,-Published%20on%2007&text=Austria's%20first%20Conservative%2DGreen%20coalition,net%20zero%20emissions%20by%202040>.
- Federal Council of Switzerland. 2019. "Federal Council Aims for Climate-Neutral Switzerland by 2050." August 28. <https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-76206.html>.
- Federal Council of Switzerland. 2020. "Climate Target 2050: Net Zero Greenhouse Gas Emissions." Background Paper. Bern: Federal Office of the Environment, Federal Council of Switzerland. [https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/klimaziel2050-netto-null-treibhausgasemissionen-hintergrundpapier.pdf.download.pdf/Hintergrundpapier\\_Netto-Null-Ziel\\_2050\\_E.pdf](https://www.bafu.admin.ch/dam/bafu/en/dokumente/klima/fachinfo-daten/klimaziel2050-netto-null-treibhausgasemissionen-hintergrundpapier.pdf.download.pdf/Hintergrundpapier_Netto-Null-Ziel_2050_E.pdf).
- French Ministry of Ecology, Sustainable Development and Energy. 2015. *French National Low-Carbon Strategy (SNBC)*. Paris: French Ministry of Ecology, Sustainable Development and Energy. [https://unfccc.int/files/mfc2013/application/pdf/fr\\_snbc\\_strategy.pdf](https://unfccc.int/files/mfc2013/application/pdf/fr_snbc_strategy.pdf).
- French Senate. 2019. "No. 622, Project de Loi." July 1. <http://www.senat.fr/leg/pjl18-622.html>.
- Government of Costa Rica. 2019. *National Decarbonization Plan, 2018–2050*. San José: Government of Costa Rica. <https://cambioclimatico.go.cr/wp-content/uploads/2020/01/NationalDecarbonizationPlan.pdf>.
- Government of Finland. 2019. *Programme of Prime Minister Antti Rinne's Government 6 June 2019: Inclusive and Competitive Finland—a Socially, Economically and Ecologically Sustainable Society*. Helsinki: Government of Finland. [http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161664/Inclusive%2520and%2520competent%2520Finland\\_2019.pdf?sequence=7&isAllowed=y](http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161664/Inclusive%2520and%2520competent%2520Finland_2019.pdf?sequence=7&isAllowed=y).

Government of Iceland. 2020. "New Climate Action Plan—Iceland Will Fulfill Its Commitments and More." June 23. <https://www.government.is/news/article/2020/06/23/New-Climate-Action-Plan-Iceland-will-fulfill-its-commitments-and-more/>.

Government of Japan. 2019a. "Global Warming Prevention Headquarters." Prime Minister of Japan and His Cabinet, June 11. [https://japan.kantei.go.jp/98\\_abe/actions/201906/\\_00031.html](https://japan.kantei.go.jp/98_abe/actions/201906/_00031.html).

Government of Japan. 2019b. *The Long-Term Strategy under the Paris Agreement*. Tokyo: Government of Japan. <http://www.env.go.jp/press/111913.pdf>.

Government of Scotland. 2019. "Climate Change Action." May 2. <https://www.gov.scot/news/climate-change-action-1/>.

Government of the Republic of Fiji. 2018. *Fiji Low Emission Development Strategy 2018–2050*. Suva: Ministry of Economy, Government of the Republic of Fiji. [https://unfccc.int/sites/default/files/resource/Fiji\\_Low%20Emission%20Development%20Strategy%202018%20-%202050.pdf](https://unfccc.int/sites/default/files/resource/Fiji_Low%20Emission%20Development%20Strategy%202018%20-%202050.pdf).

Griscom, B.W., J. Busch, S.C. Cook-Patton, P.W. Ellis, J. Funk, S.M. Leavitt, G. Lomax, et al. 2020. "National Mitigation Potential from Natural Climate Solutions in the Tropics." *Philosophical Transactions of the Royal Society B: Biological Sciences* 375 (1794): 20190126. <https://doi.org/10.1098/rstb.2019.0126>.

HCC (Haut Conseil pour le Climat). 2019. "Climate Emergency: France Behind Schedule." June 29. <https://www.hautconseilclimat.fr/actualites/urgence-climatique-la-france-en-retard-sur-ses-objectifs/>.

Hepburn, C., B. O'Callaghan, N. Stern, J. Stiglitz, and D. Zenghelis. 2020. "Will COVID-19 Fiscal Recovery Packages Accelerate or Retard Progress on Climate Change?" *Oxford Review of Economic Policy*, May 8. <https://doi.org/10.1093/oxrep/gra015>.

HMT (Her Majesty's Treasury). 2019. "Net Zero Review Launched to Support UK's World Leading Climate Commitment." November 2. <https://www.gov.uk/government/news/net-zero-review-launched-to-support-uks-world-leading-climate-commitment>.

Höhne, N., M. den Elzen, and D. Escalante. 2014. "Regional GHG Reduction Targets Based on Effort Sharing: A Comparison of Studies." *Climate Policy* 14 (1): 122–47. <https://doi.org/10.1080/14693062.2014.849452>.

IDB (Inter-American Development Bank). 2020. "IDB-AFD Strengthen Partnership in Times of COVID-19 Crisis and Beyond." May 20. <https://www.iadb.org/en/news/idb-afd-strengthen-partnership-times-covid-19-crisis-and-beyond>.

IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2014: Synthesis Report*. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, edited by R.K. Pachauri and L.A. Meyer. Geneva: IPCC. [https://www.ipcc.ch/site/assets/uploads/2018/05/SYR\\_AR5\\_FINAL\\_full\\_wcover.pdf](https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf).

IPCC. 2018a. *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, edited by V. Masson-Delmotte, P. Zhai, H.O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C.

Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield. Geneva: IPCC. [https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15\\_Full\\_Report\\_Low\\_Res.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf).

IPCC. 2018b. "Summary for Policymakers." In *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, edited by V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield. Geneva: IPCC. [https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15\\_SPM\\_version\\_report\\_LR.pdf](https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf).

Iyer, G., C. Ledna, L. Clarke, J. Edmonds, H. McJeon, P. Kyle, and J.H. Williams. 2017. "Measuring Progress from Nationally Determined Contributions to Mid-century Strategies." *Nature Climate Change* 7 (12): 871–74. <https://doi.org/10.1038/s41558-017-0005-9>.

Klinsky, S., D. Waskow, E. Northrop, and W. Bevins. 2017. "Operationalizing Equity and Supporting Ambition: Identifying a More Robust Approach to 'Respective Capabilities.'" *Climate and Development* 9 (4): 287–97. <https://doi.org/10.1080/17565529.2016.1146121>.

Kuramochi, T., N. Höhne, M. Schaeffer, J. Cantzler, B. Hare, Y. Deng, S. Sterl, et al. 2018. "Ten Key Short-Term Sectoral Benchmarks to Limit Warming to 1.5°C." *Climate Policy* 18 (3): 287–305. <https://doi.org/10.1080/14693062.2017.1397495>.

Levin, K., and C. Davis. 2020. "What Does 'Net-Zero Emissions' Mean? 6 Common Questions, Answered." *Insights* (blog), June 4. <https://www.wri.org/blog/2019/09/what-does-net-zero-emissions-mean-6-common-questions-answered>.

Levin, K., J. Finnegan, D. Rich, and P. Bhatia. 2014. *Mitigation Goal Standard: An Accounting and Reporting Standard for National and Subnational Greenhouse Gas Reduction Goals*. Washington, DC: Greenhouse Gas Protocol, World Resources Institute. [https://files.wri.org/s3fs-public/Mitigation\\_Goal\\_Standard.pdf](https://files.wri.org/s3fs-public/Mitigation_Goal_Standard.pdf).

Levin, K., T. Fransen, K. Ross, C. Elliott, M. Manion, R. Waite, E. Northrop, J. Worker, and C. Schumer. 2018. "Long-Term Low Greenhouse Gas Emission Development Strategies: Approaches and Methodologies for Their Design." Working Paper. Washington, DC: World Resources Institute; Buenos Aires: Ministerio de Ambiente y Desarrollo Sustentable de la República Argentina. <https://files.wri.org/s3fs-public/long-term-low-greenhouse-gas-emission-development-strategies.pdf>.

McLaren, D., D.P. Tyfield, R. Willis, B. Szerszynski, and N.O. Markusson. 2019. "Beyond 'Net-Zero': A Case for Separate Targets for Emissions Reduction and Negative Emissions." *Frontiers in Climate* 1 (August). <https://doi.org/10.3389/fclim.2019.00004>.

METI (Ministry of Economy, Trade and Industry). 2018. *Long-Term Goal and Strategy of Japan's Automotive Industry for Tackling Global Climate Change*. Tokyo: METI, Government of Japan. [https://www.meti.go.jp/english/press/2018/pdf/0831\\_003a.pdf](https://www.meti.go.jp/english/press/2018/pdf/0831_003a.pdf).



- Ministry of Climate and Environment. 2018. *Better Growth, Lower Emissions—the Norwegian Government’s Strategy for Green Competitiveness*. Oslo: Ministry of Climate and Environment, Government of Norway. <https://www.regjeringen.no/contentassets/4a98ed15ec264d0e938863448ebf7ba8/t-1562e.pdf>.
- MOE (Ministry of the Environment). 2020. *Submission of Japan’s Nationally Determined Contribution (NDC)*. Tokyo: MOE, Government of Japan. <https://www.env.go.jp/en/headline/2442.html>.
- Mulligan, J., G. Ellison, R. Gasper, and A. Rudee. 2018a. “Carbon Removal in Forests and Farms in the United States.” Working Paper. Washington, DC: World Resources Institute. [https://files.wri.org/s3fs-public/carbon-removal-forests-farms-united-states\\_0.pdf](https://files.wri.org/s3fs-public/carbon-removal-forests-farms-united-states_0.pdf).
- Mulligan, J., G. Ellison, and K. Levin. 2018b. “Foundational Questions on Carbon Removal in the United States.” Working Paper. Washington, DC: World Resources Institute. <https://files.wri.org/s3fs-public/foundational-questions-carbon-removal-united-states.pdf>.
- Mulligan, J., G. Ellison, K. Levin, K. Lebling, and A. Rudee. 2020a. “6 Ways to Remove Carbon Pollution from the Sky.” *Insights* (blog), June 9. <https://www.wri.org/blog/2020/06/6-ways-remove-carbon-pollution-sky>.
- Mulligan, J., A. Rudee, K. Lebling, K. Levin, J. Anderson, and B. Christensen. 2020b. “CarbonShot: Federal Policy Options for Carbon Removal in the United States.” Working Paper. Washington, DC: World Resources Institute. [https://files.wri.org/s3fs-public/carbonshot-federal-policy-options-for-carbon-removal-in-the-united-states\\_1.pdf](https://files.wri.org/s3fs-public/carbonshot-federal-policy-options-for-carbon-removal-in-the-united-states_1.pdf).
- NCCS (National Climate Change Secretariat). 2020. *Charting Singapore’s Low-Carbon and Climate Resilient Future*. Singapore: NCCS, Strategy Group, Prime Minister’s Office. <https://www.nccs.gov.sg/docs/default-source/publications/nccsleads.pdf>.
- NEC (National Environment Commission). 2015. *Communication of INDC of the Kingdom of Bhutan*. Thimphu: National Environment Commission, Government of Bhutan. <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Bhutan%20First/Bhutan-INDC-20150930.pdf>.
- New Zealand Parliament. 2019. *Climate Change Response (Zero Carbon) Amendment Bill 2019*. Wellington: Ministry for the Environment, Government of New Zealand. <https://www.parliament.nz/en/pb/bills-and-laws/bills-digests/document/52PLLaw25931/climate-change-response-zero-carbon-amendment-bill-2019>.
- Norway Energy and Environment Committee. 2016. *Recommendation of the Energy and Environment Committee on Consent to Ratify the Paris Agreement of 12 December 2015 under the United Nations Framework Convention on Climate Change of 9 May 1992*. Sett. 407 S (2015–2016). Oslo: Energy and Environment Committee, Government of Norway. <https://www.stortinget.no/no/Saker-og-publikasjoner/Publikasjoner/Innstillinger/Stortinget/2015-2016/inns-201516-407/?l=0>.
- Portuguese Republic. 2019. *Roadmap for Carbon Neutrality 2050 (RNC 2050): Long-Term Strategy for Carbon Neutrality of the Portuguese Economy by 2050*. Lisbon: Portuguese Republic. [https://unfccc.int/sites/default/files/resource/RNC2050\\_EN\\_PT%20Long%20Term%20Strategy.pdf](https://unfccc.int/sites/default/files/resource/RNC2050_EN_PT%20Long%20Term%20Strategy.pdf).
- Prensa Presidencia. 2019. “Climate Ambition Alliance: Nations Push to Upscale Action by 2020 and Achieve Net Zero CO<sub>2</sub> Emissions by 2050.” September 23. <https://prensa.presidencia.cl/comunicado.aspx?id=102021>.
- Republic of Slovenia. 2020. *Comprehensive National Energy and Climate Plan of the Republic of Slovenia*. Ljubljana: Republic of Slovenia. [https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/nepn/dokumenti/nepn\\_5.0\\_final\\_feb-2020.pdf](https://www.energetika-portal.si/fileadmin/dokumenti/publikacije/nepn/dokumenti/nepn_5.0_final_feb-2020.pdf).
- Republic of the Marshall Islands. 2018. *Tile Til Eo 2050 Climate Strategy “Lighting the Way.”* Majuro: Republic of the Marshall Islands. [https://unfccc.int/sites/default/files/resource/180924%20mi%202050%20climate%20strategy%20final\\_0.pdf](https://unfccc.int/sites/default/files/resource/180924%20mi%202050%20climate%20strategy%20final_0.pdf).
- Rust, S. 2020. “Net-Zero Asset Owner Alliance Sets Out ‘Demanding’ Methodology Needs.” IPE News, April 28. <https://www.ipe.com/news/net-zero-asset-owner-alliance-sets-out-demanding-methodology-needs/10045184.article>.
- Sachs, J.D., G. Schmidt-Traub, and J. Williams. 2016. “Pathways to Zero Emissions.” *Nature Geoscience* 9 (11): 799–801. <https://doi.org/10.1038/ngeo2826>.
- Searchinger, T., R. Waite, C. Hanson, J. Ranganathan, and E. Matthews. 2019. *Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050 (Final Report)*. Washington, DC: World Resources Institute. <https://www.wri.org/publication/creating-sustainable-food-future-final-report>.
- Shindell, D.T., N. Borgford-Parnell, M. Brauer, A. Haines, J.C.I. Kuylenstierna, S.A. Leonard, V. Ramanathan, A. Ravishankara, M. Amann, and L. Srivastava. 2017. “A Climate Policy Pathway for Near- and Long-Term Benefits.” *Science* 356 (6337): 493–94. <https://doi.org/10.1126/science.aak9521>.
- Somanathan, E., T. Sterner, T. Sugiyama, D. Chimanikire, N.K. Dubash, J. Essandoh-Yeddu, S. Fifita, et al. 2014. “National and Sub-national Policies and Institutions.” In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S., Kadner, K. Seyboth, A. Adler, et al. Cambridge and New York: Cambridge University Press. <https://doi.org/10.1017/CBO9781107415416>.
- State of Green. 2019. “During COP25, Denmark Passes Climate Act with a 70 Per Cent Reduction Target.” December 9. <https://stateofgreen.com/en/partners/state-of-green/news/during-cop25-denmark-passes-climate-act-with-a-70-per-cent-reduction-target/>.
- Swedish Environmental Protection Agency. 2019. “Sweden’s Climate Act and Climate Policy Framework.” December 1. <http://www.swedishepa.se/Environmental-objectives-and-cooperation/Swedish-environmental-work/Work-areas/Climate/Climate-Act-and-Climate-policy-framework/>.
- Time. 2019. “‘It’s the One I Love.’ Costa Rica President Carlos Alvarado Quesada on Fighting Climate Change for His Son.” November 14. <https://time.com/5727110/costa-rica-president-carlos-alvarado-quesada-time-100-next/>.
- UNFCCC (United Nations Framework Convention on Climate Change). 2005. *Paris Agreement*. New York: United Nations. [https://unfccc.int/sites/default/files/english\\_paris\\_agreement.pdf](https://unfccc.int/sites/default/files/english_paris_agreement.pdf).
- Unruh, G.C. 2000. “Understanding Carbon Lock-In.” *Energy Policy* 28 (12): 817–30. [https://doi.org/10.1016/S0301-4215\(00\)00070-7](https://doi.org/10.1016/S0301-4215(00)00070-7).

---

## ACKNOWLEDGMENTS

We are pleased to acknowledge our institutional strategic partners, who provide core funding to WRI: Netherlands Ministry of Foreign Affairs, Royal Danish Ministry of Foreign Affairs, and Swedish International Development Cooperation Agency.

The authors are very grateful to the following reviewers: Alysha Bagasra, Richard Baron, Pankaj Bhatia, Emilie Brown, Subrata Chakrabarty, Cynthia Cummis, Yamide Dagnet, Janine Felson, Jonas von Freiesleben, Peter Frumhoff, Lindy Fursman, Adrian Gault, Bernd Hackmann, Thomas Hale, Nancy Harris, Xiaolian Jiang, Gregg Johnstone, Kevin Kennedy, Takeshi Kuramochi, Dan Lashof, Pedro Martins Barata, Duncan McLaren, Andrea Meza, the Ministry of Environment of Japan, Siddharth Pathak, Miles Perry, Gwenael Podesta, Nilesh Prakash, Anna Ragnarsdottir, Roger Ramer, Matt Ramlow, David Waskow, and Jessica Zionts.

Thank you also to Lauri Scherer, Emily Matthews, Romain Warnault, Carni Klirs, Mary Levine, Zilin Wang, and Emilia Suarez for providing editing, design, and administrative support. This publication was produced with support from the 2050 Pathways Platform.



## ABOUT THE AUTHORS

**Kelly Levin** is a Senior Associate in the Global Climate Program at WRI.

Contact: [kelly.levin@wri.org](mailto:kelly.levin@wri.org)

**David Rich** is a Senior Associate in the Global Climate Program at WRI.

Contact: [david.rich@wri.org](mailto:david.rich@wri.org)

**Katherine Ross** is an Associate in the Global Climate Program at WRI.

Contact: [katie.ross@wri.org](mailto:katie.ross@wri.org)

**Taryn Fransen** is a Senior Fellow in the Global Climate Program at WRI.

Contact: [taryn.fransen@wri.org](mailto:taryn.fransen@wri.org)

**Cynthia Elliott** is an Associate in the Global Climate Program at WRI.

Contact: [cynthia.elliott@wri.org](mailto:cynthia.elliott@wri.org)

## ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

### Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

### Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

### Our Approach

#### COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

#### CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

#### SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.



Copyright 2020 World Resources Institute. This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of the license, visit <http://creativecommons.org/licenses/by/4.0/>