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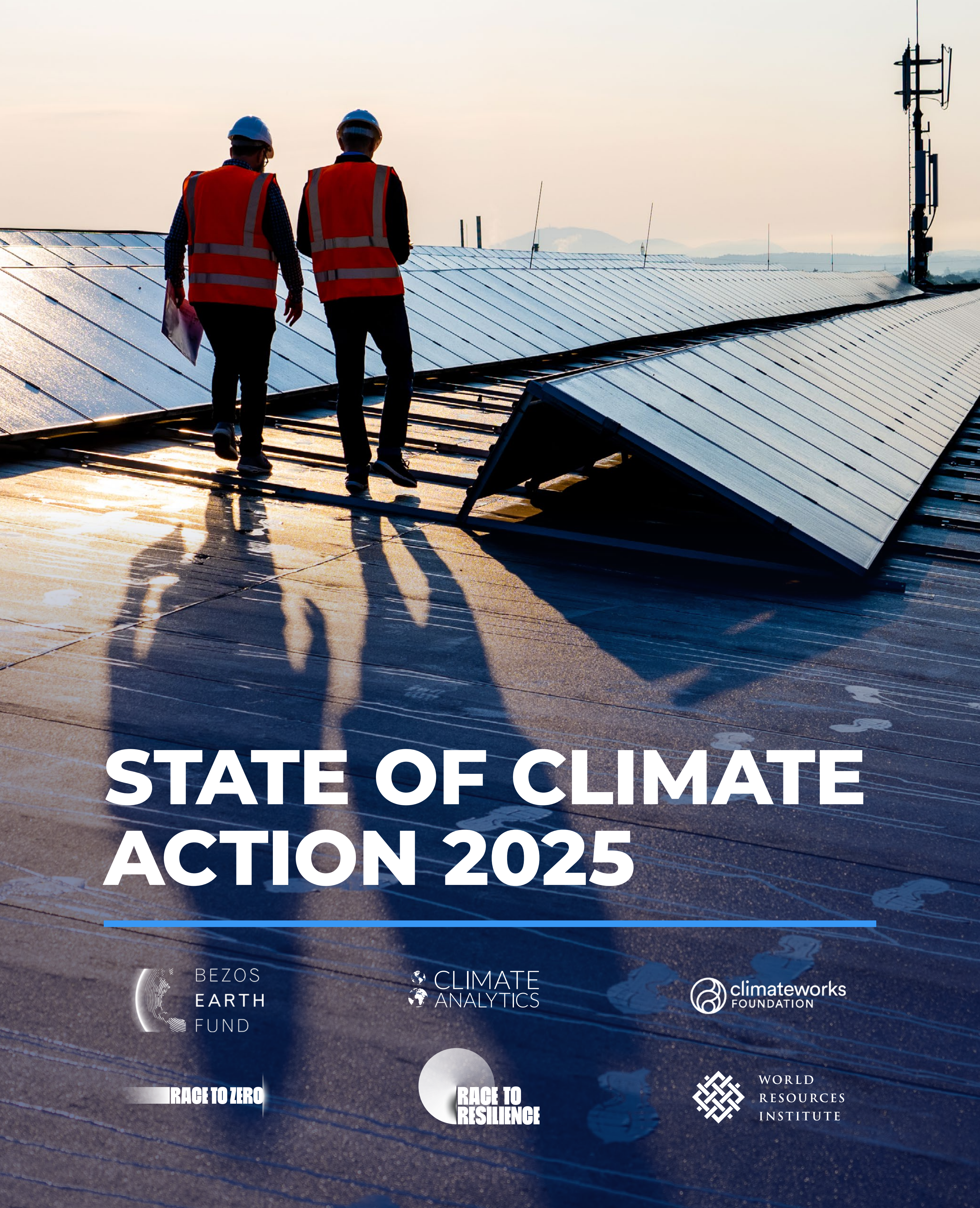

STATE OF CLIMATE ACTION 2025

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RACE TO ZERO

RACE TO RESILIENCE

WORLD RESOURCES INSTITUTE

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Contents

Foreword

Ten years after countries around the world united to adopt the Paris Agreement, we find ourselves at a precarious juncture. A bold vision of collective action has now given way to a decade of mixed progress: remarkable advances, particularly in scaling up renewable energy and shifting to more sustainable forms of transportation, as well as the emergence of entirely new mitigation technologies, but slow progress and even backsliding in other areas. Global emissions today are higher than when the Paris Agreement was signed, and warming to date has already brought devastation to communities and ecosystems around the world. While the Paris vision is alive, the pace and scale of delivery will determine whether we fulfill its promise.

This edition of the *State of Climate Action* report underscores this reality. While most indicators of progress are headed in the right direction, not one of the 45 indicators assessed is on track to achieve its 1.5°C-aligned benchmark for 2030. For some of the world's most critical shifts — such as phasing out coal and effectively halting deforestation — progress is faltering. Indeed, efforts to reduce coal-fired power must accelerate by more than 10 times this decade, equivalent to retiring nearly 360 average-sized coal-fired power plants each year through 2030, while progress in halting permanent forest loss must simultaneously accelerate nine-fold. This is a wake-up call — underscoring that while the breakthroughs we need are still possible, achieving them will demand far greater and better aligned efforts and investments around both proven and emerging solutions.

In the last decade, countries have come to the realization that climate action is not just about tinkering around the edges to reduce emissions and avoid losses but transforming entire economies. This economic transition is underway, and despite the challenges, we are seeing trillions of dollars flowing into sustainable technologies, solar outcompeting fossil fuels in many parts of the world, cities becoming more resilient, and businesses integrating climate action into their core strategies. The transition is no longer a question of "if" — but of "how fast." The blueprints for climate action are being written every day in boardrooms, ministries, and living rooms.

The stakes could not be higher. The hottest decade on record has left no doubt that delay will carry disastrous costs. Climate impacts are intensifying, with lives, livelihoods, and ecosystems already under severe and increasing strain. But, we are also reminded that climate action is arguably the defining economic opportunity of this century — one that can increase competitiveness, strengthen energy security, advance sustainable socio-economic development, and lift hundreds of millions of people out of poverty.

This report not only serves as a reckoning with where we stand but also offers a roadmap for where we must go. Its sectoral benchmarks illuminate the paths that can bring global emissions into alignment with the 1.5°C limit in the Paris Agreement, while delivering cleaner air and water, healthier communities and ecosystems, and more resilient and competitive economies. Our job now is to continue to move from pledges to implementation — scaling what works, unlocking what's missing, and overcoming roadblocks.

If the story of Paris was one of collective vision, the story of the decade ahead must be one of accelerated action — pragmatic, inclusive, and unstoppable.

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Executive summary

Halfway through the middle of what the climate community has dubbed the "decisive decade," urgency is fading, vested interests in maintaining the status quo are playing defense as strongly as ever, and complacency is on the rise (Mishra 2024; García Santamaría et al. 2024; Ekberg et al. 2022). This past year saw a troubling backsliding of action, precisely when the world needed it most. The international solidarity that led to the Paris Agreement a decade ago has weakened, with countries facing roadblocks at the negotiating table that are stifling progress when it's more important than ever. In many major economies, primarily those with large oil and gas reserves, entrenched fossil fuel interests continue to exert powerful political influence, stymieing climate ambition and action (InfluenceMap 2025). Geopolitical tensions, trade wars, substantial cuts to development aid, and wealthy countries' failure to meet existing climate finance commitments have further eroded the foundation for global cooperation on climate change.

In a particularly notable development this year, the world's second-largest emitter and largest historical emitter, the United States, has scaled back climate policies and programs, reduced the scope of environmental agencies, and discontinued long-standing investments in climate science and decarbonization measures (Lockman 2025; US EPA 2025). In January 2025, the United States announced its intention to once again withdraw from the Paris Agreement (Perez and Waldholz 2025). At the same time, a growing global backlash among corporate and political leaders against environmental, social, and governance principles has prompted several leading corporations to retreat from their commitments, while the Net Zero Banking Alliance has seen an exodus of its members even though it has softened its targets by dropping 1.5°C-aligned lending requirements (Gayle 2025; London Business School 2025; Segal 2025b).

Global greenhouse gas (GHG) emissions continue to climb, intensifying climatic changes and impacts that are already more severe and widespread than anticipated. To keep the Paris Agreement temperature limit within reach, GHG emissions should already be peaking and starting a sharp decline (IPCC 2022b). But they have instead increased by roughly 0.65 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) per year since 2000, reaching 56.6 $GtCO_2e$ in 2023 (Figure ES-1), with global CO_2 emissions from fossil fuels showing no signs of slowing down (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025). Consequently, the past 10 years have been the hottest on record, with 2024 the warmest yet (WMO 2025a). Ocean heat content also reached an all-time high (Cheng et al. 2025), with marine heatwaves unparalleled in severity, scale, and duration occurring within multiple ocean basins (Dong et al. 2025) and triggering catastrophic coral bleaching across more than 80 percent of the world's reefs (NOAA Coral Reef Watch 2025). In the Arctic, winter sea ice cover fell to its lowest level ever observed in March 2025 (Riordon 2025), while Antarctica saw its summertime sea ice cover simultaneously reach its second-lowest extent since recordkeeping began (NOAA 2025). Elevated sea surface temperatures also intensified hurricanes, increasing the wind speeds of every Atlantic hurricane in 2024 (Climate Central 2024; Gilford et al. 2024). And on land, unprecedented fires scorched entire communities and

Highlights

- Ten years since the Paris Agreement was signed, this report card on climate action shows that global efforts across the highest-emitting sectors fall far short of what's needed to limit warming to 1.5 degrees Celsius (°C).
- While progress is heading in the right direction for most of the 45 indicators assessed, none are on track to achieve 2030 targets compatible with this temperature goal. The pace of change is promising, albeit still too slow, for 6 indicators and at well below the required speed for another 29. For 5, trends are heading in the wrong direction entirely. Data are insufficient to evaluate the remaining 5.
- Several bright spots underscore that rapid change is possible. Private climate finance has increased sharply, shifting from well off track to off track; solar is the fastest-growing power source ever; and nascent innovations like green hydrogen saw meaningful one-year gains.
- Yet such positive changes have occurred alongside far more troubling trends. For electric vehicle sales—the only indicator previously on track—growth slowed, such that progress is now off track for 2030. Efforts to reduce coal-fired power and deforestation remain well off track for multiple installments in a row. And even consistent year-on-year growth in renewables is not enough, as, with each passing year, the pace of change needed to get on track for 2030 increases.
- An enormous acceleration in effort is needed across every sector. By 2030, for example, electricity generated from unabated gas needs to be phased out seven times faster, declines in deforestation need to accelerate ninefold, and growth in total climate finance needs to increase four times faster.

ecosystems (Granados et al. 2025; MacCarthy et al. 2025; *New York Times* 2025), fueled by human-caused temperature rise superimposed on the warm phase of El Niño–Southern Oscillation (Otto et al. 2024). These fires, alongside extreme heat and drought across the tropics, contributed to an unprecedented weakening of the land sink in 2023 that, in turn, led to a significant rise in atmospheric concentrations of CO_2 (Ke et al. 2024; Friedlingstein et al. 2025). Searing heatwaves in China and India also spiked demand for cooling, driving a surge in coal consumption (IEA 2025j). In fact, about half of the growth in global energy-related CO_2 emissions in 2024 can be attributed to record high temperatures (IEA 2025e).

These worsening climate impacts lay bare countries' collective failure to act at the pace and scale required to combat the crisis, but that doesn't necessarily mean that efforts are not underway. We continue to see progress emerge in some governments, markets, local communities, and boardrooms. (PwC 2025). Clean energy investments hit a new milestone, surpassing $2 trillion in 2024, approximately twice the investments in fossil fuels (IEA 2025i).[1] The world had its largest-ever increase in renewable energy generation in 2024 (Ember 2025), and the share of global electricity produced from zero-carbon sources is now over 40 percent (Graham et al. 2025). China's cumulative installed capacity of solar energy, alone, surpassed 1 terawatt (TW) in June 2025, 10 times more than solar capacity in 2017 and 1,000 times more than solar capacity in 2010 (Shaw 2025; Ember 2025). Notably, 37 percent of companies strengthened the ambition of their climate commitments, compared to only 16 percent that weakened them (PwC 2025). These developments demonstrate that change is underway and, in some cases, occurring at rates much faster than analysts had predicted (Bond et al. 2024).

A decade ago, the Paris Agreement was adopted with the shared goal of putting humanity on a more sustainable path, not only averting climate impacts but also advancing energy security, safeguarding ecosystem services, improving human health, and enhancing overall well-being. Although the global emissions trajectory is far from being aligned with the Paris Agreement's goals, some notable progress has been achieved in the past decade (Box ES-1). Projections before the Paris Agreement indicated we would see global average temperature rise increase by around 4°C by the end of the century (Rogelj and Rajamani 2025). Today, current policies put the world on course for 2.7°C–3.1°C of warming (CAT 2025b; UNEP 2024a), and projections fall to between 2.1 and 2.8°C if governments fully implement their nationally determined contributions (NDCs), with the lower end of this range conditional on developing countries' receipt of finance and support (UNFCCC Secretariat 2024).

This year, Parties to the Paris Agreement have the chance to step up ambition further still and submit new NDCs that will determine the global emissions trajectory through 2035. As of October 2025, 62 new NDCs, representing 31 percent of global GHG emissions today, have been submitted. Yet these new national commitments barely make a dent in closing the 26.6-29.9 $GtCO_2e$ gap in 2035 needed to limit warming to 1.5°C. If fully implemented, they will collectively cut GHG emissions in 2035 by just 1.3-1.6 $GtCO_2e$, relative to 2035 levels implied by countries' previous NDCs[2] (Climate Watch 2025b).

Far steeper and more rapid GHG emissions reductions are needed immediately to keep the Paris Agreement within reach. For the first time, 2024 saw global temperature rise reach 1.55°C for a full year, and, while this does not mean that the world has breached the Paris Agreement temperature goal (WMO 2025b), there is increasing evidence that the world is fast approaching this limit (Cannon 2025; Bevacqua et al. 2025).[3] With many continuing to delay climate action, the prospect of avoiding low overshoot of 1.5°C is getting more and more remote (Peters 2024; Bertram et al. 2024). Limiting warming to 1.5°C even with higher levels of overshoot entails unprecedented transformational change across every sector, alongside large-scale carbon removal (Gambhir et al. 2023). And, as this report shows, while rapid, nonlinear change is possible and already underway in some sectors, the pace and scale of global progress continues to fall far short of what's needed.

In spite of these grave challenges—and indeed, precisely because collective efforts are so far behind—achieving 1.5°C-aligned sectoral targets is all the more vital (Rogelj and Rajamani 2025). Should warming exceed 1.5°C even temporarily, already devastating impacts will only intensify, subjecting more and more people to increasingly frequent and severe storms, even longer heatwaves and droughts, more extreme precipitation and flooding, rapid sea level rise, and more. Overshooting this limit also increases the likelihood that future impacts will compound one another, with multiple hazards battering communities at the same time (IPCC 2022a). Every fraction of a degree matters when it comes to avoiding these increasingly catastrophic impacts, and even if global temperature rise crosses the Paris Agreement's limit, the world should still be doing exactly what it needs to be doing today—rapidly reducing GHG emissions and enhancing removals. The global, sector-specific targets outlined in this report provide a comprehensive roadmap for doing just that across the highest-emitting sectors. Achieving these targets is not only still technically feasible but also more important than ever.

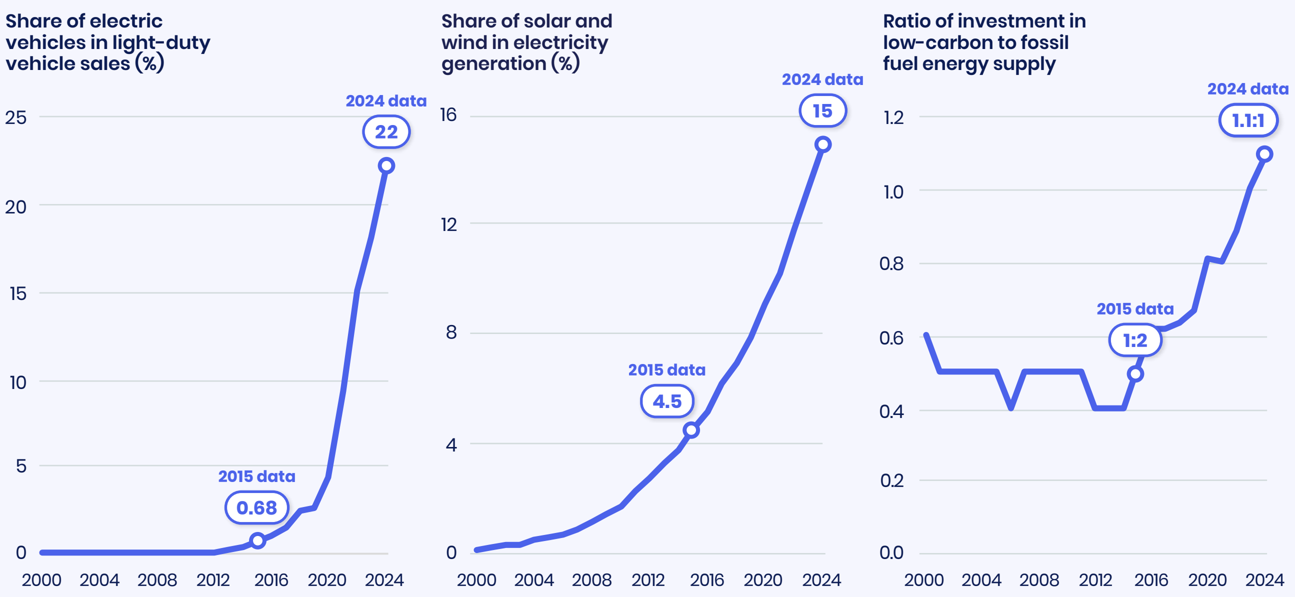
It is in Parties' interests to step up climate ambition and action to secure their tremendous and myriad benefits, from curbing harmful air pollution and creating new industries and jobs to bolstering food security and safeguarding both ecosystems and the irreplaceable, life-sustaining services they provide to humanity (OECD and UNDP 2025). We have also never had more knowledge and tools about how to realize these benefits, and, indeed, the sectoral indicators and targets tracked in this report paint a clear picture of the transformations that must occur to unlock them.

We still have a small window of time not to avoid all impacts but rather to limit harm to people and ecosystems, but we must use it wisely and act with the urgency this moment demands. Considering the alternative, the benefits of urgent climate action are impossible to overstate and the costs of inaction too high to quantify.

BOX ES-1 | Ten years after the Paris Agreement was signed, what progress has been made to transform sectors?

Since more than 190 countries signed the Paris Agreement in 2015, the world has seen the transition to a net-zero future take off, with many changes underway today that were unfathomable just 10 years ago. Electric vehicles, for example, accounted for less than 1 percent of light-duty vehicle sales in 2015. By 2024, that share surged to roughly a quarter, and, in China, the world's largest car market, electric vehicles account for almost half of all passenger car sales (IEA 2025k). Similarly, the global share of electricity generated from solar and wind has more than tripled since 2015 (Ember 2025), while the ratio of investment in low-carbon to fossil fuel energy supply more than doubled (Figure BES-1.1) (IEA 2025i). And some technologies that were merely ideas or small pilot projects in 2015, such as green hydrogen and direct air carbon capture and storage, are being tested, developed, and deployed around the world.

FIGURE BES-1.1 | Rapid growth in electric vehicle passenger car sales share, solar and wind generation share, and the ratio of investment in low-carbon to fossil-fuel energy supply since 2015



Sources: IEA 2025i, 2025k; Ember 2025.

BOX ES-1 | Ten years after the Paris Agreement was signed, what progress has been made to transform sectors? (continued)

While such rapid changes warrant recognition, not every sector has seen such momentous gains. Some have seen more modest, albeit still positive, changes in the 10 years following the Paris Agreement's adoption. Since 2015, for instance, the carbon intensity of global cement production improved by 7 percent, while the number of kilometers of metro rails, light-rail train tracks, and bus lanes in the world's largest cities increased by 26 percent, growing from an average of 19 kilometers per 1 million inhabitants in 2015 to 24 kilometers per 1 million inhabitants in 2024. At the same time, some trends have not improved at all, or even worsened.

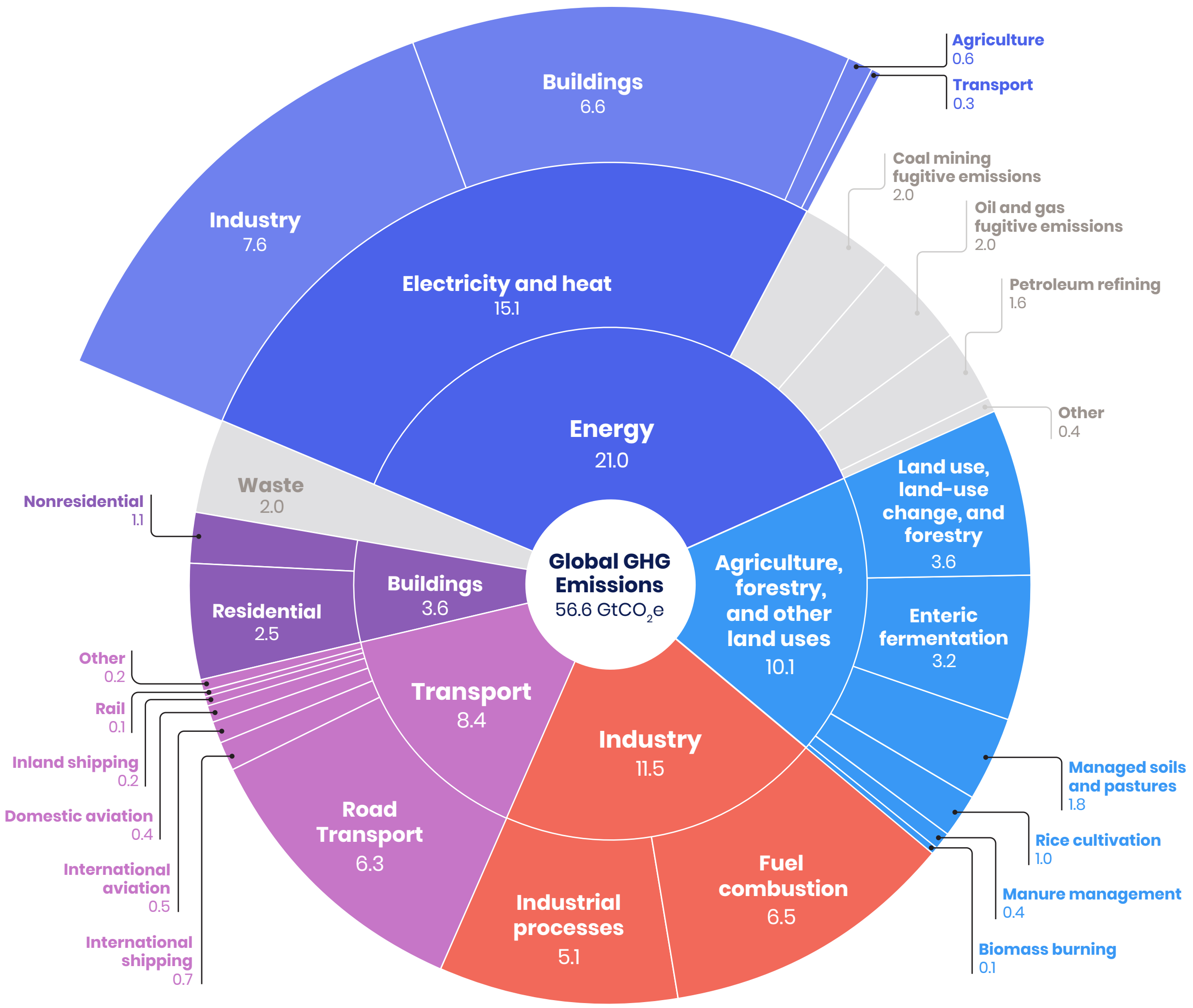
In the three years leading up to the Paris Agreement,[a] the world permanently lost an average 7.6 million hectares per year (Mha/yr) of forests. Deforestation has not fallen since,[b] with the last three years witnessing permanent forest losses occurring at an annual average rate of 8.3 Mha/yr (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025).[c] Meanwhile, public fossil fuel finance increased from an average of $1.1 trillion per year[a] to $1.6 trillion per year,[d] such that a step-change in action is now needed to achieve the Paris Agreement.

Notes:
[a] This trend is measured between 2013 and 2015.
[b] The methods behind one of the data sources (Hansen et al. 2013) used to produce this estimate have changed over time, resulting in increased sensitivity in detecting tree cover loss in recent years. As a result, comparison of different time periods should be interpreted with caution, as methodological changes may contribute to increases in tree cover loss over time (Weisse and Potapov 2021).
[c] This trend is measured between 2022 and 2024.
[d] This trend is measured between 2021 and 2023.

About this report

The *State of Climate Action* series provides the world's most comprehensive roadmap for closing the global gap in climate action across key sectors to help limit global warming to 1.5°C. Building on CAT 2020a, 2020b, 2023b, 2024a, 2024b; Lebling et al. 2020; Boehm et al. 2021, 2022, 2023; and Climate Analytics 2023, it translates the Paris Agreement's temperature goal into global, sector-specific targets primarily for 2030, 2035, and 2050 across power, buildings, industry, transport, forests and land, and food and agriculture. Together, these sectors accounted for 86 percent of GHG emissions in 2023, with waste and upstream energy emissions like those from fossil fuel extraction and petroleum refining comprising the remaining 14 percent (Figure ES-1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025). Additionally, the series includes targets and indicators to track progress made in scaling up technological carbon dioxide removal (CDR) and climate finance, both of which are urgently needed to limit global temperature rise to 1.5°C. While this report's scope is limited to mitigation, a similar effort is warranted for adaptation, though achieving some targets featured in this series would also help build resilience to intensifying impacts.

FIGURE ES-1 | Global net anthropogenic GHG emissions by sector in 2023



Notes: GHG = greenhouse gas; $GtCO_2e$ = gigatonnes of carbon dioxide equivalent. Carbon dioxide (CO_2) equivalent emissions are calculated using global warming potentials with a 100-year time horizon from IPCC 2022b. Note that for agriculture, forestry, and other land uses (AFOLU), Crippa et al. 2024; IEA 2024h; and Friedlingstein et al. 2025 only consider non-CO_2 emissions from agricultural production, which accounts for 89 percent of total methane (CH_4) emissions from AFOLU and 96 percent of total nitrous oxide (N_2O) emissions from AFOLU (IPCC 2022b). Accordingly, these data exclude non-CO_2 emissions from land use, land-use change, and forestry, such as N_2O from drained peatlands or CH_4 from fires set to permanently clear forests and grasslands. Also, sectors in gray are not covered in this report.

Sources: Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025.

This report also issues a global report card on collective efforts to combat the climate crisis, including those focused on delivering the sector-specific mitigation goals outlined in the Global Stocktake (Box ES-2). To assess global progress for the majority of these climate action indicators, we use the most recent 5 years of data (or 10 years to account for high interannual variability in some indicators) to project a linear trendline from the latest available year of data to 2030 and then compare this extended historical trendline to the rate of change required to reach 1.5°C-aligned targets for the same year. With these data, we calculate acceleration factors to quantify how much the pace of recent change needs to increase over this decade (Appendix A). Based on these acceleration factors, indicators fall into one of five categories of progress: heading in the right direction and on track, heading in the right direction but off track, heading in the right direction but well off track, heading in the wrong direction entirely, or insufficient data.

BOX ES-2 | How does the *State of Climate Action* series contribute to monitoring implementation of the Global Stocktake outcome?

Recognizing the need for deep, rapid, and sustained reductions in GHG emissions to keep the 1.5°C limit within reach, the first Global Stocktake broke new ground by calling on Parties to collectively accelerate action across key sectors, from tripling renewable energy capacity by 2030 to enhancing efforts to halt and reverse deforestation by the end of this decade (UNFCCC 2024a). While several of the mitigation commitments made under this landmark COP28 decision are quantitative and time-bound, most indicate only the direction of travel. Some, for example, call on Parties to achieve transitions by mid-century but do not provide near-term benchmarks needed to chart credible pathways toward these longer-term goals, while others lack deadlines altogether. Additionally, several goals remain open-ended about the level of ambition required to align emissions trajectories with the Paris Agreement temperature limit—for example, in accelerating zero- and low-emissions technologies or in reducing road transport emissions. This report's 2030, 2035, and 2050 targets can help translate many of these calls to action into a more concrete roadmap—for example, by specifying how quickly uptake of solar, wind, electric vehicles, green hydrogen, and technological CDR removal approaches, among other zero- and low-carbon technologies, increases in pathways that limit warming to 1.5°C. Each installment of the *State of Climate Action* then tracks global progress made toward these 2030 targets, as well as collective efforts to achieve the Global Stocktake's goals (Appendix B).

For a handful of indicators—namely, those that directly track the adoption of innovative technologies—future change will likely follow more of an S-curve than a purely linear trajectory. To account for such instances of rapid, nonlinear growth, we first consider the likelihood that future change in indicators would follow an S-curve, whereby a technology's market share grows slowly in the beginning, then accelerates once a breakthrough is achieved, and eventually levels off. We then classify indicators as S-curve unlikely, S-curve possible, or S-curve likely, and adjust our methods for assessing progress made toward 2030 targets for S-curve likely indicators. More specifically, we consider multiple lines of evidence, including the shape of each indicator's past trajectory, a review of the literature, and consultations with sectoral experts. We also fit S-curves to historical data where appropriate. In instances where we find compelling evidence of S-curve dynamics, we upgrade our assessment of progress from what it would have been based on a linear trendline. For example, a purely linear assessment would suggest that recent efforts to increase the share of electric vehicles in light-duty sales are well off track, but given recent exponential growth and projections for further rapid, near-term change, we categorize progress as off track in this report.

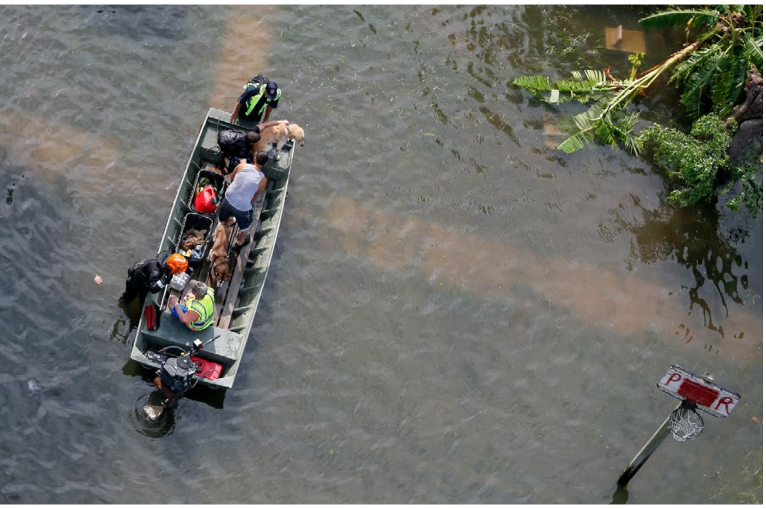
Finally, this report highlights notable recent developments that have occurred since COP28 in Dubai to complement the global assessment of progress and provide a more holistic picture of climate action. They include a wide range of actions, from adopting new policies to investing in the development of nascent zero-carbon technologies to disbursing financial pledges.[4] For many of our 45 indicators, it can take time for sectoral actions undertaken by governments, civil society, and the private sector to spur (or impede) global progress. Yet these recent developments may still represent meaningful changes made in the real-world economy, and they can offer insights into where momentum for positive change may be gaining traction, as well as where considerably more effort will be needed to achieve 1.5°C-aligned targets for 2030.

Key findings across sectors

Halfway through this decisive decade, climate action has failed to materialize at the pace and scale required to achieve the Paris Agreement's temperature goal. None of the 45 indicators assessed are on track to reach their 1.5°C-aligned targets for 2030 (Figure ES-2). For 5 of these indicators, recent rates of change are heading in the wrong direction entirely. Public fossil fuel finance, for example, has grown by an average of $75 billion per year since 2014 (OECD and IISD 2025; Laan et al. 2023; OCI 2025; Gerasimchuk et al. 2024); progress made in decarbonizing steel has largely stagnated, such that CO_2 emissions per tonne of crude steel produced increased over the last five years (World Steel Association 2024a); and the share of trips taken by passenger cars, many of which still rely on the internal combustion engine, continue to rise, now accounting for about half of all kilometers traveled (ITF 2025).

Recent rates of change for another 29 indicators are well off track, such that at least a twofold—and for most, more than a fourfold—acceleration will be required this decade to keep the 1.5°C limit within reach. That progress made in effectively halting permanent forest loss falls within this category for the third installment in a row is particularly worrying (Box ES-3) (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025). Not only does deforestation, alone, account for just over 10 percent of global GHG emissions (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025), but alongside other forms of land-use change, it also poses among the most significant threats to biodiversity across terrestrial ecosystems (Jaureguiberry et al. 2022). Equally concerning are sluggish efforts to phase out electricity generated from coal, the largest source of GHG emissions in the power sector (Ember 2025). Lackluster declines in this indicator also stymie mitigation across buildings, industry, and transport that all, to varying degrees, rely on electrification and a fully decarbonized grid. The scale-up of total climate finance, particularly from public sources, also remains well off track. Failure to mobilize sufficient funds similarly risks constraining climate action across all sectors (CPI 2025c).

Most of today's bright spots, while promising, represent isolated instances of rapid change—a far cry from the systemwide transformations urgently needed to close the GHG emissions gap for 1.5°C. Progress for another six indicators is heading in the right direction at a promising, albeit still inadequate, pace. Private climate finance, for example, increased sharply from roughly $870 billion in 2022 to $1.3 trillion in 2023, with individual consumers, businesses, and institutional investors, particularly in China and Western Europe, driving much of these recent gains (CPI 2025c). Electric vehicle sales also continue to rise rapidly, fueled by impressive growth across China, the world's leading consumer and manufacturer of these light-duty vehicles (IEA 2025k). But in 2024, momentum stalled in two other major markets. According to recent analysis from IEA (2025k), EV sales fell slightly across Europe, following the rollback of supportive subsidies in countries like Germany and France, while in the United States, growth in EV sales decelerated due to a combination of factors like a relatively slow buildout of public charging infrastructure and limited availability of affordable electric sports utility vehicles, which account for three-quarters of the country's passenger car sales. Consequently, annual growth rates in EVs' share of total light-duty vehicle sales fell to an average of roughly 20 percent in 2023 and 2024 compared to growth rates of more than 60 percent in each of the three previous years (IEA 2025k). So, while EVs are still achieving meaningful gains in the global share of light-duty vehicle sales, more recent progress is off track and falls short of what's needed to help achieve the Paris Agreement temperature goal (Box ES-3).



Getting on track for 2030 and staying on track for 2035 will therefore require an enormous acceleration of efforts across every sector. The world must, for example, do the following:

- Phase out coal generation more than 10 times faster—equivalent to retiring nearly 360 average-sized coal-fired power plants each year through the end of this decade.[5] As countries continue to plan and build out new coal-fired power plants, reducing coal generation will only become more challenging.
- Rapidly increase growth in solar and wind power. These technologies' share of electricity generation has risen by an average of 13 percent per year since 2020 (Ember 2025), but recent growth rates must more than double to 29 percent per year to get on track for 2030.
- Achieve a fivefold acceleration in the construction of affordable and reliable public transit systems in the world's highest-emitting cities by building at least 1,400 kilometers of new transit routes, including light rail, metro rail, and bus rapid transit lanes, every year through 2030.
- Reduce deforestation nine times faster. Current levels are far too high–roughly equivalent to permanently losing nearly 22 football (soccer) fields of forest every minute in 2024.[6]
- Lower consumption of beef, lamb, and goat meat across high-consuming regions more than five times faster, which will entail eating about 1.9 fewer servings per week in Australia and New Zealand, 1.3 fewer servings per week in South America, and 1.2 fewer servings per week in North America by 2030.[7]
- Scale up technological CDR more than 10 times faster—equivalent to building nine of the largest direct air capture facilities currently in development each month through the end of this decade.[8]
- Increase global climate finance by nearly $1 trillion each year through the end of this decade. This annual increase is roughly equal to two-thirds of public fossil fuel finance in 2023 (Gerasimchuk et al. 2024).

FIGURE ES-2 | Assessment of global progress made toward 2030 targets

LIKELIHOOD OF FOLLOWING AN S-CURVE — ACCELERATION FACTOR[a]

N/A — S-curve Likely

These indicators track technology adoption directly. They are either following an S-curve or are likely to do so in the future. For those in early stages of an S-curve, a meaningful increase may not occur immediately. Our assessment relies on author judgment of multiple lines of evidence.

5x — S-curve Unlikely

These indicators are not closely related to technology adoption so are unlikely to follow an S-curve. Our assessment of progress relies on acceleration factors—calculations of how much recent rates of change (as estimated by linear trendlines) need to accelerate to achieve the 2030 targets.

5x — S-curve Possible

These indicators indirectly or partially track technology adoption so could experience non-linear change, although likely in a different form than an S-curve. Our assessment of progress relies on acceleration factors—calculations of how much recent rates of change (as estimated by linear trendlines) need to accelerate to achieve the 2030 targets. Change may occur faster than expected.

RIGHT DIRECTION, OFF TRACK

Acceleration factor	Indicator
N/A[b]	Share of electric vehicles in light-duty vehicle sales (%)
N/A[b,d]	Share of electric vehicles in the light-duty vehicle fleet (%)
1.8x	Reforestation (total Mha)
1.2x	GHG emissions intensity of soil fertilization (gCO_2e/1,000 kcal)
1.6x	Ruminant meat productivity (kg/ha)
1.8x[d]	Global private climate finance (trillion US$/yr)

RIGHT DIRECTION, WELL OFF TRACK

Acceleration factor	Indicator
N/A[b]	Share of zero-carbon sources in electricity generation (%)
N/A[b]	Share of solar and wind in electricity generation (%)
>10x	Share of coal in electricity generation (%)
7x	Share of unabated fossil gas in electricity generation (%)
>10x	Carbon intensity of electricity generation (gCO_2/kWh)
3x	Energy intensity of building operations (kWh/m²)
4x	Carbon intensity of building operations ($kgCO_2/m^2$)
5x	Share of electricity in the industry sector's final energy demand (%)
4x	Carbon intensity of global cement production ($kgCO_2$/t cement)
N/A[b,d]	Green hydrogen production (Mt)
5x	Number of kilometers of rapid transit per 1 million inhabitants (km/1M inhabitants)
N/A[b,d]	Share of electric vehicles in bus sales (%)
N/A[b,d]	Share of electric vehicles in medium- and heavy-duty commercial vehicle sales (%)
N/A[b,d]	Share of sustainable aviation fuels in global aviation fuel supply (%)
N/A[b]	Share of zero-emissions fuels in maritime shipping fuel supply (%)
>10x	Share of fossil fuels in the transport sector's total energy consumption (%)
9x	Deforestation (Mha/yr)
>10x	Mangrove restoration (total ha)

RIGHT DIRECTION, WELL OFF TRACK

Acceleration factor	Indicator
5x	GHG emissions intensity of agricultural production (gCO_2e/1,000 kcal)
2.5x[c]	GHG emissions intensity of enteric fermentation (gCO_2e/1,000 kcal)
6x	GHG emissions intensity of manure management (gCO_2e/1,000 kcal)
6x	GHG emissions intensity of rice cultivation (gCO_2e/1,000 kcal)
10x	Crop yields (t/ha)
5x	Ruminant meat consumption in high-consuming regions (kcal/capita/day)
>10x[d]	Technological carbon dioxide removal ($MtCO_2$/yr)
4x	Global total climate finance (trillion US$/yr)
6x[c]	Global public climate finance (trillion US$/yr)
>10x[c]	Weighted average carbon price in jurisdictions with emissions pricing systems (2024 US$/$tCO_2e$)
7x	Ratio of investment in low-carbon to fossil fuel energy supply

WRONG DIRECTION, U-TURN NEEDED

Acceleration factor	Indicator
U-turn needed	Carbon intensity of global steel production ($kgCO_2$/t crude steel)
U-turn needed	Share of kilometers traveled by passenger cars (% of passenger-km)
U-turn needed[d]	Mangrove loss (ha/yr)
U-turn needed	Share of food production lost (%)
U-turn needed[d]	Public fossil fuel finance (trillion US$/yr)

INSUFFICIENT DATA

Acceleration factor	Indicator
Ins. data	Retrofitting rate of buildings (%/yr)
Ins. data	Share of new buildings that are zero-carbon in operation (%)
Ins. data	Peatland degradation (Mha/yr)
Ins. data	Peatland restoration (total Mha)
Ins. data	Food waste (kg/capita)

FIGURE ES-2 | Assessment of global progress made toward 2030 targets (continued)

Notes: gCO_2e = grams of carbon dioxide equivalent; gCO_2/kWh = grams of carbon dioxide per kilowatt-hour; ha = hectares; kcal = kilocalories; kcal/capita/day = kilocalories per capita per day; kg = kilograms; kg/ha = kilograms per hectare; $kgCO_2/m^2$ = kilograms of carbon dioxide per square meter; $kgCO_2/t$ = kilograms of carbon dioxide per tonne; km = kilometers; km/1M inhabitants=kilometers per 1 million inhabitants; kWh/m^2 = kilowatt-hour per square meter; Mha = million hectares; Mha/yr = million hectares per year; Mt = million tonnes; $MtCO_2$ = million tonnes of carbon dioxide; tCO_2 = tonnes of carbon dioxide; tCO_2e = tonnes of carbon dioxide equivalent; t/ha = tonnes per hectare; yr = year. For more information on indicators' definitions, deviations from our methodology to assess progress, and data limitations, see corresponding indicator figures in each section.

[a] For acceleration factors between 1 and 2, we round to the 10th place (e.g., 1.2 times); for acceleration factors between 2 and 3, we round to the nearest half number (e.g., 2.5 times); for acceleration factors between 3 and 10, we round to the nearest whole number (e.g., 7 times); and for acceleration factors higher than 10, we note as >10.

[b] For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are not presented, as they would not accurately reflect an S-curve trajectory. The category of progress was determined based on author judgment, using multiple lines of evidence. See Appendix C and Boehm et al. 2025 for more information.

[c] The most recent year of data represents a concerning worsening relative to recent trends.

[d] The most recent year of data represents a meaningful improvement relative to recent trends.

Sources: Authors' analyses based on data sources listed in each section.

A handful of indicators experienced meaningful advances in 2023 or 2024 that, if sustained, could represent early signals of acceleration ahead. For nine indicators, the most recent year of data available represents a notable improvement over the previous historical trend. The scale-up of relatively nascent innovations like green hydrogen, technological CDR approaches, and sustainable aviation fuels saw some of the greatest one-year gains, though current levels of adoption remain relatively low and are not yet close to a mainstream breakthrough. More mature technologies like electric passenger cars, buses, and trucks also experienced meaningful advances. Across these indicators, additional measures to stimulate demand and incentivize investments will prove critical to ensuring that these recent signs of acceleration translate into longer-term momentum rather than a temporary upswing. At the same time, immediate and supportive actions could also help reverse one year of underperformance in efforts to increase total climate finance, expand carbon pricing schemes, and reduce methane emissions from enteric fermentation, which all saw a concerning worsening, relative to recent trends.

BOX ES-3 | What has changed since the *State of Climate Action 2023*?

Since the last installment of this report series, four indicators' statuses have changed. Electric buses have experienced a course correction since Boehm et al. 2023, with global sales shifting from heading in the wrong direction to heading in the right direction, but well off track. Private climate finance also increased so substantially that its progress advanced from well off track to off track. While such upgrades are promising, another two indicators suffered setbacks. Beyond the downgrade in electric passenger car sales from on track to off track, zero-carbon sources' share in electricity generation also fell from off track to well off track. Globally, the share of solar and wind in electricity generation continues to grow rapidly at roughly 13 percent per year (Ember 2025) and is the primary driver of recent increases in zero-carbon power sources. But maintaining these historical growth rates won't be enough to get on track. This underscores a critical reality across many sectors—each year an indicator sustains rather than accelerates progress, the gap between climate action today and climate action needed by the end of this decade widens. Only by substantially picking up the pace of change can the world make up for delayed efforts and moving another year closer to 2030.

While most indicators' overall statuses have not shifted since Boehm et al. 2023, many have seen progress accelerate or decelerate marginally. Of all indicators that were included in both reports and have sufficient data, approximately a third had acceleration factors that improved such that required rates of future change are now lower. Boehm et al. (2023), for example, found that global efforts to decarbonize global cement production had stagnated, with progress needing to occur more than 10 times faster. But in recent years, cement's carbon intensity has begun to decline thanks to alternative fuels, substituting clinker with other materials, and increased efficiency. Now, getting on track for 2030 entails a fourfold acceleration. However, for another quarter of these indicators, progress has occurred too slowly, which means that future changes must occur even faster to keep 1.5°C-aligned targets within reach. See Appendix D for a more in-depth comparison of results across reports.

SECTION 1

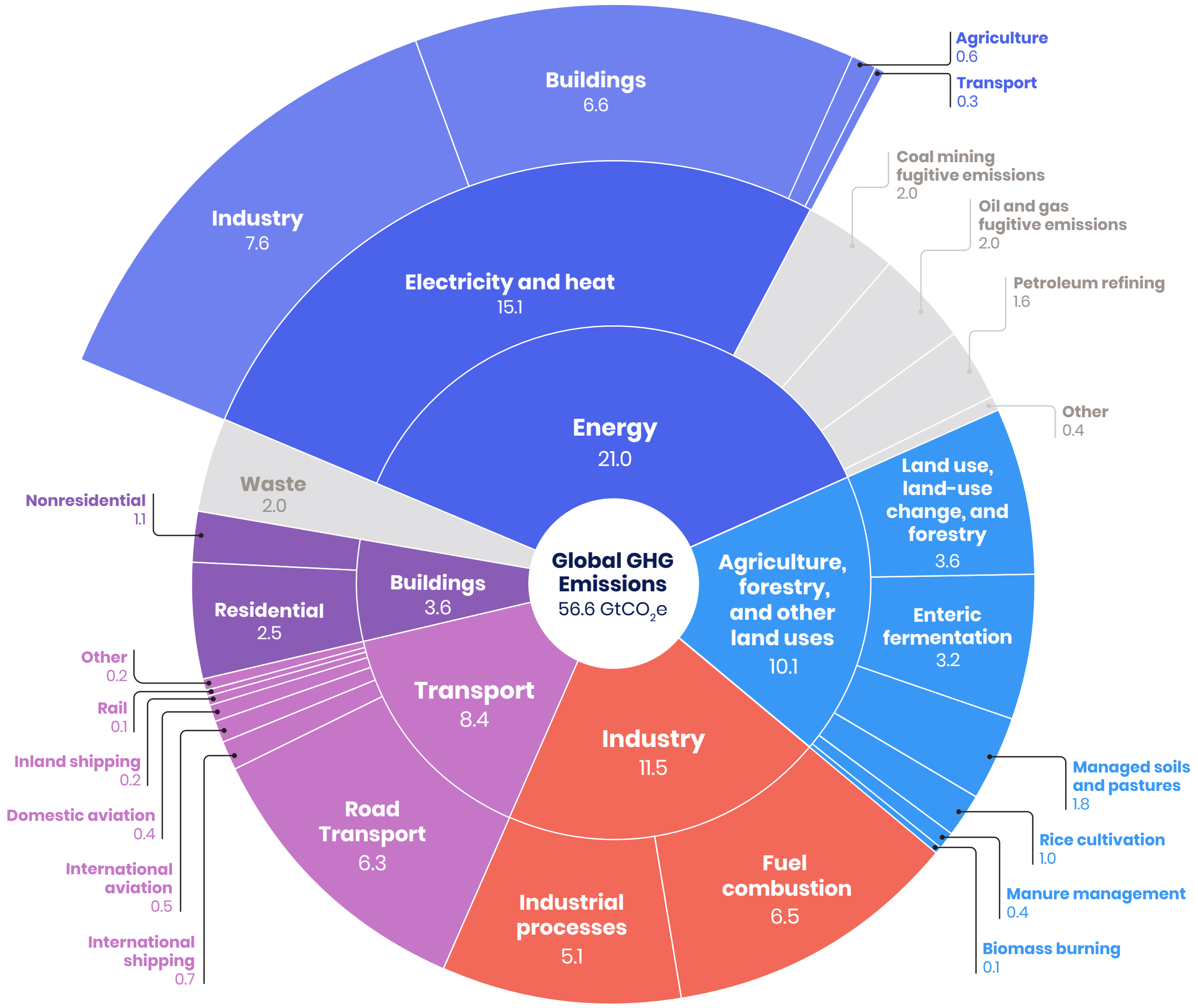
Methodology for assessing progress

This section provides a summary of this report's methodology. An accompanying technical note, Boehm et al. 2025, provides a more detailed explanation of the selection of sectors, targets, indicators, and datasets, as well as the methods used for assessing progress toward 1.5°C-aligned targets.

Selection of sectors, targets, and indicators

In modeled pathways that limit global temperature rise to 1.5°C above preindustrial levels with no or limited overshoot, greenhouse gas (GHG) emissions peak before 2025 at the latest and then fall by a median of 43 percent by 2030 and 60 percent by 2035, relative to 2019.[9] In these pathways, carbon dioxide (CO_2) emissions reach net zero by around mid-century. Achieving such deep reductions, the Intergovernmental Panel on Climate Change (IPCC) finds, will require rapid transformations across power, buildings, industry, transport, forests and land, and food and agriculture—sectors that collectively accounted for 86 percent of GHG emissions in 2023 (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025)—as well as the immediate scale-up of climate finance and technological carbon dioxide removal (CDR) (IPCC 2022b; IPCC 2023).[10]

FIGURE 1 | Global net anthropogenic GHG emissions by sector in 2023



Notes: GHG = greenhouse gas; $GtCO_2e$ = gigatonnes of carbon dioxide equivalent. Carbon dioxide (CO_2) equivalent emissions are calculated using global warming potentials with a 100-year time horizon from IPCC 2022b. Note that for agriculture, forestry, and other land uses (AFOLU), Crippa et al. 2024; IEA 2024h; and Friedlingstein et al. 2025 only consider non-CO_2 emissions from agricultural production, which accounts for 89 percent of total methane (CH_4) emissions from AFOLU and 96 percent of total nitrous oxide (N_2O) emissions from AFOLU (IPCC 2022b). Accordingly, these data exclude non-CO_2 emissions from land use, land-use change, and forestry, such as N_2O from drained peatlands or CH_4 from fires set to permanently clear forests and grasslands. Also, sectors in gray are not covered in this report.

Sources: Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025.

The *State of Climate Action* series translates these far-reaching transformations into an actionable set of shifts for each sector that, taken together, can help overcome the deep-seated carbon lock-in common to them all (Seto et al. 2016). For each shift, we established global near-term and long-term targets—primarily for 2030 and 2050—that are aligned with pathways that hold global temperature rise to 1.5°C. We also identified interim targets for 2035 and 2040 where possible.[11] We then selected corresponding indicators with historical data to assess global progress made toward each set of near-term and long-term targets.

Critically, the sectoral shifts identified in this report, as well as associated targets and indicators, do not provide a complete picture of what's needed to limit warming to 1.5°C—mitigation measures focused on reducing GHG emissions from landfills or the production of fossil fuels, for example, are excluded. Rather, they form a set of priority actions needed to keep this temperature goal within reach.

Global assessment of progress

To assess global progress for the majority of indicators, we used the most recent 5 years of data (or 10 years to account for high interannual variability in some indicators) to project a linear trendline from the latest available year of data to 2030 and then compared this extended historical trendline to the rate of change required to reach 1.5°C-aligned targets for the same year.[12] With these data, we calculated acceleration factors to quantify how much the pace of recent change needs to increase over this decade and then used these acceleration factors to place indicators in one of five categories of progress (Appendix A).[13]

Right direction, on track. The historical rate of change is equal to or above the rate of change needed. Indicators with acceleration factors between 0 and 1 fall into this category. However, we do not present these acceleration factors since the indicators are on track.

Right direction, off track. The historical rate of change is heading in the right direction at a promising yet inadequate pace. Extending the historical linear trendline would get these indicators more than halfway to their near-term targets, and so indicators with acceleration factors between 1 and 2 fall into this category.

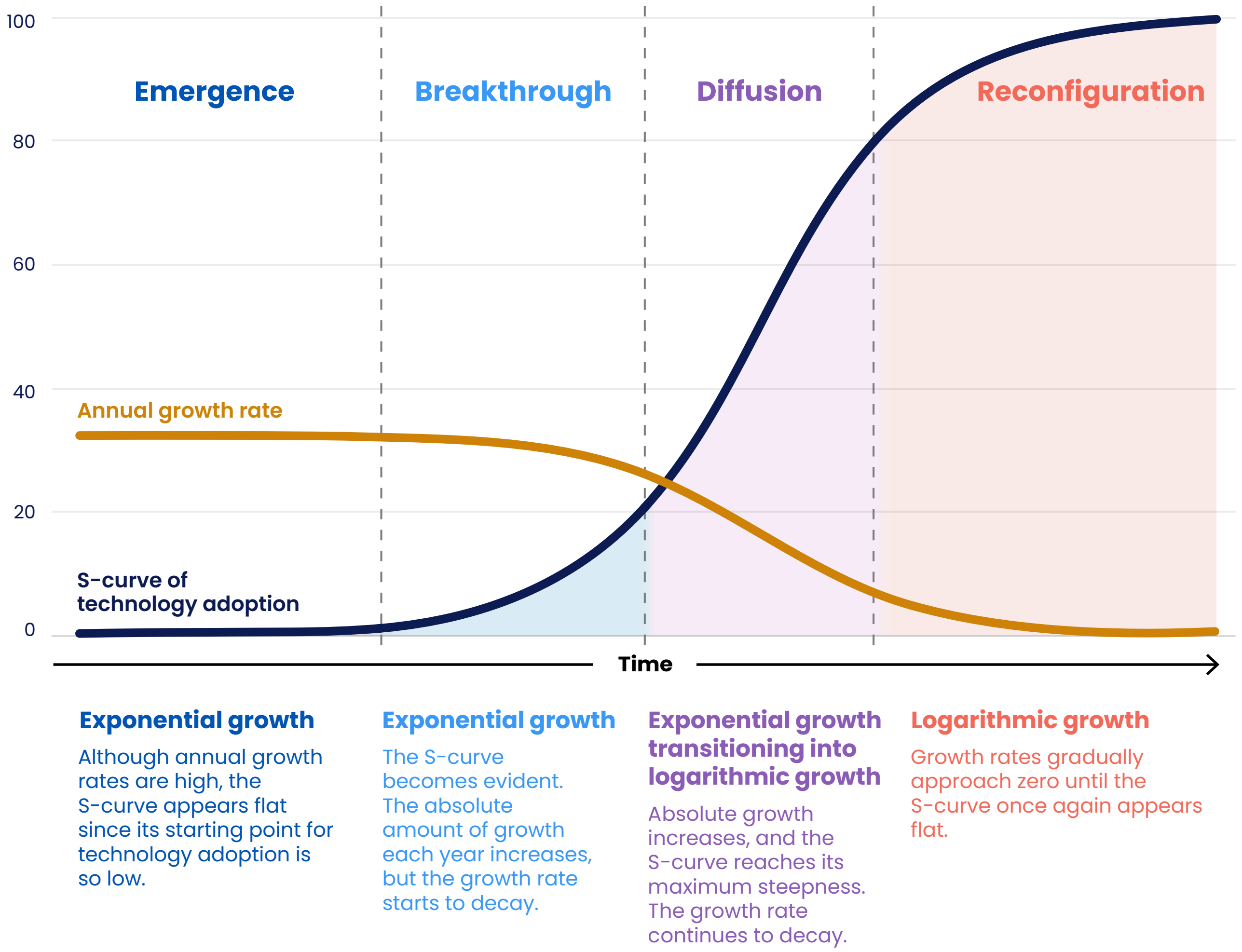
Right direction, well off track. The historical rate of change is heading in the right direction but well below the pace required to achieve the 2030 target. Extending the historical linear trendline would get them less than halfway to their near-term targets, and so indicators with acceleration factors of greater than or equal to 2 fall into this category.

Wrong direction, U-turn needed. The historical rate of change is heading in the wrong direction entirely. Indicators with negative acceleration factors fall into this category. However, we do not present these acceleration factors since a reversal in the current trend, rather than an acceleration of recent change, is needed for indicators in this category.

Insufficient data. Limited data make it difficult to estimate the historical rate of change relative to the required action.

For a handful of indicators—namely, those that directly track the adoption of innovative technologies—future change will likely follow more of an S-curve rather than a purely linear trajectory (Appendix C). The steepness of such a curve is highly uncertain, and technologies may encounter obstacles that alter or limit their growth. However, given the right conditions (e.g., supportive policies and investments), the adoption of new technologies can reach positive tipping points, after which self-amplifying feedback loops kick in to spur rapid, far-reaching changes (Figure 2) (Arthur 1989; Lenton et al. 2008, 2019; Lenton 2020).

FIGURE 2 | Illustrative S-curve



Source: Authors.

To account for this rapid, nonlinear growth, we first considered the likelihood that future change in indicators would follow an S-curve and classified each indicator as "S-curve unlikely," "S-curve possible," or "S-curve likely."[14] Categorizing an indicator as "S-curve likely" does not guarantee that it will experience rapid, nonlinear change over the coming years; rather, it signifies that, if and when adoption rates of these technologies begin to increase, such growth will likely follow an S-curve. For "S-curve likely" indicators, we then adjusted our methods for assessing progress made toward 2030 targets. More specifically, we considered multiple lines of evidence, including the shape of each indicator's S-curve and recent progress along it, a review of the literature, and consultations with sectoral experts. We also fitted S-curves to historical data, where appropriate. In instances where we found compelling evidence of S-curve dynamics, we upgraded our assessment of progress from what it would have been based on a purely linear trendline (Appendix C).

In addition to assessing global progress made toward 2030 targets, we also analyzed whether an indicator's most recent data point represented a meaningful improvement or worsening, relative to its historical trendline. Where sufficient data were available, we extended the historical trendline from the previous 5 years (or 10 years) of data to project a data point for the most recent year for which we have data. For example, if our most recent data point is 2024, we used data from 2019 to 2023 to construct a historical trendline and then extended that trendline to project a data point for 2024. We then compared our most recent data point to this projected data point on the extended historical trendline. If the most recent data point was more than 5 percent higher than the projected value on the extended trendline for an indicator that needs to increase to achieve its 2030 target, we concluded that the most recent year of data for this indicator represents an improvement relative to the historical trendline.

But if the most recent data point fell more than 5 percent below the projected value on the extended historical trendline for the same indicator, we concluded that the most recent year of data for this indicator represents a worsening relative to the historical trendline. Determining the extent to which an improvement or worsening is either temporary or part of a longer-term trend, however, will only be possible in future years.

Selection of recent developments

To identify the recent developments most relevant to each sector, we restricted our search to those that fall into one of the categories of enabling conditions outlined in Boehm et al. 2022: innovations in technologies, supportive policies, institutional strengthening, leadership, and shifts in behavior and social norms. The significance of enabling conditions differs by sector. In power, for example, many of the technologies needed to decarbonize the sector are mature and commercialized, while in industry or food and agriculture, these innovations remain far more nascent, such that achieving these sectoral targets will likely require considerable investment in research, development, and deployment. Similarly, while many countries have set targets and published national strategies focused on electrifying transport or conserving ecosystems, far fewer have put in place similar goals or plans to decarbonize buildings or shift consumption patterns. Thus, we hewed closely to the specific enabling conditions outlined for each sector in Boehm et al. 2022 when identifying recent developments. Additionally, we focused primarily on developments that are global in scope, though we also included those that are from particularly influential locales—for example, major emitters, large economies that can shape global trends, and countries that contain disproportionate amounts of the world's forests.

In addition to peer-reviewed journal articles, we relied on searches of gray literature, newsletters, and policy trackers from leading organizations within these sectors (e.g., the International Energy Agency, World Steel Association, International Council on Clean Transportation, and the Food and Agriculture Organization of the United Nations), newspaper articles from major outlets (e.g., the *New York Times*, and *The Guardian*), and government plans and strategies (e.g., nationally determined contributions). We primarily restricted these searches to the period from November 2023 to August 2025, though we included some recent developments that predated this period where relevant.

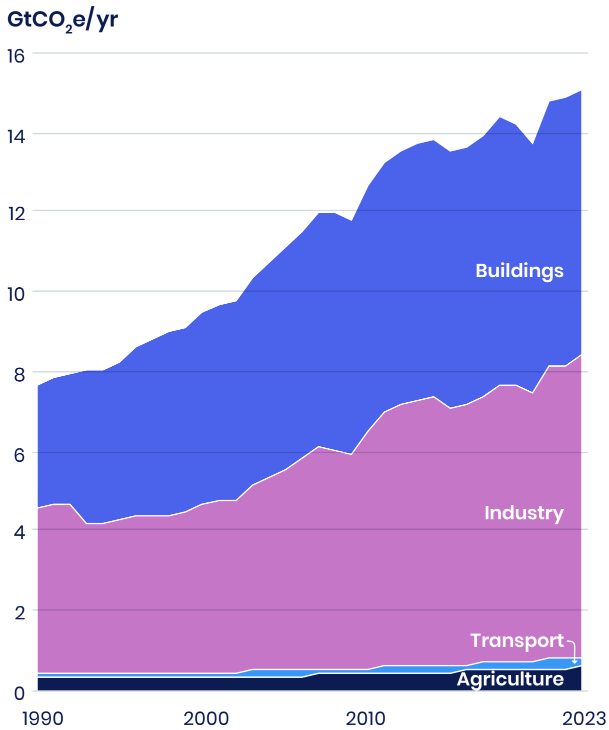
SECTION 2

Power

The power sector underpins the global economy, but burning fossil fuels for electricity is the world's single-largest contributor to climate change (IPCC 2022b). In 2023, electricity and heat generation accounted for 27 percent of global GHG emissions (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025).[15] Though total power emissions dipped during the COVID-19 pandemic in 2020, they rebounded and have been growing since 2021 (Figure 3).

Decarbonizing power generation will play a vital role in reducing emissions from end-use sectors—including industry, buildings, and transport—that consume electricity.[16] The largest current users of electricity and heat are industry and buildings, responsible for 95 percent of all these emissions (Figure 3) (Crippa et al. 2024; IEA 2024h). The transport sector will also use more electricity as the electric vehicle (EV) fleet expands, further motivating the decarbonization of the power sector.[17]

FIGURE 3 | Global GHG emissions from power and heat by end-use sector



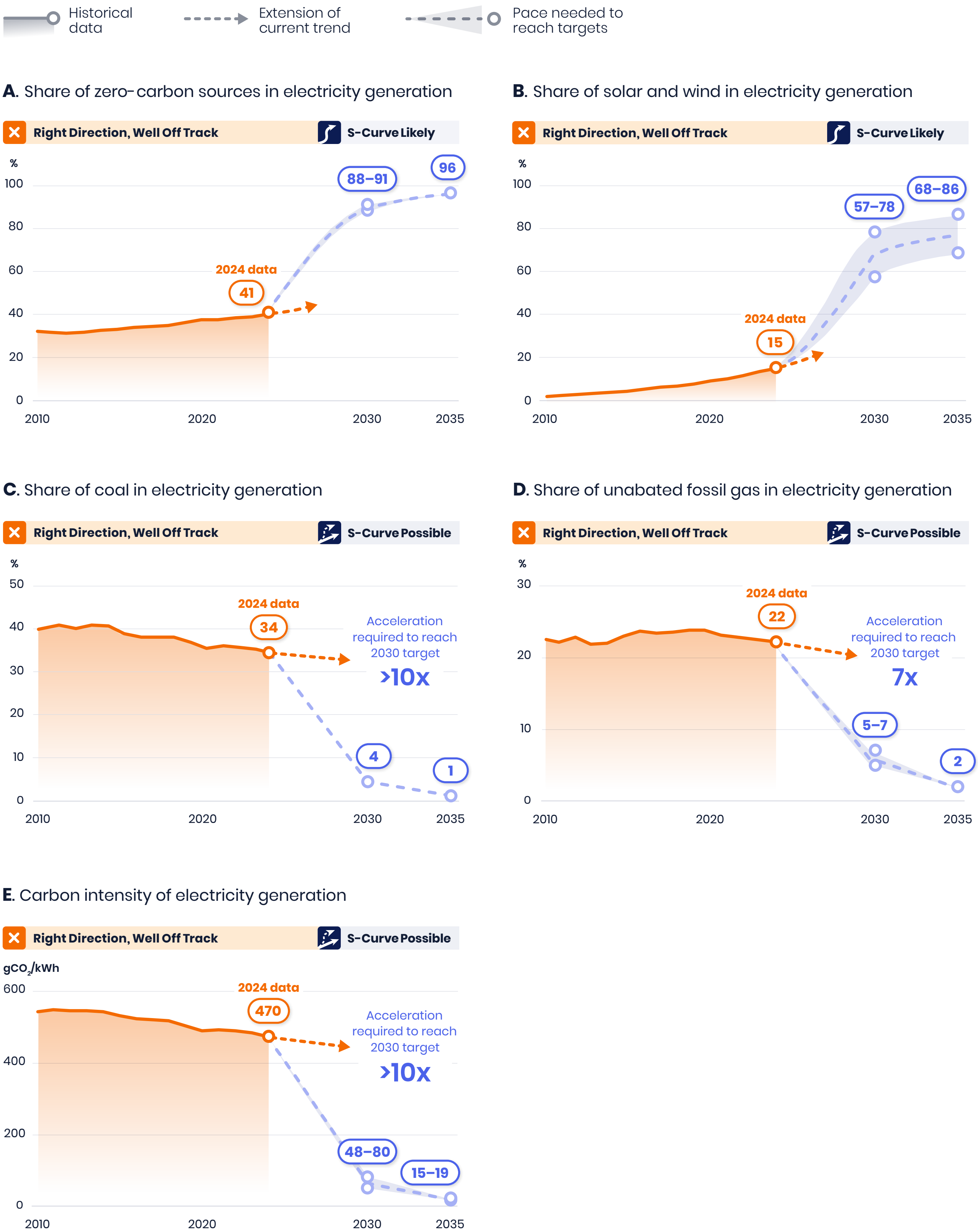
Notes: GHG = greenhouse gas; $GtCO_2e/yr$ = gigatonnes of carbon dioxide equivalent per year. This figure shows GHG emissions from both electricity and heat. Heat production is not covered in this section, but between 1998 and 2019, it accounted for just 15 percent of these emissions on average, according to a comparison of data from Crippa et al. 2024 and IEA 2024h to data presented in Boehm et al. 2023.

Sources: Crippa et al. 2024; IEA 2024h.

Global assessment of progress

Decarbonizing the power sector will require rapidly scaling up zero-carbon power and phasing out electricity generated from fossil fuels.[18]

FIGURE 4 | Summary of global progress toward power targets



Notes: gCO_2/kWh = grams of carbon dioxide per kilowatt-hour. For indicators categorized as S-curve possible, the acceleration factors and status of progress are determined by a linear trendline based on the past five years of data. For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are not presented, as they would not accurately reflect an S-curve trajectory. The current trend arrow is based on an S-curve trendline, and the category of progress for these indicators was determined based on author judgment, using multiple lines of evidence. The share of zero-carbon sources in electricity generation is a special case, because the current trend arrow is extrapolated based on an S-curve trendline for solar and wind and a linear trendline for other zero-carbon technologies such as nuclear and hydropower. See Appendix C and Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

Source: Historical data from Ember 2025. Targets from CAT 2023 and Boehm et al. 2025.

Shifting to zero-carbon power

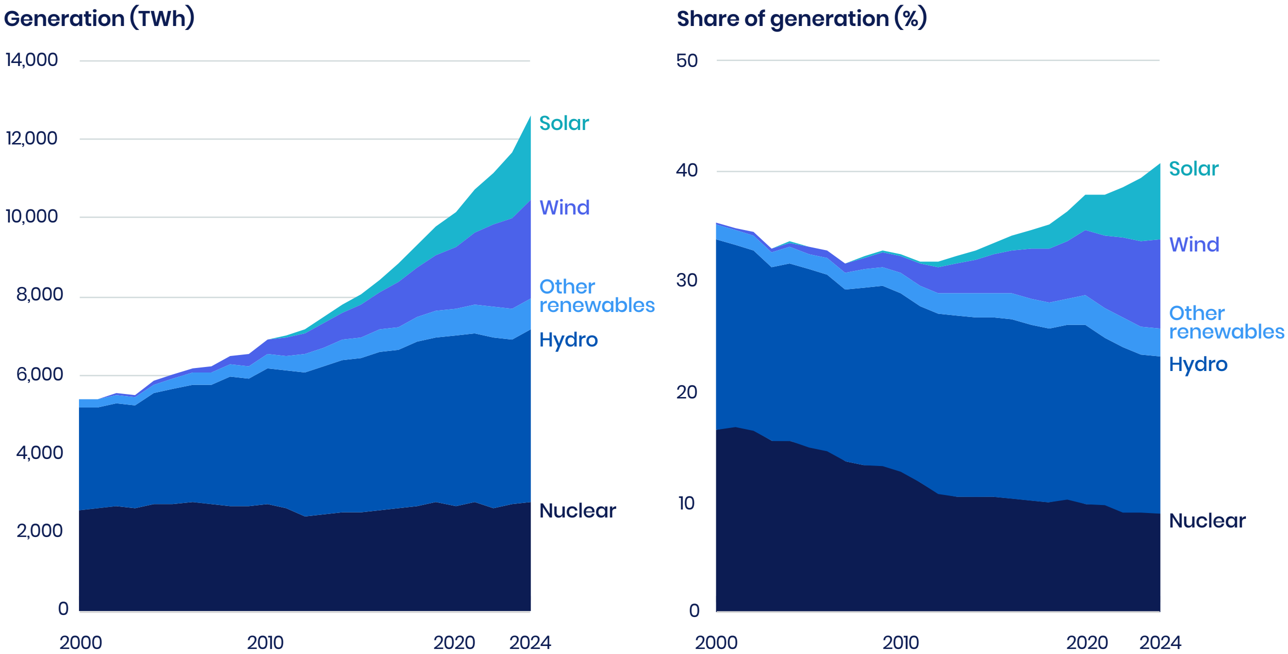
Scaling up zero-carbon power sources—such as solar, wind, hydro, and nuclear—can reduce CO_2 emissions and local air pollutants while meeting rising global electricity needs.[19] The share of zero-carbon sources in electricity generation depends on two factors: the amount of zero-carbon generation and the amount of total electricity demand. Total global electricity demand is consistently growing (IEA 2025b), so the scale-up of zero-carbon generation needs to outpace electricity demand growth in order to displace fossil fuels.

From 2019 to 2024, the share of solar and wind in electricity generation nearly doubled, growing from 8 percent to 15 percent of global electricity generation. Rapid adoption was driven by decreasing costs, improved technology, and supportive policies (Ember 2025).[20] China, which is home to more solar and wind generation in absolute terms than any other country in the world, had its largest increase ever in 2024 (Ember 2025). Globally, solar power is growing exponentially and is in the breakthrough stage of an S-curve (Appendix C). It has grown faster than any other electricity technology in history (Graham et al. 2025) and has repeatedly exceeded expectations (Lopez et al. 2025). Meanwhile, wind power has moved into the diffusion stage of an S-curve; it grew exponentially in the past but is now growing linearly (Appendix C). Wind generation grew at a slower rate in 2024 than in the two previous years: new capacity additions remained similar to the year before but slightly lower wind speeds in key regions limited generation gains (Ember 2025; Graham et al. 2025).

However, assuming that the current growth of solar and wind continues along an S-curve, the share of solar and wind would still get less than half of the way from the current level to the goal of comprising 57–78 percent of power generation in 2030; it is thus well off track to limiting temperature rise to 1.5°C (Figure 4b) (Appendix C) (CAT 2023; Boehm et al. 2025). The share of electricity produced from solar and wind increased by 13 percent per year on average from 2020 to 2024 (Ember 2025). That rate would have to more than double to increase by 29 percent per year to meet the 2030 target. The steepest rise in solar and wind must happen between now and 2030, but continued progress will be needed for these technologies to reach 68–86 percent of power generation in 2035 and 79–96 percent in 2050 (CAT 2023; Boehm et al. 2025).

Beyond solar and wind alone, the share of all sources of zero-carbon power in electricity generation increased from 38 percent in 2019 to 41 percent in 2024 (Ember 2025). Solar and wind have grown rapidly, as mentioned above, but hydropower and nuclear power have remained flat in absolute terms and thus are losing market share as electricity demand grows (Figure 5). Assuming that solar and wind follow an S-curve (Appendix C), while nuclear and hydropower continue on a linear trajectory, the share of zero-carbon sources in electricity would get less than half of the way from the current level to the ambitious 1.5°C-aligned target of 88–91 percent in 2030; it is thus considered well off track (Figure 4a) (CAT 2023; Boehm et al. 2025).[21] Acceleration is needed beyond the current path. Indeed, the share of zero-carbon sources in electricity generation rose by 2 percent per year on average from 2020 to 2024 (Ember 2025), but it would need to increase by 14 percent per year to meet the 2030 target. The fastest expansion in zero-carbon electricity must happen between now and 2030, but continued progress is needed for it to reach 96 percent of global power production in 2035 and 99–100 percent in 2050 (CAT 2023; Boehm et al. 2025). At the country level, progress is mixed. In all of the jurisdictions with the highest emissions from the power sector, zero-carbon power is expanding, though the speed at which this is displacing fossil fuels varies. Since 2019, zero-carbon sources have grown from 61 to 71 percent of electricity generation in the European Union, from 32 to 38 percent in China, from 38 to 42 percent in the United States, and from 21 to 22 percent in India (Ember 2025).

FIGURE 5 | Zero-carbon sources in global electricity generation



Note: TWh = terawatt hours.
Source: Graham et al. 2025.

Phasing out fossil fuel use in power generation

The scale-up of zero-carbon electricity must be accompanied by a phaseout of fossil fuels to limit global warming to 1.5°C. All countries must dramatically decrease fossil fuel power production by 2030, but wealthy countries that have historically emitted the most GHGs and have the greatest capacity to phase out fossil fuel power have the responsibility to do so first, as well as to provide technical and financial support to lower-income countries.

Coal causes two-thirds of power emissions, so it is absolutely critical to reduce (Ember 2025). Coal power has slightly declined as a share of global electricity generation from 37 percent in 2019 to 34 percent in 2024, but it is at a record high in absolute terms because of more overall electricity demand (Ember 2025). Progress is well off track: the global share of coal power must drop more than 10 times faster than the current trend to decline to 4 percent by 2030 (Figure 4c) (CAT 2023). While the most drastic reductions in coal power must take place between now and 2030, further progress will be needed for coal power to fall to 1 percent by 2035 and 0 percent by 2040 (CAT 2023; Boehm et al. 2025).[22] At the country level, China alone is responsible for more than half of the world's total coal power generation. Although coal decreased from 65 percent of power generation in 2019 to 58 percent in 2024, coal power generation in China grew in absolute terms due to increased electricity demand (Ember 2025). Responsible for another 14 percent of the world's coal power, India's coal usage is holding steady at about 75 percent of its electricity generation, though also growing in absolute terms due to electricity demand (Ember 2025). Ultimately, all countries must reduce their absolute amount of coal power generation in order to limit warming to 1.5°C.

Meanwhile, fossil gas, also known as natural gas, accounts for more than a quarter of power emissions (Ember 2025). A further buildout of new fossil gas infrastructure globally would be incompatible with limiting global warming to 1.5°C and would lock in emissions for decades to come (CAT 2023). While fossil gas declined from 24 percent of the global electricity mix in 2019 to 22 percent in 2024 (Ember 2025), progress is well off track, and the share of unabated fossil gas power must fall 7 times faster to reach 5–7 percent by 2030 (Figure 4d) (CAT 2023).[23] While most of the progress on cutting down gas power must take place between now and 2030, further reductions will be needed to reach 2 percent by 2035, 1 percent by 2040, and 0 percent by 2050 (CAT 2023; Boehm et al. 2025). The United States is responsible for more than one-quarter of the world's total gas power generation. Its gas power generation has steadily grown since the early 2000s as a share of the electricity mix and in absolute terms as unconventional gas production ramped up. In Russia, which is responsible for another 8 percent of total gas power generation, gas has held steady as a share of generation but increased in absolute terms (Ember 2025).

For both coal and gas, the rate of decrease as a share of the electricity mix has been linear in recent years. However, with the relatively fast buildup of renewables and battery storage, given their decreasing costs, it is possible that the share of coal and gas in power generation could fall rapidly and nonlinearly in the future.

Decarbonizing electricity generation

Finally, the carbon intensity of electricity generation—defined as the amount of CO_2 emitted per kilowatt-hour (kWh) of electricity produced—provides an overall measure of progress toward decarbonization of the power sector.[24] It takes into account the types of energy sources used as well as the efficiency of power production. Global carbon intensity of electricity generation has decreased gradually, falling from approximately 490 grams of carbon dioxide (gCO_2) emitted per kWh of electricity in 2020 to approximately 470 gCO_2 per kWh in 2024 (Ember 2025). However, it needs to fall more than 10 times faster to get on track to reach the 1.5°C-aligned target of 48–80 gCO_2 per kWh by 2030 (Figure 4e). Further progress is needed after 2030, with the carbon intensity of electricity generation needing to fall to 15–19 gCO_2 per kWh in 2035 and to less than zero in 2050 to limit warming to 1.5°C (CAT 2023; Boehm et al. 2025).[25] While global progress remains well off track, several countries are achieving promising reductions, offering potential for replication (Box 1).

BOX 1 | Spotlight on the 10 countries decarbonizing electricity generation the fastest

To decarbonize the power sector, countries must replace fossil fuels with zero-carbon electricity sources. Swapping out the most-carbon-intensive fossil fuels for less-carbon-intensive fossil fuels, such as coal power for gas power, will also reduce carbon intensity. However, it is impossible to fully decarbonize the power sector without phasing out essentially all fossil fuels, and installing new gas infrastructure is counterproductive as it locks in carbon emissions.

Tracking the amount of CO_2 emitted per unit of electricity generated is an effective way to understand overall progress of power sector emissions reductions and compare countries of different sizes on a like-for-like basis. Globally, the current level of carbon intensity of electricity generation is at about 470 grams of carbon dioxide per kilowatt-hour (gCO_2/kWh) (Ember 2025) and needs to fall by 68 gCO_2/kWh per year (28 percent per year) on average to be aligned with the 1.5°C target for 2030 (CAT 2023). However, the world has averaged only 7 gCO_2/kWh of decline each year from 2019 to 2024, far short of what is needed (Ember 2025). While no countries are decarbonizing their power sectors at the rate that is needed, the 10 countries highlighted in Table B1-1 are all reducing the carbon intensity of electricity generation more than four times faster than the global average.

The United Arab Emirates tops the list, having reduced the carbon intensity of its electricity generation at a rate of 39 gCO_2/kWh per year between 2019 and 2024. In 2019, fossil gas composed 97 percent of its electricity generation, but then in the span of five years the UAE increased the share of its electricity generated by zero-carbon sources from 3 to 31 percent (Figure B1-1) (Ember 2025). In large part, the transformation was due to the construction of the Barakah nuclear power plant, which first began operating in 2020, with the final unit brought online in 2024 (World Nuclear Association 2025). The UAE also prioritized investments in solar power, including multiple gigawatt-level sites, such as the Al Dhafra solar farm, which has 4 million solar panels and is one of the largest sites in the world (WEF n.d.).

Chile comes in second place, decarbonizing at only a slightly lower rate than the UAE. In Chile, coal-fired power plants were booming as recently as a decade ago, but the country has quickly reversed course. Chile's Ministry of Energy convened a working group of relevant stakeholders in 2018 to develop a plan for phasing out coal (Hauser et al. 2021). Since 2019, Chile has retired 11 of its 28 coal plant units, and it plans to retire another 9 coal plant units by the end of 2025, 7 of which are 15 years old or less (GEM 2025b). The main replacement has been solar and wind, which grew from 13 percent of the electricity mix in 2019 to 34 percent in 2024 (Figure B1-1) (Ember 2025). Renewable energy in Chile has flourished due to the falling cost of solar and wind, as well as supportive government policies such as a renewable energy quota and a small carbon tax (Jaeger 2023).

The 10 countries decarbonizing electricity the fastest are detailed in Table B1-1; all of them are replacing fossil fuels with zero-carbon electricity.

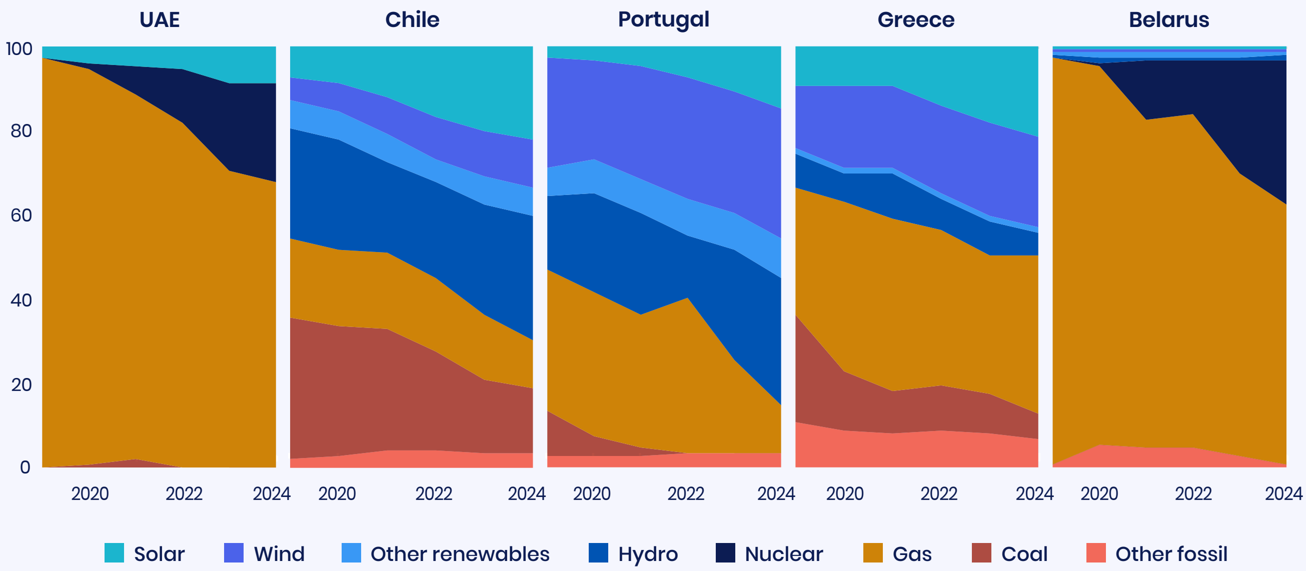
BOX 1 | Spotlight on the 10 countries decarbonizing electricity generation the fastest (continued)

TABLE B1-1 | Top 10 countries decarbonizing electricity generation the fastest

	AVERAGE ANNUAL CHANGE, 2019–24 (GCO_2E PER KWH)	REDUCED AS SHARE OF ELECTRICITY GENERATION	INCREASED AS SHARE OF ELECTRICITY GENERATION
1. United Arab Emirates	-39	Gas	Nuclear, solar
2. Chile	-38	Coal, gas	Solar, wind
3. Portugal[a]	-38	Gas, coal	Hydro, solar, wind
4. Greece	-35	Coal	Solar, gas, wind
5. Belarus	-35	Gas	Nuclear
6. Bulgaria	-35	Coal	Solar
7. Estonia[a]	-34	Oil shale	Solar, wind
8. Netherlands	-31	Gas, coal	Wind, solar
9. Poland	-31	Coal	Solar, wind
10. El Salvador[a]	-28	Oil	Solar, hydro
World	-7		
World (what's needed to be on track for 1.5°C, 2024–30)	-68		

Notes: °C = degrees Celsius; gCO_2e = grams of carbon dioxide equivalent; kWh = kilowatt-hour.
Ranking excludes countries with less than 1 terawatt of electricity generation and countries with drastically reduced electricity demand due to conflict. Average annual change is based on the difference between the values from 2019 and 2024, not a linear trendline over all years.
[a] The calculations of power generation carbon intensity in this table do not account for imports. Net imports of electricity make up 18 percent of Portugal's electricity demand, 32 percent of Estonia's electricity demand, and 12 percent of El Salvador's electricity demand. For all other countries in the table, net imports made up 1 percent or less of electricity demand, or they were net electricity exporters (Ember 2025).
Sources: Authors, based on historical data from Ember 2025. Global target from CAT 2023.

FIGURE B1-1 | Electricity generation by source in top 5 fastest decarbonizing countries



Notes: UAE = United Arab Emirates.
Source: Ember 2025.

Snapshot of recent developments

At the multilateral level, momentum for clean electricity has swelled in recent years. In November 2023, at COP28, governments pledged to collectively triple renewable energy capacity globally by 2030 and accelerate the phasedown of unabated coal power (UNFCCC 2024a) (Appendix B). The following year, the Group of Seven (G7) countries agreed to shut down coal-fired power plants by 2035 and scale up battery storage sixfold by 2030 (G7 2024).[26]

Meanwhile, energy investments are shifting, but not fast enough. Global investments in zero-carbon power rose from $520 billion in 2021 to $840 billion in 2024 (IEA 2025i). Despite this significant growth, renewable energy investment still needs to double by 2030 to meet the COP28 pledge to triple renewables capacity (IEA 2025i). On a promising note, there has been a surge in the construction of new clean energy factories; there is already more than enough manufacturing capacity for solar panels and batteries to allow for a rapid acceleration of deployment (IEA 2024i).

Electric grids need to be modernized and expanded rapidly to integrate clean energy into existing systems and improve reliability. Insufficient transmission and distribution lines have become a bottleneck in the growth of zero-carbon power; in 2024, 1,700 gigawatts (GW) of solar, wind, and hydropower projects in advanced stages of development were awaiting grid connections (IEA 2024f). Investments in electricity grids increased from $310 billion in 2022 to $390 billion in 2024, but more acceleration is needed (IEA 2025i). From 2019 to 2023, the world added or replaced about 260,000 kilometers (km) of transmission lines per year (IEA 2024i). But, to reach 1.5°C, the world would need to add or replace 440,000 km every year until 2030 (IEA 2024i). Energy storage is also essential to enable growth in renewables. Globally, annual additions of battery storage almost quadrupled between 2022 and 2024 (Nsitem and Sekine 2025), and investments in battery storage increased from $23 billion to $57 billion during that same period. However, in order to meet the COP28 goal of tripling renewable energy capacity, energy storage would need to increase sixfold by 2030 (IEA 2024a).

At a national level, China and the United States are the two most important countries to watch, given that they have the highest total emissions from the power sector (Ember 2025). Both have made significant progress in scaling zero-carbon power but have a long way to go to lessen their reliance on fossil fuel power. China continues to lead the world in zero-carbon power deployment (Myllyvirta 2025), but it also had 200 GW of coal capacity under construction in 2024, a 49 percent jump from the year before and the most in the past decade of tracking (GEM 2025a). In the United States, the Biden-era Inflation Reduction Act spurred billions of dollars in investment in zero-carbon power between 2022 and 2024, but the current administration has passed legislation rolling back supportive zero-carbon power policies, pursued regulatory changes at the Environmental Protection Agency and other agencies to disadvantage renewable energy, and introduced tariffs that are causing global economic uncertainty, delaying investments, and raising domestic prices for zero-carbon power technologies, such as solar panels and components (Abrahams 2025; US EPA 2025; King et al. 2025). By one estimate, new buildout of clean power capacity in the United States will be 53–59 percent lower from 2025 through 2035 than it would have been without the new legislation (King et al. 2025), while the effects of environmental deregulation and new tariffs remain to be seen.

As of 2023, 750 million people globally still lacked access to electricity, largely in sub-Saharan Africa, highlighting the urgent need to expand clean, reliable power as global electricity demand continues to grow (IEA n.d.a.). Global electricity demand grew by about 1,200 terawatt-hours (TWh) (4 percent) in 2024, the third-highest absolute increase in electricity demand ever, only behind the rebounds after the global recession and the COVID-19 pandemic (Graham et al. 2025). The increase was due to economic growth, greater need for air conditioning due to heat waves, and, to a lesser extent, rising power demand from data centers and electric vehicles (Graham et al. 2025). Decarbonizing the power sector will require bringing online enough new zero-carbon electricity to both displace existing fossil fuel power and meet rising electricity demand. Improved energy efficiency in end-use sectors such as buildings and industry will also be crucial to minimize total electricity demand while meeting electricity access needs around the world.

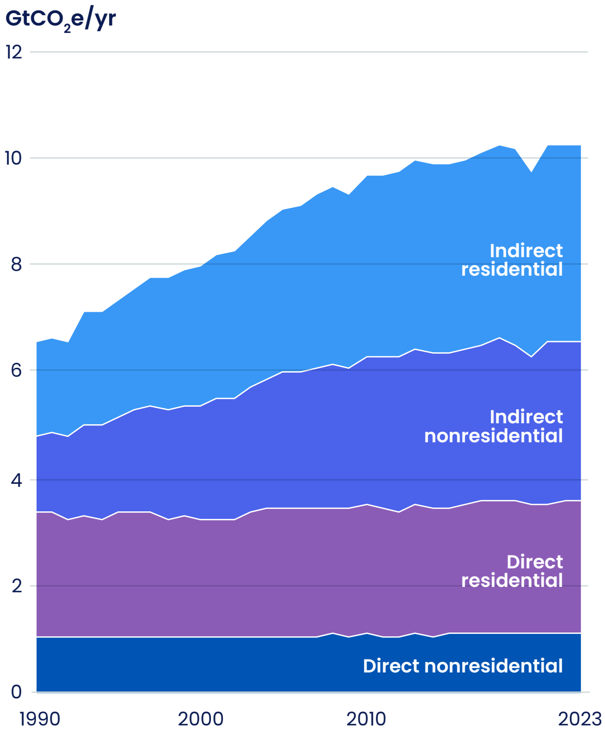
SECTION 3

Buildings

Buildings—the structures that provide housing, workspaces, and other amenities for people around the globe—are also a significant source of GHG emissions. Direct emissions from burning fuel for heating and cooking in buildings accounted for about 3.6 gigatonnes of carbon dioxide equivalent ($GtCO_2e$) in 2023, or roughly 6 percent of global GHG emissions. When also considering indirect, off-site emissions from the buildings sector, such as those from the production of electricity for heating, cooling, lighting, and other uses, this number almost triples, to 10.2 $GtCO_2e$ (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025) (Figure 1). These emissions do not include embodied emissions—which are additionally generated throughout a building's life cycle, including from the production, manufacturing, and transportation of building materials and the construction and disposal of buildings.[27]

Operational direct and indirect emissions from the buildings sector have been steadily rising, growing by an annual average of 1.4 percent since 1990 (Crippa et al. 2024; IEA 2024h) (Figure 6). In 2020, the COVID-19 pandemic spurred behavioral shifts such as increased teleworking and declines in hotel occupancy and restaurant dining, which led to a drop in buildings emissions of about 4 percent relative to 2019. However, operational emissions have since rebounded to prepandemic levels (Crippa et al. 2024; IEA 2024h).

FIGURE 6 | Global direct and indirect GHG emissions from buildings



Notes: GHG = greenhouse gas; $GtCO_2e/yr$ = gigatonnes of carbon dioxide equivalent per year. GHG emissions are split into residential and nonresidential sectors for both direct (69% and 31%) and indirect (55% and 45%) emissions based on GlobalABC's Global Status Report, 2024/25 (UNEP 2025).

Sources: Crippa et al. 2024; IEA 2024h.

Global assessment of progress

To transform the global buildings sector, operational emissions must see sustained declines globally, which will require four shifts: improving buildings' energy efficiency, decarbonizing their operations, retrofitting existing buildings, and constructing new buildings that are strictly zero-carbon in operation.[28] While embodied emissions must also decline rapidly, shifts to decarbonize construction materials, such as steel and cement, are covered in the "Industry" section of this report.

FIGURE 7 | Global progress toward buildings targets

Notes: $kgCO_2/m^2$ = kilograms of carbon dioxide per square meter; kWh/m^2 = kilowatt-hour per square meter; yr = year. For indicators categorized as S-curve possible and S-curve unlikely, the acceleration factors and status of progress are determined by a linear trendline based on the past five years of data. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

Sources: Historical data from IEA 2023e, 2023d, 2021, 2020b, and 2023h. Targets from CAT 2025a.

Improving energy efficiency

Improving the energy efficiency of buildings by reducing the energy intensity of operations within these structures has significant potential to reduce the sector's emissions while also reducing global energy demand (IPCC 2022c; ETC 2025). Efficiency improvements can be achieved by designing for efficiency, using more efficient electrical appliances and lighting, incorporating efficient heating and cooling systems, altering building envelopes (such as upgraded roof and wall insulation to reduce heating and cooling loads), and promoting behavioral changes in energy use (IPCC 2022b).[29]

Data on the global energy intensity of building operations indicate only modest improvement over recent years, with an average annual decline of just 1.8 kWh/m^2 between 2018, in which energy intensity was 153 kWh/m^2, and 2022, by which energy intensity had fallen to 145 kWh/m^2 (Figure 7a) (IEA 2023e). In the absence of more recent, updated figures, global efforts made toward achieving 85–115 kWh/m^2 of energy intensity of building operations by 2030 remain well off track and will require a threefold acceleration (CAT 2025a). Continued progress will be needed thereafter to achieve 80–110 kWh/m^2 of energy intensity of building operations by 2035 and 55–80 kWh/m^2 by 2050 (CAT 2025a).

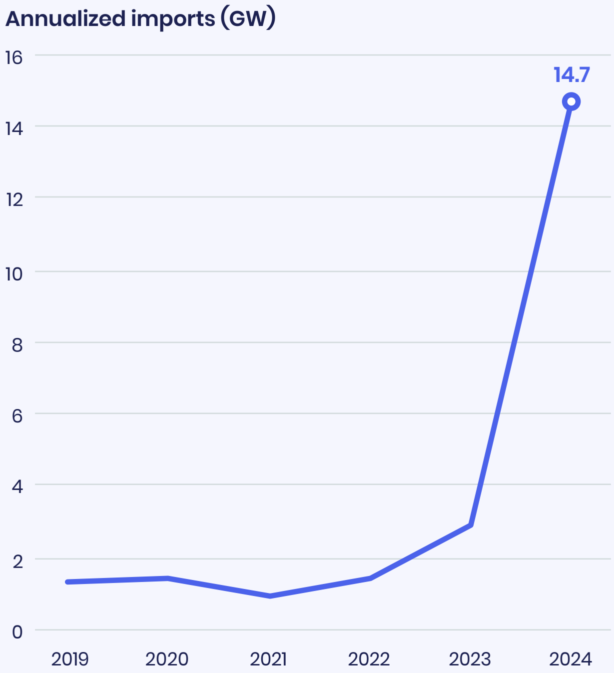
Decarbonizing building operations

To reduce emissions in line with a 1.5°C pathway, it is also essential to reduce the carbon intensity of building operations, calculated by dividing total carbon emitted from all energy end uses within buildings, including electricity, by global total floor area. This can be achieved by reducing demand through efficiency measures, as well as the electrification of building energy end uses, such as heating and cooling systems, while also ensuring that the electricity supply itself is derived from zero-carbon sources, such as a decarbonized power grid or through the use of rooftop solar (IPCC 2022b, 2022c).[30]

Figure 7b shows that the carbon intensity of building operations has seen a steady but inadequate decline in recent years, with an average annual decline of 0.79 kilograms of carbon dioxide per square meter (kgCO_2/m^2) between 2018 and 2022 (IEA 2023d). The most recent global data—though not updated since Boehm et al. 2023—show that between 2021 and 2022, this intensity fell from 40 kgCO_2/m^2 to 39 kgCO_2/m^2 (IEA 2023d). The modest improvements in carbon intensity have so far largely been a result of decarbonizing power grids, rather than meaningful progress in retrofitting buildings and electrification. Getting on track to reach the target of 13–16 kgCO_2/m^2 by 2030 will require a fourfold acceleration in recent efforts (CAT 2025a). Even greater acceleration will be needed to reach 5–8 kgCO_2/m^2 in carbon intensity of buildings operations by 2035 and 0–2 kgCO_2/m^2 by 2050 (CAT 2025a). While progress remains insufficient at the global level, some countries' successes provide examples from which others can learn (Box 2).

BOX 2 | Spotlight on Pakistan's rapid uptake of rooftop solar, helping to reduce buildings sector emissions

FIGURE B2-1 | Annual imports of solar panels from China to Pakistan between 2019 and 2024



Note: GW = gigawatts. Most of this capacity is imported for "behind the meter" usage (i.e., on residential, commercial, and industrial rooftops, where power is generated for on-site use), meaning it is not reflected in statistics collected for the national grid and therefore difficult to track in terms of deployment and generation (Renewables First and Herald Analytics 2024).

Source: Renewables First and Herald Analytics 2024.

Rooftop solar photovoltaic (PV) systems are a highly accessible, low-cost mitigation option with significant potential for near-term emissions reductions in the buildings sector (Becque et al. 2019). While rooftop solar photovoltaic systems could mitigate around 3.4–8.9 gigatonnes of carbon dioxide equivalent (GtCO_2e) per year globally, real world buildouts of such systems have lagged their projected mitigation potential (Joshi et al. 2021; Zhang et al. 2025). In the last few years, however, Pakistan has emerged as a leader in rooftop solar photovoltaic, witnessing a significant surge since 2022 (Figure B2-1). Over these three years, Pakistan imported over 20 GW of solar panels (mainly from China), primarily for residential, commercial, and industrial rooftops—increasing the country's existing solar fleet by nearly 20 times (Renewables First and Herald Analytics 2024). For comparison, this is more than the solar capacity added to the grids of Canada, France, New Zealand, and the United Kingdom combined during the same period (Ember 2025).

By the end of 2025, Pakistan is projected to have imported more than 20 GW of rooftop solar, nearly matching its peak electricity demand and marking a significant shift away from power through Pakistan's largely fossil fuel–heavy grid (Renewables First and Herald Analytics 2024).

BOX 2 | Spotlight on Pakistan's rapid uptake of rooftop solar, helping to reduce buildings sector emissions (continued)

How did Pakistan unlock this rapid growth?

Consumers in Pakistan have been provided with new incentives to move to rooftop solar photovoltaic in recent years, as a sharp decline in the cost of solar PV coincided with multiple market factors such as the introduction of net metering in 2015, which allowed consumers to install rooftop solar and sell surplus electricity back to the grid; the removal of a 33 percent import duty on solar equipment; and the expansion of low-interest financing options (Renewables First and Herald Analytics 2024; Saeed 2015). High grid tariffs and unreliable supply also made rooftop solar an attractive way to secure personal access to electricity. Consequently, rooftop solar adoption soared, with payback periods as little as one year (Bloomberg 2024). By the end of 2024, Pakistan's rooftop solar photovoltaic systems were generating around 16 TWh of zero-carbon electricity annually (Bloomberg 2024), reducing emissions by up to 9.5 $MtCO_2e$—about 13 percent of the country's electricity and heat sector emissions (Climate Watch 2025a).[a]

Pakistan's solar rush has not come without challenges. As consumers increasingly self-generate through rooftop solar photovoltaic, utility revenues have fallen, exacerbating the state-owned power utilities' debt load and undermining their ability to invest in essential grid developments and upgrades (Bloomberg 2024). Experts are calling for urgent market reforms to open new markets, such as grid balancing and ancillary services, which could help stabilize utilities' finances as this transformation unfolds (Isaad and Shah 2025).

Note: [a] Emissions calculated assuming a grid emissions factor of 0.57 tonnes CO_2 per megawatt (Umer et al. 2024).

Retrofitting existing buildings

In regions like North America and Europe, where most of the buildings stock that will exist in 2050 has already been constructed, lowering energy and carbon intensity will require deep retrofits of existing buildings (CAT 2020a, 2024a).[31] Retrofitting entails energy efficiency improvements, shifts to cleaner technologies, and upgrades to efficient appliances and devices, including LED lights.[32] Although typically associated with higher upfront costs, such improvements can lead to significant savings in running costs and total cost of ownership, while also starkly reducing operational emissions and buildings' energy demand (ETC 2025).

Currently, data measuring annual retrofitting rates of buildings both at global and national levels are insufficient to assess global progress, but available evidence suggests that recent efforts are inadequate (Figure 7c). Most recent data, though not updated since Boehm et al. 2023, indicate that less than 1 percent of buildings were retrofitted annually in both 2019 and 2020 (IEA 2020b, 2021). Across Organisation for Economic Co-operation and Development (OECD) countries—where many current buildings are likely to still be in operation in 2050—this annual retrofitting rate is slightly higher, reaching more than 2 percent in 2022 (IEA 2023h). But limiting warming to 1.5°C will require global rates to rise to between 2.5 and 3.5 percent per year by 2030 and to 3.5 percent each year by 2040, with developed countries that are home to substantial existing stock leading the way (CAT 2025a).

Constructing zero-carbon new buildings

The construction of new buildings around the world continues to increase, with 80 percent of total floor area growth through 2030 expected in emerging and developing economies (IEA 2023b). Building these structures to zero-carbon specifications—including by ensuring that buildings are in compliance with high energy efficiency standards and on-site renewables and that electric heating systems such as heat pumps, as well as electric stoves (in residential buildings), are installed—will be crucial to limit warming to 1.5°C.[33] For new buildings still powered by purchased electricity, the power supplying the buildings' energy will also need to be fully decarbonized by 2050 (CAT 2020a).

According to one report, 5 percent of new buildings were zero-carbon in operation in 2020 (IEA 2021), indicating a large gap to ensure that all new buildings are zero-carbon in operation by 2030 (CAT 2024a).[34] With no other global time series datasets available, our ability to formally track global progress over time is to date limited (Figure 7d). From the data that are available, however, it is evident that efforts are insufficient for all new buildings to be zero-carbon in operation by 2030.

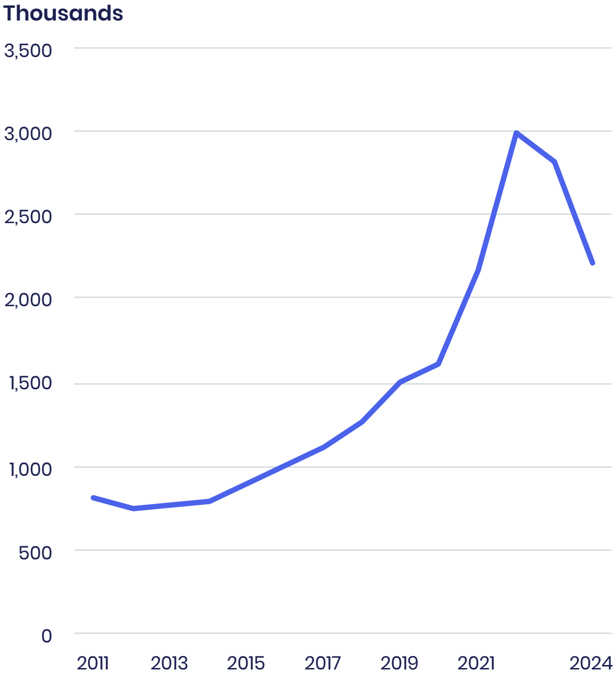
Snapshot of recent developments

The global rate of building decarbonization is far from sufficient, and recent setbacks are concerning. For instance, global sales of heat pumps decreased by 3 percent in 2023, largely due to inflation, higher costs, and interest rates (IEA 2024c; UNEP 2025).[35] In Europe—a major market for heat pumps—sales decreased by 25 percent since 2022 after a decade of sustained annual growth, largely due to changes in governmental subsidies and support for heat pumps (Figure 8) (EHPA 2024; Rosenow and Gibb 2023).

Still, there are some bright spots globally. In 2024, the European Union revised its Energy Performance of Buildings Directive to strengthen the minimum requirements for new and existing buildings, with a goal of 100 percent zero-emissions new construction by 2030 (European Commission 2024b).[36] And, in 2023, Türkiye outlined a goal to reduce whole life-cycle carbon emissions from buildings by 30 percent by 2033 in its Building Sector Decarbonization Roadmap, among other measures (Bayraktar et al. 2023; UNEP 2025).[37]

Meanwhile, a handful of countries adopted or strengthened their building codes between 2023 and 2025.[38] Examples include India's Energy Conservation and Sustainable Building Code, introduced in 2025, and Kenya's Building Codes, launched in 2024 (Government of India, Ministry of Power 2024; UNEP 2025). Kenya's building code, for instance, introduced energy performance standards to encourage energy efficient design while also promoting renewable energy integration (UNEP 2025). In the years ahead, the adoption and enforcement of these kinds of codes must especially be boosted across emerging economies, where the majority of floor area growth is expected to occur by 2030 (UNEP 2024c; IEA et al. 2023).

FIGURE 8 | Heat pump sales in Europe between 2011 and 2025



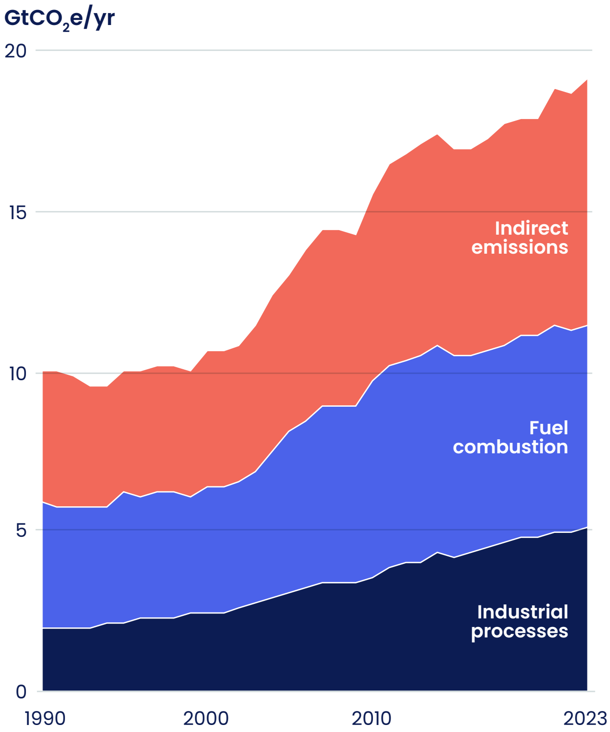
Sources: EHPA 2025, 2023.

SECTION 4

Industry

Industry—a sector that encompasses the manufacturing of products like cement, steel, and chemicals—represents a major source of GHG emissions. These emissions include GHGs directly released by fuel combustion and industrial processes, as well as those indirectly emitted from generating purchased electricity, steam, heat, or cooling (IEA 2023f).[39] Direct fuel combustion and process GHG emissions accounted for 11.5 $GtCO_2e$ in 2023, representing about one-fifth of global emissions (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025).[40] When accounting for indirect GHG emissions, the total emissions value rises to 19.1 $GtCO_2e$—higher than ever before (Figure 1) (Crippa et al. 2024; IEA 2024h).

FIGURE 9 | Global direct and indirect GHG emissions from industry



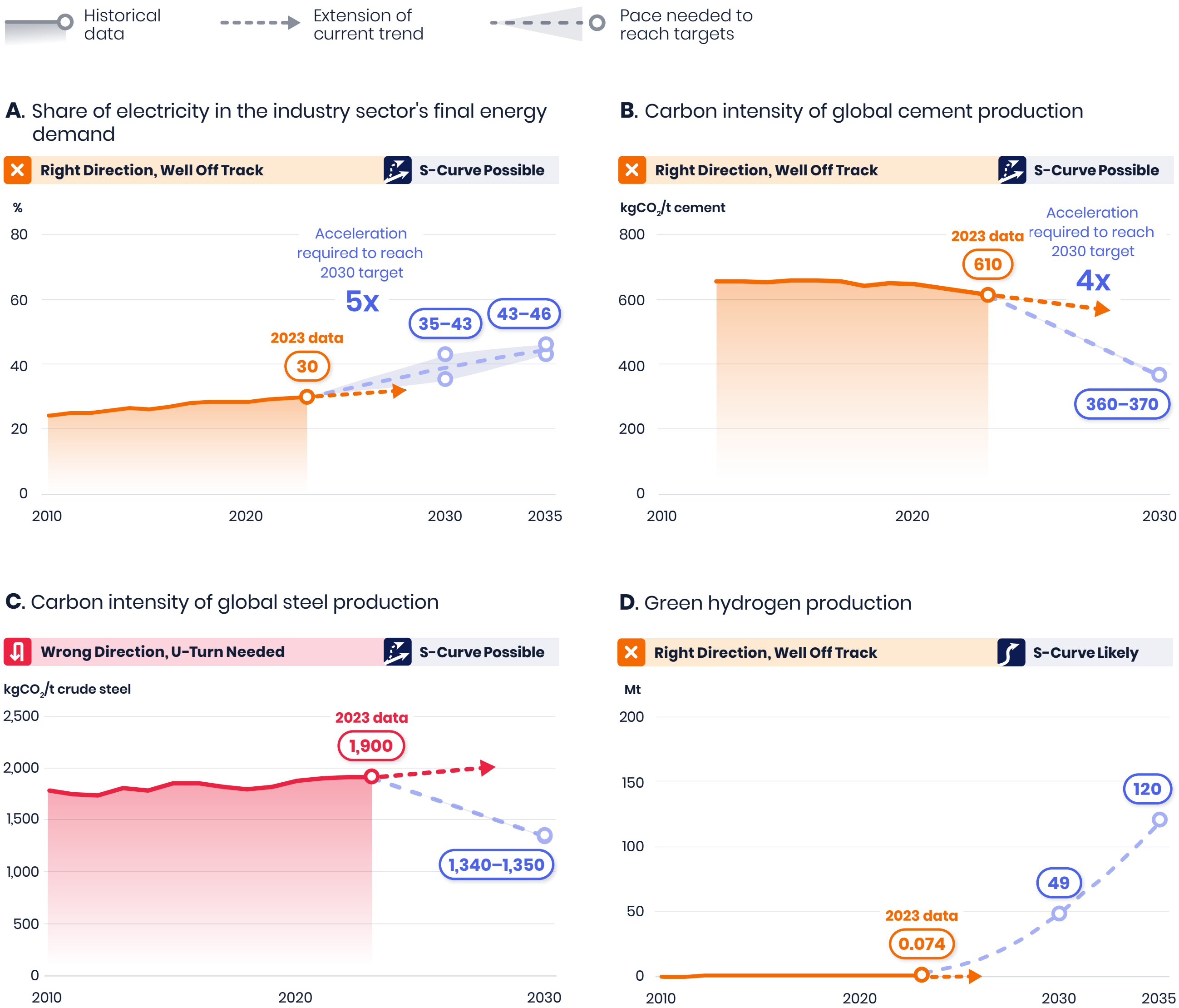
Notes: GHG = greenhouse gas; $GtCO_2e/yr$ = gigatonnes of carbon dioxide equivalent per year.
Sources: Crippa et al. 2024; IEA 2024h.

Increasing demand for industrial products, driven by rising incomes, population growth, urbanization, and infrastructure development, has fueled significant growth in the global extraction and production of industrial materials and contributed to the ongoing upward trajectory of GHG emissions from industry (Figure 9). While industrial GHG emissions are produced by a number of subsectors, including cement, steel, chemicals, glass, paper, and plastic, cement and steel production alone account for more than a third of industry's direct and indirect GHG emissions (Rissman et al. 2020).

Global assessment of progress

Decarbonizing industry to help limit warming to 1.5°C requires a multipronged approach using several levers. These levers include reducing demand for materials, improving efficiency, electrifying industrial production processes where feasible, and developing new technological solutions, particularly in emissions-intensive industrial subsectors.[41] In industrial subsectors that use low- and medium-temperature heat, electrification with zero-carbon electricity to replace fossil fuel combustion is key to reducing the emissions intensity of industrial production. In the case of heavy industries such as cement and steel, improvements in energy and material efficiency will need to be paired with commercialization of new manufacturing processes and technologies to minimize process and energy-related emissions, and to capture remaining emissions. Production of alternative zero-carbon fuels and feedstocks, such as green hydrogen, also needs to ramp up for use in heavy industries.[42]

FIGURE 10 | Summary of global progress toward industry targets



Notes: $kgCO_2$/t = kilograms of carbon dioxide per tonne; Mt = million tonnes. For indicators categorized as S-curve possible, the acceleration factors and status of progress are determined by a linear trendline based on the past five years of data. For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are not presented, as they would not accurately reflect an S-curve trajectory. The current trend arrow is based on an S-curve trendline, and the category of progress for these indicators was determined based on author judgment, using multiple lines of evidence. See Appendix C and Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

For the carbon intensity of global cement production, targets include direct and indirect GHG emissions, while historical emissions intensity includes direct emissions and excludes those from on-site power generation. Given that these indirect CO_2 emissions account for a relatively small share of total CO_2 emissions associated with cement, this does not impact the acceleration factor nor the category of progress, which would still be 4 times faster and well off track if the 2030 target is adjusted to include direct emissions only. Historical data are from the Global Cement and Concrete Association (GCCA)'s Getting the Numbers Right (GNR) 2023 database, which tracks progress in the cement and concrete sector and has developed a sector-specific Net Zero Roadmap to 2050. However, cement-related targets used in this report are determined independently and may not align with those in the GCCA roadmap. Full historical data description and licensing information are available from GCCA 2023. For the carbon intensity of global steel production, targets and historical emissions data include direct and indirect GHG emissions, and account for both primary and secondary steel. For green hydrogen production, the targets refer to what is needed for the whole economy to decarbonize and not just for the industry sector to do so.

Sources: Historical data from IEA 2024h, accessed with a paid license to the IEA's datasets, GCCA 2023, World Steel Association 2024a, and IEA 2024e. Targets from CAT 2020a, 2020b, 2025a, and IEA 2024i.

Electrifying industry

Monitoring the share of electricity in industry measures how well the sector is doing in reducing its reliance on fossil fuels for generating heat for manufacturing processes. To limit warming to 1.5°C, the share of electricity in the industry sector's final energy demand needs to increase to 35–43 percent by 2030, 43–46 percent by 2035, and 60–69 percent by 2050 (CAT 2025a). In recent years, however, this share has remained fairly steady, with a slight increase from 29 percent of the sector's final energy demand being fulfilled by electricity to 30 percent between 2019 and 2023 (Figure 10a) (IEA 2024h). With this lack of progress, current efforts remain well off track and must accelerate fivefold to reach the 1.5°C-aligned target for 2030. Industrial processes involving low- and medium-temperature heat (e.g., in food and beverages and textiles subsectors) provide significant opportunities for electrification using already available technologies (van Niel and Somers 2024).

Commercializing new solutions for cement and steel

Due to the large share of process-related emissions that cement and steel production generates, decarbonizing these subsectors will further require the commercialization of new technologies to replace conventional industrial processes. Decarbonization will also depend on the scale-up of zero- and low-carbon fuels and feedstocks—including green hydrogen in steel—to eliminate emissions as much as possible, and carbon capture, utilization, and storage (CCUS) in cement to capture and store remaining, or residual, emissions.

Even as production of cement has been increasing, the carbon intensity of such production has continued to gradually decrease, from nearly 650 to approximately 610 kilograms of carbon dioxide per tonne ($kgCO_2/t$) of cement between 2019 and 2023 (Figure 10b) (GCCA 2023). This has largely stemmed from the use of alternative fuels, substitution of clinker with other materials, and increased energy and process efficiency (St. John 2023; IEA 2023c, 2025a). However, progress has been slow and recent rates of change remain well off track. Indeed, the carbon intensity of cement needs to decline four times faster to reach 360–70 $kgCO_2/t$ by 2030, with continued progress to achieve a further drop to 55–90 $kgCO_2/t$ by 2050 (CAT 2020a, 2020b).[43]

Achieving these targets will require using less cement in construction through more efficient designs as well as developing and scaling technological solutions for decarbonization. A key near-term solution is to substitute clinker, the main binder used in cement, with other supplementary cementitious materials (e.g., calcined clay, fly ash) to produce blended cement (IPCC 2022b).[44] Yet the global average clinker-to-cement ratio has remained almost steady, at 75–78 percent, over the last decade (Boehm et al. 2022; GCCA 2025). This is in part due to prescriptive building codes and standards that regulate which materials are used in construction projects, rather than performance-based standards that allow for greater clinker substitution (Gangotra et al. 2024).[45] Finally, mitigating process emissions from cement will also require laying the groundwork for accelerated adoption of CCUS technologies, such as investment in research and development and carbon transport and storage infrastructure (Chen et al. 2023b).

Meanwhile, the carbon intensity of global steel production needs to decline to 1,340–50 kilograms of carbon dioxide per tonne of crude steel ($kgCO_2/t$) by 2030 and 0–130 $kgCO_2/t$ of crude steel by 2050 to limit warming to 1.5°C (CAT 2020a, 2020b).[46] Rather than decreasing, though, the carbon intensity of global steel production has recently increased, growing from 1,830 $kgCO_2/t$ in 2019 to 1,920 $kgCO_2/t$ in 2023. Some of this increase can be attributed to the evolving representation of companies in the underlying dataset, which has grown from primarily representing European companies to including companies from India and Southeast Asia (World Steel Association n.d.). Nonetheless, collective efforts are moving in the wrong direction or are, at best, stagnant (Figure 10c) (World Steel Association 2024a).[47] To get on track, carbon intensity must fall by almost 30 percent of the subsector's current intensity level by 2030. This will require using new, low-carbon technologies with clean electricity for primary steel production, and producing more secondary steel from steel scrap despite limited availability. Using green hydrogen to produce primary steel is also at the forefront of decarbonization solutions for steel, but it requires economically produced green hydrogen and high quality of iron ore (Hasanbeigi et al. 2024). Reducing the carbon intensity of steel will also require phasing out older plants running on conventional technology, as well as greater adoption of decarbonization technologies across conventional steelmaking facilities, where 70 percent of the world's steel is currently produced (World Steel Association 2024b).[48]

Finally, global green hydrogen production—hydrogen produced through electrolysis of water using renewable energy sources—increased from 0.002 Mt in 2019, to 0.016 Mt in 2022, to 0.074 Mt in 2023, a more than quadrupling in one year alone (Figure 10d) (IEA 2024e). Nonetheless, green hydrogen production remains limited, representing less than 0.1 percent of the overall hydrogen market globally.[49] On a 1.5°C-aligned pathway, green hydrogen production capacity would need to grow to 49 Mt by 2030, 120 Mt by 2035, and 330 Mt by 2050 (IEA 2024i). Green hydrogen has the potential to follow an S-curve trajectory, and rates of adoption could experience rapid, nonlinear change if nurtured by supportive conditions (Appendix C). An S-curve trajectory of green hydrogen production could lead to cascading effects to other industrial sectors such as steel and cement. However, this technology is still within the emergence phase of such a trajectory, whereby high costs, low demand, uneven performance, constrained availability of zero-carbon electricity, and a lack of complementary technologies make it difficult for these innovations to compete with existing technologies. Progress accordingly remains well off track (Appendix C).

Snapshot of recent developments

Despite the insufficient pace of progress for each of these industry indicators, policy momentum for industrial decarbonization has continued to build in key cement- and steel-producing countries and globally over the last few years. For instance, the European Union released the Clean Industrial Deal in February 2025, aiming to decarbonize energy-intensive manufacturing by mobilizing finance and creating markets for low-carbon products, among other actions (European Commission 2025a). The European Commission (2025c) released the European Steel and Metals Action Plan about a month later to accelerate decarbonization in the sector. In March 2025, China announced plans to expand its national emissions trading system to include steel, cement, and aluminum (International Carbon Action Partnership 2025). And, earlier this year, India finalized the mechanism governing its carbon trading system, which includes heavy industries, and released emissions intensity benchmarks for the subsectors (Bureau of Energy Efficiency 2024). Türkiye has also released a draft regulation for a national emissions trading system including high-emitting sectors (ICAP 2024), and, in 2024, Brazil launched a national policy to decarbonize 11 of its industrial sectors, including cement and steel (Demirkol 2024).

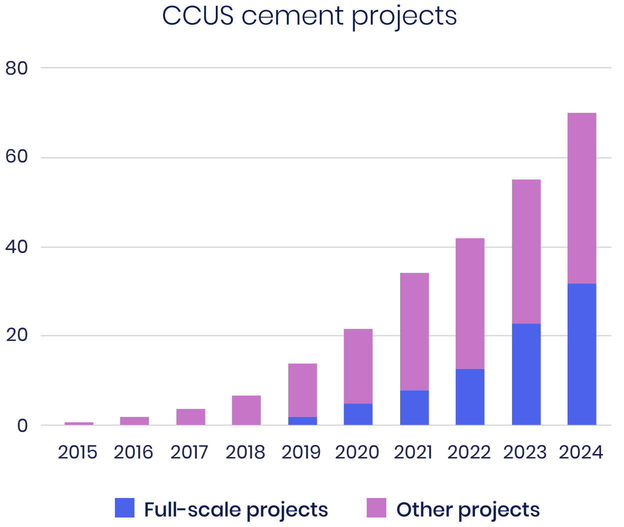
International collaboration and cooperation efforts have also ramped up with the formation of the OECD/IEA-led Climate Club in 2023, which brings together a group of 46 countries to accelerate cross-border ambition in industrial decarbonization (IEA and OECD 2023). In 2024, the Climate Club launched the Global Matchmaking Platform in partnership with the UN Industrial Development Organization (UNIDO 2024), offering technical and financial support to industrial decarbonization efforts in developing countries. Additionally, several countries, including Brazil and Japan, have joined the Industrial Deep Decarbonization Initiative, with nine member countries now working with the initiative on aligning public procurement strategies for low-carbon cement and steel (IDDI 2025).

Recent years have also seen a surge in announced projects of varying scales to deploy decarbonization technologies across cement and steel and for green hydrogen production (Figure 11). The increasing number of projects illustrates the pace of innovation and commercialization across different subsectors and low-carbon technologies. In cement, according to the Green Cement Tracker, 20 calcined clay projects—producing calcined clay to substitute for clinker—were announced between 2020 and 2024, making a total of 23 ongoing calcined projects globally (Lorea et al. 2024).[50] Similarly, 56 CCUS projects have been announced since 2020, bringing the global total to 70 (Lorea et al. 2024). The world's first industrial-scale CCUS cement plant has recently become operational (Heidelberg Materials 2025).

In the case of steel, 89 percent of all existing low-carbon steel projects were added between 2021 and 2024 (LeadIT 2024), with every year during this period seeing at least 20 percent growth in the number of announced projects (Figure 11).[51] Of these recently announced projects, almost 60 percent are full-scale projects, which is a step up from demonstration and pilot projects and illustrates progress toward commercializing low-carbon steel technologies. However, announced projects continue to face challenges and need strong demand signals; for example, in the European Union, only one-third of projects have started construction so far given low conventional steel prices, high energy costs, and inadequate demand for low-carbon steel products (Tarasenko 2025).

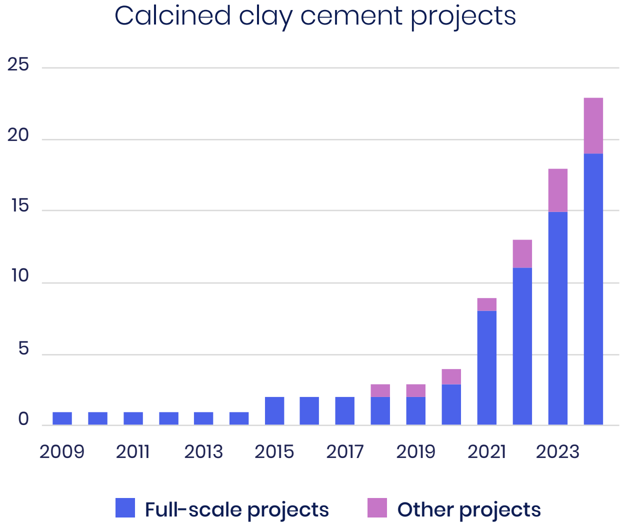
Recent years have also witnessed a rapid acceleration in the deployment of electrolyzers, devices that use water and electricity to produce hydrogen. Globally, electrolyzer capacity grew from 330 megawatts (MW) in 2020 to approximately 1,400 MW in 2023 (IEA 2025c). Electrolyzer price curves are also declining at faster rates than anticipated, improving green hydrogen's cost competitiveness against other means of hydrogen production (e.g., blue and gray) (IEA 2024d). Echoing other recent jumps in progress, 96 percent of cumulative green hydrogen production announced since 2010 occurred during the period between 2020 and 2023 (IEA 2024e).

FIGURE 11 | Cumulative number of announced projects (globally) for low-carbon cement and steel and green hydrogen



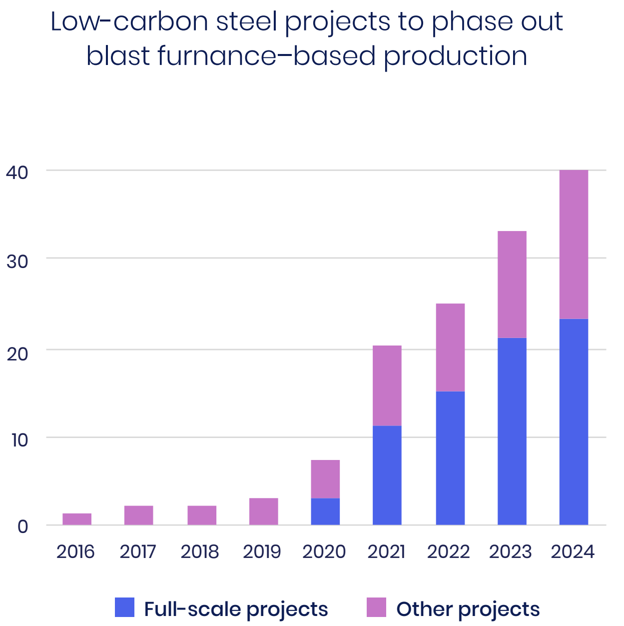
Notes: CCUS = carbon capture, utilization, and storage. Other projects include pilot and demonstration projects and feasibility studies.

Source: Lorea et al. 2024.



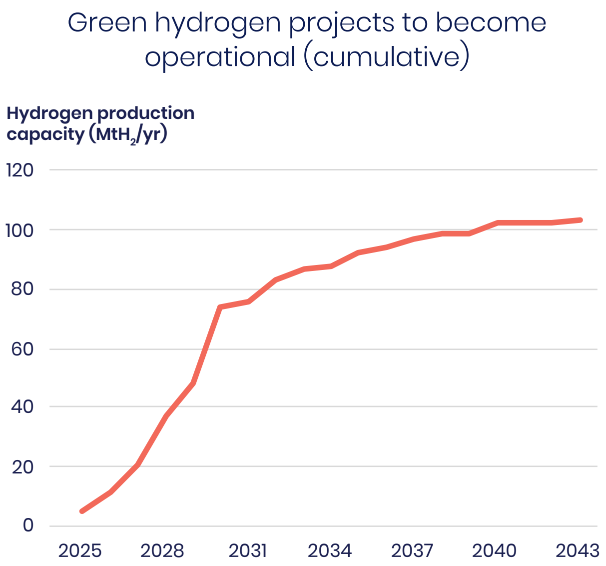
Note: Other projects include pilot and demonstration projects and feasibility studies.

Source: Lorea et al. 2024.



Note: Other projects include pilot and demonstration projects and feasibility studies.

Source: LeadIT 2024.



Note: MtH_2/yr = million tonnes of hydrogen per year.

Source: IEA 2024f.

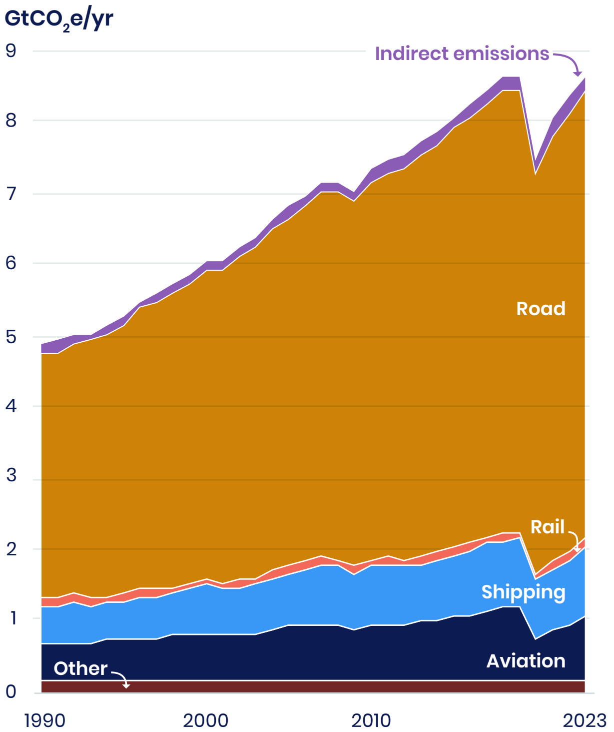
SECTION 5

Transport

Transportation networks connect people to one another, as well as to education, jobs, goods, and services. Yet today's global transport system remains inaccessible to many, a contributor to dangerous local air pollution, and a significant source of global GHG emissions. In total, transport emitted approximately 8.4 $GtCO_2e$ in 2023, accounting for about 15 percent of direct global GHG emissions (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025). Road transport comprised 75 percent of transport emissions in 2023, while domestic and international aviation and maritime shipping each contributed around 11 percent of emissions (Crippa et al. 2024; IEA 2024h). Indirect emissions associated with the purchase of electricity, steam, and heat for transport contributed only a small quantity of emissions—0.25 $GtCO_2e$, or less than 3 percent of all transport emissions—in 2023 (Crippa et al. 2024; IEA 2024h).

Emissions from the global transport sector have increased steadily in recent years, with the exception of a brief dip caused by COVID-19-related lockdowns in 2020. But, as the world began to reopen after the pandemic ended, emissions rebounded to prepandemic levels, nearly matching 2019 levels in 2023 (Figure 12) (Crippa et al. 2024; IEA 2024h).

FIGURE 12 | Global direct and indirect GHG emissions from transport



Notes: GHG = greenhouse gas; $GtCO_2e/yr$ = gigatonnes of carbon dioxide equivalent per year.

Sources: Crippa et al. 2024; IEA 2024h.

Global assessment of progress

Transforming the global transport system will require a holistic "avoid-shift-improve" approach (IEA 2024j; BNEF 2024a; ICCT 2020; IPCC 2022b). First, planners and developers must redesign cities to bring goods and services closer to where people live and work to **avoid** the need for motorized passenger travel whenever possible. Simultaneously, the world must also **shift** passenger transport toward less carbon-intensive, shared, and more active modes, such as public transit, walking, and cycling. Shifting air- and road-based freight transport to rail and water networks where feasible will also be paramount. Finally, **improving** the size-, material-, and fuel-efficiency of vehicles, including by scaling up zero- and low-carbon transport options like EVs and sustainable aviation and shipping fuels will be critical to decarbonizing existing transport modes. Although "improve"-based measures are expected to drive the largest amount of mitigation across the sector, modeling has demonstrated that future scenarios in which avoid, shift, and improve interventions are all prioritized will result in significantly greater total emissions reductions (Teter and Reich 2024; SLOCAT 2023).[52]

FIGURE 13 | Summary of global progress toward transport targets

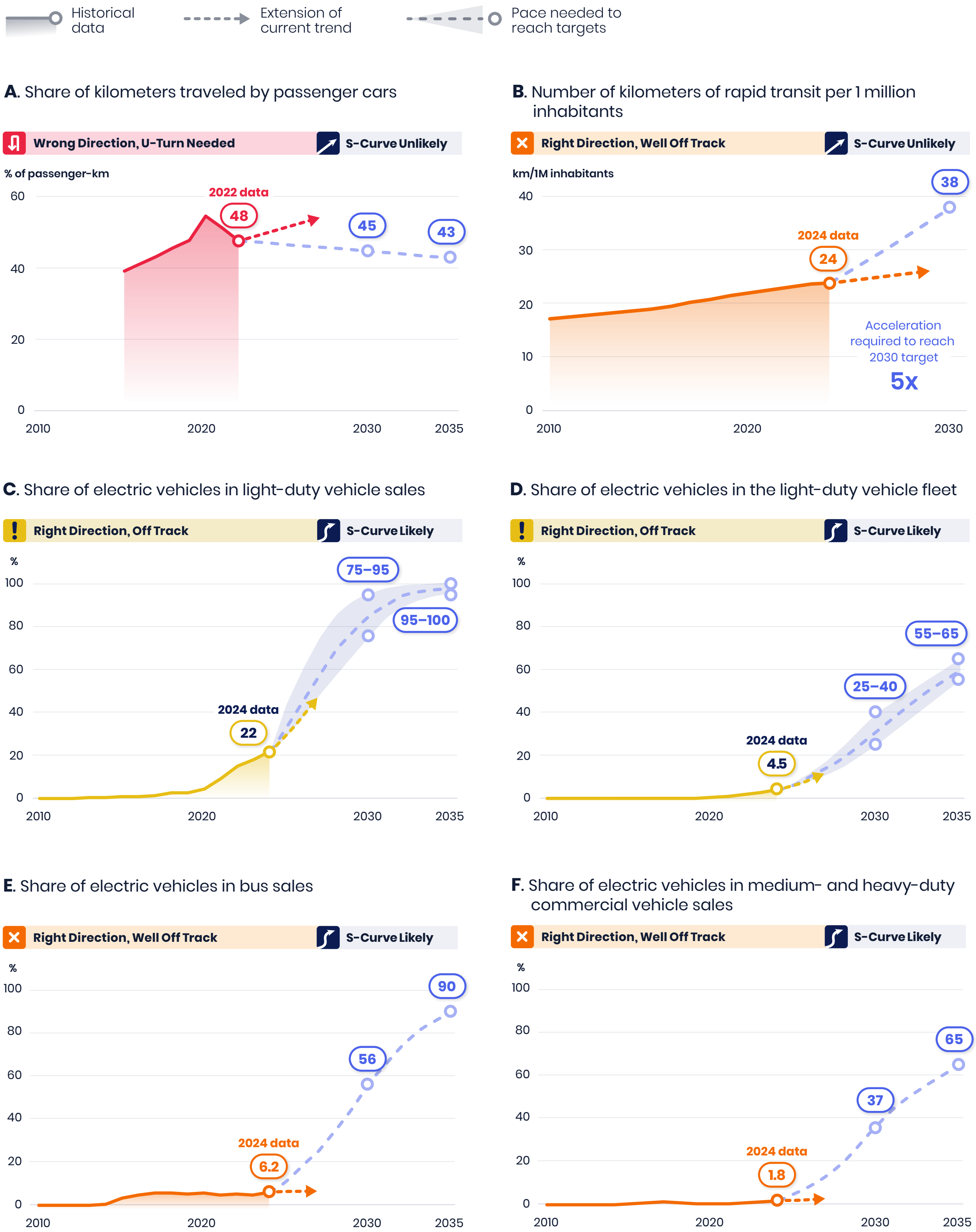


FIGURE 13 | Summary of global progress toward transport targets (continued)

Notes: km/1M inhabitants = kilometers per 1 million inhabitants; passenger-km = passenger-kilometers. For indicators categorized as S-curve possible and S-curve unlikely, the acceleration factors and status of progress are determined by a linear trendline based on the past five years of data. For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are not presented, as they would not accurately reflect an S-curve trajectory. The current trend arrow is based on an S-curve trendline, and the category of progress for these indicators was determined based on author judgment, using multiple lines of evidence. See Appendix C and Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

For the share of kilometers traveled by passenger car, we use the share of passenger-kilometers traveled in light-duty vehicles. Following methods outlined in Boehm et al. 2025, we also exclude 2020 data from this indicator's linear trendline given evidence that 2020 data constituted a temporary outlier in response to the COVID-19 pandemic (Das et al. 2021; Ciuffini et al. 2023). We instead draw a linear trendline using data points from 2015, 2019, and 2022, the only available such points within the last 10 years if we omit 2020. For the number of kilometers of rapid transit per 1 million inhabitants, we also deviate from our regular method of using five recent consecutive data points to draw a trendline given that no data are available for 2021 and 2022. Instead, we draw a trendline using data from just 2020, 2023, and 2024.

Indicators that measure electric light-duty vehicles sales and fleet, as well as electric bus and medium- and heavy-duty commercial vehicles, track the scale-up of battery electric vehicles, as well as plug-in hybrid and fuel cell electric options.

Sources: Historical data from ITF 2023; ITDP 2024b; IEA 2024h, 2025k; IATA 2023, 2025; and Baresic et al. 2024. Data from IEA 2024h are accessed with a paid license to the IEA's datasets. Targets from ITF 2025; Teske et al. 2021; Moran et al. 2018; ITDP 2024b; CAT 2024; IEA 2023h; Mission Possible Partnership 2022; Baresic et al. 2024; and Baresic et al. 2025.

Avoiding the need for motorized travel

Reducing motorized travel or limiting its growth are important strategies to reduce emissions from transport while providing additional benefits such as preventing road fatalities and increasing access to jobs and opportunities. The pandemic offered a glimpse at the types of trips that some could avoid, for example, by transitioning to remote or hybrid work. Continuing such patterns—even if reduced compared to the height of the pandemic—will likely fundamentally alter commuting behaviors around the world (Hensher et al. 2024; Aksoy et al. 2025).[53] Land-use and urban planning interventions that bring destinations closer to where people live and work, such as planning and zoning regulations that promote denser, mixed-use areas, can also enable urban residents to avoid some forms of emissions-intensive, motorized travel altogether (Yang et al. 2023; IPCC 2022b). However, due to data limitations and a lack of 1.5°C-aligned targets, this report's assessment of global progress does not include indicators focused exclusively on avoiding motorized travel.

Shifting to shared, collective, or active transport

Sustainable and accessible car-free transport is essential for vibrant, livable cities, as such access reduces road fatalities, traffic congestion, and air and noise pollution while also promoting equitable access to jobs, opportunities, and essential services (WRI 2025a). However, recent trends suggest the world is moving in the wrong direction entirely. In modeled pathways that limit warming to 1.5°C, the share of passenger-kilometers traveled by passenger cars falls to 45 percent by 2030, 43 percent by 2035, and 40 percent by 2050 (ITF 2025); but this share—48 percent in 2022—has only grown (Figure 13a) (ITF 2023). As urbanization continues to accelerate, especially across Africa and Asia, transport demand is expected to surge (ITF 2023), and, in many of these regions, private vehicle ownership is not yet common. This reinforces the need for increased global investment in high-quality public transport and active mobility infrastructure. Governments must rise to the challenge of meeting growing demand while reducing private vehicle travel to avoid locking in car-dependent, unsustainable patterns of urban development.

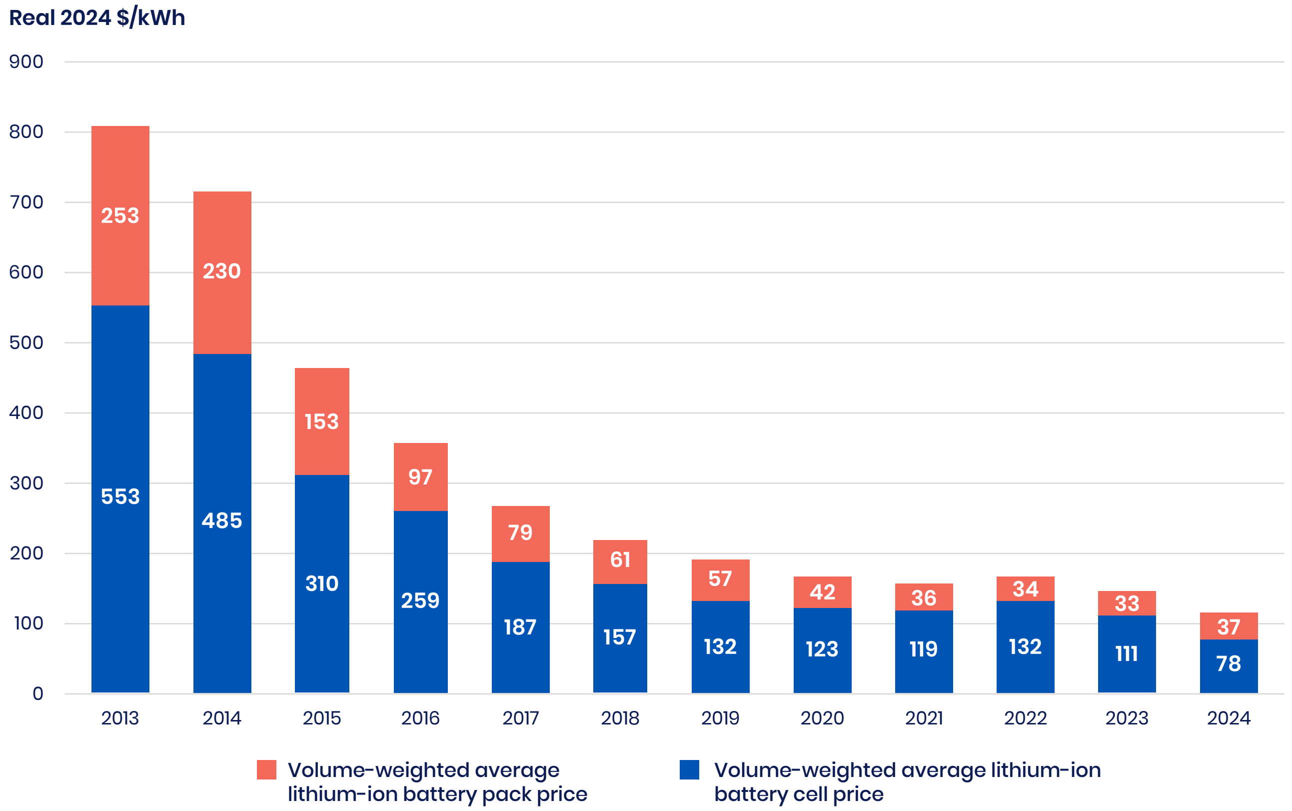
Far greater investment in public transport and high-quality infrastructure for walking and cycling will be critical.[54] For instance, the number of kilometers of rapid transit (bus rapid transit, light-rail, and metro) needs to grow from the 22 kilometers per 1 million inhabitants available in high-emitting urban areas in 2020 to 38 kilometers per 1 million inhabitants by 2030 (Teske et al. 2021; Moran et al. 2018; ITDP 2024b).[55] Cities in Asia have seen particularly notable progress; Seoul (Korea) and Tianjin (China), for example, increased the length of their rapid transit infrastructure by 49 and 41 percent, respectively, between 2020 and 2025 (ITDP 2024b). Despite these bright spots, recent global progress would need to accelerate fivefold to achieve the 2030 target and is therefore well off track of the pace needed to align with a 1.5°C pathway by the end of this decade (Figure 13b).

Improving carbon-intensive road transport

While avoid and shift measures could reduce a considerable amount of today's GHG emissions, and at relatively low costs, these measures alone will only deliver a part of the mitigation across the transport sector needed to limit warming to 1.5°C (SLOCAT 2023; Teter and Reich 2024). Improving existing road transport modes by rapidly scaling up electric vehicles and increasing the efficiency of vehicles will play the largest role in this effort (IPCC 2022b).

It is highly promising that more than one in five cars sold is now electric. Indeed, the share of electric vehicles in light-duty vehicle (LDV) sales increased from just 4.4 percent of all LDV sales in 2020 to 22 percent in 2024 (IEA 2025k).[56] This rapid, nonlinear growth, as well as continuously falling vehicle and battery costs (Figure 14), improvements in battery performance, and the growing availability of charging infrastructure, suggest that light-duty electric vehicle sales are in the diffusion stage of an S-curve growth trajectory (Appendix C). However, the growth of electric vehicles as a share of light-duty sales was less rapid in 2023 (20 percent growth) and 2024 (22 percent growth) compared to prior years (growth rates averaged more than 60 percent in each of the three previous years), causing the share of electric vehicles in LDV sales to fall from on track (Boehm et al. 2023) to off track to reach 75–95 percent by 2030 (Figure 13c).[57] China continues to experience rapid growth, and is the world's top passenger EV manufacturer and consumer. However, in two other major markets —the European Union and the United States— momentum stalled. Following the rollback of supportive subsidies in countries like Germany and France, sales fell slightly in Europe, while, in the United States, growth in EV sales decelerated due to a combination of factors like a relatively slow buildout of public charging infrastructure and limited availability of affordable electric sports utility vehicles, which account for three-quarters of the country's passenger car sales (IEA 2025k). To limit warming to 1.5°C, the pace of sales must rapidly pick up again this decade. Continued progress will be needed thereafter to reach a 95–100 percent sales share by 2035 and 100 percent sales share by 2040 (CAT 2024).

FIGURE 14 | Declines over the last decade in electric vehicle battery prices



Notes: kWh = kilowatt-hours. Lithium-ion battery packs hold multiple individual battery cells. "Volume" refers to the amount of energy storage capacity sold, measured in kWh. Battery packs with more total kWh sold influence the average price more than battery packs with less total kWh sold. Historical prices have been updated to reflect real 2024 dollars. Weighted average survey value includes 343 data points from passenger cars, buses, commercial vehicles, and stationary storage.

Source: BNEF 2024c.

Meanwhile, the share of electric vehicles in the total LDV fleet depends on both new car sales and turnover of older internal combustion cars on the market.[58] As a result, it has lagged well behind sales share trends alone, growing from 0.9 percent in 2020 to just 4.5 percent in 2024 (IEA 2025k). Rapid growth in EV sales suggests a forthcoming breakthrough in EVs as a share of the LDV fleet, and that growth of the electric LDV fleet along an S-curve is likely (Appendix C). But, with the share of EVs in LDV sales off track, and no compelling evidence that stock turnover will occur quickly enough to meet the 25–40 percent fleet share goal by 2030 (CAT 2024), the share of EVs in the LDV fleet is also off track in this year's assessment (Figure 13d).[59] To get on track for 2030, both sales and turnover will need to grow rapidly this decade. Thereafter, this growth will need to continue in order to electrify 55–66 percent of the LDV fleet by 2035 and 95–100 percent by 2050 (CAT 2024).

Large-scale electrification of other road vehicles, including buses and trucks, has yet to occur as quickly.[60] Electric buses experienced a burst of rapid growth in the mid-2010s, with sales share increasing from just 0.63 percent in 2014 to 5.7 percent in 2018 (IEA 2025k).[61] This growth was driven primarily by progress in China (IEA 2025k), where the government encouraged the development of an electric bus manufacturing ecosystem and subsidized initial electric bus purchases (Jaeger 2025). But, as the market for new buses in China has shrunk because so many were deployed in a short amount of time (Jaeger 2025), growth in the global electric bus sales share has stagnated over the last five years (reaching just 6.2 percent by 2024; IEA 2025k), and is currently well off track to reach 56 percent of sales by 2030 (Figure 13e) (Appendix C) (IEA 2023h).[62] This decade, the barriers that are preventing a global breakthrough in further electric bus uptake must be overcome. Thereafter, electric bus sales share must grow to 90 percent by 2035 and 100 percent by 2050 to stay on a 1.5°C-aligned pathway (IEA 2023h). Meanwhile, the share of electric vehicles in medium- and heavy-duty commercial vehicle sales has followed a modest, nonlinear growth trajectory over the last decade, indicating that these trucks are in the emergence stage of an S-curve growth trajectory (Appendix C). Yet, with technology still nascent and sales share growing from just 0.4 percent in 2020 to 1.8 percent in 2024 (IEA 2025k), sales remain well off track (Figure 13f) (Appendix C) (IEA 2023h). A considerable acceleration in efforts will be needed to reach 37 percent of sales by 2030, 65 percent by 2035, and 100 percent by 2050.

Accelerating the deployment of supportive infrastructure, including EV charging networks, will be critical for rapid expansion of electric LDV, bus, and truck sales, especially in lower- and middle-income countries. In 2024, over 1.3 million public EV chargers were installed globally, led by China and Europe, though installation also doubled in regions like India, Latin America, and Africa compared to 2022 (IEA 2025k). However, to meet 1.5°C-aligned targets for vehicle electrification, the world will need to address structural bottlenecks impeding further charging buildout—including high costs of installation and grid integration, limited public accessibility, and unstandardized systems for utilization or payment (IEA 2025k; Mastoi et al. 2022; Mahmud et al. 2023).

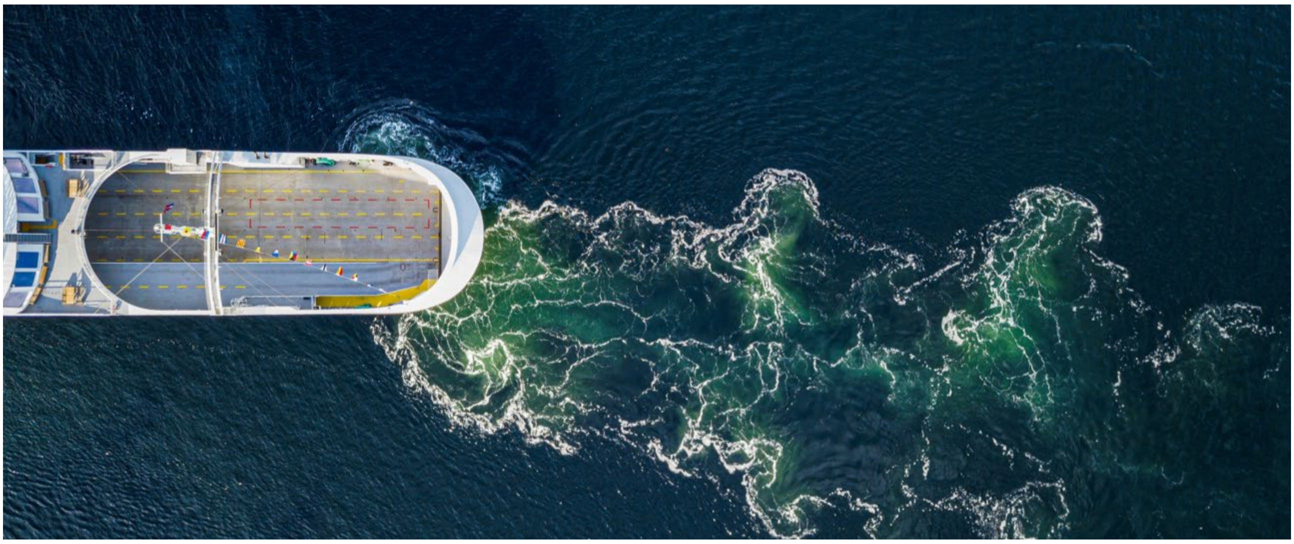
Improving carbon-intensive aviation and shipping

Beyond decarbonizing road transport, the world must also prioritize strategies for reducing emissions from aviation and maritime shipping. While demand reduction, efficiency improvements, contrails mitigation, and development of future zero-emissions aircrafts will all likely play a role, scale-up of sustainable aviation fuels (SAFs) is one of the most promising solutions for aviation, with many studies indicating that the majority of air travel decarbonization through 2050 will likely depend on the large-scale usage of these alternative fuels (Bardon and Massol 2025; Watson et al. 2024c; IATA 2025; Air Transport Action Group 2025).[63] Between 2019 and 2024, the share of SAF in aviation fuel rose from under 0.01 percent to 0.3 percent (IATA 2023, 2025), indicating that the technology is still in the emergence phase of an S-curve trajectory (Appendix C) and well off track for the 13–15 percent share that is needed by 2030 to align with a 1.5°C future (Figure 13g).[64] While the rate of change will likely be nonlinear in the future, there are no guarantees that progress will move fast enough to get on track (Appendix C). Growing thereafter to reach 32 percent by 2035 and 100 percent by 2050 will require further scale-up still (Mission Possible Partnership 2022).

Meanwhile, while there have been some small-scale pilots in recent years, the current share of zero-emissions fuels (ZEFs) in the maritime shipping fuel supply is effectively 0 percent (Baresic et al. 2024).[65] Although we expect this technology will likely follow an S-curve growth trajectory if further demand is stimulated (Baresic et al. 2024) (Appendix C), barriers that have prevented demand from scaling indicate that this share is well off track to reach 5–10 percent by 2030 (Baresic et al. 2024) (Figure 13h). Meeting this 2030 benchmark, reaching a 22 percent share by 2035, and ultimately achieving a 100 percent share by 2050 (Baresic et al. 2024; 2025) will require more targeted policy interventions that increase research, development, and demonstration, stimulate demand, and drive the transformation of small-scale demonstration projects into a commercial ZEF industry.

Advancing avoid, shift, and improve measures

Finally, assessing collective efforts made to reduce the share of fossil fuels in the transport sector's total energy consumption provides a comprehensive snapshot of progress across all shifts—avoiding motorized travel, transitioning to walking, cycling, and public transport, and improving existing transport options.[66] But, in 2023, 95 percent of total energy consumption across the transport sector was derived from fossil fuels, only slightly down from 96 percent in 2019 (IEA 2024h). As these trends would need to accelerate by more than 10 times to fall to 80 percent by 2030 (IEA 2023h), efforts to reduce fossil fuel use in the transport sector are well off track (Figure 13i). Thereafter, the share of fossil fuels used in the transport sector's energy consumption needs to decline further still to help limit warming to 1.5°C—to 64 percent by 2035 and 11 percent by 2050 (IEA 2023h).

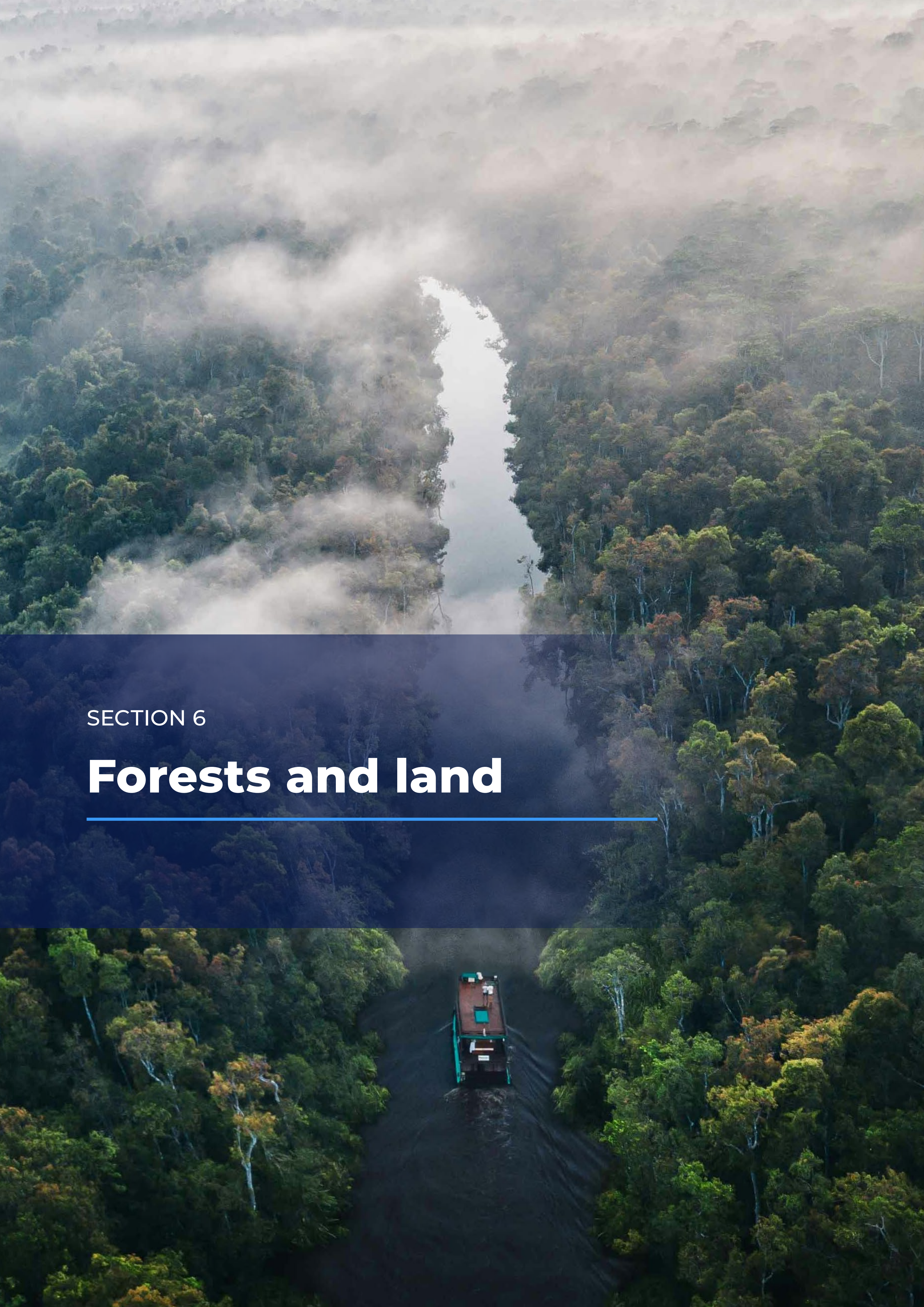


Snapshot of recent developments

To date, large-scale, global developments in shifting to collective and active transport have been limited, largely because interventions are often made at the subnational or city level. But across the world's major cities, construction of urban transit systems, as well as cycling and walking infrastructure, demonstrate that change is underway. For example, in response to growing air quality and traffic concerns, the city of Dakar leveraged a multilateral development partnership with the World Bank to launch a bus rapid transit (BRT) network in January 2024 comprised entirely of electric buses—the first BRT line on the African continent (ITDP 2024a).[67] Meanwhile, while cities in the Netherlands, Germany, and Denmark continue to lead in building extensive, accessible cycling networks, cities in emerging economies are also making strides. Jakarta aims to install 500 km of bike lanes by 2030, Pune's Bicycle Plan envisions 400 km of dedicated paths, and Buenos Aires has built over 260 km of cycle lanes (ITDP 2025). There is also an increasing push to decarbonize the informal transport sector—specifically "popular transport" modes like minibus taxis and tuk-tuks—which often fill an accessibility or operational gap left by more formalized transportation services.[68] In an attempt to make electrification and decarbonization more accessible to independent informal transport operators, for example, BasiGo, a private-sector e-bus maker, opened Kenya's first dedicated assembly line for electric buses in April 2024 (Dosunmu and Wangari 2024).

In addition to urging countries to scale up infrastructure to reduce transport emissions, the Global Stocktake also called upon countries to rapidly deploy zero- and low-emission vehicles (Appendix B) (UNFCCC 2024a). The last several years have seen a number of countries and regions respond by adopting supportive policies. For instance, the European Commission recently affirmed a regulation that will prevent new internal combustion engine passenger vehicle sales by 2035, requiring that vehicles sold thereafter produce no CO_2 emissions (Sawyer 2025). However, the Commission pushed back an interim target for 2025 due to pressure from automakers, which will result in additional lifetime emissions from internal combustion engine vehicles as compared to the initial proposal (ICCT 2025a; *Transport & Environment* 2025b). In China—the world leader in making and using EVs—the light-duty EV sales share reached 48 percent in 2024, surpassing a government target that 20 percent of all vehicles sold must be electric by 2025 (Chinese Government 2020; IEA 2025k). Amid this progress, however, the recent rollback of an EV sales share target and adoption incentives in the United States is projected to inhibit uptake in the US market (St. John and Daly 2025; Nolan 2025).

At the same time, recent developments in decarbonizing shipping and aviation may help to drive faster growth of both SAF and ZEF technologies. For instance, in April 2025, the International Maritime Organization approved its Net-Zero Framework regulating emissions from international shipping (IMO 2025). This regulation includes a financial penalty if GHG intensity exceeds predetermined thresholds and sets an initial rate of \$100 per tonne of carbon dioxide equivalent (tCO_2e), which ratchets up to \$280/tCO_2e by the end of this decade. If adopted, the framework would serve as the world's first global tax on GHG emissions (McDermott and Arasu 2025; UMAS and UCL Energy Institute 2025), but it currently faces steep opposition among several key countries (Ship and Bunker News Team 2025). By increasing costs associated with existing carbon-intensive shipping practices—as well as allocating revenues from the tax to subsidize highest-performing mitigation solutions—this measure is projected to significantly incentivize uptake of decarbonization solutions like ZEF (Gabbatiss 2025; Smith et al. 2025).[69] In the aviation sector, an increasing number of large airlines around the world—including United, British Airways, Japan Airlines, and Qatar Airways—have invested in SAF companies to help more rapidly scale the industry (Puckett 2025; i6 Group 2024), although ensuring that these fuels are produced from nonfood or nonfeed alternatives that do not compete with food production for water and land will be paramount (Searchinger et al. 2019; Lashof and Denvir 2025). The European Union has also set binding targets requiring that airports in the region reach a 2 percent SAF share from this year and a 70 percent such share by 2050 (European Commission 2023). While there is still a long way to go, and increased policy support is needed, these interventions invite cautious optimism about the future of both SAF and ZEF uptake in the years ahead.



SECTION 6

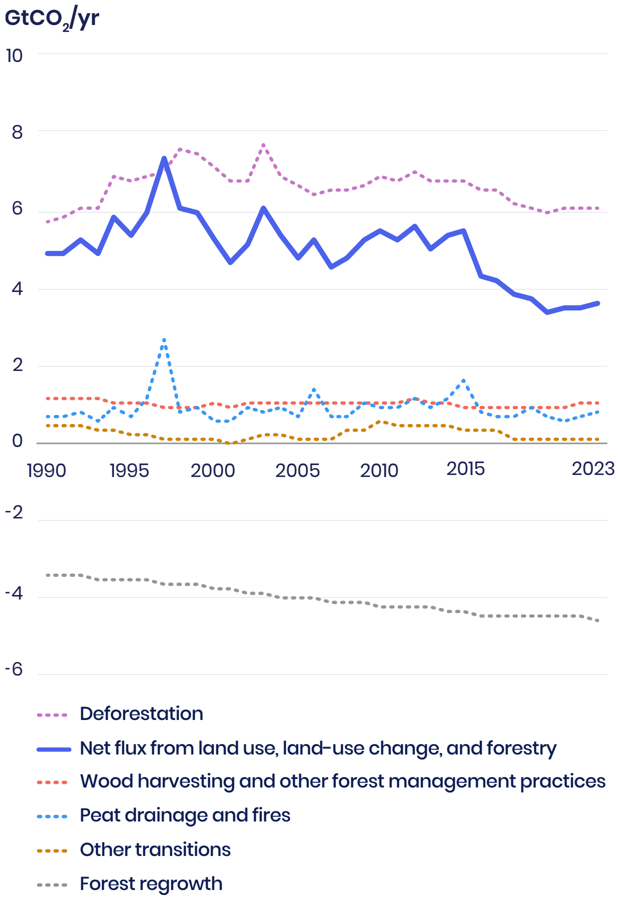
Forests and land

Nature's vital, oftentimes irreplaceable contributions to humanity range widely, from improving water and air quality, to provisioning food and lifesaving medicines, to safeguarding communities from extreme weather events like floods and hurricanes (IPBES 2019; Brauman et al. 2020). Yet people's interactions with the natural world can also impact the delivery of these life-sustaining services, including the critical role that forests, peatlands, coastal wetlands, and grasslands play in regulating the climate. Deforestation, alongside other forms of ecosystem conversion and degradation, release GHGs into the atmosphere, while protecting, restoring, and sustainably managing these same ecosystems can reduce emissions, as well as maintain or even enhance carbon sequestration (IPCC 2022b).

Measuring CO_2 emissions and removals from land use, land-use change, and forestry (LULUCF), however, remains challenging due to limitations in nationally reported data, incomplete representations of management practices across models, and methodological differences in defining the "anthropogenic" flux across land (IPCC 2022b; Grassi et al. 2023).[70] According to a synthesis of global bookkeeping models, deforestation, the decomposition of logging debris, decay of wood products, peat drainage, and peat fires released 12.1 $GtCO_2$ in 2023, while forest regrowth and tree cover gains following wood harvesting removed 8.6 $GtCO_2$ in the same year (Friedlingstein et al. 2025).[71] Taken together with the flux from other land-use transitions, net anthropogenic emissions from LULUCF totaled 3.6 $GtCO_2$, accounting for just over a third of emissions from agriculture, forestry, and other land uses in 2023 (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025).

Global bookkeeping models also indicate that these net anthropogenic emissions have recently decreased by roughly 0.8 $GtCO_2$ per decade, falling from an annual average of 5.7 $GtCO_2$ in the 1990s to 4.1 $GtCO_2$ in the last 10 years (Figure 15).[72] Both increasing carbon removals from forest regrowth, as well as a drop in deforestation-related emissions, have largely driven these declines (Friedlingstein et al. 2025).

FIGURE 15 | Global net anthropogenic CO_2 emissions from land use, land-use change, and forestry



Notes: CO_2 = carbon dioxide; $GtCO_2$/yr = gigatonnes of carbon dioxide per year. Note that the relatively small net flux from wood harvesting and other forest management practices contains more substantial gross CO_2 emissions and removals that largely compensate for one another. In 2023, for example, the nearly 5.2 $GtCO_2$ released by the decomposition of logging debris and the decay of wood products more than offset the 4.1 $GtCO_2$ sequestered by regrowth following wood harvesting, resulting in net emissions of just over 1.0 $GtCO_2$.

Source: Friedlingstein et al. 2025.

Global assessment of progress

Achieving even steeper reductions in net anthropogenic LULUCF emissions will require immediate action to protect the world's forests, peatlands, coastal wetlands, and grasslands, as well as more concerted efforts to restore and sustainably manage these carbon sinks and stores. Together, land-based measures across these ecosystems can mitigate between 4.2 and 7.3 $GtCO_2e$ annually through 2050 at up to $100/$tCO_2e$ (IPCC 2022b)—a range that roughly aligns with pathways limiting warming to 1.5°C (Roe et al. 2019, 2021).[73] When implemented appropriately, such measures can also bolster climate resilience, support sustainable development, and conserve biodiversity (Roe et al. 2021).

Yet collective progress made in deploying land-based mitigation continues to fall woefully short of what is needed to combat the climate crisis. None of the indicators assessed for forests, peatlands, and mangroves, specifically, are on track to achieve their 1.5°C-aligned targets for 2030 (Figure 16).[74] And due to data limitations, this global assessment of progress excludes efforts to protect and restore grasslands, as well as to improve management practices across carbon-rich ecosystems.[75]

FIGURE 16 | Summary of global progress toward forests and land targets

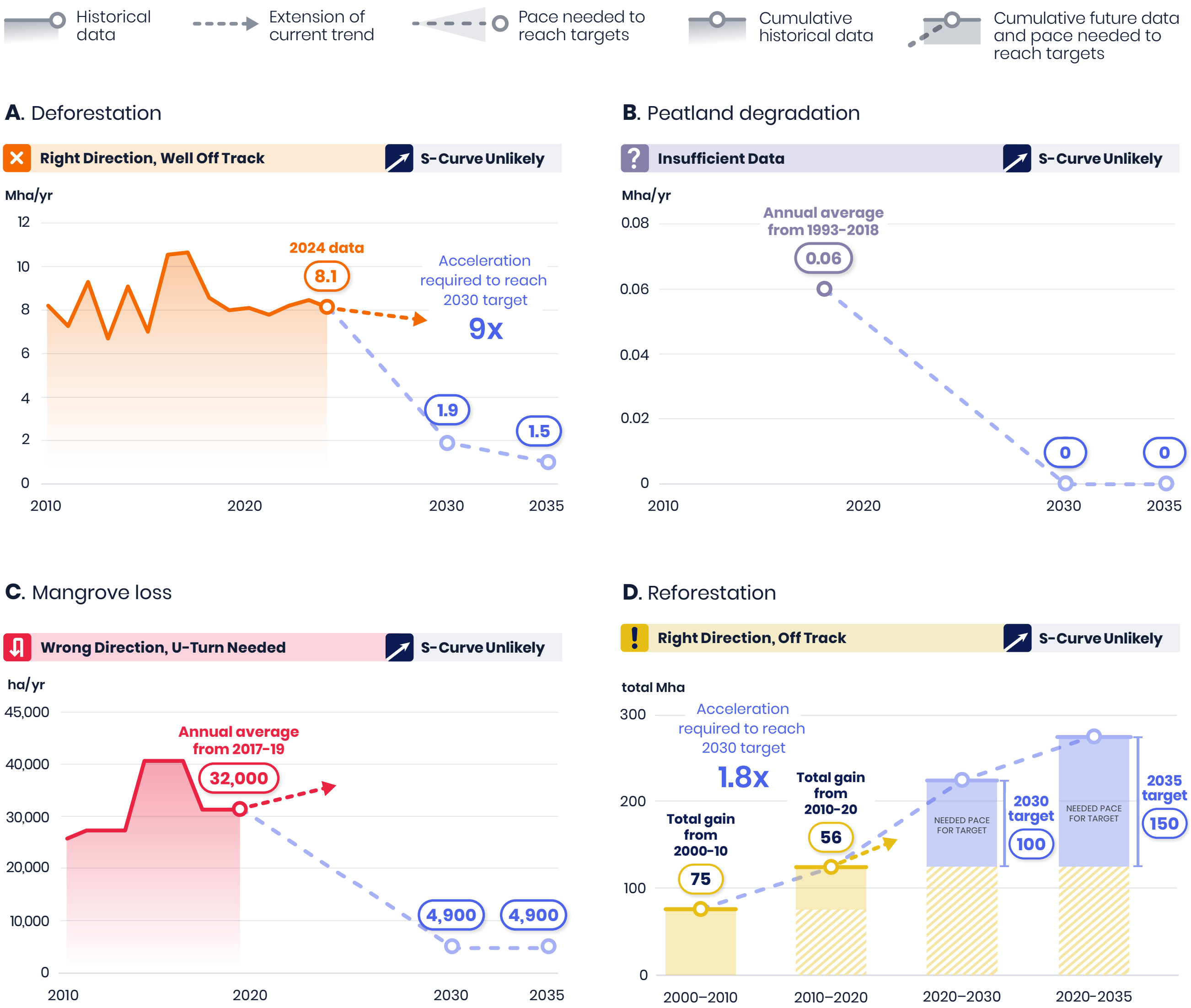


FIGURE 16 | Summary of global progress toward forests and land targets (continued)

Notes: ha = hectares; ha/yr = hectares per year; Mha = million hectares; Mha/yr = million hectares per year. Reforestation, peatland restoration, and mangrove restoration targets are additional to any gains that occurred prior to 2020, and these targets are cumulative from 2020 to 2050. Peatland restoration targets, specifically, were adapted from Humpenöder et al. (2020) and Roe et al. (2021), who assume that 0 Mha of peatlands globally were rewetted as of 2015. This assumption, however, does not mean that peatland restoration is not occurring, as there is evidence of rewetting, for example, in Canada, Indonesia, and Russia (UNEP 2022), but rather speaks to the lack of global data available on peatland restoration.

To track progress toward these targets, as well as those focused on effectively halting deforestation and degradation, the most recent 10 years instead of 5 years were used to calculate linear trendlines wherever possible to smooth out high interannual variability in these indicators' historical data, which can be attributed to both anthropogenic and natural causes. For mangrove losses, however, a 12-year trendline was calculated, using data from 2008 to 2019 to account for the full range of years included in four 3-year epochs from Murray et al. 2022. To estimate the average annual loss rate from 2008 to 2019, gross loss was divided by the number of years in each epoch. Similarly, the most recent data point for mangrove restoration was estimated by taking 8% of the total gross mangrove area gained from 1999 to 2019 (15,000 ha), as Murray et al. (2022) found that only this relatively small share of total gross mangrove area gained (180,000 ha) could be attributed to direct human activities like mangrove planting. Finally, due to data limitations, the average annual rate of change across the most recently available periods was used to estimate the historical rate of change for both mangrove restoration (1999-2019) and reforestation (2010-20), following methods from Boehm et al. 2021.

Historical data for all indicators were estimated using maps derived from remotely sensed data, and accordingly, they contain a degree of uncertainty. See Boehm et al. 2025 for more information on methods for selecting targets, indicators (including the known limitations of each), and datasets, as well as our approach for assessing progress.

Sources: Historical data approximating deforestation and reforestation are from Global Forest Watch. For deforestation, datasets were updated to 2024 by relying on methods published in Hansen et al. 2013; Turubanova et al. 2018; and Sims et al. 2025, and for reforestation, data were taken directly from Potapov et al. 2022a. Data for peatland degradation and restoration are from Conchedda and Tubiello 2020; and Humpenöder et al. 2020, respectively, while data for mangrove loss and restoration are from Murray et al. 2022. Targets are from Roe et al. 2019, 2021; and Humpenöder et al. 2020.

Protecting ecosystems

Effectively halting deforestation and degradation can deliver the lion's share of near-term, land-based mitigation (Roe et al. 2019, 2021). Forests, peatlands, and mangroves collectively hold nearly 1,500 gigatonnes of carbon (GtC) (Pan et al. 2024; Temmink et al. 2022)—equivalent to roughly triple the total carbon emissions from fossil fuels since 1850 (Friedlingstein et al. 2025). By one estimate, at least a fifth of these carbon stocks (~340 GtC) are highly vulnerable to human disturbances, such that they would be released following conversion, for example, to croplands, aquaculture ponds, or urban development (Noon et al. 2021). Some of these carbon losses may occur quite rapidly, such as when large-scale commodity producers clear forests for agricultural production (Cook-Patton et al. 2021). And once lost, much of this carbon would be difficult for ecosystems to recover on timescales relevant to reaching net zero by mid-century (Goldstein et al. 2020; Noon et al. 2021). Fully rebuilding depleted carbon stocks could take 6 to 10 decades for forests, well over a century for mangroves, and centuries to millennia for peatlands (Goldstein et al. 2020; Temmink et al. 2022).

Keeping the Paris Agreement's temperature limit within reach, then, will require immediate and sharp declines in permanent forest loss (Box 3)—to 1.9 million hectares per year (Mha/yr) by 2030, 1.5 Mha/yr by 2035, and 0.31 Mha/yr by 2050 (Roe et al. 2019). But for the third installment in a row, global efforts to achieve these targets are well off track (Boehm et al. 2022, 2023). Although deforestation dropped from a record high of 10.7 Mha/yr in 2017 to 7.8 Mha/yr in 2021, it has since ticked upward to reach 8.1 Mha/yr in 2024. This most recent spike in permanent forest loss has dampened a longer-term downward trend, such that deforestation fell at an annual average rate of just 0.12 Mha/yr between 2015 and 2024. To get on track for 2030, these declines must accelerate ninefold (Figure 16a). Advancing efforts to protect forests will prove especially critical in Brazil, Indonesia, the Democratic Republic of the Congo, Bolivia, and Malaysia—countries that, together, accounted for over half of the total 86 Mha deforested during this 10-year period (Box 4) (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025).

BOX 3 | How do we account for forest losses from fires when tracking global progress made toward effectively halting deforestation?

Tree cover loss can occur from both natural or anthropogenic causes, including fires, logging, storms, or the conversion of forests to other land uses. In 2024, specifically, hot and dry conditions (WMO 2025b) caused by climate change (Otto et al. 2024) fueled massive wildfires around the world, which led to large spikes in tree cover loss across some regions like Latin America (Goldman et al. 2025). Burned areas were particularly extensive in tropical rainforests, where fires intentionally started to clear land for agriculture escaped from fields and spread across nearby forests. In 2024, the world lost 3.2 Mha of humid tropical primary forests to fires, with Brazil accounting for 1.9 Mha of these losses (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025).

However, not all tree cover losses are considered "deforestation," which typically refers to the permanent conversion of forests to new, nonforest land uses (WRI 2025b). To estimate deforestation, we include tree cover loss (Hansen et al. 2013) attributed to permanent agriculture, hard commodities, settlements, and infrastructure development (Sims et al. 2025), as well as to shifting cultivation in humid tropical primary forests (Turubanova et al. 2018), as these are likely to represent long-term land-use change. Forest conversion to agriculture that involves the use of fire, such as when trees are cut down and residue vegetation is burned, are classified as permanent agriculture and therefore included (Sims et al. 2025). This approach is generally aligned with how deforestation-related emissions from fires are accounted for in global bookkeeping models' estimate of net anthropogenic emissions from land use, land-use change, and forestry (Friedlingstein et al. 2025). However, fires that were not followed by agricultural conversion, including those that were ignited to clear land but then escaped and spread across nearby forests not later converted, are excluded from our estimate of deforestation since they do not represent a land-use change. However, these fires can still lead to forest degradation and have long-term impacts on forest health, particularly in tropical ecosystems that are not adapted to fire. As a result, trends in deforestation may differ from broader trends in tree cover loss from year to year.

BOX 4 | Spotlight on 10 countries with the highest total levels of deforestation since 2015

The top 10 countries with the highest total levels of deforestation between 2015 and 2024 collectively accounted for nearly two-thirds of all deforestation globally during this period and, therefore, play an outsized role in efforts to sharply reduce permanent forest loss by 2030 (Table B4-1). Seven of these countries, including Brazil and Indonesia, experienced average annual declines from 2015 to 2024. But while many have seen lower rates of deforestation in recent years compared to the relatively high levels experienced nearly a decade ago, progress made in reducing permanent forest losses has been uneven, with none of these seven nations achieving consistent, year-on-year declines (Figure B4-1).

The remaining three countries—Democratic Republic of Congo, Bolivia, and Mozambique—saw an average annual increase over the last 10 years, a particularly concerning trend for the Democratic Republic of Congo, which contains much of the world's second-largest tropical rainforest. Across all 10 countries, agricultural expansion drove the vast majority of deforestation since 2015 (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025). Indonesia and Malaysia, for example, represent recent hotspots of deforestation spurred by conversion to oil palm plantations, while in Brazil, Bolivia, Paraguay, and Colombia, pastureland expansion served as the primary driver of permanent forest losses (Singh and Persson 2024).

TABLE B4-1 | Trends for the top 10 countries with the highest total levels of deforestation between 2015 and 2024

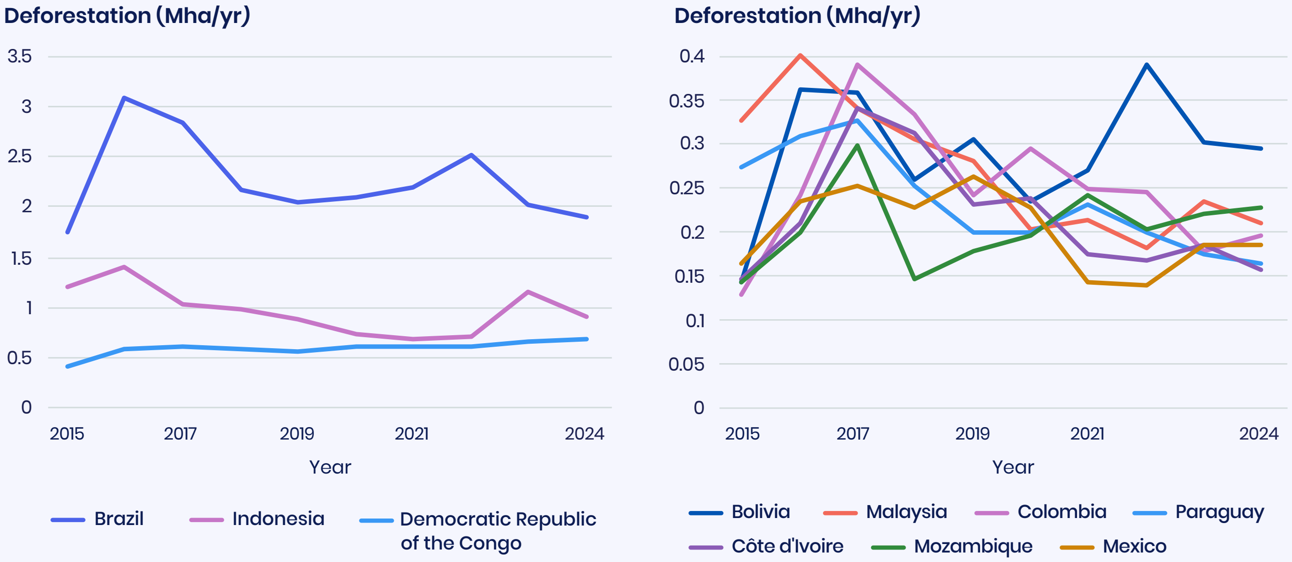
	TREE COVER EXTENT IN 2000 (MHA)	TOTAL DEFORESTATION, 2015–24 (MHA)	SHARE OF TOTAL GLOBAL DEFORESTATION, 2015–24 (%)	AVERAGE ANNUAL CHANGE, 2015–24 (HA/YR)	SHARE OF 2000 TREE COVER EXTENT LOST, 2015–24 (%)
Brazil	520	23	26%	-47,000	4.4%
Indonesia	160	10	11%	-43,000	6.0%
Democratic Republic of the Congo	200	5.9	6.9%	18,000	2.9%
Bolivia	65	2.9	3.4%	6,400	4.5%
Malaysia	29	2.7	3.2%	-20,000	9.2%
Colombia	82	2.5	2.9%	-4,600	3.1%
Paraguay	24	2.3	2.7%	-16,000	9.6%
Côte d'Ivoire	15	2.2	2.5%	-8,300	15%
Mozambique	29	2.1	2.4%	4,600	7.1%
Mexico	53	2.0	2.4%	-6,200	3.8%

Notes: ha/yr = hectares per year; Mha = million hectares. The drivers of tree cover loss data (Sims et al. 2025) do not distinguish between the loss of natural, managed, or planted forests. Loss due to permanent agriculture may include some management (e.g., clearing and replanting) of tree crop or agroforestry systems. While tree cover loss due to tree crop management is estimated to be a small percentage of the permanent agriculture class globally (Sims et al. 2025), in some areas with a long history of tree crop establishment before the year 2000, such as peninsular Malaysia, this proportion may be larger. Therefore, deforestation may be overestimated in these regions.

Sources: Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025.

BOX 4 | Spotlight on 10 countries with the highest total levels of deforestation since 2015

FIGURE B4-1 | Annual trends for the top 10 countries with the highest total levels of deforestation between 2015 and 2024



Note: Mha/yr = million hectares per year.
Sources: Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025.

Reducing deforestation often requires both public and private sector policies targeting international and domestic supply chains, as well as broader land governance reforms (e.g., those focused on bolstering tenure security, particularly for Indigenous Peoples), improved enforcement, and assistance for smallholder farmers (Seymour and Harris 2019; Pendrill et al. 2022). In Indonesia and Malaysia, for example, both government and corporate actions have likely helped spur declines in deforestation over the past decade, including legislation capping the total area of plantations at a national level in Malaysia (Weisse et al. 2023); a permanent, nationwide moratorium on new concessions within Indonesia's primary forests and peatlands (Weisse and Goldman 2022); and widespread adoption of corporate zero-deforestation commitments and certifications in both countries (Carlson et al. 2018; Albert et al. 2020). In Indonesia, however, many of these government actions were spearheaded by the previous administration, and sustaining progress amid changes in political leadership will require continued commitments to protect the nation's forests.

In Brazil, following steep declines after 2016, the uptick in deforestation from 2019 to 2022 coincided with Jair Bolsonaro's administration, which rolled back efforts to conserve the Amazon by weakening environmental legislation, pursuing policies that undermined Indigenous Peoples' rights, and dismantling federal agencies charged with monitoring and enforcement (Vale et al. 2021; HRW 2022). Brazil has since experienced declines in deforestation after 2022, an encouraging shift as President Luiz Inácio Lula da Silva's new administration restarts efforts to halt permanent forest loss.

While some of the average annual declines in deforestation seen at a country level over the past 10 years are promising, reductions in deforestation across all nations need to dramatically accelerate to get on track to help limit warming to 1.5°C.

While not updated since Boehm et al. 2023, best available data on peatland degradation and mangrove loss also indicate that collective progress made in protecting both ecosystems remains inadequate. The world's mangrove forests have lost a total of 560,000 hectares (ha) since the turn of the century, and between 2008 and 2019, specifically, these losses increased at an annual average rate of almost 950 hectares per year (ha/yr). With these recent changes heading in the wrong direction entirely, a step-change in action is urgently needed to reduce mangrove losses from an average of nearly 32,000 ha/yr between 2017 and 2019 to no more than 4,900 ha/yr by 2030, with no additional losses through 2050 (Figure 16c) (Roe et al. 2021; Murray et al. 2022).[76] At the same time, the world must also halt peatland degradation by the end of this decade to help limit warming to 1.5°C (Roe et al. 2019). But despite recent advances in peatland mapping (e.g., Melton et al. 2022), monitoring degradation lags behind, and data are still insufficient to assess progress made toward this target. Global estimates of the area of organic soils drained for agriculture offer a helpful, albeit limited, proxy and show that an average of 0.06 Mha of organic soils were drained each year for crop cultivation and grazing between 1993 and 2018 (Figure 16b) (Conchedda and Tubiello 2020).[77] In total, 57 Mha of peatlands—an area roughly the size of Kenya—are currently degrading, such that they are no longer forming peat, and carbon-rich peat accumulated over centuries to millennia is disappearing (UNEP 2022).

Across all three ecosystems, agriculture represents the primary driver of deforestation and degradation, with mining, urban development, and climate change impacts like drought and sea level rise posing smaller, albeit increasingly significant, threats (UNEP 2022; FAO 2023; Sims et al. 2025). Expanding croplands and pasturelands, for example, accounted for nearly 95 percent of permanent forest losses worldwide between 2015 and 2024 (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025), while aquaculture, as well as rice and palm oil cultivation, spurred about 43 percent of mangrove losses globally from 2000 to 2020 (FAO 2023). Similarly, large-scale agriculture, industrial plantations, and other smaller-scale farming practices (e.g., using fire to clear vegetation for croplands) are primarily responsible for tropical peatland degradation (Dohong et al. 2017; UNEP 2022).

Much of the demand for these agricultural commodities originates in the world's wealthiest countries and communities. Roughly 30 percent of deforestation driven by agricultural expansion was embodied in internationally traded commodities like beef, soy, and palm oil in 2022, with developed countries and emerging economies importing the largest shares (Singh and Persson 2024). Consumption patterns across G7 nations, alone, drive annual losses averaging 3.9 trees per person (Hoang and Kanemoto 2021). And high-income communities within forested countries also exert pressure on these carbon-rich ecosystems, with one recent study finding that domestic demand, particularly from the country's more economically developed regions, accounted for nearly 60 percent of deforestation in the Brazilian Amazon (Haddad et al. 2024).

Effectively halting commodity-driven deforestation and degradation, then, will depend on demand-side shifts like accelerating dietary changes among regions with high per capita consumption of ruminant meat (Food indicator 10) and halving food loss and waste (Food indicators 8 and 9). Supply-side changes that enable farmers to sustainably produce more food, feed, and fiber on existing agricultural lands (Food indicators 1–7) will also prove critical to preventing further expansion of croplands and pasturelands (Searchinger et al. 2019).

Restoring ecosystems

Limiting warming to 1.5°C will also require large-scale restoration of the world's high-carbon ecosystems (Roe et al. 2019). Reforestation, particularly natural regeneration, can deliver substantial, near-term carbon removal at relatively low costs when compared to more nascent technological approaches like direct air carbon capture and storage (DACCS) (IPCC 2022b; Robinson et al. 2025), while prompt restoration of ecosystems that primarily store carbon belowground like peatlands and mangroves can not only reduce emissions from their degrading soils but also enhance carbon sequestration and storage (Temmink et al. 2022). Together, these measures can contribute nearly a third of the land-based mitigation needed globally in 1.5°C pathways (Roe et al. 2019, 2021). Critically, restoration can complement efforts to halt deforestation, as well as other forms of ecosystem conversion and degradation. But it cannot cancel out the impacts of losing forests, peatlands, and mangroves. Not only does recovering these ecosystems oftentimes cost more than protecting them (Cook-Patton et al. 2021), but it may also take decades (if not longer) to regain species diversity, ecosystem structure, and ecological functions, all of which impact GHG fluxes and carbon stocks (Poorter et al. 2021; Kreyling et al. 2021; Su et al. 2021; Loisel and Gallego-Sala 2022; Bourgeois et al. 2024; Ascenzi et al. 2025).

The most recent data on gross gains in ecosystem extent suggest that, globally, restoration efforts aren't faring much better than those dedicated to protecting the world's forests, peatlands, and mangroves. Between 2010 and 2020, for example, a total of 56 Mha—an area roughly the size of France—experienced tree cover gain, which offers a best available proxy for reforestation and likely represents the upper bound of forest area reestablished during this 10-year period (Potapov et al.

2022a).[78] Getting on track to reforest 100 Mha by 2030, 150 Mha by 2035, and 300 Mha by 2050 will require at least a 1.8-fold acceleration in these recent efforts, such that annual tree cover gains increase from an average of 5.6 Mha between 2010 and 2020 to 10 Mha through the end of this decade (Figure 16d) (Roe et al. 2021; Potapov et al. 2022a). Prioritizing natural regeneration in the immediate future will prove especially critical to reaching net zero by mid-century, as new research finds carbon-removal rates are highest for secondary forests aged 20–40 years old. Delaying efforts by even 5 or 10 years would dampen these young forests' sequestration potential by a quarter or half, respectively, through 2050 (Robinson et al. 2025).

Progress made in restoring the world's most carbon-rich wetlands also remains lackluster. Best available estimates of global gains in mangrove extent, though not updated since Boehm et al. 2023, indicate that these forests expanded across just over 180,000 hectares (ha) between 1999 and 2019. But direct human interventions like planting mangroves or reestablishing tidal regimes accounted for just 8 percent of these total gains (15,000 ha) (Murray et al. 2022). Global efforts to restore another 240,000 ha of mangrove forests by 2030, then, remain well off track and will require direct gains, which increased by an average of roughly 750 ha each year during this 20-year period, to accelerate more than 10-fold (Figure 16f) (Roe et al. 2021; Murray et al. 2022). Global estimates of mangrove restoration from FAO (2023) also indicate that progress made in reestablishing these coastal wetlands over the last two decades falls well short of the direct gains needed through 2030.[79] Similarly, although data remain insufficient to assess global progress, available evidence suggests that peatland rewetting is occurring in some countries like Canada, Indonesia, and Russia but likely not yet at the pace and scale required to restore 15 Mha by 2030, 16 Mha by 2035, and 20–29 Mha by 2050 (Figure 16e) (Humpenöder et al. 2020; Roe et al. 2021; UNEP 2022).

Sustainably managing ecosystems

Improving ecosystem management can also help combat the climate crisis (IPCC 2022b), with adoption of more sustainable practices accounting for roughly 15 percent of the land-based mitigation needed in 1.5°C pathways (Roe et al. 2019, 2021). In both natural and planted forests, adopting reduced-impact logging practices (e.g., felling strategies that decrease wood waste and minimize damage to nearby trees), extending harvest rotations to increase the age at which trees are cut, and setting aside protected areas to conserve biodiversity can reduce GHG emissions and enhance carbon sequestration (Ellis et al. 2019; Austin et al. 2020; Griscom et al. 2020). That said, ensuring that changes in management practices do not dampen yields and displace production to other forests (e.g., Kallio and Solberg 2018) will prove especially critical in delivering these climate benefits at scale.

In grasslands and savannas, the efficacy of practices will vary by context but may focus on enhancing native plant diversity, fertilization, and grazing management through rotational grazing and adaptive multipaddock grazing (Bai and Cotrufo 2022). Improved fire management can also benefit some grasslands and savannas, for example, by prescribing early dry season burns to minimize more extensive and severe fires later in the dry season (Lipsett-Moore et al. 2018; Griscom et al. 2020). But here too, these interventions' mitigation potential will differ across regions, and in some places, notable biodiversity tradeoffs can arise, such as in East and Southern African savannas (Croker et al. 2023). Data limitations, however, preclude an assessment of global progress made in adopting more sustainable forest, grassland, and savanna management practices.

Snapshot of recent developments

While collective progress made in scaling mitigation measures across the world's forests, peatlands, and mangroves continues to lag far behind what's needed to limit warming to 1.5°C, there is no shortage of multilateral commitments to conserve these ecosystems. Most recently, for example, the Global Stocktake emphasized the importance of halting and reversing deforestation by 2030, echoing previous pledges like the Glasgow Leaders' Declaration on Forests and Land Use and the Kunming-Montreal Global Biodiversity Framework (Appendix B) (UNFCCC 2024a). Yet follow-through in translating these global ambitions into supportive laws and regulations, strong institutions that can effectively implement conservation policies, and sufficient finance is uneven. Notably, Brazil, the Democratic Republic of Congo, and Indonesia—three countries that, together, can deliver nearly 40 percent of land-based mitigation needed to help achieve the Paris Agreement's temperature goal (Roe et al. 2019, 2021)—have seen both bright spots and setbacks since COP28, while efforts to reduce international demand for commodities that threaten these ecosystems have largely been delayed.

Upon reelection, President Luiz Inácio Lula da Silva pledged to end deforestation and degradation across Brazil (Vetter 2022), and shortly after taking office in 2023, he reinstated policies to reduce deforestation across the Amazon and Cerrado (Government of Brazil 2024). In 2024, his administration formally launched complementary strategies focused on protecting the Pantanal and Caatinga biomes, as well as began developing action plans to extend these efforts to all of Brazil's major biomes; revised a national plan to restore 12 Mha of degraded lands by 2030; reestablished a program that channels federal funding earmarked for activities focused on reducing deforestation to municipalities across the Amazon (Government of Brazil 2024, 2025); and formally recognized a handful of the more than 260 Indigenous territories awaiting demarcation (Wenzel 2024). More recently, Lula's government bolstered enforcement efforts (e.g., conducting raids and levying fines for illegal logging) (Marcelino 2025), strengthened real-time deforestation monitoring, and slowed financial flows to embargoed areas (Mendes 2025). And on the global stage, Brazil is leading the charge to establish the Tropical Forest Forever Facility—an innovative financing mechanism that aims to raise $25 billion in loans from governments and another $100 billion from philanthropists, invest those funds in a diversified portfolio, and then use the net returns from these investments to finance forest conservation in tropical countries (Catanoso 2024). But amid such achievements, Brazil has also encountered setbacks. Its Congress recently passed a bill that would simplify environmental licensing for infrastructure projects (Wells 2025), and while Lula struck down the most harmful provisions when he signed the legislation in August 2025, Congress may still overturn his vetoes (Rogero 2025). The Supreme Court will also allow states to withdraw tax incentives for companies participating in the Soy Moratorium (Mano and Brito 2025), and the federal environmental agency approved oil exploration near the mouth of the Amazon River (Maisonnave 2025).

Elsewhere, recent developments are less promising. Within a year after taking office in October 2024, Indonesia's new president, Prabowo Subianto, has advocated to expand oil palm plantations (Jong 2025); announced plans to convert 20 Mha of forests into agricultural lands to produce bioenergy crops, as well as other commodities to bolster food security, like rice (AFP 2025); and taken steps to accelerate the development of the country's nickel mining and processing industry (Reuters 2025), which represents a fast-growing driver of deforestation and forest degradation (FDA Partners 2024). Taken together, such policies may signal a departure from the previous administration's conservation priorities and risk backsliding on nearly a decade of progress made in reducing permanent forest loss (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025) and restoring peatlands and mangroves (BRGM 2022, 2023). In the Democratic Republic of Congo, Parliament adopted legislation in January 2025 to establish the world's largest protected forest area, the Kivu-Kinshasa Green Corridor, which stretches across 54 Mha of tropical forests and peatlands (Einhorn and de Merode 2025). But less than six months later, the government placed more than 50 oil blocks up for auction. If sold, these permits would allow drilling across 124 Mha, including within much of the Kivu-Kinshasa Green Corridor and the world's largest region of tropical peatlands, known as the Cuvette Centrale (Weston 2025).

Finally, on the demand side, the European Union issued a one-year delay in implementing a landmark regulation that mandates companies to conduct due diligence on major forest-risk commodities (i.e., cattle, cocoa, coffee, oil palm, rubber, soy, and timber) sold within or exported from the region to ensure that these goods, as well as those derived from them (e.g., chocolate, beef, and furniture), are produced without deforesting or degrading forests (European Council 2024). This postponement comes amid opposition to the regulation from some governments like Brazil and Malaysia, calls for a delay from a number of agricultural ministries across the European Union, and concerns over supply chain disruptions from companies (Meijer and Angel 2024; Brändlin 2024). Efforts to pass similar legislation in other major markets, such as in the United States and the United Kingdom, have also stalled (Radwin 2025).

SECTION 7

Food and agriculture

The world's population is projected to rise from roughly 8 billion in 2023 to nearly 10 billion by 2050 (UN DESA 2024). Achieving food and nutrition security for this growing population, while also enhancing producers' and farmworkers' livelihoods, effectively halting deforestation and degradation (Forests and land indicators 1–3), enabling large-scale restoration of high-carbon ecosystems (Forests and land indicators 4–6), safeguarding natural resources like water and soil, improving agricultural resilience, and limiting warming to 1.5°C, will be enormously difficult—but paramount. However, global efforts to reduce emissions from food production, loss and waste, and consumption—necessary components of broader food systems transformation objectives and UN Sustainable Development Goals—have yet to progress at a pace and scale commensurate with the challenges humanity faces.

GHG emissions from agricultural production, which are primarily methane and nitrous oxide, have been growing at an average annual rate of 0.7 percent since 2000, with the rate slowing to a 0.5 percent increase per year from 2018 to 2022 (Figure 17) (FAOSTAT 2025).[80] These emissions totaled roughly 6.5 $GtCO_2e$—about 11 percent of global GHG emissions—in 2023 (Figure 1) (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025). When on-farm production-related emissions are combined with emissions from agriculture-related land-use change, pre- and post-farmgate energy-related emissions across food supply chains, and methane emitted from food waste in landfills, total food system emissions account for roughly 16 $GtCO_2e$ per year—almost 30 percent of global GHG emissions (Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025; FAOSTAT 2025).[81]

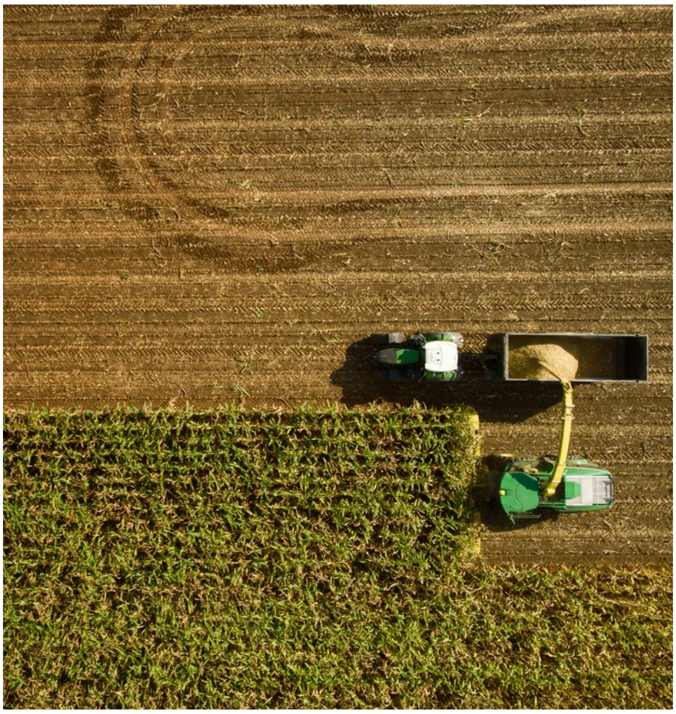
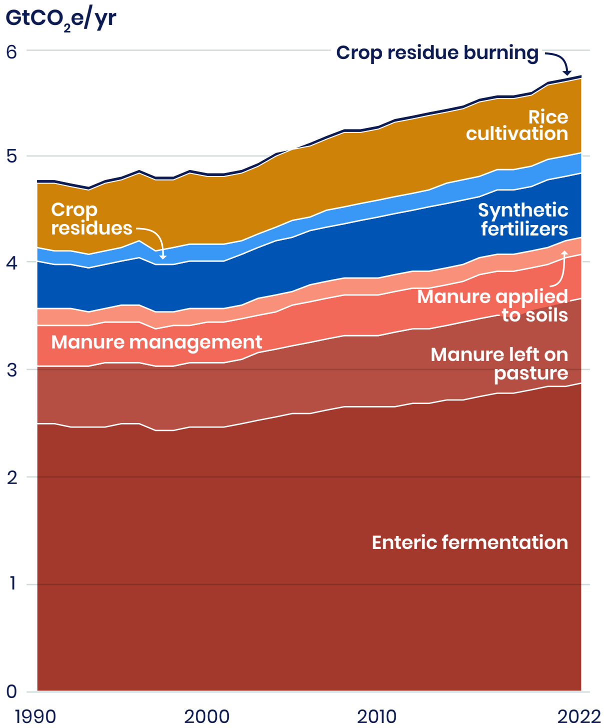


FIGURE 17 | Global direct GHG emissions from agriculture



Notes: GHG = greenhouse gas; $GtCO_2e/yr$ = gigatonnes of carbon dioxide equivalent per year. This figure only includes GHG emissions from agricultural production and carbon dioxide equivalencies are calculated using global warming potentials with a 100-year time horizon from IPCC 2014. We use FAOSTAT data in lieu of data from Crippa et al. 2024; IEA 2024h; and Friedlingstein et al. 2025 in this section because it has more granular disaggregation of agricultural production emissions. For example, emissions from synthetic fertilizers, crop residues, and manure applied to soils, as well as manure left on pasture, from FAOSTAT 2025 are aggregated in the managed soils and pastures category reported by Crippa et al. 2024; IEA 2024h; and Friedlingstein et al. 2025.

Source: FAOSTAT 2025.

Global assessment of progress

Feeding the world's growing population more nutritiously, equitably, and sustainably will require a combination of supply- and demand-side shifts to sustainably increase agricultural productivity, reduce food loss and waste, and shift diets in high-consuming regions. This report focuses on opportunities to reduce greenhouse gas emissions to mitigate climate change, which are one component of the broader changes needed to advance a healthier and more sustainable food system. These shifts must occur alongside broader changes to agricultural production and consumption practices to strengthen food and nutrition security; protect water, soil, and other natural resources; improve agricultural resilience; and diversify farming systems and dietary patterns.

FIGURE 18 | Summary of global progress toward food and agriculture targets

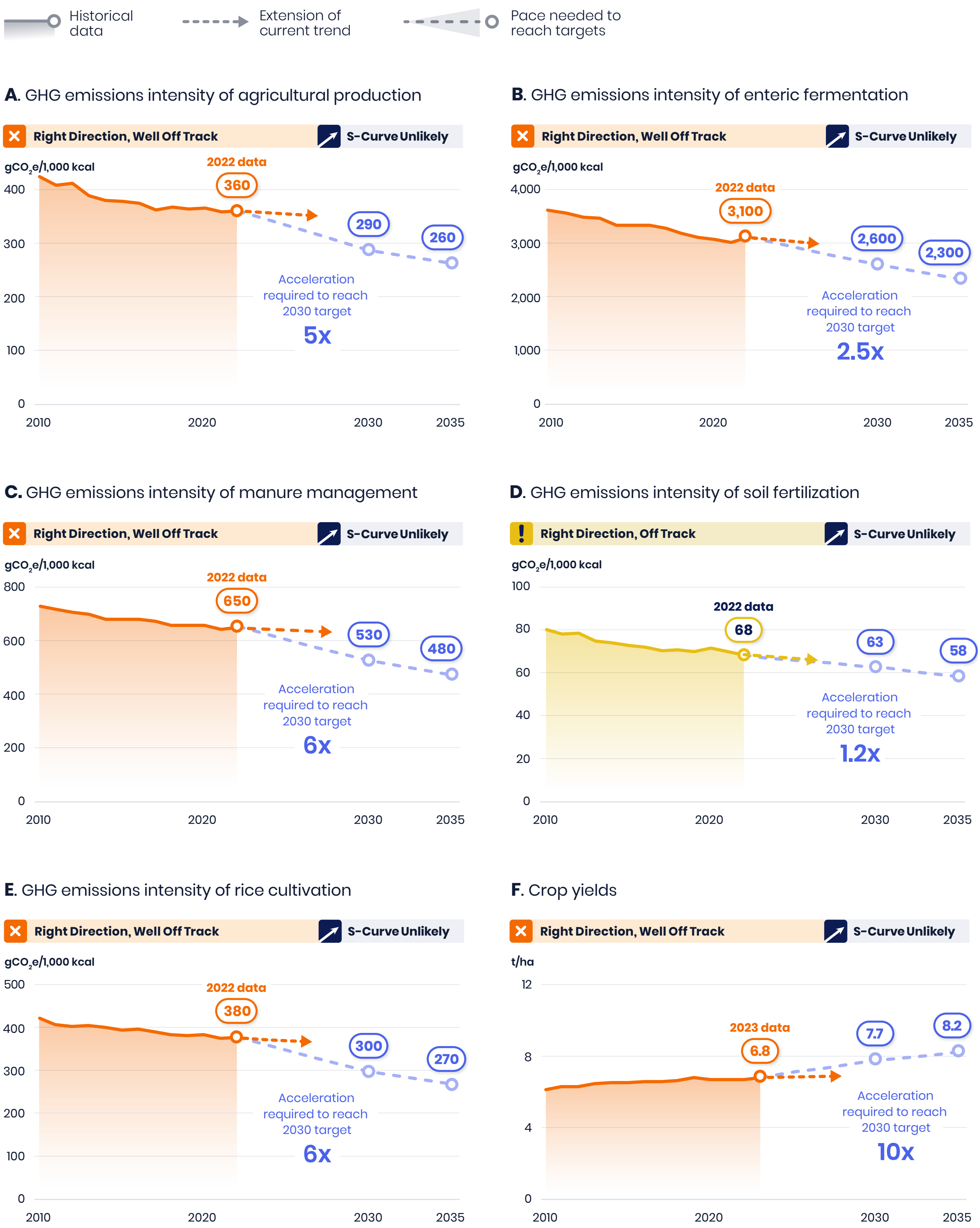


FIGURE 18 | Summary of global progress towards food and agriculture targets (continued)

Notes: GHG = greenhouse gas; gCO_2e = grams of carbon dioxide equivalent; kcal = kilocalories; kcal/capita/day = kilocalories per capita per day; kg/capita = kilograms per capita; kg/ha = kilograms per hectare; t/ha = tonnes per hectare. For the emissions intensity indicators, the denominator differs by indicator, based on which food groups contribute the majority of emissions for that source (see Table 6 in Boehm et al. 2025). Manure emissions intensity includes emissions from manure left on pasture and manure management. Fertilizer emissions intensity includes emissions associated with the application of synthetic fertilizers, crop residues, and manure applied to soils. For the share of food production lost, progress was assessed using a linear trendline estimated with three data points across six years — 2016, 2020, and 2021 — due to data limitations. Ruminant meat consumption data are provided in terms of availability, which is the per capita amount of ruminant meat available at the retail level and is a proxy for consumption. Critically, this diet shift applies specifically to the high-consuming regions (Americas, Europe, and Oceania). It does not apply to populations within the Americas, Europe, and Oceania that already consume less than 60 kcal/capita/day, have micronutrient deficiencies, and/or do not have access to affordable and healthy alternatives to ruminant meat. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

Sources: Historical data from FAOSTAT 2025 and UNEP 2021, 2024b. Targets from Searchinger et al. 2019, 2021; and United Nations 2015.

Reducing agricultural emissions intensity

Because global demand for food and other agricultural products is projected to continue growing (Falcon et al. 2022), the emissions intensity of agricultural production needs to fall even faster than absolute emissions. The GHG emissions intensity of agricultural production is influenced by changes to food production practices, food loss and waste, and the composition of diets, as well as the share of agricultural products used for nonfood and nonfeed uses, providing an overall measure of progress across the sector. Global GHG emissions intensity declined by an average of only 1.9 grams of carbon dioxide equivalent per 1,000 kilocalories (gCO_2e/1,000 kcal) per year between 2018 and 2022 (FAOSTAT 2025), reaching 360 gCO_2e/1,000 kcal per year in 2022. As a result, progress remains well off track and would need to accelerate five times faster to meet the 2030 target of 290 gCO_2e/1,000 kcal (Figure 18a) (Searchinger et al. 2019). It would thereafter need to continue to decline to 260 gCO_2e/1,000 kcal by 2035 and 200 gCO_2e/1,000 kcal by 2050 to align with a 1.5°C pathway (Searchinger et al. 2019).

Disaggregating the major sources of agricultural emissions allows for a more targeted approach to track progress toward reducing agricultural emissions intensity. Nearly half of agricultural production emissions come from enteric fermentation, the digestive process that causes ruminant animals like cattle, goats, and sheep to release methane emissions primarily through belching (FAOSTAT 2025). Other significant contributors include manure-related emissions from all livestock from manure left on pasture and manure management (20 percent); soil fertilization emissions from the application of synthetic fertilizers, crop residues, and manure applied to soils (16 percent); and rice cultivation (11 percent) (FAOSTAT 2025).[82] Across all of these four major sources of emissions, progress in reducing emissions intensity from 2018 to 2022 was off track or well off track from the pace needed to achieve 2030 targets aligned with limiting warming to 1.5°C. The emissions intensity of soil fertilization needs to decrease 1.2 times faster, enteric fermentation emissions intensity needs to decrease 2.5 times faster, and the emissions intensity of manure management and rice cultivation both need to decline roughly 6 times faster through the end of the decade (Table 1) (Figure 18b-e). Importantly, these emissions intensity targets represent progress needed at the *global* level; targets and the pace of progress will differ by country and region given existing differences in production practices, available finance, effects on yield, and socioeconomic circumstances.

TABLE 1 | Agricultural emissions intensity by major source

	Most recent data point (year)	2030 TARGET	2035 TARGET	2050 TARGET	AVERAGE ANNUAL CHANGE, 2018–22	ACCELERATION FACTOR	STATUS
GHG emissions intensity of enteric fermentation (gCO_2e/1,000 kcal)	3,100 (2022)	2,600	2,300	1,600	-24	2.5x	✕
GHG emissions intensity of manure management (gCO_2e/1,000 kcal)	650 (2022)	530	480	320	-2.8	6x	✕
GHG emissions intensity of soil fertilization (gCO_2e/1,000 kcal)	68 (2022)	63	58	45	-0.55	1.2x	!
GHG emissions intensity of rice cultivation (gCO_2e/1,000 kcal)	380 (2022)	300	270	170	-1.8	6x	✕

Notes: gCO_2e/1,000 kcal = grams of carbon dioxide equivalent per 1,000 kilocalories; GHG = greenhouse gas. For the emissions intensity indicators, the denominator differs by indicator, based on which food groups contribute the majority of emissions for that source (see Table 6 in Boehm et al. 2025). Manure emissions intensity includes emissions from manure left on pasture and manure management. Fertilizer emissions intensity includes emissions associated with the application of synthetic fertilizers, crop residues, and manure applied to soils.

Sources: Historical data from FAOSTAT 2025. Targets from Searchinger et al. 2019.

Sustainably increasing agricultural productivity

Sustainably increasing crop yields and livestock production efficiency, especially where yields are low, offers key opportunities to reduce agricultural emissions and help meet growing food demand without additional agricultural expansion (supporting the "Forest and land" targets above). While crop yields increased steadily over the past few decades, they stayed relatively flat from 2019 to 2023, growing at an average of 0.01 tonnes per hectare (t/ha) per year to reach 6.8 t/ha by 2023 (FAOSTAT 2025). Such slow recent change means crop yields are well off track the pace needed to meet the 2030 target of 7.7 t/ha by 2030, and, accordingly, progress would need to accelerate by roughly 10-fold by 2030 (Figure 18f) (Searchinger et al. 2019, 2021). Crop yields will then need to continue to increase to 8.2 t/ha by 2035 and 9.5 t/ha by 2050 (Searchinger et al. 2019, 2021).

Some agricultural practices, such as agroforestry systems where trees and shrubs are integrated into crop and animal farming systems, offer opportunities to increase yields while sequestering emissions, improving biodiversity, and enhancing resilience to climate change. Agroforestry systems have the greatest potential to increase yields (Reed et al. 2017) and carbon sequestration (Sprenkle-Hyppolite et al. 2024) in Africa and Central and South America. But, due to data limitations, this global assessment of progress excludes an indicator to track agroforestry for its climate mitigation benefits.[83]

Ruminant meat productivity, which improved by 0.42 kg/ha per year from 2018 to 2022 to reach approximately 30 kg/ha in 2022, remains off track from the pace needed to reach 35 kg/ha by 2030 (Figure 18g) (FAOSTAT 2025). Getting on track this decade would require recent rates of change to accelerate by a factor of 1.6, after which ruminant meat productivity would need to increase further still to 37 kg/ha by 2035 and 44 kg/ha by 2050 (Figure 18g) (Searchinger et al. 2019, 2021). While this metric tends to favor intensive production systems, productivity can be increased by improving feed and forage quality, grazing management, breeding practices and animal genetics, and animal health, especially in the tropics where yields are low (Searchinger et al. 2019; Cardoso et al. 2016). Achieving productivity gains does not require shifting to feedlots, which are associated with negative impacts on worker and community health (Chamanara et al. 2021), air and water pollution (Chamanara et al. 2021), antimicrobial resistance (Cameron and McAllister 2016), and animal welfare (Salvin et al. 2020).

In addition to reducing production emissions, increasing productivity allows more food to be produced on less land, which can reduce pressure from agricultural expansion in driving land use changes (and associated GHG emissions) if accompanied by strong ecosystem protection policies. Unfortunately, while crop yields are increasing, total cropland has expanded by more than 100 Mha since the year 2000 (Potapov et al. 2022b), indicating that yield growth has not kept pace with rising demand for food, livestock feed, biofuels, and other agricultural products used for industry. Additionally, although ruminant meat productivity has slowly increased, pastureland expansion is a leading driver of deforestation (Pendrill et al. 2022). Data on pastureland area is more limited but suggests that as pastureland expands and retracts in different areas, these changes offset each other so that net pastureland area stayed relatively stable at 3.2 billion hectares between 2018 and 2022 (FAOSTAT 2025).[84] More granular data are needed to assess how changes in pastureland productivity can reduce conversion and support restoration.

Reducing food loss and waste

Food loss and waste occur across the supply chain, with as much as 40 percent of all food produced by weight going uneaten each year (WWF-UK 2021). Food loss occurs before food gets to market, during harvest, storage, and transport to market, whereas food waste occurs at retail markets, restaurants, or in homes (Flanagan et al. 2019).[85] Reducing global food loss and waste creates the opportunity to make more food available for a growing global population while also decreasing land use, emissions, and other environmental impacts associated with producing uneaten foods.

In a recent five-year period, the world has made almost no dent in reducing food loss. While not updated since Boehm et al. 2023, best available data show that the global rate of food loss rose slightly from 13.0 percent to 13.3 percent between 2016 and 2020 and then declined slightly to 13.2 percent in 2021, indicating that these global trends are, on average, moving in the wrong direction from the target of just 6.5 percent share lost by 2030 (Figure 18h) (FAOSTAT 2025).[86]

Meanwhile, though the estimated per capita food waste in 2022 (130 kilograms per capita, or kg/capita) (UNEP 2024b) was higher than the first global estimate reported for 2019 (120 kg/capita) (UNEP 2021), UNEP (2024b) primarily attributes this increase to improvements in monitoring food waste, and as a result, there are insufficient data to assess progress yet. However, both numbers clearly are far too high relative to the 2030 target of 61 kg/capita (Figure 18i).

Modeling exercises show how halving global food loss and waste rates has substantial mitigation potential and can help bring food system–related GHG emissions in line with pathways that limit warming to 1.5°C (Clark et al. 2020; IPCC 2022b), in addition to being aligned with

Sustainable Development Goal Target 12.3 to halve food waste and reduce food losses across the supply chain (United Nations 2015). Given the stubbornly high rates of food loss and waste, a course correction is urgently needed to halve food loss and waste by 2030 and maintain that level of reduction through 2035 and 2050.

Advancing healthy and sustainable dietary shifts

Dietary shifts will also be necessary to keep emissions in line with pathways that limit warming to 1.5°C (Clark et al. 2020; Searchinger et al. 2019). Moderating consumption of emissions- and land-intensive foods, especially ruminant meats like beef and lamb, should be concentrated among high-consuming regions (primarily in the Americas, Europe, and Oceania), where animal protein consumption is well above dietary requirements and alternative sources of protein are more widely available and affordable.[87] By contrast, improving nutrition and food security in low-income and underconsuming populations will likely involve increasing animal product consumption (which may include ruminant meats), especially among young children. Across all regions, consumption of produce, legumes, whole grains, and nuts generally needs to increase, alongside balancing under- and overconsumption (Willett et al. 2019). Together, these dietary shifts can also improve health and reduce risks of micronutrient deficiencies and diet-related diseases. Dietary shifts will differ across contexts based on existing production and consumption practices, socioeconomic conditions, policy environments, and cultural and religious traditions.

While best available data indicate that ruminant meat consumption in high-consuming regions has slowly declined from 107 kilocalories per capita per day (kcal/capita/day) in 2018 to 104 kcal/capita/day in 2022 (FAOSTAT 2025), recent efforts are still well off track and would need to accelerate fivefold across these regions to achieve the 2030 target of being at or below 79 kcal per day (Figure 18j) (Searchinger et al. 2019). Ruminant meat consumption in high-consuming regions would then need to continue to decline to reach the 2035 target of 74 kcal per day and the 2050 target of 60 kcal per day (Searchinger et al. 2019).

Among regions with high per capita consumption of ruminant meat, the levels of consumption differ considerably. South America, as well as Australia and New Zealand, saw some of the greatest average annual percent reductions in ruminant meat consumption between 2018 and 2022 but also remained among the highest-consuming subregions, with per capita consumption at 160 and 130 kcal/day, respectively, in 2022 (FAOSTAT 2025). Northern America is also among the highest (130 kcal/day in 2022). Western Asia (88 kcal/day in 2022) and Polynesia (120 kcal/day in 2022) saw the greatest relative increases in per capita consumption over the same period, with average increases of about 5 and 3 percent per year, respectively (FAOSTAT 2025).[88] Based on the average rate of change from 2018 to 2022, Western Europe (75 kcal/day in 2022) is on track, while Southern Europe (81 kcal/day in 2022) is off track and declines in ruminant meat consumption would need to occur 1.2 times faster to achieve the 2030 target of 74 kcal/capita/day (Searchinger et al. 2019; FAOSTAT 2025).

Snapshot of recent developments

While world leaders are beginning to recognize the important role that the food and agriculture sector plays in climate mitigation, more efforts are needed to move from high-level aspirational goals to more specific, legally binding commitments. For example, the COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action, a voluntary multilateral agreement launched in December 2023 that has been signed by 160 countries as of July 2025, represented an important step forward in global agenda-setting to integrate food and agricultural solutions into climate change mitigation and adaptation strategies, including through more sustainable production and consumption approaches (UNFCCC 2023). A step further than the COP28 UAE Declaration was taken by the Alliance of Champions for Food Systems Transformation in December 2023, led by the governments of Brazil, Cambodia, Norway, Rwanda, and Sierra Leone, which have committed to transforming food systems to drive improved outcomes across climate mitigation, adaptation, and resilience ("Alliance of Champions for Food Systems Transformation" n.d.). Alliance members commit to using a "whole of government" approach to act across 10 priority action areas, and to report on progress annually starting at COP30.

At the same time, agricultural mitigation targets were notably absent in the 2023 Global Stocktake decision (UNFCCC 2024a), which countries were required to consider when developing their latest nationally determined contributions (Appendix B). This indicates that more effort is needed to advance specific, time-bound, and quantifiable targets for the sector both globally and nationally to drive meaningful reductions in agricultural emissions. As one notable example of increased ambition, in February 2025, the European Union passed the first legally binding targets among all regions and countries of the world for reducing food loss and waste, directing member states to reduce food waste by 30 percent and food losses in processing and manufacturing by 10 percent, relative to 2020, by the end of 2030 (European Commission 2024a).

Some recent policy advances also hold promise for advancing progress in the sector. Denmark passed a groundbreaking agriculture and climate policy in 2024, including the world's first carbon tax on agricultural GHG emissions, incentives to minimize nitrogen pollution from farming, and measures to protect and restore forests and peatlands to support biodiversity and sequester carbon (Danish Ministry of Economic Affairs 2024). Together with its other plans to support plant-based protein production and reduce food loss and waste, Denmark offers a model for how to meaningfully address the three major shifts needed in the food and agricultural sector, along with the shifts needed in the forest and land sector (Searchinger and Waite 2024). Notably, as part of its EU presidency during the second half of 2025, Denmark has announced that it will focus on the potential of developing a common EU action plan for plant-based foods and a common EU protein strategy (Danish Presidency, Council of the European Union 2025).

While multilateral commitments and advances from ambitious leaders can play a helpful role in encouraging the adoption of supportive policies, insufficient finance, economic and structural disincentives, the lack of affordable and readily scalable technologies to reduce emissions, and social norms are other major barriers to sectoral progress. The share of total climate finance dedicated to agriculture and food systems increased between 2019–20 and 2021–22 from 3.6 percent ($29 billion) to 7.2 percent ($95 billion) but remains far below the $1.1 trillion needed annually by 2030 to meet climate goals (Vishnumolakala et al. 2025).

In addition to efforts to make plant foods (e.g., legumes, vegetables, and fruits) more accessible, affordable, and appealing, new funding has emerged in recent years to advance innovations in the production of conventional and alternative proteins. In December 2023, a group of philanthropists announced the launch of a $200-million Enteric Fermentation Research and Development Accelerator, the largest globally coordinated investment in reducing livestock-related methane emissions to date (Global Methane Hub 2023). There has also been a notable increase in public investments to support research, development, and commercialization of alternative proteins, with over $1 billion out of the estimated $2.1 billion in global investments across all time made in 2023 and 2024 alone (Battle et al. 2025).

As another example, the feed additive 3-Nitrooxypropanol (3-NOP), which may reduce enteric methane emissions by up to about 30 percent depending on animal type, diet, and dose (van Gastelen et al. 2024; Kebreab et al. 2023), was approved for use in dairy cows in the United States in 2024. As the second-largest dairy-producing country in the world, the United States joins the European Union and more than 50 other countries, including Brazil, Canada, and the United Kingdom, in beginning to implement this technology (dsm-firmenich 2024). While advances in livestock management and alternative protein technologies offer promising potential to mitigate agricultural emissions, these technologies should be designed and implemented in ways that optimize benefits and minimize risks for smallholder livelihoods and communities facing food insecurity, ensuring that advances in climate mitigation support broader efforts to foster healthier, more equitable, and more sustainable food systems.

SECTION 8

Technological carbon dioxide removal

In addition to deep and rapid emissions reductions across all sectors, large-scale carbon dioxide removal (CDR) will be needed to keep the Paris Agreement's temperature limit within reach (IPCC 2022b). CDR is needed to reach net-zero GHG emissions by counterbalancing emissions that can't be reduced or avoided because abatement options don't exist, are not widely available, or are otherwise infeasible. Ultimately, carbon removal will be needed to go beyond net zero and reach net-negative emissions to reduce the total cumulative amount of CO_2 in the atmosphere that is already causing negative climate impacts. In the case that the Paris Agreement's temperature limit is exceeded, CDR is critical to limiting the magnitude and duration of overshoot.

Carbon removal includes a wide range of approaches at different stages of development that all remove carbon dioxide from the atmosphere—from direct air capture (DAC) machines that use chemicals to scrub CO_2 from the air, after which it can be permanently stored, to mineralization processes that accelerate natural CO_2 sequestering reactions with certain minerals, to restoring forests (IPCC 2022b). This section focuses on novel technological approaches to carbon removal, complementing indicators focused on nature-based approaches that are explored in the "Forests and land" section above.[89]

Protecting existing natural carbon sinks, like forests and wetlands, is critical to maintain the carbon sequestration they provide—and restoring these ecosystems should be the first line of effort to expanding global carbon-removal capacity. However, there is not enough land area to meet global carbon-removal goals with nature-based solutions alone (Dooley et al. 2024), so interest and investment in technological approaches to remove carbon dioxide from the atmosphere have surged in the past several years. Technological CDR approaches are in different stages of development and early commercialization and are often more costly than nature-based removals, but they typically provide higher certainty of permanence.

Scaling technological CDR to the level needed to limit the worst impacts of climate change will require increased research and development funding to understand where and how to deploy CDR technologies most effectively, public and private finance to accelerate deployment of a portfolio of approaches, mechanisms to spur long-term demand, and governance frameworks to create consistency across measurement, reporting, and verification frameworks; minimize negative environmental and social impacts; and maximize local benefits.

Global assessment of progress

A key indicator for tracking progress toward the scale-up of technological CDR is identifying how many tonnes of CO_2 have been captured from the air by carbon-removal technologies and sequestered durably.[90] Meaningful progress has been made over the past several years in scaling carbon removal, with around 1.5 million tonnes (Mt) of CO_2 removed by CDR technologies in 2023, up from around 0.5 $MtCO_2$ in 2019 (Figure 19) (Pongratz et al. 2024; US EPA 2024).[91]

FIGURE 19 | Summary of global progress toward technological carbon dioxide removal targets

Notes: $MtCO_2$/yr = million metric tonnes of carbon dioxide per year. For indicators categorized as S-curve possible, the acceleration factors and status of progress are determined by a linear trendline based on the past five years of data. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

Sources: Historical data from Pongratz et al. 2024 and US EPA 2024. Targets from CAT 2025a and Boehm et al. 2025.

However, current progress remains well off track and would require the rate of change over the past five years to accelerate more than 10-fold to achieve the 2030 target of 30–690 $MtCO_2$/yr (CAT 2025a; Boehm et al. 2025; Pongratz et al. 2024; US EPA 2024). Even greater acceleration of progress will be needed to reach 150–1,700 $MtCO_2$/yr by 2035 and 740–5,500 $MtCO_2$/yr by 2050 (CAT 2025a). Critically, each year that emissions reduction efforts stall, more CDR will be needed to achieve net zero.

Since scaling up technological CDR approaches depends to varying extents on technology development and adoption, the coming years may see nonlinear growth in the amount of CO_2 removed. While data are incomplete and cover less than 10 years, annual levels of removal have begun to increase nonlinearly over the past four years. However, unlike other climate technologies that provide a good or service of immediate value while they decarbonize (e.g., solar PV, electric vehicles), CDR is primarily a public good of atmospheric cleanup—thus, its likelihood of following an S-curve trajectory is dependent upon government policies that stimulate its supply and demand (Honegger et al. 2021).[92] Tracking whether early indications of nonlinear growth continue will be critical to estimating the future growth trajectory for technological CDR.

Snapshot of recent developments

Significant progress has been made over the past several years in advancing research, development, and deployment; expanding policy and governance; and increasing demand for technological CDR. In 2023, the outcome text from COP28 included a call to accelerate removal technologies (Appendix B) (UNFCCC 2024a). This was the first time technological CDR was included in this type of outcome text and signals growing recognition of its importance. Progress varies at the national level; while some carbon removal technologies are beginning to be demonstrated at commercial scales (Box 5), many are still in research, development, and pilot testing phases.

The United States was an early leader in policy support for carbon removal (WRI 2022; Jones et al. 2024b), with the Biden administration (2021–25) enacting a suite of policies supporting early research through commercial deployment and taking initial steps to increase demand and develop governance frameworks to guide responsible scaling (US DOE 2024b, 2024a). However, as of 2025, the federal government has scaled back many of these policies, creating uncertainty about the future of federally supported projects and the CDR sector in the United States (Silverman-Roati et al. 2025).

The European Union has also been an early leader in CDR, focusing on setting standards for quality through its Carbon Removals and Carbon Farming (CRCF) certification regulation, and providing initial public funding for research and development (Carbon Gap 2025a).[93] Among other advanced economies, Canada's government under Prime Minister Mark Carney, which began in March 2025, announced plans to increase funding for innovation and establish a target for CDR scale-up (Liberal Party of Canada 2025).

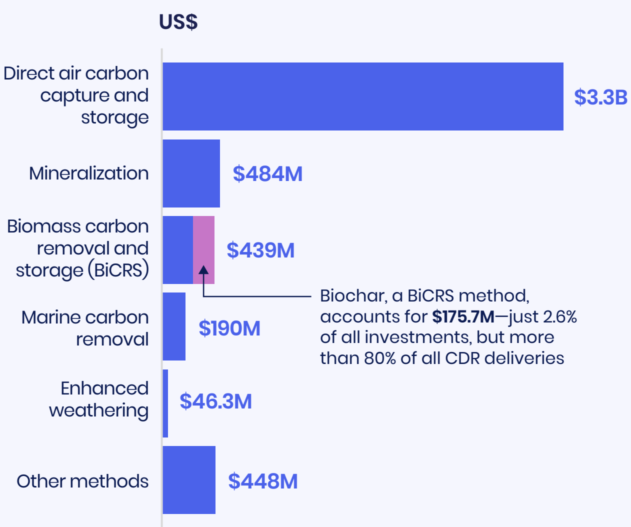
Interest in carbon removal technologies is also growing in emerging markets such as Brazil, India, and Kenya, which are hosting initial CDR projects. Kenya's abundant geothermal capacity and suitable geology for subsurface mineralization support DAC and are enabling the first generation of projects there (Kamadi 2024; Octavia Carbon 2025). India and Brazil both have large agricultural land areas suitable for enhanced rock weathering and biochar. Carbon removal companies are operating in all of these countries, beginning field tests to understand efficacy and other impacts of their approaches (Carbon Removal Kenya 2025; CRIA n.d.; Frontier 2024). CDR projects also provide the opportunity for economic development and job creation.

BOX 5 | Spotlight on innovation and deployment of direct air capture technologies

Direct air capture (DAC) includes a range of technologies that use chemicals to capture carbon dioxide (CO_2) from the air (Faber et al. 2025). The CO_2 can then be permanently stored through injection into underground geological formations or used in durable products, like concrete.

While DAC coupled with sequestration (direct air carbon capture and storage, or DACCS) is just one category among technological carbon dioxide removal (CDR) approaches, it is arguably the best-known and has received the largest share of public and private investment to date (Figure B5-1). It is relatively easy to measure the amount of carbon removed and stored through DACCS, so buyers of DACCS credits can have high confidence in the credibility of their purchase; while constrained by some factors, including access to resources like energy and water, it is theoretically highly scalable due in part to siting flexibility; and the technology has received hundreds of millions of dollars of US federal tax credits and grants, which has helped spur private investment (Roberts and Nemet 2024; IEA 2024g; Ma and Merrill 2025).

FIGURE B5-1 | Announced investments in different types of carbon removal 2020–24



Notes: BiCRS = biomass carbon removal and storage; B = billion; M = million; US$ = US dollar.

Source: Ma and Merrill 2025, based on CDR.fyi data through November 14, 2024.

More than 30 DAC projects were operating globally as of mid-2025, the largest of which, the Mammoth plant in Iceland, operated by Climeworks (2024a), can capture up to 36,000 tCO_2/yr. Other operational plants remove carbon at smaller scales, with a combined capture capacity of around 50,000 tCO_2/yr. Not all CO_2 captured is stored permanently, however, so total durable removal is less (DAC Coalition 2025; Balaji 2025; IEA 2024g).

Many more DAC plants are in development. Estimates vary, but they indicate that around 50 additional DAC plants could be operational by the mid-2030s (IEA 2024g; Balaji 2025). Several of these are significantly larger than what is operating today. The Stratos plant in west Texas is set to begin operation in 2025 and is expected to capture 500,000 tCO_2/yr (1PointFive 2025). Two other plants of this scale are in early stages of development in Louisiana and south Texas.[a] While not all CDR is expected to come from DAC, 60 plants operating at this scale would be needed to achieve the lower bound of the 2030 target (30 $MtCO_2$/yr) and more than 1,300 would be needed to meet the upper bound (690 $MtCO_2$/yr).

US policies have supported basic research, demonstration, and deployment of DAC, as well as funding for enabling infrastructure like CO_2 pipelines and geologic sequestration. In part because of this policy environment, more than half of the roughly 150 DAC companies around the world are in the United States (Faber et al. 2025).

Interest in DAC is growing outside of the United States as well, and projects are in operation on five continents (Figure B5-2). Countries including Kenya, the United Kingdom, and Japan are operating pilots and demonstrations at the 10- to multi-hundred-tonne-per-year scale. As the first generation of projects moves from the lab to demonstration and deployment around the world, they are enabling the testing needed to improve DAC technologies based on real-world challenges (Climeworks 2024b).

BOX 5 | Spotlight on innovation and deployment of direct air capture technologies

FIGURE B5-2 | Map of operational DAC plants

Notes: DAC = direct air capture; HIF = highly innovative fuels; HQ = headquarters; SAF = sustainable aviation fuel. Many operational DAC projects today do not permanently sequester CO_2, and instead use it in other ways (and for some no data is provided on the end use of the CO_2). Dots are sized based on total capture capacity. Data as of September 2025.

Source: DAC Coalition 2025.

Today, carbon removal credits generated by DAC are predominantly bought on the voluntary market by companies seeking to meet their climate targets. The price of a tonne of CO_2 removed using DAC on the voluntary market varies from \$100/tCO_2 to more than \$2,000/tCO_2 depending on the technology, energy source, use of policy incentives, and other factors. The weighted average price has declined from \$692/tCO_2 in 2023 to \$316/tCO_2 in 2024 (Chen et al. 2025), though the number of DAC offtakes underlying these data is relatively small. Accordingly, while the directionality is promising, there will likely be variation in the coming years.

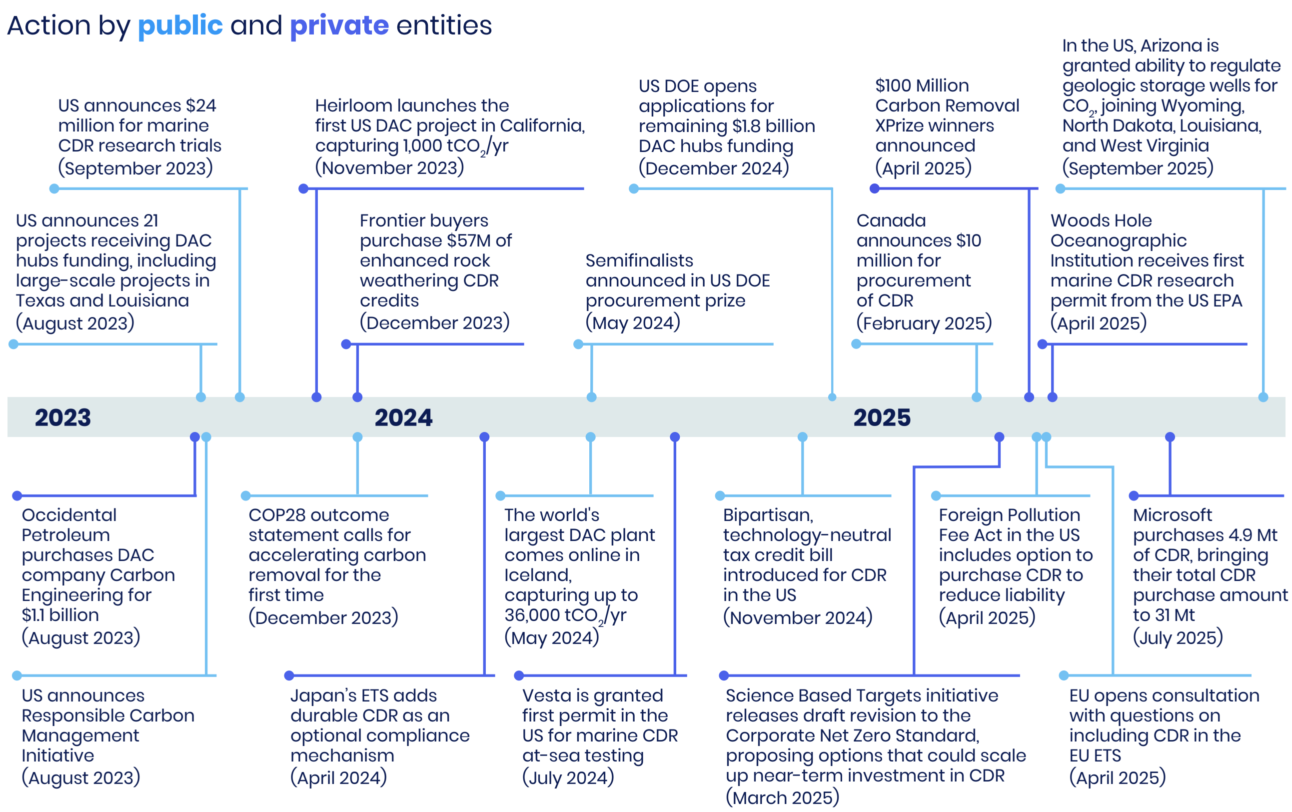
While DAC has been a de facto frontrunner among CDR technologies, interest and investment are growing in other types of CDR, like enhanced rock weathering and the range of biomass-based approaches. As the CDR sector advances, investment will likely continue to diversify, which will be critical to developing the portfolio of approaches needed to reach global carbon removal goals (Smith et al. 2024).

Note:
[a] These projects have been supported by the Regional DAC Hubs program funded under the 2021 Bipartisan Infrastructure Law, which provides \$3.5 billion to build four million-tonne-per-year-scale DAC plants in the United States. The federal government's actions to freeze federal funding in 2025 have caused uncertainty around the future of this program.

The past couple of years have also seen significant growth in voluntary purchases of carbon removal, which are critical to creating demand for CDR. Such purchases increased from around half a million tonnes (Mt) in 2022 to 8 Mt in 2024, and 13 Mt by May 2025 (Chen et al. 2025; CDR.fyi 2025). Deliveries of purchased technological CDR have also increased at an accelerating rate, growing from 65,000 tonnes in 2022 to 319,000 tonnes in 2024. More than 80 percent of delivered tonnes of CDR are from biomass-based approaches, namely biochar.

However, more than 80 percent of these purchases have come from a single buyer—Microsoft (CDR.fyi 2025). Developing a broader and more diverse base of buyers will be critical to enable long-term demand growth to reach gigatonne scale by mid-century (Mistry et al. 2024). The Science Based Targets initiative's corporate net-zero standard revision, which is expected by the end of 2026, provides one potential opportunity to drive corporate demand for carbon removal, depending on how the guidance is finalized (SBTi 2025). Increased government procurement and integration into compliance markets would also help address this. For example, the United States began a $35-million procurement program for CDR in 2022, and Canada announced that it will purchase $10 million worth of CDR (Government of Canada 2025).[94] Discussions are ongoing in the European Union and the United Kingdom around the potential for carbon removal to be included in emissions trading systems (Carbon Gap 2025b; Department of Energy Security and Net Zero 2024). The European Union is also considering options for an EU purchasing program to increase near-term demand (European Commission 2025b). Similarly, Japan has already added durable carbon removal (e.g., direct air capture, bioenergy with carbon capture and storage) as a compliance option under its emissions trading system (Figure 20) (Ghosh 2024). Ensuring that CDR is used to counterbalance emissions that are difficult to abate is critical so that CDR is a complement to, not a replacement for, emissions reductions (Shindell and Rogelj 2025).

FIGURE 20 | Recent developments related to technological CDR projects, policies, and investments from both public and private entities



Notes: CDR = carbon dioxide removal; COP = Conference of the Parties; CO_2 = carbon dioxide; DAC = direct air capture; DOE = Department of Energy; EPA = Environmental Protection Agency; ETS = Emissions Trading System; M = million; Mt = million tonnes; tCO_2/yr = tonnes of carbon dioxide per year.

Source: Authors.

SECTION 9

Finance

Finance is a vital enabler of climate action. Transforming power, buildings, industry, transport, forests and land, and food and agriculture, as well as scaling up CDR technologies, will require significant increases in climate finance, phasing out finance for high-emitting activities, and accelerating the replacement of high-carbon assets with clean substitutes (Kessler et al. 2019; Lubis et al. 2022). These shifts in financial flows from investments in fossil fuels, commodities that drive deforestation, and other high-emissions activities to finance that unlocks mitigation and adaptation objectives will enable the transition toward low-emissions and climate-resilient development, as specified in Paris Agreement Article 2.1c (UNFCCC 2015; IPCC 2022b). Indeed, the investment decisions made today by public and private actors will determine if the transition to a 1.5°C world takes place and have massive ramifications for the future by either locking in higher future emissions or paving the way for sustainable global development.

Global assessment of progress

FIGURE 21 | Summary of global progress toward finance targets

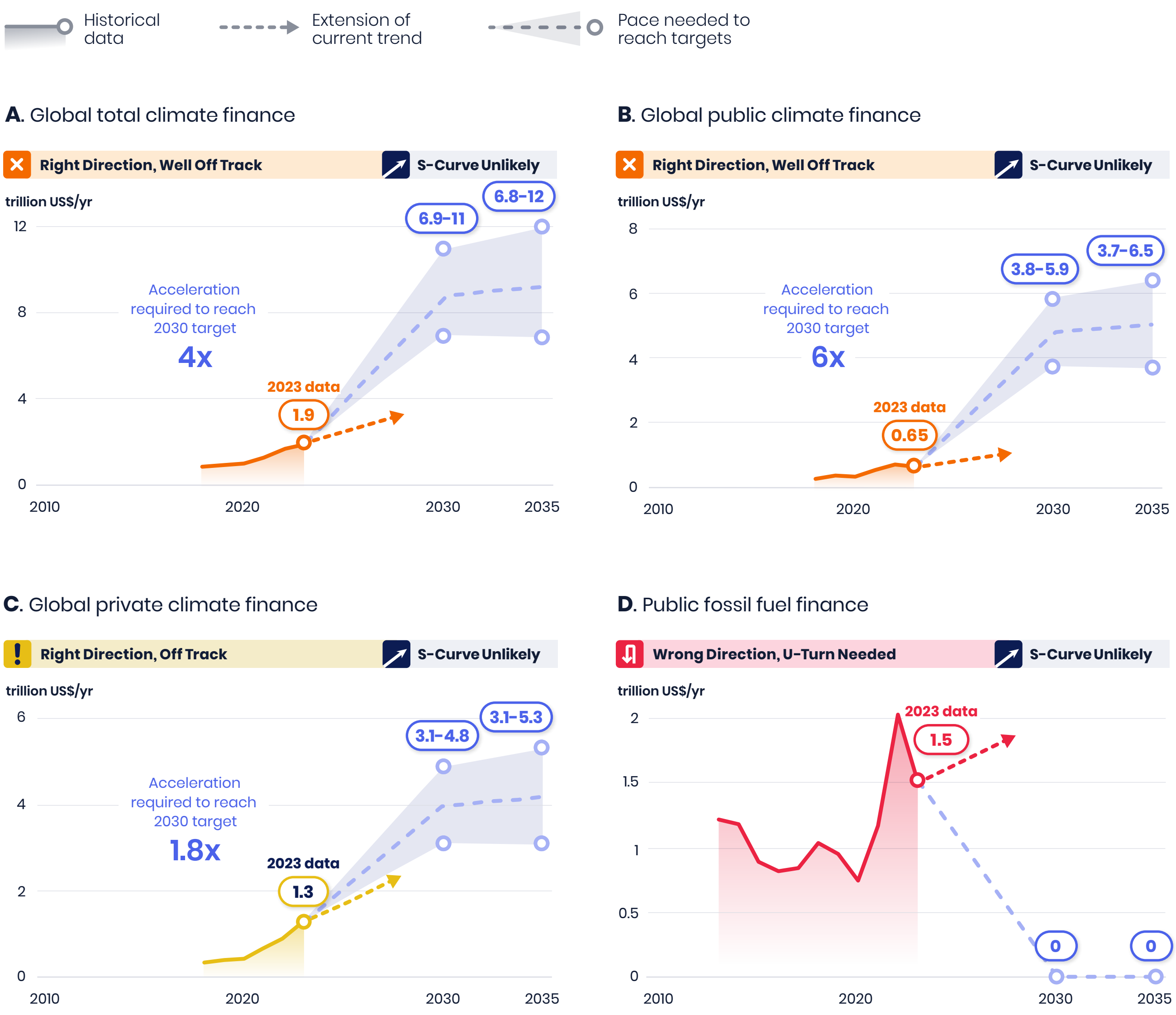
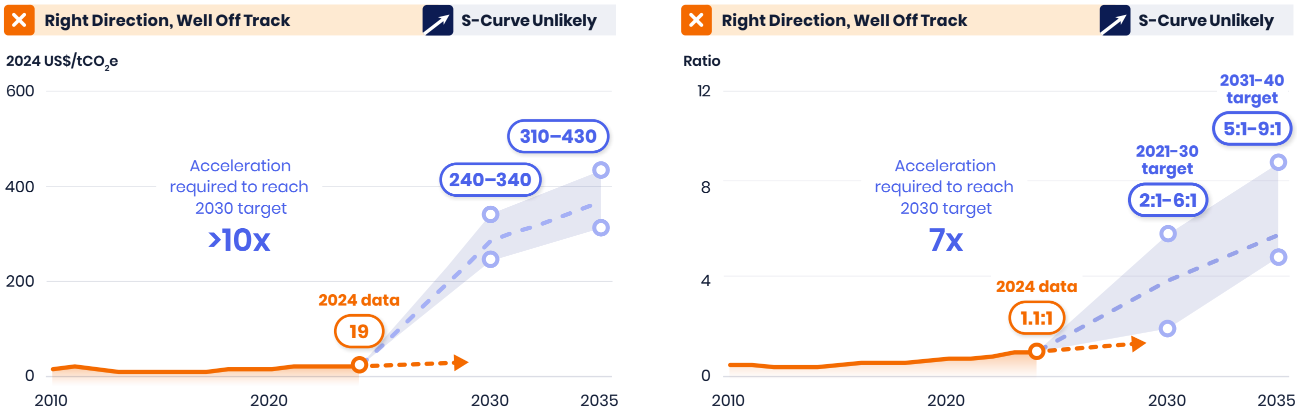


FIGURE 21 | Summary of global progress toward finance targets (continued)

E. Weighted average carbon price in jurisdictions with emissions pricing systems

F. Ratio of investment in low-carbon to fossil fuel energy supply



Notes: tCO_2e = tonne of carbon dioxide equivalent; US$ = US dollar; yr = year. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress. The global total climate finance indicator includes public and private as well as domestic and international flows. The global public climate finance and global private climate finance indicators include domestic and international flows. To track progress toward public fossil fuel finance, 10 years instead of 5 years were used to calculate linear trendlines to account for high interannual variability in this indicator's historical data, which can be attributed in large part to fluctuations in oil prices. Data for this indicator are a compilation of production and consumption subsidies, G20 state-owned entity fossil fuel capital expenditure, and international public fossil fuel finance from multilateral development banks and G20 countries' development finance institutions and export credit agencies. Production and consumption subsidies data were only available for 82 economies in 2023, compared to 192 economies in 2022 and prior years. Finally, Lubis et al. 2022 derived target ratios for investment in low-carbon to fossil energy supply of 2:1 to 6:1 for 2021–30 and 5:1 to 9:1 for 2031–40. Targets for 2030 and 2035 correspond to their respective decadal ratios.

Sources: Historical data from CPI 2025c; OECD and IISD 2025; Laan et al. 2023; OCI 2025; Gerasimchuk et al. 2024; World Bank 2025a; 2025b; and IEA 2025i. Targets from CPI 2025c; Bhattacharya et al. 2024; G20 2009; G7 2016; UNFCCC 2022; IEA 2021; IPCC 2022b; and Lubis et al. 2022.

Scaling up climate finance

Scaling up climate finance is a crucial piece of achieving overall alignment of global financial flows with low-emissions and climate-resilient development pathways, and limiting global temperature rise to 1.5°C will require annual investment in mitigation and adaptation activities to reach an estimated $6.9 trillion to $11 trillion per year by 2030 and $6.8 trillion to $12 trillion per year by 2035, sustained through 2050 (CPI 2025c).[95] These targets will only be achieved with massive mobilization of public and private finance, from both domestic and international sources, at a much faster pace than current levels.

To date, global climate finance flows have not scaled up at the rate needed to meet the 1.5°C goal. Although flows more than doubled between 2019 and 2023, from $0.9 trillion to $1.9 trillion, global efforts to accelerate total climate investment remain well off track, requiring acceleration roughly four times faster than current growth to reach the 2030 target (Figure 21a) (CPI 2025c).

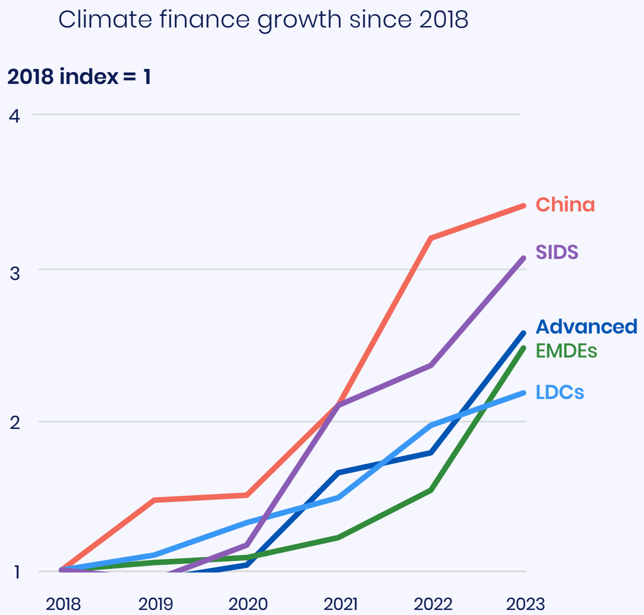
Despite this inadequate global rate of progress, some country groups have experienced rapid growth in scaling up climate finance (Box 6). China's domestic climate finance flows alone account for about 40 percent of the 2023 global total, with the distribution of climate finance across other regions remaining fairly uneven (CPI 2025c).

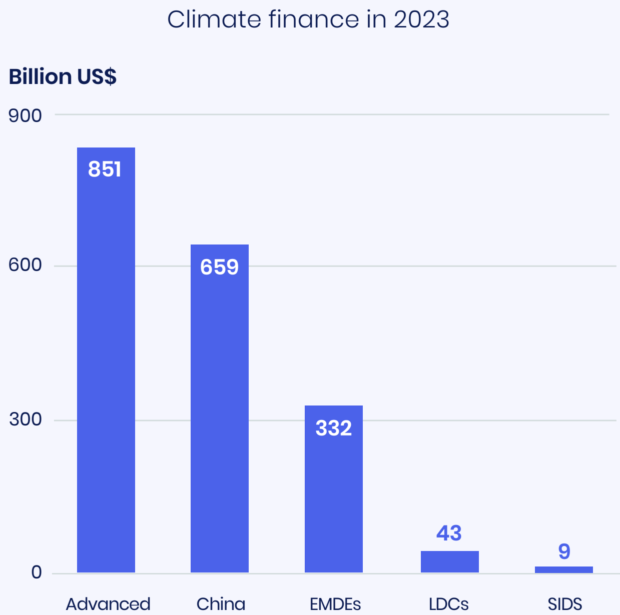
BOX 6 | Spotlight on climate finance mobilized by economic groupings

Climate finance figures reflect investments from domestic and international sources, both public and private, that are disbursed to recipient countries.[a] Historically, the growth and volume of climate finance flows have not been uniform across regions, a phenomenon that can be traced to differences in development stages and economic capacities leading to varying levels of interest from public and private capital allocators. To better understand the different growth trajectories and levels of mobilization of climate finance, global figures can be disaggregated by economic groupings corresponding to the economic development of countries: advanced economies, China, emerging markets and developing economies (EMDEs), least developed countries (LDCs), and small island developing states (SIDS).[b] The groupings are mutually exclusive, except for SIDS since its countries are included in EMDEs and LDCs, but SIDS is shown separately for comparison purposes (CPI 2024, 2025c). Advanced economies and China currently mobilize the vast majority of climate finance, primarily through their large domestic resources, while LDCs and SIDS mobilize comparatively little due to major structural barriers, including unequal economic structures that result in uneven development and high levels of foreign currency debt (CPI 2025c; Sokona et al. 2023; Kvangraven 2025).

However, climate finance flows more than doubled from 2018 to 2023 in all economic groupings, including EMDEs, SIDS, and LDCs. Some economic groupings, such as advanced economies and EMDEs, have accelerated climate finance mobilization in the most recent year at rates significantly faster than their historical pace (Figure B6-1).

FIGURE B6-1 | Growth in climate finance 2018–23, by economic grouping





Notes: EMDEs = emerging markets and developing economies; LDCs = least developed countries; SIDS = small island developing states. The figure shows tracked climate finance flows from domestic and international sources, both public and private, mobilized by recipient countries within each economic grouping. While climate finance tracking continues to improve in both data quality and analytical methods, figures remain subject to data availability. All economic groupings are mutually exclusive, except for SIDS since its members are also included in EMDEs and LDCs. SIDS is shown separately for comparison purposes (CPI 2024, 2025c). Climate finance numbers, both historical and relative to 2018 benchmarks, are shown in nominal terms.

Source: CPI 2025c.

BOX 6 | Spotlight on climate finance mobilized by economic groupings (continued)

Advanced economies saw about a 160 percent increase in climate finance flows from 2018 to 2023 in nominal terms, including an acceleration of 45 percent year-on-year growth in 2023 (CPI 2025c).[c] The United States and Germany are the leading advanced economies mobilizing climate finance (CPI 2025c). In the United States, investments in clean technologies and infrastructure increased by 71 percent in the two years following the passage of the Inflation Reduction Act, totaling over $490 billion (Bermel et al. 2024). However, the new Republican-led Congress has passed a law rolling back supportive zero-carbon power policies, which is expected to significantly slow the rate of climate finance mobilization in the United States (King et al. 2025). In contrast, Germany is increasing funding to its energy transition fund, having allocated $63 billion in 2024, 60 percent more than the previous year, and articulating plans to increase funding to more than $110 billion in 2025 (DW 2023; Wehrmann 2025).

Meanwhile, climate finance in China rose more than 240 percent since 2018 and was directed mostly to the energy and transportation sectors (CPI 2025c). China is now the world's dominant producer of low-carbon technologies, driven by a strategic national focus on building these industries through industrial policies and public financial support (Shepherd and Li 2025). In addition to rapidly deploying low-carbon technologies domestically, China is ramping up exports to other countries seeking to scale up renewable energy generation (Fickling 2025). It is important to note here that climate finance in advanced economies and China have been predominantly domestically sourced (81 and 99 percent, respectively) as their large economies, deep capital markets, and fewer fiscal constraints enable them to mobilize domestic resources without relying on international funding (CPI 2025c).

EMDEs saw an increase of about 150 percent in climate finance flows between 2018 and 2023, with an acceleration of 60 percent year-on-year growth in 2023. About 45 percent of climate finance flows to EMDEs was internationally funded in 2023 as developing countries increasingly look to attract foreign investments into their energy supply and transportation sectors to develop their economies and increase energy security (CPI 2025c; United Nations 2025). Brazil is a leading country within emerging economies for climate finance mobilization, with flows rising nearly 480 percent since 2018 (CPI 2025c). Climate finance in Brazil has predominantly (CPI 2025c; United Nations 2025) flowed to renewable energy generation, particularly solar and onshore wind, thanks in large part to targeted policies to scale up those industries and to the country's national development bank, which provided $36 billion in renewable energy financing from 2004 to 2023, making it the world's leading supporter of renewable projects (IRENA 2024; BNEF 2024b; CPI 2025c).

Finally, although SIDS and LDCs bear little responsibility for causing climate change, they are disproportionately affected by its impacts due to their geographical and socioeconomic vulnerabilities, including the existential threat of rising sea levels (Watson et al. 2024a; CPI 2024). Thus, finance for adaptation and loss and damage is essential to them (UNDP 2025). Yet their economies face major structural constraints on the mobilization of domestic climate finance due to their smaller economies, high dependence on food and energy imports, limited foreign exchange reserves, and high levels of foreign currency debt (Sokona et al. 2023). These countries have been leading voices for more ambitious international climate finance goals, better quality of finance, and reforming the global financial architecture (UNDP 2025; Rambarran 2024).

LDCs and SIDS have experienced a rise of around 120 and 210 percent in climate finance, respectively, between 2018 and 2023, albeit from a small baseline (CPI 2025c). Given the limited amount of domestically funded finance that these countries can mobilize, more than 90 percent and 80 percent of climate finance flows to LDCs and SIDS are internationally funded, respectively (CPI 2025c). Major international sources of climate finance have been developed countries and multilateral climate funds, such as the Green Climate Fund, which has often prioritized adaptation finance (OECD 2024; Watson et al. 2024a, 2024b). However, recent major cuts in foreign aid budgets by many developed countries are expected to significantly reduce the flow of international climate finance to SIDS and LDCs (Mathiasen and Martinez 2025). Even without these looming cuts, foreign aid has long fallen short of the UN target of dedicating 0.7 percent of gross national income, never exceeding 0.37 percent since 2015 (OECD 2025a; Focus 2030 2025). Donor countries need to reverse course to meet their international commitments.

Notes:
[a] Climate finance flows, whether domestic or international, are tracked at the recipient level to avoid double counting. For example, international climate finance originating from developed countries as development assistance to LDCs is counted toward LDCs' climate finance figures, rather than being attributed to the source country.
[b] The economic groupings are based on the IMF World Economic Outlook, UNCTAD, and UN classifications (IMF 2023; UNCTAD 2024; United Nations 2024; CPI 2025a). EMDEs exclude China and LDCs (CPI 2025c). SIDS also include associated overseas island territories.
[c] All historical climate finance figures, both in absolute and growth terms, are presented in nominal values, unless otherwise specified.

Progress on ramping up global climate finance has varied across economic sectors. In 2023, the energy supply, transport, and buildings and infrastructure sectors received the vast majority of private and public climate finance, collectively totaling nearly \$1.7 trillion, or over 85 percent of all global flows (CPI 2025c). By contrast, the AFOLU sector only drew around \$38 billion in climate investment in 2023 (~2% of global flows), despite the sector's accounting for nearly a fifth of net global GHG emissions (CPI 2025c; Crippa et al. 2024; IEA 2024h; Friedlingstein et al. 2025). In the AFOLU sector, as well as in the water and waste sectors, where recent climate finance tracking results indicate severe underinvestment, this is often tied to the fact that these sectors have historically attracted minimal interest from commercial investors due to limited returns and high perceived risk (Wattel et al. 2023).

To get on track, both public and private capital providers will need to take steps to accelerate climate investment at a pace far exceeding current flows, particularly in emerging markets and developing economies, where financial flows have been most constrained to date.

Public finance, from local, regional, and national governments, as well as domestic and international development finance institutions, is crucial to facilitate the transition to 1.5°C-aligned, climate-resilient societies. In particular, public capital fills key climate financing gaps in areas where the private sector is currently unwilling or poorly positioned to invest at speed and scale due to high perceived risk or low expected returns, such as public services, sustainable infrastructure, and early-stage development of new zero- and low-carbon technologies (CPI 2024). To drive progress toward reaching financing goals in these contexts, public finance can assume greater leadership as well as crowd-in philanthropic and commercial investment by shaping markets for emerging climate solutions, de-risking projects, and creating investable pipelines of assets, including in hard-to-finance sectors such as adaptation (CPI 2025b). Public finance is also essential to meet the new \$300 billion international climate finance goal for developing countries.

Global public climate finance totaled about \$650 billion in 2023, indicating a current trajectory that remains well off track of long-term targets, requiring acceleration of more than six times the current trajectory to meet 2030 targets of \$3.8 trillion to \$5.9 trillion per year and increase thereafter to \$3.7 trillion to \$6.5 trillion per year by 2035 and 2050 (Figure 21b) (CPI 2025c; Bhattachayra et al. 2024). Notably, tracked public climate finance declined in 2023 relative to the previous year, following continuous year-on-year growth in the period 2020–22, due to large-scale fiscal contractions among the world's governments (CPI 2025c; Bhattachayra et al. 2024). This reversal underscores the urgent need to establish durable mechanisms for delivering public climate finance on a rising trajectory.

Meanwhile, private finance from commercially oriented financial institutions and companies, as well as philanthropic sources and household consumption, should play a complementary role in bringing market-ready climate solutions to scale and advancing net-zero transition plans for commercial enterprises in emissions-intensive sectors. Across sectors, for example, philanthropies and risk-tolerant commercial

capital sources, like venture capital firms and wealth management entities of high net-worth individuals, can work alongside public sector efforts to catalyze new low-emissions, climate-resilient technologies and sustainable business models, particularly for precommercial and first-of-a-kind climate mitigation and adaptation ventures (Esmaeili et al. 2024; Uy and Brandon 2025; Lu et al. 2025). As innovative climate solutions become increasingly commercially viable, private corporations and institutional investors are well-positioned to capitalize on the corresponding investment opportunity.

Private climate finance reached a record high of $1.3 trillion in 2023 and is now off track to reach $3.1 trillion–$4.8 trillion per year by 2030 (Figure 21c) (CPI 2025c; Bhattachayra et al. 2024). To close the gap between the current trajectory and global goals, including to reach $3.1 trillion to $5.3 trillion per year by 2035 and sustain that through 2050 (CPI 2025c; Bhattachayra et al. 2024), private climate finance flows need to grow at about twice the rate of current trends. Major barriers to scaling up finance are the lack of sufficient bankable projects and mismatch between investors' risk-return expectations and the commercial maturity of the projects (Gouled 2024).

Phasing out finance for high-emissions activities

Scaling climate finance alone will not be sufficient to achieve net-zero goals if high-emissions activities continue to receive financing and high-carbon assets are not retired sooner than their technical and economic lifetimes (Kessler et al. 2019). Phasing out finance for high-emissions activities is made possible by, among other things, curtailing public fossil fuel finance and accounting for the full climate costs of GHG emissions through carbon pricing mechanisms to incentivize sustainable consumption and investment patterns. Phasing out financing for other environmentally harmful activities, such as deforestation, unsustainable agricultural practices, and nature degradation, is also critical. Data limitations, however, preclude a comprehensive assessment of global progress made in reducing all harmful public and private finance flows.

Public finance continues to play a critical role in propping up fossil fuel industries.[96] Public financial support materializes through production and consumption subsidies, public financing (including subsidized financing from domestic and international development finance institutions and export credit agencies, as well as from sovereign guarantees), and capital expenditures and project financing from state-owned enterprises. Total public fossil fuel finance reached over $1.5 trillion in 2023, a 26 percent drop from 2022 driven by a $400 billion reduction in subsidies for consumption in line with falling international oil and gas prices (Gerasimchuk et al. 2024).[97] Subsidies, which generally follow fluctuations in oil and gas prices and represent the largest form of financial support for fossil fuels, totaled $1 trillion in 2023, with Russia, Germany, and Iran providing the largest amounts (Gerasimchuk et al. 2024). The original signatories of the Clean Energy Transition Partnership, which include Canada, Germany, and the United States, reduced their international public financing for fossil fuels in 2023 by up to two-thirds compared with previous years (Jones et al. 2024a). Yet, in spite of these drops, public financial flows for fossil fuels have still increased $75 billion per year on average over the last 10 years.[98] While part of this increase in financial support is attributable to the 2021 energy crisis, progress toward phasing out fossil fuel subsidies and aligning all financial flows with climate-resilient development is moving in the wrong direction entirely (Figure 21d) (IEA 2021; IPCC 2022b; G20 2009; G7 2016; UNFCCC 2022; OECD and IISD 2025; Laan et al. 2023; OCI 2025; Gerasimchuk et al. 2024).

Well-designed carbon pricing systems can also play a role in helping align economies with a 1.5°C trajectory by internalizing the costs associated with rising GHG emissions and thus sending a price signal that shifts consumption, production, and investments. Direct carbon pricing covered around 28 percent of global GHG emissions in 2024, up from 24 percent in the previous year, primarily due to the expansion of China's emissions trading system to cover new sectors such as cement, steel, and aluminum (World Bank 2025b). But in jurisdictions with carbon pricing systems in place, prices are not high enough. In 2024, the average global carbon price was roughly $19/tCO$_2$e, a 13 percent decrease from $22/tCO$_2$e in 2023 and nowhere near the minimum end of a 1.5°C-aligned target range of $240–340/tCO$_2$ by 2030 (IPCC 2022b; World Bank 2025a).[99] Only Uruguay, Sweden, Liechtenstein, Switzerland, Norway, and Denmark have implemented carbon pricing above $100/tCO$_2$e due to a combination of factors, including the maturity of their pricing mechanisms, favorable political economy contexts, and preparation for the European Union's Carbon Border Adjustment Mechanism (World Bank 2025b; Pryor et al. 2023; Funke and Mattauch 2018; Jonsson et al. 2020).[100] Global progress in increasing carbon pricing has been slow, with prices growing by an average of $1.20/tCO$_2$e per year since 2020, and is well off track to meet the needed 2030 target (Figure 21e) (IPCC 2022b; World Bank 2025a). Indeed, the average price needs to accelerate by more than 10 times to reach the 2030 target range, and continued progress will be needed to meet the $310–430/tCO$_2$ and $580–970/tCO$_2$ targets for 2035 and 2050, respectively (Figure 21e) (IPCC 2022b; World Bank 2025a; Boehm et al. 2025; Johnson 2025a; G20 2024; IMF 2025).

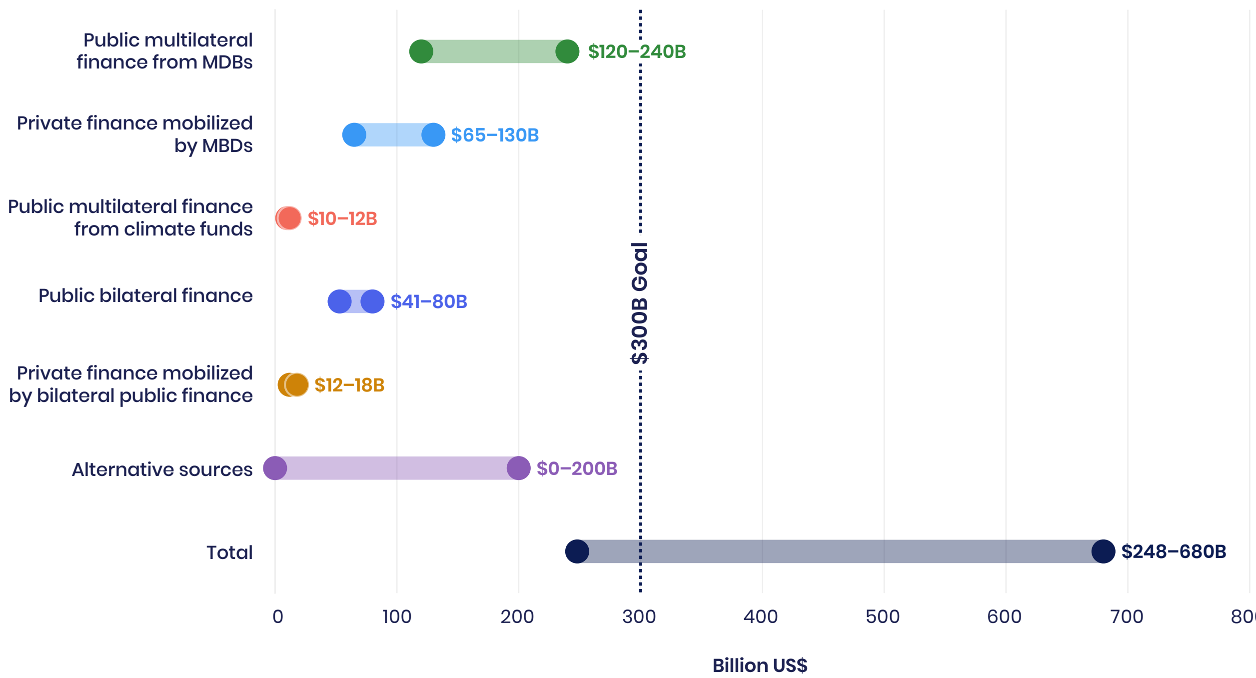
Replacing investments in fossil fuels with low-carbon energy supply

Finally, increasing investments in low-carbon energy supply, especially zero-carbon power sources, along with the simultaneous phaseout of high-carbon assets, will enable the decarbonization of the energy supply.[101] In 2024, for the second consecutive year, investment in low-carbon energy supply exceeded that in fossil fuels: $1.3 trillion to $1.2 trillion (IEA 2025i). This reflects the accelerating commercial maturity of low-carbon energy and government strategies to support such investments for energy security and meeting rising energy demand (United Nations 2025). But while investment in low-carbon energy supply has been rising at an average rate of 15 percent annually since 2021, trends are not moving fast enough, particularly as, concerningly, fossil fuel investment actually increased at a 5 percent average annual rate over the same period (IEA 2025i). Thus, although the ratio of investment in low-carbon energy to fossil energy supply reached 1.1:1 in 2024, the ratio is well off track to reach the range of 2:1 to 6:1 by 2030, requiring nearly seven times faster progress than the current trend (Figure 21f) (Lubis et al. 2022; IEA 2025i).[102] Beyond 2030, further progress will be needed to reach the target ranges of 5:1 to 9:1 across 2031–40 and 6:1 to 16:1 across 2041–50 (Lubis et al. 2022).

Snapshot of recent developments

At COP29 in 2024, nations set a new goal for international climate finance for developing countries, committing to triple the previously agreed target to at least $300 billion annually and move toward $1.3 trillion by 2035 (UNFCCC 2024b). Although it is far less than what developing countries need to support widespread adoption of zero-carbon technologies and build resilience to climate change impacts, following through on it would be an important step to put them on the path to meeting their climate mitigation, adaptation, and loss and damage needs (Bhattacharya et al. 2024). Exploration of innovative financing sources and reform of international financial institutions, particularly multilateral development banks, will be paramount to meet the new target (Figure 22) (Thwaites et al. 2024; Thwaites 2024; Alayza and Larsen 2025).

FIGURE 22 | Potential ranges for contributions to the $300 billion goal



Notes: B = billion. MDBs = multilateral development banks. Potential sources of finance to reach the $300 billion goal include bilateral finance (through increased contributions), public multilateral finance (through capital increases and reforms in multilateral development banks and climate funds), private finance mobilized by public funds, and additional sources of finance such as levies on aviation emissions and rechanneling the International Monetary Fund's special drawing rights (Alayza and Larsen 2025).

Source: Adapted from Alayza and Larsen 2025.

At the same time, an increasing number of developing countries have integrated climate goals into their economic development plans, recognizing the mutual benefits between climate action and economic prosperity. Bangladesh, Brazil, Colombia, and Egypt, for instance, have developed "country platforms" to coordinate and mobilize investments for specific climate and development goals, bringing together international financial institutions, private finance, and donors under a shared vision of national priorities set by the countries (Robinson and Olver 2025). Other countries, like Hungary and Indonesia, are attracting foreign investments in zero-carbon technologies mostly from China to clean their energy mix, modernize their industries, and enter the low-carbon value chain to drive economic growth (Jiaying and Xinyue 2025; Yutong et al. 2025).

However, political shifts can risk undoing progress. Recent years have seen political forces opposing climate action either come to power or significantly expand their influence, enabling them to reverse climate policies that incentivize investments. In the United States, the new Republican-led government has rolled back financial incentives for solar and wind energy, and for domestic public funding programs, such as the US Department of Energy's Loan Program Office and the Greenhouse Gas Reduction Fund, that mobilize private capital for low-carbon technologies (Lutz et al. 2025; Kelly and Smith 2025). It has also pulled out of or cancelled outstanding pledges to UN climate funds such as the Fund for Responding to Loss and Damage, the Adaptation Fund, and the Green Climate Fund (Harlan 2025; Bravender and Schonhardt 2024; Mathiesen 2025; Thwaites 2025). Additionally, the United States has withdrawn from the Just Energy Transition Partnerships, which aimed to help Indonesia, South Africa, and Vietnam transition from coal to renewable energy, further complicating the initiatives, which have failed to deliver financing at the speed and scale originally planned (Cocks et al. 2025; Curtin et al. 2024). This new investment landscape, further disrupted by tariff policies, has created instability and uncertainty around domestic investment outlooks, resulting in a reduction in US climate finance flows and the cancellation of substantial climate mitigation projects, particularly for emerging technologies that have yet to achieve commercial viability (Meyer 2025).

US political opposition has also dampened the ambition of private financial institutions in aligning their businesses with net-zero goals. Since 2023, after a series of legal threats through investigations, lawsuits, and blacklisting, many of the world's largest financial institutions have withdrawn from net-zero finance alliances and investor-engagement initiatives (Nelson 2025). Firms are also rebranding their activities to avoid political backlash against some of their sustainability practices (Schenkman 2025). At the same time, banks and investors have weakened their net-zero commitments, often citing the lack of supportive public policy and technological progress as barriers preventing their portfolio companies, and consequently themselves, from achieving their targets (Johnson 2024, 2025b).

Several other countries, such as Belgium, Canada, France, Germany, Switzerland, and the United Kingdom, have also significantly cut their foreign aid budgets, with aid falling by 9 percent in 2024 and projected to decrease an additional 9–17 percent in 2025 (Laub et al. 2025; OECD 2025b). European development aid has been cut due to political opposition, prioritization of domestic interests such as defense, and a shift from traditional grants toward investment-driven projects that benefit European companies (Laub et al. 2025; Lahiri 2025; Chase-Lubitz 2025). This is all the more worrying as official development assistance remains a major source of international climate finance, particularly for concessional funding that low-income countries depend on to drive mitigation aligned with the Paris Agreement and to strengthen adaptation and resilience (Kenny 2025; Hirvonen and Kuusela 2025).

The mixed picture of progress and setbacks is also evident in how governments and corporations are integrating climate-related risks into corporate decision-making. In the United States and Canada, efforts to mandate climate-related risk reporting have been deprioritized or paused (Ceres 2025a; Segal 2025a). In contrast, more governments have adopted such requirements since 2023, including China, Japan, and Mexico, with India and South Korea expected to follow by the end of 2025 (IFRS 2024; UNEP FI 2025; Garden 2024; Fisher Phillips 2025; Manikandan 2025; Shin & Kim 2025). Meanwhile, subnational regulations, such as California's legislation, are expected to cover many of the largest US companies, effectively filling gaps left by federal inaction (Ceres 2025b). Together, these developments point to a broader global trend of regulators and companies increasingly assessing climate-related risks to prepare for physical climate impacts and seize the opportunities of a decarbonized economy.

SECTION 10

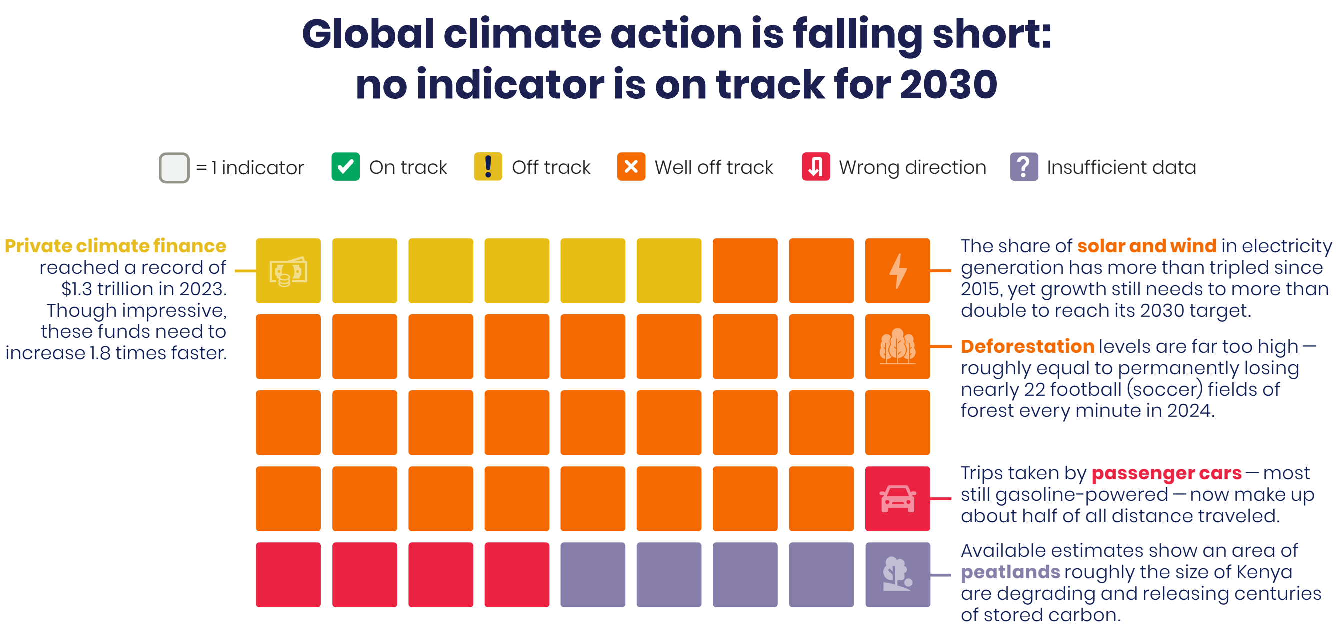
Conclusion

Achieving the Paris Agreement temperature goal demands bold systemic transformations across all sectors of the economy—from power, buildings, industry, and transport, to land use and food. The rapid scale-up of carbon removal technologies and high-quality climate finance will also prove critical to combatting the climate crisis.

Encouragingly, recent rates of change are heading in the right direction toward most targets across these emissions-intensive sectors. However, the pace and scale of change remains woefully inadequate, with not a single indicator assessed in this report currently on track to achieve a 2030 target consistent with limiting warming to 1.5°C. Change is heading in the right direction at a promising, albeit insufficient speed for 6 indicators; for another 29 indicators, it remains well below the pace required to achieve near-term targets. Worse still, change for 5 indicators is heading in the wrong direction entirely. A further 5 indicators lack sufficient data for assessment (Figure 23).

Still, progress in several areas deserves recognition, as these bright spots demonstrate that change is possible and underway, even if it is not yet evident across the full set of headline indicators. For example, the share of electric vehicles in light-duty vehicle sales has quintupled in recent years, growing from just 4.4 percent of all LDV sales in 2020 to 22 percent of LDV sales in 2024, or more than one in five cars sold (IEA 2025k). Solar and wind's share of global electricity generation nearly doubled between 2019 and 2024, from 8 percent to 15 percent, thanks to decreasing costs, improved technology, and supportive policy (Ember 2025). In heavy industry, announced projects deploying decarbonization technologies for cement, steel, and green hydrogen are surging (Figure 11). Alternative proteins are also gaining momentum, with public investments to support research, development, and commercialization reaching over $1 billion in 2023 and 2024—nearly half of the estimated $2.1 billion in total global investments to date (Battle et al. 2025).

FIGURE 23 | Summary of progress toward 2030 targets



Source: Authors' analysis based on data sources listed in each section.

However, for every promising development, there are worrying signs of stalling or backsliding. For example, while coal power has declined as a share of global electricity generation over the past five years, its usage is at a record high in absolute terms because of more overall electricity demand (Ember 2025). The carbon intensity of global steel production has increased in recent years (World Steel Association 2024a), requiring a U-turn to get back on track. Deforestation is also worryingly well off track, increasing from 7.8 Mha/yr in 2021 to 8.1 Mha/yr in 2024. Between 2015 and 2024, the world permanently lost a total of 86 Mha of tree cover—an area roughly the size of Pakistan (Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025).

Accelerating progress and reversing these worsening trends will require unprecedented cooperation and support from governments, the private sector, and civil society, particularly during this challenging geopolitical era. Now, 10 years after the adoption of the Paris Agreement, governments must urgently strengthen action and develop new partnerships to ramp up implementation on the ground across all sectors. At the same time, they must boost research and development, create long-term demand signals, and establish governance frameworks to guide responsible technological CDR scale-up, phase out finance that perpetuates continued reliance on fossil fuels and funds commodity-driven deforestation, and turbocharge supportive climate finance through mechanisms that do not increase debt or drive further sustainability challenges. Justice and equity must be at the center of climate action, ensuring that no one is left behind in the transition.

While the global response still falls woefully short of what science and justice demand, citizens around the world are seeking a different future. The UN Development Programme recently released the world's largest standalone public opinion survey on climate change, which found that almost 9 out of 10 people surveyed want more climate action from their governments. Eighty-six percent of participants urged countries to set aside their differences, including on issues of trade and security, and instead collaborate on climate change. And almost three-quarters of those surveyed around the world supported a quick transition away from fossil fuels, including those in the largest fossil-fuel-producing regions. More than half of the respondents thought about climate change daily or at least weekly and were more worried about climate change than they were a year ago (UNDP 2024).

Although past years have seen growing public demand and ever more proven solutions at hand, the world is still lacking bold leadership—and time. Most indicators assessed in this report are moving in the right direction, albeit far too slowly. To turn these sparks of hope into a firestorm of change, we must not retreat. Instead, now is the moment to rise with resolve and turn scattered gains into systemic change that delivers for everyone.

Appendices

Appendix A.

Summary of acceleration factors

TABLE A-1 | Summary of acceleration factors

INDICATOR	MOST RECENT DATA POINT (Year)	2030 TARGET	2035 TARGET	2050 TARGET	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL RATE OF HISTORICAL CHANGE (Most recent five years of data for most indicators)	AVERAGE ANNUAL RATE OF CHANGE REQUIRED TO MEET 2030 TARGET (Estimated from the most recent year of data to 2030)	ACCELERATION FACTOR (How much the pace of recent average annual change needs to accelerate to achieve 2030 targets)[a]	STATUS (Based on acceleration factors and, in some cases, expert judgment)
Power									
Share of zero-carbon sources in electricity generation (%)	41 (2024)	88–91	96	99–100		0.73 (2020–24)	8.1	>10x[b]	
Share of solar and wind in electricity generation (%)	15 (2024)	57–78	68–86	79–96		1.5 (2020–24)	8.8	6x[b]	
Share of coal in electricity generation (%)	34 (2024)	4	1	0 (2040) 0 (2050)		-0.33 (2020–24)	-5.0	>10x	
Share of unabated fossil gas in electricity generation (%)	22 (2024)	5–7	2	1 (2040) 0 (2050)		-0.37 (2020–24)	-2.7	7x	
Carbon intensity of electricity generation (gCO_2/kWh)	470 (2024)	48–80	15–19	<0		-4.9 (2020–24)	-68	>10x	
Buildings									
Energy intensity of building operations (kWh/m^2)	150 (2022)	85–120	80–110	55–80		-1.8 (2018–22)	-5.6	3x	
Carbon intensity of building operations ($kgCO_2/m^2$)	39 (2022)	13–16	5–8	0–2		-0.79 (2018–22)	-3	4x	
Retrofitting rate of buildings (%/yr)	<1 (2020)	2.5–3.5	2.5–3.5	3.5 (2040)		Insufficient data	0.2	Insufficient data	
Share of new buildings that are zero-carbon in operation (%)	5 (2020)	100	100	100		Insufficient data	9.5	Insufficient data	
Industry									
Share of electricity in the industry sector's final energy demand (%)	30 (2023)	35–43	43–46	60–69		0.25 (2019–23)	1.3	5x	
Carbon intensity of global cement production ($kgCO_2$/t cement)	610 (2023)	360–70	Forthcoming	55–90		-9.7 (2019–23)	-36	4x	

TABLE A-1 | Summary of Acceleration Factors (continued)

INDICATOR	MOST RECENT DATA POINT (Year)	2030 TARGET	2035 TARGET	2050 TARGET	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL RATE OF HISTORICAL CHANGE (Most recent five years of data for most indicators)	AVERAGE ANNUAL RATE OF CHANGE REQUIRED TO MEET 2030 TARGET (Estimated from the most recent year of data to 2030)	ACCELERATION FACTOR (How much the pace of recent average annual change needs to accelerate to achieve 2030 targets)[a]	STATUS (Based on acceleration factors and, in some cases, expert judgment)
Carbon intensity of global steel production (kgCO_2/t crude steel)	1,900 (2023)	1,340–50	Forthcoming	0–130		21 (2019–23)	-82	N/A; U-turn needed	
Green hydrogen production (Mt)	0.074 (2023)	49	120	330		0.015 (2019–23)	7	>10x[b]	
Transport									
Share of kilometers traveled by passenger cars (% of passenger-km)	48 (2022)	45	43	40		1.3 (2015–22)	-0.38	N/A; U-turn needed	
Number of kilometers of rapid transit per 1 million inhabitants (km/1M inhabitants)	24 (2024)	38	N/A	N/A		0.47 (2020–24)	2.3	5x	
Share of electric vehicles in light-duty vehicle sales (%)	22 (2024)	75–95	95–100	100 (2040) 100 (2050)		4.4 (2020–24)	11	2.5x[b]	
Share of electric vehicles in the light-duty vehicle fleet (%)	4.5 (2024)	25–40	55–65	95–100		0.91 (2020–24)	4.7	5x[b]	
Share of electric vehicles in bus sales (%)	6.2 (2024)	56	90	100		0.11 (2020–24)	8.3	>10x[b]	
Share of electric vehicles in medium- and heavy-duty commercial vehicle sales (%)	1.8 (2024)	37	65	100		0.36 (2020–24)	5.9	>10x[b]	
Share of sustainable aviation fuels in global aviation fuel supply (%)	0.3 (2024)	13–15	28–32	100		0.07 (2020–24)	2.3	>10x[b]	
Share of zero-emissions fuels in maritime shipping fuel supply (%)	0 (2024)	5–10	22	100		0	Insufficient data	>10x[b]	
Share of fossil fuels in the transport sector's total energy consumption (%)	95 (2023)	80	64	11		-0.2 (2019–23)	-2.1	>10x	

TABLE A-1 | Summary of Acceleration Factors (continued)

INDICATOR	MOST RECENT DATA POINT (Year)	2030 TARGET	2035 TARGET	2050 TARGET	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL RATE OF HISTORICAL CHANGE (Most recent five years of data for most indicators)	AVERAGE ANNUAL RATE OF CHANGE REQUIRED TO MEET 2030 TARGET (Estimated from the most recent year of data to 2030)	ACCELERATION FACTOR (How much the pace of recent average annual change needs to accelerate to achieve 2030 targets)[a]	STATUS (Based on acceleration factors and, in some cases, expert judgment)
Forests and land									
Deforestation (Mha/yr)	8.1 (2024)	1.9	1.5	0.31		-0.12 (2015–24)	-1	9x	✕
Peatland degradation (Mha/yr)	0.06 (annual average, 1993–2018)	0	0	0		Insufficient data	-0.005	Insufficient data	?
Mangrove loss (ha/yr)	32,000 (annual average, 2017–19)	4,900	4,900	4,900		950 (2008–19)	-2,400	N/A; U-turn needed	
Reforestation (total Mha)	56 (total gain, 2010–20)	100 (2020–30)	150 (2020–35)	300 (2020–50)		5.6 (2010–20)	10	1.8x	!
Peatland restoration (total Mha)	0 (as of 2015)	15 (2020–30)	16 (2020–35)	20–29 (2020–50)		Insufficient data	1	Insufficient data	?
Mangrove restoration (total ha)	15,000 (total direct gain, 1999–2019)	240,000 (2020–30)	N/A	N/A		750 (1999–2019)	24,000	>10x	✕
Food and agriculture									
GHG emissions intensity of agricultural production (gCO_2e/1,000 kcal)	360 (2022)	290	260	200		-1.9 (2018–22)	-9.2	5x	✕
GHG emissions intensity of enteric fermentation (gCO_2e/1,000 kcal)	3,100 (2022)	2,600	2,300	1,600		-24 (2018–22)	-66	2.5x	✕
GHG emissions intensity of manure management (gCO_2e/1,000 kcal)	650 (2022)	530	480	320		-2.8 (2018–22)	-16	6x	✕
GHG emissions intensity of soil fertilization (gCO_2e/1,000 kcal)	68 (2022)	63	58	45		-0.55 (2018–22)	-0.68	1.2x	!
GHG emissions intensity of rice cultivation (gCO_2e/1,000 kcal)	380 (2022)	300	270	170		-1.8 (2018–22)	-9.8	6x	✕
Crop yields (t/ha)	6.8 (2023)	7.7	8.2	9.5		0.014 (2019–23)	0.13	10x	✕
Ruminant meat productivity (kg/ha)	30 (2022)	35	37	44		0.42 (2018–22)	0.66	1.6x	!

TABLE A-1 | Summary of Acceleration Factors (continued)

INDICATOR	**MOST RECENT DATA POINT** (Year)	**2030 TARGET**	**2035 TARGET**	**2050 TARGET**	**LIKELIHOOD OF FOLLOWING AN S-CURVE**	**AVERAGE ANNUAL RATE OF HISTORICAL CHANGE** (Most recent five years of data for most indicators)	**AVERAGE ANNUAL RATE OF CHANGE REQUIRED TO MEET 2030 TARGET** (Estimated from the most recent year of data to 2030)	**ACCELERATION FACTOR** (How much the pace of recent average annual change needs to accelerate to achieve 2030 targets)[a]	**STATUS** (Based on acceleration factors and, in some cases, expert judgment)
Share of food production lost (%)	13 (2021)	6.5	6.5	6.5		0.054 (2017–21)	-0.75	N/A; U-turn needed	
Food waste (kg/capita)	130 (2022)	61	61	61		Insufficient data	-8.9	Insufficient data	
Ruminant meat consumption in high-consuming regions (kcal/capita/day)	104 (2022)	79	74	60		-0.58 (2018–22)	-3.1	5x	
Technological carbon dioxide removal									
Technological carbon dioxide removal ($MtCO_2$/yr)	1.5 (2023)	30–690	150–1,700	740–5,500		0.25 (2019–23)	51	>10x	
Finance									
Global total climate finance (trillion US$/yr)	1.9 (2023)	6.9–11	6.8–12	6.8–12		0.27 (2019–23)	0.99	4x	
Global public climate finance (trillion US$/yr)	0.65 (2023)	3.8–5.9	3.7–6.5	3.7–6.5		0.093 (2019–23)	0.60	6x	
Global private climate finance (trillion US$/yr)	1.3 (2023)	3.1–4.8	3.1–5.3	3.1–5.3		0.22 (2019–23)	0.39	1.8x	
Public fossil fuel finance (trillion US$/yr)	1.5 (2023)	0	0	0		0.075 (2019–23)	-0.22	N/A; U-turn needed	
Weighted average carbon price in jurisdictions with emissions pricing systems (2024 US$/$tCO_2e$)	19 (2024)	240–340	310–430	580–970		1.2 (2020–24)	45	>10x	
Ratio of investment in low-carbon to fossil fuel energy supply	1.1:1 (2024)	2:1–6:1 (2021–30)	5:1–9:1 (2031–40)	6:1–16:1 (2041–50)		0.072 (2020–24)	0.49	7x	

Notes: gCO_2/kWh = grams of carbon dioxide per kilowatt-hour; gCO_2e/1,000 kcal = grams of carbon dioxide equivalent per 1,000 kilocalories; GHG = greenhouse gas; ha = hectares; ha/yr = hectares per year; kcal/capita/day = kilocalories per capita per day; kg = kilograms; kg/capita = kilograms per capita; $kgCO_2/m^2$ = kilogram of carbon dioxide per square meter; $kgCO_2$/t = kilograms of carbon dioxide per tonne; kg/ha = kilograms per hectare; km = kilometers; km/1M inhabitants = kilometers per 1 million inhabitants; kWh/m^2 = kilowatt-hour per square meter; Mha = million hectares; Mha/yr = million hectares per year; Mt = million tonnes; $MtCO_2$ = million tonnes of carbon dioxide; N/A = not applicable; passenger-km = passenger-kilometers; t = tonnes; tCO_2e = tonnes of carbon dioxide equivalent; t/ha = tonnes per hectare; US$ = US dollar; yr = year. Notes on definitions and methodology for assessing progress for each indicator are contained in the figures accompanying each section of this report. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

[a] For acceleration factors between 1 and 2, we round to the 10th place (e.g., 1.2 times); for acceleration factors between 2 and 3, we round to the nearest half number (e.g., 2.5 times); for acceleration factors between 3 and 10, we round to the nearest whole number (e.g., 7 times); and acceleration factors higher than 10, we note as >10.

[b] For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are not presented in the report, as they would not accurately reflect an S-curve trajectory. The category of progress was determined based on author judgment, using multiple lines of evidence. See Appendix C and Boehm et al. 2025 for more information.

Source: Authors' analysis based on data sources listed in each section.

Appendix B.

Assessing collective efforts to achieve sector-specific mitigation targets in the Global Stocktake

In addition to tracking progress made across the 45 indicators featured in this report, we also assessed collective efforts to achieve sector-specific targets outlined in paragraphs 28, 29, 33, 35, and 36 of the Global Stocktake outcome (UNFCCC 2024a). More specifically, we inferred indicators, as well as both quantitative, time-bound targets and those that are more qualitative and directional in nature, from this negotiated decision text. We then identified indicators and associated datasets from the *State of Climate Action* series and Systems Change Lab's data platform that most closely matched indicators inferred from the Global Stocktake outcome. Finally, we assessed global progress made toward targets inferred from the Global Stocktake outcome, using the methods outlined in Boehm et al. 2025 (Table B-1).

TABLE B-1 | Summary of global progress made toward sectoral mitigation targets in the Global Stocktake outcome

DIRECT REFERENCE IN GST DECISION TEXT	INFERRED INDICATOR FROM THE GST	INFERRED TARGET FROM THE GST (TARGET YEAR)	RELATED SCL AND/OR SOCA INDICATOR (UNITS)[a]	MOST RECENT DATA POINT (YEAR)	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL CHANGE OVER MOST RECENT 5 YEARS OF DATA[b]	ACCELERATION FACTOR RELATIVE TO THE INFERRED TARGET FROM THE GST	STATUS RELATIVE TO THE INFERRED TARGET FROM THE GST	HISTORICAL DATA SOURCE	KEY CONSIDERATIONS
Tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030	Renewable energy capacity	11,600 GW (2030)	Renewable energy capacity (GW)	4,450 (2024)		410	N/A; author judgment		IRENA 2025a	The decision text does not specify a base year from which renewable energy capacity should be tripled. To derive a time-bound, quantitative target, we tripled the estimate of renewable energy capacity in 2023 (3,860 GW), as this was the year in which the GST outcome was agreed.
	Average annual rate of energy efficiency improve-ments	4%/yr (2030)	Rate of increase in primary energy efficiency (%/yr)[c]	1 (2023)		-0.09[d]	N/A; U-turn in action needed		IEA 2025d	The decision text does not specify a base year from which the average annual rate of energy efficiency improvements is doubled. We derived this time-bound, quantitative target by doubling the estimate of the rate in 2022 (2%/yr), as this was the year in which the GST outcome was ne-gotiated, and 2% is also a longer-term historical av-erage that was used as a reference in the creation of the target. In 2023, the rate declined from the prior year's levels.
Accelerating efforts toward the phase down of unabated coal power	Unabated coal power	Not quantified	Share of coal in electricity generation (%)	34 (2024)		-0.33	N/A; no target	Right direction; no target	Ember 2025	There is a difference in scope between the in-ferred indicator in the GST and in the SoCA series / SCL data platform. Crit-ically, the decision text limits its indicator's scope to unabated coal, while our indicator focuses on the share of both abated and unabated coal in electricity generation.

TABLE B-1 | Summary of global progress made toward sectoral mitigation targets in the Global Stocktake outcome (continued)

DIRECT REFERENCE IN GST DECISION TEXT	INFERRED INDICATOR FROM THE GST	INFERRED TARGET FROM THE GST (TARGET YEAR)	RELATED SCL AND/OR SOCA INDICATOR (UNITS)[a]	MOST RECENT DATA POINT (YEAR)	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL CHANGE OVER MOST RECENT 5 YEARS OF DATA[b]	ACCELERATION FACTOR RELATIVE TO THE INFERRED TARGET FROM THE GST	STATUS RELATIVE TO THE INFERRED TARGET FROM THE GST	HISTORICAL DATA SOURCE	KEY CONSIDERATIONS
Accelerating efforts globally toward net zero emission energy systems, utilizing zero- and low-carbon fuels well before or by around mid-century	Energy system emissions	Not quantified	Energy system emissions ($GtCO_2e$)	39.5 (2023)	N/A	0.39	N/A; no target		IEA 2024h; Crippa et al. 2024	Energy system emissions include those from electricity, heat, and fuel production in the energy supply sector, as well as those from fuel combustion in the buildings, industry, and transport sectors.
	Zero- and low-carbon fuels	Not quantified	Green hydrogen production (Mt)	0.074 (2023)		0.015	N/A; no target	Right direction; no target	IEA 2024e	Zero and low-carbon fuels are not explicitly defined in the decision text but likely include green hydrogen, sustainable aviation fuels (e.g., power-to-liquid synthetic fuels and advanced biofuels), and zero-emissions maritime shipping fuels (e.g., green ammonia and e-methanol).
			Share of sustainable aviation fuels in global aviation fuel supply (%)	0.3 (2024)		0.07	N/A; no target	Right direction; no target	IATA 2023, 2025	
			Share of zero-emissions fuels in maritime shipping fuel supply (%)	0 (2024)		0	N/A; no target	Right direction; no target	Baresic et al. 2024	
Transitioning away from fossil fuels in energy systems in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science	Fossil fuels in energy systems	Not quantified	Share of coal in electricity generation (%)	34 (2024)		-0.33	N/A; no target	Right direction; no target	Ember 2025	Fossil fuels in the energy system are not explicitly defined in the decision text but include coal, gas, and oil. Our indicators focus specifically on the shares of coal and unabated fossil gas in electricity generation, as well as the share of all fossil fuels, including oil, in the transport sector's total energy consumption.
			Share of unabated fossil gas in electricity generation (%)	22 (2024)		-0.37	N/A; no target	Right direction; no target	Ember 2025	
			Share of fossil fuels in the transport sector's total energy consumption (%)	95 (2023)		-0.20	N/A; no target	Right direction; no target	IEA 2023h	
Accelerating zero- and low-emission technologies, including, inter alia, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production	Renewables	Not quantified	Share of solar and wind in electricity generation (%)	15 (2024)		1.5	N/A; no target	Right direction; no target	Ember 2025	Renewables are not explicitly defined in the decision text, but likely include solar and wind, as well as several other zero-carbon sources used for electricity generation (e.g., hydropower, geothermal, and wave energy technologies). Notably, nuclear power, which is included in the SoCA/SCL data platform's definition of zero-carbon power sources, is not renewable.
			Share of zero-carbon sources in electricity generation (%)	41 (2024)		0.73	N/A; no target	Right direction; no target	Ember 2025	
	Nuclear power	Not quantified	Share of zero-carbon sources in electricity generation (%)	41 (2024)		0.73	N/A; no target	Right direction; no target	Ember 2025	There is a difference in scope between the inferred indicator in the GST and the SoCA series/SCL data platform. Critically, our indicator includes all zero-carbon sources in electricity generation, which includes, but is not limited to, nuclear power.
	Abatement and removal technologies	Not quantified	Technological carbon dioxide removal ($MtCO_2$/yr)	1.5 (2023)		0.25	N/A; no target	Right direction; no target	Pongratz et al. 2024; US EPA 2024	There is a difference in scope between the inferred indicator in the GST and the SoCA series/SCL data platform. The decision text focuses on both abatement and removal technologies, while the SoCA series/SCL data platform features an indicator focused on technological carbon dioxide removal only.

TABLE B-1 | Summary of global progress made toward sectoral mitigation targets in the Global Stocktake outcome (continued)

DIRECT REFERENCE IN GST DECISION TEXT	INFERRED INDICATOR FROM THE GST	INFERRED TARGET FROM THE GST (TARGET YEAR)	RELATED SCL AND/ OR SOCA INDICATOR (UNITS)[a]	MOST RECENT DATA POINT (YEAR)	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL CHANGE OVER MOST RECENT 5 YEARS OF DATA[b]	ACCELERATION FACTOR RELATIVE TO THE INFERRED TARGET FROM THE GST	STATUS RELATIVE TO THE INFERRED TARGET FROM THE GST	HISTORICAL DATA SOURCE	KEY CONSIDERATIONS
	Low-carbon hydrogen production	Not quantified	Green hydrogen production (Mt)	0.074 (2023)		0.015	N/A; no target	Right direction; no target	IEA 2024e	There is a difference in scope between the inferred indicator in the GST and in the SoCA series/SCL data platform. Critically, the decision text focuses on low-carbon hydrogen broadly, while our indicator focuses on green hydrogen only.
Accelerating the substantial reduction of non-carbon dioxide emissions globally, in particular, methane emissions, by 2030	Non-CO_2 GHG emissions	Not quantified	Non-CO_2 GHG emissions ($GtCO_2e$)[e]	14 (2023)	N/A	0.19	N/A; no target		IEA 2024h; Crippa et al. 2024	N/A
	Methane emissions	Not quantified	Methane emissions ($GtCO_2e$)[e]	9.8 (2023)	N/A	0.1	N/A; no target		IEA 2024h; Crippa et al. 2024	N/A
Accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero-and low-emission vehicles	Road transport emissions	Not quantified	Road transport emissions ($GtCO_2e$)	6.3 (2023)	N/A	0.07	N/A; no target		IEA 2024h; Crippa et al. 2024	N/A
	Infrastructure enabling reduction of road transport emissions	Not quantified	Number of kilometers of rapid transit per 1 million inhabitants (km/1M inhabitants)	24 (2024)		0.47[e]	N/A; no target	Right direction; no target	ITDP 2024b	Infrastructure enabling the reduction of road transport emissions is not explicitly defined in the decision text but likely includes and extends beyond public transit, bicycle lanes, and charging stations.
			Number of kilometers of high-quality bike lanes per 1 million inhabitants (km/1M inhabitants)	18 (2024)		3.8	N/A; no target	Right direction; no target	Open StreetMap 2025	
			Number of public charging stations (millions)	5.4 (2024)		1.05	N/A; no target	Right direction; no target	IEA 2025k	
	Zero- and low-emissions vehicles	Not quantified	Share of elec-tric vehicles in light-duty vehicle sales (%)	22 (2024)		4.4	N/A; no target	Right direction; no target	IEA 2025k	Zero- and low-emission vehicles are not explicitly defined in the decision text, but likely include electric light-duty vehicles, buses, and medium- and heavy-duty commercial vehicles.
			Share of electric vehicles in the light-duty vehicle fleet (%)	4.5 (2024)		0.91	N/A; no target	Right direction; no target	IEA 2025k	
			Share of electric vehicles in bus sales (%)	6.2 (2024)		0.11	N/A; no target	Right direction; no target	IEA 2025k	
			Share of electric vehicles in medium- and heavy-duty commercial vehicle sales (%)	1.8 (2024)		0.36	N/A; no target	Right direction; no target	IEA 2025k	

TABLE B-1 | Summary of global progress made toward sectoral mitigation targets in the Global Stocktake outcome (continued)

DIRECT REFERENCE IN GST DECISION TEXT	INFERRED INDICATOR FROM THE GST	INFERRED TARGET FROM THE GST (TARGET YEAR)	RELATED SCL AND/OR SOCA INDICATOR (UNITS)[a]	MOST RECENT DATA POINT (YEAR)	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL CHANGE OVER MOST RECENT 5 YEARS OF DATA[b]	ACCELERATION FACTOR RELATIVE TO THE INFERRED TARGET FROM THE GST	STATUS RELATIVE TO THE INFERRED TARGET FROM THE GST	HISTORICAL DATA SOURCE	KEY CONSIDERATIONS
Phasing out inefficient fossil fuel subsidies that do not address energy poverty or just transitions as soon as possible	Inefficient fossil fuel subsidies	Not quantified	Public fossil fuel finance (trillion US$/yr)	1.5 (2023)		0.075 (2014–23)	N/A; no target		ECD and IISD 2025; Laan et al. 2023; OCI 2025; Gerasimchuk et al. 2024	There is a difference in scope between the inferred indicator in the GST and in the SoCA series / SCL data platform. Critically, the decision text limits this indicator to inefficient fossil fuel subsidies, while our indicator includes all public finance for fossil fuels that includes, as well as extends beyond, subsidies.
Recognizes that transitional fuels can play a role in facilitating the energy transition while ensuring energy security	Transitional fuels	Not quantified	Share of unabated fossil gas in electricity generation (%)	22 (2024)		-0.37	N/A; no target	Right direction; no target	Ember 2025	While transitional fuels are not defined in the decision text, some Parties have argued that this indicator includes fossil gas (Chandrasekhar and Gabbatiss 2023). For this reason, we include the share of unabated gas in electricity generation and note that, in pathways that limit warming to 1.5°C, this share falls to 5%–7% by 2030, 2% by 2035, 1% by 2040, and 0% by 2050 globally (CAT 2023).
Further emphasizes the importance of conserving, protecting, and restoring nature and ecosystems toward achieving the Paris Agreement temperature goal, including through enhanced efforts toward halting and reversing deforestation and forest degradation by 2030, and other terrestrial and marine ecosystems acting as sinks and reservoirs of greenhouse gases and by conserving biodiversity, while ensuring social and environmental safeguards, in line with the Kunming-Montreal Global Biodiversity Framework	Deforestation	0 Mha/yr (2030)	Deforestation (Mha/yr)	8.1 (2024)		-0.12 (2015–24)	>10x		Hansen et al. 2013; Turubanova et al. 2018; Sims et al. 2025	N/A
	Forest degradation	0 Mha (2030)	Forest degradation, as measured by the global extent of forests that transitioned to a lower integrity class (Mha)	63 (2022)		Insufficient data	Insufficient data		Grantham et al. 2020; FDA Partners 2024	N/A
	Reforestation (total Mha)	Not quantified	Reforestation (total Mha)	56 (total gain, 2010–20)		5.6 (annual average gain, 2010–20)	N/A; no target	Right direction; no target	Potapov et al. 2022a	N/A
Invites Parties to preserve and restore the ocean and coastal ecosystems and scale up, as appropriate, ocean-based mitigation action	Loss of ocean and coastal ecosystems	Not quantified	Mangrove loss (ha/yr)	32,000[g] (annual average, 2017–19)		950 (annual average, 2008–19)	N/A; no target		Murray et al. 2022	Ocean and coastal ecosystems are not defined in the decision text but likely include and extend beyond mangrove forests, which is currently the only indicator presented in the SoCA series. Additional indicators are forthcoming on SCL's data platform.
	Ocean and coastal ecosystem restoration	Not quantified	Mangrove restoration (total ha)	15,000[h] (total direct gain, 1999–2019)		750 (annual average gain, 1999–2019)	N/A; no target	Right direction; no target	Murray et al. 2022	

TABLE B-1 | Summary of global progress made toward sectoral mitigation targets in the Global Stocktake outcome (continued)

DIRECT REFERENCE IN GST DECISION TEXT	INFERRED INDICATOR FROM THE GST	INFERRED TARGET FROM THE GST (TARGET YEAR)	RELATED SCL AND/ OR SOCA INDICATOR (UNITS)[a]	MOST RECENT DATA POINT (YEAR)	LIKELIHOOD OF FOLLOWING AN S-CURVE	AVERAGE ANNUAL CHANGE OVER MOST RECENT 5 YEARS OF DATA[b]	ACCELERATION FACTOR RELATIVE TO THE INFERRED TARGET FROM THE GST	STATUS RELATIVE TO THE INFERRED TARGET FROM THE GST	HISTORICAL DATA SOURCE	KEY CONSIDERATIONS
Notes the importance of transitioning to sustainable lifestyles and sustainable patterns of consumption and production in efforts to address climate change, including through circular economy approaches, and encourages efforts in this regard	Sustainable patterns of consumption and production	Not quantified	Food waste (kg/capita)	130 (2022)		Insufficient data	Insufficient data		UNEP 2024b	Sustainable lifestyles, as well as sustainable patterns of consumption and production, are not defined in the decision text but likely include and extend beyond actions that reduce food waste, as well as ruminant meat consumption in high-consuming regions.
			Ruminant meat consumption in high-consuming regions (kcal/capita/day)	104 (2022)		-0.58	N/A; no target	Right direction; no target	FAOSTAT 2025	

Notes: CO_2 = carbon dioxide; GHG= greenhouse gas; GST = Global Stocktake; $GtCO_2e$ = gigatonnes of carbon dioxide equivalent; GW = gigawatt; ha = hectares; ha/yr = hectares per year; kcal =kilocalories; kcal/capita/day = kilocalories per capita per day; kg = kilograms; kg/capita = kilograms per capita; km/1M inhabitants = kilometers per 1 million inhabitants; Mha = million hectares; Mha/yr = million hectares per year; Mt = million tonnes; $MtCO_2$ = million tonnes of carbon dioxide; N/A = not applicable; SCL = Systems Change Lab; SoCA = State of Climate Action; US$ = US dollar; yr = year.

[a] These indicators do not always represent one-to-one matches with those inferred from the negotiated decision text; accordingly, we note when such differences in scope exist.

[b] We used the 5 most recent years of historical data to calculate the average annual change for most indicators, but for several indicators, we calculated average annual change over 10 years of historical data to account for and smooth out high interannual variability. In these exceptions, we note the years that were used in parentheses.

[c] This indicator does not appear on the Systems Change Lab data platform or in the *State of Climate Action* report series.

[d] We used the 2010–19 annual average to estimate an annual data point for 2019, which we then used alongside annual data from 2020–23 to calculate an acceleration factor for this indicator.

[e] Annual GHG emissions data are available on the Systems Change Lab data platform and in the *State of Climate Action* report series but are disaggregated by sector rather than by gas.

[f] For this indicator, we deviated from our regular method of using five recent consecutive data points to draw a trendline given that no data are available for 2021 and 2022. Instead, we draw a trendline using data from just 2020, 2023, and 2024.

[g] Historical data from Murray et al. 2022, which estimated gross mangrove area lost from 1999 to 2019, were broken into three-year epochs. Loss for each epoch was divided by the number of years in the epoch to determine the average annual loss rate.

[h] Murray et al. 2022 estimated that a gross area of 180,000 ha (95 percent confidence interval of 0.09 to 0.30 Mha) of mangrove gain occurred from 1999 to 2019, only 8 percent of which can be attributed to direct human activities, such as mangrove restoration or planting. We estimated the most recent data point for mangrove restoration by taking 8 percent of the total mangrove gain from 1999 to 2019 (15,000 ha). See Boehm et al. 2025 for more information.

[i] For this indicator, we deviated from our regular method of using five recent consecutive data points to draw a trendline given that no data are available for 2022, 2023, and 2024. Instead, we draw a trendline using data from 2016, 2020, and 2021.

Appendix C.

Assessment of progress for “S-curve likely” indicators

Table C-1 presents our assessment of progress for the S-curve likely indicators in this report, following the methodology described in Boehm et al. 2025. We first evaluated each indicator’s shape of change over the last five years by comparing the historical data to a linear trendline, an exponential trendline, and a logarithmic trendline. We then calculated what the current value of the indicator was as a proportion of its saturation level, which we assumed was the same as the upper bound of the long-term target. Considering these two elements, we determined what stage of an S-curve each indicator was in: emergence, breakthrough, diffusion, or reconfiguration. For indicators in the breakthrough, diffusion, or reconfiguration stage with sufficient available data, we fitted two types of S-curve to the historical data to inform author judgment of the category of progress. Logistic S-curves are symmetrical, while Gompertz S-curves are asymmetrical and approach the upper saturation value more gradually. S-curve fitting was possible for the share of zero-carbon sources in electricity generation (Figure C-1), the share of solar and wind in electricity generation (Figure C-2), and the share of electric vehicles in light-duty vehicle sales (Figure C-3). For other S-curve likely indicators, we did not fit an S-curve to the historical data because they are in the emergence stage, when S-curve fitting is too uncertain to be relied upon. For all indicators, we reviewed the literature, consulted with experts, and considered the category of progress based on a linear trendline to inform ultimate author judgment.

TABLE C-1 | Additional analysis for “S-curve likely” indicators

WHICH TRENDLINE REPRESENTS THE BEST FIT FOR THE LAST 5 YEARS OF DATA?	WHAT PERCENTAGE OF THE SATURATION VALUE DOES THE MOST RECENT DATA POINT REPRESENT?	WHAT STAGE OF S-CURVE IS THE TECHNOLOGY IN?	WHAT WAS OUR S-CURVE ANALYSIS?	WHAT OTHER LINES OF EVIDENCE WERE CONSIDERED?	WHAT IS THE STATUS USING A LINEAR TRENDLINE?	WHAT IS THE STATUS USING AUTHOR JUDGMENT?
Share of zero-carbon sources in electricity generation (%)						
Because this indicator describes a set of related technologies, we examined trendlines for each technology separately. For solar, the exponential trendline was the best fit, while for wind, the linear trendline was the best fit. We do not expect nuclear, hydropower, and other renewables to follow an S-curve, and, as expected, the linear trendline was the best fit.	We assume that solar and wind together have a saturation value of 96% (the upper bound of our 2050 target). It is difficult to know how much of this would be from solar compared to wind, but the current value of 6.9% for solar and the current value of 8.1% for wind would each exceed 5% of their respective saturation values, no matter what the breakdown was between solar and wind. Thus they are above the cutoff for the emergence stage of an S-curve. For nuclear, hydropower, and other renewables, we do not calculate the saturation value since we assume that linear growth will continue.	Breakthrough stage for solar power, given that the indicator’s current value is greater than 5% of its saturation value and the historical trendline is exponential. Diffusion stage for wind power, given that the indicator’s current value is greater than 5% of its saturation value and the historical trendline is linear. For nuclear, hydropower, and other renewables, we do not determine the stage of the S-curve since we assume that linear growth will continue.	We fitted S-curves to the historical data for solar and wind and used linear trendlines for nuclear, hydropower, and other renewables. Using this combined trajectory, a logistic S-curve indicates that the share of zero-carbon sources in electricity generation will reach 53% in 2030. A Gompertz S-curve indicates that the share of zero-carbon sources in electricity generation will reach 46% in 2030. Both values are less than half of the way from the current value (41%) to the midpoint of our 2030 target (90%). More than a doubling of progress is needed. Using this as a conceptual comparison to our analysis of other indicators using acceleration factors, this suggests that the indicator is well off track (see Figure C-1). In the “Power” section of the report we also present a simple mathematical comparison of growth rates. The share of zero-carbon sources in electricity generation has been growing by 2% per year on average from 2020 to 2024, but it would need to increase to 14% growth per year in the future to meet the midpoint of the 2030 target. Growth rates would have to more than double, yet, in an S-curve, growth rates typically decrease as a percentage over time (even as they increase in absolute value). Using this as a conceptual comparison to our analysis of other indicators using acceleration factors, this also suggests that the indicator is well off track.	The IEA (2024i) estimates that zero-carbon electricity sources are on track to reach 56% of electricity generation in 2030 in its Stated Policies Scenario based on current policies. That is less than half of the way from the current value (41%) to the midpoint of our 2030 target (90%), which suggests that the indicator is well off track. Note that the IEA rates solar PV as “on track” but wind, bioenergy, and hydropower as “more efforts needed” in order to meet its Net Zero Emissions (NZE) scenario (IEA 2024i, 2025g, 2025h). However, the NZE scenario only sees zero-carbon electricity sources reach 70% of electricity generation by 2030 compared to this report’s midpoint target of 90%. The IEA’s NZE scenario has a higher overall carbon intensity of power generation than the average 1.5°C-compatible scenarios used in this report, which means that in the NZE scenario other sectors would have to decarbonize faster to make up for slower decarbonization in power.	✕	✕

TABLE C-1 | Additional analysis for "S-curve likely" indicators (continued)

WHICH TRENDLINE REPRESENTS THE BEST FIT FOR THE LAST 5 YEARS OF DATA?	WHAT PERCENTAGE OF THE SATURATION VALUE DOES THE MOST RECENT DATA POINT REPRESENT?	WHAT STAGE OF S-CURVE IS THE TECHNOLOGY IN?	WHAT WAS OUR S-CURVE ANALYSIS?	WHAT OTHER LINES OF EVIDENCE WERE CONSIDERED?	WHAT IS THE STATUS USING A LINEAR TRENDLINE?	WHAT IS THE STATUS USING AUTHOR JUDGMENT?
Share of solar and wind in electricity generation (%)						
Because this indicator describes two related technologies, we examined trendlines for each technology separately. For solar, the exponential trendline was the best fit, while for wind, the linear trendline was the best fit.	We assume that solar and wind together have a saturation value of 96% (the upper bound of our 2050 target). It is difficult to know how much of this would be from solar compared to wind, but the current value of 6.9% for solar and the current value of 8.1% for wind would exceed 5% of their respective saturation values, no matter what the breakdown was between solar and wind. Thus, they are above the cutoff for the emergence stage of an S-curve.	Breakthrough stage for solar power, given that the indicator's current value is greater than 5% of its saturation value and the historical trendline is exponential. Diffusion stage for wind power, given that the indicator's current value is greater than 5% of its saturation value and the historical trendline is linear.	We fitted an S-curve to the historical data for solar and wind. A logistic S-curve indicates that the share of solar and wind in electricity generation will reach 31% in 2030. A Gompertz S-curve indicates that the share of solar and wind in electricity generation will reach 25% in 2030. Both values are less than half of the way from the current value (15%) to the midpoint of our 2030 target (68%). More than a doubling of progress is needed. Using this as a conceptual comparison to our analysis of other indicators using acceleration factors, this suggests that the indicator is well off track (see Figure C-2). In the "Power" section of the report we also present a simple mathematical comparison of growth rates. The share of electricity produced from solar and wind has been growing 13% per year on average from 2020 to 2024. However, it would have to increase by 29% per year in the future to meet the midpoint of the 2030. Growth rates would have to more than double, yet, in an S-curve, growth rates typically decrease as a percentage over time (even as they increase in absolute value). Using this as a conceptual comparison to our analysis of other indicators using acceleration factors, this also suggests that the indicator is well off track.	The IEA (2024i) estimates that solar and wind are on track to reach 30% of electricity generation in 2030 in its Stated Policies Scenario based on current policies. That is less than half of the way from the current value (15%) to the midpoint of our 2030 target (68%), which suggests that the indicator is well off track. Note that the IEA rates solar PV as "on track" but wind as "more efforts needed" in order to achieve the Net Zero Emissions scenario (IEA 2024i, 2025h). However, the NZE scenario only sees solar and wind reach 41% of electricity generation by 2030 compared to this report's midpoint target of 68%. RMI has estimated that, following an S-curve, solar and wind would reach 33% of electricity generation by 2030 (Bond et al. 2023). That is also less than half of the way from the current value (15%) to the midpoint of our 2030 target (68%).	✕	✕
Green hydrogen production (Mt)						
Exponential	Assuming green hydrogen production has a saturation value of 330 Mt (our 2050 target), the current value of 0.074 Mt is only 0.02% of the saturation value.	Emergence stage, given that the indicator's current value is less than 5% of its saturation value.	S-curve fitting is too uncertain in the emergence stage. Given these uncertainties, we default to well off track unless there is compelling evidence to upgrade this indicator's category of progress.	The IEA (2024d) notes that, despite a strong increase in the number of announced green hydrogen projects in recent years, the sector would need to grow at an "unprecedented" compounded annual growth rate of 90% during 2024–30 to achieve 2030 targets.	✕	✕
Share of electric vehicles in light-duty vehicle sales (%)						
A linear trendline is the best fit for the past 5 years of data, but an exponential trendline is the best fit for the past 10 years of data.	Assuming the share of EVs in LDV sales has a saturation value of 100% (our 2040 target), the current value is 22% of the saturation value.	Diffusion stage, given that the indicator's current value is greater than 5% of its saturation value and the historical trendline from the past 5 years is linear.	We fitted S-curves to the historical data. A logistic S-curve indicates that the share of EVs in LDV sales will reach 76% by 2030. A Gompertz S-curve indicates that the share of EVs in LDV sales will reach 57% by 2030. Both values are more than halfway from the current value (22%) to the midpoint of the 2030 target (85%). These are not on track, but less than a doubling of progress is needed. Using this as a conceptual comparison to our analysis of other indicators using acceleration factors, this suggests that the indicator is off track (see Figure C-3).	The IEA (2025f) estimates that EV sales will reach 42% of LDV sales in 2030. This is less than halfway from the current value (22%) to the midpoint of the 2030 target (85%), suggesting that the indicator is well off track. A projection from BNEF 2024a—that EV sales will reach 45% of LDV sales in 2030—is also less than halfway from the current value to the midpoint of the 2030 target. But, as the IEA and BNEF have historically underestimated the growth of light-duty EVs in their projections (see Figure 2 of Boehm et al. 2025), we primarily rely on our S-curve fitting results instead.	✕	!

TABLE C-1 | Additional analysis for "S-curve likely" indicators (continued)

WHICH TRENDLINE REPRESENTS THE BEST FIT FOR THE LAST 5 YEARS OF DATA?	WHAT PERCENTAGE OF THE SATURATION VALUE DOES THE MOST RECENT DATA POINT REPRESENT?	WHAT STAGE OF S-CURVE IS THE TECHNOLOGY IN?	WHAT WAS OUR S-CURVE ANALYSIS?	WHAT OTHER LINES OF EVIDENCE WERE CONSIDERED?	WHAT IS THE STATUS USING A LINEAR TRENDLINE?	WHAT IS THE STATUS USING AUTHOR JUDGMENT?
Share of electric vehicles in the light-duty vehicle fleet (%)						
Exponential	Assuming the share of EVs in the LDV fleet has a saturation value of 100% (the upper bound of our 2050 target), the current value is only 4.5% of the saturation value.	Emergence stage, given that the indicator's current value is less than 5% of its saturation value.	S-curve fitting is too uncertain in the emergence stage. Given these uncertainties, we default to well off track unless there is compelling evidence to upgrade this indicator's category of progress.	Strong growth in EV sales suggests a forthcoming breakthrough in EVs as a share of the LDV fleet. Logically, the indicators for the share of EVs in LDV sales and the LDV fleet should both have the same status of progress because the targets for these two indicators were developed in tandem and assume that increased EV sales translate to an increased EV fleet over time. This indicator should thus also be upgraded to off track. It could be that new EV sales do not necessarily correspond with equal removal or turnover of old cars from the market (Keith et al. 2019). However, there is not yet sufficient evidence to understand current rates of global LDV fleet turnover as they relate to EVs. The IEA (2025f) estimates that EV stock will reach 15% of the LDV fleet in 2030. This is less than halfway from the current value (4.5%) to the midpoint of the 2030 target (33%), suggesting that the indicator is well off track. A projection from BNEF 2024a—which also projects that EV stock will reach ~15% of the LDV fleet in 2030—is also less than halfway from the current value to the midpoint of the 2030 target. But, as the IEA and BNEF have historically underestimated the growth of light-duty EVs in their projections (see Figure 2 of Boehm et al. 2025), we default to assume that EVs in the LDV fleet will have the same status of progress as EVs in LDV sales.	×	!
Share of electric vehicles in bus sales (%)						
Linear	Assuming the share of electric vehicles in bus sales has a saturation value of 100% (our 2050 target), the current value is 6.2% of the saturation value.	The indicator is not following a smooth S-curve. The current value is more than 5% of the saturation value because the indicator grew quickly from 2014 to 2017, but it doesn't meet the criteria for the breakthrough stage of an S-curve because progress has been flat over the past 5 years, indicating that a barrier came up that prevented it from reaching a breakthrough.	S-curve fitting is not applicable given that the indicator is not following a smooth S-curve. These uncertainties lead us to default to the linear trendline. Here, the data show that recent rates of change have been well off track.	The IEA (2025f) estimates that EVs will account for 17% of bus sales in 2030. This is less than halfway from the current value (6.2%) to the midpoint of the 2030 target (56%), suggesting that the indicator is well off track. BNEF 2024a provides future projections for the electrification of municipal buses only, so this analysis is excluded from consideration here.	×	×

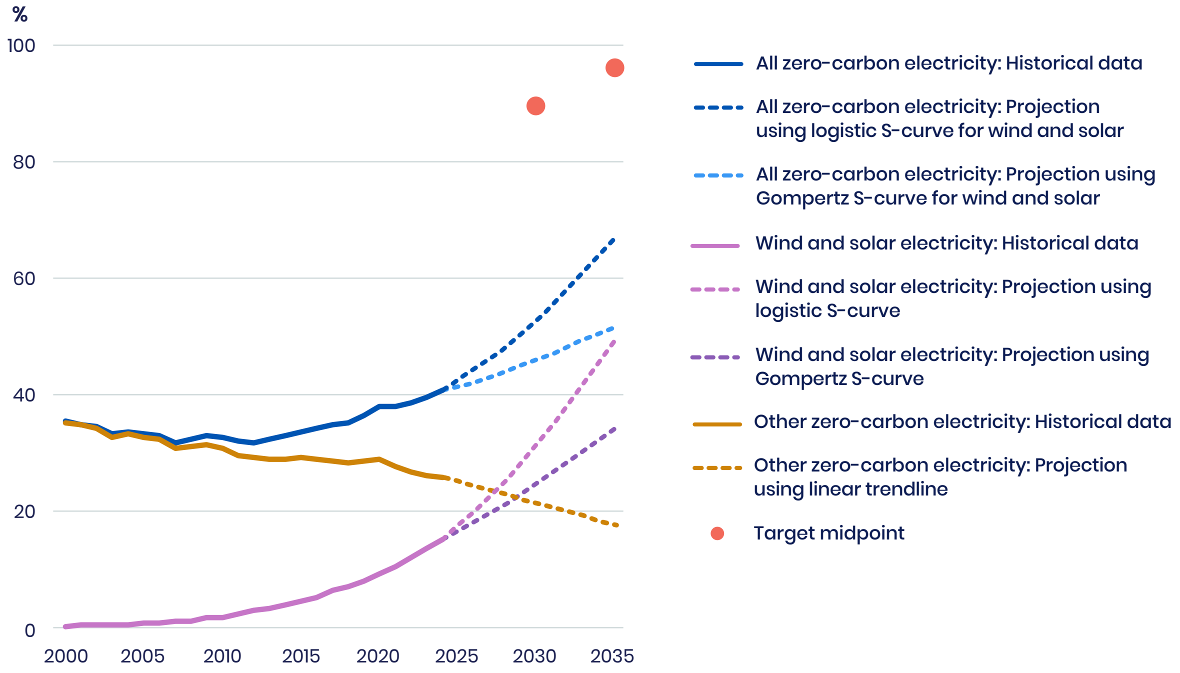
TABLE C-1 | Additional analysis for "S-curve likely" indicators (continued)

WHICH TRENDLINE REPRESENTS THE BEST FIT FOR THE LAST 5 YEARS OF DATA?	WHAT PERCENTAGE OF THE SATURATION VALUE DOES THE MOST RECENT DATA POINT REPRESENT?	WHAT STAGE OF S-CURVE IS THE TECHNOLOGY IN?	WHAT WAS OUR S-CURVE ANALYSIS?	WHAT OTHER LINES OF EVIDENCE WERE CONSIDERED?	WHAT IS THE STATUS USING A LINEAR TRENDLINE?	WHAT IS THE STATUS USING AUTHOR JUDGMENT?
Share of electric vehicles in medium- and heavy-duty commercial vehicle sales (%)						
Exponential	Assuming the share of electric vehicles in medium- and heavy-duty commercial vehicle sales has a saturation value of 100% (our 2050 target), the current value is only 1.8% of the saturation value.	Emergence stage, given that the indicator's current value is less than 5% of its saturation value.	S-curve fitting is too uncertain in the emergence stage. Given these uncertainties, we default to well off track unless there is compelling evidence to upgrade this indicator's category of progress.	The IEA (2025f) estimates that EVs will account for 13% of MHDV sales in 2030. This is less than halfway from the current value (1.7%) to the midpoint of the 2030 target (37%), suggesting that the indicator is well off track. A projection from BNEF 2024a—that EV sales will reach 18% of MHDV sales in 2030—is also less than halfway from the current value to the midpoint of the 2030 target.	✕	✕
Share of sustainable aviation fuels in global aviation fuel supply (%)						
Exponential	Assuming the share of SAFs in the global aviation fuel supply has a saturation value of 100% (our 2050 target), the current value is only 0.3% of the saturation value.	Emergence stage, given that the indicator's current value is less than 5% of its saturation value.	S-curve fitting is too uncertain in the emergence stage. Given these uncertainties, we default to well off track unless there is compelling evidence to upgrade this indicator's category of progress.	The IEA (2023a) finds that aviation is "not on track" to achieve its net-zero emissions goal by 2050, although this assessment does not refer specifically to sustainable aviation fuels. Although their analysis focuses on US SAF supply only, Calderon et al. (2024) find that domestic SAF production would need to expand by 130 times to reach the US 2030 target.	✕	✕
Share of zero-emissions fuels in maritime shipping fuel supply (%)						
Linear	0%	Emergence stage, given that the indicator's current value is less than 5% of its saturation value.	S-curve fitting is too uncertain in the emergence stage. Given these uncertainties, we default to well off track unless there is compelling evidence to upgrade this indicator's category of progress.	The IEA (2023g) finds that shipping is "not on track" to achieve its net-zero emissions goal by 2050, although this assessment does not refer specifically to zero-emissions fuels. Baresic et al. (2024) also find indicators that measure ZEF demand and ZEF financing as "not on track." While Baresic et al. (2024) do categorize several ZEF technology, supply, and policy indicators as "partially on track" in light of technological advancements in green ammonia and e-methanol fuels, recent announcements of a growing number of ZEF production projects, and the adoption of the 2023 IMO GHG Strategy, these positive enabling conditions have not yet translated into any commercial ZEF scale-up, and the indicator remains well off track.	✕	✕

Notes: BNEF = Bloomberg New Energy Finance; EV = electric vehicle; GHG = greenhouse gas; IEA = International Energy Agency; IMO = International Maritime Organization; LDV = light-duty vehicle; MHDV = medium- and heavy-duty vehicle; Mt = million tonnes; PV = photovoltaic; RMI = Rocky Mountain Institute; SAF = sustainable aviation fuel; ZEF = zero-emissions fuel.

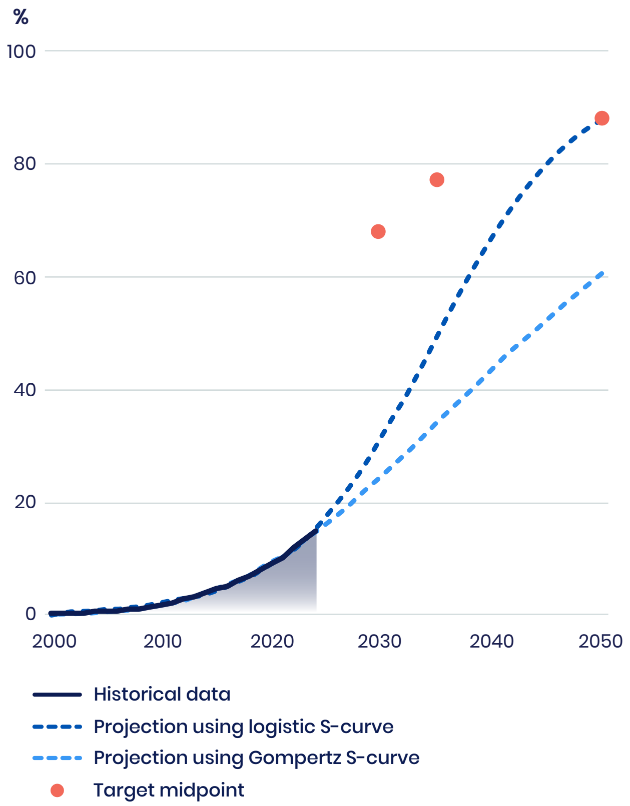
Source: Authors.

FIGURE C-1 | Share of zero-carbon sources in electricity generation: S-curve analysis combined with linear analysis



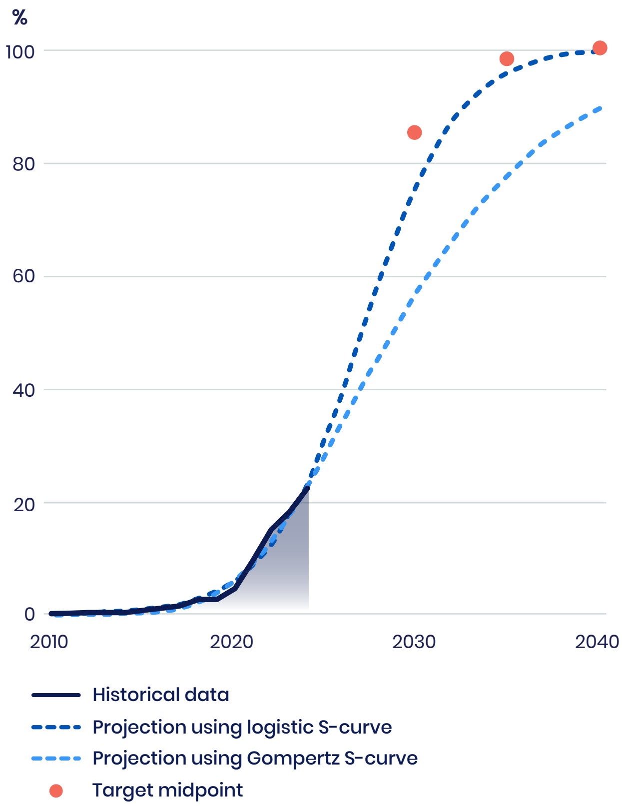
Sources: Historical data from Ember 2025. Targets from CAT 2023 and Boehm et al. 2025. Extrapolation by authors.

FIGURE C-2 | Share of solar and wind in electricity generation: S-curve analysis



Sources: Historical data from Ember 2025. Targets from CAT 2023 and Boehm et al. 2025. Extrapolation by authors.

FIGURE C-3 | Electric vehicles as a share of light-duty vehicle sales: S-curve analysis



Sources: Historical data from IEA 2025f. Targets from CAT 2024. Extrapolation by authors.

Appendix D.

Changes in acceleration factors and categories of progress between *State of Climate Action 2023* and *State of Climate Action 2025*

Table D-1 indicates if and why each indicator's acceleration factor and category of progress changed from the *State of Climate Action 2023* (Boehm et al. 2023) to the *State of Climate Action 2025*. For most indicators, a combination of several factors, such as target changes, an additional year of data, or changes in underlying datasets, likely spurred these differences. And while it is difficult to disentangle these effects, we identify several key explanations for each indicator.

1. **Target change.** For some indicators, the target itself has changed. This means that, in the *State of Climate Action 2025*, the goal toward which progress is measured differs from the goal in last year's report. As such, acceleration factors and categories of progress for these indicators are not directly comparable to last year's report. The reasons for changing individual targets are described further in our updated, complementary technical note (Boehm et al. 2025).
2. **Data change.** A change in historical data between the 2023 and 2025 reports—either through the addition of just one new data point or through switching the full historical dataset due to new availability of an improved source—impacts the acceleration factor in two ways. First, the 5-year (or 10-year) trendline changes with a new data point and/or different data. Second, the average annual rate of change needed to reach the 2030 target changes as we get closer to 2030 with an additional year of data. Hence, every change in data affects the acceleration factor. In Table D-1, we indicate whether we switched to a new dataset or whether a new data point was added for each indicator. Note that even for indicators where the dataset has not changed, data providers typically update historical data every time they publish a new year of data; for the most part (though not always) these updates are relatively small.

Finally, some indicators and targets have been established in this report that we did not track in previous iterations of the series. These indicators are labeled as **new indicator**. For others, we adjusted the indicator to better reflect the latest, best available science or to match a newly published data source. We label these indicators as updated indicator. For several indicators, we tracked them in previous iterations but do not do so any longer, so we have labeled them as a **discontinued indicator**. Finally, for still more indicators, we observe no change between the reports, and accordingly, we label these as **no difference**.

When this report features new or revised targets and indicators relative to the *State of Climate Action 2023*, we note these changes as a first-order explanation of differences between the assessments of progress across both publications. However, in some instances, underlying historical data have changed as well.

TABLE D-1 | Changes in acceleration factor and category or progress between *State of Climate Action 2023* and *State of Climate Action 2025*

2025 INDICATOR	SOCA 2023 ACCELERATION FACTOR[a]	SOCA 2023 STATUS	SOCA 2025 ACCELERATION FACTOR[a]	SOCA 2025 STATUS	EXPLANATION OF DIFFERENCES BETWEEN 2022 AND 2023
Power					
Share of zero-carbon sources in electricity generation (%)	8x[b]	!	>10x[b]	×	Data change; additional year(s) of data
Share of solar and wind in electricity generation (%)	N/A; new indicator	N/A; new indicator	6x[b]	×	New indicator
Share of coal in electricity generation (%)	7x	×	>10x	×	Data change; additional year(s) of data

TABLE D-1 | Changes in acceleration factor and category or progress between *State of Climate Action 2023* and State of *Climate Action 2025* (continued)

2025 INDICATOR	SOCA 2023 ACCELERATION FACTOR[a]	SOCA 2023 STATUS	SOCA 2025 ACCELERATION FACTOR[a]	SOCA 2025 STATUS	EXPLANATION OF DIFFERENCES BETWEEN 2022 AND 2023
Share of unabated fossil gas in electricity generation (%)	>10x	×	7x	×	Data change; additional year(s) of data
Carbon intensity of electricity generation (gCO_2/kWh)	9x	×	>10x	×	Data change; additional year(s) of data
Buildings					
Energy intensity of building operations (kWh/m^2)	3x	×	3x	×	No difference
Carbon intensity of building operations ($kgCO_2/m^2$)	4x	×	4x	×	No difference
Retrofitting rate of buildings (%/yr)	Insufficient data	?	Insufficient data	?	No difference
Share of new buildings that are zero-carbon in operation (%)	Insufficient data	?	Insufficient data	?	No difference
Industry					
Share of electricity in the industry sector's final energy demand (%)	4x	×	5x	×	Data change; additional year(s) of data
Carbon intensity of global cement production ($kgCO_2$/t cement)	>10x	×	4x	×	Data change; additional year(s) of data
Carbon intensity of global steel production ($kgCO_2$/t crude steel)	N/A; U-turn needed		N/A; U-turn needed		No difference
Green hydrogen production (Mt)	>10x[b]	×	>10x[b]	×	No difference
Transport					
Share of kilometers traveled by passenger cars (% of passenger-km)	N/A; U-turn needed		N/A; U-turn needed		No difference
Number of kilometers of rapid transit per 1 million inhabitants (km/1M inhabitants)	6x	×	5x	×	Target and data change; additional year(s) of data
Number of kilometers of high-quality bike lanes per 1,000 inhabitants (km/1,000 inhabitants)	>10x	×	N/A; discontinued indicator	N/A; discontinued indicator	Discontinued indicator

TABLE D-1 | Changes in acceleration factor and category or progress between *State of Climate Action 2023* and State of *Climate Action 2025* (continued)

2025 INDICATOR	SOCA 2023 ACCELERATION FACTOR[a]	SOCA 2023 STATUS	SOCA 2025 ACCELERATION FACTOR[a]	SOCA 2025 STATUS	EXPLANATION OF DIFFERENCES BETWEEN 2022 AND 2023
Share of electric vehicles in light-duty vehicle sales (%)	4x[b]	✔	2.5x[b]	!	Data change; additional year(s) of data
Share of electric vehicles in the light-duty vehicle fleet (%)	>10x[b]	!	5x[b]	!	Target and data change; additional year(s) of data
Share of electric vehicles in 2- and 3- wheeler sales (%)	1.3x[b]	!	N/A; discontinued indicator	N/A; discontinued indicator	Discontinued indicator
Share of electric vehicles in bus sales (%)	N/A; U-turn needed	⮌	>10x[b]	✕	Target and data change; additional year(s) of data
Share of electric vehicles in medium- and heavy-duty commercial vehicle sales (%)	8x[b]	✕	>10x[b]	✕	Target and data change; additional year(s) of data
Share of sustainable aviation fuels in global aviation fuel supply (%)	>10x[b]	✕	>10x[b]	✕	No difference
Share of zero-emissions fuels in maritime shipping fuel supply (%)	>10x[b]	✕	>10x[b]	✕	No difference
Share of fossil fuels in the transport sector's total energy consumption (%)	N/A; new indicator	N/A; new indicator	>10x	✕	New indicator
Forests and land					
Deforestation (Mha/yr)	4x	✕	9x	✕	Data change; additional year(s) of data and revised historical dataset
Peatland degradation (Mha/yr)	Insufficient data	?	Insufficient data	?	No difference
Mangrove loss (ha/yr)	N/A; U-turn needed	⮌	N/A; U-turn needed	⮌	No difference
Reforestation (total Mha)	1.5x	!	1.8x	!	Data change; revised historical dataset
Peatland restoration (total Mha)	Insufficient data	?	Insufficient data	?	No difference
Mangrove restoration (total ha)	>10x	✕	>10x	✕	No difference

TABLE D-1 | Changes in acceleration factor and category or progress between *State of Climate Action 2023* and *State of Climate Action 2025* (continued)

2025 INDICATOR	SOCA 2023 ACCELERATION FACTOR[a]	SOCA 2023 STATUS	SOCA 2025 ACCELERATION FACTOR[a]	SOCA 2025 STATUS	EXPLANATION OF DIFFERENCES BETWEEN 2022 AND 2023
Food and agriculture					
GHG emissions intensity of agricultural production (gCO_2e/1,000 kcal)	3x	×	5x	×	Updated approach for calculating indicator, leading to target change, and data change; additional year(s) of data
GHG emissions intensity of enteric fermentation (gCO_2e/1,000 kcal)	N/A; new indicator	N/A; new indicator	2.5x	×	New indicator
GHG emissions intensity of manure management (gCO_2e/1,000 kcal)	N/A; new indicator	N/A; new indicator	6x	×	New indicator
GHG emissions intensity of soil fertilization (gCO_2e/1,000 kcal)	N/A; new indicator	N/A; new indicator	1.2x	!	New indicator
GHG emissions intensity of rice cultivation (gCO_2e/1,000 kcal)	N/A; new indicator	N/A; new indicator	6x	×	New indicator
Crop yields (t/ha)	>10x	×	10x	×	Target and data change: Additional year(s) of data
Ruminant meat productivity (kg/ha)	1.2x	!	1.6x	!	Target and data change: Additional year(s) of data
Share of food production lost (%)	N/A; U-turn needed	↩	N/A; U-turn needed	↩	No difference
Food waste (kg/capita)	Insufficient data	?	Insufficient data	?	No difference
Ruminant meat consumption in high-consuming regions (kcal/capita/day)	8x	×	5x	×	Data change; additional year(s) of data
Technological carbon dioxide removal					
Technological carbon dioxide removal ($MtCO_2$/yr)	>10x	×	>10x	×	No difference
Finance					
Global total climate finance (trillion US$/yr)	2.5x	×	4x	×	Target and data change; update to historical dataset

TABLE D-1 | Changes in acceleration factor and category or progress between *State of Climate Action 2023* and State of *Climate Action 2025* (continued)

2025 INDICATOR	SOCA 2023 ACCELERATION FACTOR[a]	SOCA 2023 STATUS	SOCA 2025 ACCELERATION FACTOR[a]	SOCA 2025 STATUS	EXPLANATION OF DIFFERENCES BETWEEN 2022 AND 2023
Global public climate finance (trillion US$/yr)	8x		6x		Target and data change; additional year(s) of data
Global private climate finance (trillion US$/yr)	>10x		1.8x		Target and data change; additional year(s) of data
Share of global GHG emissions under mandatory corporate climate risk disclosure (%)	1.5x		N/A; discontinued indicator	N/A; discontinued indicator	Discontinued indicator
Public fossil fuel finance (trillion US$/yr)	N/A; U-turn needed		N/A; U-turn needed		No difference
Weighted average carbon price in jurisdictions with emissions pricing systems (2024 US$/$tCO_2e$)	>10x		>10x		No difference
Ratio of investment in low-carbon to fossil fuel energy supply	>10x		7x		Target and data change; additional year(s) of data

Notes: gCO_2/kWh = grams of carbon dioxide per kilowatt-hour; gCO_2e/1,000 kcal = grams of carbon dioxide equivalent per 1,000 kilocalories; GHG = greenhouse gas; ha = hectares; ha/yr = hectares per year; kcal/capita/day = kilocalories per capita per day; kg/capita = kilograms per capita; $kgCO_2$ /m² = kilogram of carbon dioxide per square meter; $kgCO_2$/t = kilograms of carbon dioxide per tonne; kg/ha = kilograms per hectare; km/1M inhabitants = kilometers per 1 million inhabitants; kWh/m² = kilowatt-hour per square meter; Mha = million hectares; Mha/yr = million hectares per year; Mt = million tonnes; $MtCO_2$ = million tonnes of carbon dioxide; N/A = not applicable; passenger-km = passenger-kilometers; SoCA = State of Climate Action; t = tonnes; tCO_2e = tonnes of carbon dioxide equivalent; t/ha = tonnes per hectare; US$ = US dollars; yr = year. A label of "no difference" does not imply that there are no new data for the affected indicator. It simply indicates that the acceleration factor required to meet that indicator's 2030 target has not changed since the last installment in this report series. Notes on definitions and methodology for assessing progress for each indicator are contained in the figures accompanying each section of this report. See Boehm et al. 2025 for more information on methods for selecting targets, indicators, and datasets, as well as our approach for assessing progress.

[a] For acceleration factors between 1 and 2, we round to the 10th place (e.g., 1.2 times); for acceleration factors between 2 and 3, we round to the nearest half number (e.g., 2.5 times); for acceleration factors between 3 and 10, we round to the nearest whole number (e.g., 7 times); and acceleration factors higher than 10, we note as >10.

[b] For indicators categorized as S-curve likely, acceleration factors calculated using a linear trendline are included in this table for informational purposes but are not presented in the report, as they would not accurately reflect an S-curve trajectory. The category of progress was determined based on author judgment, using multiple lines of evidence. See Appendix C and Boehm et al. 2025 for more information.

Source: Author's analysis based on Boehm et al. 2023 and data sources listed in each section of this report.

ABBREVIATIONS

AFOLU	agriculture, forestry, and other land use
BRT	bus rapid transit
CCUS	carbon capture, utilization, and storage
CDR	carbon dioxide removal
CRCF	Carbon Removals and Carbon Farming regulation
EV	electric vehicle
FAO	Food and Agriculture Organization of the United Nations
gCO_2/kWh	grams of carbon dioxide per kilowatt-hour
$gCO_2e/1{,}000$ kcal	grams of carbon dioxide equivalent per 1,000 kilocalories
GHG	greenhouse gas
GtC	gigatonnes of carbon
$GtCO_2$	gigatonnes of carbon dioxide
$GtCO_2e$	gigatonnes of carbon dioxide equivalent
GW	gigawatt
ha/yr	hectares per year
IPCC	Intergovernmental Panel on Climate Change
$kgCO_2/m^2$	kilograms of carbon dioxide per square meter
$kgCO_2/t$	kilograms of carbon dioxide per tonne
km/1M inhabitants	kilometers per 1 million inhabitants
kWh/m^2	kilowatt-hours per square meter
LDV	light-duty vehicle
LULUCF	land use, land-use change, and forestry
Mha	million hectares
Mha/yr	million hectares per year
MW	megawatt
NDC	nationally determined contribution
OECD	Organisation for Economic Co-operation and Development
PV	photovoltaic
RPV	rooftop photovoltaic
SAF	sustainable aviation fuel
t/ha	tonnes per hectare
TW	terawatt
TWh	terawatt-hour
ZEF	zero-emissions fuels

ENDNOTES

1. By the IEA's definition, clean energy investment includes renewable power, nuclear power, battery storage, electricity networks, clean fuels, fossil fuels with carbon capture and storage, end-use efficiency, and other end-use investments such as in electrification, renewables for end-use, hydrogen, and carbon capture and storage for industry.

2. The US Biden-era nationally determined contribution, which will be inactive upon formalization of the United States' withdrawal from the Paris Agreement, contributes the majority of these total emissions reduction projections. While subnational coalitions like America Is All In (2025) have announced their intention to fill the gap left by the US government, their action alone will likely not be enough to close it entirely.

3. A single year in which global temperature rise averages 1.5°C does not mean that the Paris Agreement's temperature goal has been breached or is no longer within reach. Depending on the method used, the long-term estimate of global average temperature rise is currently around 1.34°C–1.41°C (WMO 2025b).

4. Wind, solar, nuclear, geothermal energy, tide energy, wave energy, and bioenergy with carbon capture and storage (when limited to sustainable quantities—see Boehm et al. 2025—are zero-carbon technologies in their operation, as are battery electric vehicles, battery electric planes, battery electric ships, and green hydrogen if the electricity they use is generated from zero-carbon sources. Other technologies that contribute to reducing emissions, such as those that help improve energy efficiency or facilitate electrification, are described as low-carbon in this report. Technologies that rely on carbon capture, utilization, and storage to reduce emissions in the power and industry sectors (not including bioenergy with carbon capture and storage, a carbon removal approach) are also described as low-carbon.

5. This equivalency calculation was made using coal plant capacity data from GEM 2025a and electricity generation data from Ember 2025. The average coal-fired power plant (including those with multiple units) was 898 MW in 2024. This calculation assumes that total global electricity use remains the same from 2024 until 2030 and that the average capacity factor of coal-fired power plants remains the same over that time period.

6. This equivalency calculation assumes a football (soccer) pitch size of 0.714 hectares.

7. This equivalency calculation is based on a 100-gram serving of 80 percent lean beef that contains 248 kilocalories (USDA 2019). Following Searchinger et al. 2019, we assume actual consumption is 87 percent of retail-level food availability.

8. The largest direct air capture plant in development today is the Stratos plant in west Texas, which, when complete, is expected to capture 500,000 tCO_2/year.

9. The IPCC developed its category of "no or limited overshoot" pathways in its *Special Report on Global Warming of 1.5°C*. The IPCC's recent AR6 Working Group III report uses the same definition for its category C1 pathways, which are defined as follows: "Category C1 comprises modelled scenarios that limit warming to 1.5°C in 2100 with a likelihood of greater than 50 percent, and reach or exceed warming of 1.5°C during the 21st century with a likelihood of 67 percent or less. In this report, these scenarios are referred to as scenarios that limit warming to 1.5°C (>50 percent) with no or limited overshoot. Limited overshoot refers to exceeding 1.5°C global warming by up to about 0.1°C and for up to several decades." The report also notes that "scenarios in this category are found to have simultaneous likelihood to limit peak global warming to 2°C throughout the 21st century of close to and more than 90%" (IPCC 2022b).

10. Note that, while the IPCC treats agriculture, forestry, and other land uses as one sector, this report splits it into two sections: forests and land, as well as food and agriculture, given the number of indicators in each section.

11. Although we did not systematically consider equity or biodiversity in our target selection, we did apply additional criteria like environmental and social safeguards wherever feasible and appropriate. See Boehm et al. 2025 for more details on the specific safeguards we considered and for a more thorough discussion of the report's limitations.

12. We collected historical data for each indicator, relying on datasets that are open, independent of bias, reliable, and consistent. We strove to use the most recent data, but there is often a time lag before data become available (between one and three years for most indicators, but up to six years for some). As a result, the year of most recent data varies among indicators. In some cases, data limitations prevented us from evaluating the current level of effort made toward a particular target, and we note this accordingly. Note that for the indicators with targets presented as a range, we assessed progress based on the midpoint of that range—that is, we compared the historical rates of change to the rates of change required to reach the midpoint.

13. For acceleration factors between 1 and 2, we rounded to the 10th place (e.g., 1.2 times); for acceleration factors between 2 and 3, we rounded to the nearest half number (e.g., 2.5 times); for acceleration factors between 3 and 10, we rounded to the nearest whole number (e.g., 7 times); and we noted acceleration factors higher than 10 as >10.

14. See Boehm et al. 2025 for additional details on each indicator's likelihood of following an S-curve.

15. This number includes GHG emissions from electricity and heat, but heat is not part of the power sector and is not covered in this section. Heat includes GHG emissions from the burning of fossil fuels in heat plants to provide heating to industrial processes, such as steel production, and district heating for large buildings. Heat production accounted for approximately 15 percent of electricity and heat emissions on average between 1998 and 2019. We are unable to separate electricity emissions from heat emissions while still being able to disaggregate electricity emissions into subsectors in Figure 3. Therefore we present electricity and heat together, assuming that the trajectory is broadly indicative of electricity emissions.

16. For end-use sectors such as industry, buildings, and transport, purchased power is considered to be a source of indirect emissions.

17. In the transport sector, the shift from internal combustion engine vehicles to electric vehicles will reduce emissions through efficiency gains alone, even if the electricity mix does not change. Shifting the electricity mix to zero-carbon power would increase these emissions reductions.

18. Our targets for reduction of fossil fuels in the power sector focus on coal and gas power, because only 4 percent of power sector emissions come from other fossil fuels such as oil (Ember 2025). Oil must also be reduced in electricity generation, but most of the efforts needed to reduce oil will be in other sectors, such as transport.

19. Additional zero-carbon power sources include geothermal energy, tide energy, wave energy, and bioenergy with carbon capture and storage (BECCS). Notably, the scenarios from which CAT 2023 derived the targets used in our zero-carbon power indicator, as well as historical data from Ember 2025, also include electricity generation from biomass without CCS. While bioenergy without CCS is technically not zero-carbon (due, for example, to land use–related emissions that occur during production of bioenergy), we were unable to exclude it from our zero-carbon targets. Bioenergy without CCS will only be a marginal part of the decarbonization of the power sector. In the Intergovernmental Panel on Climate Change scenarios assessed as part of CAT's target-setting exercise, bioenergy remains under 2 percent of generation in a decarbonized power sector, with the majority being used for BECCS. Even when it comes to BECCS, there are constraints on the amount of biomass feedstock that can be used within sustainable limits. Our targets limit use of BECCS to five gigatonnes of carbon dioxide per year in 2050 in total across both the power sector and other sectors (e.g., liquids production or BECCS in industry). See Boehm et al. 2025 for more information about the sustainability criteria used in target-setting.

20. Data from Ember 2025 were accessed on August 26, 2025.

21. In the Net-Zero Emissions scenario prepared by the International Energy Agency (IEA), zero-carbon power sources make up approximately 70 percent of the electricity mix in 2030 (IEA 2024i). This is substantially less than our 88–91 percent target; the discrepancy arises because the IEA assumes higher levels of electrification in other sectors than our targets as well as lower levels of renewables. Despite the difference, even if we used the IEA's targets rather than our own for our assessment of progress for the share of zero-carbon power, global progress would still remain well off track.

In our previous report (Boehm et al. 2023), the share of zero-carbon sources in electricity generation was categorized as off track, while in this report it is considered well off track (Appendix C). Zero-carbon power continues to grow as a share of electricity generation, but the average growth rate remains at 2 percent annually. While this is promising, it is still not enough; 2 percent annual growth is not an improvement from the situation two years ago when Boehm et al. 2023 was published, and now there are fewer years remaining until 2030, so the acceleration needed to meet the 1.5°C-aligned 2030 targets continues to steepen.

22. The methodology used by CAT 2023 to calculate a 1.5°C compatible benchmark for the share of coal yields a range of 0–1 percent in 2040. According to CAT, the range was 0.1 to 0.5 percent, but the 0.5 percent was rounded to the nearest percentage. Ultimately, CAT 2023 set 0 percent as the final benchmark for 2040, which this report uses. This is because some models can exhibit a bias against complete decarbonization, leading to small tails in long-term fossil fuel consumption due to model structure (Kaya et al. 2017). In reality, when the share of coal in the power mix has fallen to as low as 0.1–0.5 percent, the remaining tail of coal generation could be phased out by incrementally higher deployment of renewables.

23. This indicator tracks unabated fossil gas, which means fossil gas without carbon capture and storage. It is important to note that the models used for determining targets in this report show that gas with carbon capture and storage only plays a minor role in the decarbonization of the power sector, making up 0.1 percent of global power generation in 2030 and 0.5 percent in 2050 (CAT 2023). See Boehm et al. 2025 for a more comprehensive overview of how targets for this indicator were developed.

24. Carbon intensity of electricity generation is unaffected by changes in overall electricity demand. It is important to also track the power sector's total emissions to measure if overall electricity demand is increasing faster than the emissions intensity is falling.

25. Achieving below-zero carbon intensity implies the use of biomass power generation with carbon capture and storage (BECCS). Our targets limit BECCS to five gigatonnes of carbon dioxide per year in 2050 in total across both the power sector and other sectors (e.g., liquids production or BECCS in industry). See Boehm et al. 2025 for more information about the sustainability criteria used in target-setting.

26. The G7 includes Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The G7 communiqué also includes a watered-down alternate to the 2035 goal of phasing out coal-fired power plants, saying that countries could phase out coal plants "in a timeline consistent with keeping a limit of a 1.5°C temperature rise within reach, in line with countries' net-zero pathways," which may give leeway to countries without firm national-level commitments to phase out coal more slowly.

27. Embodied emissions stem from the production and transportation of materials that are used to construct and furnish buildings (Boehm et al. 2023). Globally, embodied emissions from the construction of new residential and commercial buildings account for about 2.6 $GtCO_2$ (ETC 2025). Some of these embodied emissions are accounted for in other sectors of this report, including transport and industry.

28. "Operational emissions" in buildings refers to those that occur from activities within the building over the building's lifetime, such as emissions from heating, cooling, powering of electronics or appliances, ventilation, and others. Operational emissions include both direct and indirect emissions (Boehm et al. 2022).

29. Cooling is the fastest growing source of operational energy use in buildings, with demand expected to more than double across the world by 2050 (UNEP 2025; ETC 2025). Implementing minimum energy efficiency standards, overall technological energy efficiency advancements for air conditioners, as well as the adoption of passive cooling techniques (e.g., painting roofs white to reduce heat absorption) will be crucial to reduce cooling energy needs (ETC 2025).

"Building envelopes" refers to the parts of the building that separate the indoors from the outdoors, including windows, roofs, exterior walls, and building foundations (IEA n.d.b).

30. Decarbonizing electricity generation rapidly will be crucial to offset the growing demand for cooled floor area (UNEP 2025; ETC 2025).

31. "Deep retrofits" refers to the upgrading of the building envelope and systems in order to meet zero-carbon standards (CAT 2025a).

32. Examples of energy efficiency improvements include upgrading insulation to improve heat retention or painting building facades in light colors to reflect sunlight and reduce heat absorption. Examples of shifts to cleaner technologies include installing efficient electric cookers or heat pumps to replace fossil fuel–based cooking and heating.

33. Heat pumps are an efficient, electric-powered technology, fundamental to decarbonizing both heating and cooling in buildings. Building to zero-carbon specifications will be crucial to limit warming to 1.5°C and to avoid energy-specific retrofits in the future. Such retrofits would entail higher costs than building to zero-carbon specifications from the start (CAT 2020a; Currie & Brown 2019; IEA 2020b).

34. Another study found that less than 1 percent of new and existing buildings were zero-carbon ready in 2022; however, that includes the construction of new buildings and deep renovations of existing buildings so does not directly compare to the 2020 value (IEA 2024h).

35. China, with a 12 percent increase, was the only major market where sales grew (IEA 2024c).

36. While nonbinding, the directive prioritizes accelerating renovation rates and provides a framework for Member States to align national laws with EU-wide energy performance objectives (European Commission 2024b).

37. Several countries have developed and published climate action roadmaps for buildings and construction, which are meant to guide national and subnational buildings decarbonization efforts while also setting targets. Many of such roadmaps follow the "Guidance for Climate Action Roadmaps in Buildings" methodology developed by the UN Environment Programme, GlobalABC, and the UN Office for Project Services, who as of 2024 have supported the development of 32 roadmaps (UNEP 2025). Türkiye also strengthened its regulations, requiring new buildings to meet the Nearly Zero-Energy Buildings requirements; buildings must have an energy performance class B and source at least 10 percent of their primary energy demand from renewable sources (IEA 2024b; Bayraktar et al. 2023).

38. Building codes—regulatory instruments that set energy efficiency standards—are a key tool to curb energy consumption and therefore operational emissions in residential and nonresidential buildings (UNEP 2025). Such codes most commonly include energy efficiency requirements but may also promote renewable energy adoption and other innovative technologies; they are often accompanied by compliance mechanisms to ensure adherence to the code. In about 80 percent of the 85 countries with national building energy codes, those codes are mandatory, although many are outdated and in need of updating to reflect technological advances (UNEP 2025).

39. GHGs released by fuel combustion include fuel combustion for energy needed for heating processes in manufacturing. Those released by industrial processes are also known as process emissions, which originate from chemical reactions inherent to production processes rather than from burning fossil fuels for energy.

40. Process emissions accounted for 44 percent of direct emissions.

41. It is important to note that, while other industries such as chemicals, food and beverages, glass, and aluminum are not tracked in this report, addressing their emissions is also needed to fully decarbonize the sector.

42. Use of green hydrogen will likely need to be prioritized across various industries (e.g., in chemicals and steel). Liebreich (2023) provides a framework to approach this.

43. The carbon intensity of cement indicator is based on data from the Global Cement and Concrete Association (GCCA), which tracks progress in the cement and concrete sector and has developed a sector-specific Net Zero Roadmap to 2050. Cement-related targets used in this report are determined independently and may not align with those in the GCCA roadmap.

With current technologies, it is likely impossible to achieve zero emissions in the cement sector, and any remaining emissions will need to be addressed with technologies such as carbon capture, utilization, and storage.

44. Clinker accounts for 85 percent of cement's emissions (US DOE 2023). Clinker substitution involves lowering the amount of clinker in cement and replacing it with supplementary cementitious materials (SCMs), which include slag, fly ash, calcined clay, and more.

45. Performance-based standards could advance alternative cements that use different chemical reactions that do not generate process emissions to create cement.

46. Achieving net-zero emissions in the global steel sector will likely require addressing remaining, or residual, emissions that cannot be mitigated with current technologies.

47. Historical values for carbon intensity of steel production are from the World Steel Association, which has updated its calculation methodology to estimate carbon intensity values. The updated methodology has been applied to carbon intensity values after 2021 (World Steel Association 2024a).

48. Examples of low-carbon steel production technologies include green hydrogen–based direct reduced iron to electric arc furnace (H2 DRI-EAF) and iron ore electrolysis (Boehm et al. 2023). While the shift to low-carbon technologies along with more use of scrap is needed, scrap is limited in quantity, and conventional steelmaking will thus likely continue to represent a large share for several years. Accordingly, it is also important to reduce emissions from conventional steelmaking (e.g., by partially replacing coal with low-carbon fuels).

49. Global hydrogen demand was 97 Mt in 2023 and was almost entirely met by hydrogen produced from unabated fossil fuels (IEA 2024d).

50. Calcined clay is a type of supplementary cementitious material that can be used to reduce the amount of clinker in cement and can achieve up to 30–40 percent reduction in cement emissions (Scrivener et al. 2018).

51. Projects using technologies that signal moving away from conventional steelmaking technology (e.g., green hydrogen-based direct reduced iron) are considered here as low-carbon steel projects. Decarbonization projects that complement conventional steelmaking (such as using CCS in blast furnace–basic oxygen furnace setups) are not included here.

52. Increased access to mobility services for moving both people and goods—including through shared transit networks and personal vehicles—will be particularly critical in populations that currently lack access to reliable transportation networks. "Avoid"-based measures in particular may be of greater relevance in wealthier populations with greater preexisting access to nearby jobs, goods, and services.

53. Teleworking or virtual participation may not be feasible in communities that rely on blue-collar manufacturing jobs and the informal sector (IRENA 2025b).

54. In past reports, we included an indicator to track the number of kilometers of high-quality bike lanes per 1,000 inhabitants. However, because it is difficult to identify targets for this indicator that are explicitly aligned with a 1.5°C pathway, we exclude consideration of this indicator from this year's report.

55. This indicator tracks rapid transit infrastructure in the 50 highest-emitting agglomerations (large, densely populated areas consisting of a city and its surrounding suburbs and towns) identified by Moran et al. 2018.

56. Battery electric light-duty vehicles, as well as plug-in hybrid and fuel cell electric options, are included in the share of electric vehicles in LDV sales.

57. In Boehm et al. 2023, the share of electric vehicles in light-duty vehicle sales was categorized as on track. The light-duty EV sales share continues to grow rapidly, but not quite as fast as previously. Growth of 63 percent in 2020, 111 percent in 2021, and 61 percent in 2022 has subsided to 20 percent growth in 2023 and 22 percent in 2024 (Appendix C). While continued growth in the light-duty EV sales share points to a fundamental shift toward EVs in the medium term, time is running out to meet the ambitious short-term target for 2030.

58. Battery electric light-duty vehicles, as well as plug-in hybrid and fuel cell electric options, are included in the share of electric vehicles in the total LDV fleet.

59. Global internal combustion engine turnover rates are poorly quantified, with little data available to track trends. But, even if EV sales follow a 1.5°C-compatible pathway, the existing internal combustion engine vehicle fleet will continue to release emissions. Existing internal combustion engine vehicles will need to be taken off the roads at accelerated rates if road transport emissions are to fall sufficiently (CAT 2024; Morfeldt et al. 2021).

60. In past reports, we included an indicator to track the share of electric vehicles in two- and three- wheeler sales. However, because these vehicles contribute a relatively low share of total road transport emissions

(IEA 2020a), we exclude consideration of this indicator from this year's report. For similar reasons, we omit consideration of indicators that track other relatively low contributors to total global road transport emissions, including light-duty commercial vehicles (or vans below 3.5 tonnes) and rail (IEA 2020a).

61. Battery electric buses, as well as plug-in hybrid and fuel cell electric options, are included in the share of electric vehicles in bus sales.

62. In Boehm et al. 2023, the share of electric buses in bus sales was categorized as moving in the wrong direction. Our recategorization in this report is a result of updated historical data for years before 2023 and new data for 2023 and 2024 provided in IEA (2025k) (Appendix C). Collectively, these data updates show a relatively flat linear trajectory over the last five years, but no longer movement in the wrong direction entirely.

63. Sustainable aviation fuel includes power-to-liquid synthetic fuels and advanced biofuel, such as that produced from nonfood or nonfeed alternatives that do not compete with food production for water and land (Searchinger et al. 2019; Lashof and Denvir 2025). In the future, alternate aviation fuel will need to be made from waste biomass, carbon captured from the atmosphere, and clean hydrogen as feedstocks.

64. While the sector is making progress, it is not evenly distributed geographically, with only a few airlines and airports, mostly based in Europe and North America, having increased their consumption of SAFs significantly (Transport & Environment 2024).

65.This indicator tracks industry-defined "scalable" zero-emissions shipping fuel that is producible with GHG intensity reductions of 90–100 percent relative to incumbent fossil-based fuels on a full life-cycle (well-to-wake) basis, including green ammonia and e-methanol. Following conventions established in Baresic et al. 2024, this excludes biofuels, less-polluting fossil fuels (including liquified natural gas), blue fuels (i.e., those derived from fossil fuel sources, such as hydrogen produced from natural gas), or applications of carbon capture.

66. This indicator is new to the *State of Climate Action* series this year. It includes all end-use fossil fuels within its scope, including oil, natural gas, and electricity dependent on upstream fossil fuel usage.

67. In addition to reducing emissions and air pollution in Dakar, which is seven times higher than WHO-recommended levels, this infrastructure investment is estimated to carry 300,000 passengers a day, reduce average travel times from 95 minutes to 45 minutes, make 170,000 new jobs accessible, and ensure that 59 percent of all job opportunities in Dakar are reachable in an hour or less (Chen et al. 2023a). However, ex-ante assessments of transport projects can at times reflect overly optimistic projections (Flyvbjerg et al. 2004), so ex-post data will be critical for assessing the long-term impact of this project.

68. Over half of public transit trips in Latin America and the Caribbean, a large share of trips in South and Southeast Asia, and as high as 95 percent of trips in sub-Saharan Africa are made by semiformal and informal transit services (Kustar et al. 2023).

69. While this development is a step in the right direction, the compromised outcome that was ultimately agreed allows for substantial flexibilities that may diminish the full-intended effectiveness of the policy and omits equitable transition considerations pushed for by small island developing states during negotiations (Transport & Environment 2025a).

70. Direct human activities (e.g., deforestation or reforestation), indirect human activities (e.g., more frequent and severe climate impacts like wildfires or increasing CO_2 fertilization), and natural effects (e.g., climate variability due to El Niño and La Niña) all contribute to emissions and removals across the world's land. Scientists have developed several approaches—including those employed by global bookkeeping models, dynamic global vegetation models, and national greenhouse gas inventories—to try to distinguish human-caused emissions and removals from those that occur naturally. But each approach disentangles these fluxes differently. Global bookkeeping models, for example, consider CO_2 fluxes from direct human activities on managed lands only when estimating net anthropogenic emissions from LULUCF, while dynamic global vegetation models account for fluxes from indirect human activities and natural effects on both managed and unmanaged lands when quantifying the world's land sink. Both approaches contribute to the annual *Global Carbon Budget*, which reports these human-caused and natural fluxes separately. National greenhouse gas inventories, in contrast, approximate net anthropogenic CO_2 emissions from LULUCF as CO_2 fluxes from direct and indirect human activities, as well as natural effects, on managed lands. Consequently, national greenhouse gas inventories include a greater share of the land sink in their estimates of net anthropogenic CO_2 emissions from LULUCF than global bookkeeping models (IPCC 2022b; Grassi et al. 2023; Friedlingstein et al. 2025).

71. This report, specifically, relies on four global bookkeeping models, with supplementary data on emissions from peat drainage and burning, to estimate net anthropogenic CO_2 emissions from LULUCF (Friedlingstein et al. 2025). While no method is inherently preferable over another, this section follows the precedent set by the "Summary for Policymakers" in IPCC 2022b in reporting estimates of net anthropogenic LULUCF emissions from global bookkeeping models, which aligns with Grassi et al.'s (2023)'s suggested approach that analyses focused on mitigation efforts at the global level and relative to modeled emissions pathways present estimates of net anthropogenic LULUCF emissions from global bookkeeping models used in Friedlingstein et al. 2025.

Gross CO_2 emissions and gross CO_2 removals from wood harvesting and other forest management practices are presented separately to provide a more comprehensive snapshot of LULUCF's contribution to global GHG emissions. But the mitigation potential associated with improving wood harvesting and other forest management practices is limited, because these gross emissions and removals do not occur independently of one another. More specifically, decreasing the amount of wood harvested would reduce gross CO_2 emissions from the decomposition of logging debris and the decay of wood products, but it would also result in less forest regrowth following harvesting and, therefore, lower gross CO_2 removals from these newly planted trees.

72. While national greenhouse gas inventories report substantially lower net anthropogenic CO_2 emissions from LULUCF, this approach similarly finds that net anthropogenic CO_2 emissions have declined in recent decades, from -1.2 $GtCO_2$ in 2000 to -2.4 $GtCO_2$ in 2020 (Grassi et al. 2023).

73. "Land-based mitigation measures," or "land-based measures" in the "Forests and land" section of this report, focus on activities to protect, restore, and sustainably manage forests and other ecosystems. Land-based mitigation measures that focus on actions to reduce GHG emissions and enhance carbon removals across agricultural lands are discussed in the "Food and agriculture" section.

74. Following Roe et al. 2021, this report focuses solely on mangrove forests, rather than coastal wetlands more broadly.

75. While efforts are underway to develop datasets that approximate both grassland conversion and restoration (e.g., from Land and Carbon Lab), recently published literature used to quantify the land sector's contribution to 1.5°C (e.g., Roe et al. 2019, 2021) excludes mitigation potentials from which quantitative, time-bound targets can be derived for both of these land-based measures. Similarly, although the Food and Agriculture Organization of the United Nations publishes national-level statistics on the area of managed forests every five years, global datasets that map adoption of improved management practices across forests, as well as other ecosystems, are extremely limited.

76. More recent historical data on global mangrove losses are available in FAO 2023, but these data lack the temporal resolution needed to calculate an acceleration factor. More specifically, indicators with high interannual variability require at least 7 years of annual or nearly annual data within a 10-year period, but historical data from FAO 2023 are presented as annual averages over two 10-year periods and, therefore, are insufficient to assess progress. As such, we continue to present historical data from Murray et al. 2022.

77. While the area of histosols drained for agriculture represents a best available proxy for peatland degradation, these data may underestimate peatland degradation for several reasons. First, the data estimate drainage of histosols solely for agricultural activities, and although agriculture is a primary driver of peatland degradation globally, other causes of degradation—including road and infrastructure development, forestry, oil sands mining, and peat extraction, among others—are not included in the estimates (Conchedda and Tubiello 2020; UNEP 2022). Moreover, the threshold of peat depth used to define peatland varies by country, and some countries have yet to establish a nationally recognized definition of peat altogether (e.g., Myanmar, Lao People's Democratic Republic, Cambodia) (Sulaeman et al. 2022). In nations where this threshold is lower than the depth of organic material used to define organic soil in Conchedda and Tubiello 2020, peatland degradation may not be included in these estimates of drained organic soils. For example, if the threshold used to define peatlands is two meters of organic matter, but the threshold used to define organic soils is three meters of organic matter, then these peatlands would be excluded from this estimate of organic soils. As a result, the global extent of histosols is significantly lower than most recent estimates for peatland area (e.g., UNEP 2022), and estimates of the area of histosols drained for agricultural activities (25 Mha) are substantially lower than estimates of the global area of degraded peatlands (57 Mha) (Conchedda and Tubiello 2020; UNEP 2022).

78. "Tree cover gain" is defined as the establishment or recovery of tree cover (i.e., woody vegetation with a height of greater than or equal to five meters) by the year 2020 in areas that did not have tree cover in the year 2000 (Potapov et al. 2022a). See Boehm et al. 2025 for more information.

Data limitations pose significant challenges to monitoring reforestation globally, with remotely sensed data on the gross area of tree cover gain offering the best available proxy. However, these data may include tree cover gains that, although potentially beneficial to climate mitigation and biodiversity, do not meet common definitions of reforestation and would not constitute progress toward these 2030, 2035, and 2050 targets, such as afforestation across historically nonforested lands or regrowth after harvesting within already established plantations, and are therefore likely an overestimation of reforestation (Reytar et al. 2024).

79. A global assessment of progress that relies on historical data from FAO 2023 and employs methods from Boehm et al. 2021 still finds that efforts to restore mangroves are well off track, though the acceleration factor of 7 is lower than the >10 calculated from the data in Murray et al. 2022.

80. While agricultural emissions used in cross-sector comparisons in Figure 1 are sourced from Crippa et al. 2024, values used here and in the agricultural emissions intensity indicators are sourced from FAOSTAT 2025 due to the increased granularity of FAOSTAT's agricultural emissions categorization. While there are some differences in the data sources, including that FAOSTAT carbon dioxide equivalent values were calculated using global warming potentials from the IPCC's Fifth Assessment Report instead of Sixth Assessment Report, the overall sectoral emissions totals from both sources differ by only 8 percent.

81. Several other emissions sources related to food and agriculture are covered elsewhere in this report. To avoid double counting with other sections of this report, carbon dioxide emissions from fossil fuel combustion during the production of agricultural inputs (e.g., synthetic fertilizers), in conjunction with on-farm energy use, and throughout the food system (e.g., food processing, transport, and packaging) are covered in the "Power," "Industry," and "Transport" sections. Similarly, carbon dioxide and other emissions from land-use change and drained organic soils (or peatlands) are covered in the "Forests and land" section.

82. Emissions from the manufacturing of synthetic fertilizers, as well as those from synthetic pesticides, are accounted for in the "Industry" section of this report.

83. Agroforestry systems can sequester significant amounts of carbon, though global estimates of mitigation potential can vary greatly (Nabuurs et al. 2023) due to the complexity of agroforestry systems, combined with methodological differences, data limitations, and geographical variations. One recent analysis suggests a maximum mitigation potential of 3.3 Gt CO_2e/year (Sprenkle-Hyppolite et al. 2024).

84. The current data available to track global pastureland area are not differentiated into different types of pasturelands, including cultivated pastures, natural grasslands, rangelands, and bushland. This limitation makes it difficult to accurately assess changes in pastureland areas (especially to track expansion into high-carbon, biodiverse ecosystems) and their impacts on productivity and ecosystems. Additionally, FAOSTAT does not differentiate pasturelands for ruminant meat production from those for dairy production, which means these numbers do not perfectly capture productivity per hectare for ruminant meat only.

85. Food loss that occurs on farms (e.g., unharvested produce) is typically excluded from food loss and waste inventories, including those reported in the FAO Food Loss Index, due to measurement challenges as well as underlying differences in the nature of the data (Hanson et al. 2017). That said, preharvest food losses represent a significant additional source of emissions that could be measured and reduced moving forward (WWF-UK 2021), especially as climate change is expected to threaten crop yields given the projected increase in frequency of droughts and floods, as well as elevated pest and disease pressure (Mbow et al. 2019).

86. The Food and Agriculture Organization of the United Nations (FAO) published its first estimates of global food loss in its 2019 *Food Loss Index Report*, which estimated the share of food production lost globally in 2016.

87. The consumption of beef, pork, and poultry in high-income countries is almost six times the average intake in low-income countries (Resare Sahlin et al. 2020). In high-income countries, the cost of a diet that meets dietary guidelines comprises a smaller share of total household budget than in low-income countries, and most of the population can afford a healthy diet (Ambikapathi et al. 2022). By contrast, in many low-income populations with limited access to a diversity of foods, diets are based primarily on starchy staples, leading to protein and micronutrient deficiencies (Beal et al. 2017; Moughan 2021; Yilmaz and Yilmaz 2025). Animal-based foods are dense in easily absorbable protein and micronutrients, which can improve undernutrition in low- and middle-income countries, especially in South Asia and sub-Saharan Africa (Beal et al. 2023).

88. Northern Africa also saw a high annual average reduction from 2018 to 2022. While Northern Africa qualified as a "high-consuming" region, with an average ruminant meat consumption above 60 kcal/capita/day in 2017, per capita ruminant meat consumption decreased to about 60 kcal/capita/day in 2019 and has remained below that threshold since.

89. Novel CDR methods include direct air carbon capture and storage (DACCS), enhanced rock weathering, biochar, bioenergy with carbon capture and storage (BECCS), other biomass carbon removal and storage approaches like biomass burial and bio-oil injection, and marine CDR approaches like ocean alkalinity enhancement.

90. "Durability" refers to the duration of CO_2 storage. There is no agreed-upon definition of what duration of CO_2 storage counts as "durable," although most definitions range from at least 100 years (State of California 2023) to at least 1,000 years (Bennet 2024).

91. Data included in this report are sourced from the *State of Carbon Dioxide Removal* report, which provides a centralized estimate of removal across all technological approaches and is updated roughly annually. This data source replaces the manual data collection used in past *State of Climate Action* reports.

92. Some approaches can provide benefits with economic value, but these are generally not sufficient to spur the level of investment needed. Supply and demand need to be created by policy or other mechanisms.

93. The CRCF framework is aimed at improving quality of credits for permanent removals, carbon storage in products, and carbon farming (land or coastal management techniques that increase carbon sequestration). Certification under the CRCF is voluntary and will be granted for activities that meet the standards. As of 2025, an expert group is supporting development of methodologies under the CRCF.

94. While the US CDR Purchase Pilot Prize is not explicitly canceled, it appears stalled and unlikely to continue under this administration.

95. All climate finance target figures (global, public, and private) are expressed in constant 2023 US dollars (CPI 2025c; Bhattachayra et al. 2024). All historical climate finance figures, both in absolute and growth terms, are presented in nominal values, unless otherwise specified.

96. Public finance also supports fossil fuel production and consumption by influencing demand pathways that entrench fossil fuel dependency. For example, the failure to invest in high-density urban development and efficient public transportation limits access to clean mobility options, which can lock populations into continued reliance on personal internal combustion engine vehicles.

97. The $1.5 trillion figure is higher than the investments in fossil fuel supply figure presented in the ratio of investment in low-carbon to fossil fuel energy supply indicator because it goes beyond just supply and includes financial support in the form of production and consumption subsidies.

98. To track progress toward total public financing for fossil fuels, 10 years instead of 5 years were used to calculate linear trendlines to account for high interannual variability in this indicator's historical data, which can be attributed in large part to fluctuations in oil prices.

99. Carbon pricing targets are adjusted to 2024 US dollars.

100. The political resilience of carbon pricing is also connected to how the generated revenues are used. Some countries earmark funds toward developing low-carbon projects, while others primarily offset the price impacts through direct transfers to households (World Bank 2025; Funke and Mattauch 2018).

101. The BNEF study from which targets for this indicator are derived defines "low-carbon energy supply" as "low-carbon power supply (electricity generation, storage, transmission and distribution); hydrogen infrastructure and uses; carbon capture and storage (CCS); [and] fossil fuel-based electricity generation with abatement technology" (Lubis et al. 2022). Some technologies included within this definition (e.g., electricity supplied by wind, solar, nuclear, and some biomass) fit within this report's definition of "zero-carbon," whereas others (e.g., CCS) fit within this report's definition of "low-carbon."

102. The ratio range of 2:1 to 6:1 should be met across the 2021–30 decade.

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About Systems Change Lab

Systems Change Lab aims to spur action at the pace and scale needed to tackle some of the world's greatest challenges: limiting global warming to 1.5 degrees C, halting biodiversity loss and building a just economy. Convened by World Resources Institute and the Bezos Earth Fund, Systems Change Lab supports the Climate High-Level Champions and works with key partners and funders, including the Children's Investment Fund Foundation, Climate Analytics, ClimateWorks Foundation, Climate and Land Use Alliance, Global Environment Facility, Just Climate, Mission Possible Partnership, National Institute for Environmental Studies – Japan, Rocky Mountain Institute, Systemiq, UN Environment Programme World Conservation Monitoring Centre, the University of Exeter and the University of Tokyo's Center for Global Commons, among others. Systems Change Lab is a component of the Global Commons Alliance.

About Systems Change Lab's Partners

Bezos Earth Fund

The Bezos Earth Fund is helping transform the fight against climate change with the largest ever philanthropic commitment to climate and nature protection. Jeff Bezos has committed $10 billion to protect nature and address climate change. By providing funding and expertise, we partner with organizations to accelerate innovation, break down barriers to success and create a more equitable and sustainable world. Join us in our mission to create a world where people prosper in harmony with nature.

Climate Analytics

Climate Analytics is a global climate science and policy institute engaged around the world in driving and supporting climate action aligned to the 1.5°C warming limit. It has offices in Africa, Australia and the Pacific, the Caribbean, Europe, North America and South Asia.

Climate High-Level Champions

The Climate High-Level Champions, mandated at COP21 and appointed by COP Presidents each year, drive ambitious climate action by connecting the work of governments with the many voluntary and collaborative solutions provided by cities, regions, businesses, investors and civil society. This includes delivering the five-year plan of the Marrakech Partnership, in collaboration with the UN Climate Change secretariat and other partners, and flagship campaigns such as Race to Zero and Race to Resilience. Ms. Nigar Arpadarai and Mr. Dan Ioschpe serve as the current High-Level Champions for COP29 and COP30.

ClimateWorks Foundation

ClimateWorks Foundation is a catalyst for accelerating climate progress, driving bold solutions that benefit people and the planet. We connect funders and implementing partners worldwide to co-create and scale transformative solutions across sectors and geographies, achieving faster, greater impact together. Since 2008, ClimateWorks has granted over $2 billion to 850+ partners in more than 50 countries and in collaboration with 80+ funders.

World Resources Institute

World Resources Institute works to improve people's lives, protect and restore nature and stabilize the climate. As an independent research organization, we leverage our data, expertise and global reach to influence policy and catalyze change across systems like food, land and water; energy; and cities. Our 2,000+ staff work on the ground in more than a dozen focus countries and with partners in over 50 nations.

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