The Climate Action Monitor 2023

PROVIDING INFORMATION TO MONITOR PROGRESS TOWARDS NET-ZERO

OECD

The Climate Action Monitor 2023

PROVIDING INFORMATION TO MONITOR PROGRESS TOWARDS NET-ZERO

OECD
BETTER POLICIES FOR BETTER LIVES

Please cite this publication as:
OECD (2023), *The Climate Action Monitor 2023: Providing Information to Monitor Progress Towards Net-Zero*, OECD Publishing, Paris, https://doi.org/10.1787/60e338a2-en.

ISBN 978-92-64-59932-1 (pdf)
ISBN 978-92-64-83520-7 (HTML)

The Climate Action Monitor
ISSN 2958-1591 (online)

Photo credits: Cover design by Baseline Arts using images from © Shutterstock.com.

Corrigenda to OECD publications may be found on line at: www.oecd.org/about/publishing/corrigenda.htm.

Preface

This year is on track to become the hottest year on record, amplifying the frequency and intensity of extreme weather events. Greece and Canada had their worst wildfire season ever and the United States alone experienced 23 extreme weather events. We have seen devasting floods in Libya, Hong Kong, China and Brazil. Losses and damages from these events are estimated to have reached hundreds of billions of US dollars.

The need to act on climate change, in a way that is globally effective, is urgent and real. Climate impacts – and the risk of crossing irreversible tipping points – are increasing, foreshadowing the catastrophic changes to come should policy efforts fail. Indeed, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change shows that human-induced climate change is under way and accelerating, and that action to first achieve a peak and then a steep reduction in global emissions towards net-zero needs to rapidly accelerate, starting now.

The OECD's *Climate Action Monitor 2023* presents systematic and comprehensive data on the evolution of climate-related hazards, which confirm that climate impacts are accelerating and becoming more severe, leaving an increasing share of the world's population and land surface area exposed. These previously rare events are becoming more frequent and more intense. And they may compound existing economic and geopolitical risks.

Our efforts at the OECD are centred around five pillars drawing on the OECD's key strengths: 1) supporting policy pathways to net zero 2) enhancing adaptation and building resilience to climate impacts 3) mobilising finance, investment and business action 4) monitoring and measuring progress towards climate ambitions, and 5) multilateral and multi-disciplinary approaches to build co-operation.

Building on the OECD multidisciplinary competences, the International Programme for Action on Climate (IPAC) is providing comparable and harmonised information to monitor national climate action and global net-zero trajectories. It also supports countries by identifying best practices and providing a platform for dialogue. In doing so, IPAC helps participating countries to achieve their climate goals and to better co-ordinate their climate action to reach global objectives, and it complements and supports the United Nations Framework Convention on Climate Change and Paris Agreement monitoring frameworks.

This third *Climate Action Monitor*, a key publication of the IPAC, presents trajectories in greenhouse gas emissions, trends in climate-related hazards, and an assessment of the evolution of global climate action. It shows current greenhouse gas emission targets are well below the emission reductions necessary to achieve the Paris Agreement temperature goal, and the evidence presented in this report suggests that overall national climate action slowed in 2022 compared to the previous two decades.

More is needed to translate ambition into real actions and real outcomes by ensuring the effective implementation of national policies – and there is no time to waste.

Mathias Cormann

OECD Secretary-General

Foreword

The Climate Action Monitor provides a summary of climate action centred on 51 countries covered under the International Programme for Action on Climate (IPAC). It is directed towards policy makers and practitioners to give them a broad overview of trends in climate action.

IPAC was established in 2021 by the OECD Ministerial Council Meeting to support progress towards net-zero greenhouse gas (GHG) emissions and a more resilient economy by mid-century. It is overseen by the OECD Environment Policy Committee and is an integral part of the OECD's strategy to incorporate climate action into all its work, harnessing a multi-disciplinary and whole-of-economy approach.

To support these global objectives, IPAC provides governments, through an indicator dashboard and analytical reports, with information and tools to monitor, evaluate and assess climate action based on data published by official sources or otherwise validated by countries. However, information for all countries and policies is not yet fully available. The challenge in the coming years is to ensure a coherent, consistent, and comprehensive set of indicators that can support countries' policy choices to accelerate their transitions towards net zero.

The programme draws on a wealth of international climate-related data, indicators and research developed in partnership with the International Energy Agency (IEA), the United Nations Framework Convention on Climate Change (UNFCCC), the International Transport Forum (ITF), and the Nuclear Energy Agency (NEA), covering environmental, economic, and social dimensions of climate change. The information contained herein is based on the indicators developed by IPAC and on analytical work from the OECD and sister organisations.

This report was drafted by Rodrigo Pizarro, Abenezer Zeleke Aklilu, Hélène Blake, Amy Cano-Prentice, Mikaël J.A. Maes, and Daniel Nachtigall. It builds on data collection by Carla Bertuzzi, Mauro Migotto, Santaro Sakata, Andrzej Suchodolski, Pinhas Zamorano, David Winkler, and Su Min Park. The work was carried out under the supervision of Nathalie Girouard, Head of the Environmental Performance and Information Division in the OECD Environment Directorate. Natasha Cline-Thomas, Beth Del Bourgo and Amelia Smith provided communications and publication support. Lydia Servant ensured administrative support and formatted the final document.

The authors would like to thank OECD and IEA Secretariat colleagues for their helpful comments on a previous version of the paper, including Ben Henderson, Kilian Raiser, Simon Touboul, Roberta Quadrelli, Luca Lo Re, Dan Wetzel, Gabriel Saive, Sarah Barahona, Santaro Sakata, Carla Bertuzzi, Kathleen Dominique, Sarah Miet, Andrzej Suchodolski, Julia Wanjiru, and Frédérique Zegel.

Table of contents

Preface 3

Foreword 5

Reader's guide 9

Executive summary 13

1 How far are countries from achieving national and global mitigation objectives? 17

GHG emission targets 17
GHG emissions trends 22
GHG per capita and per unit of GDP emissions intensity 23
Consumption- and production-based emissions 25
Drivers of GHG emissions 27

2 What are the trends in climate-related hazards and disasters? 36

Societies' exposure to climate-related hazards 39
Economic losses from climate disasters 52

3 How has countries' climate action to meet emission targets progressed? 55

The number of adopted national climate policies and their stringency slowed in 2022 55
Climate action is increasingly diverging across countries over time 57
Climate action in international climate co-operation policies and cross-sectoral policies expanded marginally, but slowed down for sectoral policies 58
The relative importance of market-based instruments decreased in the last decade 60
Climate action of non-market-based instruments increased marginally in 2022 65
Countries should further strengthen climate governance and climate data 67
Climate action and the policy landscape 68

Glossary 70

Annex I. Data gaps, methodology and limitations 74

Chapter 1: How far are countries from achieving national and global mitigation objectives? 74
Chapter 2: What are the trends in climate-related hazards and disasters? 77
Chapter 3: How has countries' climate action to meet emission targets progressed? 79

References 83

Notes 95

Figures

Figure 1. IPAC analytical framework 11
Figure 2. OECD and OECD partner countries are not on the net-zero pathway 19
Figure 3. NDCs commit to higher emissions in some countries by 2030 20
Figure 4. 105 countries including the EU have or proposed net-zero pledges, but only 27 countries, accounting for 16% of GHG emissions, have these commitments in law 21
Figure 5. OECD countries are expected to reduce their emissions by 2030 but global emissions are expected to rise 23
Figure 6. Emissions per capita have decreased in the OECD but increased in OECD partner countries 24
Figure 7. Emission intensities of both OECD and OECD partner countries have decreased 25
Figure 8. OECD countries export emissions partly to OECD partner countries through imported goods 26
Figure 9. Most GHG emissions in OECD countries come from the energy sector 27
Figure 10. Most GHG emissions in OECD partner countries come from the energy and agricultural sectors 28
Figure 11. Energy supply is still reliant on fossil fuels, but the share is declining globally 29
Figure 12. The global sale of passenger cars peaked in 2016, and electric vehicle sales are rising 30
Figure 13. Reducing deforestation is key to achieving Paris Agreement goals 31
Figure 14. Emissions sources vary considerably across countries 32
Figure 15. In the OECD, GDP growth per capita is decoupled from GHG emissions per capita 33
Figure 16. Both GDP and emissions per capita have increased in OECD partner countries but the trends show relative decoupling 34
Figure 17. To achieve substantive and structural reductions in GHG emissions, the OECD must reduce material consumption and increase circularity 35
Figure 18. Key climate-related hazards and exposure domains 36
Figure 19. Global warming threshold estimates for global core and regional impact climate tipping points 38
Figure 20. Population exposure to hot days increasing across OECD and OECD partner countries 39
Figure 21. Population exposure to more than two weeks of hot days varies between OECD and OECD partner countries 40
Figure 22. Increasing extreme temperatures across southern Europe 41
Figure 23. Decreasing population exposure to icing days across OECD and OECD partner countries 42
Figure 24. Agricultural drought is worsening for a majority of OECD and OECD partner countries 43
Figure 25. Intensifying drought impacts across Central and South America 44
Figure 26. Increasing forest exposure to wildfire danger 46
Figure 27. Increasing extreme precipitation events across Southeast Asia 48
Figure 28. Population exposure to river flooding varies between OECD and OECD partner countries 50
Figure 29. Built-up area exposure to coastal flooding increased across OECD and OECD partner countries 51
Figure 30. Population in northwestern Europe and East Asia are particularly exposed to violent windstorms 52
Figure 31. Storms, floods, droughts, extreme temperatures and wildfires increasingly claim the largest economic losses 53
Figure 32. Overall, countries expanded climate action by only 1% in 2022 56
Figure 33. Climate action is diverging between OECD and OECD partner countries 58
Figure 34. Climate action in cross-sectoral and international policies marginally increased in 2022 59
Figure 35. Climate action in sectoral policies decreased in the electricity and industry sectors 60
Figure 36. Climate action on market-based policy instruments slowed down significantly 61
Figure 37. Very few countries price more than half of emissions above 60 EUR per tonne 62
Figure 38. Fossil fuel consumption subsidies reached a new record high of over USD 1 trillion in 2022 63
Figure 39. Public spending on clean energy-related RD&D is increasing 64
Figure 40. Policy mixes differ significantly across countries 65
Figure 41. Bans and phase-outs of fossil fuel assets have become increasingly popular 66
Figure 42. Most countries adopted climate actions related to targets and international co-ordination, but could strengthen action in governance and climate data 68

Boxes

Box 1. The OECD Pressure-State-Response model 10
Box 2. The ambition and implementation gap 21
Box 3. Climate tipping points 38
Box 4. Taming wildfires in the context of climate change 47
Box 5. Loss and Damage Fund 54
Box 6. Developing forward-looking indicators for climate-related hazards 78

Reader's guide

This is the third edition of *The Climate Action Monitor*. It is an annual publication by the OECD prepared by the International Programme for Action on Climate (IPAC) team that provides key insights on global climate action, building on the IPAC Dashboard of climate-related indicators as well as other OECD, IEA, ITF and NEA research and data. IPAC deliverables, including this report, complement and support the United Nations Framework Climate Change Convention (UNFCCC) and Paris Agreement monitoring frameworks by reviewing key trends and developments and assessing progress in countries' climate policies.

IPAC supports countries in making informed decisions and allows stakeholders to measure improvements more accurately. IPAC focuses on developing country-level indicators for 51 countries. The countries covered under IPAC are: all 38 OECD member countries (Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, United States), key partner economies (Brazil, People's Republic of China, India, Indonesia, South Africa), six prospective members (Argentina, Brazil, Bulgaria, Croatia, Peru, Romania), other G20 countries (Saudi Arabia) and Malta. While the Russian Federation is not an IPAC member, it is included in IPAC emission totals as part of IPAC's global monitoring effort.

This report presents data for countries covered under IPAC referred to collectively as OECD and OECD partner countries (which includes accession candidate countries), usually making an explicit distinction between the two. However, some indicators are not available for all countries and for all years covered. In such cases, the report will either highlight these gaps in the text or provide estimates to ensure comprehensive aggregates are presented. IPAC uses only official data for estimations and, as such, figures differ from other databases such as Climate Watch data. IPAC estimates are preliminary, and work is currently underway on statistical methods to fill data gaps. For instance, data gaps for annual GHG emissions from OECD partner countries were estimated based on a weighted average of trends of CO_2 emissions from fuel combustion and GDP growth, taking into consideration official data validated by countries as base values. Details on data availability and methodologies are provided in notes and the Annex.

The analytical approach of this report is based on an expanded conceptualisation of the OECD Pressure-State-Response (PSR) environmental indicator model (Box 1). The approach considers broad criteria that influence the effectiveness of countries' policy choices, such as constraints or barriers, potential social and economic impacts, and the external policy environment. As responses are not implemented in a policy vacuum, there may be positive and negative external conditions that impact their effectiveness. "Tailwinds" can help support policy responses. However, there may also be pushback for policy adoption and effectiveness associated with unfavourable external conditions ("headwinds"). For example, general economic conditions such as unemployment, debt-to-GDP ratio and other social inequalities, as well as countries' endowment of natural resources, including energy resources, are relevant when considering policy alternatives (Figure 1).

Over time, the set of IPAC data and indicators presented in *The Climate Action Monitor* will be broadened to support this conceptual approach, allowing for a more extensive analysis of the challenges and opportunities for policy makers as they adopt and implement different policy choices in the climate change sphere. This multidisciplinary lens is the principal contribution of the OECD to the climate change policy debate, given its broad experience in policy analysis and considering best practices.

Looking forward, IPAC will continue to construct extensive datasets for all covered countries and refine and develop indicators associated with this broader analytical perspective, thus supporting countries in making informed decisions to face the climate emergency in the context of their country-tailored policy approaches, institutional landscapes and economic and social realities.

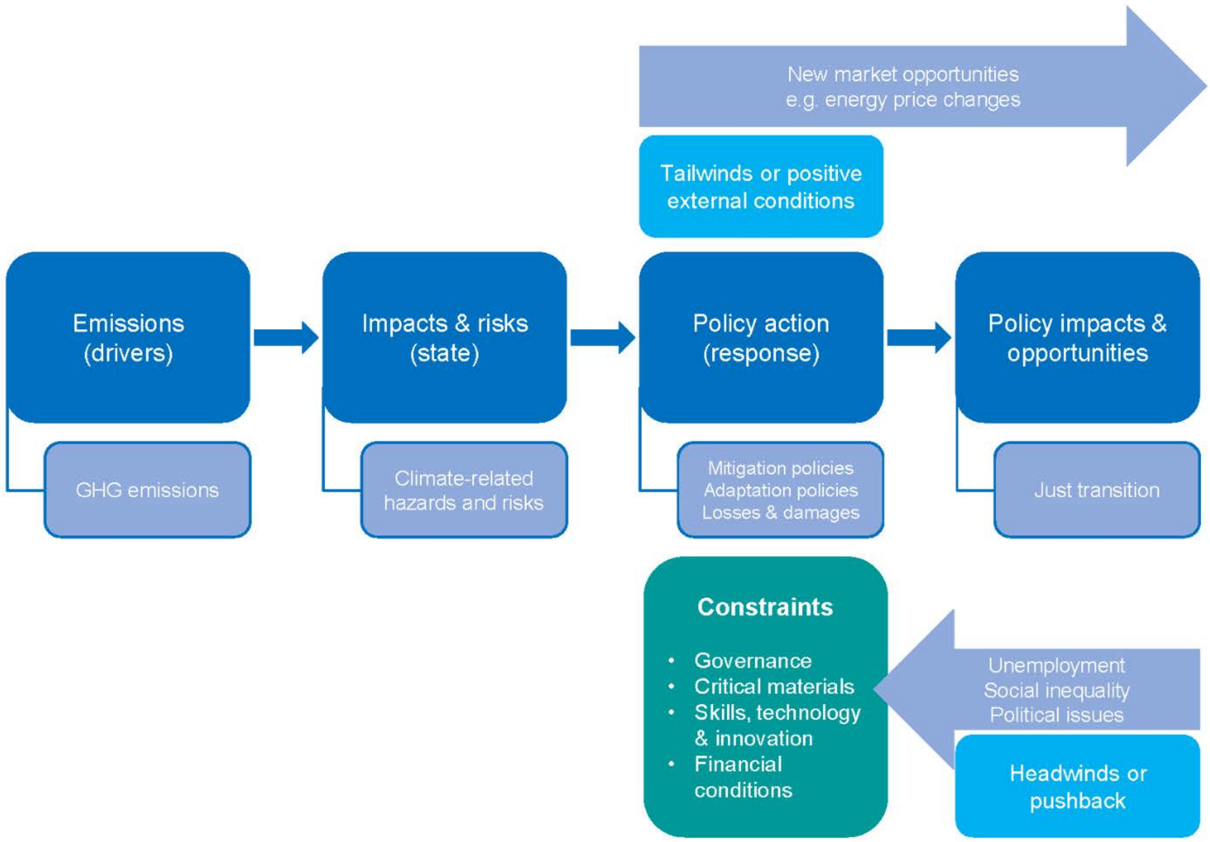
Box 1. The OECD Pressure-State-Response model

The Pressure-State-Response (PSR) model is a conceptual framework for impact analysis designed to facilitate the provision of relevant information for evaluating and analysing environmental management. The model, developed by the OECD and adopted by other international organisations, is based on the connection between environmental pressures, their impact, and associated policy responses.

The PSR model was designed based on the logical sequence of policy responses to the state of the environment. The model underscores that the state of the environment, and its direct pressures, ultimately depend on drivers associated with economic and social activities, such as transport, industry, population, and consumption patterns.

- Pressures on the environment: emissions of GHGs constitute the main cause or direct pressure that generates climate change.
- Drivers of climate change: drivers of environmental pressures are determined by production and consumption patterns as well as population growth.
- State of the environment: the condition of the environment is referred to as its “state”. In the case of climate change, it is typically described using essential climate variables, such as the concentration of the different GHGs and related variables. More generally, it is interpreted as the impact of climate change on humans, such as the increase in climate hazards, exposure and risk.
- Policy response: refers to direct and indirect policy responses to address climate change and its impacts. These policies can be focused on the drivers or pressures or the state and impacts. In the climate change policy sphere, response is grouped into mitigation and adaptation policies.

Figure 1. IPAC analytical framework



Source: Authors, based on the OECD Pressure-State-Response (PSR) model.

Executive summary

Climate impacts are rapidly intensifying and expanding

In 2023, the impacts of climate change have been dramatic worldwide. This year, the Earth experienced the hottest three-month period on record, with unprecedented surface temperatures and extreme weather events. Heatwaves, wildfires, floods, and hurricanes have raged across the globe, destroying lives and livelihoods.

Accelerating and unprecedented climate impacts are confirmed by OECD data. Systematic data on the evolution of climate-related hazards from countries covered under the International Programme for Action on Climate (IPAC), considering both OECD and OECD partner countries (including accession countries), confirm that climate impacts are accelerating and becoming even more extreme, exposing a greater share of the world's population and land surface area. The 2023 climate-related extreme events are consistent with long-term trends.

The population exposed to extreme temperatures is growing rapidly. An estimated 11.3% more people are exposed to days with maximum temperatures exceeding 35°C in OECD and OECD partner countries in the period 2018-22 compared to the reference period 1981-2010, reaching over half a billion people. As a result, in 2022, over 45% of the population in OECD and OECD partner countries experienced at least two weeks of extreme temperatures. Temperatures recorded this year attest to the continuation of this trend, which not only has direct impacts but can also intensify hazards such as hurricanes, heatwaves, droughts, and extreme rainfall, affecting vulnerable populations, ecosystems, and economic infrastructure.

Population exposure to tropical nights (above 20°C at night) is increasing. Twenty countries — out of 51 OECD and partner countries — experienced a 10% increase in the population exposed to tropical nights over the period 2018-22 compared to 1981-2010. Korea (28%), Italy (18%) and Greece (16%) had the highest increase in population exposed to more than eight weeks of tropical nights.

Agricultural droughts in OECD and partner countries are intensifying. Countries such as Argentina, Brazil and Romania have experienced an average fall in soil moisture of more than 6% in the last four decades (period comparison average 2018-2022 compared to 1981-2010). These drought conditions can be even more acute at the sub-national level and during specific seasons, generating additional social and economic impacts.

Wildfires have been raging at unprecedented scales with a record-breaking land area burnt this year. An increasing area of forest land is exposed to wildfires across the OECD and partner countries. Between 2000-2003 and 2019-2022, the percentage of forest exposed to wildfires increased from 15% to 18%.

Increasing mean temperatures alter rainfall patterns affecting agricultural production and increasing vulnerability. Six out of the ten countries across OECD and OECD partners whose cropland area is the most exposed to extreme precipitation events are also highly dependent on agriculture as a share of GDP. For example, the countries with the highest share of cropland are exposed to extreme precipitation events between 2018 and 2022 included Indonesia (31.6%), Colombia (13.2%), Costa Rica

(9.8%), Peru (8%) and Brazil (3.3%). This illustrates how climate change also threatens national and global food security.

Many countries are exposed to river and coastal flooding. Flooding events in 2023 were devastating and are likely to continue. Over 18% of the population of OECD and partner countries are exposed to the risk of river flooding. For some countries this can be as high as 40%. Similarly, over 2.6% of the population in OECD and partner countries are exposed to the risk of coastal flooding.

There is progress but more ambition and efforts are needed to achieve carbon neutrality by 2050

The Paris Agreement has been instrumental in increasing climate mitigation ambitions. 196 Parties have communicated their GHG mitigation commitments through NDCs and, as of September 2023, 105 countries have pledged a net-zero target, with 90 aiming to reach this target by 2050. Most targets are not legally binding, however. Net-zero targets cover about 83% of global GHG emissions, only 26 countries and the EU, representing 16% of global GHG emissions, have enshrined these into law.

NDCs' mitigation commitments fall below those need to meet Paris Agreement targets. The IPCC estimates that a global GHG emissions reduction of 43% by 2030 (from 2019) is necessary to be on track to achieve the Paris Agreement goal of limiting temperature to 1.5°C by the end of this century. However, OECD countries have committed to an estimated emissions reduction of 28% and OECD partner countries to an emissions reduction of 5% compared to their 2020 emissions. OECD and OECD partner countries need to increase their emissions reduction targets by, at least, an additional 30% in aggregate to achieve the projected reductions estimated by the IPCC necessary to reach the Paris Agreement goal and fill the "ambition gap".

The number of adopted national climate policies, tracked by the OECD, slowed in 2022

The growth rate of national climate actions adopted by both OECD and OECD partner countries only increased by 1% in 2022. By contrast, the average growth of adopted policies between 2000 and 2021 was 10%, as tracked by the IPAC Climate Actions and Policies Measurement Framework (CAPMF).

Policy coverage and policy stringency are not necessarily indicative of policy effectiveness in reducing GHG emissions. However, the slowdown in 2022 may pose a risk to countries' policy implementation. Countries still have multiple options to increase the stringency of existing policies or adopt new policies that are currently not widely used (e.g., carbon pricing in the building and transport sector, bans and phase-outs of fossil fuel extraction or fossil-based infrastructure).

The overall slowdown of climate action masks significant differences across countries and instrument types. For example, 22 OECD and 8 OECD partner countries – jointly accounting for 29% of global GHG emissions – intensified climate action in 2022. This increase was driven principally by new or enhanced net-zero pledges, strengthened regulatory measures, higher prices in most emissions trading schemes and small advances in international climate co-operation and international climate finance. The energy crisis provided further impetus for countries to adopt more ambitious targets on renewables and energy efficiency and to accelerate implementation.

Geopolitical and macroeconomic shocks, however, led some governments to backtrack on climate action. The energy crisis delayed or postponed planned climate actions such as carbon pricing and the phase-out of fossil fuel infrastructure. At the same time, countries ramped up fossil fuel support to new record levels, reaching over USD 1 trillion (1000 billion) in 2022. Some countries, notably in Europe, significantly reduced public expenditure for research, development and demonstration (RD&D) for low-carbon technologies.

Climate action is increasingly diverging across countries. Most OECD countries already had stronger policies in place and were able to accelerate climate action faster than OECD partner countries. Diverging climate action reinforces the need for more international co-ordination and co-operation on climate action. Otherwise, diverging climate action may increase risks of carbon leakage, therefore limiting the overall effectiveness of increased climate action.

The expansion of market-based instruments (MBIs) was substantially lower than that of other instrument types between 2000 and 2022, implying a continuous decrease of MBIs' relative importance in countries' policy mixes. Despite their potential to incentivise cost-effective emissions reductions, few countries strengthened MBIs, such as carbon pricing. While countries face challenges to implementing carbon pricing due to lack of public acceptability, proper design, such as revenue recycling, can boost public support for such schemes.

Looking ahead

Making progress towards the net-zero challenge demands ambitious mitigation targets and effective implementation, as well as navigating the policy landscape. It is crucial that climate policies are inclusive and cognisant of social and economic impacts. Countries will have to adapt their policies to ensure a just transition and that vulnerable households and communities are not disproportionately affected. Without identifying and understanding the full impact of these trends and events, it is difficult to assess the final impact of climate policy on mitigation outcomes.

The OECD horizontal project Net Zero+ explores how governments can build climate and economic resilience. IPAC is one of the project's components and considers these and other key challenges including skills shortages, the supply of critical minerals and other potential bottlenecks to a rapid and resilient net-zero transition.

1 How far are countries from achieving national and global mitigation objectives?

The Paris Agreement sets the goal of limiting global warming well-below 2ºC and resolves to pursue further efforts to limit global average temperature rise to 1.5°C. A further target is to achieve net-zero global GHG emissions or worldwide carbon neutrality in the second half of this century (UNFCCC, 2016[1]).[1] The basis of the Paris Agreement is a bottom-up approach where countries present commitments in nationally determined contributions (NDCs). NDCs present national GHG emissions targets and climate policies as pledges to progressively mitigate GHG emissions, enhance their adaptive capacity to climate change and, in some cases, address loss and damage caused by extreme climate events.

Drawing on data from the UNFCCC, IEA, and OECD, as well as indicators developed by IPAC, this chapter examines countries' commitments as well as their GHG emissions trends. The chapter highlights differences across groups of countries, assesses emissions trends based on indicators of emissions intensities, and discusses emissions sources and structural drivers.

The Paris Agreement has been instrumental in increasing climate mitigation ambitions. 196 Parties have communicated their GHG emissions mitigation commitments through NDCs, and, as of September 2023, 105 countries have pledged a net-zero target, with 90 aiming to reach this target by 2050 (https://www.oecd.org/climate-action/ipac/).

The implementation of these pledges has led to lower global GHG emissions than previously projected (UNFCCC, 2023[2]). This is still not enough, however, leaving what is referred to as an "ambition gap". Full implementation of NDCs presented in 2022 will achieve an estimated 2.4°C average temperature rise by the end of the century considering unconditional and conditional pledges, and a 2.6°C temperature rise considering only unconditional pledges (UNEP, 2022[3]). Moreover, the updated national pledges since COP26 (March 2023) make a negligible difference to predicted 2030 emissions (UNEP, 2022[3]).[2]

To stay on a path to the 1.5°C goal, global GHG emissions must be limited to 33 Gt CO_2e by 2030 and to 8 Gt CO_2e by 2050 – yet global emissions are projected to reach 58 Gt CO_2e by 2030 based on implemented policies assessed in 2022 (UNEP, 2022[3]).

GHG emission targets

Effective climate action relies on clear GHG emission targets and the operationalisation of a mitigation strategy. Although climate goals need to be delivered globally, in the context of the Paris Agreement framework the targets and measures designed to achieve them are set by governments at the national level.

The Paris Agreement covers 196 countries that together generate about 94% of global GHG emissions.[3] In 2020, OECD countries contributed just under a third of global emissions; G20 countries contributed about 70%. Countries covered under IPAC – which include, in addition to OECD and G20 countries, candidates for accession to the OECD, and Malta – generated around 74% of global emissions in 2020.[4] As such, tracking the IPAC country grouping, referred to in this report as "the OECD and OECD partner countries" provides a significant barometer of global climate action.

NDCs present mitigation targets using different approaches and scopes, reflecting countries' common but differentiated responsibilities and respective capabilities, as recognised under the Paris Agreement. Targets are often expressed in terms of percentage changes relative to the emissions level in a reference year or in a business-as-usual scenario, which makes a direct comparison of targets difficult across different base years and scenarios. Further, targets are adjusted as countries update their commitments, making it difficult to monitor progress in a harmonised manner and evaluate the implications for the Paris Agreement long-term temperature goal.

To facilitate the analysis (and comparability) of countries' mitigation targets, the OECD has developed a methodology translating 2030 NDC mitigation targets into physical amounts of GHG emissions and comparing them with historical emissions levels to express the difference between the target and current emission levels in a harmonised manner (OECD, forthcoming[4]).

The combined estimated unconditional physical GHG emissions targets for 2030 for the OECD and OECD partner countries is 29 900 $MtCO_2e$, according to NDCs submitted to the UNFCCC by 30 June 2023. This implies an emissions reduction commitment, between 2020 and 2030, of 4 600 $MtCO_2e$, or about 13%, compared to 2020 (and 17% compared to 2019), with OECD countries committing to emissions reductions of 28% and OECD partner countries of 5%.[5] [6]

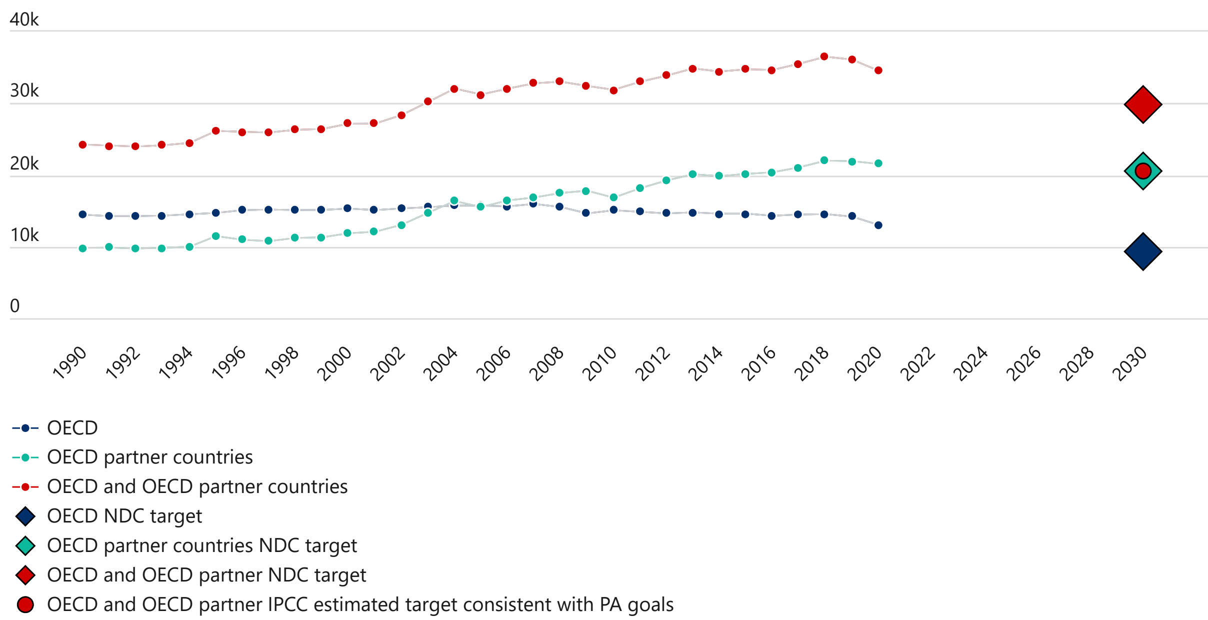
Complying with the Paris Agreement temperature goal requires reducing global emissions by 43% by 2030 compared to 2019 levels (IPCC, 2023[5]). If used as a benchmark for the OECD and OECD partner countries, this means that, in the aggregate, OECD and OECD partner countries' national targets fall short of this estimated amount by at least 9 315 $MtCO_2e$ (Figure 2). To fill the "ambition gap"[7], these countries would therefore need to reduce their aggregate emission target by about one-third, from 29 900 to 20 585 $MtCO_2e$. The ambition gap refers to the estimated maximum GHG emissions that can be emitted to achieve 1.5°C median pathway compared to the NDC unconditional target.[8]

In terms of contribution to global emissions reduction, OECD and OECD partner countries' commitments for 2030 imply a fall of global emissions of 12.5% compared to 2019, a very modest improvement from the 12% reported in *The Climate Action Monitor 2022* (OECD, forthcoming[4]; Climate Watch, 2023[6]).

Nevertheless, estimated trajectories of total global emissions from OECD and OECD partner countries (official estimates are not available) suggest that targets will not be achieved. Current policies are not consistent with achieving these goals – that is, there is an "implementation gap". In effect, global emissions are expected to increase by more than 10% by 2030 as compared to 2010 levels (UNEP, 2022[3]).[9] This implies that global emissions will surpass by about 24 300 $MtCO_2e$ the maximum estimated amount that can be emitted by 2030.

Figure 2. OECD and OECD partner countries are not on the net-zero pathway

Total emissions including LULUCF (1990 - 2020), NDC targets and IPCC estimated targets consistent with PA goals, OECD and OECD partner countries, $MtCO_2e$

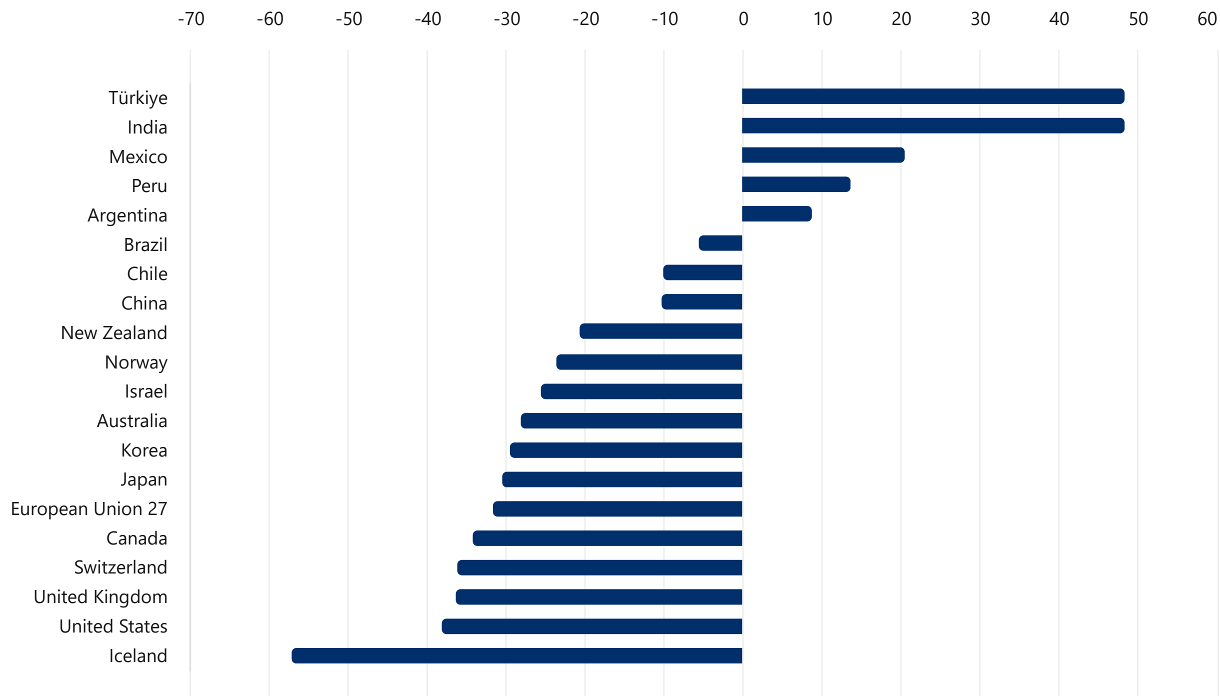


Note: Data gaps for OECD partner countries were estimated based on a weighted average of trends of CO_2 emissions from fuel combustion and GDP growth taking into consideration official data validated by countries. IPAC uses only official data (such as national inventories and biennial update reports submitted to the UNFCCC). The benchmark for calculating the OECD and OECD partner country aggregate target consistent with the Paris Agreement uses the estimate of the IPCC's Sixth Assessment Report.
Source: (OECD, 2023[7]), (OECD, 2023[8]), (OECD, 2023[9]), and countries' official reports submitted to the UNFCCC, https://unfccc.int/reports.

A few countries have committed to GHG emissions targets by 2030 that are higher than their current emissions levels. For example, India, Mexico, Peru, and Türkiye, which together account for 12% of GHG emissions from OECD and OECD partner countries, have committed to targets that imply an increase in GHG emissions compared to 2020 by an amount equivalent to 3% of OECD and OECD partner country emissions. Although it is important to recognise that countries have different development levels and conditions, achieving the Paris Agreement long-term temperature goal requires increasing ambition across all countries (Figure 3).

Figure 3. NDCs commit to higher emissions in some countries by 2030

Percentage difference between 2020 emission levels and 2030 targets, OECD and OECD partner countries

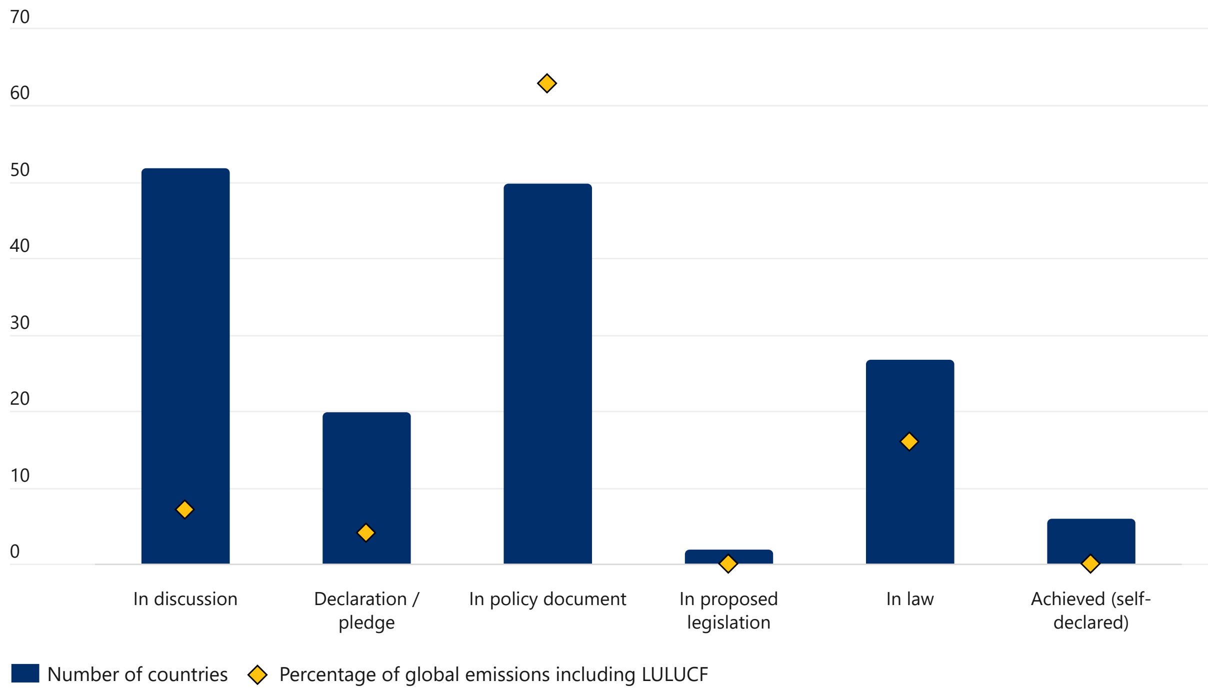


Note: Data gaps for OECD partner countries were estimated based on a weighted average of trends of CO_2 emissions from fuel combustion and GDP growth taking into consideration official data validated by countries. IPAC uses only official data. These are preliminary estimates and IPAC is currently working on the development of statistical methods to fill data gaps.
Source: OECD calculations based on (OECD, forthcoming[4]).

Beyond the 2030 targets, an increasing number of national and sub-national governments have made net-zero GHG emission pledges.[10] As of September 2023, IPAC identified 105 countries that have adopted or proposed net-zero targets, including the European Union, covering around 83% of global GHG emissions.[11] However, only 26 countries and the EU,[12] representing approximately 16% of global GHG emissions, have enshrined their net-zero targets into law (Figure 4). The rest of the countries have pledged net-zero targets either in their Long-Term Strategies, NDCs, or in speeches in high-level meetings such as the UNFCCC Conferences of the Parties (COPs).[13] Legally binding commitments ensure a long-term commitment to mitigation and the Paris Agreement temperature goal.

Figure 4. 105 countries including the EU have or proposed net-zero pledges, but only 27 countries, accounting for 16% of GHG emissions, have these commitments in law

Number of countries with a net-zero pledge by type and their percentage share in global emissions



Note: Net-zero targets, climate neutrality, carbon neutrality and zero carbon are all considered as a net-zero pledge. The EU commits to net-zero by 2050 for the whole EU region. To avoid double counting, emissions for individual EU countries that have adopted net-zero commitments are not considered, they are covered by total EU emissions identified in the bar "in law".
Source: OECD (2023), IPAC Dashboard, https://www.oecd.org/climate-action/ipac/dashboard.

Box 2. The ambition and implementation gap

Although countries have increased their mitigation commitments considerably, a discrepancy remains between emissions targets and the emissions reductions necessary to achieve the Paris Agreement temperature goal, this is known as the ambition gap. The IPCC's Sixth Assessment Report estimates that an additional reduction of 43% of emissions is necessary between 2019 and 2030 to achieve the Paris Agreement temperature goal. The ambition gap estimates are based on the maximum GHG emissions that can be emitted to achieve a 1.5°C median pathway and on unconditional NDCs.

Moreover, even the emission reduction goals presented in NDCs may not be achieved. That is, the policies in place are insufficient to achieve these targets—the implementation gap. To estimate the implementation gap, it is necessary to assess countries' emissions trajectories and the effectiveness of different mitigation approaches. The OECD is leading a major initiative to assess policy effectiveness and determine emissions trajectories for participating countries (See https://www.oecd.org/climate-change/inclusive-forum-on-carbon-mitigation-approaches/).

New net-zero pledges in international aviation and shipping

Important global sectoral developments include the 2022 adoption of a net-zero carbon emissions goal for international flights by 2050 by the international aviation industry, and in 2023 a pledge to reach net-zero emissions 'by or around 2050' by the international maritime sector.[14] [15] Both sectors jointly account for roughly 4% to 5% of global GHG emissions, and each account for 2% of global energy-related CO_2 emissions (IEA, 2023[10]).

Member states of the International Maritime Organisation (IMO) revised their GHG targets in 2022 to collectively reduce emissions by at least 20% by 2030 (but striving for 30%) and at least 70% by 2040 (but striving for 80%). Members of the International Civil Aviation Organisation (ICAO) revised downwards the emissions baseline of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – the major global market-based policy instrument to curb emissions from international aviation – from 100% to 85% of 2019 emissions. As of 2022, 42 OECD and OECD partners participate in CORSIA. These are important steps towards addressing global emissions outside the scope of NDCs and jurisdiction of individual countries. However, GHG emissions from aviation strongly rebounded after the COVID-19 pandemic (Clarke et al., 2022[11]). In fact, 6 July 2023 was the busiest day of commercial aviation ever recorded in history.[16]

GHG emissions trends

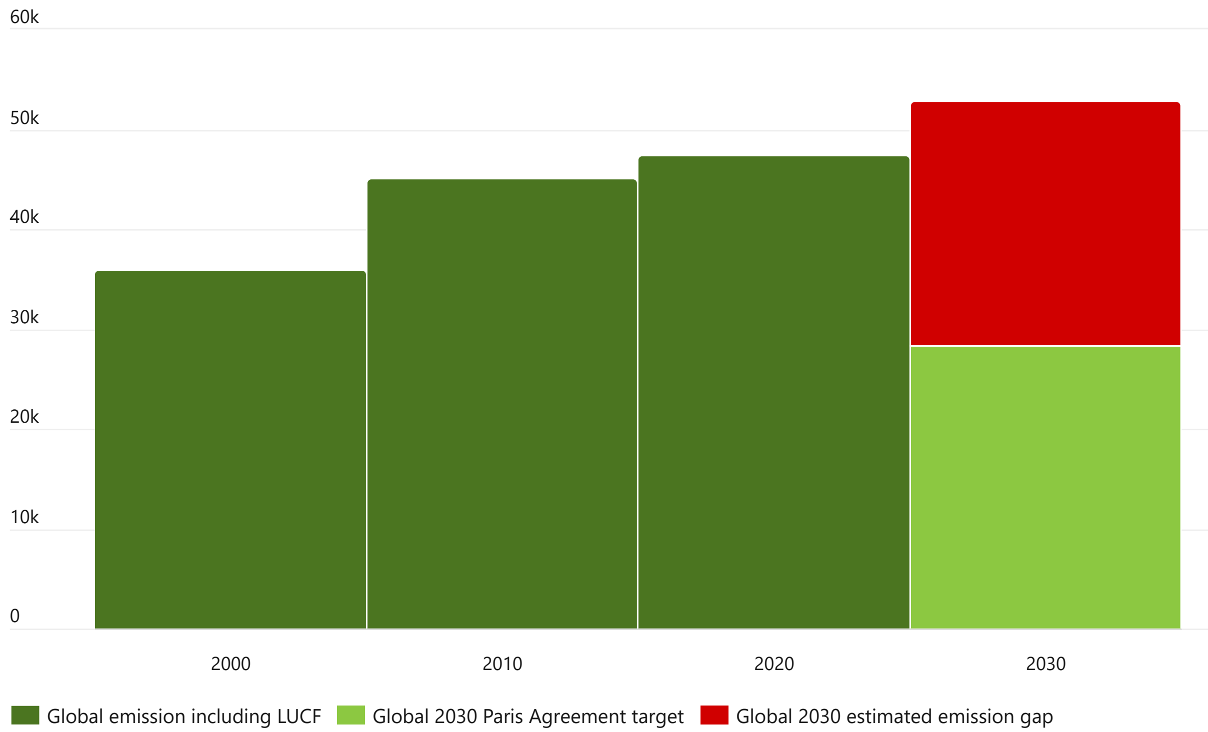
OECD countries' net GHG emissions (including LULUCF) have been gradually falling since peaking in 2007 (Figure 2). OECD countries' net emissions fell by 15% between 2007 and 2021, and by 10% since 2010, reaching 13 600 $MtCO_2e$ in 2021. This is partly due to a slowdown in economic activity following the 2008 economic crisis, but also thanks to strengthened climate policies (OECD, 2023[12]).

Progress varies considerably across countries. Between 2010 and 2021, net emissions of large OECD emitters, i.e. the United States, the European Union and Japan decreased by 11%, 15%, and 9% respectively (compared to the previous edition of *The Climate Action Monitor*, where emissions reductions between 2010 to 2020 were 17%, 20% and 11% respectively).[17] However, to achieve their respective emission targets, these emitters would need to further accelerate climate action and reduce emissions from 2021 levels by 42%, 35% and 32% respectively.

Meanwhile, 14 countries have increased their net emissions (including LULUCF) from 2010 to 2020. Emissions in large-emitting countries such as Brazil, the People's Republic of China (hereafter "China"), Indonesia and India are still rising and have not yet reached their expected peak. Emissions increases in 2020 are estimated at 34% in China and 37% in India compared to the 2010 levels.[18] Countries will have to reduce their emissions considerably over the next ten years to achieve the Paris Agreement targets (Figure 5). For data on individual countries see the IPAC Dashboard.

Figure 5. OECD countries are expected to reduce their emissions by 2030 but global emissions are expected to rise

Total emissions 2000-2020 and 2030 target, $MtCO_2e$



Note: (UNFCCC, 2022[13]) estimates global emissions accounting for NDC targets to be 53 700 $MtCO_2e$ by 2030. OECD estimated 2030 emissions using 2023 updated NDCs that reduced NDC targets to 52 870 $MtCO_2e$.
Source: Climate Watch (2023) Washington, DC: World Resources Institute, https://www.climatewatchdata.org/ghg-emissions.

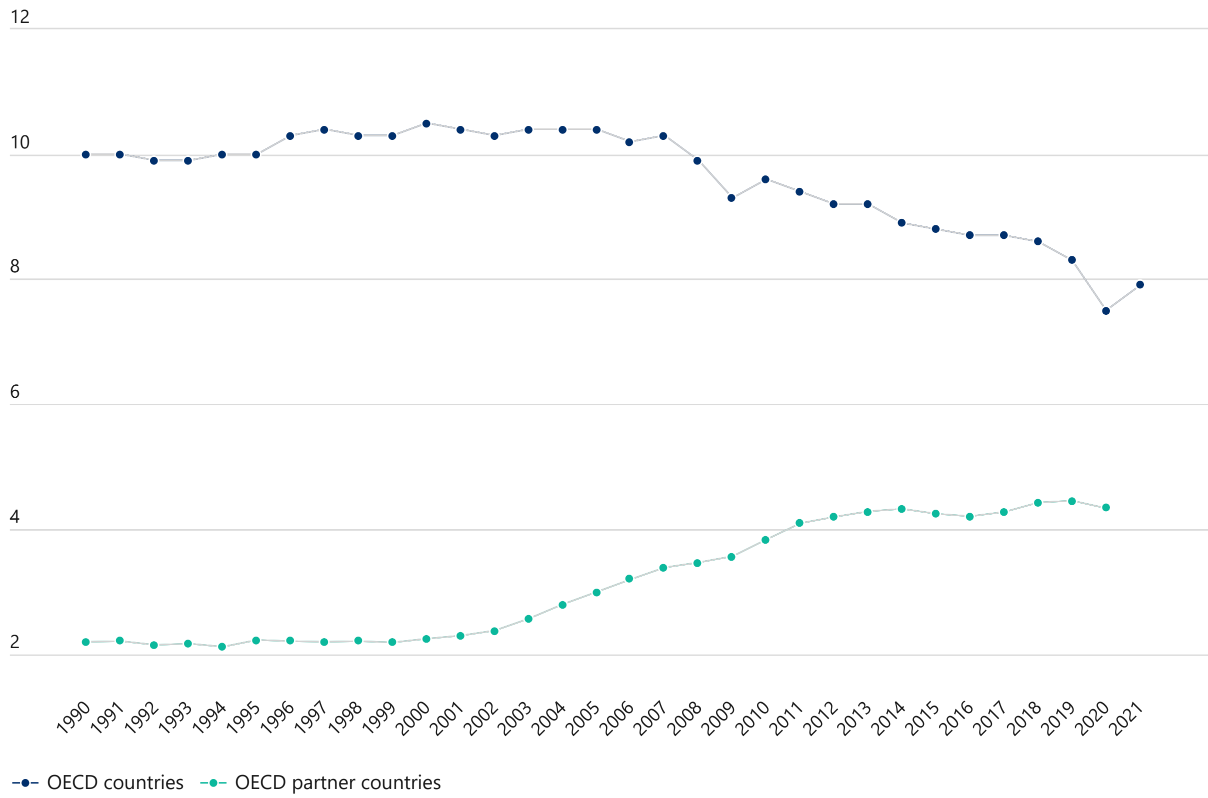
GHG per capita and per unit of GDP emissions intensity

Decoupling emissions from economic and population growth, which is reflected in the relationship between emissions intensity and economic growth trends, is key for long-term mitigation. Total GHG emissions do not take account of countries' economies or population. Two complementary indicators are used to compare countries' emissions intensity: energy-related CO_2 emission intensity per capita, and GHG emission intensity per unit of GDP.[19]

From mid-2000, OECD countries succeeded in reducing energy-related CO_2 emissions per capita to 7.9 tonnes in 2021 (OECD, 2023[8]). By contrast, and although below the OECD, OECD partner countries have steadily increased per capita emissions since early 2000 (Figure 6).

Figure 6. Emissions per capita have decreased in the OECD but increased in OECD partner countries

CO_2 intensity, energy-related CO_2 emissions per capita, tonnes, 1990-2021

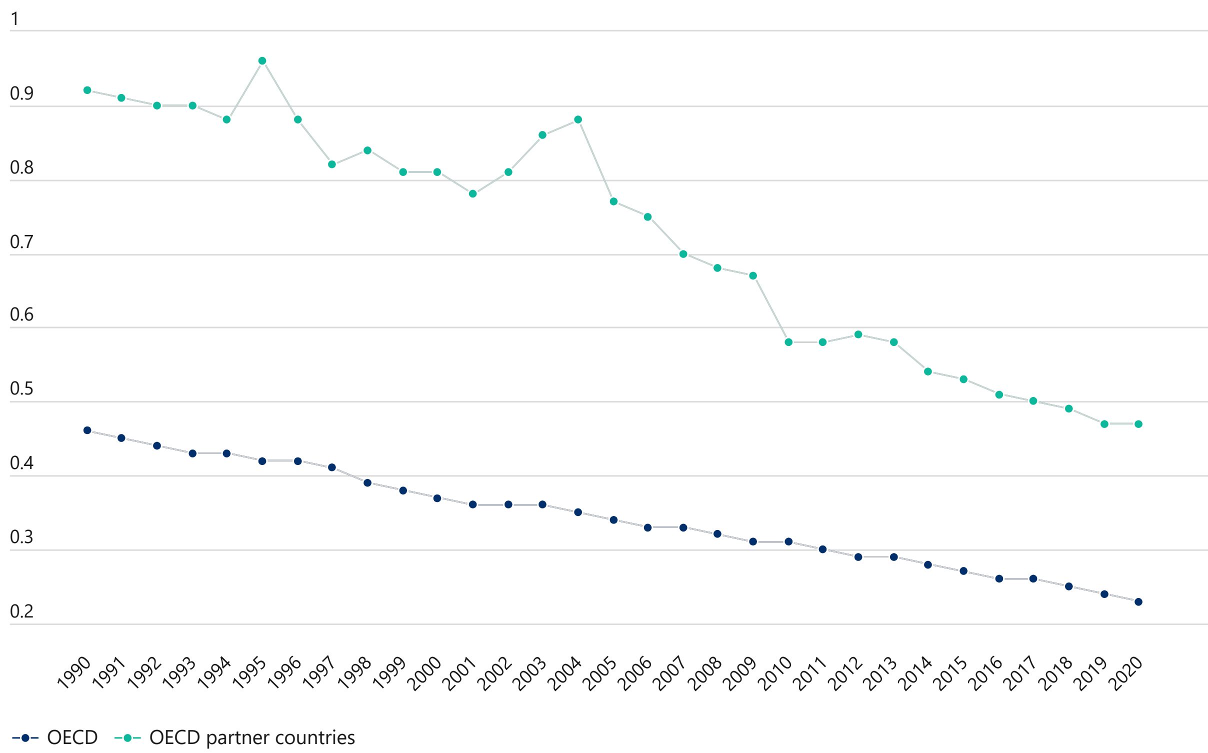


Source: OECD (2023), "Green growth indicators", OECD Environment Statistics (database), https://doi.org/10.1787/data-00665-en.

GHG emissions intensity per unit of GDP has experienced a significant decrease since 1990 in both OECD and OECD partner countries. Nevertheless, emissions intensity in OECD partner countries is more than double that of OECD countries (Figure 7).[20] If these countries were to reduce the emissions intensity of their economies to OECD levels in 2020, total global emissions would fall by one-fifth.

Figure 7. Emission intensities of both OECD and OECD partner countries have decreased

Total GHG (including LULUCF) intensity per unit of GDP, kilograms per USD, constant prices PPP, 1990-2020



Source: OECD (2023), "Air and climate: Greenhouse gas emissions by source", OECD Environment Statistics (database), https://doi.org/10.1787/data-00594-en. "Green growth indicators", OECD Environment Statistics (database), https://doi.org/10.1787/data-00665-en. Countries' official reports submitted to the UNFCCC.

Consumption- and production-based emissions

In a global economy the full picture of countries' individual contributions to global warming cannot be assessed without examining the impact of trade patterns on emissions. The impact is shown in the type of products consumed, or more specifically their carbon content. Achieving the Paris Agreement temperature goal, while ensuring long-term economic growth, requires an energy transition that reduces the carbon footprint of both economic production and individual consumption. This is reflected in consumption and production-based emission indicators.

At the heart of the Paris Agreement are individual country GHG emissions reduction targets and policies. However, the objective is to reduce emissions globally. Countries may comply with their emissions targets but still acquire carbon-intensive products and services from other countries, thereby increasing overall global emissions. OECD country efforts to contribute to global emissions reduction may be ameliorated if emissions are considered from the perspective of final demand.

Since GHG emissions inventories are measured based on national territories and production sources, countries underestimate their total emissions contribution by not considering their demand of goods and services from other countries. One of the reasons that OECD countries have achieved falling GHG emissions' intensity is that national emissions have been displaced by the increasing consumption of carbon-intensive imports. This implies that most OECD countries are outsourcing their carbon-intensive production through import demand to other countries, thus increasing global GHG emissions indirectly.

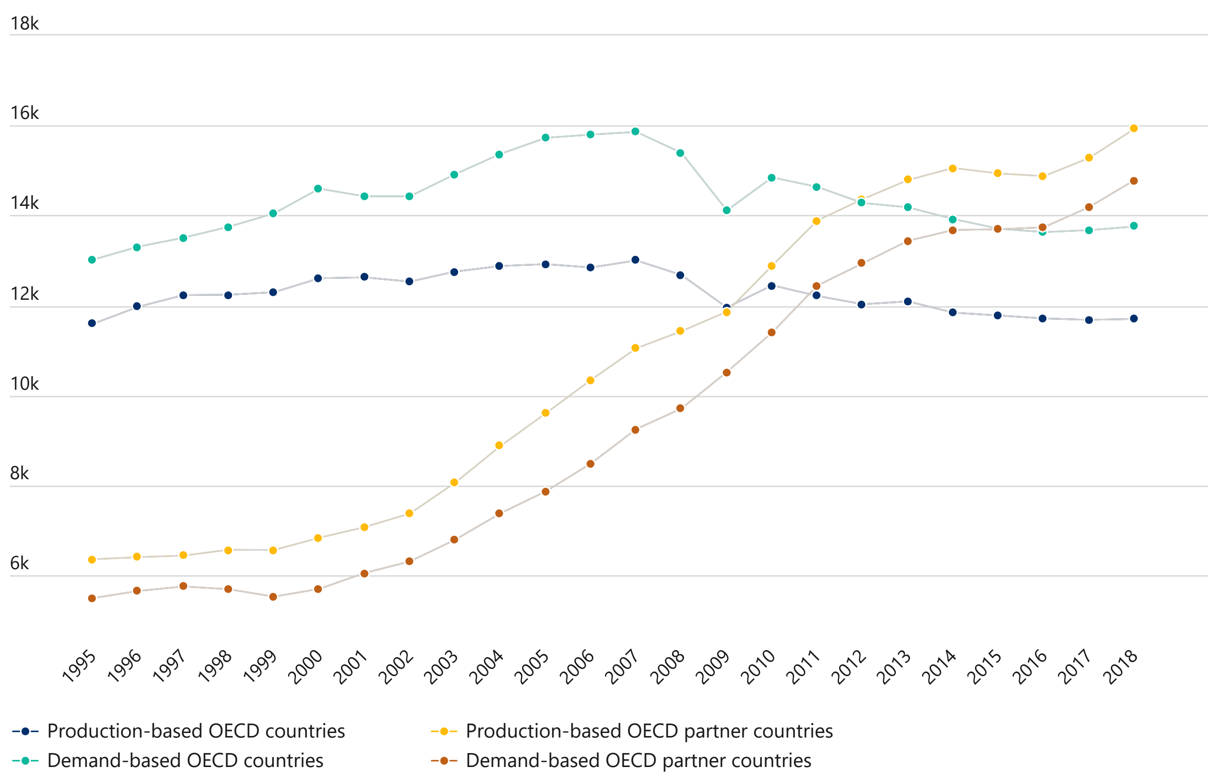
This type of outsourcing is a form of carbon leakage, which may undermine environmental and climate policies if less carbon-efficient techniques and less stringent environmental standards are used in producing countries. This has generated increased pressure for the implementation of carbon border adjustments, such as the proposed EU Carbon Border Adjustment Mechanism (European Comission, 2021[14]).

The overall carbon footprint (demand-based emissions) of OECD countries is higher than emissions from domestic production in the OECD area, and accounts for all carbon emitted anywhere in the world to satisfy final domestic demand.

Both consumption- and production-based emissions in OECD countries peaked in 2007 and have since fallen. However, consumption-based emissions are considerably higher than production-based emissions in OECD countries. Carbon-intensive imports from OECD partner countries partly explain this difference (Figure 8). In contrast, in these countries, production-based emissions are greater than consumption-based emissions and both have been continuously rising.

Figure 8. OECD countries export emissions partly to OECD partner countries through imported goods

Production- and demand-based CO_2 emissions, million tonnes



Source: OECD, "Green growth indicators", OECD Environment Statistics (database), https://doi.org/10.1787/data-00665-en, based on OECD and IEA data.

Drivers of GHG emissions

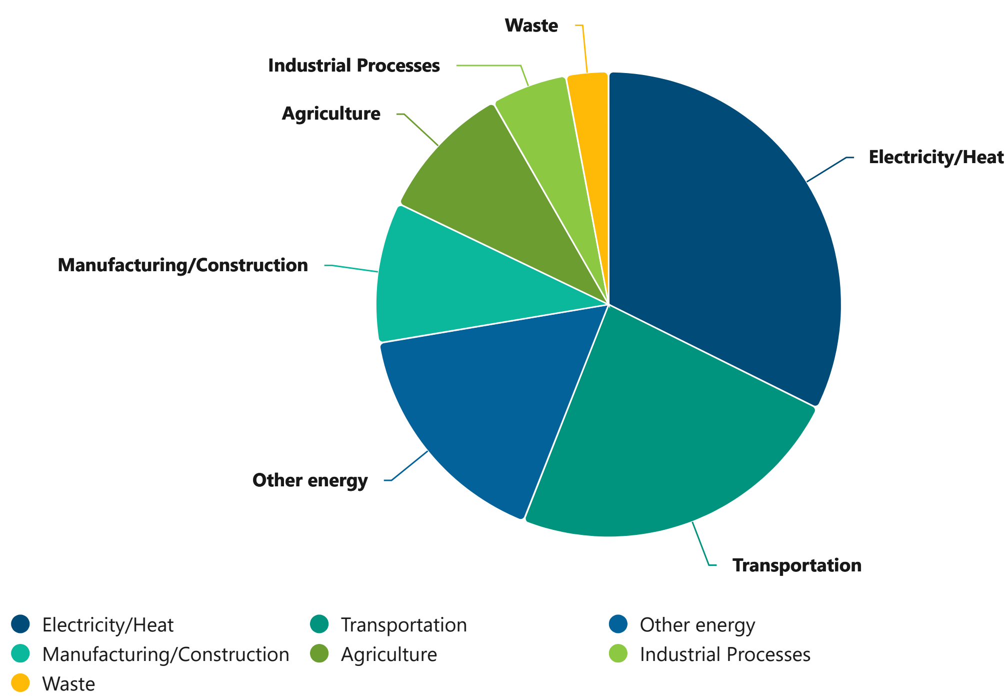
Emissions sources

Identifying emissions sources can help design more targeted climate mitigation strategies. Emissions sources vary considerably across countries depending on their level of development, natural conditions such as weather patterns, available resources, and distance to markets, as well as principal economic sectors, energy sources, and land use.

The emissions profile of OECD and OECD partner countries differs slightly, suggesting that different policy approaches may be necessary. Electricity and heat generation contributes around 32% in the case of OECD countries, while for OECD partner countries the contribution is closer to 39%. Similarly, in the case of the transport sector, emissions represent 24% and 18% respectively for OECD and OECD partner countries. (Figure 9 and Figure 10). The main explanation for the relevance of these sectors is their reliance on fossil fuels for electricity. The second most-emitting sectors are agriculture and industrial processes, which in both cases represent around 20% of total emissions.

Figure 9. Most GHG emissions in OECD countries come from the energy sector

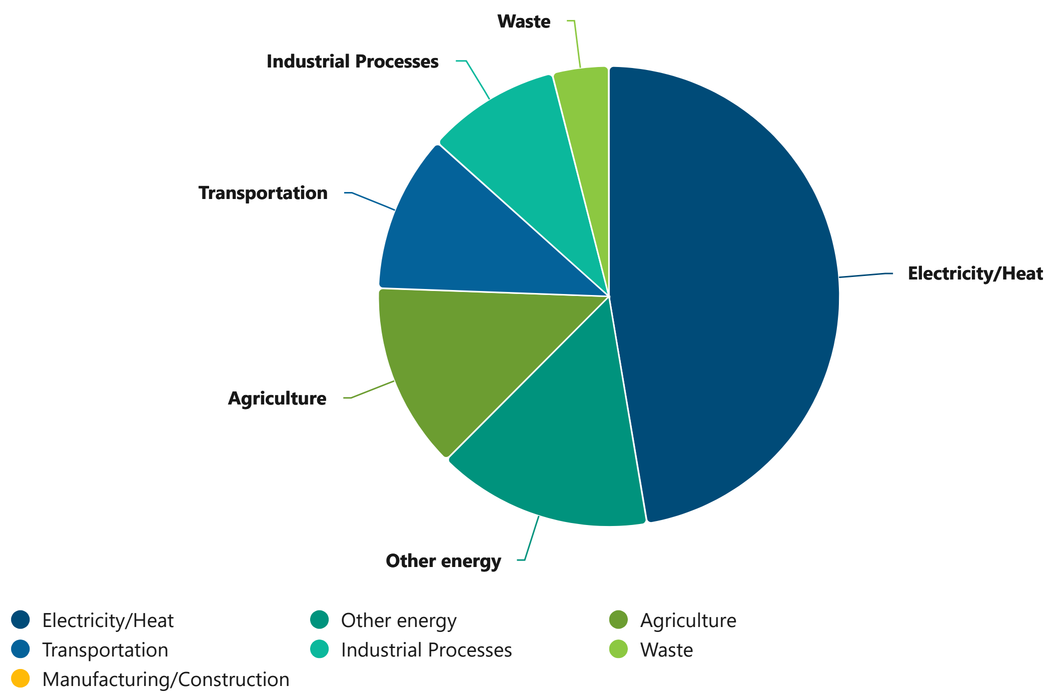
Percentage, OECD countries, 2020



Note: IPCC's emission sources classification categorizes Electricity/Heat, Transportation, Manufacturing/Construction and Other energy as part of '1. Energy'.
Source: Climate Watch (2023) Washington, DC: World Resources Institute, https://www.climatewatchdata.org/ghg-emissions.

Figure 10. Most GHG emissions in OECD partner countries come from the energy and agricultural sectors

Percentage, OECD partner countries, 2020

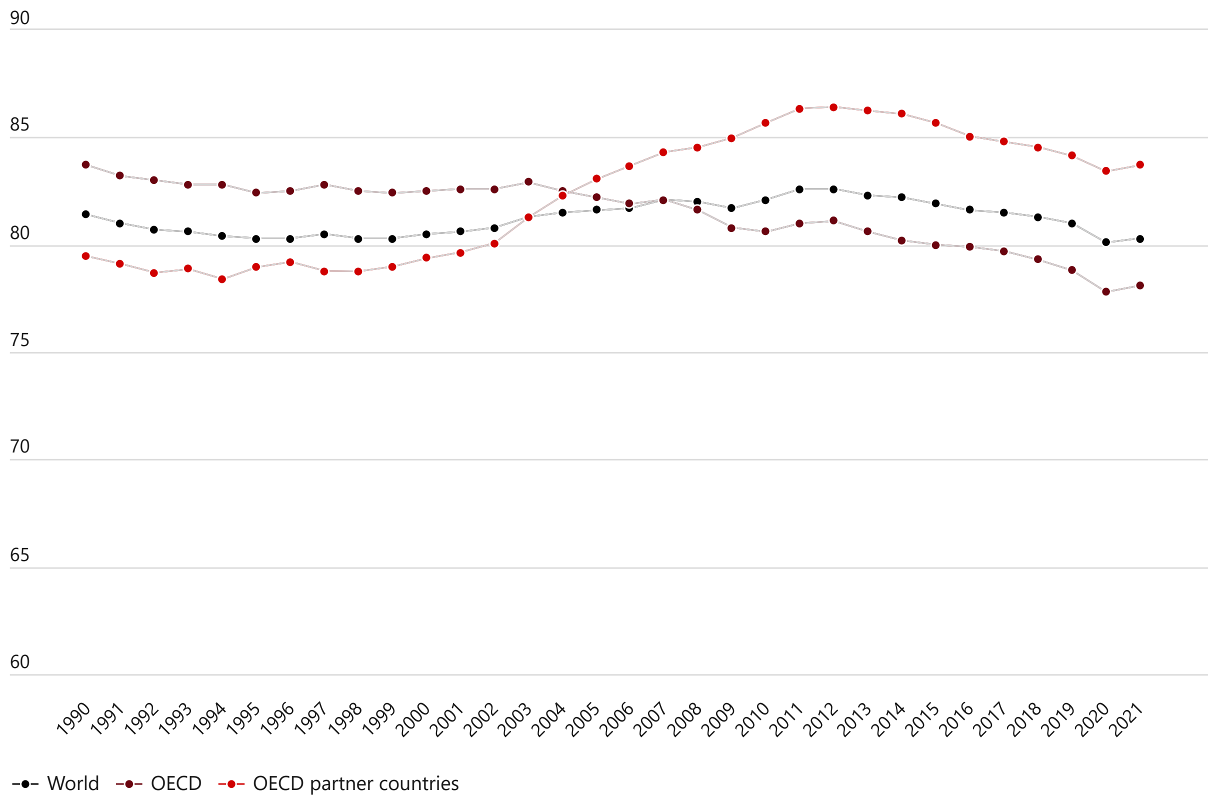


Note: IPCC's emission sources classification categorises Electricity/Heat, Transportation, Manufacturing/Construction and Other energy as part of '1. Energy'.
Source: Climate Watch (2023) Washington, DC: World Resources Institute, https://www.climatewatchdata.org/ghg-emissions.

Although the share of fossil fuels in total energy supply has declined in both OECD and OECD partner countries since 2011, it remains high (Figure 11). OECD countries reduced their share of fossil fuels from 84% to 78% from 1990 to 2020, while globally it has remained almost constant from 81% in 1990 to about 80% in 2021 with a peak of almost 83% in 2011. OECD partner countries, after a peak of 86% in 2012, have marginally decreased their share to 84% in 2021. Further investment in low-carbon energy sources and energy efficiency measures are needed to decarbonise the energy sector.

Figure 11. Energy supply is still reliant on fossil fuels, but the share is declining globally

World share of fossil fuels in total energy supply (%), OECD and OECD partner countries, 1990-2021

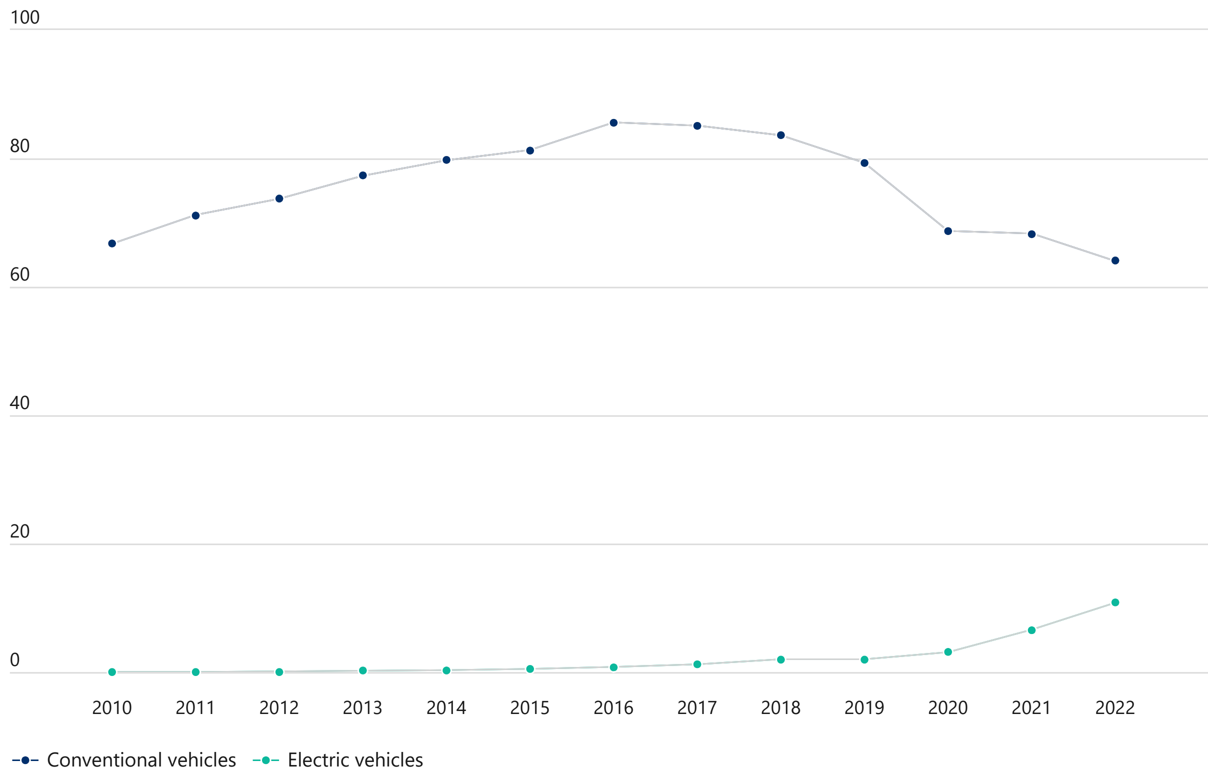


Source: OECD calculations based on (IEA, 2023[15]).

In the transport sector, emissions in OECD and OECD partner countries have continuously increased from 1990 to 2022 with a brief decline in 2020 due to COVID-19. Road transport contributes more than 70%.[21] Reducing emissions from the transport sector requires both reducing the number of passenger cars as well as the use of vehicles with internal combustion engines (ICE). Globally, the number of passenger car sales remains high, with over 75 million units sold in 2022. The share of electric vehicles (EV) is increasing, representing more than 14% of the total passenger car sales in 2022 (Figure 12).

Figure 12. The global sale of passenger cars peaked in 2016, and electric vehicle sales are rising

World passenger car sales, million vehicles, 2010-2022

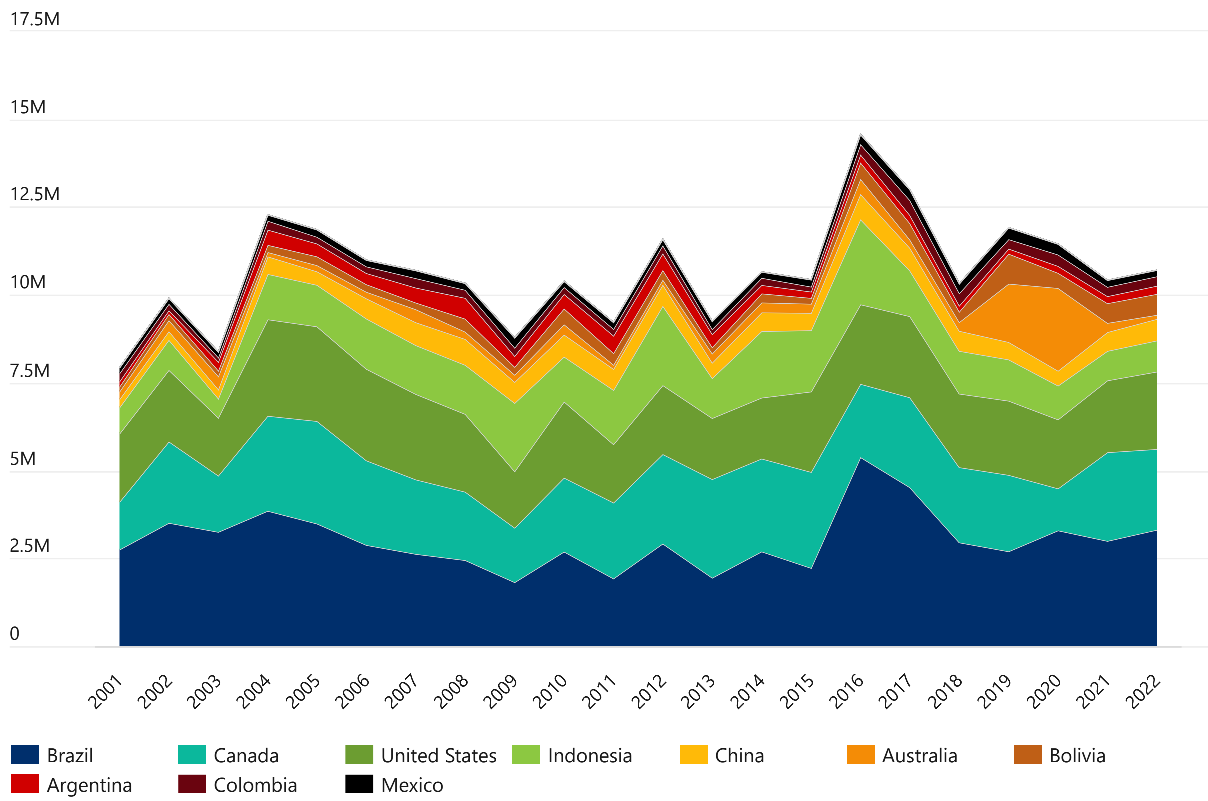


Source: IEA, Passenger car sales, 2010-2022, IEA, Paris, https://www.iea.org/data-and-statistics/charts/passenger-car-sales-2010-2022.

Land use change and forestry (LUCF) has been a net global emitter, albeit with considerable regional differences.[22] In 2020, LUCF represented around 3% of global GHG emissions (excluding LUCF) but has large variations across countries (Climate Watch, 2023[6]). These emissions are driven mainly by deforestation, land use change (such as conversion of natural land into agricultural land or built-up areas) and unsustainable management practices. Achieving net-zero targets and other environmental objectives such as biodiversity protection requires tackling deforestation in resource-rich countries (Figure 13).

Figure 13. Reducing deforestation is key to achieving Paris Agreement goals

Annual primary forest loss in the 10 OECD and OECD partner countries with the highest forest loss, hectares, 2001-2022

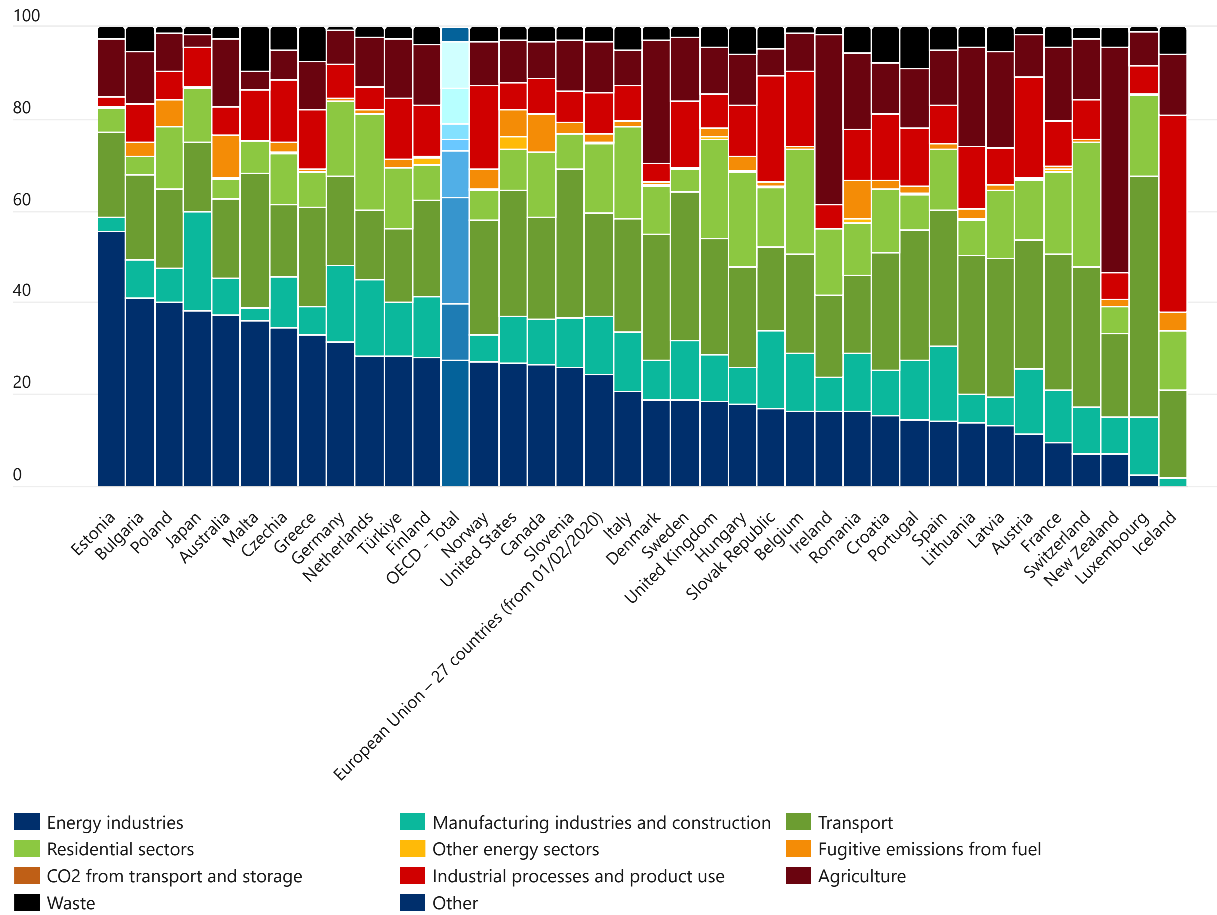


Source: University of Maryland and World Resources Institute, Global Primary Forest Loss, www.globalforestwatch.org.

Although energy consumption, transport and deforestation are the main global sources of GHG emissions, their individual contribution varies considerably across countries. Therefore, different priorities and approaches will be necessary to achieve mitigation objectives in individual countries. This implies that countries do not necessarily need to prioritise the sectors that are global drivers or reduce emissions equally in all sectors to achieve their climate targets; rather, policy choices must be consistent with countries' specific conditions (Figure 14). As is further discussed in Chapter 3, there are general trends and common drivers, but no one-size-fits-all policy for all countries.

Figure 14. Emissions sources vary considerably across countries

GHG emissions by source, %, 2021



Source: OECD (2023), "Air and climate: Greenhouse gas emissions by source", OECD Environment Statistics (database), https://doi.org/10.1787/data-00594-en.

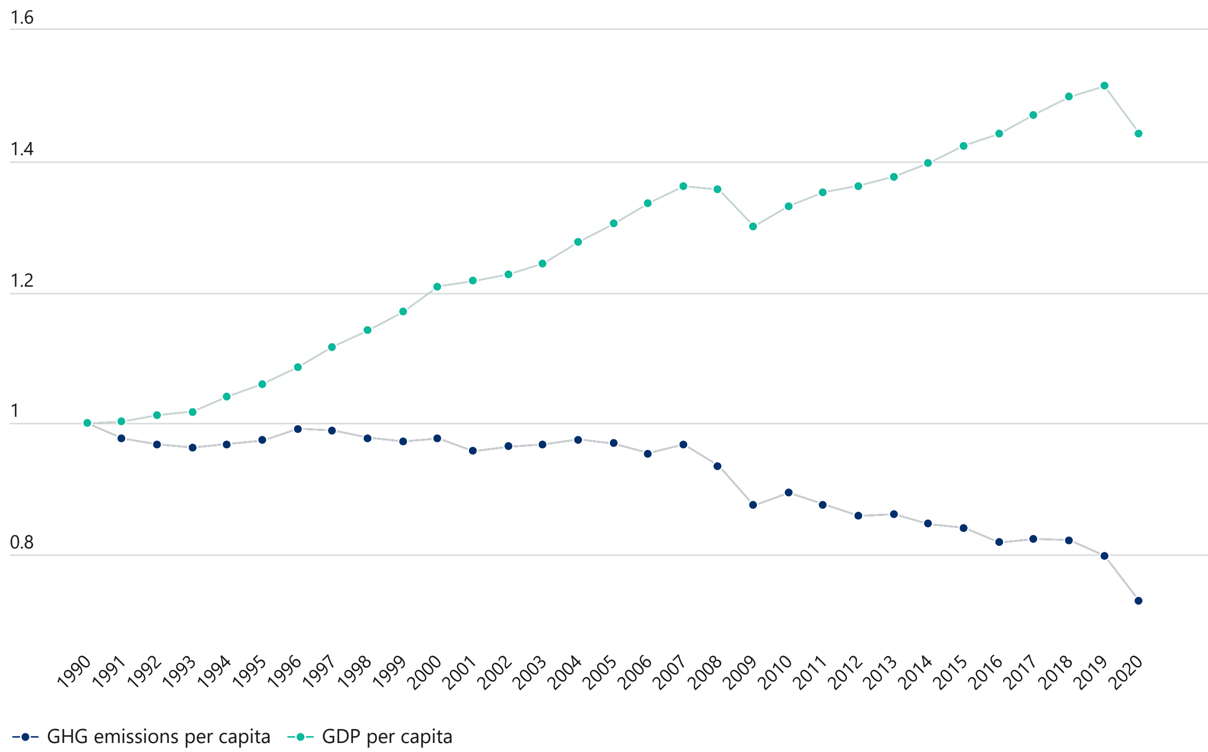
Other GHG emissions drivers

Reducing GHG emissions by focussing on individual emissions sources is not enough, since efficiency gains and progress in decoupling emissions from production activities are often outweighed by economic and population growth. In the long run, mitigation and human welfare will depend on reducing material and energy demand in all sectors. Most OECD countries have managed to decouple GHG emissions from GDP growth. On average, GDP per capita increased by 44% from 1990 to 2020, while GHG emissions per capita fell by 27% in the same period (Figure 15). OECD partner countries have achieved relative decoupling where GDP per capita has increased by 215% between 1990 and 2020, although still below the OECD average per capita in 2020, coupled with an increase of emissions by 60% during the same period (Figure 16).

Sustainable economic growth requires ensuring that countries continue to increase GDP while reducing GHG emissions progressively. However, further gains in energy efficiency alone will not be sufficient to put OECD partner countries on a path to reaching net-zero targets overall. Advancing towards the energy transition is critical to achieve their mitigation objectives (OECD, 2023[9]).

Figure 15. In the OECD, GDP growth per capita is decoupled from GHG emissions per capita

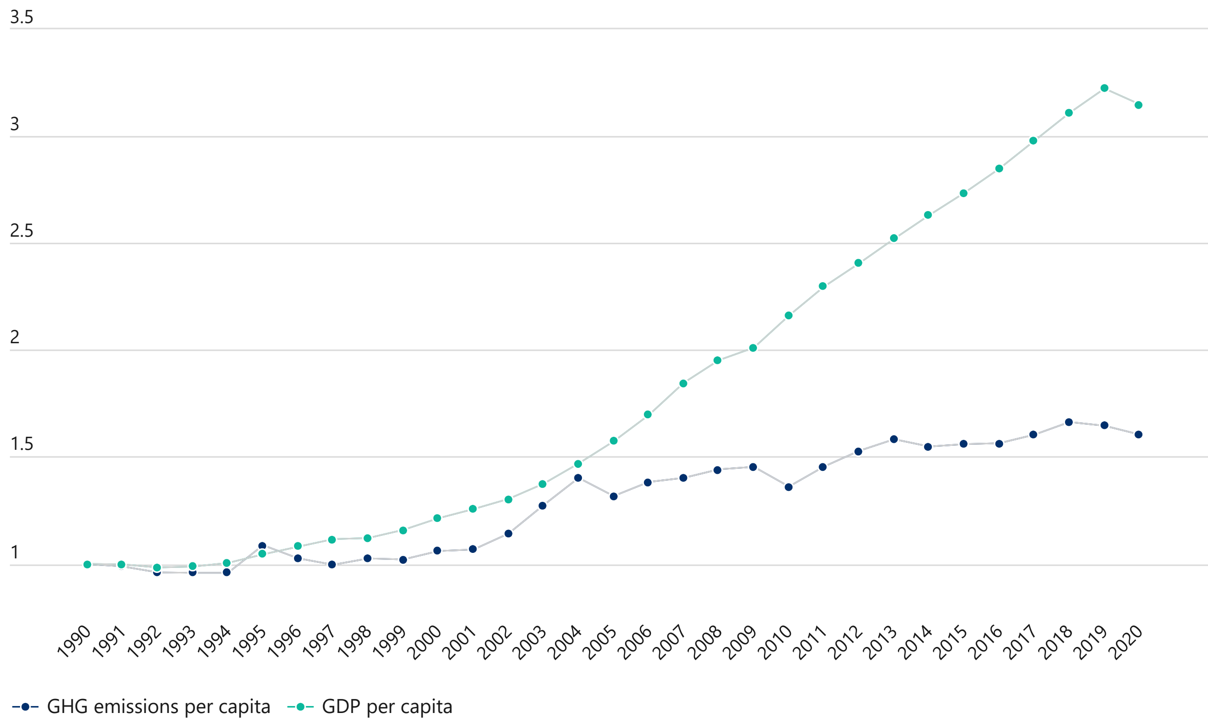
1990-2020, OECD countries, index 1990=1



Source: OECD (2023), "Air and climate: Greenhouse gas emissions by source", OECD Environment Statistics (database), https://doi.org/10.1787/data-00594-en. OECD, "Green growth indicators", OECD Environment Statistics (database), https://doi.org/10.1787/data-00665-en.

Figure 16. Both GDP and emissions per capita have increased in OECD partner countries but the trends show relative decoupling

1990-2020, OECD partner countries, index 1990=1

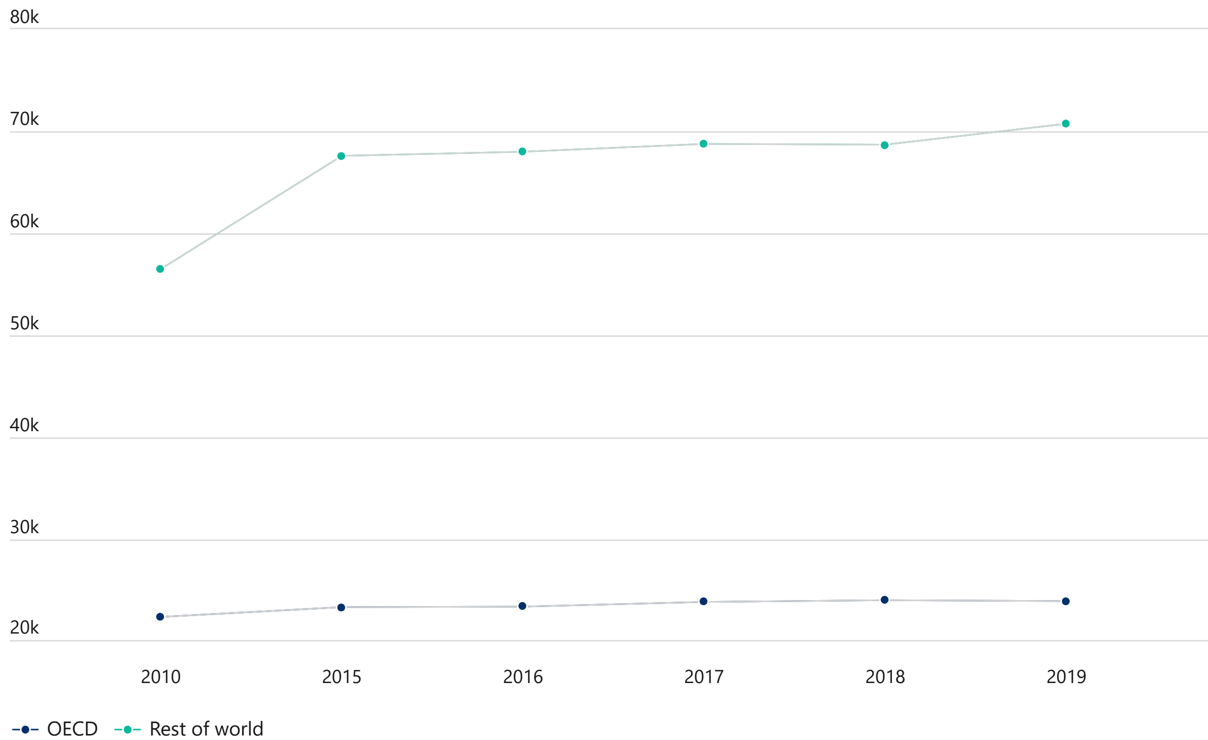


Source: OECD (2023), "Air and climate: Greenhouse gas emissions by source", OECD Environment Statistics (database), https://doi.org/10.1787/data-00594-en. OECD, "Green growth indicators", OECD Environment Statistics (database), https://doi.org/10.1787/data-00665-en.

Reducing material consumption and improving the circularity of material use is necessary to reduce GHG emissions. Material extraction is projected to surpass 111 Gt in 2030 and 167 Gt in 2060 with business-as-usual almost doubling from 89 Gt in 2017 (OECD, 2019[16]). Between COP21 and COP26, over half a trillion tonnes of virgin materials were consumed. Rising material extraction means that more than 90% of materials are either wasted, lost or remain unavailable for reuse for years as they are locked into long-lasting stock such as buildings and machinery (Circle Economy, 2023[17]). To advance toward the Paris Agreement targets, it is essential to develop a more circular economy by reducing the material footprint where GHG emissions are ultimately embedded.

Figure 17. To achieve substantive and structural reductions in GHG emissions, the OECD must reduce material consumption and increase circularity

Domestic Material Consumption, OECD and rest of world, thousand tonnes



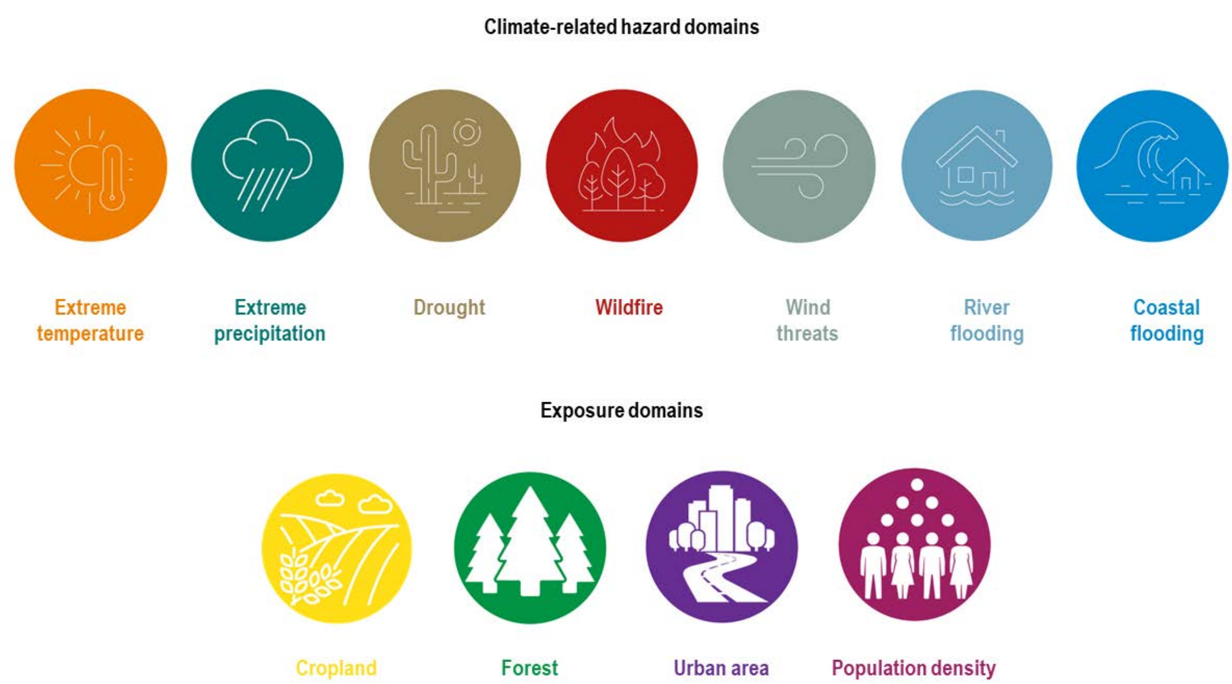
Source: OECD (2023), "Material resources: Material resources", OECD Environment Statistics (database), https://doi.org/10.1787/data-00695-en.

2 What are the trends in climate-related hazards and disasters?

The world experienced unprecedented climate change impacts in 2023. Accelerated climate change poses significant threats to ecosystems and communities worldwide, exacerbating climate-related hazards and disasters. As climate-related weather events become more extreme, losses are increasing. In 2022, losses due to natural disasters were estimated at USD 270 billion and insured losses were roughly estimated at USD 120 billion, one of the highest economic losses ever recorded (Munich RE, 2023[18]).[23] In the same year, 30 704 lives lost were recorded as a result of natural disasters, impacting an estimated 185 million people globally (CRED, 2023[19]). [24]

This chapter draws on a new set of indicators developed by IPAC on key climate-related hazards using earth observation data. The indicators focus on seven key hazards and four exposure domains, and provide a time series going back as far as 43 years for all countries globally (Figure 18). By surveying past climate-related hazards, this chapter explores the impacts and risks of climate change using historical observational data. It shows how climate-related hazard exposures can vary across and within countries due to diverse geography, environment, and weather patterns that affect each area in both OECD and OECD partner countries.

Figure 18. Key climate-related hazards and exposure domains



Source: (Maes et al., 2022[20]).

Climate-related hazards can manifest as slow onset events, such as gradual sea level rise, or sudden extreme events, such as flash floods or intense storms (IPCC, 2022[21]). These hazards and their impacts vary widely across the world depending on different ecosystems and climates, as well as socio-economic conditions. Rising global temperatures can intensify hazards such as hurricanes, heatwaves, droughts, and extreme precipitation, resulting in devastating impacts for vulnerable communities.

Meanwhile, climate tipping points risk further accelerating the pace of climate change, exacerbating the intensity and occurrence of extreme weather events as they disrupt stable climate patterns and amplify climatic disturbances (Box 3). The resulting impacts affect all aspects of socioeconomic and ecological systems, from disrupting agricultural productivity to increased health challenges associated with heat-related diseases or respiratory problems from wildfires.

Increased climate variability and climate extreme events lead to significant economic and human losses. If the world continues on the current emissions trajectory and does not meet the Paris Agreement temperature goal, estimates suggest that global GDP could fall by 10% by 2050 (Swiss Re, 2021[22]). If no action is taken, and temperatures continue to rise to 3.2°C by 2050, global GDP could fall even further by an estimated 18% (Swiss Re, 2021[22]).

Evidence in many OECD countries confirms that accelerated action on adaptation is needed to contain future loss and damage. Investments in climate adaptation measures are usually significantly less expensive than addressing loss and damage from extreme weather events. For example, one study shows that investing USD 1.8 trillion globally in five areas from 2020 to 2030 could generate USD 7.1 trillion in total net benefits (Global Commission on Adaptation, 2019[23]). However, government funding is usually only made available after a disaster. This gives rise to important considerations for adaptation finance (OECD, 2023[24]).

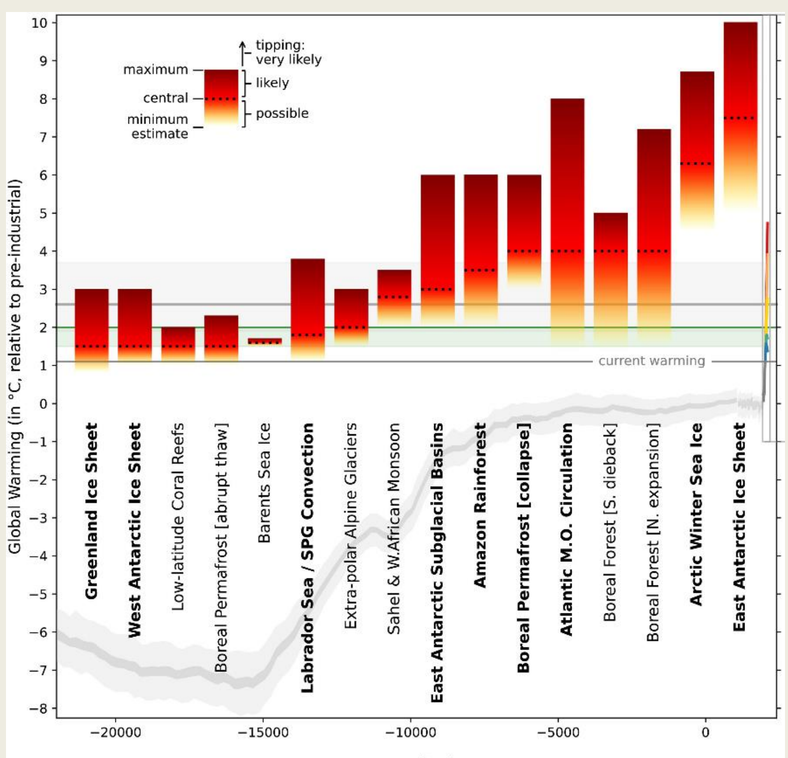
As the impacts of climate variability and extreme climate events are distributed unevenly, they contribute to socioeconomic inequality. Vulnerable populations such as the elderly and children are disproportionately affected by heatwaves (WMO, 2015[25]). Livelihoods in local communities may be disproportionately reliant on certain economic activities such as agriculture or fisheries, which are more heavily impacted by climate-related hazards and disasters. Moreover, lower-income groups will have a limited capacity to deal with climate impacts, leaving them more vulnerable to sudden onset disasters such as hurricanes or flash floods. The vulnerability of populations to climate change varies significantly and is influenced by a complex interaction of factors such as the ethnic, demographic, environmental and socioeconomic background of individuals and communities (Thomas et al., 2019[26]). In all cases, however, the expectation is that it will lead to a disproportionate and increasing impact on vulnerable populations, as well as an increase in global and local inequality.

Box 3. Climate tipping points

Climate tipping points are reached when a change in part of the climate system goes beyond a certain threshold that results in an abrupt and potentially irreversible impact. Several possible climate tipping points have been identified with potentially significant global or regional impacts, such as the disintegration of the Greenland Ice sheet, the melting of the Arctic Permafrost or the weakening of ocean circulations (Armstrong McKay et al., 2022[27]). Crossing climate tipping points may lead to catastrophic impacts for socioeconomic and ecological systems over timeframes short enough to defy the ability and capacity of these systems to adapt (OECD, 2022[28]) (Kemp et al., 2022[29]) (Lenton et al., 2019[30]).

The occurrence of specific climate tipping points varies across types and will depend on the impact of global warming (Figure 19). For example, one study predicts that, under the current emissions scenario, the Atlantic meridional overturning circulation (AMOC) will collapse in mid-century (Ditlevsen and Ditlevsen, 2023[31]). The probability of such tipping points being triggered increases significantly if average temperatures reach between 1.5-2°C (Armstrong McKay et al., 2022[27]). Considering that climate tipping points interact with each other, and can influence the likelihood of triggering another tipping point, limiting global warming to 1.5°C is crucial to avoid the potential additional accelerated catastrophic impacts of combined climate tipping points (OECD, 2022[28]).

Figure 19. Global warming threshold estimates for global core and regional impact climate tipping points



Note: Shadowed in green is the 1.5°C-2°C Paris Agreement range of warming. The shadowed area in grey shows the estimated 21st century warming under current policies (horizontal line shows central estimates). Bars show the minimum (base, yellow), central (line, red), and maximum (top, dark red) threshold estimates for each tipping element (bold font, global; regular font, regional).
Source: (Armstrong McKay et al., 2022[27]).

Societies' exposure to climate-related hazards

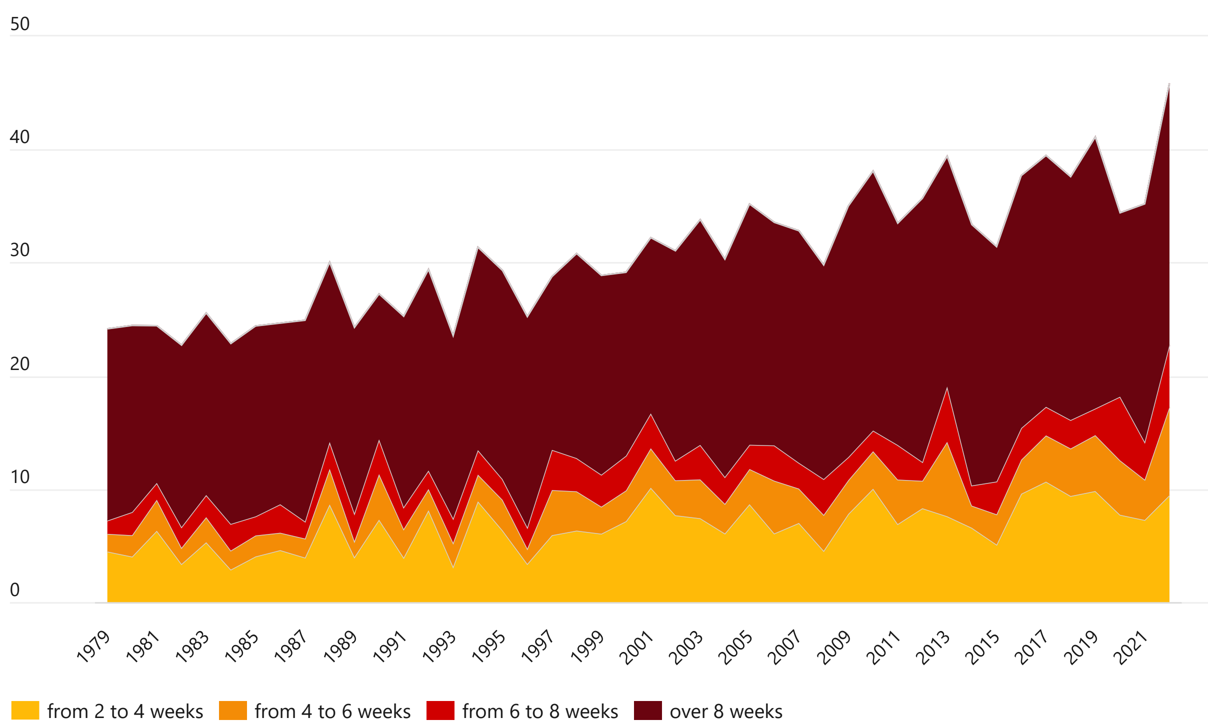
The OECD has developed a set of indicators to monitor climate-related hazards and their exposure. Through this indicator set, policy makers can better understand potential impacts and develop approaches to mitigate and adapt to climate change (Maes et al., 2022[20]). The indicators follow national and international guidelines and are based on the IPCC's conceptualisation of climate risk, which considers climate-related hazard, exposure and vulnerability as the key dimensions of disaster risk (IPCC, 2022[21]). The indicators have recently been updated and some key results are discussed below.

Extreme temperature

July and August of 2023 registered the highest average global temperature since records began.[25] Over the past decades, population exposure to extreme temperatures has increased significantly. National-level analysis shows an increase in energy consumption for cooling, as well as, crucially, a tendency for extreme heat clusters to last longer than they have over the past two decades (Scoccimarro et al., 2023[32]). During the summer of 2023, several regions in the northern hemisphere experienced record daily temperatures, for example in Phoenix (USA, 48.3°C), Death Valley (USA, 54.4°C), Rome (Italy, 42.9°C) and Sanbao (China, 52.2°C). This is not an isolated event: OECD data confirms that this is a consequence of an observed trend. Since 1979 the population in both OECD and OECD partner countries has been increasingly exposed to hot days,[26] with an estimated 11.3% more people exposed to hot days in the period 2018-22 compared to the reference period 1981-2010 (Figure 20).

Figure 20. Population exposure to hot days increasing across OECD and OECD partner countries

Percentage of population exposed to more than 2 weeks of hot days, OECD and OECD partner countries, 1979-2022

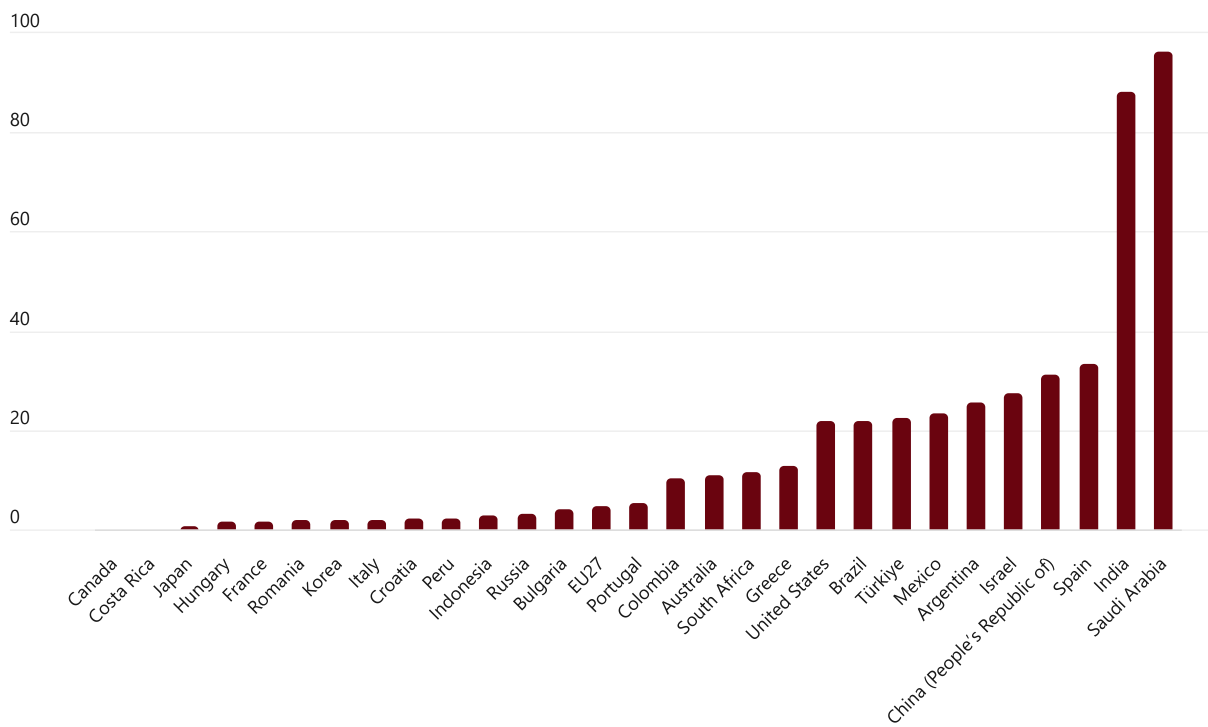


Note: Over- or under-estimations of the estimated exposure to extreme temperature are possible due to the spatial resolution of gridded data, particularly for smaller countries or regions. A variety of indicators has been developed that estimate exposure to extreme temperatures; these should be consulted for more detailed analysis of individual countries.
Source: IEA/OECD (2022), " Climate-related hazards: Extreme temperature", Environment Statistics (database), https://oe.cd/dx/58r.

Countries whose population was most exposed to hot days in 2018-22 include Saudi Arabia (98.3%), India (97.3%) and Israel (91%), an estimated 1.4 billion people in total (Figure 21). Although exposure to extreme temperatures in countries such as Saudi Arabia and Israel was already historically high, the duration of exposure is increasing.

Figure 21. Population exposure to more than two weeks of hot days varies between OECD and OECD partner countries

Percentage of population exposed to more than 2 weeks of hot days, OECD and OECD partner countries, 2018-22 average

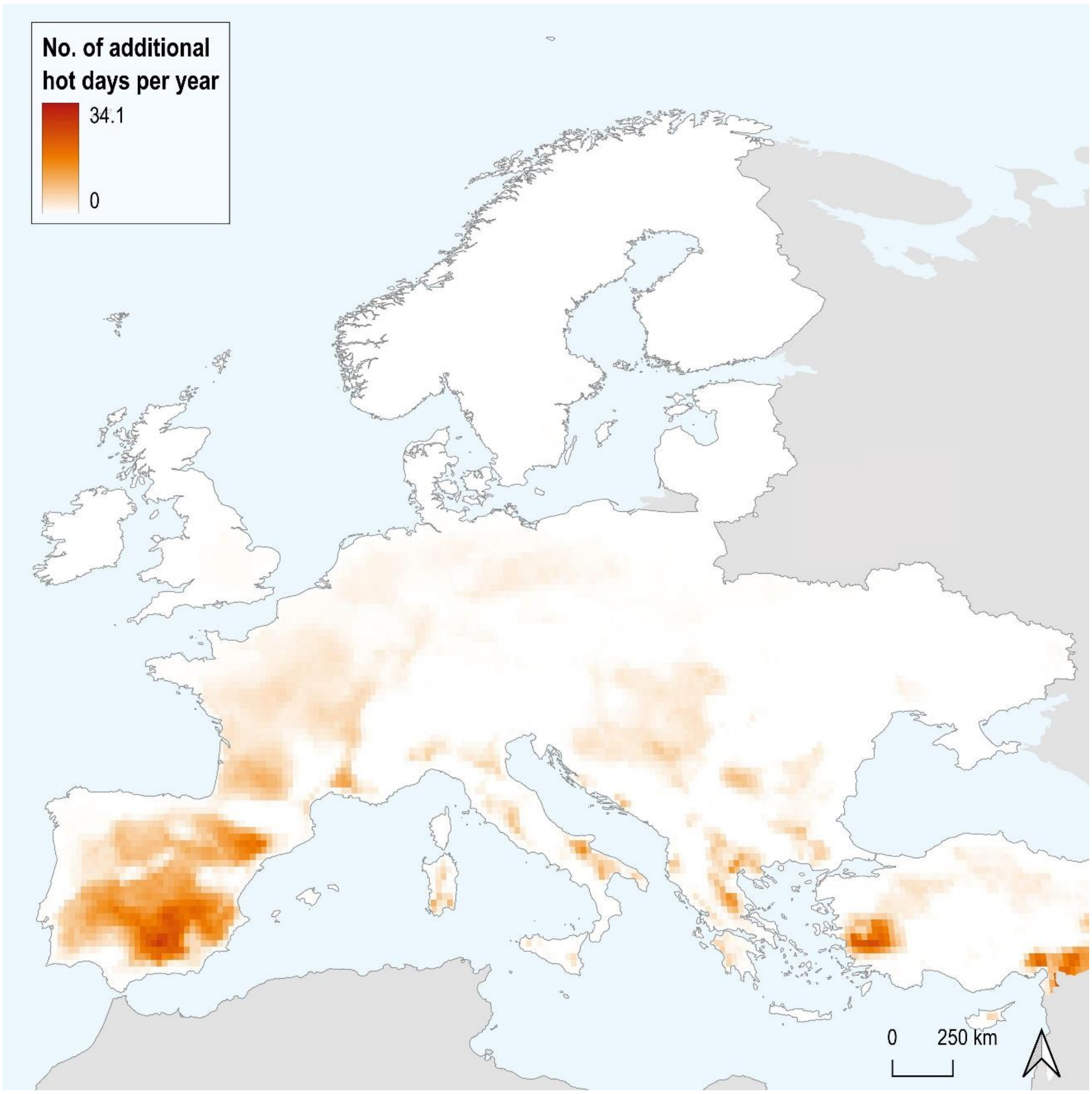


Note: Over- or under-estimations of the estimated exposure to extreme temperature are possible due to the spatial resolution of gridded data, particularly for smaller countries or regions. A variety of indicators have been developed that estimate exposure to extreme temperatures; these should be consulted for more detailed analysis of individual countries.
Source: IEA/OECD (2022), " Climate-related hazards: Extreme temperature", Environment Statistics (database), https://oe.cd/dx/58r.

Southern Europe is increasingly affected by extreme heat. In 2023 the region experienced an unprecedented heatwave that generated enormous impacts and has yet to be fully assessed. Indicators show that, between 2018 and 2022, approximately 74.7%, 55% and 68.7% of the population in countries such as Greece, Italy and Spain respectively were exposed to hot days. Furthermore, certain regions within these countries are also experiencing an increase in additional hot days per year compared to the reference period 1981-2010 (Figure 22), highlighting regional differences with regards to extreme heat. This indicates that hot European summers are likely to get worse, highlighting again the urgency of taking appropriate measures to tackle extreme heat, particularly for countries that are traditionally less prepared for extreme heat.

Figure 22. Increasing extreme temperatures across southern Europe

Annual number of additional hot days (2018-22 average) compared to the reference period 1981-2010 across the European region



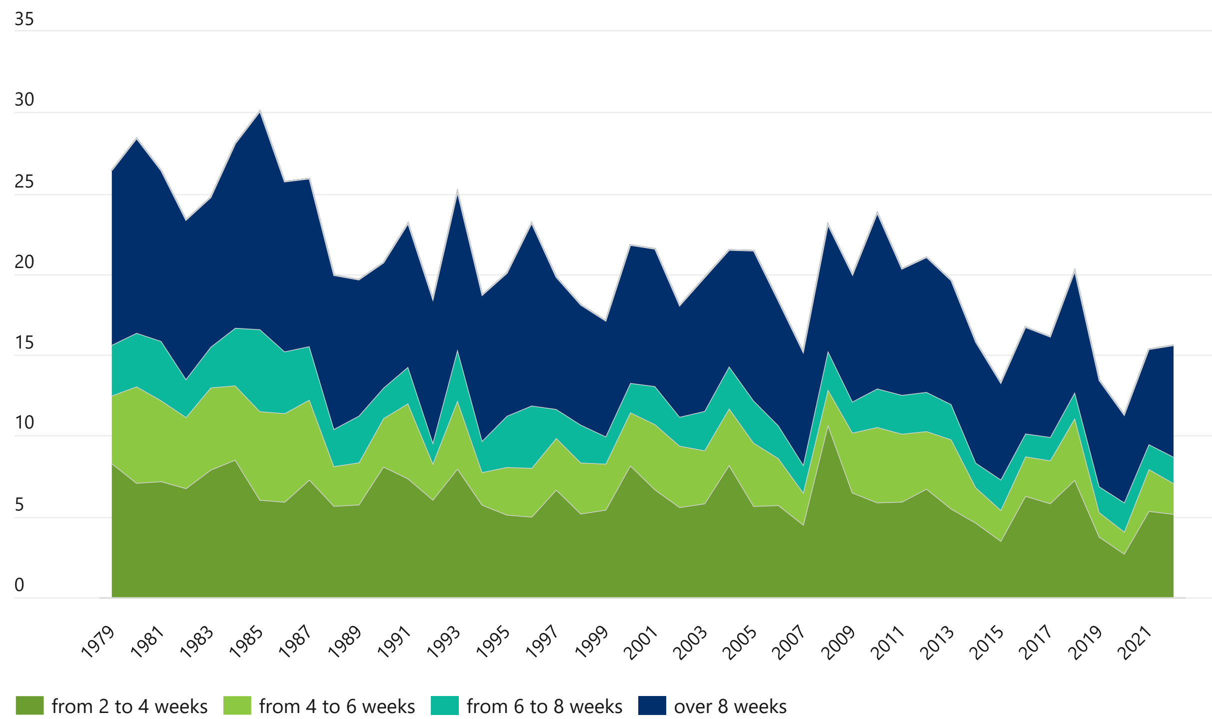
Note: A variety of indicators have been developed that assess extreme temperatures; these should be consulted for more detailed analysis of individual countries.
Source: (Maes et al., 2022[20]).

Tropical nights, associated with high night-time temperatures, are also a relevant indicator of increasing temperature, and generate risks to human health due to sleep disturbances and inability to cool down at night (Seltenrich, 2023[33]). Twenty countries — out of 51 countries covered — had more than an additional 10% of their population exposed to tropical nights[27] over the period 2018-22 compared to 1981-2010, while countries such as Korea (28%), Italy (18%) and Greece (16%) had the highest increase in population exposed to more than eight weeks of tropical nights.[28]

Consistent with evidence of increasing average temperature, exposure to extreme cold is decreasing. The share of population exposed to icing days is decreasing year by year, with an estimated 5.8% fewer people exposed to icing days in the period 2018-22 compared to the reference period of 1981-2010 (Figure 23).

Figure 23. Decreasing population exposure to icing days across OECD and OECD partner countries

Percentage of population exposed to more than 2 weeks of icing days, OECD and OECD partner countries, 1979-2022



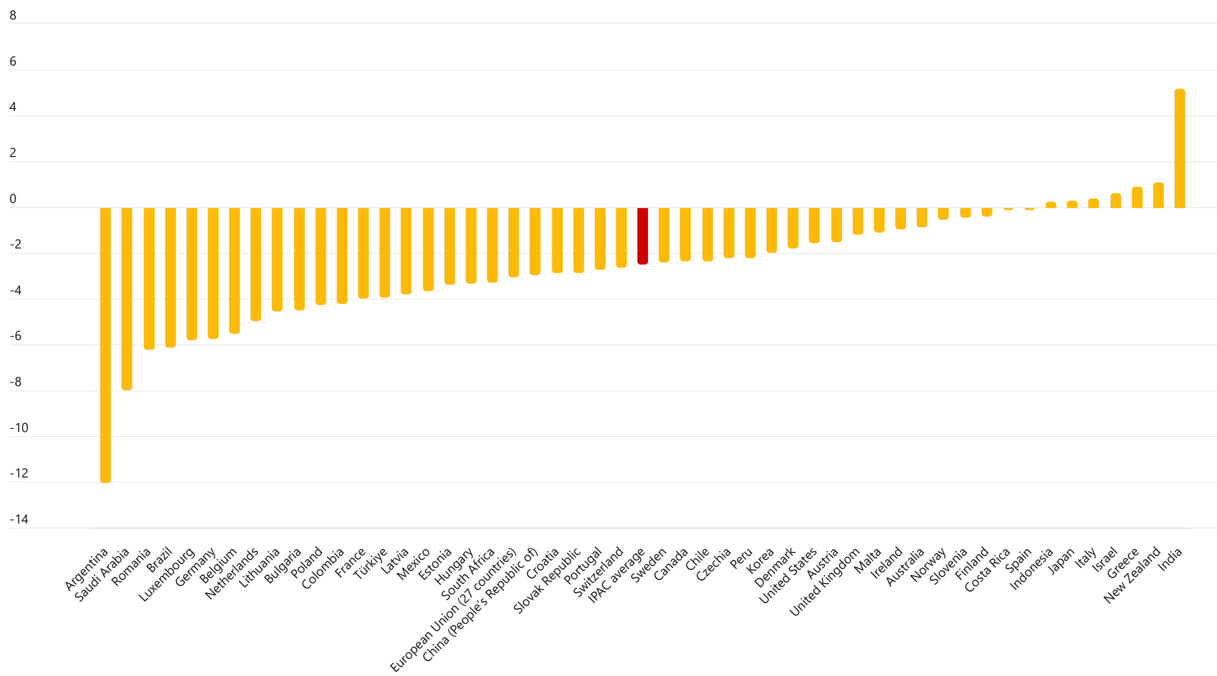
Note: Over- or under-estimations of the estimated exposure to extreme temperature are possible due to the spatial resolution of gridded data, particularly for smaller countries or regions. A variety of indicators have been developed that estimate exposure to extreme temperatures; these should be consulted for more detailed analysis of individual countries.
Source: IEA/OECD (2022), " Climate-related hazards: Extreme temperature", Environment Statistics (database), https://oe.cd/dx/58r.

Droughts and wildfires

Rising temperatures also have adverse effects on food systems, with croplands increasingly susceptible to agricultural droughts. Across the OECD and OECD partner countries there is a significant decrease in soil moisture on croplands (2.4%) over the period 2018-22 compared to the reference period 1981-2010. Some of the countries most affected by agricultural droughts include Argentina, Brazil and Romania, which all experienced average declines of more than 6% in cropland soil moisture in the past five years (Figure 24).

Figure 24. Agricultural drought is worsening for a majority of OECD and OECD partner countries

Cropland soil moisture anomaly (%), 2018-22 average compared to the reference period 1981-2010

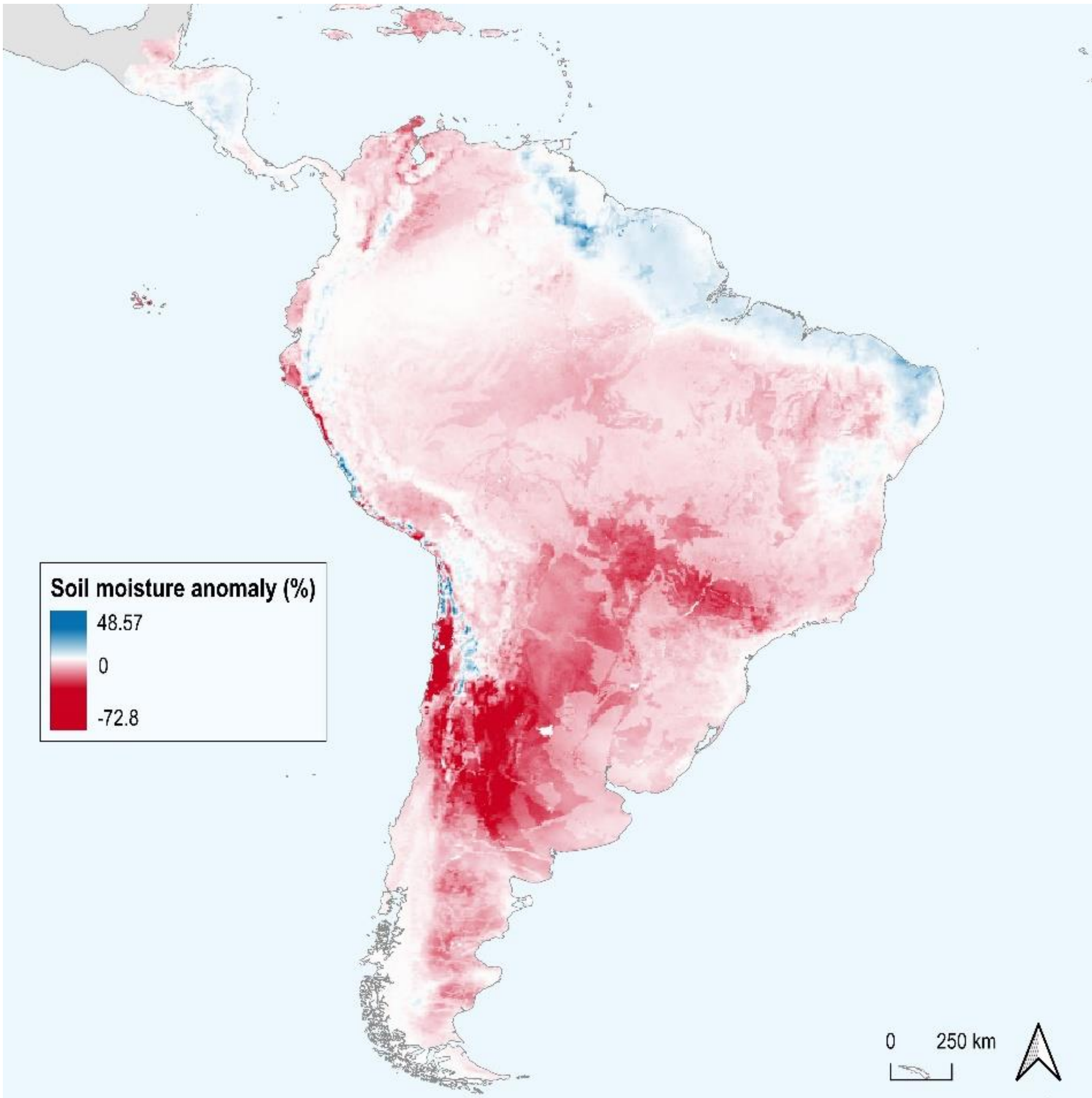


Note: No results are available for Iceland since no cropland cover is detected using Copernicus global land cover data. Caution is advised interpreting results for Saudi Arabia because cropland cover is low.
Source: IEA/OECD (2022), " Climate-related hazards: Drought", Environment Statistics (database), https://oe.cd/dx/58t.

National averages hide large differences and changes at the subnational level, where recorded drops in soil moisture are greater (Figure 25). In South America, for example, the Argentinian provinces of Córdoba, Chaco and Tucumán, which have high cropland cover, have experienced severe soil moisture declines of 19%, 18% and 17% respectively. Similarly, the Chilean regions of Valparaíso, Santiago Metropolitan Area and O'Higgins are experiencing soil moisture declines of 8%, 7% and 5% respectively. These dramatic changes have already significantly impacted local communities and agricultural production. For example, Argentina, one of the world's top grain exporters, is in the grip of its worst drought in over 60 years, facing losses of USD 14 billion and more than 50 million tonnes less grain output across soy, corn and wheat (Sigal and Raszewski, 2023[34]). Drought can also exacerbate other climate-related hazards such as conditions that increase the possibility of wildfires due to dry vegetation and fuel load and changing weather patterns.

Figure 25. Intensifying drought impacts across Central and South America

Land soil moisture anomaly (%), 2018-22 average compared to the reference period 1981-2010 across the Caribbean, Central and South America



Note: Negative values indicate increasing drought conditions in the top soil layer, while positive values indicate wetter conditions in the top soil layer compared to the reference period 1981-2010.
Source: (Maes et al., 2022[20]).

Wildfires raged across the world in 2023. In the southern hemisphere, wildfires in Chile generated a national emergency. In the northern hemisphere, more than 150 000 km^2 of land in Canada burned by the end of August, with New York City shrouded in a cloud of smoke and recording some of the highest air pollution levels in the world in July. Meanwhile, wildfires in southern Europe led to civilian casualties and threatened tourism destinations, highlighting that the impact of extreme wildfires goes beyond lives lost and includes widespread health impacts and innumerable economic disruptions (OECD, 2023[35]). This is consistent with the increasing wildfire exposure registered by OECD data.

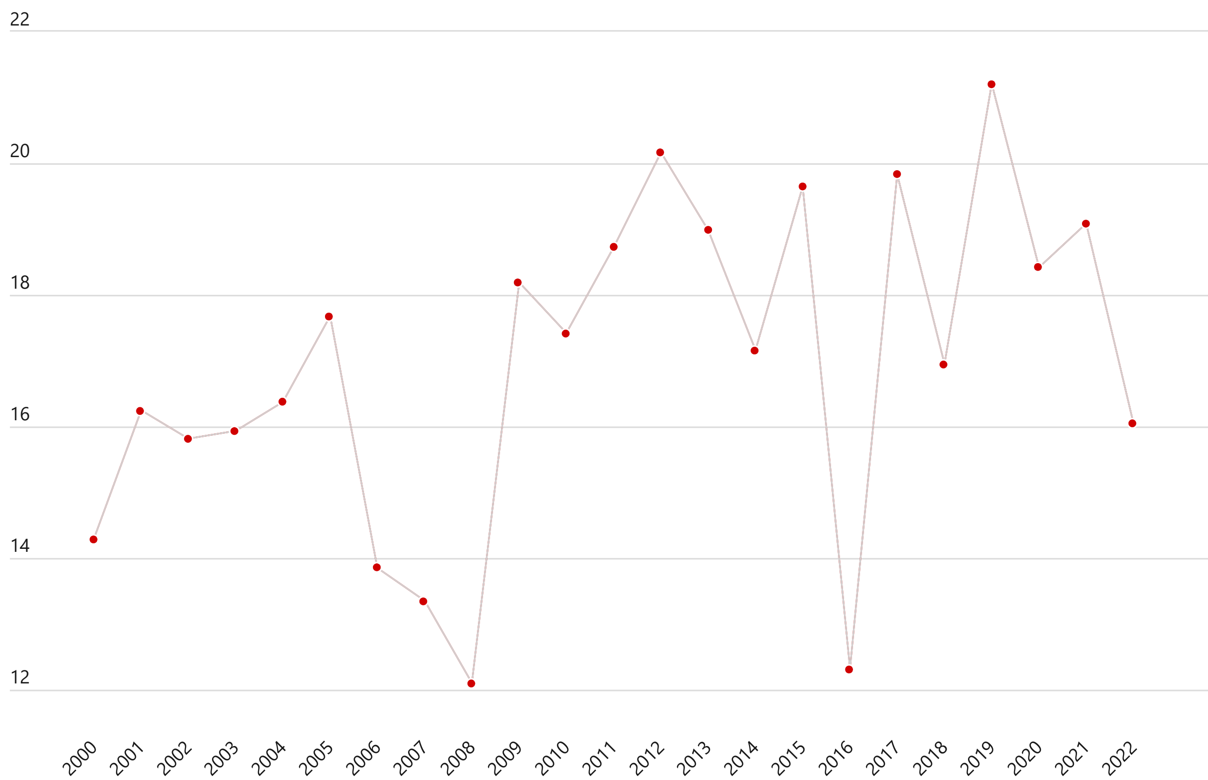
Burning of land is due to a variety of causes including wildfires or controlled and uncontrolled biomass burning. Globally, between 2018 and 2022, 20% of burned land was located in just seven OECD and partner countries. Whether this is due to wildfires or intentional biomass burning, burning can impact global mitigation efforts to combat climate change. On average, more than 1% of land area was burned per year between 2018 and 2022 in Argentina, Australia, Brazil, Colombia, India and South Africa, representing approximately 620 000 km^2, which is roughly equivalent to the size of France.

Wildfires are becoming more widespread, increasing ecosystem damage, notably biodiversity and carbon sinks, as well as harming human life. Between 2018 and 2022, an estimated 3.2% of the population across OECD and OECD partner countries lived in areas with very high or extreme wildfire danger, representing more than 160 million people. Countries with the highest population exposure to very high and extreme wildfire danger are South Africa (41.2%), Australia (19%), Costa Rica (12.4%), Brazil (9%) and Chile (8.7%), exposing a combined population of more than 51 million people. In absolute terms, India's population experiences the highest overall exposure to wildfires: between 2018 and 2022 more than 38 million people lived in areas with very high and extreme wildfire danger.

Across the OECD and partner countries there is an overall increase in forest exposure to very high or extreme wildfire danger (Figure 26). For example, Brazil experienced the largest area of forest exposed (~1.9 million km^2) to wildfire danger over the past five years. Other countries, such as the United States, Australia and Mexico, also have considerable amounts of forest exposed, with 516 000 km^2, 622 000 km^2 and 614 000 km^2 of forest areas exposed to very high or extreme fire risk respectively. Across OECD countries, Israel, Mexico and Portugal have some of the highest percentages, with more than 74% of forest exposed to wildfire danger between 2018 and 2022 (OECD, 2023[36]). These large areas of forest exposure highlight the considerable risk forests face and should be considered a policy priority given both human risk and key role that forests play as carbon sinks around the world.

Figure 26. Increasing forest exposure to wildfire danger

Percentage of forested areas exposed to very high and extreme fire danger for more than three consecutive days, OECD and OECD partner countries, 2000-2022



Source: IEA/OECD (2022), "Climate-related hazards: Wildfire", Environment Statistics (database), https://oe.cd/dx/58u.

Box 4. Taming wildfires in the context of climate change

Through a cross-country analysis, (OECD, 2023[35]) provides a global assessment of wildfire risk, underlining the urgent need for governments to scale up climate change adaptation efforts to limit future wildfire risk and impacts. The report discusses the drivers behind the growing occurrence of extreme wildfires, including the role of climate change, and outlines their growing environmental, social, and economic impacts. The report identifies emerging wildfire policies and practices to manage wildfire extremes and provides a set of policy recommendations to support countries in wildfire risk reduction.

Key policy recommendations include:

- Strengthen ecosystem protection and adaptive management for wildfire prevention.
- Scale up fuel management efforts to reduce fuel accumulation and continuity.
- Strengthen land-use planning and building regulations for wildfire prevention.
- Harness knowledge for better wildfire management and improve wildfire risk assessments.
- Strengthen the policy and institutional framework.
- Promote a whole-of-government approach to wildfire management, including through national wildfire risk management strategies and central co-ordinating agencies.
- Scale up funding and risk transfer instruments for wildfire risk reduction.

Source: (OECD, 2023[35])

Extreme precipitation, flooding and storms

Extreme precipitation events pose serious dangers to countries by potentially causing flash floods, landslides, and impacting the population and economic infrastructure. A majority of OECD and partner countries experience some level of exposure to extreme precipitation events, but the duration of exposure varies considerably. OECD and partner countries with the highest share of land exposed to extreme precipitation events between 2018 and 2022 included Indonesia (36%), Colombia (28.5%), Peru (21.2%) and Brazil (15.6%).[29] These countries experience higher precipitation due to being located in a tropical region with warmer temperatures and abundant moisture, amongst other factors.

In Europe, land exposure to extreme precipitation events remains low (< 3%). However, changing rain patterns affect ecosystems. For example, in central Europe, the wetter-than-average spring of 2023 offered partial relief after a dry winter, but the impact of severe drought in 2022 on groundwater levels means that rainfall was insufficient to replenish aquifers. At the same time, spring is less efficient than winter in replenishing aquifers, as rainwater is consumed by growing vegetation and higher evaporation rates due to higher temperatures (Copernicus Climate Change Service, 2023[37]).

Although dependent on crop types, extreme precipitation events can pose dangers to agriculture by causing flooding, soil erosion, water saturated soils and crop damage, threatening food production and livelihoods. This can be especially problematic for countries dependent on agriculture, making them overly vulnerable to precipitation changes due to climate change.

On average, Indonesia (31.6%), Colombia (13.2%), Costa Rica (9.8%), Peru (8%) and Brazil (3.3%) had the highest share of cropland exposed to extreme precipitation events between 2018 and 2022. The share of cropland exposed to extreme precipitation events has increased for countries such as Indonesia, with an estimated increase from 3.8% in 2000 to 41.1% in 2022. Six out of ten countries whose cropland area is most exposed to extreme precipitation events are also more dependent on agriculture as a share of

GDP. For example, Indonesia and Colombia have, on average, an estimated 31% and 13% of cropland exposed to extreme precipitation events while their GDP share of the agriculture, forestry and fishing sector is 12.9% and 7.2%, which is significantly higher than the average in OECD and OECD partner countries (3.2%).

Meanwhile, extreme precipitation events are also increasing significantly in certain subnational regions, such as in South America and Southeast Asia (Figure 27). In Southeast Asia, for example, the Indonesian provinces of Kalimantan and Sulawesi are experiencing an increase in extreme precipitation events (Figure 27) while an estimated 35% and 33% of the land is used for croplands. This highlights that certain subnational regions already impacted by extreme precipitation may see further increases due to climate change, increasing risks to food security, and possibly dramatic changes in migration flows.

Figure 27. Increasing extreme precipitation events across Southeast Asia

Yearly number of additional days with extreme precipitation events (2018-22 average) compared to the reference period 1981-2010 across Southeast Asia

Note: Negative values have been removed because the focus is on the occurrence of extreme precipitation events. A variety of indicators have been developed that assess extreme precipitation; these should be consulted for more detailed analysis of individual countries.
Source: (Maes et al., 2022[20]).

The South Asian monsoon season is becoming increasingly unpredictable and less dependable (Fountain, Levitt and White, 2022[38]). The 2023 monsoon season brought more extreme weather events, bringing the heaviest rainfall in decades to northern India, causing rivers to overflow, with flooding and landslides washing away vehicles, destroying bridges and roads, and disrupting power and electricity (The Guardian, 2023[39]). Over 100 people across Himachal Pradesh, Uttar Pradesh, and Delhi died over a two-week period of intense rain and flooding, with thousands of others evacuated to relief camps (Mehrotra, 2023[40]).

Flooding is caused by a combination of factors including extreme precipitation, storm surges, river overflow and increased artificial surfaces. It threatens people's lives, livelihoods and economic infrastructure. Among the 51 OECD and OECD partner countries, the Netherlands and Hungary have the highest percentage (~20%) of total land area exposed to extreme river flooding. Meanwhile, China is the most exposed country with 22% of its built-up area exposed to river flooding, followed by Latvia (20%) and the Netherlands (18%). In terms of agricultural land exposure, the most affected OECD and OECD partner countries are Hungary, the Netherlands, and the Slovak Republic with more than 17% of their cropland exposed to possible extreme events.[30]

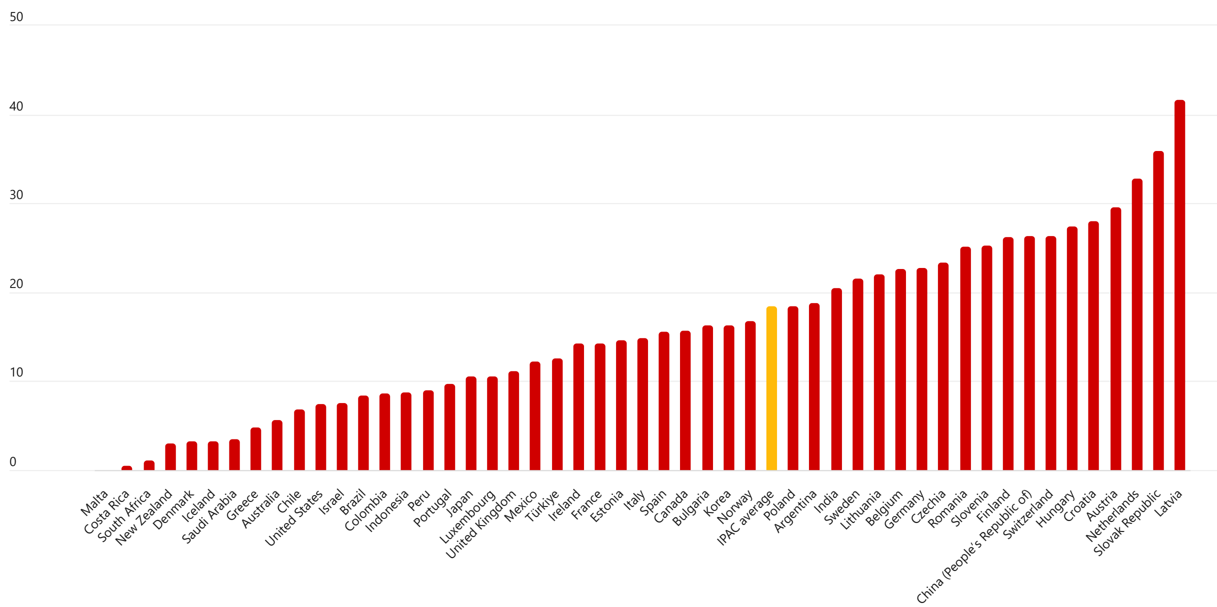
River flooding can also cause human losses. In 2021, Germany was hit by floods that generated the highest costs caused by a climate extreme event in the post-war period, killing 189 people and causing direct economic damages estimated at 33.1 billion EUR (OECD, 2023[24]). Among OECD and OECD partner countries, populations in Latvia, the Slovak Republic and the Netherlands are the most exposed, with more than 30% of people potentially affected. Due to the sheer size of China (26%) and India (20%), the total number of people exposed in these two countries to river flooding is approx. 670 million (Figure 28).

Low-lying coastal communities face a range of coastal flooding hazards such as storm surges and erosion. These hazards are expected to worsen as climate change increases the frequency and severity of coastal floods. The most exposed countries are the Netherlands, Belgium and Denmark. The Netherlands has 51% of its land area potentially exposed to coastal flooding with a ten-year return period, followed by 6.4% for Belgium and 5.6% for Denmark. However, these figures should be interpreted with caution, as they do not account for existing flood protection measures or sea-level rise. Nevertheless, they underscore the importance of maintaining existing protections to prevent future impacts and the potential economic costs of dealing with climate change.

Built-up area exposure to coastal flooding is increasing. Across OECD and OECD partner countries, the percentage has increased significantly, from 1.8% in 2000 to 2.6% in 2020 (Figure 29). This suggests that additional investment in infrastructure will be necessary, particularly if built-up area continues to expand in coastal zones. Across OECD and OECD partner countries, the Netherlands has 52% of its built-up area exposed to coastal flooding, followed by Belgium (10%) and China (6.6%). This is explained by the fact that much of the land along the North Sea coast is either below sea level or just slightly above it, exposing a sizeable amount of the land and its built-up areas to coastal flooding hazards.

Figure 28. Population exposure to river flooding varies between OECD and OECD partner countries

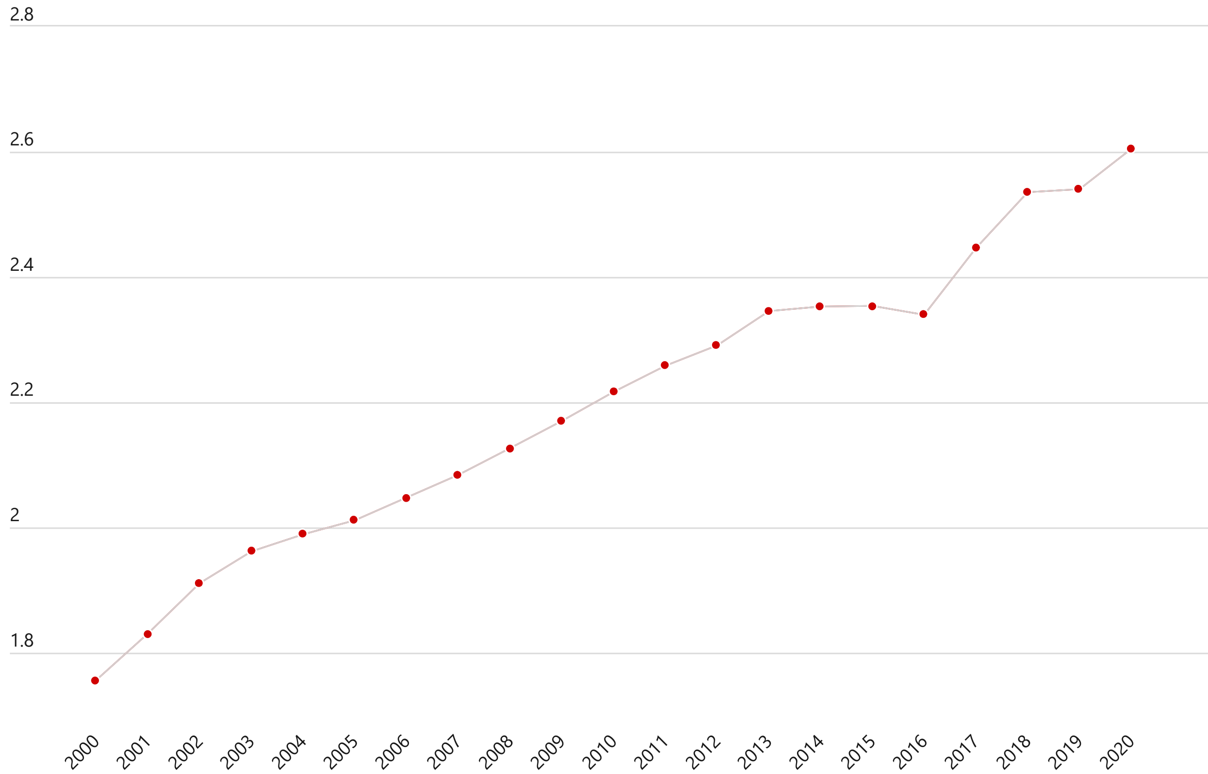
Percentage of population exposed to river flooding, with a return period of 100 years, OECD and OECD partner countries, 2020



Source: IEA/OECD (2022), " Climate-related hazards: River flooding", Environment Statistics (database), https://oe.cd/dx/58w.

Figure 29. Built-up area exposure to coastal flooding increased across OECD and OECD partner countries

Percentage of built-up area exposed to coastal flooding, with a return period of 100 years, OECD and OECD partner countries, 2000-2020

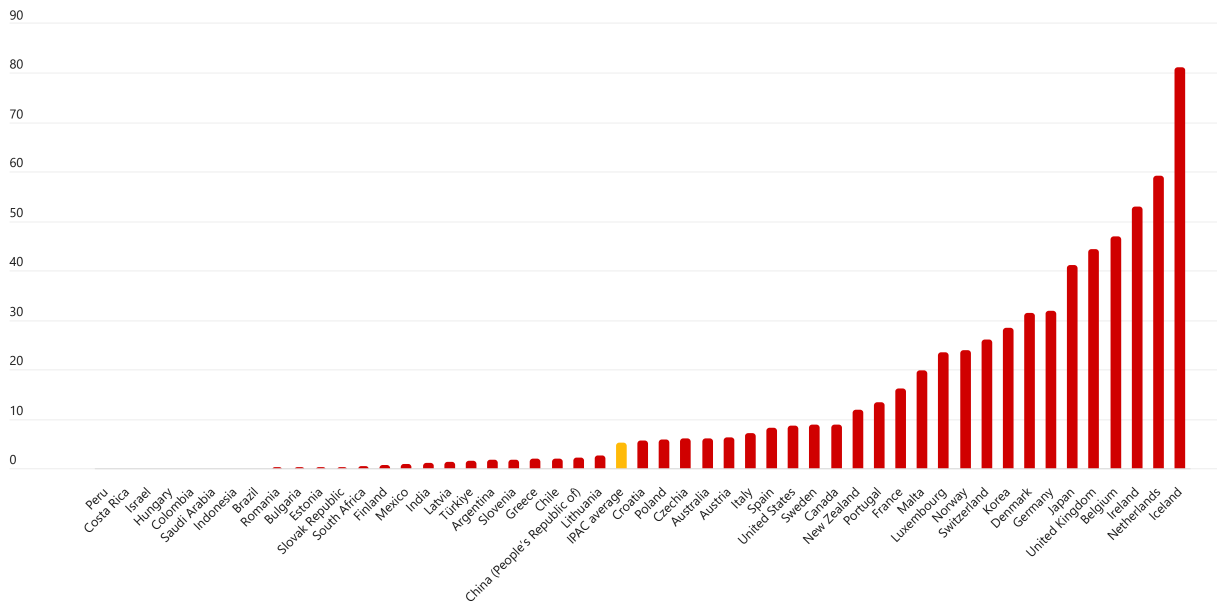


Source: IEA/OECD (2022), " Climate-related hazards: Coastal flooding", Environment Statistics (database), https://oe.cd/dx/58x.

Storms affect all OECD and partner countries with varying degrees of intensity and occurrence, and at times worsen the effects of other hazards. For example, in the United States in 2022, Hurricane Ian caused extensive storm-surge inundation in low-lying coastal areas and river flooding, becoming the fourth strongest landfall on record in Florida. Countries most exposed to violent storms are located principally in northwest Europe and east Asia. Countries such as Belgium, Iceland, Ireland, the Netherlands, and the United Kingdom had more than 45% of their population and built-up areas exposed to violent storms in the period 2018-22 (Figure 30). Meanwhile, exposure to tropical cyclones is limited to a subset of OECD and OECD partner countries due to their geographic position. The most exposed OECD and OECD partner countries are Japan and Korea (90%), where more than 90% of their populations and built-up areas are exposed to tropical cyclones (with wind speeds higher than 119 km/h or 33 m/s), followed by Mexico and China with 25%.

Figure 30. Population in northwestern Europe and East Asia are particularly exposed to violent windstorms

Percentage of population exposed to violent windstorms, OECD and OECD partner countries, 2018-22 average



Source: IEA/OECD (2022), " Climate-related hazards: Wind threats", Environment Statistics (database), https://oe.cd/dx/58v.

Economic losses from climate disasters

Extreme weather events, such as heatwaves and heavy precipitation,[31] exacerbate existing social, political and economic stressors, with food insecurity being one such factor.[32] While there is uncertainty about the trajectory of future changes in climate, increasing severity of extreme weather events, along with increasing population density in hazard-prone locations, is likely to lead to rising climate-related catastrophic losses in the future (OECD, 2021[41]).

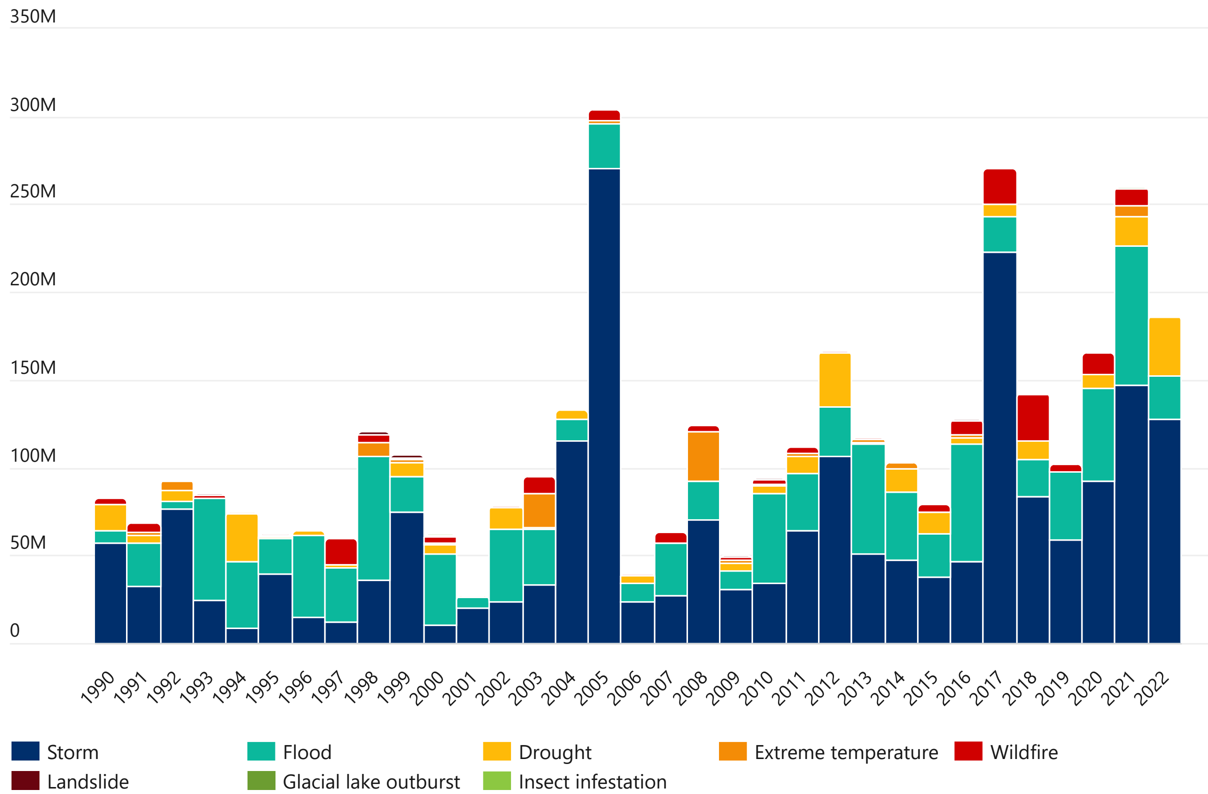
Extreme weather events can cause damage to homes and businesses, as well as economic and social infrastructure such as schools, hospitals, roads and, power generation and distribution. Extreme events are causing increasingly devastating and widespread impacts on lives and livelihoods, particularly when they occur in conjunction with broader social, economic and political stressors (OECD, 2021[41]).

The World Meteorological Organization (WMO) reported an almost eight-fold increase in average daily economic losses between 1970-79 and 2010-19. While reported economic losses from climate-related events are highly volatile from year to year, they have increased globally since 1990 (Figure 31). Storms are responsible for the largest economic costs, followed by floods, droughts, extreme temperatures and wildfires, all of which incur a growing cost every year (Figure 31). For example, the estimated economic losses from Hurricane Ian in the United States were USD 113 billion in 2022, making it the third most costly tropical cyclone on record while, with 152 deaths, it caused the greatest loss of life from a Florida tropical cyclone since the 1930s (WMO, 2023[42]).

Developing countries, including least developed countries (LDCs) and small island developing states (SIDS), are disproportionately affected by the impacts of extreme weather events. This is due to their geographic location at low latitudes, generally lower levels of development and economic diversification, fiscal constraints, and their physical characteristics (OECD, 2021[41]). Moreover, reporting gaps in these countries underestimate the damages incurred. For example, the African continent saw 35% of deaths related to weather, climate and water extremes but just 1% of reported global economic losses (WMO, 2021[43]).

Figure 31. Storms, floods, droughts, extreme temperatures and wildfires increasingly claim the largest economic losses

Total economic losses, thousand USD (adjusted), OECD and OECD partner countries, 1990-2022



Source: OECD calculations based on data on EM-DAT.

Box 5. Loss and Damage Fund

The 27th session of the Conference of the Parties (COP27) held in Sharm el-Sheikh in November 2022, led to the establishment of a Loss and Damage Fund with the aim of providing financial assistance to countries most vulnerable and impacted by the effects of climate change.

To facilitate the operationalisation of the new funding arrangements, a transitional committee has been convened to prepare recommendations for adoption at COP28 in November 2023. Recommendations shall consider:

- Establishing institutional arrangements, modalities, structure, governance, and terms of reference for the fund.
- Defining the elements of the new funding arrangements.
- Identifying and expanding sources of funding.
- Ensuring co-ordination and complementarity with existing funding arrangements.

The Loss and Damage Fund should fill gaps that current climate finance institutions such as the Green Climate Fund and Adaptation Fund do not. Campaigners argue that the Loss and Damage Fund must be accountable to the most vulnerable, drawing on the experience of community-based organisations, and favouring financial instruments that are non-debt-inducing and grant-based. Financing instruments that could be used to provide a buffer and rapid pay-outs after disasters include social protection, contingency finance, catastrophe risk insurance and catastrophe bonds. However, a broadened donor base and innovative finance tools would be needed to respond to the magnitude of loss and damage.

Source: (UNFCCC, 2023[44])

3 How has countries' climate action to meet emission targets progressed?

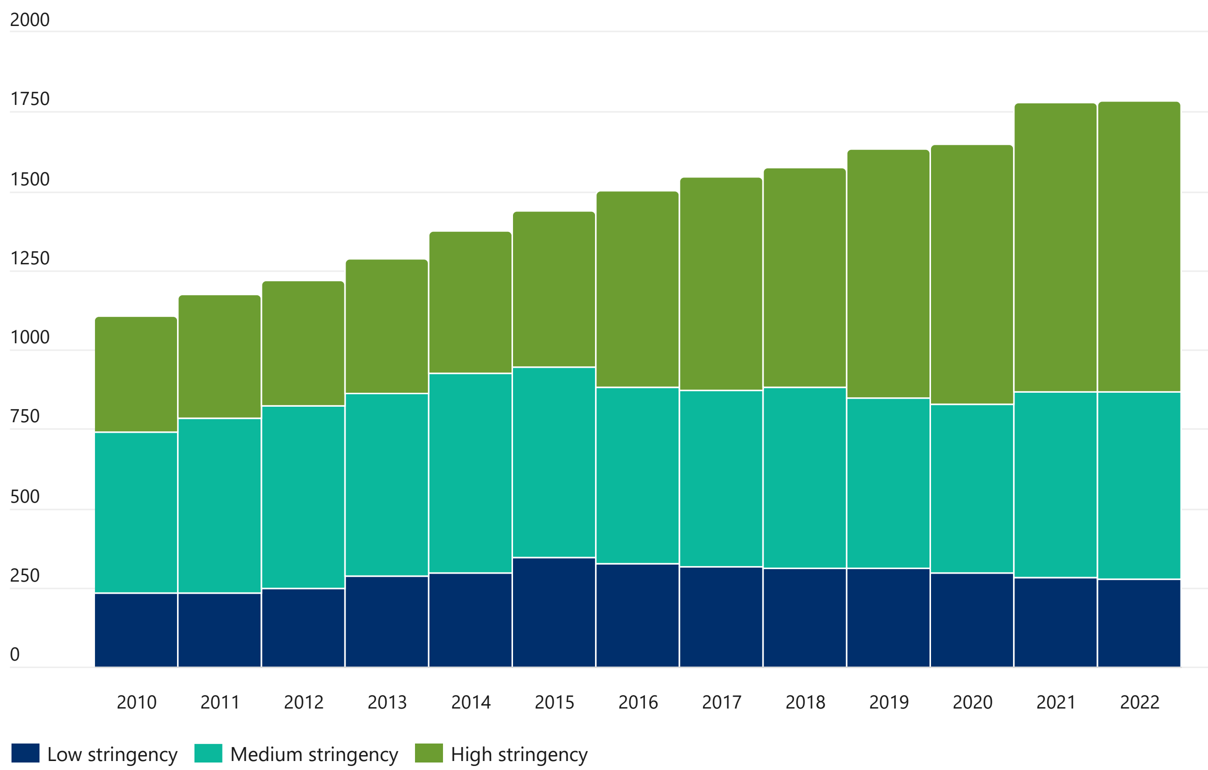
Effective climate action is key to achieving countries' NDCs and net-zero targets. The IPAC Climate Actions and Policies Measurement Framework (CAPMF)[33] monitors trends in climate mitigation policy adoption and policy stringency[34] for OECD and OECD partner countries (Nachtigall et al., 2022[45]).[35] The CAPMF covers a broad range of policy instruments (e.g. market-based, non-market based) and other climate actions (e.g. climate targets, climate governance, climate data), comprising 75% of instruments listed in the IPCC Sixth Assessment Report (IPCC, 2022[46]). It covers several important sector-specific policies that are jointly responsible for 89% of GHG emissions in OECD and OECD partner countries. Although there are still data gaps (e.g., AFOLU sector, see Annex I for details), the CAPMF still allows for an extensive overview of countries' climate action over time.

The number of adopted national climate policies and their stringency slowed in 2022

In 2022, the growth rate of the sum of national climate action as measured by the CAPMF slowed down in the OECD and OECD partner countries (Figure 32). The total number of adopted policies expanded by only 1%, while the stringency of policies remained roughly constant. By contrast, between 2000 and 2021, overall climate action as measured by the CAPMF[36] increased by an average of 10% a year (for more details see Annex Figure I.3).

Figure 32. Overall, countries expanded climate action by only 1% in 2022

Number of adopted policies by policy stringency as measured by the CAPMF, 2010-2022



Note: Low stringency is defined as a stringency score of 0-3, medium as 4-7, and high as 8-10.
Source: OECD (2023), "Climate actions and policies measurement framework", Environment Statistics (database), https://oe.cd/dx/5if.

It is important to consider geopolitical and macroeconomic shocks when assessing climate policy. On the one hand, the recent energy crisis triggered countries to ramp up fossil fuel support to record levels while postponing planned climate actions such as carbon pricing and the phasing out of fossil fuel infrastructure. With the exception of the implementation of the Inflation Reduction Act (IRA) in the United States – although not considered in the CAPMF – the fiscal space of most governments to provide additional support to low-carbon technologies became increasingly limited due to increased government spending on recovery packages in response to the COVID-19 pandemic and rising interest rates to curb inflation (OECD, 2021[47]).[37] Some policies (e.g. minimum energy performance standards, energy labels, air emissions standards for coal power plants) have already been widely adopted, further limiting the space for new policy adoption.

On the other hand, the energy crisis triggered more climate action. Concerns over energy security and reliance on fossil fuels motivated some countries to adopt more ambitious targets on renewables and energy efficiency. These targets and commitments, as well as some types of policy measures (e.g. support to green investment) are not yet fully captured by the CAPMF. Further developments of the CAPMF will reveal whether countries underpin these targets by appropriate climate policies in the coming years, and if the aggregate trends on climate action improve.

Policy coverage and policy stringency are not necessarily indicative of policy effectiveness in reducing GHG emissions. However, the trend observed by the CAPMF in 2022 may pose a risk to countries' achieving their mitigation commitments. Stronger climate action, as measured by the CAPMF, points to steeper emissions reductions (Nachtigall et al., 2022[45]). Nevertheless, CAPMF data shows that all countries still have multiple options for strengthening their climate action by increasing the stringency of existing policies or adopting new policies that are currently not widely used (e.g. carbon pricing in the building and transport sector, bans and phase-outs of fossil fuel extraction, fossil fuel-based heating and transportation modes).

Climate action differs significantly across countries and instrument types

The main causes of the overall slowdown in climate action include decreases in public expenditure in research and development of low-carbon technologies such as renewables, energy efficiency and CCS, postponement of the phase-out date of fossil fuel infrastructures, and reduced funding for climate advisory bodies. The full details of countries' actions can be observed in the IPAC Dashboard.

Some countries did, however, expand their climate action in 2022. Twenty-two OECD and eight OECD partner countries – accounting for 29% of global GHG emissions – expanded their climate action in 2022, although only three of those countries expanded climate action by more than the average increase in previous years. The 2022 increase was driven principally by new or enhanced net-zero pledges, strengthened regulatory measures and advances in international climate policy frameworks. For example, India submitted its NDC aligned to a net-zero target by 2070, Chile put its net-zero target into law and the European Union significantly enhanced its climate action with a 'Fit for 55' package that includes, among others, amendments to its Emissions Trading Scheme (ETS) as well as regulations to strengthen energy efficiency and renewables. The United Kingdom strongly increased auctions for solar and wind energy and tightened the ETS on industry and electricity. Finally, Austria launched its national ETS for the transport and building sector in 2022.

Notwithstanding these trends, it is important to underscore that countries' policy approaches are the result of a complex interaction between past climate action, climate ambitions, emissions profile, and available technologies, as well as countries' cultural, social, political and institutional conditions. There is no one-size-fits-all policy approach. Each country needs to tailor its policy approach to its specific circumstances: some may prefer to adopt few, albeit very stringent policies, whereas others prefer to adopt many policies with rather low stringency. Similarly, some countries put more emphasis on market-based instruments while others make more use of regulatory non-market-based instruments such as regulations. Ultimately, effectiveness can only be assessed through modelling techniques, such as those proposed under the OECD Inclusive Forum on Carbon Mitigation Approaches (IFCMA).

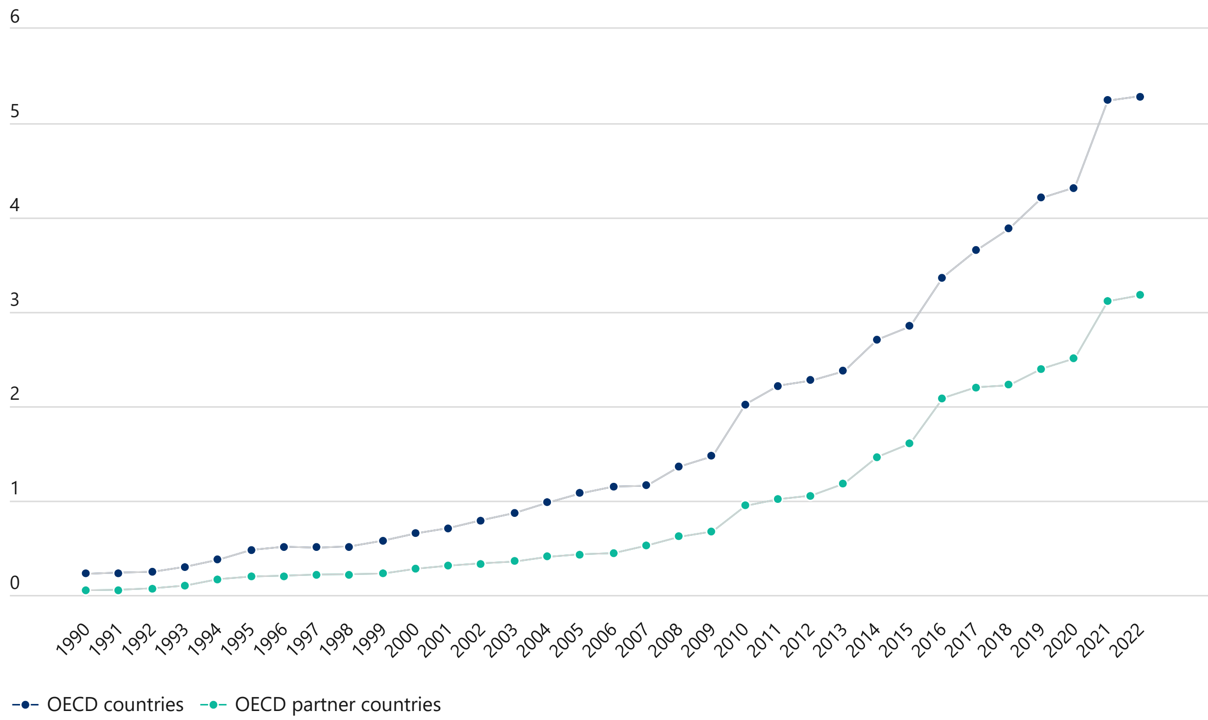
Climate action is increasingly diverging across countries over time

Climate action is increasingly diverging between OECD and OECD partner countries (Figure 33). Some OECD countries had already stronger policies in place and accelerated climate action faster than other countries. For example, European Union countries subject to EU regulation had already adopted a wide range of climate policies and have continued expanding climate action at a fast pace. While the trend of divergence can be observed between 1990 and 2020, it accelerated markedly in 2021, though not in 2022.

Diverging climate action reinforces the need for more international co-ordination and co-operation on climate action, notably in times of the current geopolitical challenges. Achieving the Paris Agreement long-term temperature goal requires improved institutional, technical, and human capacity, and scale-up of finance for climate action. Moreover, in an interconnected world, diverging climate action across countries may affect competitiveness and trigger carbon leakage, therefore limiting the effectiveness of increased climate action (Nachtigall et al., 2021[48]). Some countries, notably the European Union, started to implement safeguards such as border carbon adjustment to reduce the risk of carbon leakage and mitigate negative competitiveness effects (OECD, 2023[49]).

Figure 33. Climate action is diverging between OECD and OECD partner countries

Average policy stringency, as measured by the CAPMF, OECD and OECD partner countries, 1990-2022



Note: The sharp increase in average policy stringency in 2010 can partly be explained by the simultaneous improvement in data availability. For example, data on fossil fuel support (FFS) reform only became available from 2010. See endnotes for details on the calculation of average stringency. Country group averages are calculated using an unweighted average across the respective countries.
Source: OECD (2023), "Climate actions and policies measurement framework", Environment Statistics (database), https://oe.cd/dx/5if.

Climate action in international climate co-operation policies and cross-sectoral policies expanded marginally, but slowed down for sectoral policies

Climate action in international climate co-operation policies[38] and cross-sectoral policies[39] continued its upward trend in 2022, though at a significantly slower pace compared with previous years (Figure 34). The increase in international climate action and cross-sectoral action was stronger in OECD partner countries than in OECD countries (Figure I.4 and Figure I.5). The increase in international climate action observed after 2020 can mostly be attributed to i) the Arrangement on Officially Supported Export Credits, in which participants agreed to end the support for unabated coal power plants (OECD, 2023[50]); ii) a joint commitment forged at COP26 in 2021 that committed signatories to “align international public support towards the clean energy transition and out of unabated fossil fuels” (UK Government, 2021[51]); and iii) the launch of the pilot phase of CORSIA. Climate action in cross-sectoral policies principally increased due to enhanced NDCs and net-zero targets in some countries.

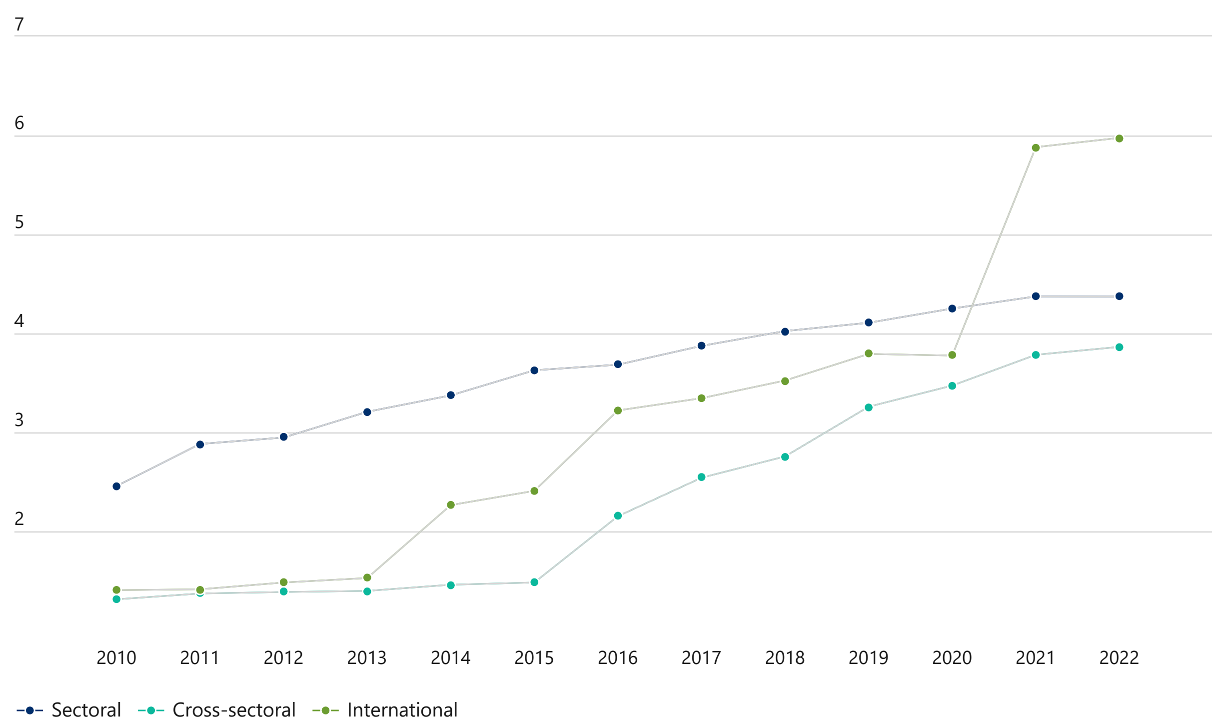
Climate action in sectoral policies[40] slowed down in 2022. The slight increase in climate action in the building sector was offset by decreases in climate action in the electricity and industry sectors (Figure 35).

This was mostly due to a decrease in governments holding renewable energy auctions, postponed phase-out dates of coal power plants, and carbon tax breaks for energy-intensive industries in view of the energy crisis. Climate action in the transport sector – the sector with least progress on climate action between 2010 and 2021 – halted in 2022.

Sectoral policies are key levers to reduce sector-specific GHG emissions. Most countries emphasise the importance of sectoral policies in their NDCs. For example, 92% and 83% of countries declare that action in the electricity and transport sectors respectively are key mitigation strategies to reach their NDCs, whereas only 78% report the same for cross-sectoral policies (UNFCCC, 2022[52]). However, a slowdown in climate action in sectoral policies is observed by the CAPMF in the two sectors that account for the highest shares of GHG emissions in OECD and OECD partner countries: electricity (36%) and industry (22%) (Chapter 1).

Figure 34. Climate action in cross-sectoral and international policies marginally increased in 2022

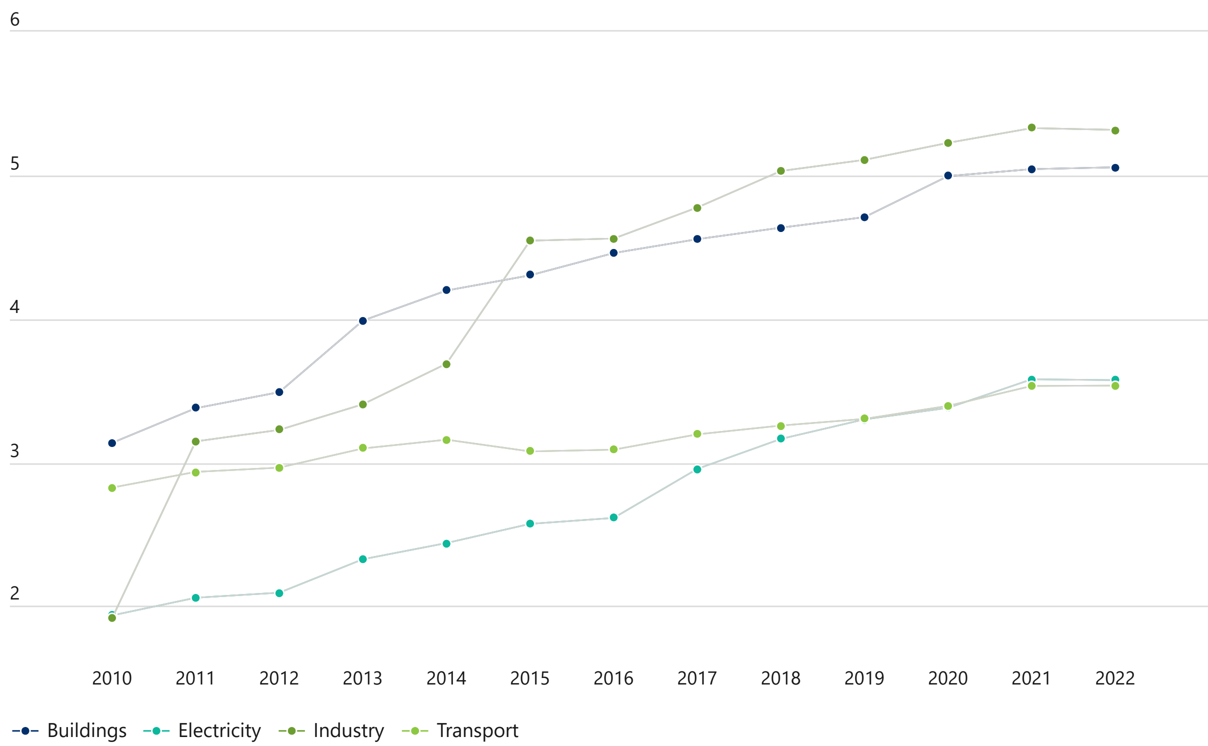
Average policy stringency (0-10) by policy area, as measured by the CAPMF, total for OECD and OECD partner countries, 2010-2022



Note: See endnotes for details on the calculation of average stringency. The average across OECD and OECD partner countries is calculated using an unweighted average across the respective countries.
Source: Nachtigall, D., et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", OECD Environment Working Papers, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en.

Figure 35. Climate action in sectoral policies decreased in the electricity and industry sectors

Average policy stringency (0-10) by sector, as measured by the CAPMF, total for OECD and OECD partner countries, 2010-2022



Note: See endnotes for details on the calculation of average stringency. The average across OECD and OECD partner countries is calculated using an unweighted average across the respective countries.
Source: OECD (2023), "Climate actions and policies measurement framework", Environment Statistics (database), https://oe.cd/dx/5if.

The relative importance of market-based instruments decreased in the last decade

As explained above, each country needs to tailor its policy approach and policy mix to its own specific circumstances. All types of climate actions and policies have a role to play in reducing emissions and achieving the long-term temperature goal of the Paris Agreement.

- Market-based instruments (MBIs), such as subsidies and carbon pricing, can cause relative prices to shift the investment, production and consumption decisions towards low-carbon alternatives. Carbon pricing schemes are also a source of revenues to finance climate action.
- Non-market-based instruments (nMBIs), such as standards and information instruments, are instrumental to mainstream advanced low-carbon technologies, provide climate-relevant information to stakeholders, steer broad, bottom-up support for climate measures, and develop infrastructure for low-carbon alternatives.
- Targets (e.g., net-zero targets and NDCs), international co-operation, governance and climate data are key enabling conditions for effective mitigation. While these actions may not have a direct material effect on emissions, they provide the policy framework with mid- and long-term signals for all

stakeholders. They also create the institutional capacity to effectively implement policies, enable the tracking of progress, and identify key emissions drivers.

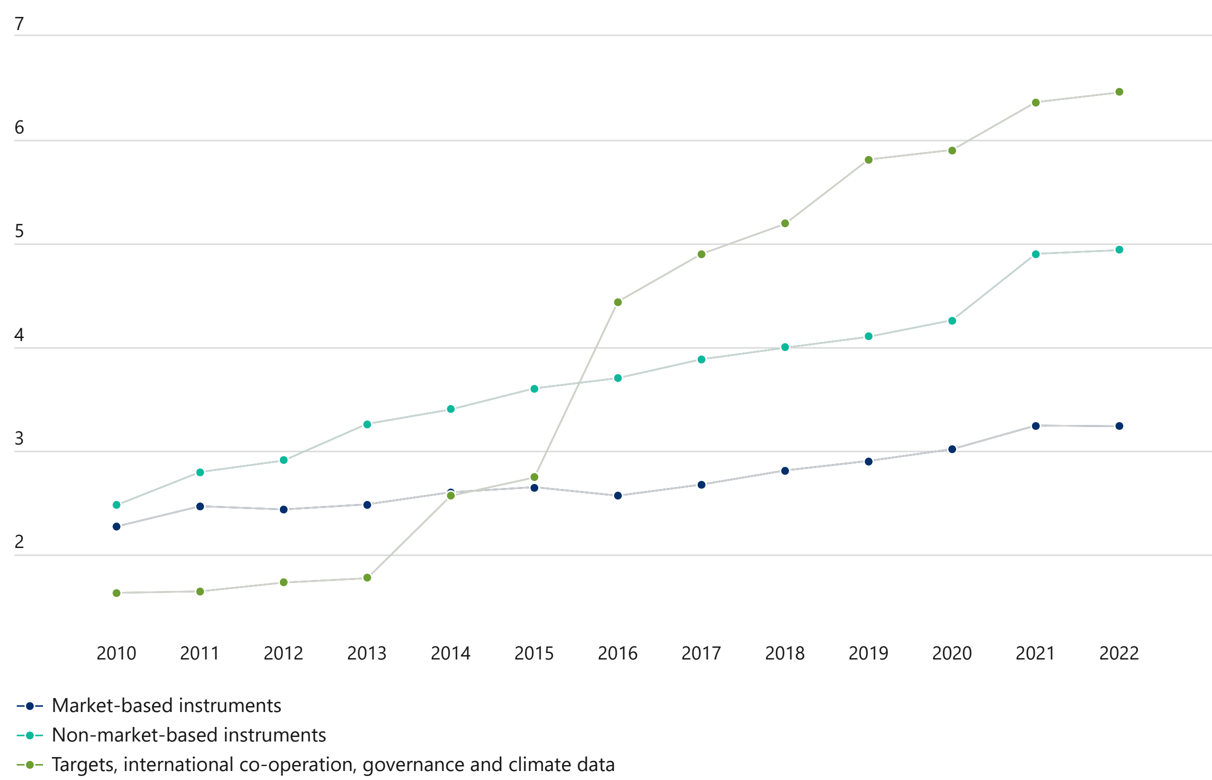
Climate action on MBIs slowed down significantly between 2010 and 2022 (Figure 36). While action on nMBIs and ‘Targets, governance and climate data’ increased by 88% and almost 300% respectively, action on MBI only increased by 43% between 2010 and 2022. While the number of adopted MBIs increased by 33% between 2010 and 2022, the number of adopted nMBIs as well as policies related to ‘Targets, governance and climate data’ increased by 66% and 250% respectively.

In 2022, overall climate action in market-based instruments slowed (Figure 36). This is the result of two opposing trends: (i) the expansion and increase in stringency of carbon pricing (e.g. permit prices in most ETS increased, partly driven by more stringent emissions caps set by countries), and (ii) backtracking on other MBI policies, notably related to fossil fuel support (see below). Out of nine countries with preliminary data, four (France, Italy, Portugal, and Slovakia) saw a reduction in energy related tax revenue in 2022, and five saw an increase (Denmark, Estonia, Luxembourg, Norway, and Sweden) (OECD, 2023[53]).

These findings suggest that the relative importance of MBIs in countries’ policy mixes has decreased, despite their potential to incentivise cost-effective emissions reductions. A possible explanation is the lack of public acceptability, notably for carbon pricing (Jenkins, 2014[54]) (Dechezleprêtre et al., 2022[55]). Carbon pricing design that contemplates revenue recycling or other mechanisms to deal with public resistance can better compensate vulnerable households and help boost public support for these approaches. Indeed, countries use different revenue recycling approaches (Nachtigall, Ellis and Errendal, 2022[56]).

Figure 36. Climate action on market-based policy instruments slowed down significantly

Average policy stringency (0-10) by policy type, as measured by the CAPMF, total for OECD and OECD partner countries, 2010-2022



Source: OECD (2023), “Climate actions and policies measurement framework”, Environment Statistics (database), https://oe.cd/dx/5if.

Countries made some progress on carbon pricing

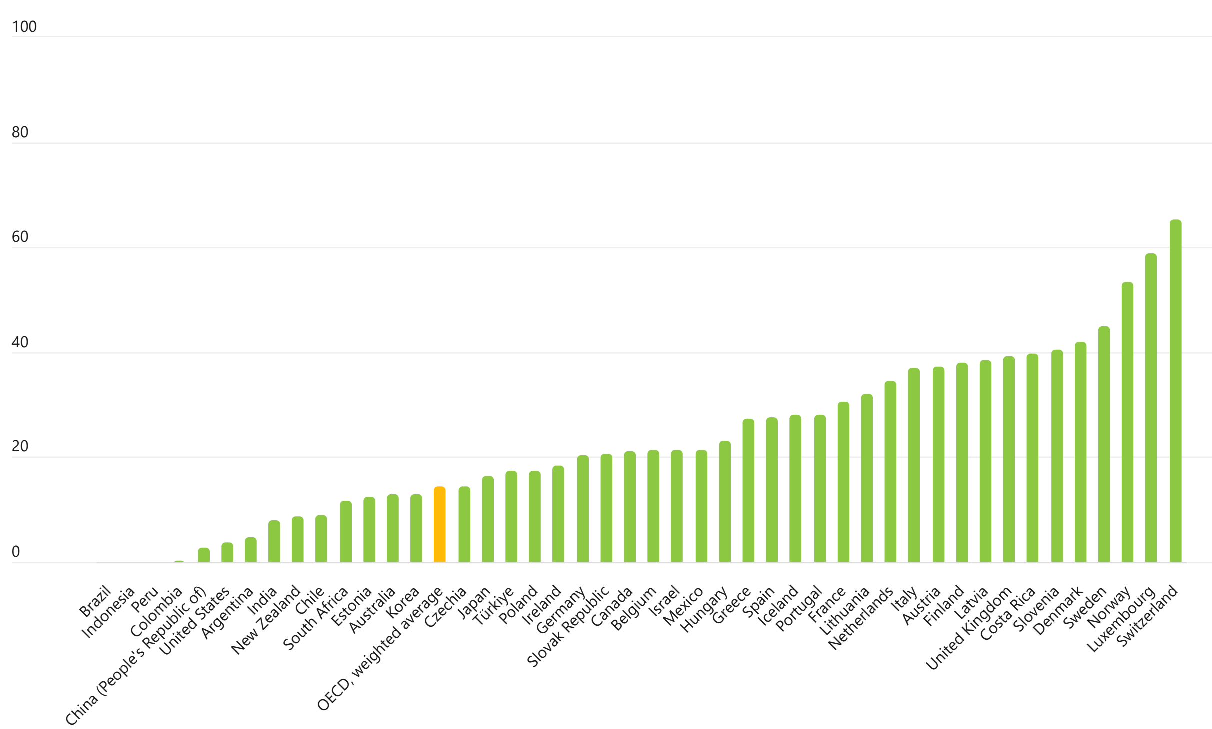
Progress on carbon pricing has been mixed since 2020. On the positive side, between 2020 and 2022 eight new carbon pricing instruments were adopted, mostly in form of ETS, covering the transport and buildings sectors. For example, Austria and Germany introduced a national ETS for transportation and buildings which are not yet covered by the EU ETS. The EU proposed, under its 'Fit for 55' package, a separate ETS to cover transport and heating fuels in the bloc from 2026 and to further expand the sectoral coverage of its existing ETS to maritime transport. In terms of price levels, ETS permit prices reached new highs, increasing from an average of EUR 11.2 per tCO_2 in 2018 to EUR 15.5 in 2021 (OECD, 2023[57]).

On the negative side, some countries responded to the energy crisis by controlling prices or (temporarily) removing or reducing taxes on energy. This price support weighs on government budgets and distorts price signals. For example, Germany temporarily froze the scheduled price increases of its national ETS (OECD, 2023[24]).

Carbon pricing systems are designed based on the socio-economic conditions of each country, including exemptions and free allocation of carbon permits. Therefore, determining effectiveness will depend on an evaluation of those conditions. While many countries have a high share of economy-wide GHG emissions subject to a positive net effective carbon rate,[41] price levels are generally considered too low to be compatible with Paris Agreement temperature goal, and only three countries price more than 50% of their GHG emissions at more than EUR 60 (Figure 37) – a medium-range estimate deemed to be necessary to reach climate goals (High-Level Commission on Carbon Prices, 2017[58]). In most countries, notably in large economies, this share is around or below 25%. In addition, GHGs such as CH_4, N_2O, and F-gases remain largely unpriced.

Figure 37. Very few countries price more than half of emissions above 60 EUR per tonne

Share of GHG emissions subject to a carbon price over 60 EUR/tCO_2e, %, 2021



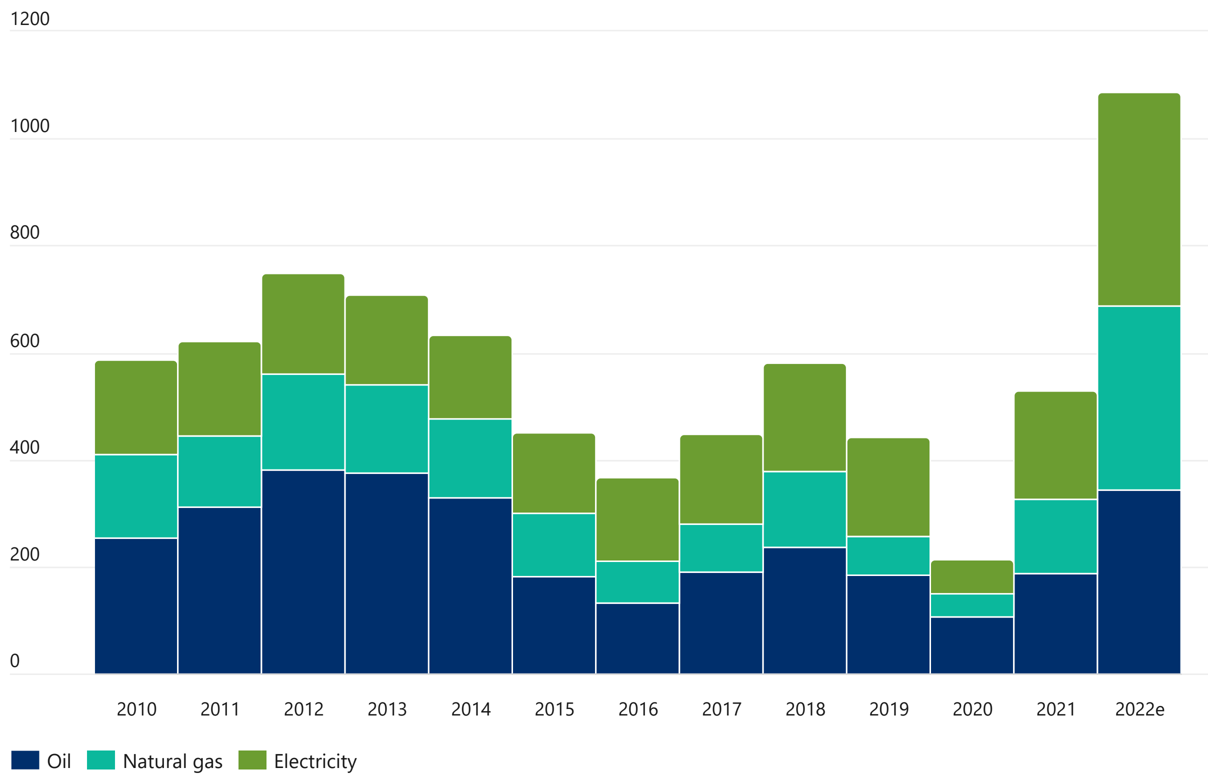
Source: OECD (2022), Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/e9778969-en.

Fossil fuel subsidies rose to a record high in 2022

Fossil fuel consumption subsidies increased dramatically, rising to a record high in 2022 by surpassing USD 1 trillion (IEA, 2023[59]).[42] Fossil fuel subsidies send the wrong price signal to energy consumers and need to be limited and restricted to meet the long-term temperature goal of the Paris Agreement.[43] Most of the rise in subsidies was related to the energy crisis, as governments shielded vulnerable consumers and firms from energy price hikes. Once energy prices normalise, it is expected that fossil fuel subsidies will decrease. By contrast, global subsidies on clean energy technologies were about 600 billion annually for the same period (IEA, 2022[60]).

Figure 38. Fossil fuel consumption subsidies reached a new record high of over USD 1 trillion in 2022

World fossil fuel consumption subsidies by fuel, billion USD, 2010-2022



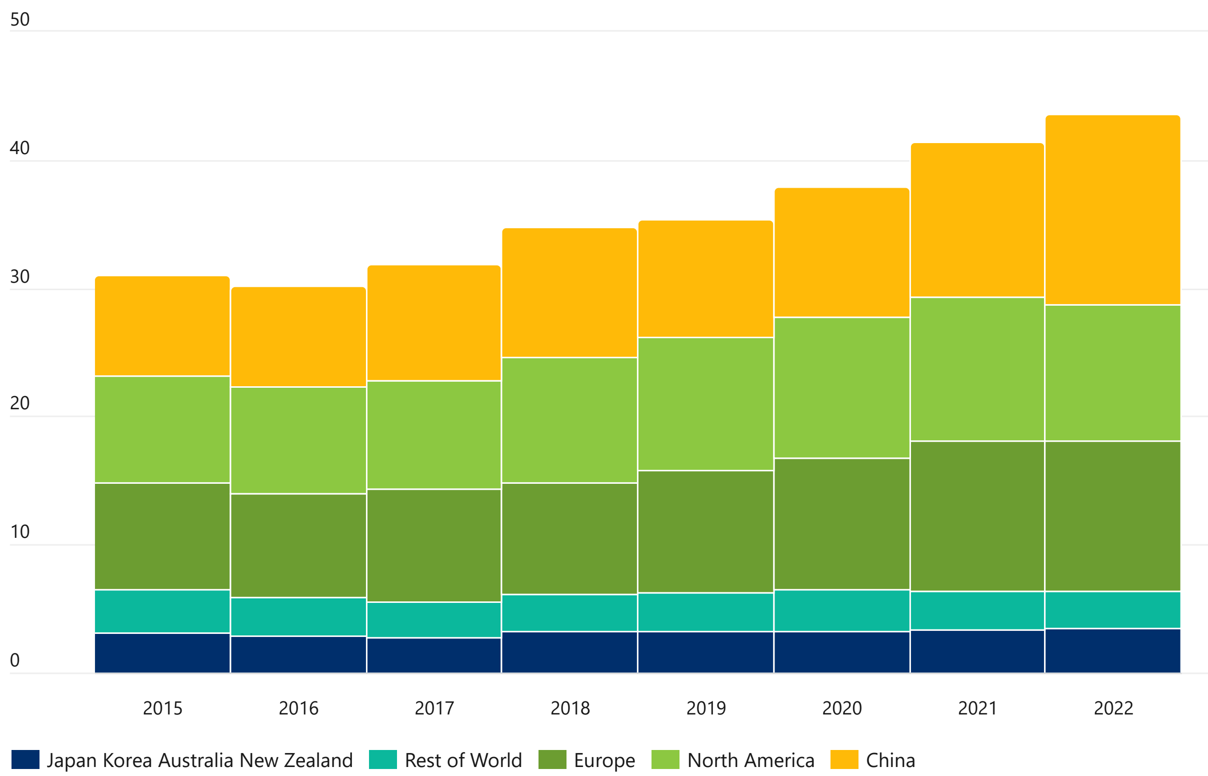
Source: (IEA, 2023[59]).

Support for RD&D for clean energy increased

Despite recent economic uncertainties, global public spending on energy research development and demonstration (RD&D) increased by 5%, up to USD 44 billion in 2022 compared to 2021 (Figure 39). The share of clean energy RD&D rose from 79% in 2020 to 80% and 81% in 2021 and 2022. Spending is expected to increase further with the implementation of the US Inflation Reduction Act, the largest funding for clean energy RD&D innovation.

Figure 39. Public spending on clean energy-related RD&D is increasing

Government spending on energy RD&D by region, billion USD (constant 2022 prices using GDP deflators and 2022 exchange rates), 2015-2022



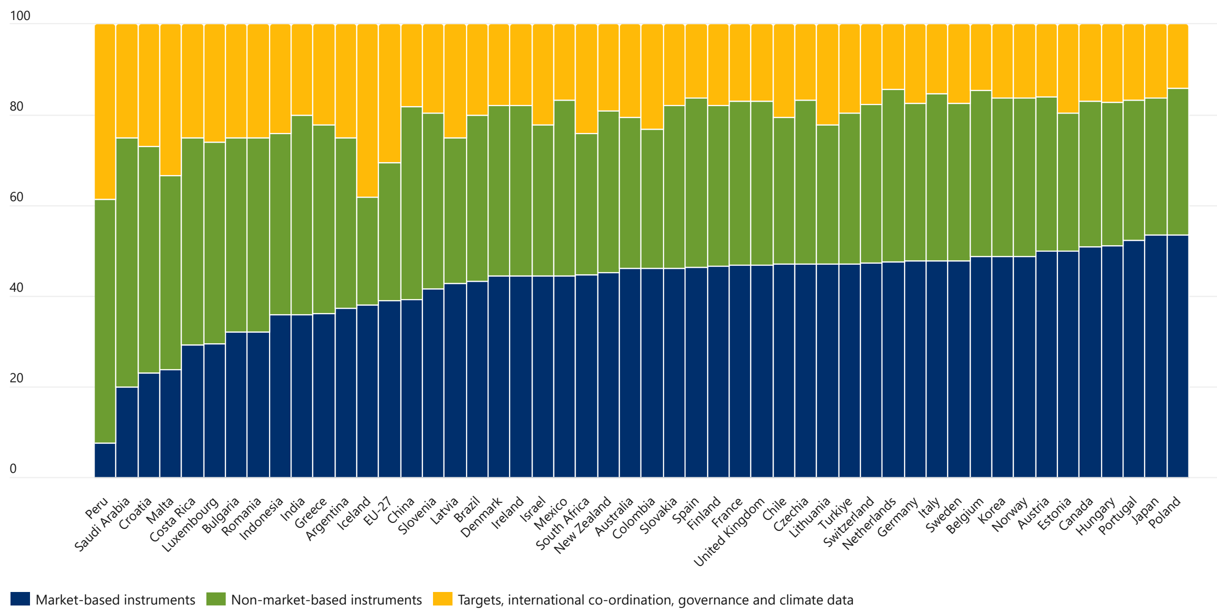
Source (IEA, 2023[61]), (IEA, 2023[62]), (IEA, 2023[63]).

Use of market-based instruments differs significantly across countries

Policy mixes differ considerably across countries (Figure 40). While some countries (e.g. Canada, Poland) emphasise market-based instruments, others (e.g. Peru, Saudi Arabia) prioritise non-market-based instruments. As mentioned above, countries use different policy mixes to meet their targets, tailored to their specific circumstances.

Figure 40. Policy mixes differ significantly across countries

Share of policies adopted by policy type, as measured by the CAPMF, OECD and OECD partner countries, 2022



Source: OECD (2023), "Climate actions and policies measurement framework", Environment Statistics (database), https://oe.cd/dx/5if.

Climate action of non-market-based instruments increased marginally in 2022

Countries marginally increased the adoption and stringency of non-market-based instruments in 2022 (Figure 40). There is still plenty of scope for them to adopt new measures or strengthen existing ones, however. Information instruments (e.g., labels for appliances and fuel efficiency for passenger cars) and some regulatory instruments such as minimum energy performance standards (MEPS) for appliances, air pollution standards for coal-power plants, and fuel efficiency standards for passenger cars have been implemented since the 1990s. Other standards (e.g. building energy codes and MEPS for electric motors) are more recent, but not all OECD and OECD partner countries had implemented these standards in 2022.

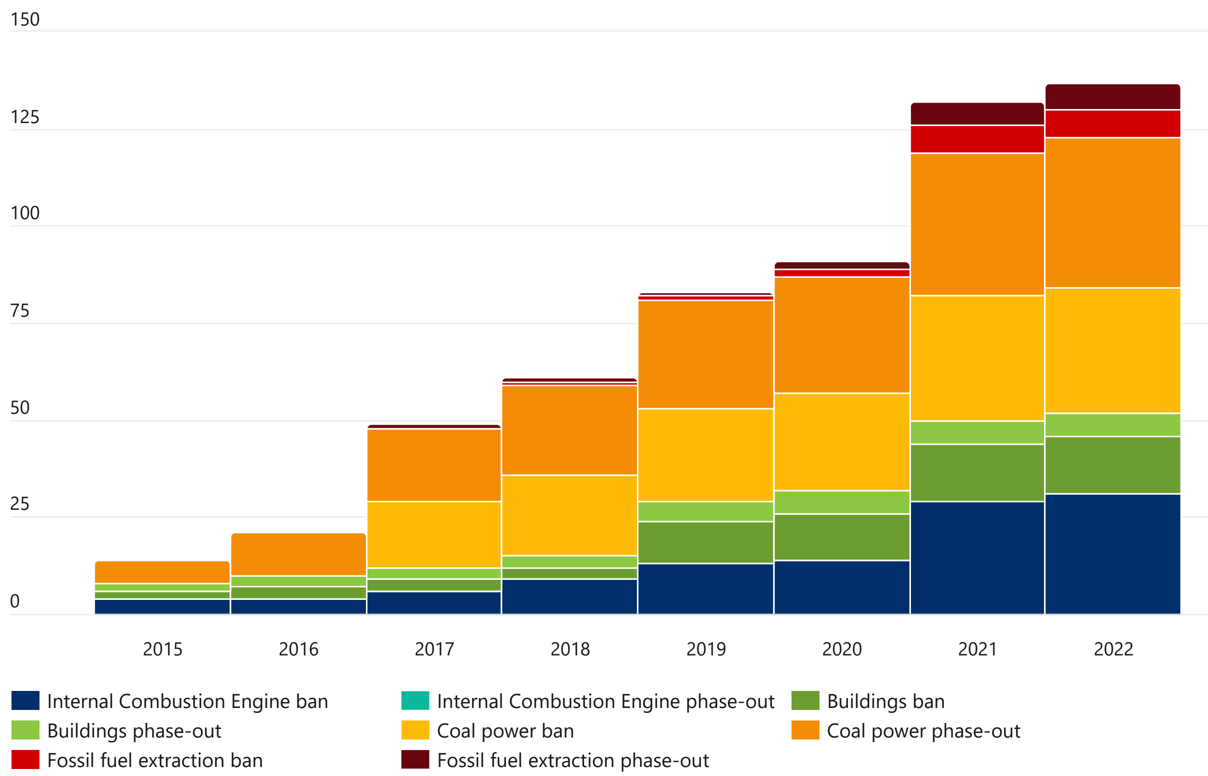
While performance standards were adopted in most countries between the 1990s and the 2010s, their stringency can be further increased to support the uptake of more advanced low-carbon technologies. For example, in 2023 the European Union plans to increase the required efficiency level of electric motors to International Efficiency level IV – the most stringent level that any country has put in place.

Bans and phase-outs of fossil fuel assets and equipment are increasingly used to shift consumption and production decisions

Bans and phase-outs of fossil fuel assets and equipment have become an increasingly popular tool for countries (Figure 41). These technology standards help mainstream low-carbon technologies by prohibiting the sale of conventional technologies based on fossil fuels (a ban) or prohibiting the use of the respective fossil-based technology altogether (a phase-out). Phase-outs also send a clear signal of government commitment for all stakeholders in the energy transition, enabling stakeholders to plan accordingly. The total number of bans and phase-outs across all technologies covered in the CAMPF (e.g. coal power plants, fossil fuel heating) increased from 12 in 2015 to 135 in 2022.

Figure 41. Bans and phase-outs of fossil fuel assets have become increasingly popular

Number of OECD and OECD partner countries adopting a policy by regulatory type and technology, as measured by the CAPMF, 2015-2022



Source: Nachtigall, D., et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", OECD Environment Working Papers, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en.

Some countries backtracked from previous commitments in 2022. For example, formerly coal-free Austria placed one coal plant in reserve in view of the energy crisis, and Hungary postponed the phase-out date of its lignite power plant from 2025 to 2030. More recently, the European Union adjusted the planned ban of the sale of diesel and petrol passenger cars from 2035, by allowing the sale of cars that run on carbon-neutral synthetic fuels. These fuels are expected to play a key role in the decarbonisation of hard-to-abate sectors such as aviation, although they are not yet produced at scale. Allowing the use of synthetic fuels for passenger cars where low-carbon alternatives in form of electric vehicles exist could divert the use of these fuels from hard-to-abate sectors, hampering mitigation efforts (Ueckerdt et al., 2021[64]).

After much momentum with the launch of the Beyond Oil and Gas Alliance (BOGA) at COP26 in 2021 by seven countries (e.g. Costa Rica), no additional country announced banning the exploration of fossil fuels within their territory in 2022 (Beyond Oil and Gas Alliance, 2023[65]). Conversely, many countries accelerated fossil fuel extraction or the construction of fossil fuel infrastructure such as liquified natural gas (LNG) terminals for energy security reasons. For example, to reduce its dependency on Russian gas supply, Germany built two new public LNG terminals within less than one year (OECD, 2023[24]). In August 2023, the UK unfolded a plan approving the drilling of untapped fossil fuel reserves in the North Sea. Worryingly, almost 50% of fossil fuel producing countries state their intention to maintain or even increase fossil fuel production in their latest NDCs (International Institute for Sustainable Development et al., 2023[66]).

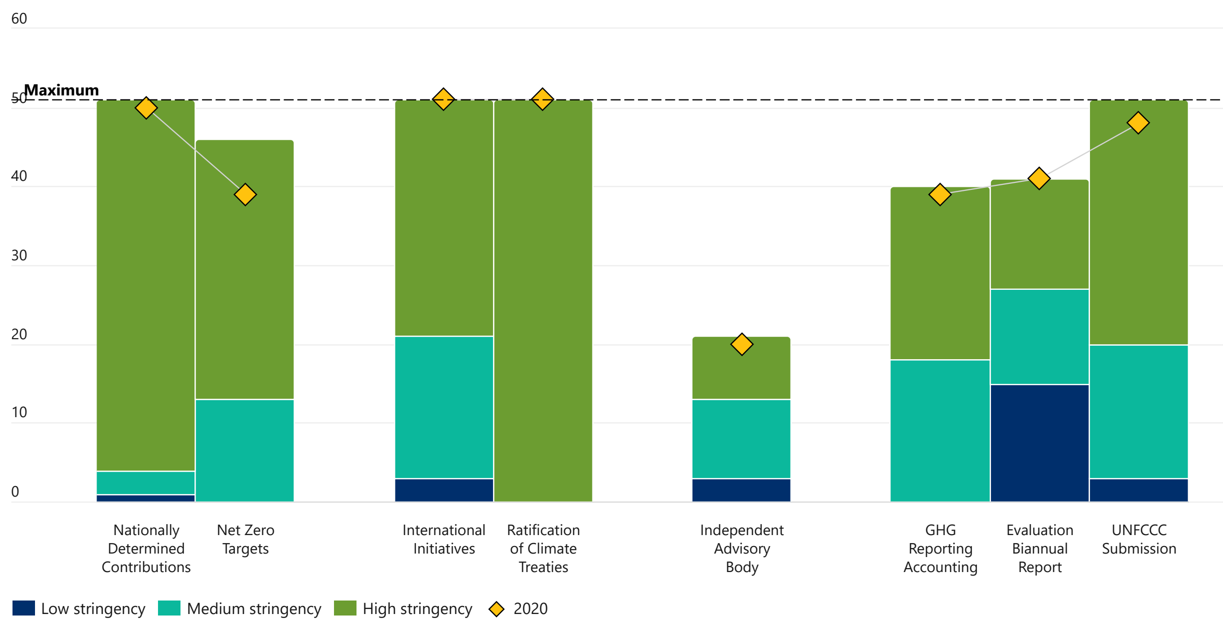
The increasing availability of low-cost renewable technologies such as solar photovoltaics (PV) and wind power has supported progress in banning or phasing out coal power. Lower renewables cost implies that reducing coal's share in the electricity mix has become both feasible and economically viable. In fact, solar PV has seen a massive increase in adoption in recent years, rendering it one of the few clean energy technologies whose adoption is in line with limiting global warming to 1.5°C (IEA, 2023[67]). Phase-out dates vary across countries, ranging from 2023 (e.g. Slovakia) to 2030 (e.g. Mexico) to 2056 (e.g. Indonesia). In a welcome move, in 2023, India – the country with the second largest coal plant fleet after China – announced a ban on the construction of new coal power plants beyond those that are already under construction.

Countries should further strengthen climate governance and climate data

Adoption of targets, governance, international co-ordination and climate data vary widely across climate actions (Figure 42). All OECD and OECD partner countries submitted NDCs and most of them have net-zero targets in place. All these countries are signatories to the Paris Agreement and most other key international climate treaties.[44] Similarly, these countries are part of at least two international initiatives (e.g. Malta, Saudi Arabia) and some up to 38 (e.g. United Kingdom).[45] All countries also provide information to the UNFCCC in the form of official documents (e.g. National Communications). However, not all countries provide all mandatory or recommended information, or do so in a timely manner. For example, 13 countries covered by the CAPMF have not yet submitted their long-term low emissions development strategy (LT-LEDS), a key document providing guidance to stakeholders on national plans for reaching long-term targets (Aguilar Jaber et al., 2020[68]).

Figure 42. Most countries adopted climate actions related to targets and international co-ordination, but could strengthen action in governance and climate data

Number of OECD and OECD partner countries that adopted climate actions related to targets, international co-ordination, governance or climate data by policy stringency, as measured by the CAPMF, 2020 and 2022



Note: The stringency of NDC and net-zero targets does not refer to the ambition of these targets and whether they are in line with the long-term temperature goal of the Paris Agreement. Instead, the stringency is evaluated based on key characteristics of those targets such as sectoral scope, GHG scope, target type, target date. Low stringency is defined as a stringency score of 0-3, medium as 4-7, and high as 8-10. The maximum number of countries to adopt policies is 51, representing all 50 countries for which CAPMF is available plus the EU-27.
Source: OECD (2023), "Climate actions and policies measurement framework", Environment Statistics (database), https://oe.cd/dx/5if.

Climate advisory bodies play a role in supporting climate action through stakeholder involvement and providing key scientific information. As of 2022, only 13 countries had established independent climate advisory bodies, of which 12 are created by law. In 2021 or 2022 some countries, including Australia, Canada and Denmark, stepped up their funding of climate advisory bodies. Switzerland, on the other hand, abolished its advisory body in 2021, though it plans to reinstate a similar entity while mainstreaming institutions to provide climate advice.

Despite the call for countries to ramp up ambition and submit updated (second) NDCs ahead of COP27, only eight countries did so, including Brazil and Korea.[46] While most countries submitted their second NDCs in 2020 or 2021, India submitted its second NDC in 2022.

Climate action and the policy landscape

Monitoring trends in climate action is essential for assessing countries' efforts. The Climate Action and Policies Measurement Framework, the basis for the analysis presented in this section, provides data on the adoption and stringency of selected relevant climate mitigation actions and policies.

The effectiveness of policies, as well as the choices available to policy makers, must be viewed in the context of the broader policy landscape, however. Some events, conditions, or trends can act as "tailwinds" supporting and facilitating the transition to net zero, such as technological progress, renewable energy prices, or the discovery of critical materials. Others can restrict climate action policy effectiveness by acting as “headwinds” as they hamper the transition or reduce the range of feasible action against climate change, for example falling fossil fuel prices or international conflict.

Without identifying and understanding the full impact of these trends and events, it is difficult to assess the ultimate impact of climate policy on mitigation outcomes. For example, Russia’s war of aggression against Ukraine in 2022 reshuffled the climate policy landscape by disrupting global energy markets. On the one hand, it reduced access to fuels and increased energy insecurity, motivating governments to increase the development of domestic fossil fuel energy resources and supports for fuel consumption. On the other hand, high-energy prices and concerns over long-term fossil fuel supply triggered increased funding for renewable energy sources and energy efficiency actions. The final impacts are yet to be determined.

To better support decision makers' policy choices, IPAC could develop indicators that examine the broader policy landscape, as well as indicators on barriers and opportunities, and above all, on a just transition. This could build on and contribute to work under the OECD’s horizontal project Net Zero+, which explores how governments can build climate and economic resilience while taking into account the broader policy landscape, for example looking at challenges such as skills shortages, the supply of critical minerals, other potential bottlenecks to a rapid and resilient net-zero transition. Furthermore, the OECD has embarked on a major initiative, the Inclusive Forum on Carbon Mitigation Approaches (IFCMA), to both carry out a detailed stocktake of current policy instruments as well as assess their effectiveness. These initiative, as well as complementary indicators, are essential to a complete the picture of countries’ mitigation efforts, and will be the cornerstone of OECD work on climate.

Glossary

Bans and phase-outs are regulatory instruments that mandate the cessation of the construction (ban) or the usage (phase out) of certain activities.

CH_4 are methane emissions from solid waste, livestock, mining of hard coal and lignite, rice paddies, agriculture, and leaks from natural gas pipelines.

Climate actions and policy instruments (or "policies" in short) are policy instruments or other actions that have the explicit intent of achieving declared policy objectives to advance mitigation or are non-climate policies which are expected to have a material effect on GHG emissions. A policy is considered as adopted when it is effective in national legislation.

Climate actions and policies are divided into three types:

- **Sectoral policies** are defined as policies that can be constrained to or are designed to apply to a specific source or economic sector.
- **Cross-sectoral policies** refer to policies that cut across more than one emission's source or sector. These are overarching policy areas to mitigate or remove domestic GHG emissions that cannot be easily attributed to a specific sector refer to policies that cut across more than one emission's source or sector.
- **International policies** refer to policy commitments associated with international covenants or agreements where more than one country participates.

Climate-related extreme weather events are defined as a weather event resulting in 10 or more casualties, 100 or more affected people, the declaration of a state of emergency, or a call for international assistance. Climate-related weather events include meteorological (extreme temperature, fog, storm), hydrological (wave action, landslide, flood), and climatological (wildfire, glacial lake outburst, drought). EM-DAT data covers both independent countries and dependent territories.

Coastal flooding threatens coastal regions and communities, impacting the population, built-up areas and other infrastructures. This indicator presents the annual percentage of the population exposed to coastal flooding with a 10, 25, 50 and 100-year return period. Data are expressed in percentages. Measuring population exposure to coastal flooding is possible using the World Bank coastal flood hazard maps (Muis et al., 2016), presenting a global reanalysis of storm surges and extreme sea level events based on hydrodynamic modelling.

Extreme precipitation refers to a daily precipitation that exceeds the 99th percentile value over the reference period 1981-2010. Unlike a monthly approach, used for example for extreme temperature, percentiles are computed using all wet days of the reference period (i.e., 1981-2010) because the data sample would otherwise be too small to robustly compute seasonally adjusted percentiles. It defines a wet day as a day where total precipitation is above or equal to 1 mm. Since percentiles are computed using all wet days of the reference period in a given location, this implies a different occurrence frequency between different locations.

Demand-based CO_2 emissions are expressed in million metric tonnes. Demand-based emissions reflect the CO_2 from energy use emitted during the various stages of production of goods and services consumed in domestic final demand, irrespective of where the stages of production occurred.

Domestic material consumption (DMC) refers to the amount of materials directly used in an economy, which refers to the apparent consumption of materials. DMC is computed as DEU minus exports plus imports.

Effective Carbon Rate (ECR) is the sum of fuel excise taxes, carbon taxes and tradeable permits that effectively put a price on carbon emissions. The **Net ECR** equals the ECR minus fossil fuel subsidies that decrease pre-tax fossil fuel prices.

Environmentally related taxes are compulsory, unrequited payments to government levied on tax bases deemed to be of environmental relevance, i.e., taxes that have a tax base with a proven, specific negative impact on the environment.

Fire danger is estimated with the Canadian Fire Weather Index (FWI), adjusted to account for biomass availability. Fire danger is defined as FWI values of 5 or higher, indicating very high or extreme fire danger.

Greenhouse gas (GHG) emissions refer to the sum of GHGs that have direct effects on climate change and are considered responsible for a major part of global warming: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). They refer to GHGs emitted within the national territory and may include or exclude emissions and removals from land use change and forestry (LUCF). They do not cover international transactions of emission reduction units or certified emission reductions. Greenhouse gas emission estimates are divided into main sectors, which are groupings of related processes, sources and sinks.

Icing days are defined as days where the daily maximum temperature does not exceed 0°C.

Land exposure to cyclones: Category 1 cyclones on the Saffir-Simpson scale are described as "very dangerous winds that will produce some damage". Higher categories cover extensive, devastating and catastrophic damage respectively. The return period is the average or estimated time that a specific climate-related hazard is likely to recur.

Paris Agreement long-term temperature goal: In Art. 2, the Paris Agreement, seeking to strengthen the global response to climate change, reaffirms the goal of limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees.

Paris Agreement mitigation goal: In Art. 4, the Paris Agreement establishes binding commitments by all Parties to prepare, communicate and maintain a nationally determined contribution (NDC) and to pursue domestic measures to achieve them. It also prescribes that Parties shall communicate their NDCs every 5 years and provide information necessary for clarity and transparency. To set a firm foundation for higher ambition, each successive NDC will represent a progression beyond the previous one and reflect the highest possible ambition. Developed countries should continue to take the lead by undertaking absolute economy-wide reduction targets, while developing countries should continue enhancing their mitigation efforts, and are encouraged to move toward economy-wide targets over time in the light of different national circumstances.

Policy approaches define countries’ climate policy landscape. Policy approaches are the combination of countries’ climate action (i.e., the number and stringency of its policies) and the types (e.g. market-based instruments, non market-based instruments) and areas (e.g. sectoral policies, cross-sectoral policies) of climate policies.

Policy instruments are institutional vehicles or tools through which governments facilitate the implementation of domestic and international objectives.

- **Market-based instruments** are policy instruments that use markets, prices and/or other monetary means to provide incentives for producers and consumers to reduce or eliminate environmental and other externalities. Market-based instruments covered by the CAPMF include explicit (carbon taxes, emissions trading schemes) and implicit carbon pricing instruments (fuel excise taxes) amongst others.
- **Non market-based instruments** are instruments that work through the imposition of certain obligations or by installing non-monetary incentives to change behaviour (e.g. directly regulated by the government such as standards, information instruments, voluntary approaches).

Policy stringency is degree to which climate actions and policies incentivise or enable GHG emissions mitigation at home or abroad. In the CAPMF it is measured as a relative concept by assigning a stringency score between 0 (not stringent) and 10 (very stringent) for each policy variable based on the in-sample distribution across all countries and years of the policy variables' level (e.g. tax rate, emission limit value, government expenditure).

Population and built-up area exposure to river flooding: River floods exposure indicators were computed using JRC River Flood Hazard Maps for Europe and the Mediterranean Basin region, and for the World (Dottori, 2021[69]). The maps depict flood prone areas for river flood events for six different flood frequencies (from 1-in-10-years to 1-in-500-years). Cell values on these maps indicate the water depth (in m). For countries located in Europe and around the Mediterranean Basin, the regional flood hazard maps were used, as the spatial resolution is higher (100 m) than the global maps (1 km). For the remaining countries, the global maps were used. To get flood prone areas, a threshold of 1 cm was applied on the water depth. The return period is the average or estimated time that a specific climate-related hazard is likely to recur.

Hot days are defined as those during which daily maximum temperature surpasses 35°C. Due to the resolution of the raw data, it is possible that heat stress for small islands is slightly underestimated. There are also several additional indicators to describe heat stress (such as the UTCI (Universal Thermal Climate Index), which also takes moisture, wind and solar radiation into account); these should be taken into account for a more thorough analysis of exposure to heat for single countries.

Tropical nights are defined as nights where the minimum temperature does not fall below 20°C. Due to the resolution of the raw data, it is possible that heat stress for small islands is slightly underestimated. There are also several additional indicators to describe heat stress (such as the UTCI), which also takes moisture, wind and solar radiation into account); these should be taken into account for a more thorough analysis of exposure to heat for single countries.

Production-based CO_2 intensity is calculated as CO_2 emissions per capita (tonnes/person). Included are CO_2 emissions from combustion of coal, oil, natural gas and other fuels. The estimates of CO_2 emissions are obtained from the IEA's database of CO_2 emissions from fuel combustion. Default methods and emission factors are given in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

River floods exposure indicators were computed using JRC River Flood Hazard Maps for Europe and the Mediterranean Basin region, and for the World (Dottori et al., 2021). The maps depict flood prone areas for river flood events for six different flood frequencies (from 1-in-10-years to 1-in-500-years). Cell values on these maps indicate the water depth (in m). For countries located in Europe and around the Mediterranean Basin, the regional flood hazard maps were used, as the spatial resolution is higher (100 m) than the global maps (1 km). For the remaining countries, the global maps were used. To get flood prone areas, a threshold of 1 cm was applied on the water depth. The return period is the average or estimated time that a specific climate-related hazard is likely to recur.

Soil moisture anomaly in cropland is a suitable indicator for monitoring the intensity of droughts and shows similar performances in identifying droughts to the Standardized Precipitation Index. Copernicus

CDS ERA5-Land monthly averaged data and Copernicus global land cover data is used to calculate average cropland soil moisture anomaly.

Total energy supply (TES), or total primary energy supply, is made up of production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. Primary energy comprises coal, peat and peat products, oil shale, natural gas, crude oil and oil products, nuclear, and renewable energy (bioenergy, geothermal, hydropower, ocean, solar and wind). Electricity trade is included in total energy supply but excluded from the calculation of the breakdown by source.

Annex I. Data gaps, methodology and limitations

Chapter 1: How far are countries from achieving national and global mitigation objectives?

The availability of accurate, complete, and timely data is fundamental to support countries in developing and implementing their climate change policies, and critical for achieving the Paris Agreement long-term temperature goal. This information provides insights regarding the countries' GHG emission trends and can help policy makers to monitor their performance.

However, despite considerable efforts, data on GHG emissions remains limited and insufficient. Official country level data is usually based on emission inventories reported to the UNFCCC. These inventory data are compiled using territory-based and production-based principles following the IPCC guidelines. The territory-based principle does not include emissions from international transport and production-based principle does not include emission from imports of goods to satisfy consumption demand. The approaches underestimate the true carbon footprint of an economy. In addition, data quality varies considerably across countries. Often inventories use a combination of the three tiers of the IPCC guidelines to compile data for a single sector resulting in considerable data quality differences across countries as well as within a country across sectors.[47]

Furthermore, countries can use varying types of emissions factors that have different degrees of precision, for example, industrial plant specific, IPCC default, country specific data, and models. Moreover some countries do not report annually. These are mainly non-OECD countries. Therefore, GHG emissions data and associated indicators are characterised by gaps, lack of timeliness and granularity as well as varying quality. While recognising these caveats, for the analysis presented above, IPAC has used official data when possible. However, in some cases, such as for aggregates, it was necessary to make estimations. When no other data was available, Climate Watch data (Climate Watch, 2023[6]) was used, particularly for global comparisons and to compare IPAC or OECD totals with global emissions.

The data sources and approach used in this publication are summarised below:

- GHG emissions data from national inventories is currently available for all OECD countries that report annually to UNFCCC for the period 1990-2021.
- Data for other OECD countries (formerly referred to as "non-Annex 1") is obtained through the OECD GHG emissions questionnaire. However, the time coverage is not complete, for example, Colombia covers data up to 2018, Costa Rica up to 2017 and Mexico up to 2019. There are also gaps for Israel before 2002.
- For OECD partner countries many gaps remain, for example official emissions data for 2020 is not available on the UNFCCC GHG emission data interface. Major gaps are also present for large emitters, such as China and India. China has provided official data for only five years (1994, 2005, 2010, 2012 and 2014), while India has presented data only for four years (1994, 2000, 2010 and 2016). There are also important gaps for Peru (for the 1990-2010 period), Saudi Arabia (presenting only four years between 1990 and 2012), South Africa (for the 1990-2000 period), and Indonesia (for the 1990-2000 period).[48]
- In this report, when official data was not available, estimated data are used to compile country aggregates.

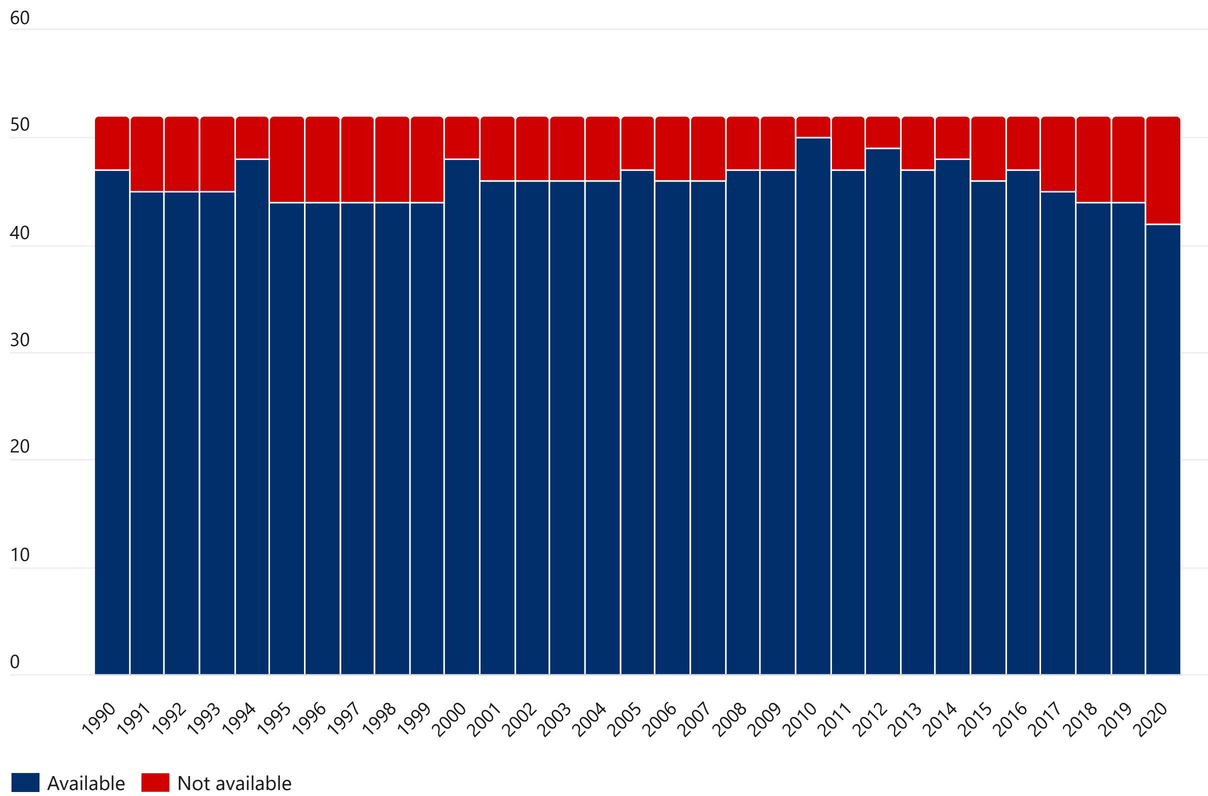
Annex Table I.1. GHG emissions data availability per year, country level

Countries	Official data
Annex I OECD countries	1990 to 2021
Chile	1990-2020
Colombia	1990-2018
Costa Rica	1990-2017
Israel	1996, 2000, 2002-2020
Korea	1990-2020
Mexico	1990-2019
OECD partner countries	Complete official data only for 2010
China (P.R. of)	1994, 2005, 2010, 2012, 2014
India	1994, 2000, 2010, 2016
Argentina	1990-2018
Peru	2008-2019
Saudi Arabia	1990, 2000, 2010, 2012
South Africa	1990, 1994, 2000-2017
Brazil	1990-2016
Bulgaria	1990-2021
Croatia	1990-2021
Indonesia	1990-1994, 2000-2014, 2019
Malta	1990-2021
Romania	1990-2021

Source: UNFCCC, GHG emissions inventory, BURs and (OECD, 2023[7])

Figure I.1. GHG emissions data available at the country level

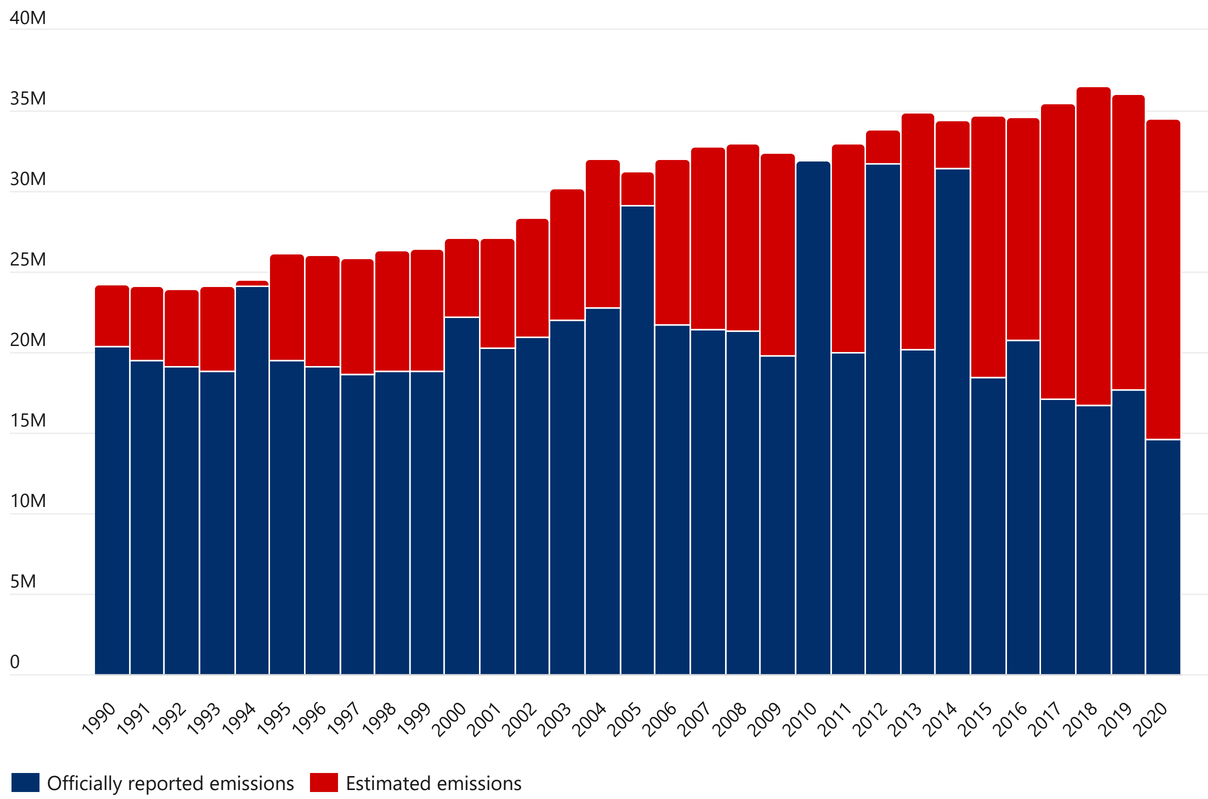
OECD and OECD partner countries, 1990-2020



Source: UNFCCC, National Inventory Reports.

Figure I.2. GHG emission data availability over time

OECD and OECD partner countries, official and estimated emissions including LULUCF, 1990-2020



Source: UNFCCC, National Inventory Reports.

Chapter 2: What are the trends in climate-related hazards and disasters?

The OECD set of indicators is based on historical observational data -collected and recorded- that goes back as far as 1979. This time-period is relatively short for analysing climate change events, nevertheless, the data, while limited, still shows the exposure of climate-related hazards to the population, croplands, forests, and urban areas.[49] These 43 years of data illustrate that climate change impacts are already visible by analysing even a short period of historical data (for a full discussion see (Maes et al., 2022[20])). A limitation is that these indicators reflect what has happened, not what will happen (Box 6). Nevertheless, the data set can support countries to understand the evolution and potential impact of climate-related hazards to guide policy choices.

Box 6. Developing forward-looking indicators for climate-related hazards

Impacts from climate-related hazards are expected to increase in the future, as climate change is projected to increase both the frequency and intensity of climate-related hazards (IPCC, 2021[70]). Understanding these hazards helps make a stronger case for pursuing ambitious mitigation policies. It also supports both disaster risk management and adaptation policies as it is crucial to know which countries and regions are particularly prone to experience climate-related hazards, and how this is projected to evolve under different climate scenarios. Developing forward-looking indicators will therefore be essential to guide policy makers to project future impacts. For this reason, the OECD is building on past work to assess the future exposure of people and assets to the climate-related hazards.

In this upcoming OECD paper would use climate model output data from multi-model ensembles to develop a set of indicators that provides predictions of the impact of climate-related hazards up to 2100. This would include indicators of climate-related hazards and exposures for three hazard types (extreme temperature, drought and sea level change) and two exposure variables (cropland and population density). This paper is expected to be delivered in Q3/Q4 2023.

Existing information on disaster events and their related costs has limitations due to inconsistent reporting by national governments and in international databases, in addition to complexities and challenges associated to the collection of accurate and representative data. The loss databases are essential to assess policy and monitor progress, but it is hardly ever mandated by national or supra-national legislations. There are several supra-national framework directives, but they remain vague when it comes to recording losses from disasters, although their implementation would hugely benefit from the availability of such information.

No single database has complete coverage of losses from disaster events, underscoring the importance of strengthening common frameworks for disaster and loss accounting databases. For example, the United Nations Disaster Risk Reduction (UNDRR) DesInventar-Sendai database provides a common platform for countries to collect loss data on a national level; however, only 10 OECD and OECD partner countries use this database to date (UNDRR, n.d.[71]).[50] The quantification of economic losses in particular faces challenges in harmonisation. Although definitions exist for calculating basic measurements of economic losses, such as affected buildings, agricultural assets and civil infrastructure, this is not consistently done for all disaster events across countries.[51] The threshold employed in a database to determine whether an extreme weather event is recorded is also significant and can generate different results and comparability issues.[52]

Finally, methods for calculating losses exist in the context of estimating damages in the immediate aftermath of a disaster to anticipate the level of support required by the international community such as the Post-Disaster Needs Assessment (PDNA). To mainstream and standardise the PDNA method, the United Nations, the World Bank and the European Commission have jointly developed methodological guidelines. Physical damages and economic losses are evaluated using the Damage and Loss Assessment (DALA) and human recovery needs are investigated through the Human Recovery Needs Assessment (HRNA) and a Recovery Framework. However, there is no central database to collect the results of PDNAs that had been conducted, except for the countries covered in DesInventar.

Chapter 3: How has countries' climate action to meet emission targets progressed?

Tracking and monitoring countries' climate mitigation policies is essential to assess progress towards targets and commitments. However, extensive, consistent, and internationally harmonised data on climate actions and policies do not exist to date.

The Climate Actions and Policies Measurement Framework (CAPMF) aims to fill this gap. It is an internationally harmonised climate policy database developed by the OECD, based on a structured policy typology that tracks a common set of policies with common definitions and harmonised policy attributes on an annual basis. The CAPMF is complementary to other international policy tracking tools such as the reporting frameworks to the UNFCCC.

The CAPMF tracks 56 climate actions and policies, which cover 75% of policies listed in the 2022 IPCC report, from 1990-2022 for 50 countries and the European Union. These countries are jointly responsible for over 63% of global GHG emissions. For each policy, the CAPMF measures policy stringency, defined as the degree to which policies incentivise emissions reductions. The CAPMF comprises climate-positive instruments (e.g. carbon taxes) as well as reform of climate-negative measures (e.g. reform of fossil fuel subsidies). The CAPMF also includes some climate-relevant policies such as air pollution standards, i.e. policies whose primary intent is not mitigation, but which have a material effect on emissions. While the focus of the CAPMF is on national climate action, it still includes key sub-national policies such as sub-national emissions trading schemes and renewable portfolio standards.

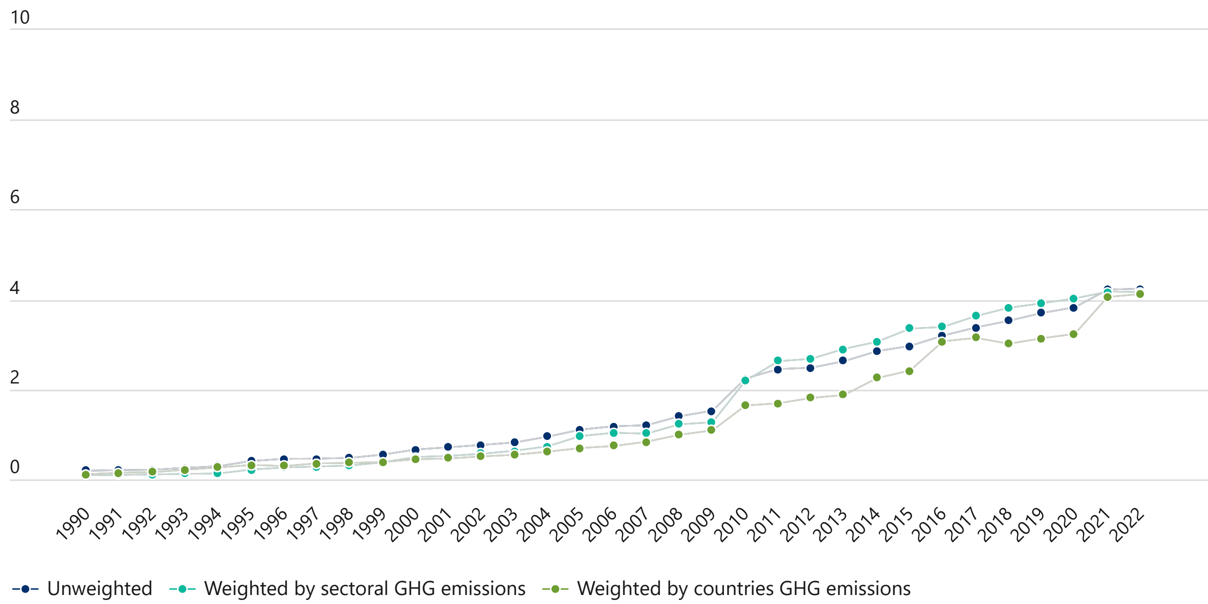
For *The Climate Action Monitor 2023*, missing policy data in 2022 was substituted by the last observed data in the last five years. While it cannot be ruled out that the conclusions change once missing 2022 data becomes available, it seems likely that this data would reinforce the core messages of Chapter 3. This is because missing data predominantly concerns fossil fuel subsidies, for which stringency levels are expected to have decreased in 2022. In addition, other variables missing in 2022 do either change only very rarely (e.g. air pollution standards) or have approached already the highest stringency levels in most countries (e.g. financing mechanisms, energy efficiency mandates).

The primary focus of the CAPMF is to monitor the evolution and stringency of mitigation policies over time (1990 to 2022) collecting a broad range of harmonised data that is internationally comparable and suitable for a broad based quantitative and qualitative analysis. However, the CAPMF has some limitations and, hence, should be interpreted carefully (Nachtigall et al., 2022[45]).

1. The country coverage of the CAPMF is not global, it covers 50 countries plus the EU, mostly developed or emerging economies, which can help illustrate policy trends and key mitigation efforts of major emitters. It covers all countries covered by IPAC except for the United States that has not yet validated its data.
2. Despite the broad coverage of policies, the CAPMF does not capture all relevant policies due to data availability constraints. Policies included in the CAPMF may, thus, not be fully representative of mitigation approaches of some countries. Important policy gaps that are planned to be filled in the coming years include policies in the agricultural, forestry and waste sector as well as policies related to climate finance.
3. The results of the CAPMF should be interpreted in an informative, not in a normative way. An increase in policy adoption or policy stringency does not necessarily imply higher effectiveness of reducing GHG emissions, although previous work found some positive associations (Nachtigall et al., 2022[45]). The effects of increased policy adoption and policy stringency depend on factors such as emissions coverage and economic costs and likely have different impacts across countries.

Figure I.3. Climate action slowed down regardless of the weighting scheme used

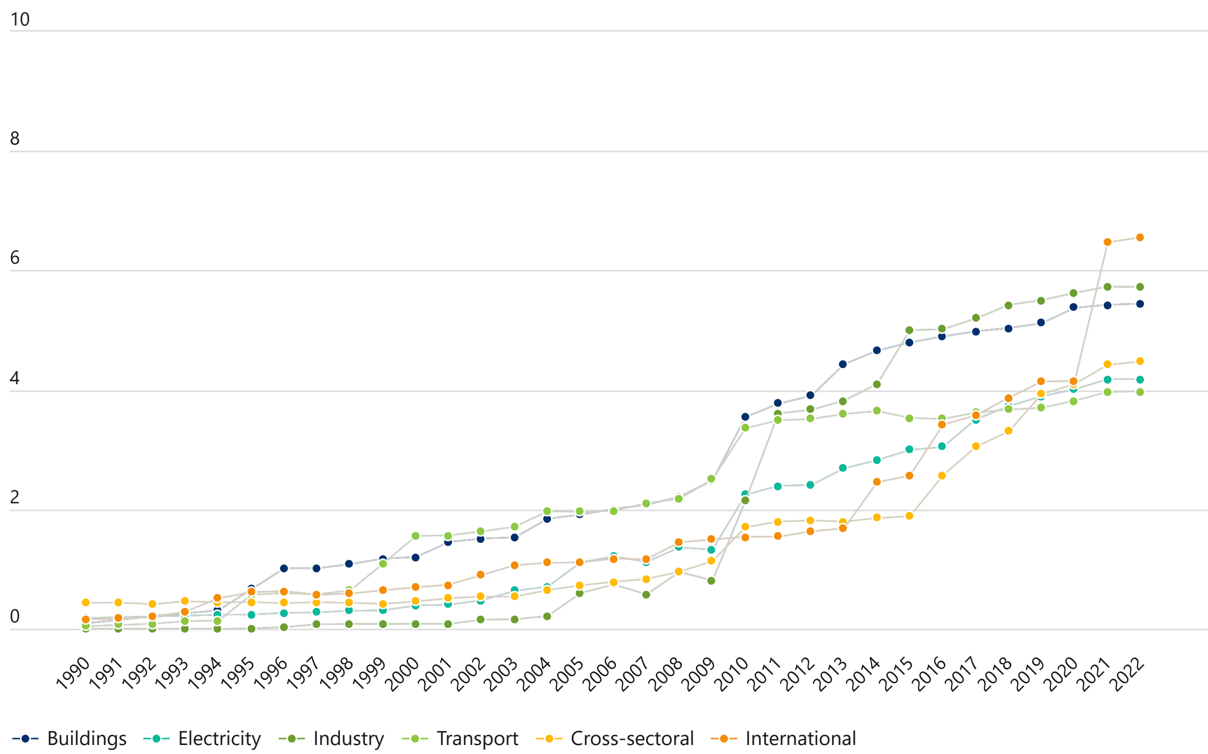
Average policy stringency (1-10) for different weighting schemes, as measured by the CAPMF, 2010-2022



Note: 'Default' refers to the default weighting scheme as explained in the endnotes and calculates the unweighted average across all OECD and OECD partner countries. 'Unweighted' calculates the country-specific overall stringency as the unweighted average across all policies included in the CAPMF and calculates the unweighted average of the country-specific stringency across all OECD and OECD partner countries. 'Weighted by countries GHG emissions weights the average by countries' total GHG emissions in 2020 or the last available date. 'Weighted by sectoral GHG emissions only applies to sectoral policies whereby those policies are weighted by the 2020 GHG emissions in OECD and OECD partner countries in each of the 4 sectors.
Source: Nachtigall, D., et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", OECD Environment Working Papers, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en.

Figure I.4. Climate action in sectoral policies slowed down in OECD countries in 2022

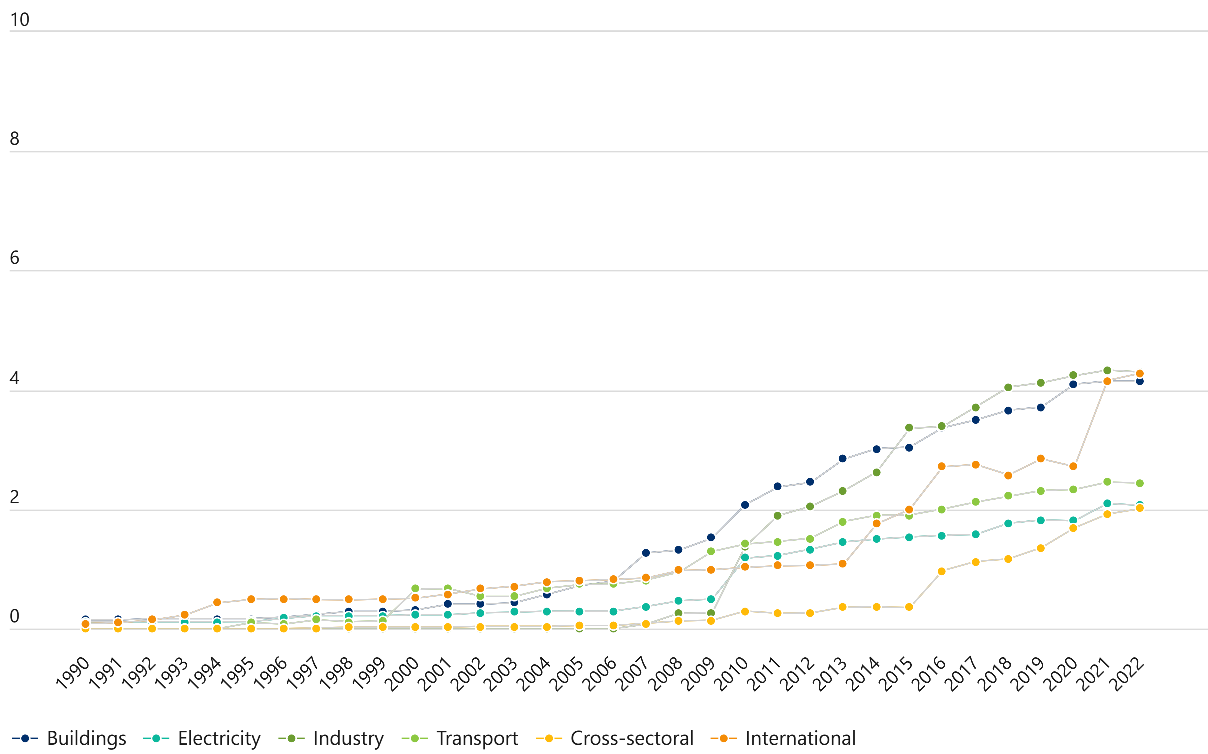
Average policy stringency (0-10) by policy area and sector, as measured by the CAPMF, OECD countries, 2010-2022



Source: Nachtigall, D., et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", OECD Environment Working Papers, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en.

Figure I.5. Climate action in sectoral policies slowed down in OECD partner countries in 2022

Average policy stringency (0-10) by policy area and sector, as measured by the CAPMF, OECD partner countries, 2010-2022



Source: Nachtigall, D., et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", OECD Environment Working Papers, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en.

References

Aguilar Jaber, A. et al. (2020), "Long-term low emissions development strategies: Cross-country experience", *OECD Environment Working Papers*, No. 160, OECD Publishing, Paris, https://doi.org/10.1787/1c1d8005-en. [68]

Armstrong McKay, D. et al. (2022), "Exceeding 1.5 C global warming could trigger multiple climate tipping points", *Science*, Vol. 377/6611. [27]

Beyond Oil and Gas Alliance (2023), *REDEFINING CLIMATE LEADERSHIP*, https://beyondoilandgasalliance.org/ (accessed on 12 September 2023). [65]

Blake, H. and T. Bulman (2022), *Surging energy prices are hitting everyone, but which households are more exposed? – ECOSCOPE*, Ecoscope, OECD, https://oecdecoscope.blog/2022/05/10/surging-energy-prices-are-hitting-everyone-but-which-households-are-more-exposed/ (accessed on 4 July 2022). [129]

Botta, E. and T. Koźluk (2014), "Measuring Environmental Policy Stringency in OECD Countries: A Composite Index Approach", *OECD Economics Department Working Papers*, No. 1177, OECD Publishing, Paris, https://doi.org/10.1787/5jxrjnc45gvg-en. [164]

Cecco, L. (2023), "Canada mourns deaths of firefighters as wildfires ravage millions of acres", *The Guardian*, https://www.theguardian.com/world/2023/jul/17/canada-wildfires-firefighters-deaths (accessed on 28 August 2023). [144]

Chen, C. et al. (2015), *University of Notre Dame Global Adaptation Index: Country Index Technical Report*, University of Notre Dame, http://index.gain.org/about/reference. (accessed on 19 July 2021). [130]

CIFFC (2023), *Canadian Interagency Forest Fire Centre*, https://ciffc.ca/. [141]

Circle Economy (2023), *Circularity Gap Report*, https://www.circularity-gap.world/2023#download. [17]

Circle Economy (2021), *The Circularity Gap Report 2021*, https://www.circularity-gap.world/2021. [96]

Clarke, D. et al. (2022), *CO2 Emissions from air transport: A near-real-time global database for policy analysis*, https://doi.org/10.1787/18152031. [11]

Climate Watch (2023), *Climate Watch Data*, https://www.climatewatchdata.org/ (accessed on 16 February 2023). [6]

Climate Watch (2022), *Climate Watch Data*, https://www.climatewatchdata.org/. [152]

Copernicus Climate Change Service (2023), *Spring 2023 in Europe: extremes amidst a relatively wet, average season*, https://climate.copernicus.eu/spring-2023-europe-extremes-amidst-relatively-wet-average-season (accessed on 26 July 2023). [37]

CPLC (2017), *REPORT OF THE HIGH-LEVEL COMMISSION ON CARBON PRICES*, Carbon Pricing Leadership Coalition. [82]

CRED (2023), *2022 Disasters in Numbers*. [19]

Dechezleprêtre, A. et al. (2022), “Fighting climate change: International attitudes toward climate policies”*, OECD Economics Department Working Papers*, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en. [99]

Dechezleprêtre, A. et al. (2022), “Fighting climate change: International attitudes toward climate policies”*, OECD Economics Department Working Papers*, No. 1714, OECD Publishing, Paris, https://doi.org/10.1787/3406f29a-en. [55]

Ditlevsen, P. and S. Ditlevsen (2023), “Warning of a forthcoming collapse of the Atlantic meridional overturning circulation”, *Nature Communications*, Vol. 14/1, p. 4254, https://doi.org/10.1038/s41467-023-39810-w. [31]

Dottori, F. (2021), *River flood hazard maps for Europe and the Mediterranean Basin region. European Commission*, European Commission, Joint Research Centre (JRC). [69]

EEA (2022), *Economic losses and fatalities from weather-and-climate-related events in Europe*, European Environmental Agency. [105]

Enerdata (2023), *World Energy and Climate Statistics - Yearbook 2023*, https://yearbook.enerdata.net/total-energy/world-energy-intensity-gdp-data.html. [175]

Energate Messenger (2021), “UVEK WILL OCCC NEU STRUKTURIEREN”, https://www.energate-messenger.ch/news/215277/uvek-will-occc-neu-strukturieren (accessed on 13 September 2023). [167]

Eskander, S. and S. Fankhauser (2020), “Reduction in greenhouse gas emissions from national climate legislation”, *Nature Climate Change*, Vol. 10/8, pp. 750-756, https://doi.org/10.1038/s41558-020-0831-z. [147]

European Comission (2021), *Carbon Border Adjustment Mechanism: Questions and Answers*, Brussels, https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661. [14]

European Commission (2023), *Energy poverty in the EU*, Brussels, https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu_en (accessed on 3 August 2023). [153]

European Commission (2022), *REPowerEU*, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131. [176]

European Commission (2022), *REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131. [128]

European Environment Agency (2021), “Improving the climate impact of raw material sourcing”. [119]

FAO (2020), *The State of the World’s Forests 2020*, FAO and UNEP, https://doi.org/10.4060/ca8642en. [133]

Filkov, A. et al. (2020), "Impact of Australia's catastrophic 2019/20 bushfire season on communities and environment. Retrospective analysis and current trends", *Journal of Safety Science and Resilience*, Vol. 1/1, pp. 44-56, https://doi.org/10.1016/j.jnlssr.2020.06.009. [109]

Fountain, H., Z. Levitt and J. White (2022), "The monsoon is becoming more extreme", *The New York Times*. [38]

Fouré, J. et al. (2023), "Public finance resilience in the transition towards carbon neutrality - Modelling policy instruments in a global net-zero emissions", *OECD Environment Working Papers*, Vol. 214, https://doi.org/10.1787/7f3275e0-en. [169]

Giuffrida, A. (2023), "Italian hospitals report sharp rise in emergency cases as Rome hits 41.8C", *The Guardian*, https://www.theguardian.com/world/2023/jul/18/italian-hospitals-report-rise-in-heat-cases-as-rome-hits-41-point-8c (accessed on 28 August 2023). [142]

Giuffrida, A. and H. Smith (2023), "Extreme temperatures recorded across northern hemisphere", *The Guardian*, https://www.theguardian.com/world/2023/jul/17/extreme-temperatures-recorded-across-northern-hemisphere (accessed on 28 August 2023). [143]

Global Commission on Adaptation (2019), *Adapt now: a global call for leadership on climate resilience*, Global Commission on Adaptation. [23]

Guha-Sapir, D., R. Below and P. Hoyois (2021), *EM-DAT: The CRED/OFDA International Disaster Database*, Université Catholique de Louvain , Brussels. [106]

Hallegate, S., J. Rentschler and J. Rozenberg (2019), *Lifelines. The Resilient Infrastructure Opportunity*, World Bank. [107]

Hemmerlé, Y. et al. (2023), "Aiming better: Government support for households and firms during the energy crisis", *OECD Economic Policy Papers,*, Vol. 32, https://doi.org/10.1787/839e3ae1-en. [170]

High-Level Commission on Carbon Prices (2017), *Report of the High-Level Commission on Carbon Prices*, World Bank, Washington, DC, http://www.carbonpricingleadership.org. (accessed on 3 August 2018). [58]

Ian W.H. Parry, Victor Mylonas and Nate Vernon (2018), "Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries", International Monetary Fund. [115]

IEA (2023), *"World energy balances", IEA World Energy Statistics and Balances (database), Paris*, https://doi.org/10.1787/data-00512-en (accessed on January 2023). [15]

IEA (2023), *Critical Minerals Market Review 2023 – Analysis*, IEA, Paris, https://www.iea.org/reports/critical-minerals-market-review-2023 (accessed on 30 August 2023). [155]

IEA (2023), *Critical Minerals Market Review 2023, Paris*, https://www.iea.org/reports/critical-minerals-market-review-2023/implications#abstract. [154]

IEA (2023), *Energy innovation investment remained resilient to shocks in a turbulent 2022*, https://www.iea.org/commentaries/energy-innovation-investment-remained-resilient-to-shocks-in-a-turbulent-2022 (accessed on 13 September 2023). [61]

IEA (2023), *Energy Technology Perspectives 2023 – Analysis*, IEA, Paris, https://www.iea.org/reports/energy-technology-perspectives-2023 (accessed on 2 August 2023). [156]

IEA (2023), *Energy Technology RD&D Budgets*, https://www.iea.org/data-and-statistics/data-product/energy-technology-rd-and-d-budget-database-2#overview (accessed on 13 September 2023). [62]

IEA (2023), *Energy Technology RD&D Budgets database*, International Energy Agency. [168]

IEA (2023), *Fossil Fuels Consumption Subsidies 2022*, https://www.iea.org/reports/fossil-fuels-consumption-subsidies-2022 (accessed on 13 September 2023). [59]

IEA (2023), *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach*, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach (accessed on 26 September 2023). [181]

IEA (2023), *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach*, https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach (accessed on 28 September 2023). [67]

IEA (2023), *Renewable Energy Market Update - June 2023*, https://www.iea.org/reports/renewable-energy-market-update-june-2023. [180]

IEA (2023), *Renewable Energy Market Update - June 2023 – Analysis*, IEA, Paris, https://www.iea.org/reports/renewable-energy-market-update-june-2023/executive-summary (accessed on 18 July 2023). [157]

IEA (2023), *Tracking Clean Energy Progress 2023, IEA, Paris*, https://www.iea.org/reports/tracking-clean-energy-progress-2023. [10]

IEA (2023), *World Energy Investment 2023*, International Energy Agency, Paris, https://www.iea.org/reports/world-energy-investment-2023 (accessed on 31 July 2023). [138]

IEA (2023), *World Energy Investment 2023*, https://www.iea.org/reports/world-energy-investment-2023 (accessed on 13 September 2023). [63]

IEA (2023), *World Energy Investment 2023 – Analysis*, IEA, Paris, https://www.iea.org/reports/world-energy-investment-2023 (accessed on 18 July 2023). [158]

IEA (2022), *Coal Market Update – July 2022 – Analysis*, IEA, Paris, https://www.iea.org/reports/coal-market-update-july-2022 (accessed on 20 July 2023). [159]

IEA (2022), *Energy Efficiency 2022*, IEA, Paris, https://www.iea.org/news/global-energy-efficiency-progress-is-accelerating-signalling-a-potential-turning-point-after-years-of-slow-improvement (accessed on 31 July 2023). [160]

IEA (2022), *Energy Efficiency 2022 – Analysis*, IEA, Paris, https://www.iea.org/reports/energy-efficiency-2022/executive-summary (accessed on 3 August 2023). [161]

IEA (2022), *Global government spending on clean energy transitions rises to USD 1.2 trillion since the start of the pandemic, spurred by energy security concerns*, https://www.iea.org/news/global-government-spending-on-clean-energy-transitions-rises-to-usd-1-2-trillion-since-the-start-of-the-pandemic-spurred-by-energy-security-concerns (accessed on 12 September 2023). [60]

IEA (2022), *Renewable Energy Market Update: Outlook for 2022 and 2023*, OECD Publishing, Paris, https://doi.org/10.1787/faf30e5a-en. [101]

IEA (2022), *Renewable Energy Market Update: Outlook for 2022 and 2023*, OECD Publishing, Paris, https://doi.org/10.1787/faf30e5a-en. [102]

IEA (2022), *World Energy Outlook 2022, Paris*, https://doi.org/10.1787/dd7e82ea-en. [171]

IEA (2021), “Executive summary”, in *The Role of Critical Minerals in Clean Energy Transitions*, IEA, Paris, https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary (accessed on 22 September 2022). [89]

IFRC (2021), *Annual Report 2021*, International Federation of Red Cross and Red Crescent Societies (IFRC). [110]

IMF (2023), *World Economic Outlook Update, July 2023: Near-Term Resilience, Persistent Challenges* , https://www.imf.org/en/Publications/WEO/Issues/2023/07/10/world-economic-outlook-update-july-2023#Overview (accessed on 31 July 2023). [139]

IMF (2021), “World Economic Outlook Database”, *International Monetary Fund, Washington, DC*, https://www.imf.org/en/Publications/WEO/weo-database/2021/April. [81]

International Institute for Sustainable Development et al. (2023), *Connecting the dots: mapping references to fossil fuel production in national plans under the UNFCCC for the 2023 Global Stocktake*, Stockholm Environment Institute, https://doi.org/10.51414/sei2023.040. [66]

IPCC (2023), *: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 184 pp.*, https://doi.org/10.59327/IPCC/AR6-9789291691647. [5]

IPCC (2023), *AR6 Synthesis Report: Climate Change 2023*, https://www.ipcc.ch/report/sixth-assessment-report-cycle/. [131]

IPCC (2022), *Climate Change 2022: Climate Change Mitigation: Summary for Policymakers*, IPCC. [117]

IPCC (2022), *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/. [79]

IPCC (2022), *Climate Change 2022: Impacts, Adaptation and Vulnerability*, Intergovernmental Panel on Climate Change, https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf (accessed on 10 March 2022). [21]

IPCC (2022), *IPCC Sixth Assessment Report Working Group III: Mitigation of Climate Change*, https://www.ipcc.ch/report/ar6/wg3/ (accessed on 28 September 2023). [46]

IPCC (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Geneva. [70]

IPCC (2021), *Climate change widespread, rapid and intensifying*, https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/. [73]

IPCC (2019), "Technical Summary", in *Climate Change and Land*, Intergovernmental Panel on Climate Change, https://www.ipcc.ch/srccl/ (accessed on 21 January 2020). [88]

IRENA (2023), *Geopolitics of the Energy Transition, Paris*, https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Jul/IRENA_Geopolitics_energy_transition_critical_materials_2023.pdf?rev=f289d177cda14b9aaf2d1b4c074798b4. [179]

IRENA (2023), *Renewable Power Generation Costs in 2022*, Paris, https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022 (accessed on 4 September 2023). [162]

IRENA (2023), *The cost fo financing for renewable power, Paris*, https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/May/IRENA_Cost_of_financing_renewable_power_2023.pdf?rev=6b95edc23fa5468190745975681a71cc. [178]

IRENA (2022), "Renewable power generation costs in 2021", http://www.irena.org (accessed on 1 August 2023). [140]

IRP (2019), *Global Resource Outlook 2019*. [111]

Jenkins, J. (2014), "Political economy constraints on carbon pricing policies: What are the implications for economic efficiency, environmental efficacy, and climate policy design?", *Energy Policy*, Vol. 69, pp. 467-477, https://doi.org/10.1016/j.enpol.2014.02.003. [54]

Kemp, L. et al. (2022), "Climate Endgame: Exploring catastrophic climate change scenarios", *Proceedings of the National Academy of Sciences*, Vol. 119/34, https://doi.org/10.1073/pnas.2108146119. [29]

Kowalski, P. and C. Legendre (2023), "Raw materials critical for the green transition - Production, international trade and export restrictions", *OECD Trade Policy Papers*, Vol. 269, https://doi.org/10.1787/c6bb598b-en. [172]

Kruse, T. et al. (2022), "Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator", *OECD Economics Department Working Papers*, No. 1703, OECD Publishing, Paris, https://doi.org/10.1787/90ab82e8-en. [163]

Lenton, T. et al. (2019), "Climate tipping points — too risky to bet against", *Nature*, Vol. 575/7784, pp. 592-595, https://doi.org/10.1038/d41586-019-03595-0. [30]

Linsenmeier, M., A. Mohommad and G. Schwerhoff (2023), "Global benefits of the international diffusion of carbon pricing policies", *Nature Climate Change*, Vol. 13/7, pp. 679-684, https://doi.org/10.1038/s41558-023-01710-8. [125]

Maes, M. et al. (2022), "Monitoring exposure to climate-related hazards: Indicator methodology and key results", *OECD Environment Working Papers*, No. 201, OECD Publishing, Paris, https://doi.org/10.1787/da074cb6-en. [20]

Mallapaty, S. (2022), *Why are Pakistan's floods so extreme this year?*, https://www.nature.com/articles/d41586-022-02813-6. [80]

Marten, M. and K. van Dender (2019), "The use of revenues from carbon pricing", *OECD Taxation Working Papers*, No. 43, OECD Publishing, Paris, https://doi.org/10.1787/3cb265e4-en. [100]

Material Economics (2018), *The Circular Economy: A Powerful Force for Climate Mitigation*, https://materialeconomics.com/publications/the-circular-economy-a-powerful-force-for-climate-mitigation-1. [78]

Mehrotra, K. (2023), "At least 100 dead in northern India after extreme monsoon flooding", *Washington Post*. [40]

MMA (2020), *Climate Ambition Alliance*, https://cop25.mma.gob.cl/wp-content/uploads/2020/12/1312-Annex-Alliance-ENGLISH-VF-2012.pdf. [134]

Munich RE (2023), *Climate change and La Niña driving losses: the natural disaster figures for 2022*, https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2023/natural-disaster-figures-2022.html#:~:text=2022%20natural%20disasters%20in%20figures,of%20years%20with%20high%20losses. (accessed on 20 July 2023). [18]

Muttitt, G. et al. (2023), "Socio-political feasibility of coal power phase-out and its role in mitigation pathways", *Nature Climate Change*, Vol. 13/2, pp. 140-147, https://doi.org/10.1038/s41558-022-01576-2. [127]

Nachtigall, D. et al. (forthcoming), *The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action*, OECD Environment Working Papers, forthcoming. [120]

Nachtigall, D. (2023), *How have governments' climate policies evolved in the last decade?*, https://oecd-environment-focus.blog/2023/02/22/how-have-governments-climate-policies-evolved-in-the-last-decade/ (accessed on 11 September 2023). [149]

Nachtigall, D., J. Ellis and S. Errendal (2022), "Carbon pricing and COVID-19: Policy changes, challenges and design options in OECD and G20 countries", *OECD Environment Working Papers*, No. 191, OECD Publishing, Paris, https://doi.org/10.1787/8f030bcc-en. [56]

Nachtigall, D. et al. (2021), "The economic and environmental benefits from international co-ordination on carbon pricing: Insights from economic modelling studies", *OECD Environment Working Papers*, No. 173, OECD Publishing, Paris, https://doi.org/10.1787/d4d3e59e-en. [48]

Nachtigall, D. et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", *OECD Environment Working Papers*, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en. [45]

OECD (2023), *Air and climate: Greenhouse gas emissions by source*, OECD Environment Statistics (database). [7]

OECD (2023), *Arrangement and Sector Understandings*, https://www.oecd.org/trade/topics/export-credits/arrangement-and-sector-understandings/ (accessed on 11 September 2023). [50]

OECD (2023), *Climate Change*, https://doi.org/10.1787/5584ad47-en. [12]

OECD (2023), *Effective Carbon Rates 2023: Pricing greenhouse gas emissions through taxes and emissions trading*, OECD publishing, Paris. [57]

OECD (2023), *Environmental policy: Environmentally related tax revenue*, https://doi.org/10.1787/df563d69-en (accessed on 28 September 2023). [53]

OECD (2023), *GHG Emissions from fuel combustion (summary)*, IEA CO2 Emissions from Fuel Combustion Statistics: Greenhouse Gas Emissions from Energy (database),. [9]

OECD (2023), *Green growth indicators*, OECD Environment Statistics (database). [8]

OECD (2023), *Net Zero+: Climate and Economic Resilience in a Changing World*, https://www.oecd.org/environment/net-zero-da477dda-en.htm. [174]

OECD (2023), *OECD Economic Outlook, Volume 2023 Issue 1*, OECD Publishing, Paris, https://doi.org/10.1787/ce188438-en. [146]

OECD (2023), *OECD Economic Surveys: European Union and Euro Area 2023*, OECD Publishing, Paris, https://doi.org/10.1787/7ebe8cc3-en. [49]

OECD (2023), *OECD Environmental Performance Reviews: Germany 2023*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/f26da7da-en. [24]

OECD (2023), *OECD Environmental Performance Reviews: Portugal 2023*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/d9783cbf-en. [36]

OECD (2023), *Policy Instruments for the Environment Database*, http://oe.cd/pine (accessed on 28 September 2023). [184]

OECD (2023), *Taming Wildfires in the Context of Climate Change*, OECD Publishing, Paris, https://doi.org/10.1787/dd00c367-en. [35]

OECD (2022), *Aggregate Trends of Climate Finance Provided and Mobilised by Developed Countries in 2013-2020*, Climate Finance and the USD 100 Billion Goal, OECD Publishing, Paris, https://doi.org/10.1787/d28f963c-en. [91]

OECD (2022), *Climate Finance Provided and Mobilised by Developed Countries in 2016-2020: Insights from Disaggregated Analysis*, Climate Finance and the USD 100 Billion Goal, OECD Publishing, Paris, https://doi.org/10.1787/286dae5d-en. [122]

OECD (2022), *Climate Tipping Points: Insights for Effective Policy Action*, OECD Publishing, Paris, https://doi.org/10.1787/abc5a69e-en. [28]

OECD (2022), *Climate-related Official Development Assistance: A snapshot*, OECD, Paris, https://www.oecd.org/dac/financing-sustainable-development/development-finance-data/climate-related-official-development-assistance-2019.pdf. [92]

OECD (2022), "Green growth indicators", *OECD Environment Statistics (database)*, https://doi.org/10.1787/data-00665-en (accessed on 17 October 2022). [114]

OECD (2022), "OECD Territorial grids", http://stats.oecd.org (accessed on 7 September 2023). [151]

OECD (2022), *Redesigning Ireland's Transport for Net Zero: Towards Systems that Work for People and the Planet*, OECD Publishing, Paris, https://doi.org/10.1787/b798a4c1-en. [98]

OECD (2022), *The Climate Action Monitor 2022: Helping Countries Advance Towards Net Zero*, OECD Publishing, Paris, https://doi.org/10.1787/43730392-en. [124]

OECD (2021), *"Climate change" in Environment at a Glance Indicators*, OECD, Paris. [118]

OECD (2021), *Effective Carbon Rates 2021 - Pricing Carbon Emissions through Taxes and Emissions Trading*, OECD Publishing, Paris. [182]

OECD (2021), *Equitable Framework and Finance for Extractive-based Countries in Transition (EFFECT)*, OECD, Paris, https://www.oecd.org/dev/Equitable-Framework-Finance-Extractive-based-Countries-Transition-EFFECT.pdf. [93]

OECD (2021), "Green growth indicators (Edition 2021)", *OECD Environment Statistics* (database), https://doi.org/10.1787/a16ddc34-en (accessed on 19 October 2022). [123]

OECD (2021), *Managing Climate Risks, Facing up to Losses and Damages*, OECD Publishing, Paris, https://doi.org/10.1787/55ea1cc9-en. [41]

OECD (2021), *OECD Companion to the Inventory of Support Measures for Fossil Fuels 2021*, OECD Publishing, Paris, https://doi.org/10.1787/e670c620-en. [121]

OECD (2021), *OECD Environmental Performance Reviews: Finland 2021*, OECD Environmental Performance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/d73547b7-en. [97]

OECD (2021), *The OECD Green Recovery Database: Examining the environmental implications of COVID-19 recovery policies*, https://www.oecd.org/coronavirus/policy-responses/the-oecd-green-recovery-database-47ae0f0d/#section-d1e324 (accessed on 11 September 2023). [47]

OECD (2020), *The consequences of a more resource efficient and circular economy for international trade patterns*, OECD, Paris. [113]

OECD (2019), *Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences*, OECD Publishing, Paris, https://doi.org/10.1787/9789264307452-en. [16]

OECD (2018), *Effective Carbon Rates 2018 - Pricing Carbon Emissions Through Taxes and Emissions Trading*, OECD publishing, Paris. [183]

OECD (2017), *Investing in Climate, Investing in Growth*, OECD Publishing, Paris, https://doi.org/10.1787/9789264273528-en. [103]

OECD (2015), *Climate Change Mitigation: Policies and Progress*, OECD Publishing, Paris, https://doi.org/10.1787/9789264238787-en. [87]

OECD (forthcoming), *Decarbonisation Primer: Designing and Monitoring Strategies to Achieve Climate Change Targets while Boosting Growth and Social Cohesion*, OECD Publishing, Paris. [74]

OECD (forthcoming), *GHG Emissions Trends and Targets (GETT) Indicators: Harmonised Quantification of 2030 NDC GHG Emissions Targets*. [4]

OECD/Eurostat (1999), *The Environmental Goods and Services Industry: Manual for Data Collection and Analysis*, OECD Publishing, Paris, https://doi.org/10.1787/9789264173651-en. [94]

OECD-IEA (2022), *Support for fossil fuels almost doubled in 2021, slowing progress toward international climate goals, according to new analysis from OECD and IEA - OECD*, https://www.oecd.org/environment/support-for-fossil-fuels-almost-doubled-in-2021-slowing-progress-toward-international-climate-goals-according-to-new-analysis-from-oecd-and-iea.htm (accessed on 28 September 2022). [86]

Parry, I. (2021), *Five things to know about carbon pricing*, International Monetary Fund. Finance & Development. [83]

PWC (2017), *The Long View. How will the global economic order change by 2050?*, PWC. [112]

Reuters (2023), "India's pledge to stop new coal power plants to hit key states", https://www.reuters.com/markets/commodities/indias-pledge-stop-new-coal-power-plants-hit-key-states-2023-05-09/ (accessed on 12 September 2023). [165]

Rosenow, J. et al. (2023), "Clean heating: Reforming taxes and levies on heating fuels in Europe", *Energy Policy*, Vol. 173, p. 113367, https://doi.org/10.1016/J.ENPOL.2022.113367. [166]

Scoccimarro, E. et al. (2023), "Country-level energy demand for cooling has increased over the past two decades", *Communications Earth & Environment*, Vol. 4/1, p. 208, https://doi.org/10.1038/s43247-023-00878-3. [32]

Seltenrich, N. (2023), "No Reprieve: Extreme Heat at Night Contributes to Heat Wave Mortality", *Environmental Health Perspectives*, Vol. 131/7, https://doi.org/10.1289/EHP13206. [33]

Senate Democrats (2022), *Summary: the Inflation Reduction Act of 2022*, https://www.democrats.senate.gov/imo/media/doc/inflation_reduction_act_one_page_summary.pdf. [177]

Sigal, L. and E. Raszewski (2023), "Argentina's 'unprecedented' drought pummels farmers and economy", *Reuters*, https://www.reuters.com/business/environment/argentinas-unprecedented-drought-pummels-farmers-economy-2023-03-09/ (accessed on 11 September 2023). [34]

Swiss Re (2021), *The economics of climate change: no action not an option*, Swiss Re Institute, Zurich. [22]

The Economist (2022), *Could the EV boom run out of juice before it really gets going?*, https://www.economist.com/business/2022/08/14/could-the-ev-boom-run-out-of-juice-before-it-really-gets-going (accessed on 22 September 2022). [90]

The Guardian (2023), "Death Valley approaches global heat record as US reels from extreme weather", *The Guardian*, https://www.theguardian.com/world/2023/jul/17/death-valley-record-earth-temperature-california-extreme-weather (accessed on 29 August 2023). [145]

The Guardian (2023), "India floods: monsoon rains leave 22 dead in north as Delhi sees wettest July day in decades", *The Guardian*. [39]

Thomas, K. et al. (2019), “Explaining differential vulnerability to climate change: A social science review”, *Wiley Interdisciplinary Reviews: Climate Change*, Vol. 10/2, p. e565, https://doi.org/10.1002/WCC.565. [26]

Tikoudis, I., R. Mebiame and W. Oueslati (2022), “Projecting the fuel efficiency of conventional vehicles: The role of regulations, gasoline taxes and autonomous technical change”, *OECD Environment Working Papers*, No. 198, OECD Publishing, Paris, https://doi.org/10.1787/13b94818-en. [126]

Ueckerdt, F. et al. (2021), “Potential and risks of hydrogen-based e-fuels in climate change mitigation”, *Nature Climate Change*, Vol. 11/5, pp. 384-393, https://doi.org/10.1038/s41558-021-01032-7. [64]

UK Government (2021), *STATEMENT ON INTERNATIONAL PUBLIC SUPPORT FOR THE CLEAN ENERGY TRANSITION*, https://webarchive.nationalarchives.gov.uk/ukgwa/20230313124743/https:/ukcop26.org/statement-on-international-public-support-for-the-clean-energy-transition/ (accessed on 11 September 2023). [51]

UNDP (2017), *Circular Economy strategies for Lao PDR*, United Nations Development Programme, https://www.undp.org/publications/circular-economy-strategies-lao-pdr. [95]

UNDRR (2021), *Promoting Synergy and Alignment: Between Climate Change Adaptation Risk Reduction in the Context of National Adaptation Plans*, United Nations Office for Disaster Risk Reduction, Geneva. [116]

UNDRR (2019), *Global assessment report on disaster risk reduction 2019*, United Nations Office for Disaster Reduction. [136]

UNDRR (n.d.), *United Nations DesInventar Open Source Initiative*, https://www.desinventar.net/ (accessed on 28 July 2023). [71]

UNEP (2022), *Emissions Gap Report 2022*, https://www.unep.org/resources/emissions-gap-report-2022. [3]

UNEP (2018), *The Weight of Cities: Resource Requirements of Future Urbanization*, United Nations Environment Programme, https://www.resourcepanel.org/reports/weight-cities. [77]

UNEP (2017), *Assessing Global Resource Use: A Systems Approach to Resource Efficiency and Pollution Reduction*, United Nations Environment Programme, https://www.resourcepanel.org/reports/assessing-global-resource-use. [75]

UNEP (2011), *Decoupling natural resource use and environmental impacts from economic growth, A Report of the Working Group on Decoupling to the International Resource Panel.*. [135]

UNFCCC (2023), *Technical dialogue of the first global stocktake: Synthesis report by the co-facilitators on the technical dialogue*. [2]

UNFCCC (2023), *Transitional Committee*, https://unfccc.int/topics/adaptation-and-resilience/groups-committees/transitional-committee (accessed on 28 July 2023). [44]

UNFCCC (2022), *Nationally determined contributions under the Paris Agreement*, https://unfccc.int/sites/default/files/resource/cma2022_04.pdf (accessed on 12 September 2023). [150]

UNFCCC (2022), *Nationally Determined Contributions under the Paris Agreement: Synthesis Report by the Secretariat*, https://unfccc.int/sites/default/files/resource/cma2022_04.pdf (accessed on 4 May 2023). [52]

UNFCCC (2022), *Secretariat GST synthesis report: Synthesis report for the technical assessment component of the first global stocktake: Synthesis report on the overall effect of Parties' NDCs and overall progress made by Parties towards the implementation of their NDCs, including the information referred to in Article 13, paragraph 7(b), of the Paris Agreement*, https://unfccc.int/sites/default/files/resource/GST_SR_23c_30Mar.pdf. [132]

UNFCCC (2022), *Synthesis report on the overall effect of Parties' NDCs and overall progress made by Parties towards the implementation of their NDCs, including the information referred to in Article 13, paragraph 7(b), of the Paris Agreement)*.. [13]

UNFCCC (2021), *End of Coal in Sight at COP26*, United Nations Framework Convention on Climate Change, https://unfccc.int/news/end-of-coal-in-sight-at-cop26. [72]

UNFCCC (2016), *The Paris Agreement*, United Nations Framework Convention on Climate Change, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement. [1]

United Nations (2019), *Green economy could create 24 million new jobs*, https://www.un.org/sustainabledevelopment/blog/2019/04/green-economy-could-create-24-million-new-jobs/. [76]

Venmans, F., J. Ellis and D. Nachtigall (2020), "Carbon pricing and competitiveness: Are they at odds?", *Climate Policy*, Vol. 20/9, pp. 1070-1091, https://doi.org/10.1080/14693062.2020.1805291. [85]

WMO (2023), *State of the Global Climate 2022*, World Meteorological Organization, Geneva. [42]

WMO (2021), *Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970-2019)*, World Meteorological Organization, Geneva. [137]

WMO (2021), *New climate predictions increase likelihood of temporarily reaching 1.5 °C in next 5 years*, World Meteorological Organization, Geneva. [104]

WMO (2021), *State of the Global Climate 2020*, World Meteorological Organization, Geneva. [43]

WMO (2015), *Heatwaves and Health: Guidance on Warning-System Development*, World Meteorological Organization and World Health Organization, Geneva, https://www.who.int/globalchange/publications/WMO_WHO_Heat_Health_Guidance_2015.pdf?ua=1 (accessed on 27 October 2021). [25]

World Bank (2021), *State and Trends of Carbon Pricing 2021*. [84]

World Resources Institute (2022), *Climate Watch*, https://www.climatewatchdata.org/. [148]

Zachariah, M. et al. (2023), *Extreme heat in North America, Europe and China in July 2023 made much more likely by climate change*, Grantham Institute for Climate Change, London, https://doi.org/10.25561/105549. [173]

Zegarra, L. (2020), "Living Costs and Real Wages in Nineteenth Century Lima: Levels and International Comparisons", *Australian Economic History Review*, Vol. 60/2, pp. 186-219, https://doi.org/10.1111/aehr.12186. [108]

Notes

[1] The explicit commitment is a “balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHG) in the second half of this century”. Countries have interpreted this to establish net zero targets by 2050.

[2] Numbers will be updated in line with the forthcoming 2023 edition of the UNEP Emissions Gap Report.

[3] There are 198 parties to the UNFCCC, 196 signed the Paris Agreement, out of which all signatories but Côte d’Ivoire submitted their Nationally Determined Contributions.

[4] OECD Secretariat estimates use 2020 Climate Watch data. Physical emissions data presented in the text is from the OECD unless stated otherwise.

[5] OECD and OECD partner countries updated NDC targets presented up to 30 June 2023 commit to an additional GHG emission reduction of 900 MtCO_2e for 2030 compared to targets submitted to the UNFCCC up to August 2022 (360 MtCO_2e in OECD countries and 540 MtCO_2e in OECD partner countries, reducing their 2030 estimated emissions by 4% and 3%, respectively), mostly due to the increased ambition of India, Mexico, and Türkiye. In its updated 2022 NDC submission to the UNFCCC, India increased its ambition to reduce the emissions intensity of its GDP by 45% by 2030, from 2005 levels, which is higher than the previous 33-35%. Mexico committed to reducing its emissions by 35-51% instead of 22% in its updated NDC in 2022; and Türkiye’s emission reduction target increased from the aim of reducing by up to 21% from the BAU to 41% from the BAU in its updated NDC in 2023. Other countries also increased their ambition: Indonesia increased its target from 29% to 32% in its updated NDC in 2022, and Norway committed to a 55% reduction in emissions instead of reductions between 50% and 55% in its updated NDC in 2022.

[6] GHG emissions inventories are compiled following territory and production-based emission principles. This means that in most countries’ cases, total GHG emission does not include emissions from international transport. In addition, emissions from consumption of products produced in other territories or emissions from transporting these products are not included.

[7] The ambition gap refers to the difference between the necessary GHG emissions to achieve the 1.5°C and the NDC target.

[8] Note that the estimate of 43% emissions reduction refers to global GHG emissions reductions, it does not imply that individual countries should reduce this amount. For this reason, this document has only estimated the ambition gap for aggregate emissions for all covered countries.

[9] UNEP projected emissions consider currently implemented policies.

[10] Net-zero emission is defined as a balance between anthropogenic GHG emissions and removals by LULUCF. However, different terminologies are used in policy documents and other sources to refer to a long-term strategy of balanced emissions and removals. Some of these terms are carbon neutral and zero carbon. The definitions of these terms are not always clear and consistent.

[11] Percentages calculated using data from Climate Watch (Climate Watch, 2022[152]).

[12] Australia, Canada, Chile, Colombia, Denmark, EU (27), Fiji, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Japan, South Korea, Liechtenstein, Luxembourg, Maldives, New Zealand, Nigeria, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

[13] There are differences with other databases that also aim to identify the number of countries that have pledged for net-zero targets. One of these is a non-official database by the IEA, which presents differences with respect to some countries, in particular Brunei, Comoros, Cook Islands, Croatia, Ghana, Kuwait, Kyrgyzstan, Liechtenstein, Paraguay, Peru, Suriname, Tunisia, Tuvalu, Vanuatu, Vatican City (which IEA does not cover) and Mauritius and Morocco (which IPAC does not cover).

[14] IMO (2023), "Revised GHG reduction strategy for global shipping adopted", *International Maritime Organization*, https://www.imo.org/en/MediaCentre/PressBriefings/pages/Revised-GHG-reduction-strategy-for-global-shipping-adopted-.aspx.

[15] Often countries' NDC targets do not cover international transport. Thus, these targets strengthen the commitments communicated through NDCs.

[16] Flightradar24 (2023), *Twitter,* https://twitter.com/flightradar24/status/1677361887812493329.

[17] Percentage changes are calculated using (OECD, 2023[7]).

[18] Data is provided by Climate Watch. Physical emissions data presented in the text is from the OECD unless otherwise stated.

[19] Although focussed on CO_2 emissions from energy, the former provides a measure of emissions intensity relative to total population; while the latter, focussing on GHG emissions, provides a measure of the decarbonisation of the economy. Both measures provide insights into the relative emissions contribution of a country and its long-term emissions path.

[20] Data is provided by Climate Watch. Physical emissions data presented in the text is from OECD unless otherwise stated.

[21] IEA, Global CO_2 emissions from transport by sub-sector in the Net Zero Scenario, 2000-2030, IEA, Paris,https://www.iea.org/data-and-statistics/charts/global-co2-emissions-from-transport-by-sub-sector-in-the-net-zero-scenario-2000-2030-2 , IEA. Licence: CC BY 4.0.

[22] This subsection considers only LUCF and not LULUCF because of global estimated data availability.

[23] Including non-climate related disasters such as earthquakes.

[24] Ibid.

[25] Most recent evidence on the assessment of how average temperature in July compares historically (so far the highest month) possibly by looking at historical ice and other records ever.

[26] Hot days are defined as those during which daily maximum temperature surpasses 35°C. Due to the resolution of the raw data, it is possible that extreme heat for small islands is slightly underestimated. There are also several additional indicators to describe extreme heat (such as the UTCI (Universal Thermal Climate Index), which also takes moisture, wind and solar radiation into account); these should be taken into account for a more thorough analysis of exposure to heat for single countries.

[27] Tropical nights are defined as nights where the minimum temperature does not fall below 20°C. Due to the resolution of the raw data, it is possible that extreme heat exposure for small islands is slightly over- or underestimated. There are also several additional indicators to describe extreme heat (such as the UTCI), which also takes moisture, wind and solar radiation into account); these should be taken into account for a more thorough analysis of exposure to heat for single countries.

[28] Annual population exposure to more than 8 weeks of tropical nights.

[29] Extreme precipitation is defined here as precipitation of more than one week.

[30] River flooding events are defined in terms of a 100-year flooding event.

[31] Heatwaves in the 2022 pre-monsoon season in India and Pakistan, followed by exceptional flooding during the monsoon season caused enormous damage. Firstly, the decline in crop yields combined with the banning of wheat exports and restrictions on rice exports in India after the start of the conflict in Ukraine, threatened the availability of stability of staple foods in a country already affected by food shortages. Secondly, July and August were each the wettest on record in Pakistan, 181% and 243% above normal levels, respectively. Heavy monsoon rains caused severe flooding and landslides in Pakistan, leading to the spread of water-borne diseases, with the greatest impacts in the most vulnerable and food-insecure regions of southern and central Pakistan. Over 1 700 deaths were reported in Pakistan, along with 936 000 head of livestock, and over 2 million dwellings damaged or destroyed, bringing total damages to an assessed USD 30 billion (WMO, 2023[42]).

[32] As of June 2022, 28 million people were recorded as food insecure in Latin America and the Caribbean, making the region vulnerable to the impact of hurricanes and storms (WMO, 2023[42]). In the Greater Horn of Africa, the rains failed for the fifth consecutive season since late 2020, where, under the effects of the drought, an estimated 23 million people in Ethiopia, Kenya and Somalia faced acute levels of food insecurity as of January 2023. Heavy rainfall and flooding in Sudan and South Sudan have exacerbated crop damage, displacement, and conflictual and food insecurity conditions, putting over 7 million people at risk acute food insecurity as of July 2022. In South Sudan, four consecutive years of flooding, as well as macroeconomic challenges are expected to keep food insecurity at extreme levels (WMO, 2023[42]).

[33] The CAPMF is the most extensive climate policy database to date, covering countries responsible for 63% of global GHG emissions as well as 75% of instruments listed in the latest IPCC report in key emitting sectors, accounting for 89% of OECD and OECD partners' GHG emissions. However, results should be interpreted with care. The CAPMF does not capture all policies (sectors and instrument types) due to data availability constraints, such as agriculture and land-based sectors, tax credits and other subsidies for cleaner technologies or an expansion of voluntary approaches, or adaptation policies. Policies included in the CAPMF may, thus, not be fully representative of mitigation approaches of some countries. Rather, these policies represent a range of mitigation actions that countries could employ.

[34] Policy stringency is defined as the degree to which policies incentivise emissions reductions. Following the methodology of the OECD Environmental Policy Stringency Index (Botta and Koźluk, 2014[164]) (Kruse et al., 2022[163]), the CAPMF operationalises stringency as a relative concept by assigning a stringency score between 0 (not stringent) and 10 (very stringent) for each policy variable based on the in-sample distribution across all countries and years of the policy variables' level (e.g. tax rate, emission limit value,

government expenditure). Basing policy stringency on a relative concept implies that high stringency values in a particular country do not necessarily suggest that the policy is stringent enough to meet its mitigation goals. Rather, it means that the policy in this country and year was more stringent compared to all other countries and years.

35 The CAPMF is an extensive, harmonised policy database that measures the adoption and stringency of 56 climate actions and policies based on 130 policy variables, from 1990-2022 across 50 countries and the EU-27 as a block. The United States has been excluded from the CAPMF as the policy data has not been fully verified and validated.

36 Operationally, the CAPMF measures overall climate action as the average of policy stringency across all building blocks (sectoral, cross-sectoral, international policies). Policy stringency in each building block is calculated as the average across all underlying modules (e.g. electricity market-based instruments, electricity non market-based instruments…), which – in turn – are calculated as the average of all policies included in each module. See Figure 2.1 in the methodological paper for the structure of the CAPMF (Nachtigall et al., 2022[45]). The reason for this choice is that it is less subject to data availability compared to simply taking the unweighted average across all policies covered by the CAPMF. For some modules (e.g. electricity market-based instruments) the CAPMF comprises a large number of policies whereas for others (e.g. industry non market-based instruments) it comprises only few. Creating an unweighted average across all policies would, thus, bias overall climate action towards policy areas for which data availability is better. Figure I.3 shows that this choice does not affect the qualitative results of the report. The growth rate of climate action between 2000 and 2022 is calculated as the geometric mean of overall climate action between those years.

37 The OECD estimated that only 17% of the recovery spending tracked between 2019 and March 2021 can be accounted as environmentally-positive – the same amount as mixed and environmentally-negative measures combined. https://www.oecd.org/coronavirus/policy-responses/the-oecd-green-recovery-database-47ae0f0d/#section-d1e324 .

38 International policies are related to international climate co-operation (e.g. participation in international initiatives and agreements), international finance (e.g. participation in international emissions pricing schemes such as CORSIA) or compliance with international reporting requirements under the UNFCCC.

39 Cross-sectoral actions and policies refer to policies that cut across more than one emission source or sector. These are overarching policy areas to mitigate or remove domestic GHG emissions that cannot be easily attributed to a specific sector (e.g. GHG emissions targets, climate governance).

40 Sectoral policies are defined as policies that can be constrained or are designed to apply to a specific source or economic sector (e.g. emission limit values for passenger cars, phase out of power plants).

41 Net Effective Carbon Rate (NECR) is the sum of fuel excise taxes, carbon taxes and tradeable permits, that effectively put a price on carbon emissions, adjusted by fossil fuel support.

42 The IEA has been tracking fossil fuel subsidies for many years, examining instances where consumer prices are less than the market value of the fuel itself (adjusted for transport costs and VAT, as applicable). The IEA country coverage on fossil fuel subsidies for the numbers in Figure 38 include: Algeria, Angola, Argentina, Azerbaijan, Bahrain, Bangladesh, Bolivia, Brunei, China (P.R. of), Colombia, Ecuador, Egypt, El Salvador, Gabon, Ghana, India, Indonesia, Iran, Iraq, Kazakhstan, Korea, Kuwait, Libya, Malaysia, Mexico, Oman, Nigeria, Pakistan, Qatar, Russia, Saudi Arabia, South Africa, Sri Lanka, Chinese Taipei,

Thailand, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Ukraine, Uzbekistan, Venezuela, Vietnam, France, United Kingdom, Austria, Hungary, Poland, Slovak Republic, Croatia.

[43] Care should be taken when making international comparisons as there is a level of uncertainty associated with the data sources and measurement methods on which the indicators rely. For example, one methodological limitation of fossil fuel support data is that tax expenditures are not systematically comparable across countries and over time, due to the fact that data reported by countries are calculated using different benchmark tax systems to estimate the revenue forgone. Also note that fossil fuel support data from the OECD Inventory is available from 2010.

[44] Apart from the Paris Agreement, other climate treaties tracked by the CAPMF include: the Montreal Protocol, the Montreal Amendment, the Kigali Amendment to the Montreal Protocol, the UNFCCC framework convention.

[45] See the OECD Working Paper (Nachtigall et al., 2022[45]) for a list of international initiatives tracked by the CAPMF.

[46] Other countries that updated their NDCs in advance of COP28 include Australia, Indonesia, Mexico, Norway, Switzerland and the United Kingdom.

[47] IPCC recommends using a three-tier approach to collect and organize emissions inventories. Tier 1 is less demanding and less detailed while Tier 3 is the most detailed process.

[48] Additional data may be available in other sources such as national statistics websites. IPAC is exploring different alternatives to fill data gaps including conducting desk research to examine different sources and developing statistical methods.

[49] The development of this set of indicators is informed by standards from the World Meteorological Organization, the US National Ocean and Atmospheric Administration, latest research and standard developed by well-recognised organisations and builds on international frameworks for assessing climate-related hazards. Notwithstanding, over- or under-estimations of the actual exposure to climate-related hazards may occur and further details on these limitations can be found in the OECD Working Paper (Maes et al., 2022[20]).

[50] Several databases gather secondary data on disaster occurrence and their human and economic cost such as the EM-DAT database from the Centre for Research on the Epidemiology of Disasters' Emergency, hazard-specific databases (e.g. the Dartmouth Flood Observatory), actuaries and re-insurers (e.g. MunichRe's Natcat-SERVICE and SwissRe's Sigma databases). A weakness of such databases is the heterogeneous nature of the secondary data it relies upon, it often has problems with comparability across countries.

[51] For example, EM-DAT collects data on costs that accrue directly to assets, but it does not account for costs that accrue from business disruption in areas directly affected by the disaster, while this is included in SwissRe's Sigma database. Beyond this, more intangible losses such as the impact on health or the environment, as well as cultural heritage loss and loss of reputation, are hardly ever accounted for due to difficulties in monetisation.

[52] For example, the WMO World Atlas report compares human loss figures from nationally reported data in two databases (DesInventar and EM-DAT) with different thresholds across Colombia, Ecuador, Indonesia and Niger (WMO, 2021[137]). It concluded that different threshold levels between the two databases did not affect the reporting of intensive (high-intensity, low-frequency) disasters (WMO,

2021[137]). However, the two databases had varying thresholds for extensive disasters (low-intensity, high-frequency), responsible for the majority of economic losses from disasters (68.5% between 2005-2017) and therefore extensive disasters were sometimes included in one database but not the other (UNDRR, 2019[136]).

The Climate Action Monitor 2023

PROVIDING INFORMATION TO MONITOR PROGRESS TOWARDS NET-ZERO

The Climate Action Monitor is a key publication of the International Programme for Action on Climate (IPAC). It provides a synthesis of climate action and progress towards net-zero targets for 51 OECD and OECD partner countries. This year's edition presents a summary of information on greenhouse gas emissions, an assessment of climate-related hazards and recent trends in climate action. Directed towards policymakers and practitioners, the findings suggest that without increased ambition and a significant expansion in national climate action, countries will not be able to meet the net-zero challenge.

PDF ISBN 978-92-64-59932-1

9 789264 599321