The Climate Action Monitor 2022

HELPING COUNTRIES ADVANCE TOWARDS NET ZERO

OECD

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BETTER POLICIES FOR BETTER LIVES

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Preface

More and more countries have committed to achieving net zero emissions by 2050. By September 2022, 136 countries covering 83% of global carbon emissions had locked into net zero emissions targets in the coming decades.

However, as we look to COP27 this month, the challenge is turning these commitments into actual outcomes on the pathway to carbon neutrality as soon as possible. We know action on climate change is urgent and we know more needs to be done. It requires a whole-of-government, whole-of-economy effort.

The OECD, through its multidisciplinary competence, is ramping up efforts to support ambitious, effective, globally more coordinated, coherent, and measurable climate action.

We are building on our long-standing experience in climate-related policies to contribute by supporting the UNFCCC to monitor progress and by supporting countries to implement effective climate action. Our efforts 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.

IPAC, among other initiatives, co-ordinates these actions on climate change. It draws on our multi-disciplinary competence to provide concrete tools for monitoring climate performance on national commitments and global net-zero trajectories. IPAC explores climate action across countries, creating a dedicated space for the exchange of best practices to encourage dialogue and pragmatic solutions towards advancing climate objectives. This year's *Climate Action Monitor* continues this work and presents new data sets developed by the Programme to permanently monitor climate impacts by evaluating climate-related hazards and climate action through a comprehensive climate policy measurement framework.

Collectively, we have the ingenuity, human capital and financial resources to avoid the worst consequences of climate change. We will continue to actively support this effort, developing data methods and indicators to measure achievements and better guide action.

Mathias Cormann

OECD Secretary-General

Foreword

The International Programme for Action on Climate (IPAC) was established in May 2021 to assess and support progress towards net-zero greenhouse gas (GHG) emissions and a more resilient economy by mid-century. To support these global objectives, IPAC provides governments with information and tools to monitor, evaluate and support the effectiveness of climate measures.

IPAC draws on the wealth of international climate-related data, indicators and research developed in partnership with the International Energy Agency (IEA), the Nuclear Energy Agency (NEA) and the International Transport Forum (ITF), covering environmental, economic, financial and social dimensions of climate change. It aims to provide targeted policy advice and internationally harmonised indicators complementary to the United Nations Framework Convention on Climate Change (UNFCCC) framework for tracking the progress of the Paris Agreement goals.

IPAC covers all OECD countries, the six candidate accession countries (Argentina, Brazil, Bulgaria, Croatia, Peru and Romania), partner economies (People's Republic of China, India, Indonesia and South Africa), other G20 countries, and Malta. The IPAC Dashboard that presents a comprehensive set of climate indicators (https://www.oecd.org/climate-action/ipac/dashboard) is based on data published by official sources or otherwise validated by the countries concerned.

IPAC is an integral part of the OECD's strategic approach to incorporating climate action into all of its work, harnessing the multi-disciplinary and whole-of-economy nature of OECD activity. This strategic approach comprises five pillars of action designed to ensure a climate contribution that is broad, deep and integrated into global efforts to address climate change. IPAC contributes to support pathways to the net-zero transition (Pillar 1) and providing a monitoring and measurement framework with a wide range of OECD data and indicators (Pillar 4). It also contributes to extensive OECD work on adaptation and resilience to climate change (Pillar 2), public and private finance, climate-centred investment and business action (Pillar 3), and multilateral and multi-disciplinary approaches to build co-operation and drive progress (Pillar 5). All five pillars allow for innovative advancements for better measurement, monitoring, policy design, implementation and evaluation for enhanced climate action.

The *Climate Action Monitor* is a summary of the state of climate action worldwide, principally centred on IPAC countries. Comprehensive information is not yet fully available, however. The information contained herein is based on the indicators developed by IPAC and analytical work from the OECD and entities within the OECD family. It provides a digest of progress toward climate objectives and alignment with the goals of the Paris Agreement.

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Reader's guide

This is the second 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 (www.oecd.org/ipac), as well as other OECD research and data.[1]

It supports countries to make better-informed decisions and allows stakeholders to measure improvements more accurately. Alongside other IPAC deliverables such as the IPAC Dashboard, *The Climate Action Monitor* complements and supports 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.

The specific focus of the Monitor, and more generally IPAC, is assessing and monitoring climate action. For this, IPAC has developed an analytical approach that frames this report. The analytical approach presented is based on an expanded conceptualisation of the OECD/United Nations Environment Programme (UNEP) Pressure-State-Response (PSR) environmental indicator model (see Box 1). The approach considers broader criteria to determine countries policy choices, such as constraints or barriers, potential social and economic impacts, and the external policy environment.

Potential constraints or barriers associated with policy responses can be divided into four key groups:

1. **Governance:** Decarbonisation policies will require effective and efficient implementation which may involve new or additional governance structures.
2. **Critical materials**: Decarbonisation policies will require the use of critical materials, such as copper and lithium, among others.
3. **Skills, technologies and innovation**: Climate change policy responses will require a set of new competencies both at the individual and institutional levels, as well as new technologies.
4. **Finance**: Policy responses may require substantial financing.

Finally, policy responses are not implemented in a policy vacuum. There may be positive external conditions, or "tailwinds", that can help support policy responses. There may also be pushback for policy adoption, or "headwinds", associated with negative external conditions that generate unfavourable conditions to implement policies. An obvious recent headwind is Russia's unprovoked war of aggression against Ukraine, which has affected the supply of gas to Europe, but there may be others. For example, general economic conditions, such as unemployment, debt-to-GDP ratio and/or other social inequalities, may be relevant when considering policy alternatives (Figure 1).

The *Climate Action Monitor's* broader conceptual approach allows for a more comprehensive analysis of the challenges and opportunities for policy makers as they decide on 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 extensive experience in policy analysis and considering best practices.

As IPAC continues, it will develop a range of indicators associated with this broader analytical perspective and thus support countries in making informed decisions to face the climate emergency in the context of their policy approaches, institutional landscapes and economic and social realities.

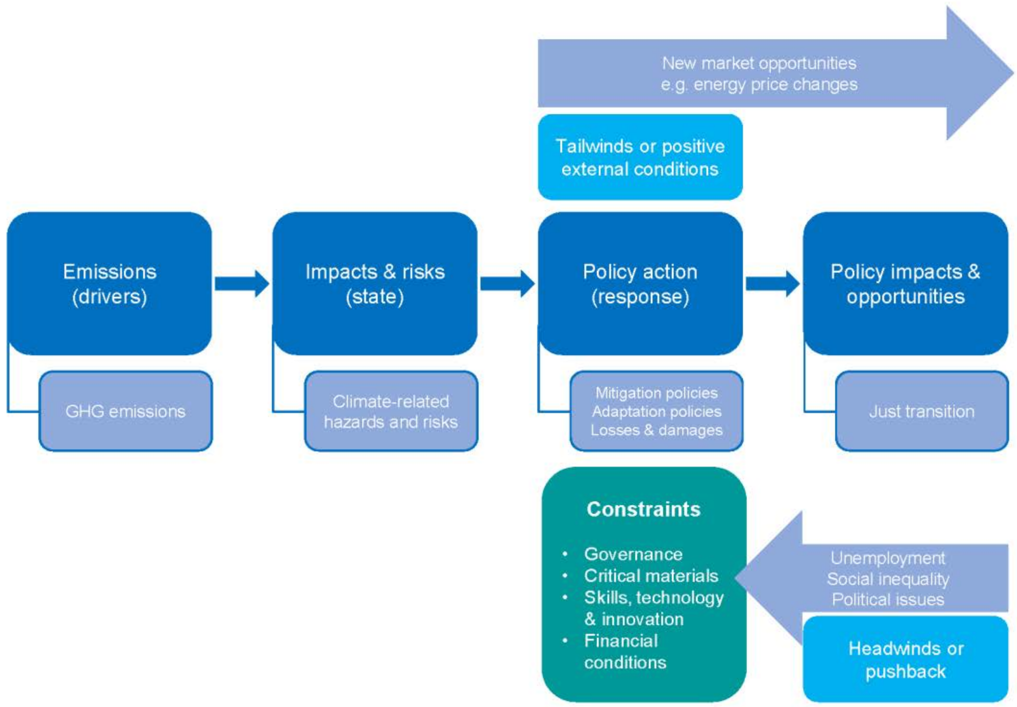
Box 1. The Pressure-State-Response Framework

The Pressure-State-Response 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 and the associated policy response.

The PSR model was designed based on the logical sequence of the policy response to the state of the environment due to environmental pressures and human drivers. The model makes transparent the fact that the state of the environment, and its direct pressures, ultimately depend on the drivers associated with economic and social activities, such as transport, industry, population, and consumption patterns, among others.

- Pressures on the environment: The emission and concentration of greenhouse gases constitute the main cause or direct pressure that generates climate change.
- Drivers of climate change: The drivers of environmental pressures are determined by production and consumption patterns. The increase in production and demand for goods and services, transportation and population growth are the drivers that generate the pressures that trigger climate change.
- State of the environment: The condition of the environment is referred to as its “state”. In the case of climate change, state is typically described using essential climate variables, such as the concentration of the different greenhouse gases and related variables. However, more generally, when referring to the “state”, how environmental change specifically impacts humans (e.g. in the increase in hazards and exposures) is of particular interest.
- Policy response: 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. More specifically, in the climate change policy sphere, response is defined as mitigation and adaptation.

Figure 1. IPAC Analytical Framework



Source: Authors' based on PSR framework.

Note

1. Countries covered by IPAC are: all OECD countries (Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Czech Republic, 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), partner economies (Brazil, People's Republic of China, India, Indonesia, South Africa), six prospective members (Argentina, Brazil, Bulgaria, Croatia, Peru, Romania) and other Group of 20 (G20) countries (Russian Federation, Saudi Arabia) and Malta.

Executive summary

Countries are facing a multitude of complex, even potentially intractable, issues: the recovery from the Covid-19 pandemic, rising energy prices, inflation, a global economic downturn, and increasing insecurity due to Russia's unprovoked war of aggression against Ukraine, are some of the most significant. These are pressing and difficult, but without a doubt, climate change remains the principal global environmental, economic and social challenge of this century.

Climate change is an existential threat intertwined with multiple environmental concerns and tipping points. It both triggers and intensifies economic and social problems, affecting less developed economies and vulnerable communities more acutely. Global action is urgent, and today's actions will not only determine the future of the global climate system, but ultimately people's lives and livelihoods.

Although countries have different development challenges, facing climate change requires shared responsibility and strong, global co-ordinated action. The Paris Agreement has been fundamental in recognising different national circumstances and countries' varied approaches on climate action, but also the need for global governance and explicit commitments. It is the cornerstone of global action on climate change.

The principal message that emerges from this year's Monitor is that countries are vulnerable; they are exposed to an increasing number of intense climate-related hazards that affect communities and livelihoods. Mitigation and adaptation must be the focus of countries development strategies. Nevertheless, it is important to recognise that countries have made progress, climate action has expanded across the world, but more can and must be done. Ambition needs to increase significantly and action must be effective. Governments have not adopted all the policy instruments available to them or the stringency level to achieve material change. This requires a broad whole-of-government approach not only to deal with the climate crisis, but also to achieve strong, sustainable, fair and resilient growth.

Other key messages that emerge from this report are presented below.

How far are countries from achieving national and global climate objectives?

As of 1 September 2022, 136 countries have adopted or proposed net-zero targets. These targets cover around 83% of global carbon emissions. However, considering the full implementation of Nationally Determined Contributions (193 NDCs) as of 31 December 2021, including conditional commitments, gross **global greenhouse gas (GHG) emissions are expected to increase by 10.6% by 2030** compared to 2010 levels (UNFCCC, 2022[1]).

GHG emissions need to decline by 2030 by around 43% from 2019 levels and reach net zero by 2050 to achieve the target of limiting global warming to 1.5°C by the end of the century (UNFCCC, 2022[1]).

For the 51 IPAC countries, who account for around 74% of global net GHG emissions (i.e. including LULUCF), the unconditional combined emission reduction target pledges in 2030 NDCs are estimated at

6 000 $MtCO_2e$, a percentage reduction of approximately 16% of their emissions compared to 2019. This represents a total global GHG emission reduction of approximately 12%. However, ambition levels vary significantly across IPAC countries. More than one-fifth of countries do not have commitments to decrease their emissions below their 2010 levels.

Governments must make significant efforts to achieve the 2030 targets. OECD countries' combined net emissions peaked in 2007 and have been gradually falling over the past 12 years. This decrease in emissions by 11% is partly due to a slowdown in economic activity following the 2008 economic crisis but also thanks to strengthened climate policies and changing energy consumption patterns.

Countries will have to reduce emissions in the next 10-30 years to achieve the Paris Agreement targets. Large emitters, such as the United States, the European Union and Japan, have decreased their gross emissions significantly, from 2010 to 2019 by 7%, 14%, and 5%, respectively, but they are still far from their target emission reductions, which require an additional reduction from 2019 to 2030 of 44% (United States), 38% (European Union) and 34% (Japan). In contrast, in many emerging economies, such as Brazil, the People's Republic of China (hereafter "China"), and India, emissions are still rising and have not yet reached their expected peak. China's target for peak emission is 2025, their net zero target is 2060.

Transformative changes in energy and production systems are needed to address key drivers behind emissions. Emission intensities per unit of GDP and per capita have decreased since 2005 in most OECD countries, revealing a strong overall decoupling from economic growth. However, further gains in energy efficiency alone will not be sufficient to put emissions on a path to reach net-zero targets.

Without substantially changing unsustainable consumption and production patterns, it will not be possible to combat climate change in the long-run. Between 1990 and 2017, the global extraction of raw materials more than doubled. At the global level, the rise in the **extraction of raw materials is expected to continue and is projected to double again by 2060** from 2017 levels, exacerbating global environmental impact.

How vulnerable are countries to climate impacts and risks?

Climate change poses a growing threat by influencing the intensity and the frequency of occurrence of climate-related hazards. Impacts may be gradual, such as those associated with the effects of rising temperatures or drought, or acute and sporadic through shocks, such as flash floods or wildfires. They can affect the economy or human health and well-being directly through the loss of life or the destruction of economic assets and indirectly through the deterioration of the multiple ecosystem services provided by the environment.

Between 1970 and 2019, disasters from weather, climate and water extremes represented 50% of all recorded disasters, 45% of deaths and 74% of related economic losses (WMO, 2021[2]). The World Meteorological Organization (WMO) assessment reported an almost eightfold increase in average daily economic losses between 1970-79 and 2010-19. This highlights the considerable increase in disasters globally and, together with OECD data on increased exposure to climate-related hazards, emphasizes the vulnerability of IPAC countries' economies and societies to climate impacts**.**

Population exposure to extreme heat has been increasing between 1979 and 2020, and potentially exposed 66% of the world population in 2021 to varying duration periods of extreme heat.

The combined challenges of changing temperatures and precipitation highlight the potentially severe implications for food security around the world. Worsening drought conditions on croplands are observed across IPAC countries, in part due to changing temperatures, while a small subset of countries experience increasing cropland exposure to extreme precipitation events.

Wildfires are increasing and are concentrated in specific countries and regions where they can have disastrous impacts. On average, around 1% of land was burned per year over the period 2017-2021 in countries such as Argentina, Australia, Brazil, Colombia, India, Portugal and South Africa, representing approximately 1.2 million square km which is roughly equivalent to the size of South Africa. Meanwhile, population and forest exposure to wildfire is significant and widespread, posing not only a problem for those countries but also affecting global climate change mitigation efforts.

How far has country climate action progressed in response to the net-zero challenge?

IPAC countries strengthened their climate action between 2010-2020. More can and must be done. Countries should consider the full range of the 56 policies available and reflect on their stringency to achieve the Paris Agreement targets.

Countries with an above-average number of adopted policies and above-average policy stringency were most successful in reducing GHG emissions. Assessing policy effectiveness involves however a number of additional factors. Heterogeneity in policy adoption and policy stringency partially reflects countries' different policy approaches and climate ambition that originate from country-specific circumstances, including emissions, drivers, and economic and social constraints

The adoption of international commitments, such as country-level targets, has been key to increase ambition. Almost all countries have implemented NDCs and net-zero targets in 2020. Stakeholders pressure for global climate action, which started around 2013, drove in part the rise in commitments, culminating with the Paris Agreement that was adopted in 2015. However, few countries have supported these commitments by providing accurate climate data, including biennial reports, biennial update reports or GHG emissions data, all of which provide the necessary information for an assessment of national climate policy implementation.

Overall, the adoption of domestic climate policies has increased significantly after 2015. For example, Canada adopted 10 additional policies between 2015 and 2020. However, some countries did not expand their policy adoption and a few others even removed policies. Increase in policy adoption after 2015 has been especially focussed on auctioning renewable electricity, carbon pricing, as well as bans and phase out of fossil fuel equipment and infrastructure such as coal power plants.

Policy packages differ substantially across countries and through time. Some countries, such as Portugal, primarily rely on market-based policies such as carbon pricing under the EU ETS or Feed-in-Tariffs for renewable energy. Others, like Costa Rica, place more emphasis on non-market based instruments such as minimum energy performance standards and bans or phase outs of fossil fuel equipment or infrastructure.

Market-based policy instruments have gained attractiveness compared to other instruments. In the early 2000s, they represented less than 30% of adopted policy instruments; today, they represent almost 50%. This has been driven primarily by the implementation of the EU Emissions Trading System and, subsequently, other carbon-pricing schemes.

The stringency and coverage for these instruments, however, remains low. Adoption of non-market based instruments have been historically higher than market-based instruments. Most countries have adopted building energy codes, minimum energy performance standards, and – increasingly – bans and phase outs of fossil fuel equipment. However, none of the IPAC countries adopted the highest possible energy performance standard for electric motors by 2020. Adoption of market-based instruments – while increasing – is still low. For example, carbon pricing covers only 50% of energy-related CO_2 emissions in OECD and G20 countries with an average effective carbon rate of below EUR 20 per tCO_2 – much lower than the price level needed to reach the goals of the Paris Agreement (EUR 50-160/tCO_2).

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

The Paris Agreement sets the goal to limit average global warming to 2ºC and recognises a need for efforts to confine the temperature rise to 1.5ºC. A further global target is “a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century” (UNFCCC, 2016[3]).[1] That is to ensure net-zero global greenhouse gas (GHG) emissions or achieve worldwide “carbon neutrality” by 2050.

The basis of the Paris Agreement is a non-binding bottom-up approach where countries’ policy commitments are nationally determined contributions (NDCs). NDCs present national climate policies as commitments to progressively mitigate GHG emissions, enhance their adaptive capacity to climate change, and address loss and damage caused by extreme climate events. Moreover, many countries have presented additional commitments, in particular, net-zero pledges by 2050 or earlier.

The Paris Agreement has been instrumental in increasing climate mitigation ambitions. The implementation of these commitments has led to lower global GHG emissions than previously projected. New estimates factoring in these commitments suggest that global GHG emissions will peak before 2030 (UNFCCC, 2022[1]). Further, at COP26, the Glasgow Climate Pact made a substantial contribution to strengthening countries’ implementation capacity by completing the Paris Agreement’s rulebook on market mechanisms and non-market approaches and detailing the requirements for transparent reporting of climate actions.

Moreover, for the first time, countries agreed to phase down unabated coal power and inefficient subsidies for fossil fuels.[2] At least 23 countries made new commitments to phase out coal power (including 5 of the world’s top 20 coal-power users) and 25 countries and public finance institutions committed to ending international public support for the unabated fossil fuel energy sector by the end of 2022 (UNFCCC, 2021[4]).

However, this is still not enough, and estimates suggest that current climate targets will not achieve the goals set out by the Paris Agreement (UNFCCC, 2022[1]). Therefore, responding to the climate emergency depends on countries’ substantially increasing their ambitions and ensuring the implementation of those targets through effective climate action.

GHG emission targets

GHG emission target-setting and operationalisation are at the core of effective climate action. 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.

Currently, the Paris Agreement covers 196 countries that together generate more than 94% of global emissions. OECD countries contributed one-third of global emissions in 2019; the Group of 20 (G20) countries contributed more than 70%. Countries covered under the International Programme for Action on Climate (IPAC) (which include, in addition to OECD and G20 countries, those in the process of accession to the OECD) generated around 74% of global emissions in 2019.

The unconditional combined GHG emission reduction target, including LULUCF, for the 51 IPAC countries in 2030 are around 6 000 $MtCO_2e$, a combined percentage reduction of approximately 16% of their net emissions compared to 2019. This represents a total global GHG emission reduction of approximately 12%.[3] However, ambition levels vary across countries. In fact, more than one-fifth of IPAC countries do not have commitments to decrease their emissions below their 2010 levels. Figure 2 compares countries' individual ambitions (in terms of the percentage of GHG emission reductions) and the global expected GHG emission reductions.

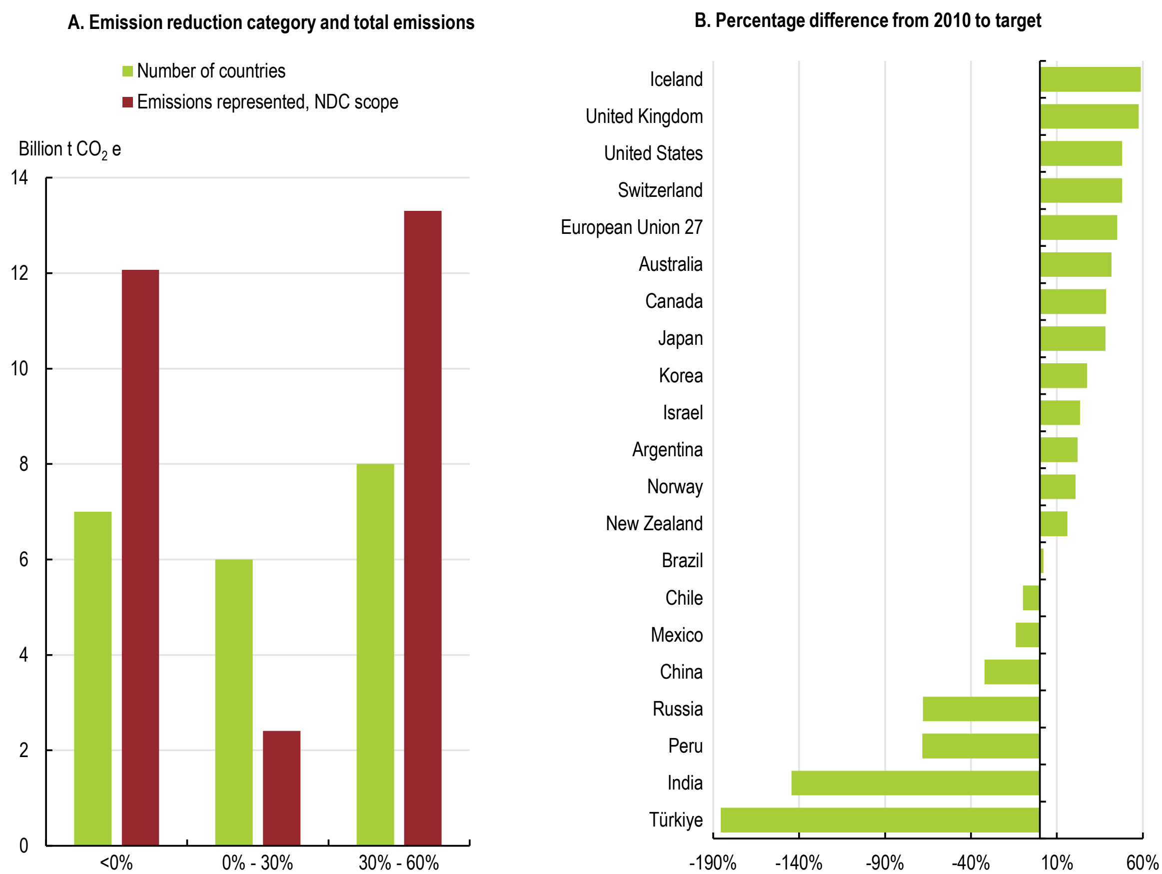
An increasing number of countries, sub-national governments and companies, have made net-zero GHG emissions pledges. As of 1 September 2022, net-zero targets have been adopted or proposed by 136 countries and the European Union (Figure 3). These targets cover around 83% of global carbon emissions.

Nevertheless, even if implemented, current policy targets and announced pledges would fall short of the GHG emissions reduction needed to achieve the Paris Agreement targets. With current NDCs, global emissions are still expected to increase by 10.6% by 2030 as compared to 2010 levels. Carbon emissions need to decline by around 43% by 2030 from 2019 levels and reach net zero by 2070 to achieve the 1.5°C target by the end of the century (UNFCCC, 2022[1]).

GHG emissions

Governments must increase efforts considerably to achieve the 2030 climate targets. OECD countries' net emissions peaked in 2007 and have been gradually falling over the past 12 years. This decrease in emissions by 11% is partly due to a slowdown in economic activity following the 2008 economic crisis but is also thanks to strengthened climate policies and changing energy mix.

Figure 2. A group of IPAC countries that account for more than a quarter of global emissions do not aim to reduce their emissions below the 2010 level

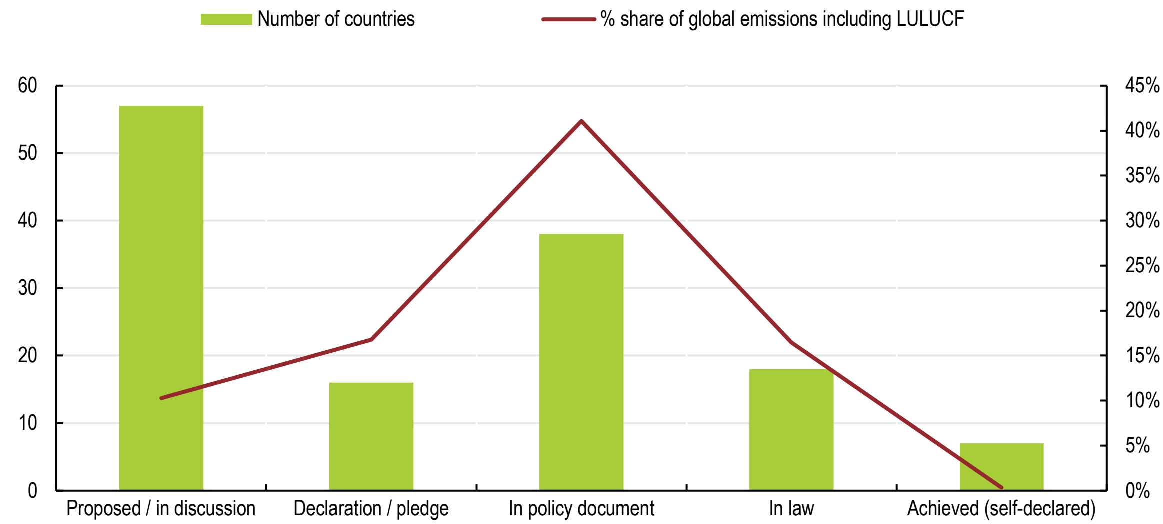


Note: in panel A, number of countries is total countries that fall in different categories of emission reduction from 2010 to 2030 target. Total emission is the combined emissions of the countries within a category where emissions are recalculated to fit to the NDC scope (for details see OECD (forthcoming[5])). Total emission is the combined emissions of the countries within a category where emissions are recalculated to fit to the NDC scope (for details see OECD (forthcoming[5])).

Source: OECD, IPAC's calculations, OECD (forthcoming[5]) and (OECD, 2022[6]).

Figure 3. 136 countries including the EU have committed to net zero pledges, 110 countries by 2050

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

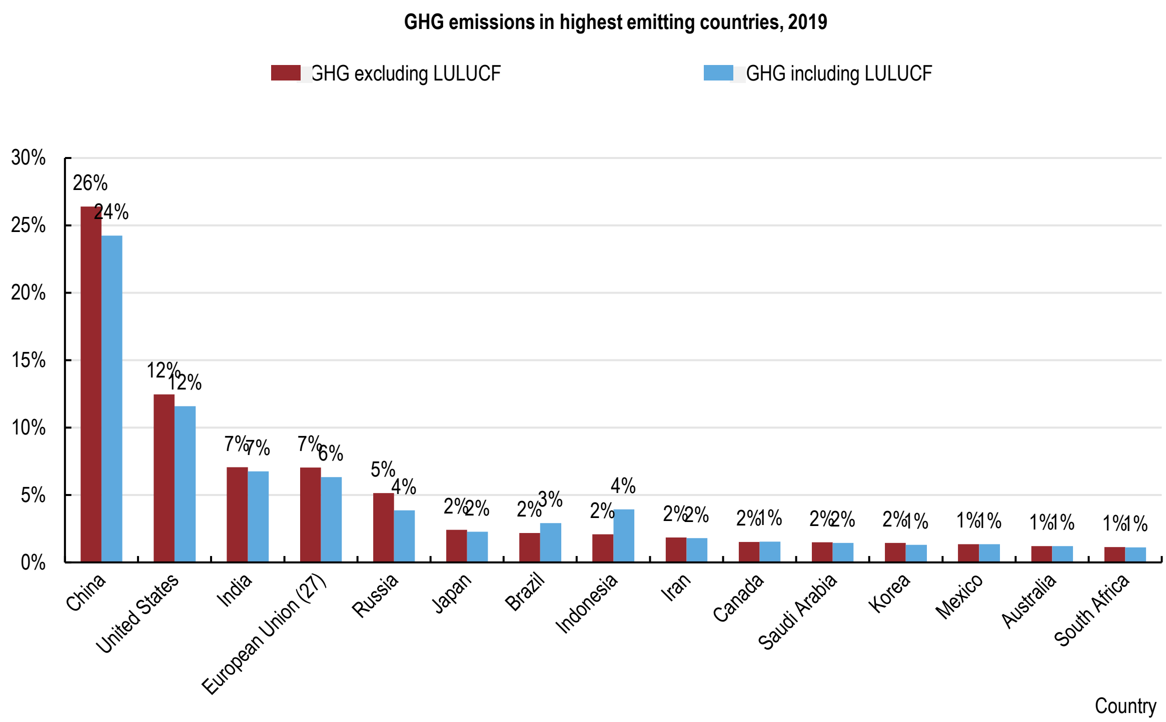


Note: Net-zero target, climate neutrality, carbon neutrality and zero carbon are all consider as a net-zero pledge. The EU commits to net-zero by 2050 for the whole EU region, but not for any specific country. To avoid double counting, emissions for individual EU countries that have adopted net-zero commitments are not considered, they are covered by total EU emissions identified in the bar "in law".
Source: (Energy and Climate Intelligence Unit, 2022[7]) (Climate Watch, 2022[8]).

Large OECD emitters, such as the **United States**, the **European Union** (see Box 2) and **Japan**, have decreased their gross emissions significantly from 2010 to 2019 by 7%, 14%, and 5%, respectively (see Figure 2).[4] But they are still far from their target emission reductions, which require an additional reduction from 2019 to 2030 of 44% (United States), 38% (European Union) and 34% (Japan). They have introduced important policies to achieve their objectives. For example, the European Union is implementing the "Fit for 55" package; the United States has passed the Inflation Reduction Act; and Japan developed a Beyond Zero Carbon roadmap and the Promotion Act on Global Warming Countermeasures.

In contrast, in many emerging economies, such as **Brazil**, the **People's Republic of China** (hereafter "China"), **Indonesia**, and **India**, emissions are still rising and have not yet reached their expected peak (Figure 5). Countries will have to reduce emissions in the next 10-30 years to achieve the Paris Agreement targets (OECD, forthcoming[5]).

Figure 4. The fifteen principal emitters generate more than 70% of global emissions



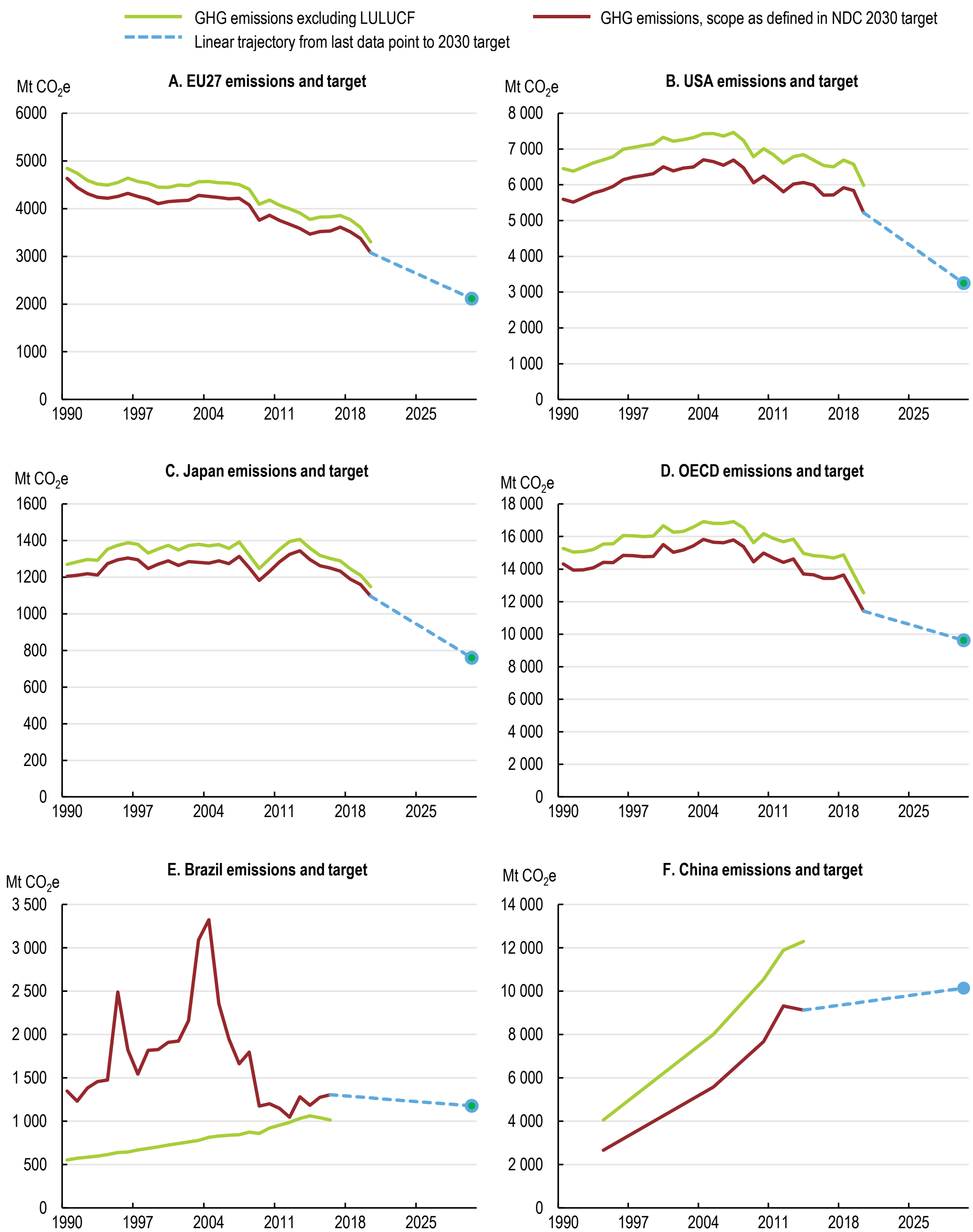
Note: Percentages indicated above graphs are a country's percentage share of estimated world emissions in 2019.
Source: Climate Watch (2022[9]).

Box 2. Identifying EU member states' individual commitments within an EU NDC

The European Union presents a common NDC for the 27 member states. Around 40% of net emissions principally associated with energy-intensive sectors are covered under the EU Emissions Trading System (EU ETS); other emissions, considered in the effort-sharing regulation (ESR) sectors, have country-specific targets. However, countries have also declared individual net-zero targets that may be more ambitious than the EU-wide commitment of a zero-net target by 2050.

The initial EU NDC, submitted on 6 March 2015, committed to at least 40% domestic (domestic referring to within the EU) GHG emissions reduction by 2030 as compared to its 1990 emissions. The European Council endorsed the strengthened binding EU target of a net domestic emissions reduction of at least 55% by 2030 compared to 1990 on 11 December 2020. This represents a net emissions reduction from 2010 of 46% and from 2020 of 32%. The European Union and its now 27 member states submitted an updated NDC corresponding to the revised target to the UNFCCC on 17 December 2020. In July 2021, the European Commission adopted a series of proposals to revise all relevant policy instruments that have yet to be approved so as to deliver the enhanced target.

Figure 5. Principal economies are required to reduce emissions significantly to stay on trajectory towards their targets



Note: EU27 and OECD values are aggregated for each year. GHG emissions, as scope defined in NDC 2030 target refers to recalculation of GHG emissions to fit to the NDC scope of each country. Direct comparison of scope adjusted emissions, linear trajectories and targets is not possible when NDC scopes differ. Further details in OECD (forthcoming[5]).
Source: OECD IPAC Climate Action Dashboard, OECD (2022[10]) and OECD (forthcoming[5]).

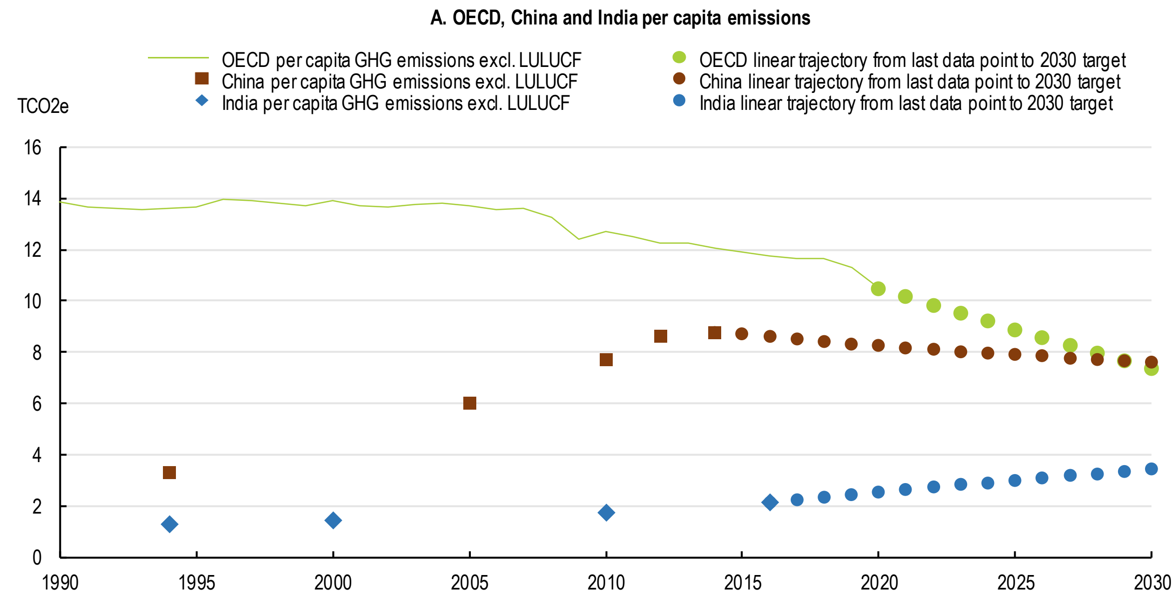
GHG emissions per capita and GDP intensity

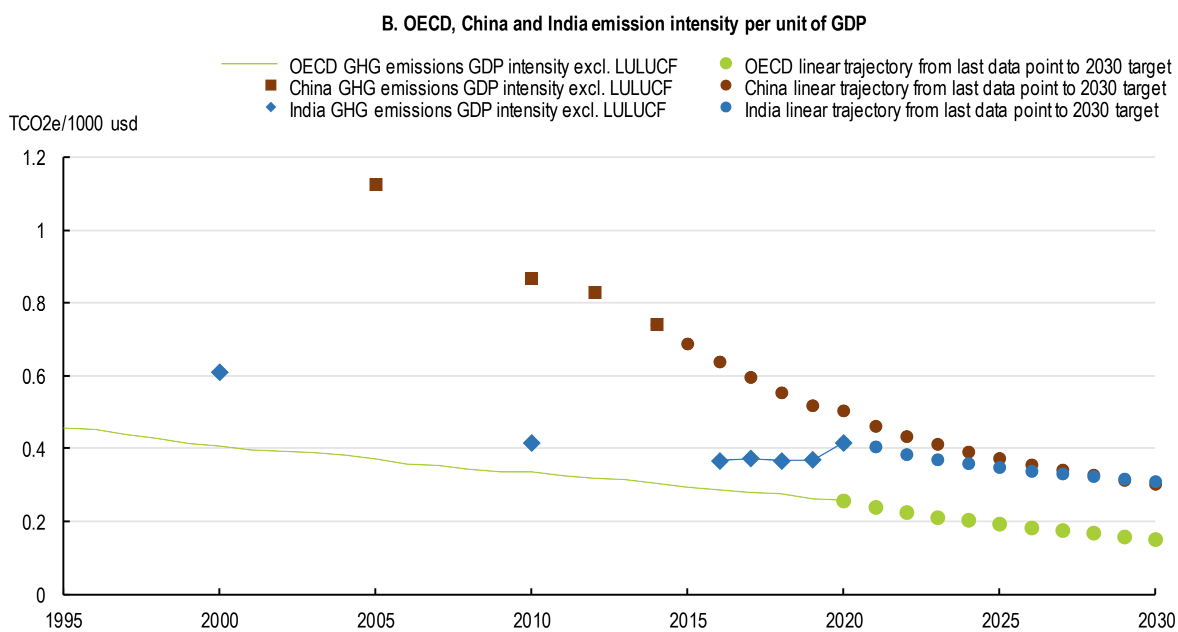
The comparison of total emissions across countries does not distinguish their relative contribution, considering the size of the economy or the population. An indicator of relative emission contribution is GHG emissions per capita and GDP intensity. In per capita terms, OECD countries emit far more CO_2 than most other world regions: 8.3 tonnes of COe_2 were emitted per capita on average in OECD countries in 2019, compared to 4.4 tonnes in the rest of the world (OECD, 2022[11]). Some high-emitting countries, such as **China** and **India**, emit much less in per capita terms than developed countries due to different consumption patterns and income levels.

Nevertheless, emission intensities per capita have decreased since 2007 in most OECD countries, revealing an overall decoupling from economic growth (Figure 6). This is not, however, the case in most emerging economies. GDP emissions intensity is an indicator of the carbonisation of an economy. Here, OECD countries have experienced a decrease. In 2020, emissions intensity was 0.25 $tCOe_2$ per thousand unit of GDP, having declined steadily since 2010 from an estimated 0.33 per thousand unit of GDP. Most emerging economies have experienced decreasing emissions intensity coefficients.

Countries must implement transformative changes in energy and production systems to address key drivers behind long-term emissions. To achieve the Paris Agreement, emerging economies will need to implement a different development path than developed economies.

Figure 6. OECD's per capita emissions is greater than India's and China's; however, OECD's emission intensity is less than India's and China's





Source: OECD IPAC Climate Action Dashboard (OECD, 2022[10]) and OECD (forthcoming[5]).

Consumption- and production-based emissions

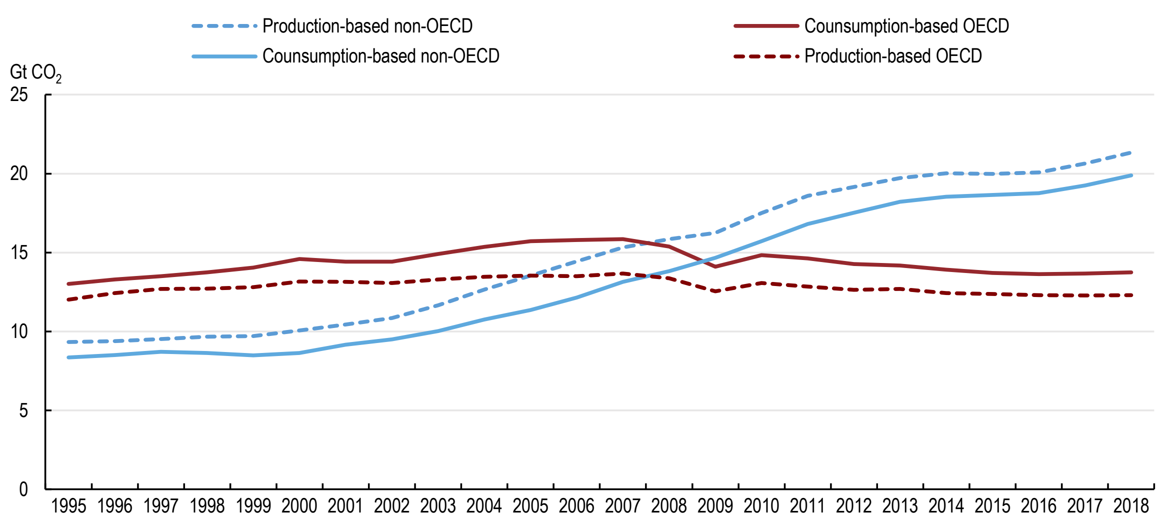
Most OECD countries are outsourcing the production of carbon-intensive goods to other countries and, thus, increasing global GHG emissions through their import demand. Such outsourcing is a form of carbon leakage, which may undermine environmental and climate policies, if less carbon-efficient techniques and less stringent environmental standards are used in other countries. This has generated increasing pressure for the implementation of carbon border adjustments.

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

The carbon footprint of OECD countries, which accounts for all carbon emitted anywhere in the world to satisfy final domestic demand in a specific country or region, is generally higher than emissions from domestic production in OECD countries.

Figure 7 presents data on GHG emissions from the consumption and production-based perspective for both OECD and non-OECD countries. The data suggests that total carbon emissions have been increasing in non-OECD countries even reaching a level above OECD countries in 2007, mainly pushed by the increase in emissions from China. On the other hand, carbon emissions from OECD countries peaked in 2006 and remained fairly constant. However, as can be observed in Figure 7 consumption-based emissions are higher than production-based emissions in OECD countries: carbon-intensive imports from non-OECD countries explains the difference.

Figure 7. OECD countries export emissions to non-OECD countries through imported goods



Source: Consumption- and production-based emissions data stems from (Yamano and Guilhoto, 2020[12]).

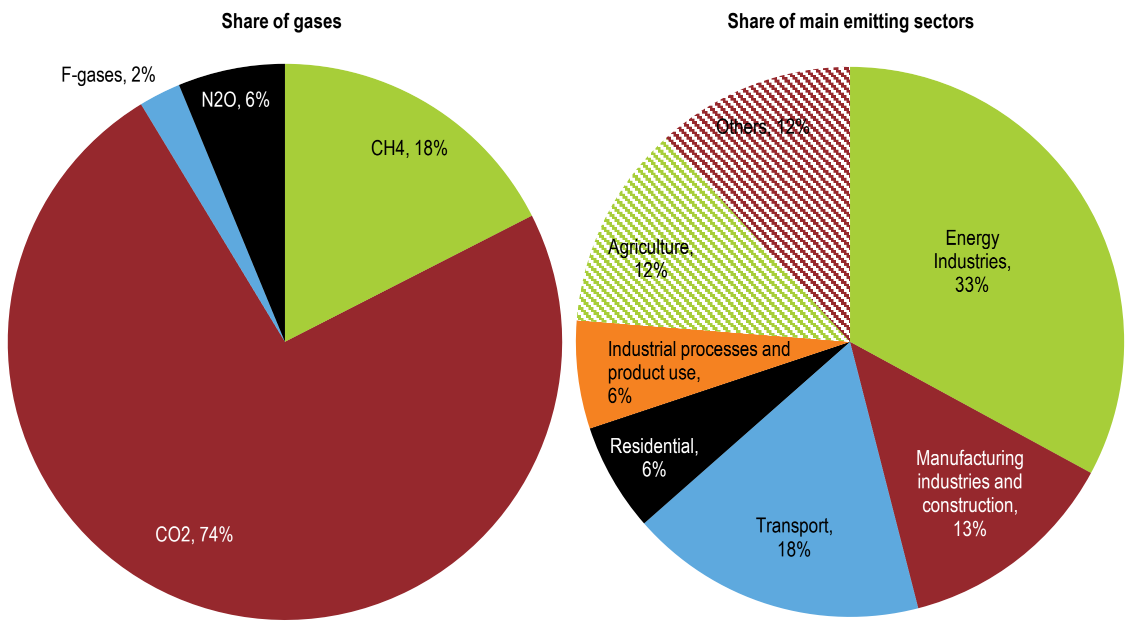
Proximate drivers of GHG emissions

The key to GHG emissions reduction in individual countries will be to identify their specific emission drivers. For example, the share of emissions from electricity production is considerably larger in countries such as **India** and **South Africa**, due to their reliance on fossil fuels for electricity production, than in **France**, **Switzerland** or **Ireland**. Emissions from human-induced greenhouse gases through fossil-fuel use and land-use change are the proximate cause of climate change, but to achieve their stated climate targets, countries must deal with the substantive drivers of GHG emissions.

Carbon dioxide is the most important greenhouse gas, mainly due to the combustion of fossil fuels and the burning of biomass in electricity and heat production, transport and manufacturing industries and construction (see Figure 8). Other greenhouse gases, such as methane, nitrous oxide, and halocarbons, also contribute to climate change. Human-induced methane is the second-largest cause of climate change today, representing approximately 18% of total emissions. It is produced mainly by agricultural activities and mining activities. Nitrous oxide is produced principally through agriculture and fossil-fuel combustion (IPCC, 2021[13]).

Panel A in Figure 8 presents the principal emissions by gas and sources for the world. Carbon dioxide (CO_2) is the most emitted gas, with an estimated share of 74% of total GHG emissions, followed by methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (F-gases). The principal sources of global emissions are energy industries, transport, manufacturing and agriculture, contributing 76% of all GHG emissions (Panel B in Figure 8).

Figure 8. Carbon dioxide is the most emitted gas globally and energy industries and transport emit more than 50% of global emissions

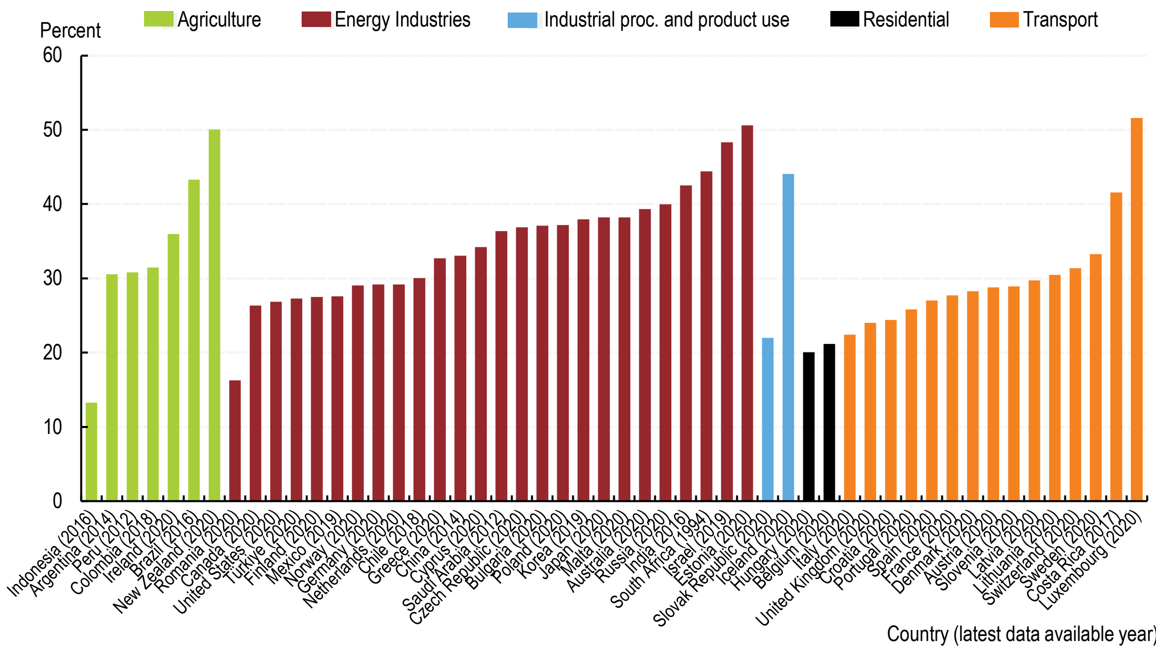


Source: percentages calculated using data from Climate Watch (2022[9]).

However, specific drivers may vary considerably across countries depending on their energy sources, weather patterns, land use and principal economic sectors.

Other main sources of GHG emissions include manufacturing industries, transport and the residential sector. Agriculture and animal farming are important sources of non-energy emissions, especially in countries such as **Ireland**, **Brazil** and **New Zealand**. Emissions from manufacturing processes generated, for example, in the production of cement, steel, and plastic, are a major concern in those countries specialising in these sectors (OECD, forthcoming[14]). Figure 9 presents the principal emission source sectors in selected countries.

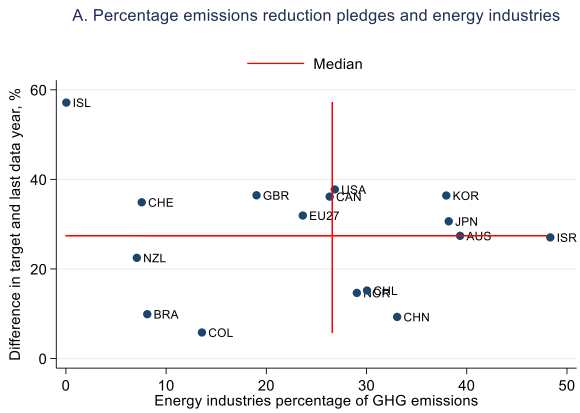
Figure 9. Energy industries is the most emitting sector in half of IPAC countries

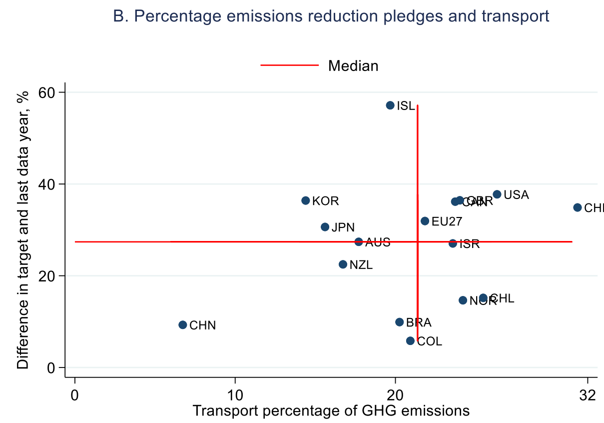


Source: OECD (2022[6]).

Therefore, although globally, the energy sector is the principal driver of GHG emissions reduction, different priorities and approaches may be necessary for specific countries. Figure 10 compares emission reduction targets (in the vertical axis) with sector-specific emissions (horizontal axis). As can be observed from the four diagrams, different countries must focus on different emission sectors to achieve their stated targets. The top-right quadrant of each diagram in Figure 10 identifies countries with an above-median emissions reduction target and an above-median emissions source, indicating sectors with the highest emissions reduction potential. More than half of IPAC countries have at least one sector that has above IPAC's median percentage share of GHG emissions. In these countries, above-average emission reduction is required at least in one sector relative to other sectors. This implies that countries do not need to reduce emissions equally from all sectors to achieve their climate targets, and therefore priorities and consequently policy choices may vary across countries. As is further discussed in Chapter 3, there are general trends and common drivers, but no one-size-fits-all policy.

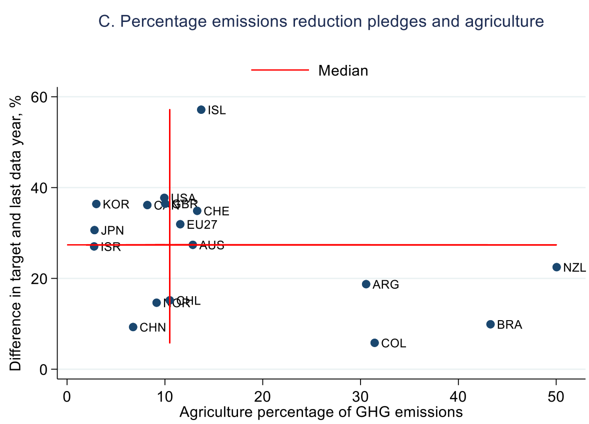
Figure 10. Higher emission reduction from sectors that are main drivers is required to achieve climate targets

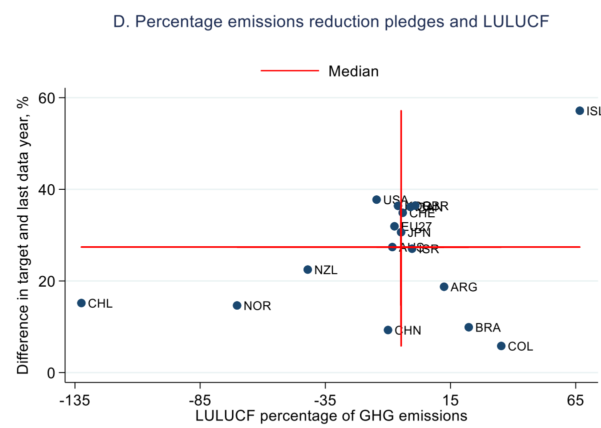




Countries in top-right quadrant: Above the median in emission reduction target and emissions from the Energy Industries; (JPN, KOR, USA)

Countries in top-right quadrant: Above the median in emission reduction target and emissions from Transport; (CAN, CHE, EU27, GBR, USA)





Countries in top-right quadrant: Above the median in emission reduction target and emissions from Agriculture; (CHE, EU27, ISL)

Countries in top-right quadrant: Above the median in emission reduction target and emissions from LULUCF; (CAN, CHE, GBR, ISL)

Note: EU27 values are aggregated for each year. X-axis indicates the percentage difference between emissions in last data available year and 2030 target. Targets are countries 2030 emissions targets as defined in NDCs. For details on targets see OECD (forthcoming[5]).
Source: OECD (2022[6]) and OECD (forthcoming[5]).

Structural drivers of GHG emissions

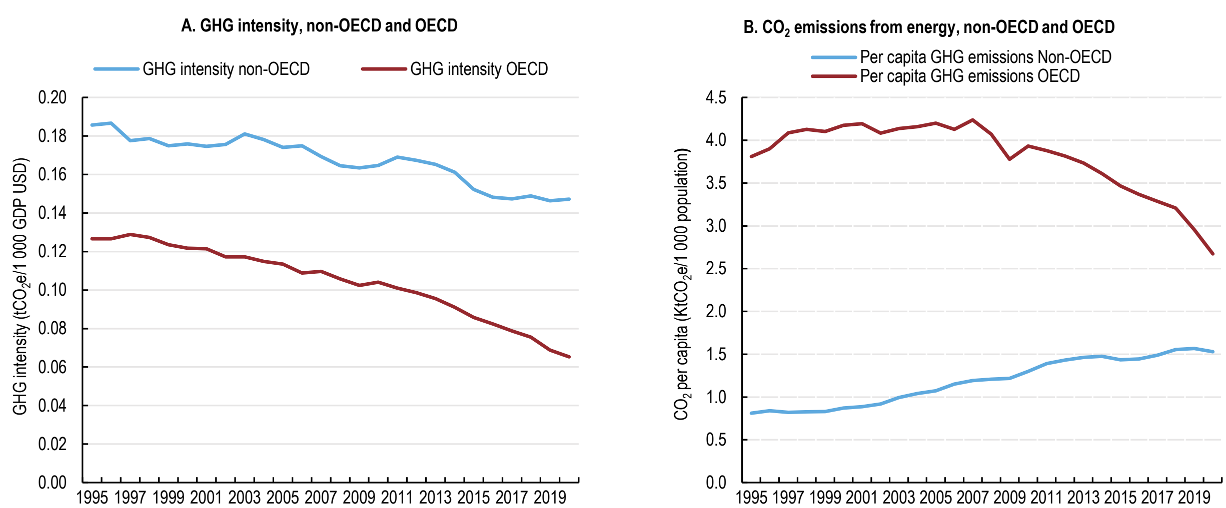
Without substantially changing unsustainable consumption and production patterns, it will not be possible to deal with climate change in the long-run. This decade is critical, especially in view of the necessary investment for economic recovery following the COVID-19 crisis.

The drivers of climate change are associated with different activities that have social and economic benefits. These economic activities provide products and services to consumers. Thus, the increase in the production and demand for goods and services, transport and population growth are, ultimately, the indirect and principal drivers that trigger climate change. This is associated with both energy intensity and material use.

Achieving the long-term GHG emission Paris Agreement targets requires decoupling GHG emissions from economic growth and consumption. This involves further reducing energy intensity as well as material consumption.

However, carbon emissions from energy per capita are increasing in non-OECD countries (Figure 11). **China** has experienced a particularly steep increase in carbon emissions, constituting the main driver of the increase (see Panel B, Figure 11). In fact, from 2017, China's total CO_2 emissions surpassed those of OECD countries. Other emerging economies, for example, **India,** have also experienced an increase in CO_2 emissions, although total CO_2 emissions remain far behind those of China. The decrease in GHG intensity is mainly driven by decoupling.

Figure 11. Per-capita emissions have fallen in the OECD but are increasing in non-OECD countries



Note: The underlying GDP data used for this chart stems from (OECD, 2022[15]), the underlying CO_2 emissions data stems from (IEA, 2022[16]).
Source: (IEA, 2022[16]).

Another factor that is associated with potentially significant environmental impacts, including contributing to roughly half of GHG emissions globally is the extraction and processing of raw materials (European Environment Agency, 2021[17]).Between 1990 and 2017, the global extraction of raw materials more than doubled. This is due to population and economic growth but, above all, a linear economic model in which materials are extracted, processed, used and disposed of after a single-use cycle. In parallel, material demand has shifted away from biomass and materials that can be sustainably sourced to non-renewable, finite materials. This has led to expanding global primary resource extraction, creating new waste flows and contributing to higher emissions and environmental impacts (UNEP, 2017[18]).

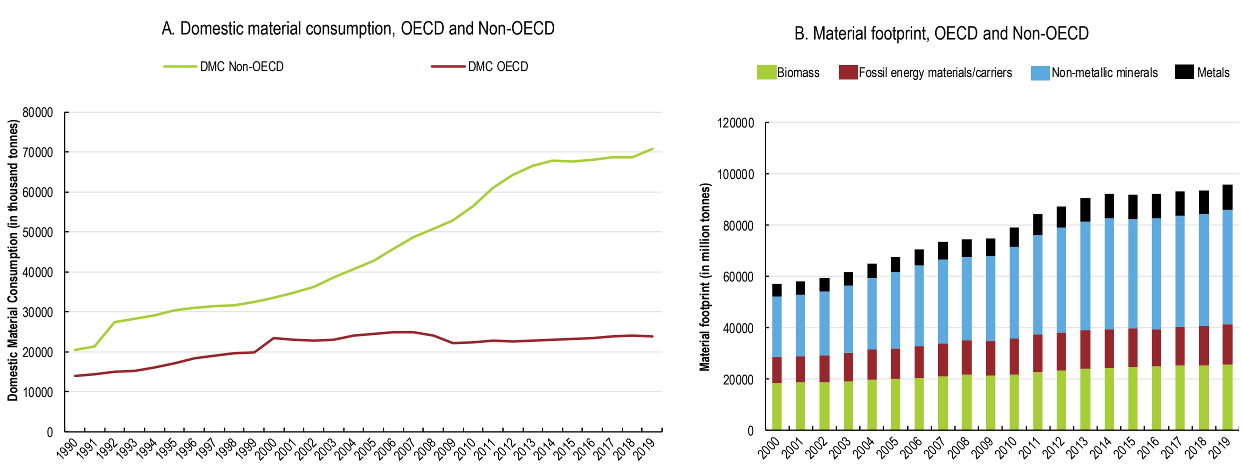
At the global level, the rise in the extraction of raw materials is expected to continue and is projected to double again by 2060 from 2017 levels, exacerbating global environmental impact (OECD, 2019[19]) (IRP, 2019[20]). Further, in the next 15-20 years, infrastructure will roughly double; in the next 20-25 years, the world economy will probably double (PWC, 2017[21]); and in the next 30 years, the urban population will increase globally from 55% in 2018 to 68% in 2050 (United Nations, 2019[22]).

These projected trends suggest that the global demand for key materials will increase significantly by 2050. Moreover, the current trend in urbanisation is estimated to increase material consumption by the world's cities from 40 billion tonnes in 2010 to about 90 billion by 2050 (UNEP, 2018[23]). As a result, the global demand for industrial materials, such as steel, cement, aluminium and plastics, is projected to increase by a factor of two to four, while global food demand is projected to increase by 42%. This will have major implications for natural resource extraction, environmental impacts and climate change (Material Economics, 2018[24])

Associated with the trend in material use are GHG emissions that are embedded in production. Over two-thirds of GHG emissions are generated from the materials necessary to bring products and services to the point of consumption, while less than one-third are associated with energy processes, such as passenger transport, thermal comfort and lighting (UNDP, 2017[25]; Circle Economy, 2021[26]). Furthermore, given the close link between materials and other natural resources, such as land, water, and biodiversity, increasing material use will likely intensify pressures on all environmental systems (OECD, 2017[27]).

If developing countries replicate the material intensity of Europe and the United States (see Figure 12), the environmental impacts will be enormous. For example, the stock of steel in industrialised countries is typically between 10 to 14 tonnes per capita but only 2 tonnes in non-OECD countries. Similar gaps exist with other materials (UNEP, 2017[18]).

Figure 12. Consumption remains unsustainable



Source: The underlying DMC and material footprint data used for this chart stems from (OECD, 2022[28]).

The situation may be further aggravated by the critical materials needed for proposed decarbonisation policies such as production in electric vehicles, solar panels and other products and materials (see chapter 3). Therefore, the choices made today on infrastructure and capital can lock the development path for the 21st century to high emissions or set the global economy on a low-carbon growth path that can be sustainable, inclusive and the basis of a just transition. If in the 21st century, the world's economic model, material use, waste, transport systems and cities are like that of the 20th century, there is no hope of meeting the goals of the Paris Agreement. The choices made today will be critical to determine the kind of world we will have by the end of the century (Stern, 2021[29]).

Notes

1. 196 Parties out of 197 Parties to the Convention are Parties to the Paris Agreement.

2. 190 members agreed to phase out coal power and to end support for new coal power plants.

3. Percentage reductions are estimated using the methodology described in the OECD (2022, GETT paper) and data from Climate Watch (2022[9]).

4. Change from 2010 to 2019 estimated for GHG emissions excluding LULUCF, using data from Climate Watch (2022[9]).

2 How vulnerable are countries to climate impacts and risks?

Unchecked, climate change is estimated to push 132 million people into poverty over the next ten years (Arga Jafino et al., 2020[30]) and could drive 216 million people to migrate within their own countries by 2050, with hotspots of internal migration emerging as soon as 2030 (World Bank, 2021a[31]). Annual adaptation costs in developing countries are currently estimated at USD 70 billion, increasing to USD 140-300 billion in 2030 and USD 280-500 billion in 2050 (EEA, 2022[32]).

Climate-related hazards put populations and economic assets at risk, and climate change further exacerbates the intensity and occurrence of such events. These impacts may be gradual, such as those associated with the effects of rising temperatures or sea levels, or acute and sporadic through shocks, such as flash floods or forest fires. They can affect the economy or human health and well-being directly, through the loss of life or the destruction of economic assets, and indirectly through the deterioration of the multiple ecosystem services provided by the environment.

Possible impacts include increases in the frequency and intensity of hot temperature extremes, marine heatwaves, heavy precipitation, droughts, intense tropical cyclones and reductions in Arctic sea ice, snow cover and permafrost. Further impacts include wildfires, coastal floods and sea-level rises (IPCC, 2021[33]). The immediate impact is increasing temperature, which has a wide-ranging physiological impact on humans. It can result in premature death and disability, especially in urban areas where populations are disproportionately affected due to the urban heat island effect (Tuholske et al., 2021[34]).

In recent years, the global excess death ratio linked to cold temperatures fell by 0.51%, and hot temperatures increased by 0.21%, providing evidence of the direct impact of climate change on human well-being (Zhao et al., 2021[35])). A single heatwave event can result in significant excess mortality (WHO, 2018[36]), and an increasing number of people are affected. OECD data shows that population exposure to extreme heat has been increasing between 1979 and 2021, potentially exposing 52% of the world population in 1979 and 66% in 2021 to varying duration periods of extreme heat (Maes et al., 2022[37]).

Greenhouse gas (GHG) emissions not only affect the global climate, they also lead to other environmental impacts, such as ocean acidification affecting marine ecosystems. Combined with higher temperatures, these forces will dramatically affect the global economy and human welfare. Overall, agricultural yield and food production will be reduced, threatening food security in vulnerable regions (IPCC, 2018[38]). In addition, millions of people could be displaced (Ferris, 2020[39]), and infrastructure destroyed.

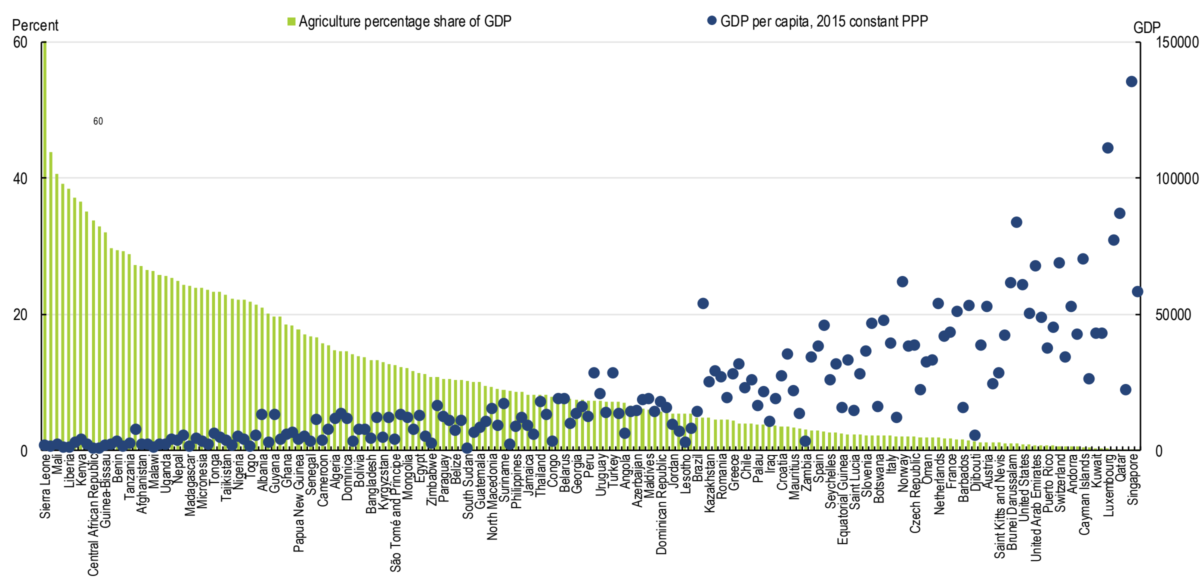
These compound effects could substantially negatively affect the global economic outlook and contribute to socio-economic inequality. The World Economic Forum cites one study that shows global annual economic output could be reduced by 4% in 2050 due to climate change and that lower-income and lower-middle income countries are more likely face GDP losses.[1] The economic losses from natural disasters alone are estimated at USD 280 billion in 2021, representing approximately 0.29% of global GDP (Munich RE, 2022[40]).

Although climate change is global, impacts will be unevenly distributed. It is expected that the most acute consequences will be observed in developing countries due to their geographical exposure, greater vulnerability, low income, greater dependence on agriculture and, in general, reduced ability to adapt to new climatic conditions (Stern, 2006[41]; IPCC, 2018[38]) (Maes et al., 2022[37]).

Due to average and extreme temperature changes, agriculture will be particularly affected, and in consequence indigenous peoples and local communities dependent on agricultural or coastal livelihood (IPCC, 2018[38]; 2021[33]). In addition, tropical and subtropical agriculture in developing countries is more climate-sensitive than temperate agriculture, meaning that low-income countries and Africa are also particularly affected (Mendelsohn, 2009[42]).

Figure 13 presents the relationship between economic dependence on agriculture and GDP per capita. The relationship highlights how less developed countries will be directly impacted by climate change. It will affect the livelihood of millions of people in developing countries, generating dramatic impacts that will have consequences on migration flows, epidemics and approximately 3.3-3.6 billion people around the world who live in areas that are highly vulnerable to climate change (IPCC, 2022[43]). (IPCC, 2022[44]).

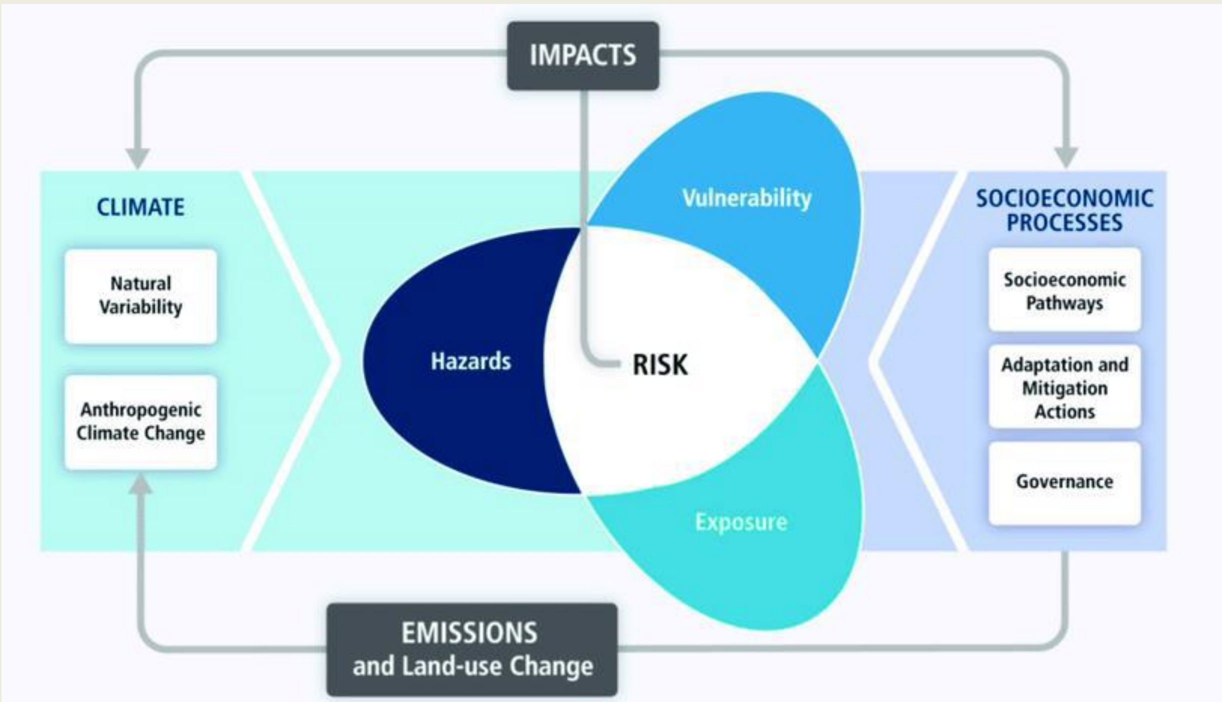
Figure 13. Less developed countries are dependent on agriculture which makes them vulnerable to climate change



Source: OECD (2022[45])

To track the most significant impacts of climate change, the OECD has developed a new set of indicators centred on IPAC countries to monitor climate-related hazards and exposure to these hazards (Maes et al., 2022[37]). The indicator set is based on the Intergovernmental Panel on Climate Change's (IPCC) conceptualisation of climate risk, which considers climate-related hazard, exposure and vulnerability as the key dimensions of disaster risk (see Box 3).

Box 3. Conceptual illustration and definitions of key risk dimensions linked to climate-related impacts



Source: (IPCC, 2014). A more elaborate version of this figure is available in AR6 Working Group II (IPCC, 2022[46]) and detailed descriptions for each dimension are available in (Maes et al., 2022[37]).

Climate-related natural hazards

Better understanding climate-related hazards can inform and support countries' efforts to mitigate and adapt to climate change. However, despite the growing availability of data from earth observation, there is a lack of readily available indicators at the national and subnational levels to measure climate-related hazards. In response, the OECD is developing internationally comparable indicators for assessing exposure to climate-related hazards (Maes et al., 2022[37]), providing evidence that countries are increasingly exposed to climate-related natural hazards but that these exposures vary considerably both across and within countries.

Extreme temperature

Over the past decades, population exposure to heat stress has increased significantly. This is alarming for at least two reasons: the potential impact this will have on human health and the economic costs involved in dealing with it.

The share of IPAC population exposed to hot summer days has grown every year, with an estimated 17% more people exposed to hot summer days in 2021 compared to 1979 (see Figure 14). Countries whose population was most exposed to heat stress include: **Saudi Arabia** (90.9%), **India** (69.7%) and Türkiye (10.3%).[2]

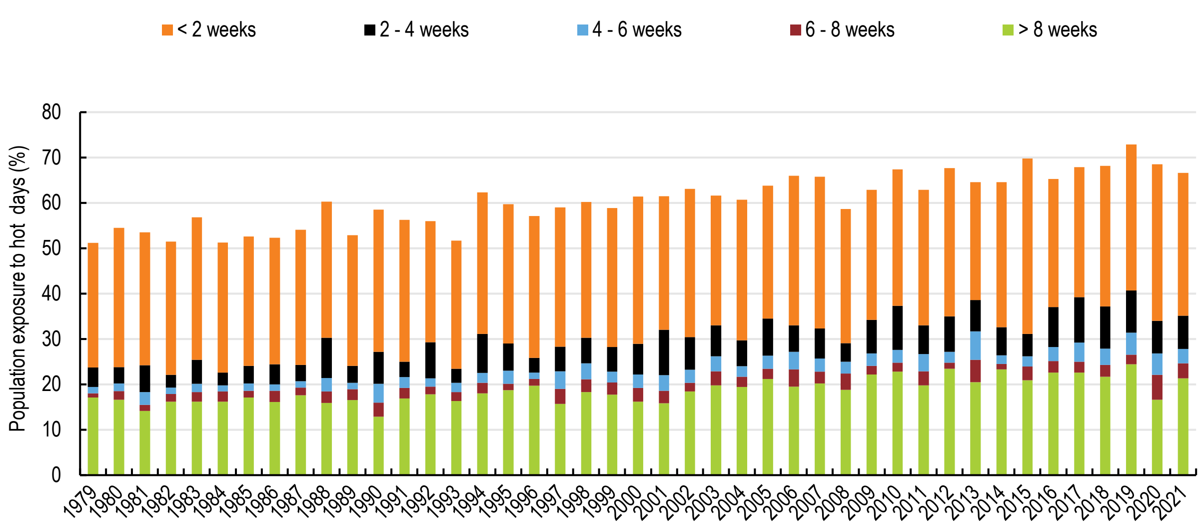
Southern Europe is also significantly affected, with **Greece, Italy** and **Spain** experiencing more than 60 days of exposure per year to strong (or worse) heat stress between 2017 and 2021 and these countries are also experiencing more than 10 additional days per year of strong (or worse) heat stress exposure compared to the reference period 1981-2010. The hot European summers are here to stay, with the recent wave in **France** and **England** in 2022 highlighting once more the urgency of taking appropriate measures to tackle extreme heat.

Similarly, **Indonesia, India** and **Saudi Arabia** are experiencing increasing exposure to heat stress of more than 250 days of strong (or worse) exposure per year. For example, in Saudi Arabia, there have been an additional 11 days per year of strong (or worse) heat stress exposure compared to the reference period 1981-2010. In India alone, heat stress exposure between 2017 and 2021 affected approximately 1.35 billion people, highlighting the serious risks associated with heat stress in certain countries.

Moreover, in 21 countries - of countries covered under IPAC - more than 10% of their populations were exposed to an increasing number of tropical nights over 2017-21. This included extreme examples, such as India and Saudi Arabia, where more than 95% of its population is being exposed to tropical nights highlighting the urgency to adapt to climate change and increase mitigation efforts.[3]

Figure 14. Over 60% and increasingly the population is exposed to hot summer days across IPAC countries

Percentage of population exposed to hot summer days (T_{max} > 35°C) across the IPAC region, 1979 – 2021



Source: (Maes et al., 2022[37]).

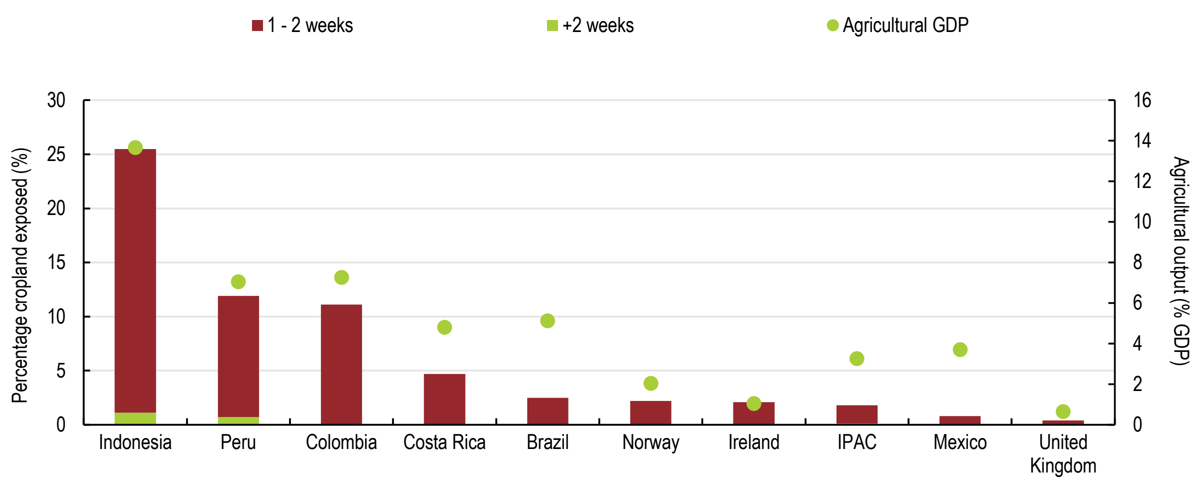
Extreme precipitation

Increasing temperatures combined with extreme rainfall means countries dependent on agriculture production may be extremely vulnerable. A majority of IPAC countries are experiencing a substantial number of days with extreme precipitation events (compared to the reference period 1981-2010). In 2021, croplands were especially exposed in several western and northern European countries, such as **Belgium, Latvia, the Netherlands, Sweden** and **Switzerland**. IPAC countries with the highest share of croplands exposed to extreme precipitation[4] include **Indonesia** (25.5%), **Peru** (11.9%) and **Colombia** (11.1%).

The economy of countries dependent on the agricultural sector is highly vulnerable to extreme precipitation. Six out of ten countries considered most dependent on the agriculture, forestry and fishing sector are also among the most exposed to extreme precipitation of more than one week per year. For example, the GDP share of the agriculture, forestry and fishing sector in **Indonesia** and **Colombia** is approximately 13.3% and 7.1%, respectively, highlighting that some countries' GDP may be more exposed to extreme precipitation events than others (Figure 15). This could lead not only to lower incomes and risks to food security but also to possible dramatic changes in migration flows.

Figure 15. Some countries' GDP is more exposed to extreme precipitation than other countries

Average annual percentage of cropland exposed to extreme precipitation events and share of GDP from Agriculture, forestry and fishing sector, 2017-21.



Note: Gross Domestic Product (GDP) values represent the average GDP value from Agriculture, forestry, and fishing over the period 2017- 2021 (OECD, 2022). These GDP values may overestimate agricultural GDP since it includes forestry and fishing. GDP values for Peru are derived from the World Bank national accounts.
Source: (Maes et al., 2022[37]).

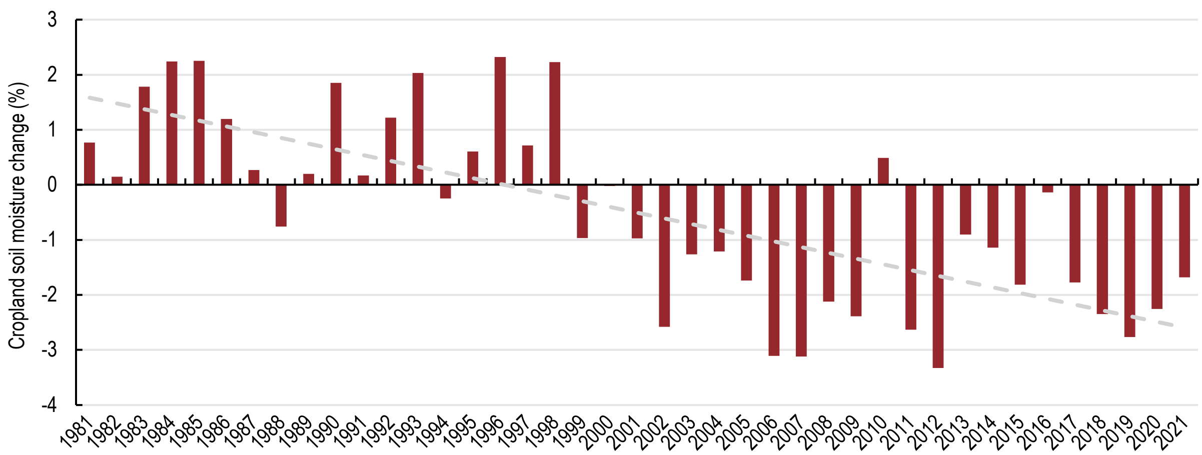
Extreme droughts

Croplands are also increasingly affected by extreme droughts. Across the IPAC region, there has been a significant decrease in soil moisture on croplands over the last four decades. Countries most affected by agricultural droughts include **Argentina** and **South Africa**, which experienced a decline of more than 6% on average in cropland soil moisture in the past five years. (Figure 16).

Drought on croplands also differs widely across regions within countries. There are increasing drought conditions on croplands for almost 70% of OECD large regions, such as the United States and Europe, where cropland soil moisture has been lower in the past five years.[5] In three OECD countries, certain subnational regions recorded a drop in soil moisture of more than 10% on average over the past five years compared to the reference period 1981-2021, including Chile, Portugal and the United States.

Figure 16. Worsening drought conditions on croplands across the IPAC region

Cropland soil moisture anomaly over the period 2017-21 compared to the climate normal period 1981-2010



Note: Iceland is not included in the IPAC aggregate because of data unavailability.
Source: (Maes et al., 2022[37]).

Wildfires

Wildfires are also increasing and concentrating in specific countries and regions, with disastrous results. For example, 20% of global burned land occurred in ten IPAC countries between 2017 and 2021. This poses a problem for those countries and affects global mitigation efforts. Of the ten countries identified, three are high-income economies (**Australia, Canada** and the **United States**), six are upper-middle-income economies (**Argentina, Brazil, China, Colombia, Mexico** and **South Africa**), and one is a lower-middle-income economy (**India**), suggesting wide disparities in terms of labour constraints, financing needs, wildfire policy implementation and coping capacity.

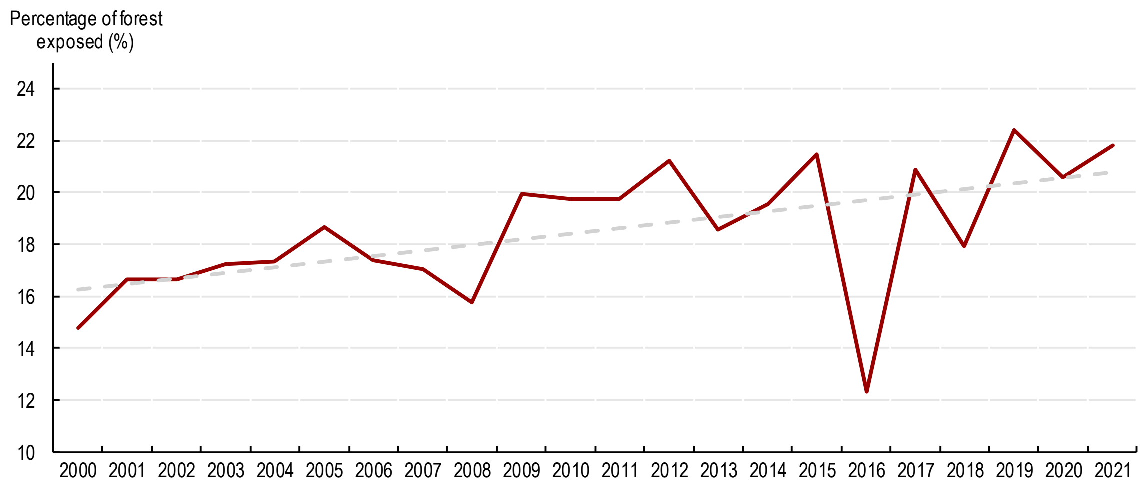
On average, approximately 1.2 million square km, which is roughly equivalent to the size of South Africa was burned per year between 2017 and 2021 in the most affected countries -**Argentina**, **Australia**, **Brazil**, **Colombia**, **India**, **Portugal** and **South Africa.**

Exposure to wildfire is significant and widespread. It risks the destruction of ecosystem services, notably biodiversity and carbon capture, as well as human life. Approximately 10% of the population in **India, Mexico** and **South Africa**, and 5-10% of the population in **Chile, Costa Rica** and **Israel** live in areas with a very high wildfire danger. An annual average of 62% of the population in **South Africa** and 44% of the population in **Australia** were exposed to very high wildfire danger between 2017 and 2021. **India**'s population is the most exposed: in 2021 alone, 160 million people were living in areas with a very high wildfire danger (see Figure 17).

Across the IPAC countries, there is an overall increase in forest exposure to very high or extreme wildfire danger (Figure 17). For example, Brazilian forests have around 2 million km^2 exposed 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 894 000 km^2, 701 000 km^2 and 632 000 km^2 of forest areas exposed to very high or extreme fire risk, respectively. The high amounts of forest exposure highlight the considerable wildfire risk forests face and should be treated with urgency given the key role forests play in climate change mitigation measures around the world.

Figure 17. Meteorological changes increase forest exposure to wildfire danger

Annual percentage of forested areas exposed to very high and extreme fire danger for more than three consecutive days, 2000-21.



Source: (Maes et al., 2022[37]).

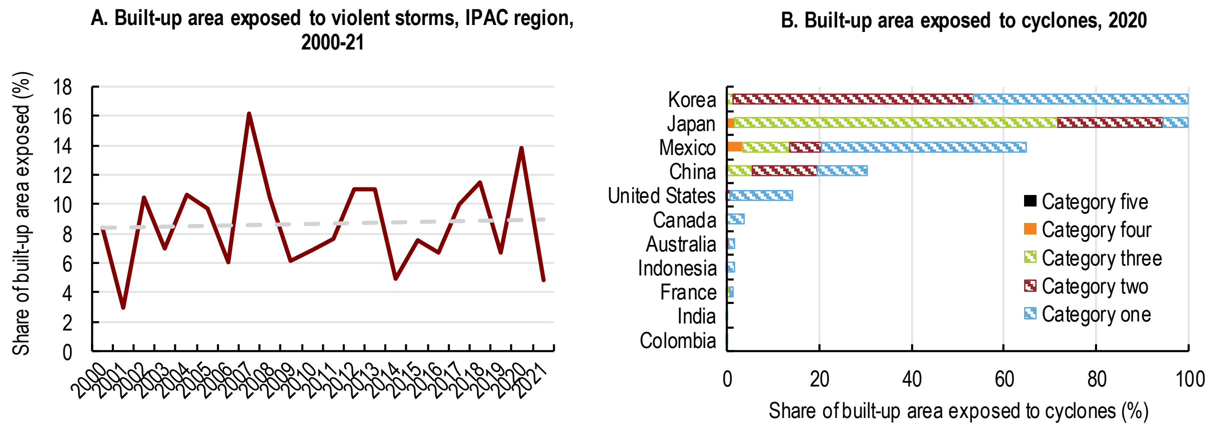
Wind threats

Climate change can also cause extreme events such as storms, which not only lead to the loss of human life, but can destroy economic infrastructure, increasing the costs of loss and damage, as well as future replacement and construction. Over the past two decades, built-up area exposure to violent storms remains consistent across the IPAC region (Figure 18). Countries most exposed to violent storms are located principally in northwestern Europe and eastern Asia. Countries such as **Belgium**, **Iceland**, **Ireland**, the **Netherlands** and the **United Kingdom** had more than 80% of their population and built-up areas exposed to violent storms in 2020, highlighting the importance of accounting for wind threats as a climate-related natural hazard (Figure 18).

Meanwhile, exposure to tropical cyclones is limited to a subset of IPAC countries due to their geographic position. The most exposed IPAC countries are **Japan**, **Korea** and **Mexico,** where more than 60% of their populations and built-up areas are exposed to tropical cyclones (with wind speeds higher than 119 km/h or 33 m/s). **Japan** is the country most exposed to violent storms, with almost 80% of its population exposed to cyclones of Category 3 or higher (with wind speeds higher than 178 km/h).

Figure 18. Wind threats due to violent storms or cyclones vary widely between IPAC countries

Share of built-up area exposed to (a) violent storms or worse for the IPAC region, 2000-21, (b) cyclone categories in 2020 with a 100-year return period



Note: Wind gust (km/h) data with a 100-year return period were first converted to sustained wind speed and separated into cyclone categories using the Saffir-Simpson scale.
Source: (Maes et al., 2022[37]).

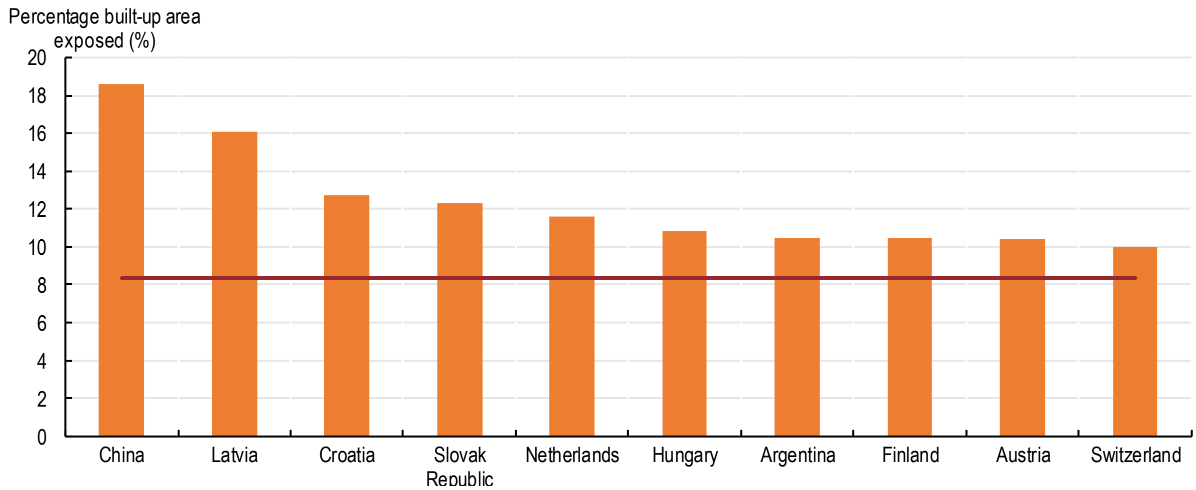
River flooding

The recent floods in **Pakistan** in September 2022 were dramatic. Early estimates suggest that one-third of the country was under water and at least two-thirds of the country was affected, displacing 33 million people and causing more than 1 200 causalities (Mallapaty, 2022[47]). These events are a reminder of how river flooding can affect people's lives directly and cause substantial economic losses by damaging infrastructure, settlements and agricultural lands. Of the 51 IPAC countries under review, the Netherlands and Hungary have around 20% of total land area exposed to extreme river flooding. Meanwhile, 18.6% of China's built-up area is exposed, followed by Latvia (16.1%), and Croatia (12.7%) (Figure 19). In terms of agricultural land exposure, the most affected IPAC countries are Hungary, the Netherlands, and the Slovak Republic with more than 17% of their cropland exposed to possible extreme events.[6]

River flooding can also cause significant human losses. Among the IPAC countries, populations in **Latvia** and the **Netherlands** are the most exposed, with more than 24% of people potentially affected, followed closely by **China** (21%) and **India** (17%). These last two countries also experienced the largest increase in population exposure to river flooding, with an additional 3 million and 5.3 million people exposed, respectively, in 2015 compared to 2000.

Figure 19. Built-up area exposure to river flooding varies between IPAC countries

Top 10 IPAC countries with share of built-up area exposed to river flooding with a 10-year return period in 2020[7]



Note: Grey line is the IPAC average built-up area exposure to river flooding. A return period is the average or estimated time that a specific climate-related hazard is likely to recur.
Source: (Maes et al., 2022[37]).

Coastal flooding

Low-lying coastal communities face a range of coastal flooding hazards, such as storm surges and erosion. These hazards are expected to increase as climate change increases the frequency and severity of coastal floods. The most exposed countries are the **Netherlands**, **Belgium** and **Denmark**: approximately 51% of the Netherlands land area is potentially exposed to coastal flooding with a ten-year return period, followed by 6.3% for Belgium and 5.6% for Denmark. These figures should, however, be interpreted with caution as they do not account for existing flood protection measures. Nevertheless, they underscore the importance of maintaining existing protections to prevent future exposures.

With respect to the exposure of built-up areas, of the IPAC countries, the **Netherlands** has 48.1% of its built-up area exposed to coastal flooding, followed by **Belgium** (7.1%) and **China** (4.3%). This reflects 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.

Compound effects

Although there are differences across countries, most experience one or more climate-related hazards with varying degrees of intensity. Moreover, countries are not only vulnerable if they are exposed to a specific hazard, but also how these hazards may be interconnected, reinforcing or undermining one another. Future analysis could investigate the interconnectedness between climate-related hazards to develop a composite indicator that identifies which climate-related hazards are more, or less, impactful for a given country.

Climate-related hazards may be reinforced by others and could exacerbate socio-economic impacts, or alternatively be undermined by adaptation policies. The effects of climate hazards are reflected in how countries are affected by losses and damages associated with climate related events. This assessment is essential for adaptation policies and emergency preparedness.

Losses and damages

Countries will face the effects of climate change directly by implementing various mitigation and/or adaptation policies. However, climate change is so pervasive and its impacts so ubiquitous that even those countries that do not respond directly will do so indirectly by implementing actions or policies that are the consequence of the deleterious effects of global warming, such as losses and damages from extreme events.

Between 1970 and 2019, disasters from weather, climate and water extreme events represented 50% of all recorded disasters, 45% of deaths and 74% of related economic losses (WMO, 2021[2]). The World Meteorological Organization (WMO) reported an almost eightfold increase in average daily economic losses between 1970-79 and 2010-19.

In Europe alone, the total economic losses from weather- and climate-related events were estimated at EUR 450-520 billion (in 2020 euros) in the period 1980 to 2020. Only one-quarter to one-third of these losses were insured. Fatalities during the same period were estimated as high as 145 000, and just 3% of all events were responsible for 60% of economic losses (EEA, 2022[32]). These estimates underscore the economic impact of natural disasters and the fact that a mere few can have dramatic effects.

The United States' National Oceanic and Atmospheric Administration (NOAA) recorded 332 separate weather and climate disasters between 1980 and September 2022, where overall damages/costs reached or exceeded USD 1 billion. More than half of them (55%) occurred after 2010. The NOAA estimates that the related total direct costs have exceeded USD 2.278 trillion since 1980, of which USD 1.193 trillion has been insured since 2010.

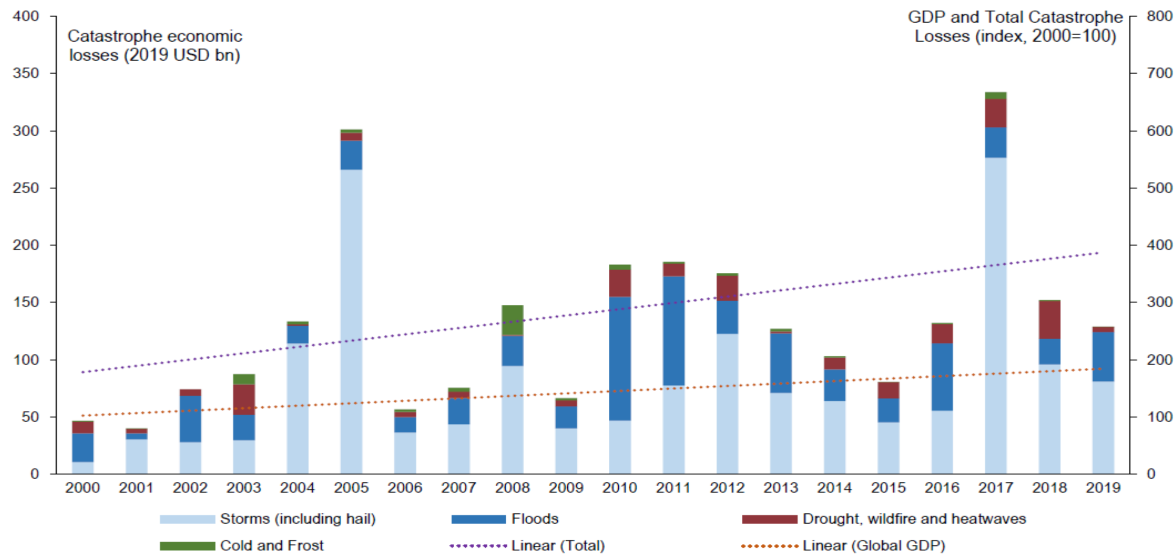
Natural disasters are estimated to cause around USD 18 billion per year in direct damage to power generation and transport infrastructure in low- and middle-income countries. Additionally, infrastructure service disruptions cost between USD 391 billion and USD 647 billion per year to households and firms in low- and middle-income countries (Hallegate, Rentschler and Rozenberg, 2019[48]). These costs will only increase in the future, with severe implications for the sustainability of public finances.

In 2018, the droughts, floods and storms in **India** caused an estimated USD 6.1 billion in damages (Guha-Sapir, Below and Hoyois, 2021[49]). When Hurricane Dorian made landfall in the **Bahamas** in 2019, it caused at least 70 deaths, with losses and damages estimated at one-quarter of the Bahamas' GDP (Zegarra, 2020[50]). The 2019-20 **Australia** wildfire season resulted in 19 million hectares (ha) of land being burned and at least 33 deaths. The economic impacts were estimated at AUD 20 billion (Filkov et al., 2020[51]).

Reported economic losses from climate-related events are highly volatile from year to year. However, they have been increasing globally since 2000 -much faster than GDP (see Figure 20).

By March 2021, 126 developing countries were formulating and implementing national adaptation plans (NAPs), with 22 countries having completed the preparation of their first NAP (UNFCCC, 2021[4]). However, with mounting losses and damages, countries are recognising the need to strengthen the coherence of their approaches to climate change with that of disaster risk reduction (OECD, 2020[52]) (UNDRR, 2021[53]). The humanitarian community now considers climate change one of the greatest threats facing communities worldwide (IFRC, 2021[54]).

Figure 20. Economic losses from climate-related catastrophes, by type (USD bln), 2021



Source: OECD calculations based on data on economic losses provided by Swiss Re sigma and data on GDP from (IMF, 2021[55]).

Notes

1. https://www.weforum.org/agenda/2022/04/climate-change-global-gdp-risk/#:~:text=A%20new%20study%20of%20135,South%20Asia%20most%20at%20risk.

2. Heat stress, defined here, is exposed to more than eight weeks of hot days over the period 2017-21.

3. Annual population exposure to more than 8 weeks of tropical nights.

4. Extreme precipitation is defined here as precipitation of more than one week.

5. Compared to the climate reference period (i.e. 1981-2010).

6. River flooding events are defined in terms of a 100-year flooding event.

7. 10-year period refers to the period of a statistically likely event of 10 years.

3 How far has country climate action progressed in response to the net-zero challenge?

At COP26, most countries updated their NDCs (Chapter 2). In addition to emission targets, countries also report the measures adopted or planned to achieve their mitigation commitments. As part of the preparation for the first global stocktake exercise, the UNFCCC compiled the principal measures reported by countries in their NDCs (UNFCCC, 2022[1]). For example, 91% of Parties communicated measures in the priority area of energy supply and 74-82% identified measures in transport; land use, land-use change and forestry (LULUCF); buildings; agriculture and waste (Figure 21).

Despite its broad coverage, the UNFCCC synthesis report on Parties' NDCs should be complemented by specific data on countries climate action. The UNFCCC report categorises countries' declared climate actions in a fairly general manner, based on areas of action and self-reporting. However, it lacks granularity to monitor countries progress and a direct mapping of policies to their emissions base or an assessment of their level of stringency.

To support the UNFCCC reporting process, IPAC has carried out a detailed assessment of climate action for 51 countries and the EU. The Climate Actions and Policies Measurement Framework (CAPMF) draws on the UNFCCC effort to identify countries' declared climate policies (UNFCCC, 2022[1]), but goes further by tracking which policies and policy instruments have actually been adopted and with what level of stringency. For example, it unpacks UNFCCC's 'renewable energy generation' category, providing information on underlying policy instruments such as renewable energy support (feed-in tariffs, auctions, renewable energy portfolio standards) and carbon pricing (carbon taxes, emissions trading schemes).

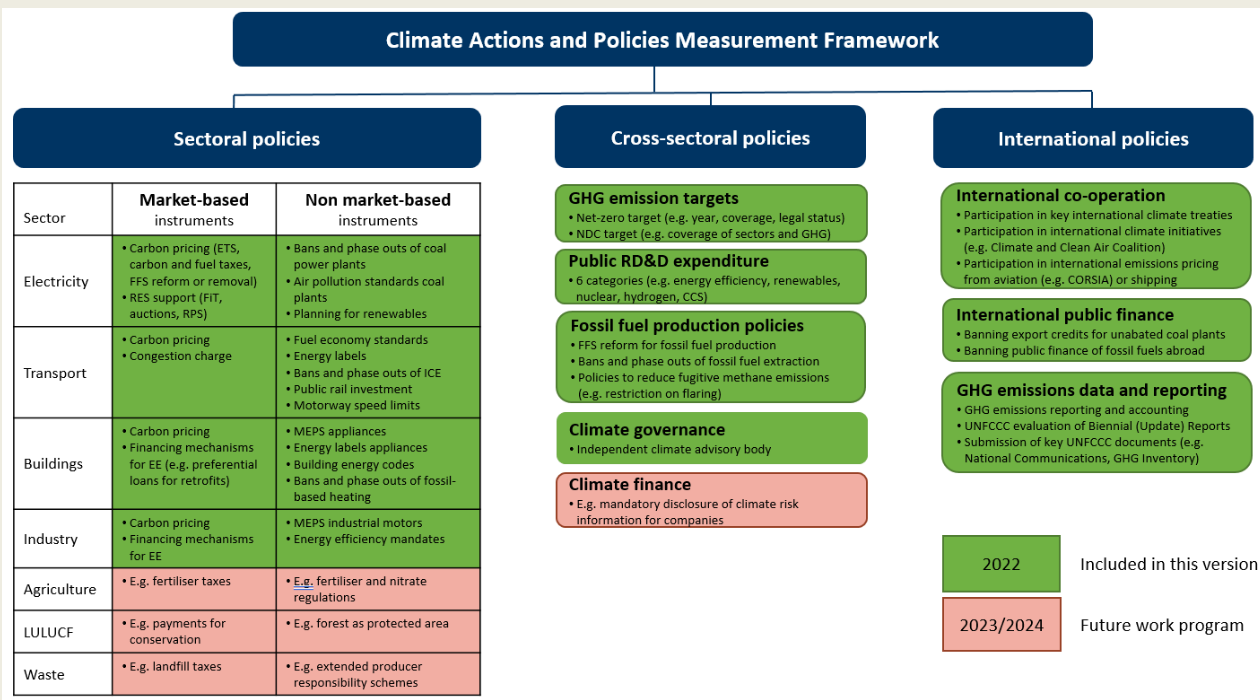
The CAPMF quantifies empirically the adoption and the stringency of the policies adopted across countries providing essential information to monitor countries' climate actions (Box 4). Policy stringency is defined as the degree to which climate actions and policies incentivise or enable GHG emissions mitigation at home or abroad. While policy coverage and policy stringency do not measure effectiveness, they are key first steps for its assessment.

Box 4. The OECD's Climate Actions and Policies Measurement Framework

The OECD's Climate Actions and Policies Measurement Framework (CAPMF) is a structured and harmonised climate mitigation policy database with 128 policy variables grouped into 57 policy instruments and other climate actions, covering 51 countries and the EU from 2000 to 2020. The CAPMF includes climate mitigation actions and policies, presented in a way that is consistent with the organisation of information on policies and measures used under the UNFCCC (UNFCCC, 2022[1]) and the IPCC frameworks (IPCC, 2022[44]).

The CAPMF covers both climate policies with explicit intent to advance mitigation as well as non-climate policies that are expected to have a positive effect on mitigation. These include sectoral, cross-sectoral and international policies of which market-based instruments (e.g. carbon taxes, subsidies for zero-carbon technologies), non-market-based instruments (e.g. standards, bans) and other climate actions (e.g. short-term and long-term emissions targets, climate governance) are further categorised (Figure 21).

Figure 21. Climate Actions and Policies Measurement Framework



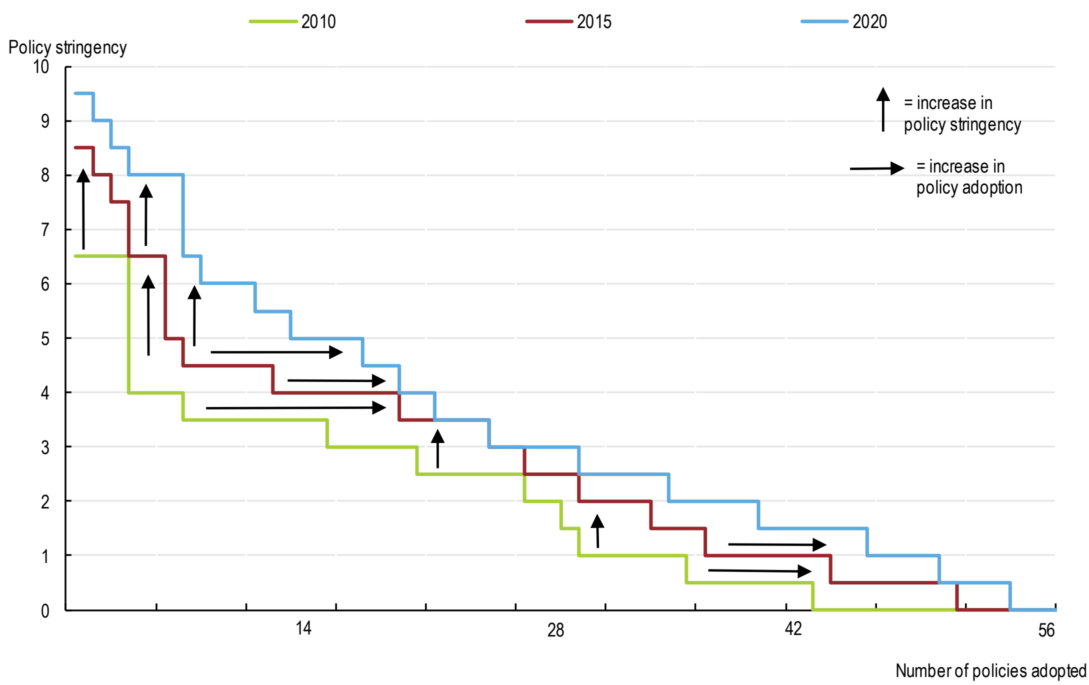
Source: (Nachtigall et al., forthcoming[56]).

Countries' climate action has expanded but more can be done

Countries have made efforts to strengthen their climate action, but many countries have not adopted the full range of policies available or used setting of the necessary stringency. More can and should be done to achieve the ambitious Paris Agreement targets.

Between 2010 and 2020, IPAC countries have, on average, accelerated their climate action in both policy adoption and stringency (Figure 22). Countries with many policies in place accelerated policy adoption at a relatively higher pace, leading to an increasing gap with countries with relatively low policy adoption. On the other hand, many countries, with previously low policy stringency, did well in terms of strengthening existing policies, leading to a convergence in terms of average policy stringency.

Figure 22. Countries strengthened their climate action between 2010-2020

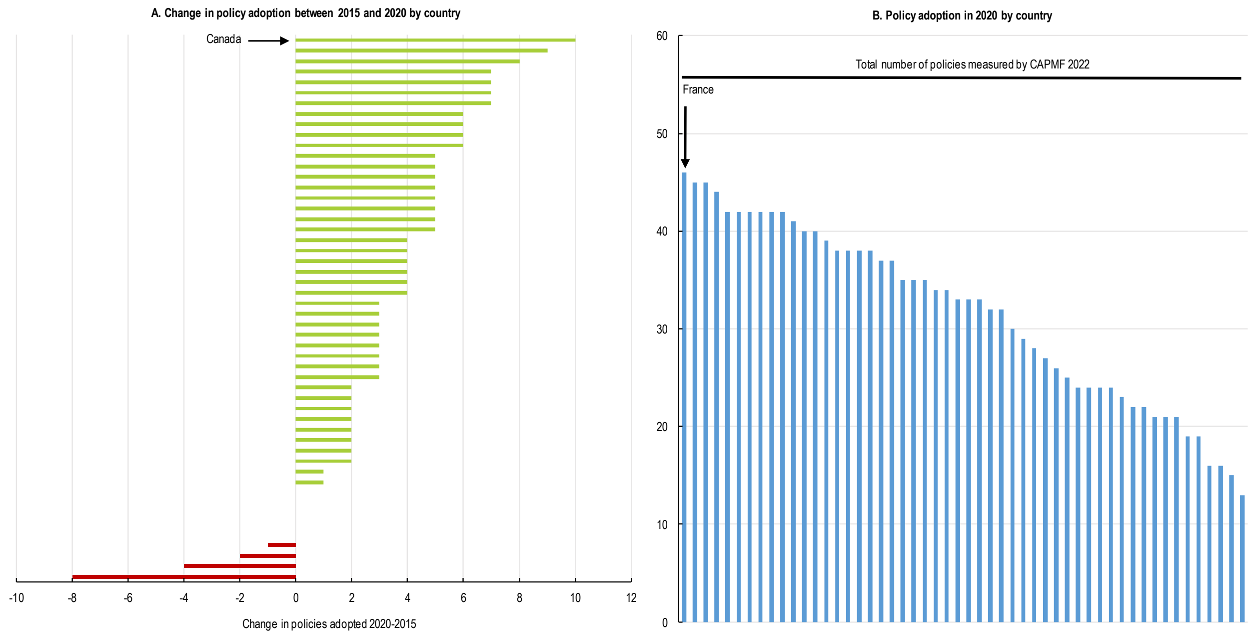


Source: (Nachtigall et al., forthcoming[56]).

The acceleration of policy adoption varies substantially across countries (Figure 23, Panel A). Looking at the average masks important cross-country differences in policy adoption. Most countries increased the number of adopted policies between 2015 and 2020. For example, Canada adopted 10 additional policies between 2015 and 2020. However, some countries did not expand their policy adoption whereas others even removed policies.

Policy adoption and stringency differs substantially across countries (Figure 23, Panel B). No country has adopted all planned policies. Policy adoption varies between 45 in France to 13 in Peru. Heterogeneity in policy adoption partially reflects countries' different policy approaches and climate ambition. In an interconnected world, differences in climate ambition and policy adoption can lead to competitive disadvantages for ambitious countries, which ultimately may slow down climate action (see discussion under carbon pricing below).

Figure 23. Policy adoption and its change differs substantially across countries



Source: (Nachtigall et al., forthcoming[56]).

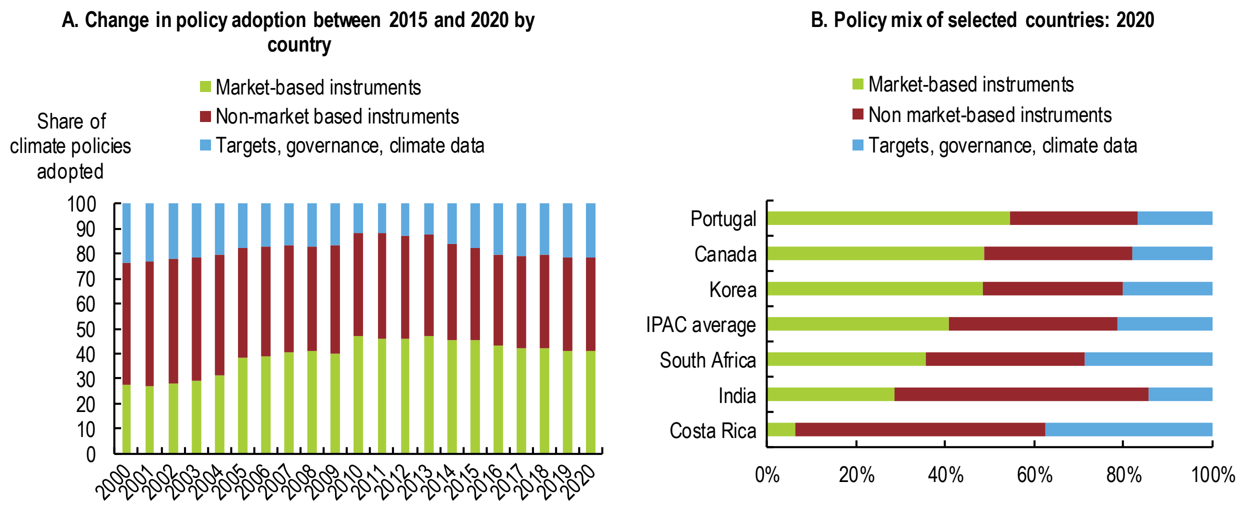
Over the last 20 years, countries have increasingly adopted market-based policy instruments such as carbon pricing or financial support for renewable energy (Figure 24, Panel A). In the early 2000s, these instruments represented less than 30% of adopted policy instruments, but they now represent almost 50%.[1] The increasing uptake of market-based instruments has occurred since 2005, primarily driven by the implementation of the EU Emissions Trading System (EU ETS) and other subsequent carbon pricing schemes.

Another issue that stands out is the increasing adoption, around 2013, of policies associated with international commitments, such as country-level targets, climate governance and the development of climate change data and information. Part of this increase was driven by pressure for global climate policy, which increased countries' governance commitments, and culminated with the Paris Agreement adopted in 2015.

Across all IPAC countries, the increase in policy adoption after 2015 has been particularly focussed on auctioning renewable electricity, carbon pricing as well as bans and phase out of fossil fuel equipment and infrastructure such as coal power plants.

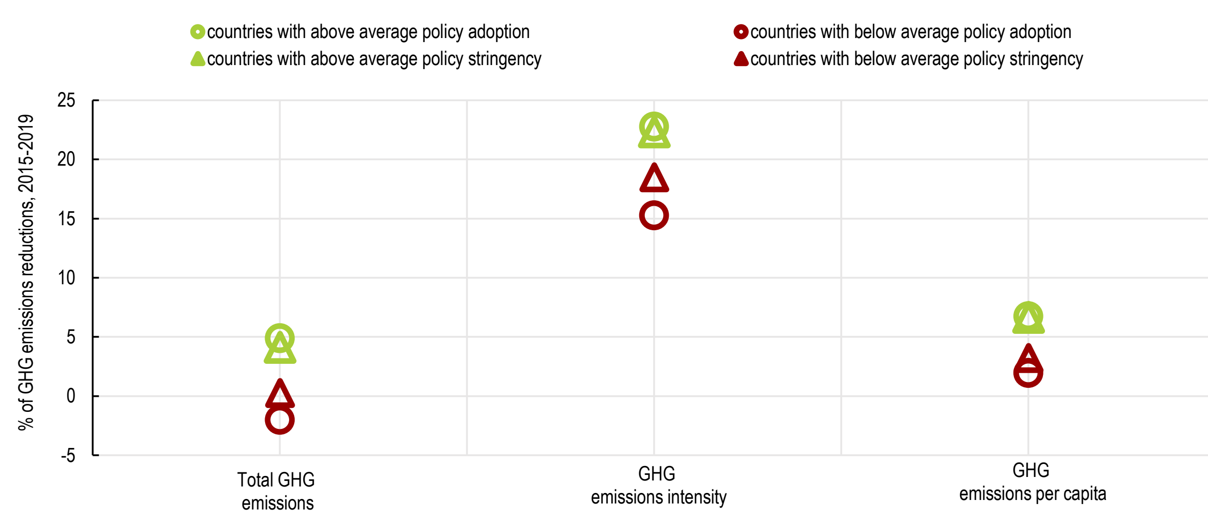
Nevertheless, since countries have different types of emissions, drivers, and economic and social constraints, there is no one-size-fits-all policy approach (Figure 24, Panel B). In fact, these differences reflect the complex interactions between country climate ambitions, pre-existing conditions, political and institutional constraints and social preferences. Countries must choose the best policy mix and instruments for effective climate action in the context of their policy landscape and principal drivers. While some countries (e.g. **Portugal**) primarily rely on market-based policies, such as carbon pricing under the EU ETS or Feed-inTariffs for renewable energy, others (e.g. **Costa Rica**) place more emphasis on non-market-based instruments, such as minimum energy performance standards and bans or phase-outs of fossil-fuel equipment or infrastructure.

Figure 24. Policy mixes varied across time and across countries



Countries with relatively larger policy adoption or higher policy stringency are associated with steeper GHG emissions reductions between 2015-2019 (Figure 25).[2] This holds true for total GHG emissions as well as GHG emissions intensity and GHG emissions per capita. This analysis, however, does not imply any causal relationship between policy adoption or policy stringency and GHG emissions reduction. Future work could shed more light on this.

Figure 25. Countries with stronger climate action are associated with steeper emissions reductions, 2020



Source: (Nachtigall et al., forthcoming[56]).

Despite countries' different policy mixes, all countries have focussed their efforts on two main cross-cutting climate action areas, which will be discussed as follows:

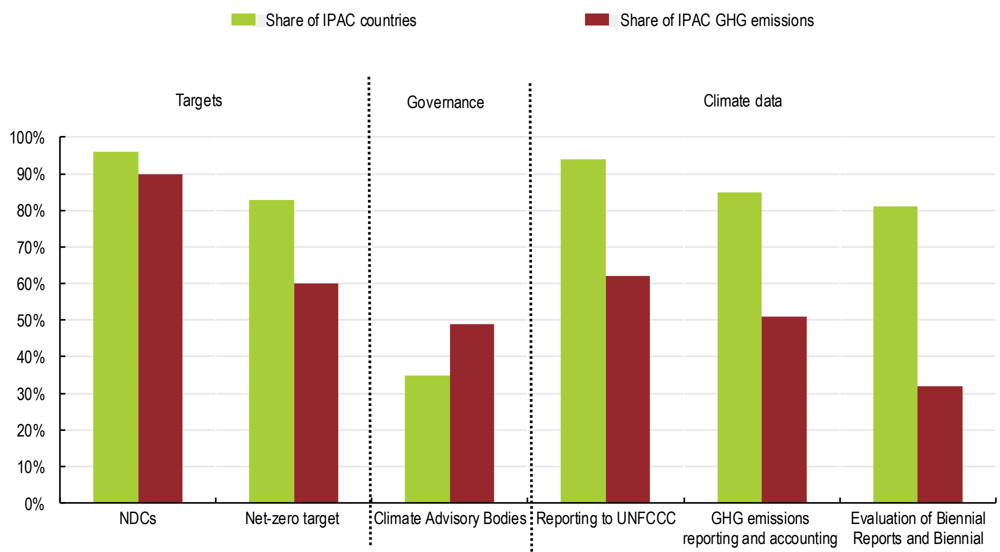
1. Enabling climate action by establishing emission targets, integrated and multi-level governance, and enabling information. Emission targets provide key short- and long-term signals to citizens and firms about a government's climate ambition. Short-term and long-term emission targets are implemented through policy packages that tackle different externalities on the road to net-zero.
2. Meeting climate objectives through policy packages, including a diverse set of instruments
    a. *Non market-based instruments* such as regulatory or information instruments are needed to support the adoption of low-carbon technologies that are already cost competitive with high-carbon alternatives.
    b. *Market-based instruments*, including carbon pricing, change behaviour through financial means.
    c. *Innovation policies* enable the development of new, and reduce the costs of advanced, mitigation technologies that are needed to further reduce GHG emissions in the coming decades.
    d. *Climate finance.*

Enabling climate action through emission targets, integrated and multi-level governance, and enabling information

Governments can set ambition and provide credible plans to reach climate goals, building confidence among investors, industry and civil society. Policy commitments and multi-level climate governance are the basis of national climate policy. Although these commitments are not, strictly speaking, policy instruments, they can have a material impact on emissions since they provide signals to firms and households on long-term government plans and, therefore, the future expectation of the implementation of climate policies. In addition, given the long-term investment horizon of GHG-emitting assets and equipment, investors may reassess projects based on the expectations of policy change.

By 2020, most countries have implemented NDCs and net-zero targets (Figure 26). However, fewer countries have supported these commitments by providing accurate climate data, including biennial reports, biennial update reports (BUR) or GHG emissions data (e.g. through National GHG Inventories or the System of Economic and Environmental Accounts), all of which provide the necessary information for an assessment of national climate policy implementation. These data will be essential as countries move from explicit commitments to the effective implementation of policy instruments to achieve their targets.

Figure 26. Targets, governance and climate data policies adopted in IPAC countries in 2020



Source: (Nachtigall et al., forthcoming[56]).

Given the broad impacts of climate change and the cross-sectoral nature of climate policy implementation, the key to coherent climate policy is a concerted whole-of-government effort establishing clear objectives and identifying the key policy frameworks and instruments to support the transition. A comprehensive approach requires governments to mainstream climate objectives and targets at all levels of government. In most countries, this means translating international commitments into national plans at different levels of government – national, sub-national and sectoral – which will require, in most cases, new institutional arrangements. At present, many countries have implemented national inter-ministerial committees, permanent and independent climate advisory bodies or other similar frameworks. In some countries, such as **Finland**, climate advisory bodies were pivotal in determining the governments' net-zero target (OECD, 2021[57]). By 2020, 18 IPAC countries had established climate advisory bodies that inform and evaluate countries' policymaking.

Many countries have developed roadmaps and implementation strategies to support their long-term climate targets. Some have further complemented these with specific national sectoral plans, such as national energy and climate plans. However, although these are important and provide precise information and signals to investors, they should be accompanied by policy packages and instruments that can achieve material change.

Meeting climate objectives through policy packages

Countries implement climate policy objectives, such as NDCs, through policy packages and policy instruments that effectively reduce GHG emissions. This includes instruments that are adopted to intentionally mitigate climate change and those that are adopted for other purposes (e.g. safety, energy affordability) but that have a material effect on GHG emissions. Effective climate policy packages consist of four broad components: non-market-based and market-based instruments, innovation policies and climate finance instruments.

Non-market-based instruments

Non market-based instruments include information instruments, planning frameworks and regulatory instruments. Regulatory instruments establish a mandate to change the behaviour of firms or households through regulation and enforcement. This includes, among others, a pre-determined level of emissions or energy performance standards or even outright bans on some economic activities, inputs or technologies.

Policy adoption of non-market-based instruments varies substantially across countries and sectors (see Table 1). Standards have historically been the key environmental policy approach in most countries, but bans and phase-outs are also increasingly being adopted.

Table 1. Non market-based policy instruments in IPAC countries, 2020

Policy	Number of countries adopting the policy	Share of IPAC countries adopting the policy	Share of global GHG emissions covered by the countries adopting the policy	Sector
Planning for renewables expansion*	44	85%	80%	Electricity
Air emission standards coal power plants	40	77%	77%	Electricity
Bans and phase out on coal power plants	31	60%	12%	Electricity
MEPS for electric motors	47	90%	72%	Industry
Energy efficiency mandates for large consumers	42	81%	80%	Industry
MEPS of appliances	52	100%	80%	Buildings
Mandatory energy labels for appliances	50	96%	80%	Buildings
Building energy codes	46	88%	78%	Buildings
Ban and phase out on fossil fuel heating systems	13	25%	5%	Buildings
Speed limits on motorways	45	87%	77%	Transport
MEPS Transport	40	77%	69%	Transport
Labels for vehicles	41	79%	73%	Transport
Share of rail expenditure on total transport expenditure	32	62%	63%	Transport
Ban and phase out of passengers cars with ICE	14	27%	7%	Transport

Note: MEPS = Minimum energy performance standards, ICE: internal combustion engine.
*: 44 countries that adopted policy instruments related to planning for renewables expansion account for 80% of global GHG emissions. The remaining 8 countries include Estonia, Ireland, Lithuania, Latvia, Luxemburg, Malta, Slovenia.
Source: (Nachtigall et al., forthcoming[56])

Most countries have adopted minimum energy performance standards (MEPS) for electric motors and electric appliances, building codes or fuel efficiency standards for vehicles. In fact, the stringency and adoption of MEPS for electric motors increased substantially in the last decade, notably from 2011, when most European countries adopted these instruments (Figure 27, Panel A). In the electricity sector, 77% of IPAC countries have adopted air emissions standards for coal power plants.

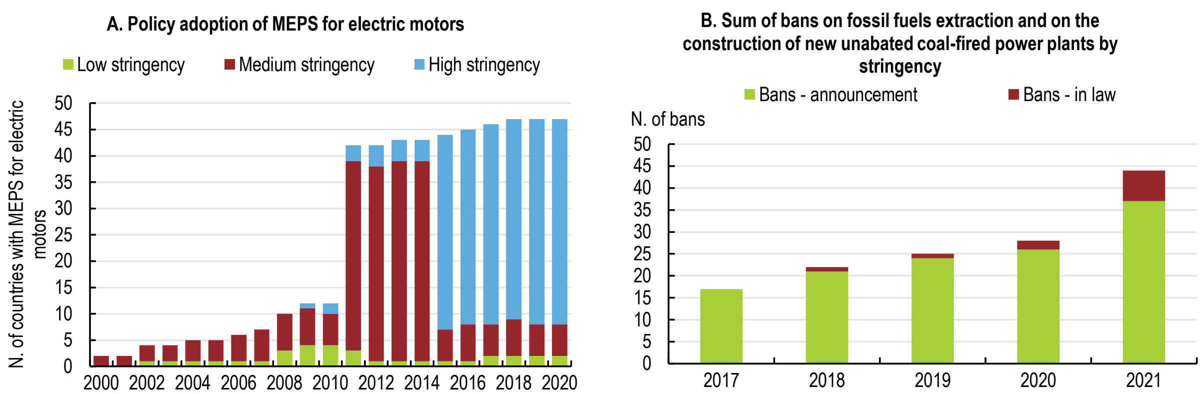
Even though policy adoption of standards is widespread, countries need to strengthen and update standards to ensure the best available technology to reach climate targets. For example, none of the IPAC countries has adopted the highest possible energy performance standard for electric motors, while 8 countries have adopted standards that have only low or medium stringency.

Bans and phase-outs of fossil-fuel equipment or assets are most prevalent in the electricity sector and have been rising in recent years (Figure 27, Panel B). Countries, however, have also started to ban fossil-fuel equipment on heating (oil and gas boilers) and in transport (passenger cars with internal combustion engines [ICE]), both on a national and sub-national level, though policy adoption is much lower. In August 2022, the US State of California announced that it would ban the sale of passenger cars with

ICE from 2035. However, no country has adopted a ban on the advertisement of fossil-fuel companies or economic activities related to high GHG emissions (e.g. air travel, sports utility vehicles) to date, which could prevent companies from greenwashing and luring customers into carbon-intense lifestyles (OECD, 2022[58]).

Therefore, although regulatory policies have been the principal policy approach to deal with environmental issues, countries can and should expand the range of policies that can be adopted, particularly in those sectors where GHG emissions are highest.

Figure 27. Countries increased the use and stringency of non-market based instruments



Note: MEPS = Minimum energy performance standards.
Source: (Nachtigall et al., forthcoming[56]).

Market-based instruments

Market-based instruments (MBIs) are policy instruments that use markets, prices and/or other economic variables to incentivise households and firms to reduce or eliminate environmental externalities. While these instruments directly price the externality of GHG emissions, non-carbon-pricing instruments financially reward low-carbon economic activities or put a price on another externality (e.g. congestion).

Non-carbon-pricing instruments

Policy adoption of non-carbon-pricing instruments varies considerably across countries (see Table 2). Most countries have adopted at least some financing mechanisms to strengthen energy efficiency in buildings or the industry sector, such as preferential loans for building retrofits or loan guarantees to channel finance to low-carbon projects. On a sub-national level, cities in four countries (**Italy, Norway, Sweden** and the **United Kingdom**) have adopted congestion charges. While these charges effectively mitigate congestion, they also reduce incentives for car use and, thus, car dependency, promoting the shift towards more sustainable modes of transport.

Most countries use some type of instrument to financially support renewable electricity. For example, of all IPAC countries, 15 use feed-in tariffs, 14 use renewable energy auctions, and 13 use renewable electricity portfolio standards combined with tradable certificates. Some countries also shifted financial support from mature renewable energy technologies, such as solar photovoltaic (PV) and wind, to less mature technologies, including offshore wind, electricity storage, etc. (see "The broader policy landscape" section).

Table 2. Non-carbon pricing MBI's in IPAC countries

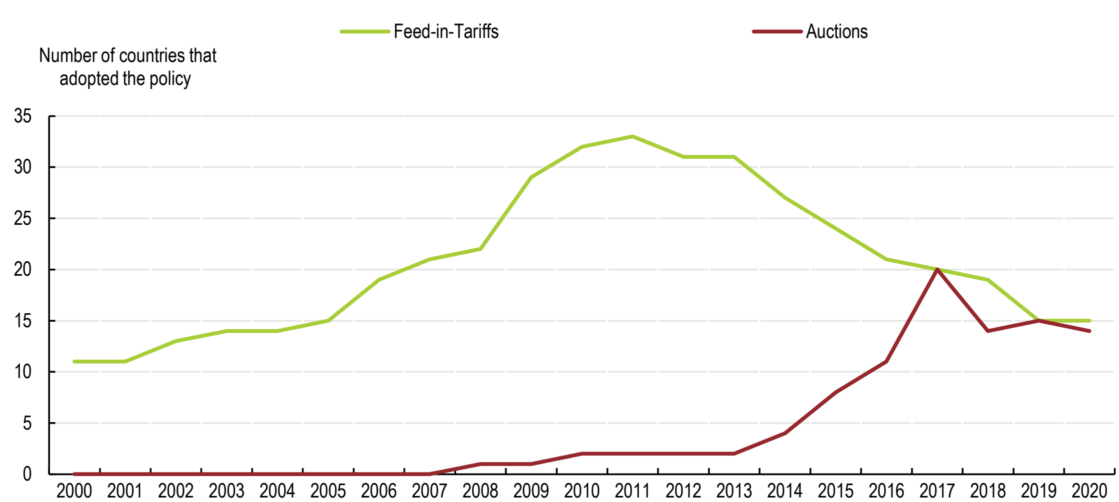
Policy	Number of countries adopting the policy	Share of IPAC countries adopting the policy	Share of global GHG emissions covered by the countries adopting the policy	Sector
Feed-in Tariffs for renewable electricity	15	29%	12%	Electricity
Auctions for renewable electricity	14	27%	60%	Electricity
Renewable electricity portfolio standards with tradable certificates	13	25%	57%	Electricity
Financing mechanisms available for energy efficiency	39	75%	80%	Industry
Financing mechanisms available for energy efficiency	40	77%	79%	Buildings
Congestion charges	4	8%	2%	Transport

Source: (Nachtigall et al., forthcoming[56]).

The support mechanisms for renewable electricity shifted between 2000 and 2020 (Figure 28). Historically, countries primarily used feed-in tariffs or feed-in premiums as instruments to support renewable electricity. In recent years, however, countries have increasingly shifted towards renewable energy auctions, at least for utility-scale projects. While auctions are administratively more complex, they enable policymakers to more effectively determine the renewables expansion path and to materialise budget savings through their inherent price discovery mechanism, making them more attractive to governments (OECD, 2021).

Figure 28. Countries are increasingly shifting towards auctioning renewable energy capacity

Number of IPAC countries with Feed-in-tariffs and renewable electricity auctions: 2000-2020



Source: (Nachtigall et al., forthcoming[56]).

Carbon pricing and effective carbon rates

Pricing carbon or GHG emissions effectively promotes low-cost mitigation measures (IPCC, 2022[43]). It is generally considered the most economically efficient tool to achieve global GHG emissions reductions, especially if combined with carbon markets that can reduce the costs of climate mitigation (Box 5). The carbon prices deemed to be necessary to achieve the targets of the Paris Agreement range between USD 50 and USD 160 per tonne of carbon dioxide equivalent (tCO_2e) by 2030, provided that an effective policy mix is in place (CPLC, 2017[59]) (Parry, 2021[60]).

Box 5. International carbon markets and co-operative approaches

Linking domestic carbon markets to enable trade in emission reduction obligations has a number of advantages, including reducing global mitigation costs, enhancing climate ambitions and providing finance for developing countries.

Findings from modelling suggest that international carbon markets can reduce global mitigation costs of achieving NDCs by between 58% and 63% compared to countries meeting these targets unilaterally. This would mean savings of between USD 220 to USD 320 billion per year by 2030 (Nachtigall et al., 2021[61]; Akimoto, Sano and Tehrani, 2017[62]; Fujimori et al., 2016[63]; IETA, 2019[64]).

This reduction in costs makes the commitments associated with the NDCs feasible and allows for greater ambitions, establishing even bolder mitigation commitments. For example, reinvesting all savings from global co-operation into climate mitigation could increase emissions removal by up to 50%, equivalent to 5 $GtCO_2e$ in 2030 (IETA, 2019[64]). Moreover, it implies a net transfer of financial resources to those countries that can abate at a lower marginal cost, which is typically developing countries, effectively financing the energy transition.

Some countries and jurisdictions have opted for linking their emissions trading systems, such as the EU Emissions Trading System (EU ETS), the Western Climate Initiative or the Regional Emissions Greenhouse Gas Initiative (RGGI). Alternatively, Article 6 of the Paris Agreement opens the door to co-operative arrangements or country-bilateral agreements on emissions reduction that could expand the carbon market considerably.

Article 6 of the Paris Agreement aims to promote cooperative approaches between countries based on the exchange of internationally transferred mitigation outcomes or ITMOs. It was conceived as a mechanism to promote markets, mainly through tradable linked emission permits or projects inspired by the Clean Development Mechanism (CDM) framework. The idea is that, under this mechanism, countries with the capacity to reduce emissions could sell their excess to those emitters whose abatement costs are higher, thus ensuring that the net reduction of emissions is at a lower total cost. Through this flexible mechanism, GHG emissions can be reduced at lower cost, along with stimulating innovative and cleaner technologies to drive an overall transition to a low-carbon economy in developing countries.

Countries have increasingly adopted carbon pricing, but more needs to be done to reach climate targets. In 2021, there were 64 explicit carbon pricing schemes – i.e. carbon taxes or emissions trading systems (ETS) – in national and sub-national jurisdictions, with 3 being scheduled for implementation (World Bank, 2021[65]). While these 64 pricing schemes covered approximately 21.5% of global GHG emissions, less than 4% of global emissions were covered by a carbon price consistent with the 2°C goal of the Paris Agreement, or USD 40 to USD 80 per tonne of CO_2 (World Bank, 2021[65]).

In addition to explicit carbon pricing, the OECD includes fuel excise taxes in its definition of effective carbon rates due to the linear relationship between fossil-fuel combustion and carbon emissions.[3] In fact, the biggest share of carbon pricing can be attributed to fuel excise taxes (Table 3). Considering this broader definition, there has been noticeable, albeit uneven, progress in carbon pricing since 2018. Half of all energy-related carbon emissions in G20 countries were priced in 2021, up from 37% in 2018. The coverage increase was largest for emissions trading systems, with the new Chinese national ETS for the power sector as the main driver.

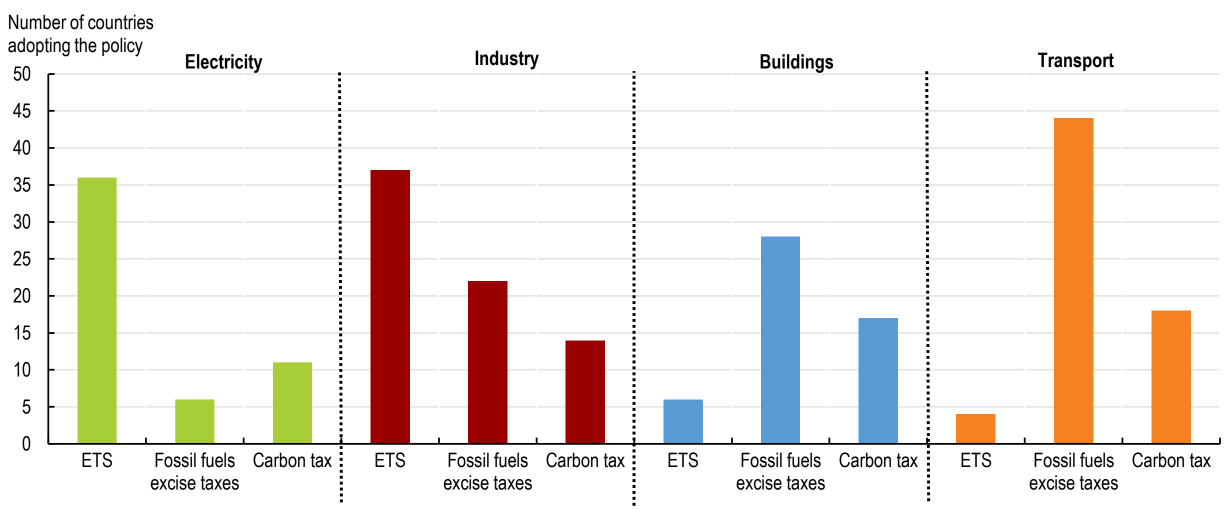
Table 3. Effective and explicit carbon prices and emissions in G20 and OECD countries, 2021

Instrument	Emissions share 2021, (%)	Average carbon price 2021, (EUR/tCO_2)
Priced by emissions trading systems (ETS)	21.7	2.95
Priced by carbon tax	6.7	0.67
Priced by explicit carbon price (ETS, carbon tax)	28.4	3.62
Priced by fuel excise	28.8	15.09
Priced by effective carbon rate	48.7	18.71

Source: (OECD, 2022[11]).

The mix of carbon-pricing instruments varies across sectors (Figure 29). Emissions trading schemes are widespread in the industry and electricity sector, mostly driven by the EU ETS that covers all installations in industry and electricity generation in EU27 countries and Iceland, Liechtenstein and Norway. Few countries use ETS in the building and transport sector. In these sectors, fuel excise taxes are more widespread. New Zealand is the first country to consider implementing an ETS in the agricultural sector and forestry.

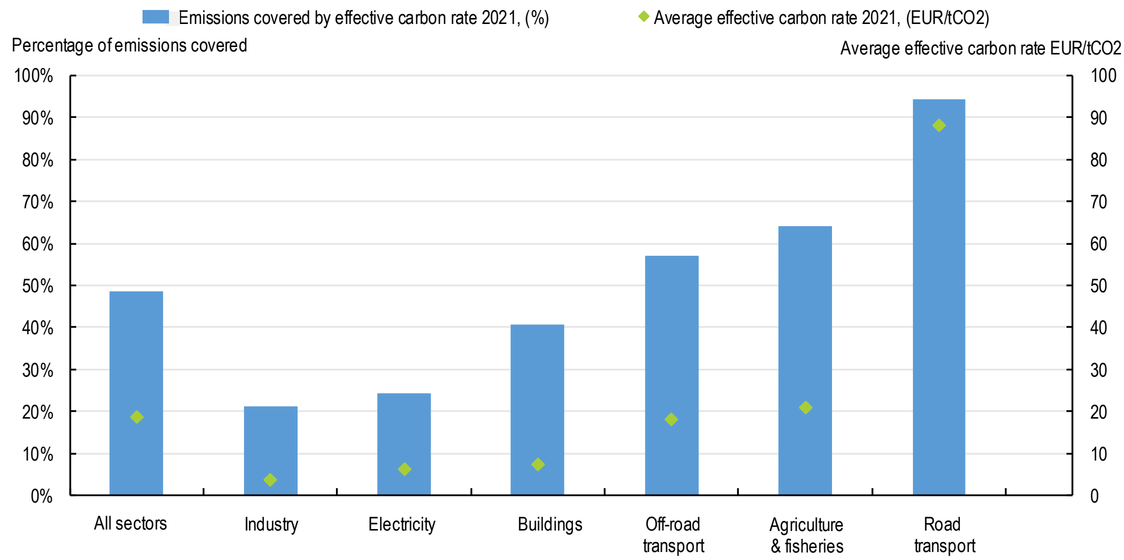
Figure 29. Use of carbon-pricing instruments across sectors in IPAC countries, 2020



Note: ETS stands for emissions trading schemes.
Source: (Nachtigall et al., forthcoming[56]).

Carbon price levels and emissions' coverage differ significantly across sectors (Figure 30). Effective carbon rates cover over 90% of energy-related carbon emissions in the road sector, with an average rate of EUR 88 per tCO_2. Other sectors, such as industry and electricity, cover less than 25%, with average effective rates of EUR 3.8 and EUR 6.36 per tCO_2, respectively.

Figure 30. Carbon price levels and emissions coverage in OECD and G20 countries, 2021



Source: (IPCC, 2022[44]) (OECD, 2021[66]).

Implementing or increasing carbon prices is currently less likely in most countries due to elevated energy prices and the Ukraine war. In fact, most governments have introduced temporary or permanent tax exemptions to alleviate the pressure of high energy prices on households and firms (e.g. **France**, **Germany** and **Italy**). These subsidies add to the uptake of support for fossil fuels that was already observed before the Ukraine war. However, once energy prices return to pre-crisis levels, policy makers should be ready to strengthen carbon pricing where feasible and make it consistent across sectors.

Regardless of the currently high energy prices, implementing or increasing carbon pricing faces problems of political acceptability, notably due to concerns about competitiveness and impacts on vulnerable households. For households, increased prices of carbon-intensive products will affect the cost of energy, food and transport. For firms, a carbon price will increase the cost of carbon-intensive inputs, which may affect firms' competitiveness. However, to date, concerns about negative short-term effects of carbon pricing on sectors' international competitiveness have not come to pass, partly because carbon prices levied on industry have been low and subject to exemptions (Venmans, Ellis and Nachtigall, 2020[67]).

In the same vein, carbon prices have also generated concerns over carbon leakage, i.e. the shift of economic activity and emissions from one jurisdiction to another as a result of carbon pricing. This has motivated proposals for a carbon border adjustment mechanism (e.g. from the **European Union** and **Canada**) to contain carbon leakage and level the playing field.

Countries can use revenues from carbon pricing to mitigate its negative effects and increase political acceptability. Compensating firms and households for higher energy costs, e.g. shifting taxes off labour and capital and onto fossil fuels, can improve the tax system's economic efficiency (often referred to as the "double dividend"). Using revenues to finance green infrastructure increases both the political acceptability and the effectiveness of carbon pricing (Dechezleprêtre et al., 2022[68]).

Carbon pricing can generate significant revenues. Potential revenues from carbon pricing to meet the Paris Agreement mitigation pledges are substantial – typically around 1-3% of gross domestic product (GDP) or more in 2030 across G20 countries (Ian W.H. Parry, Victor Mylonas and Nate Vernon, 2018[69]). For carbon-intensive economies, even low levels of carbon pricing can raise significant revenues. A EUR 30 effective carbon price would generate 4-7% of GDP in **China**, **India** and **South Africa** (Marten and van Dender, 2019[70]).

Fossil-Fuel Production and Consumption Subsidies

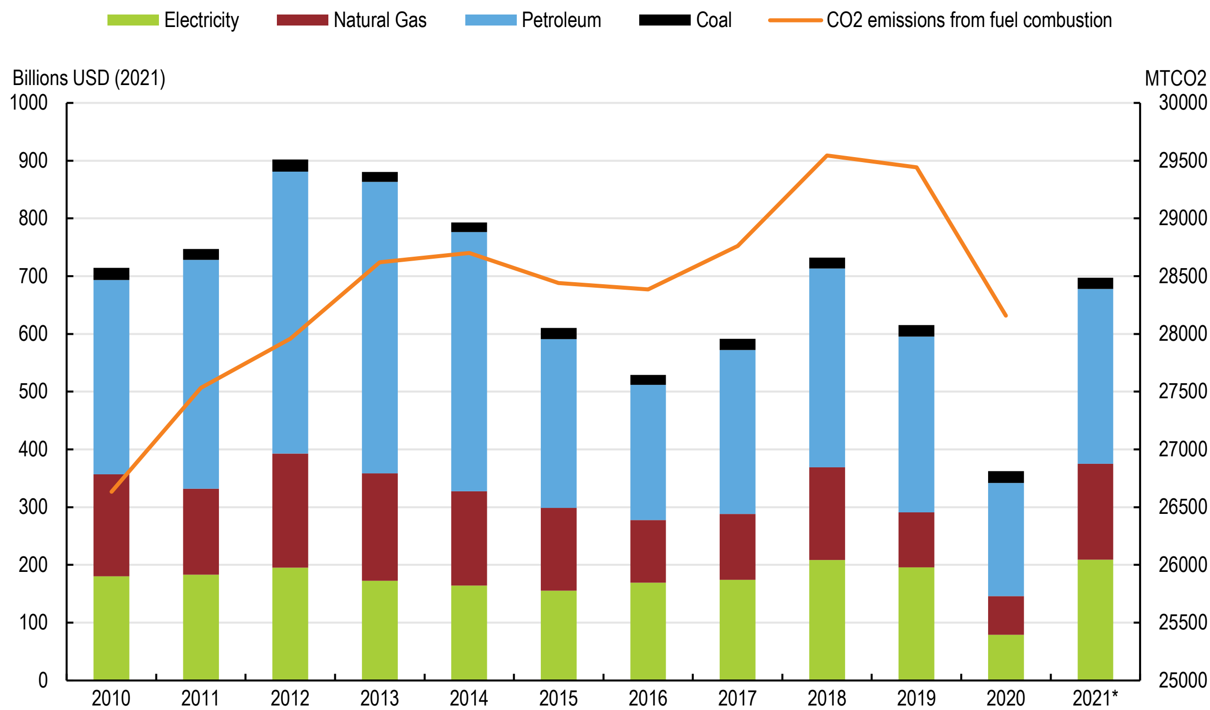
The environmental effectiveness of carbon pricing or other non-market measures is hampered by government support for fossil fuels. In 2021, major economies sharply increased their support for the production and consumption of coal, oil and natural gas by hundreds of billions of US dollars, in efforts to protect households and firms from surging energy prices. However, this is at odds with longstanding pledges to phase out inefficient fossil fuel subsidies (OECD-IEA, 2022[71]) (OECD-IEA, 2022[71]).

In 51 major energy producing and consuming countries, that represent 85% of the world's total energy supply and 88% of CO_2 emissions from fuel combustion, government support for fossil fuels almost doubled to USD 697.2 billion in 2021 compared to the previous year.[4] This is almost 10 times the total revenues from carbon taxes and emissions trading schemes of the same year (World Bank 2021). Notably, support for producers increased by 50% from the previous year, reaching USD 64 billion. Those subsidies have partly offset producer losses from domestic price controls as global energy prices surged in late 2021.

In G20 countries, consumer support reached an estimated USD 115 billion, an increase of more than 20% since 2020. Beyond G20 countries, the IEA estimates that consumer fossil fuel subsidies in 42 economies increased to USD 531 billion in 2021, nearly triple their 2020 level.[5] Consumption subsidies are anticipated to rise even further in 2022 due to higher fuel prices and energy use. See Figure 31.

Increasing fossil fuel and energy support has been a consequence of higher prices but to deal with the climate emergency and support vulnerable households, they should be replaced with means-tested subsidies and support for the development of low-carbon alternatives. Indeed, support for fossil fuels tends to favour wealthier households that consume more fuel (Van Dender et al., 2022[72]) (Van Dender et al., 2022[72]). Ongoing efforts to enhance transparency on the many ways that governments continue to encourage fossil-fuel production and use is also paramount to align energy security, affordability and climate neutrality in the wake of, and in preparation for, further shocks to the system. On the other hand, countries are increasingly committing and implementing direct mandates to control or regulate fossil fuel use, especially coal.

Figure 31. Fossil fuel support in selected countries



Note: *2021 estimates are temporary. Data are expressed in constant 2021 US dollars.
Source: (OECD, 2021[73])OECD Inventory of Fossil Fuel Support Measures database (2022), IEA analysis.

Innovation policies

Innovation helps to broaden the range and increase the efficiency of low-carbon technology options available to governments and the private sector over time. In the power sector, these options include the next generation of renewable electricity generation technologies, such as building-integrated solar photovoltaic (PV), and carbon capture, utilisation, and storage (CCUS), as well as batteries, energy storage and smart-grid technologies.

In the transport sector, low-carbon vehicles are being developed, including those that run on hydrogen fuel cells, compressed or liquefied gas and biofuels. Electric vehicles are being marketed and are increasingly competitive with traditional combustion engines. In the buildings sector, advanced building materials and energy-efficient, smart home appliances are being developed, and existing technologies are being improved. The industrial sector needs to switch to lower-carbon and alternative fuels for production, make more efficient materials and deploy the best available technologies, including carbon capture utilisation and storage (CCUS) (OECD, 2015[74]). Agriculture needs to enhance both its sustainability and productivity, notably using precision agriculture and big data, genetic innovation and sequestration in soils (IPCC, 2019[75]). (IPCC, 2019[75]).

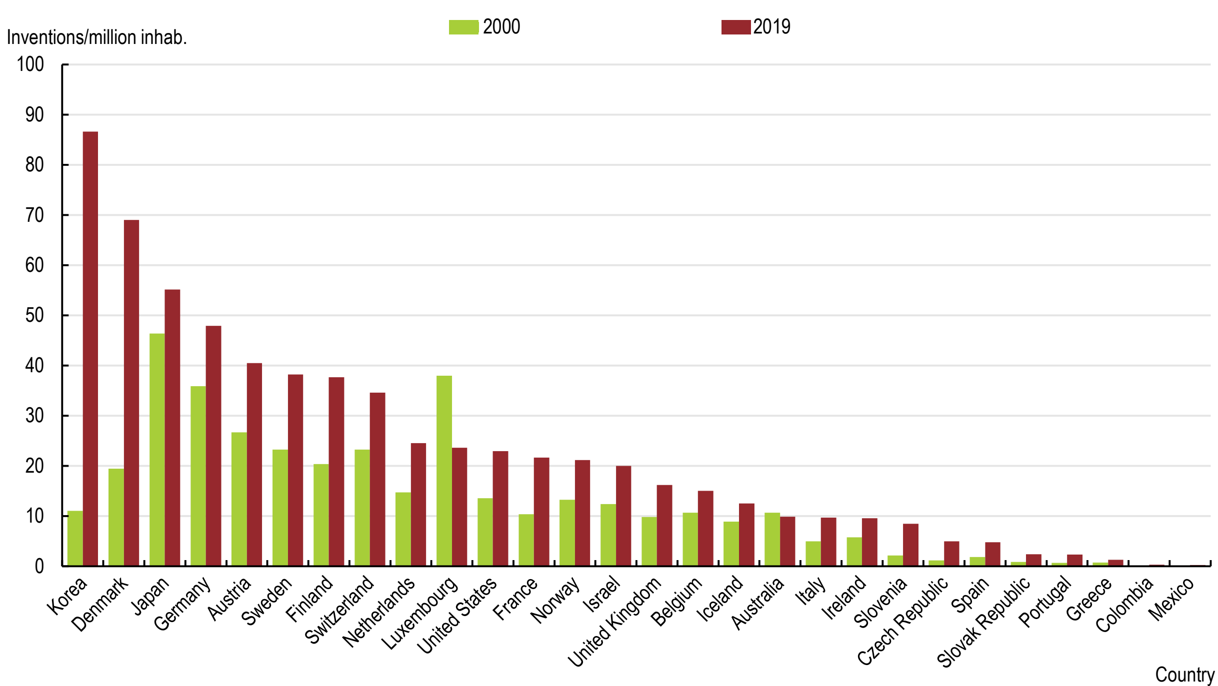
If properly deployed, technologies that are available on the market today are sufficient to provide nearly all the energy-related emissions reductions required by 2030. However, reaching net-zero emissions will require the widespread use after 2030 of technologies that are still under development. In 2050, almost 50% of carbon emissions reductions in the IEA’s net-zero scenario will come from technologies currently at the demonstration or prototype stage. This share is even higher in hard-to-abate sectors, such as heavy industry and long-distance transport (IEA, 2021[76]). (IEA, 2021[76]).

Major innovation efforts are vital in this decade to enable the technologies necessary for net-zero emissions to reach markets as soon as possible (IEA, 2021[76]) (IEA, 2021[76]). Total public research and development (R&D) spending on low-carbon energy has been increasing in most countries over the last five years (an increase of around 50% in **Australia**, **Mexico**, the **United States** and the **European Union**; 124% in the **United Kingdom**; and 18% in **Japan** between 2015 and 2020). In absolute terms, the **United States** is the leader in spending on low-carbon technologies, such as renewables, energy efficiency and CCUS, and **Japan** spends the most on hydrogen and fuel cell technologies (IEA, 2021[77]).

Several other countries have increased their government R&D spending on low-carbon technologies. For example, **Belgium** and the **Czech Republic** have more than doubled their budgets for energy efficiency over the last five years. **Norway** spends the most per unit of GDP, and, like **Finland**, its highest spending category is energy-efficiency technologies. This is followed by renewables, an area that only **Denmark**, **Korea** and **Switzerland** count as their largest category among the top spenders in relative terms (IEA, 2021[77]).

OECD countries represent the vast majority of worldwide patents on environment-related technologies (80% in 2019, including 26% in European countries, 22% in American countries and 31% in Asian and Oceanic countries) (Figure 32) and clean energy. In 2014-18, the **United States, Europe, Japan, Korea** and **China** registered 90% of clean-energy patents. The share of “high-value” climate change mitigation inventions in all technologies has increased from around 4% in the early 1990s to over 9% more recently (OECD, 2022[11]). Among selected technologies, the increase in filed inventions since 1990 has been more marked for road transport and energy storage. Renewable energy generation technologies increased the fastest up to 2011 (OECD, 2022[11]). While patent data are informative about the production of innovation, they do not indicate whether the owner is actually using the technology protected by the patent. Data on trademark filings can usefully complement patent data by focusing on the commercialisation phase of innovations.

Figure 32. Climate-related inventions



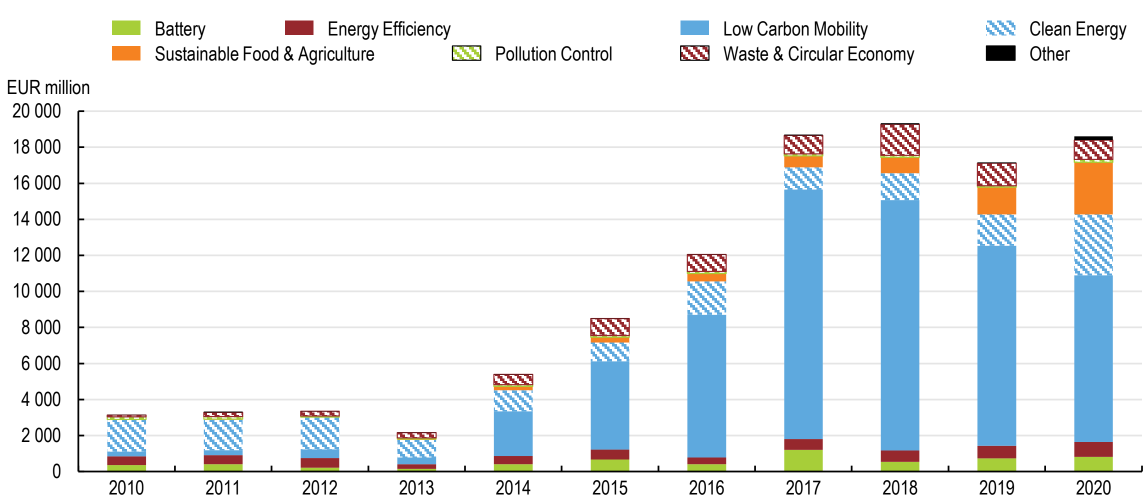
Source: OECD (2022[78])

The proportion of trademarks for climate-related goods and services has grown markedly over the last two decades. The proportion has tripled in the **United States** and **Japan** (from 1% to 3%) and has nearly quadrupled in **Europe** (from 2% to 8%). Interestingly, there is an observed decrease in climate-related patenting since 2012. However, trademarks have picked up in recent years. This suggests that firms have partly switched activities away from R&D toward diffusion and commercialisation. Accelerating the diffusion of available technologies is critical to reaching medium-term carbon emissions reductions, but in the long-run, developing breakthrough technologies that are not yet on the market is also important. An important question for policy is how to accelerate the diffusion of existing low-carbon technologies while reigniting low-carbon innovation in breakthrough technologies.

Private investments for "green" start-ups[6] have skyrocketed in the last decade. Venture capital (VC) funding has grown sixfold in a decade, rising from around USD 3 billion in 2010 to USD 18 billion in 2020. After a peak in 2018, global VC investment in green start-ups slightly decreased in 2019 and rebounded in 2020 (Figure 33). This decade-long rise notably benefitted start-ups in low-carbon mobilities and sustainable food and agriculture. Small European countries, like **Denmark**, **Finland**, **Iceland**, **Latvia** and **Switzerland,** have also taken their place in the global landscape of green start-ups. However, the share of these types of firms among overall start-ups has remained stable over the last decade (Bioret, Dechezleprêtre and Sarapatkova, forthcoming[79]) (Bioret, Dechezleprêtre and Sarapatkova, forthcoming[79]).

Figure 33. Venture capital for green technologies has surged globally in the latest decade

Amount of VC funding invested in green start-ups, by sector in OECD countries (in EUR million)



Source: OECD startup database, Worldwide Patent Statistical Database (PATSTAT) in (Bioret, Dechezleprêtre and Sarapatkova, 2022, forthcoming[80]).

Climate finance instruments

The structural transformation necessary to achieve net-zero emissions in 2050 requires an expansion in capital expenditure fuelled by climate finance. The investment needs for clean energy are estimated at approximately USD 4 trillion annually by 2030. The global economic crisis and increasing energy prices are an opportunity to increase public investment in low-carbon infrastructure to put economies on a low-carbon, climate-resilient development path (OECD, 2015[81]).

An expansion of both private and public sources of finance is needed. Governments must access new revenues to ensure that public finance is available, and implement policies to incentivise private developers to also participate in investment. The IEA estimates that around 70% of clean-energy investment must come from private developers, consumers and financiers.

Green budgeting and the introduction of carbon pricing in the appraisal of investment projects can help governments build a fiscal policy supporting climate action. Green budgeting involves classifying or tagging public expenditure according to its climate relevance. It is a systematic approach to assessing the overall coherence of a budget relative to a country's climate and environmental objectives (Battersby et al., 2021[82]).

Less than half of 39 countries studied by the OECD were identified as having green budgeting practices in place, while 9 were planning to introduce some of these practices. **Finland** and **Sweden** highlight measures that have a clear impact on specific environmental objectives within their budget documents. **France**, **Ireland** and **Italy** tag the budget to identify items with a potential environmental impact (Battersby et al., 2021[82]).

Notes

1. Part of the increasing share of market-based instruments is driven by data availability. For example, data on fossil fuel subsidy reform only became available from 2010.

2. This analysis uses data on GHG emissions up to 2019 to not confound the results with those of the effects of the COVID-19 pandemic on emissions.

3. Effective carbon rates are defined as "the total price that applies to carbon dioxide emissions from energy use as a result of market-based instruments (fuel excise taxes, carbon taxes and carbon emission permit prices)"

4. These are the following: Australia, Brazil, Canada, the People's Republic of China, Germany, France, United Kingdom, Indonesia, India, Italy, Japan, Korea, Mexico, Russian Federation, Republic of Türkiye, United States, South Africa, Algeria, Angola, Argentina,

5. The IEA estimate of consumer fossil fuel subsidy identifies 42 economies where there is a lower consumer end-use price of fossil fuels relative to the international reference price. The 42 economies covered in the latest IEA's estimate are: Algeria, Angola, Argentina, Azerbaijan, Bahrain, Bangladesh, Bolivia, Brunei, PR China, Colombia, Ecuador, Egypt, El ,Salvador, Gabon, Ghana, India, Indonesia, Iraq, Iran, Kazakhstan, Republic of Korea, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Pakistan, Qatar, Russia, Saudi Arabia, South Africa, Sri Lanka, Chinese Taipei, Thailand, Trinidad and Tobago, Turkmenistan, Ukraine, United Arab Emirates, Uzbekistan, Venezuela, and Vietnam.

6. Green start-ups here include start-ups in the sectors of: battery, energy efficiency, low-carbon mobility, clean energy, sustainable food and agriculture, pollution control, waste and circular economy.

4 Barriers and opportunities for the net-zero challenge and a just transition

Advancing with the net-zero challenge requires dealing with the barriers or constraints to implementing decarbonisation policies, as well as ensuring that no one is left behind. These factors will determine the range of policies that can be implemented and their effectiveness in reducing GHG emissions. A tailored policy mix implies considering the critical materials associated with policy responses and considering the possible headwinds and tailwinds from the broader policy landscape.

Barriers

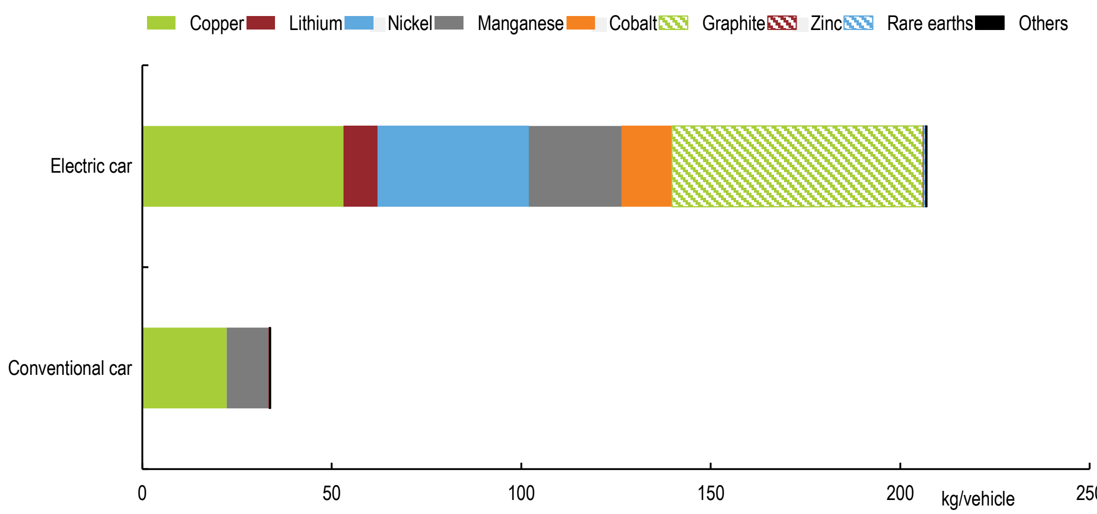
Critical materials

The transition to net zero requires the use of critical materials. Green technologies, such as batteries, electric vehicles, PV panels or wind turbines, require more material than their fossil-fuel equivalents. This particularly includes copper and aluminium for electric systems, or lithium, cobalt and graphite for batteries. Rare earths are crucial for wind turbines, electric and hybrid vehicles, cellular telephones, computer hard drives, flat-screen monitors and televisions. For instance, according to the IEA, an average electric car requires six times the mineral inputs of a conventional car (see Figure 34), and an onshore wind plant requires nine times more mineral resources than a gas-fired plant (IEA, 2021[83]).

Considering the current technology, achieving the Paris Agreement goals would require that the material used for green technology be multiplied by four by 2040, a trend far above the current development pace of these markets (current resources and mining projects will only allow for the doubling of production) (IEA, 2021[83]). Bottleneck risks are looming in the short- and medium- terms, and tensions are already beginning to show. Material prices are increasing (the price of lithium increased sevenfold between early 2021 and May 2022), and lithium shortages prompted interruptions of the production chain in some manufacturers (The Economist, 2022[84]). Markets are expected to get even tighter in the next decade as developing new mining sources takes time (an average of 16.5 years between discovery to first production) (IEA, 2021[83]), and countries are rapidly increasing their climate ambitions, including with the development of electric vehicles.

Figure 34. Technologies supporting decarbonisation require additional material

In Kg/vehicle

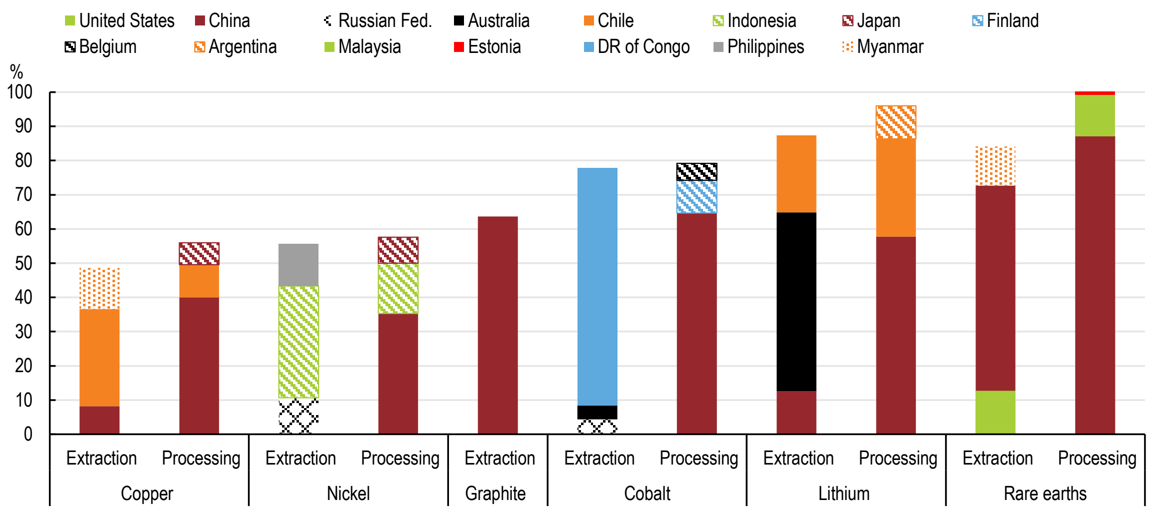


Source: IEA, Minerals used in electric cars compared to conventional cars, IEA, Paris (IEA, 2021[85])

Dependence on these materials puts a new risk on the global energy system. The extraction of these critical materials is concentrated in a very small number of countries. For example, three countries produce 77% of lithium, and one accounts for 65% of graphite production (IEA, 2021[83]) (see Figure 35). Concentration gets even stronger in the processing phase, where **China** is predominant. This makes the supply chain particularly vulnerable to unilateral shocks, with possible bottlenecks and soaring prices that would hamper the transition. Indeed, raw materials make up a significant share of green technology costs (e.g. 50-70% of total battery costs), and tight material markets could prevent the large take-up of these technologies.

Figure 35. Extraction and processing of critical materials are very concentrated in some countries

Share of the top three extracting and producing countries (2019)



Source: (IEA, 2021[85]).

Climate plans and announcements must therefore factor in the risks related to critical materials and, most importantly, strive to alleviate these risks so that they do not hamper the climate transition. Implementing a credible and stable pathway to net zero calls for the development of new sources throughout the world, new processing manufactures and accelerated investments. In parallel, dependence of the transition on extracted materials can be reduced with new technologies and the development of recycling chains for these specific materials.

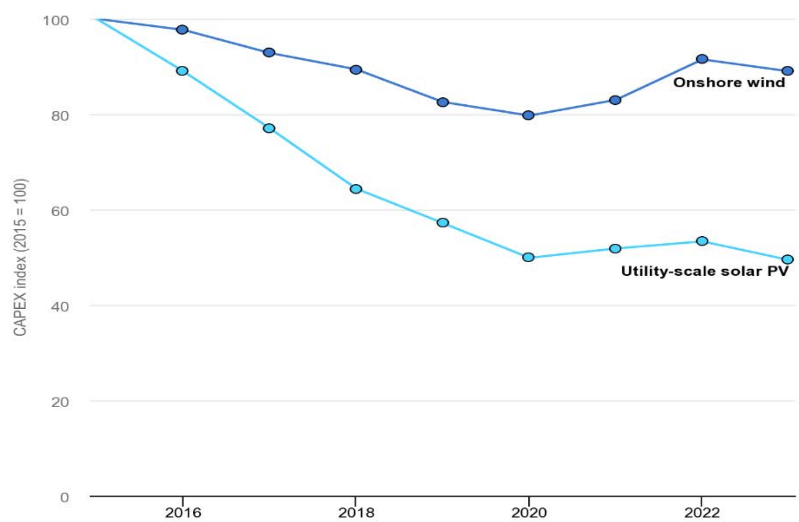
The broader policy landscape

Tailwinds

Tailwinds refers to a broad range of events outside the climate change policy space, such as changing economic or social conditions, discoveries, and/or innovations, that can support and facilitate the transition to net-zero. For example, between 2015 and 2020, the costs estimate for solar PV and onshore wind investment for new contracted projects fell by 50% and 20% respectively (see Figure 36). Countries should consider market trends, such as these, in the development of their net-zero strategies (IEA, 2022[86]).

Investment in renewable energy has been driven by innovation and strong public support (e.g. public investment or feed-in tariffs). However, increasing efficiency gains are driven by learning-by-doing and additional investment from the private sector. As a result, a large part of renewable energy is now equal to or even more profitable than energy based on fossil fuels in many countries, attracting new private investments and research and nurturing a virtuous circle between innovation and production (see Box 6). Increased private investment and research would allow for a phasing down of public support, particularly feed-in tariffs, which have already been reduced or cut in some countries. Between 2000 and 2020, energy production from renewable sources has grown by 63% globally and by 82% among OECD countries (IEA, 2022[87])

Figure 36. Solar PV and onshore wind investment cost estimates for new contracted projects



Source: (IEA, 2022[87])

Box 6. The renewable energy boom in Denmark

In **Denmark**, support for renewable energy generation through a complementary combination of R&D funding, streamlined planning processes, subsidies and national targets has driven down costs through learning-by-doing and economies of scale. This is particularly the case in offshore wind, where it took decades of sustained support to bring down high installation costs. Key initiatives to incentivise deployment included, first, feed-in tariffs, complemented by the introduction of a carbon tax in 1992, then an environmental premium added to the market price and, finally, tenders for new renewable capacity.

This approach has seen risk gradually shift from the government and electricity consumers to investors. A range of renewable technologies is now competitive with fossil-fuel generation, particularly after taking into account a mid-range estimate of the cost of carbon consistent with the Paris Agreement. While sunk capital reduces the economic cost of existing plants, renewable energy facilities are still set to be installed without subsidies in the decade ahead. Denmark's lead in wind energy has contributed to the development of a sophisticated export industry. The manufacture of wind turbines embodies a continuous accumulation of sophisticated knowledge, with the technological advantage of a few leading companies growing over time.

Source: OECD (2021[88]).

Headwinds

Headwinds refer to a range of events outside the climate change policy sphere, such as changing political conditions, discoveries, economic crises or conflict that can hamper or even undermine the climate transition. The war in Ukraine has increased uncertainty, restricted supply lines, reduced grain production, and above all affected energy markets, already under pressure due to the post-COVID crisis. The European gas market has been particularly affected, and potential shortages might call for, at least the temporary, reversal of European countries' decarbonisation plans, particularly related to the access to natural gas considered as a transitional fuel while countries increase renewable energy sources

Reduced access to natural gas has prompted the reopening of coalmines, and there is a risk that decarbonisation pathways are compromised. Therefore, policy must address the challenge of climate change while managing the energy crisis. Developing stable energy systems with diverse and complementary renewable sources and bringing storage solutions to maturity are all the more urgent.

The **United States** provides an example of dealing with the energy crisis and supporting decarbonisation. The recent Inflation Reduction Act (2022) simultaneously deals with increased energy costs and promotes low-carbon investment. The bill introduces tax credits for clean sources of electricity and energy storage, and roughly USD 30 billion in targeted grant and loan programmes for states and electric utilities to accelerate the transition to clean electricity, as well as clean fuels and commercial vehicles (see Box 7).

Box 7. The US Inflation Reduction Act

On 12 August 2022, the US House of Representatives passed the Inflation Reduction Act, a major climate and tax bill. The bill includes measures to improve energy security and address climate change. Revenue will be raised by introducing a minimum corporate tax rate of 15%, a new tax on share buybacks, improved tax enforcement by the Internal Revenue Service and prescription drug price reform.

According to the Congressional Budget Office, this legislation is expected to result in a net decrease in the deficit, totalling USD 102 billion over the 2022-31 period. The enhanced health insurance subsidies and energy-related subsidies will be the largest spending items, while the minimum tax on corporations will be the largest contributor to reductions in the deficit.

The Rhodium Group, an independent climate research centre, estimated that the Inflation Reduction Act could cut US net greenhouse gas emissions to 31-44% below 2005 levels in 2030 – with a central estimate of 40% below 2005 levels – compared to 24-35% under current policy (King, Larsen and Kolus, 2022[89]).

Specific measures include:

- **Lowering consumer energy costs** through consumer home energy rebate programmes consumer tax credits for energy-efficient and clean energy in homes, and clean vehicles.
- **Improving energy security and domestic manufacturing** with production tax credits to accelerate US manufacturing and investment in clean technology manufacturing facilities.
- **Decarbonising the economy** with tax credits for clean sources of electricity and energy storage and clean vehicles, as well as a Methane Emissions Reduction Program to reduce the leaks from the production and distribution of natural gas.
- USD 10 billion to invest in community-led projects to ensure e**nvironmental justice.**
- Over USD 25 billion in grants and loans to support climate-smart agriculture practices, and forest conservation and urban tree planting **in agriculture and rural communities**.

Source: US Government (2022[90]).

Ensuring a just transition

Costs and opportunities from the transition

Public acceptance of climate action is crucial for the design and implementation of effective and feasible climate policies. There is ample evidence that public opinion constrains (Burstein, 2003[91]) and directs the actions of decision-makers (Erikson, Mackuen and Stimson, 2002[92]). Public opinion may be especially relevant in the case of climate change mitigation, with many studies arguing that the introduction of effective policies to curb climate change is constrained by the lack of public support. For example, Harrison (Harrison K., 2010[93]) demonstrates how **Canadian** climate opinion has affected federal policy choices. (Crowley Kate, 2017[94]) suggests that the **Australian** repeal of its carbon tax in 2014 was at least partly due to public opposition. The cases of **France**[1] and **Ecuador**[2] provide clear examples that public opinion and opposition were critical in changing carbon-pricing policies.

International comparisons show that perceptions of distributional fairness and personal losses and gains can play a significant role in public acceptability around climate action. Clear communication on the effectiveness of policies is also crucial (Dechezleprêtre et al., 2022[68]). Integrating environmental costs and social inclusiveness aspects into recovery packages and measures for the net-zero transition may be a way forward (Kallbekken and Saelen, 2011[95]). In the case of carbon-pricing policies, using revenues to compensate vulnerable groups or ease the transition of carbon-intensive firms that lose competitiveness may also be a viable strategy (UN, 2021[96]).

Therefore, enhancing public acceptability requires, on the one hand, protecting vulnerable groups from socio-economic impacts associated with the net-zero transition and, on the other, ensuring the creation of new opportunities. Providing thorough information to households and firms on how policies will contribute to climate change mitigation and deliver the expected outcomes is also crucial, particularly if sacrifices are projected.

In the first case, the design of accompanying and compensating policy measures may be key. A first step for policymakers is to ensure that alternatives to fossil fuels and emission-intensive goods and services are available. For instance, developing clean public transport and supporting the procurement of electric vehicles or heat pumps will allow households to reduce their emissions without much deprivation. In the short term, when these alternatives are not available, compensating measures, notably social protection, can be used to avoid the deterioration of households' well-being.

The transition to a green economy could profoundly impact individuals and communities. A power station or a manufacturing plant closure can shape family circumstances and livelihoods. Social protection will be a crucial building block of governments' strategies to promote a just green transition by preventing and cushioning individuals and communities from potentially damaging disruptions to their livelihoods, thus easing voter resistance to carbon pricing and other mitigation efforts. The co-ordination of migration and housing policies should also be anticipated.

While modest overall, the estimated employment impacts of decarbonisation will be much higher in some regions. On average across OECD regions, only 2.3% of employment is in sectors at potential risk from climate policies consistent with the Paris Agreement. However, in some large regions, this may exceed 6%. For example, in the **Polish** region of Silesia, more than half of employment is in at-risk sectors (in the mining of coal and lignite), and one-quarter is in the manufacturing of rubber and plastics products (IEA, 2021[97]).

Employment opportunities may not materialise where losses occur, which is why vulnerable regions and communities will need targeted support. Countries are considering implementing mechanisms to support communities in this transition, including with new dedicated institutional frameworks. **Spain** has developed such a framework to ensure dialogue and participation with relevant stakeholders, an interesting model countries may wish to explore.[3]

In the second case, new investment and economic opportunities may reduce the risk of resistance. Recent estimates suggest that new investments in the energy sector alone are USD 1 trillion by 2050 for production of wind turbines, solar panels, lithium-ion batteries, electrolysers and fuel cells (IEA, 2021[97]). Moreover, a recent study by the International Monetary Fund points out that the multipliers of aggregate demand for investments associated with activities linked to the green economy are considerably higher than traditional investments, by two to seven times, suggesting these investments will generate new employment opportunities (Batini et al., 2021[98]).

Therefore, countries will need to seize the opportunities of the transition to alleviate the costs. New "green" skills can help local economies secure employment for workers who lose jobs in the transition. By way of balance, it is estimated that some 24 million jobs worldwide could be created by the green economy by 2030 (United Nations, 2019[22]). Ensuring that workers have the necessary green skills is thus essential.

The transition to a green activity is easier among high-skilled workers, however (IMF, 2022[99]). This highlights the key role of labour market and skills policies in countries' capacities to manage and profit from the green transition. Greening of skills is likely to require upskilling, as low-carbon sectors are estimated to require more skills than carbon-intensive industries. In addition, on-the-job training should be given priority over external retraining programmes to ensure a connection to job prospects. Skills mapping can also help identify skill needs in future investment priority areas. This is particularly important in regions in industrial transition, where it is often uncertain how workers' skills in "brown" industries are transferable to emerging jobs in low-carbon sectors (OECD, 2021[100]).

The above discussion suggests that green recovery packages that combine local development with the energy transition may be a way forward.. Governments' responses to the COVID-19 pandemic initially focused on containing the virus and limiting damage to the economy. As vaccines were progressively rolled out, governments drew up ambitious recovery plans to restart their economies. Furthermore, several governments issued pledges to "build back better" and adopted net-zero targets by mid-century (UN, 2021[101]). However, faced with the energy crisis, countries have been slow to implement.

Since 2021, there has been a significant increase in green recovery measures in OECD countries, the European Union and selected non-OECD large economies (OECD, 2021[102]). The estimated budget allocated to environmentally positive measures is USD 1 090 billion. This amounts to around 33% of total recovery spending announced since the pandemic's start (up from 21%). **Korea**, **Germany** and **Spain** lead in total green spending. Under the lens of green spending as a proportion of GDP, **Korea**, **Spain** and the **United Kingdom** take the lead. Despite these countries' efforts, other countries' recovery measures lacked a green focus in 2020 (O'Callaghan and Murdock, 2021[103]).

Furthermore, budgets allocated to measures with mixed and negative environmental impacts have also slightly increased, to USD 290 billion and USD 178 billion, respectively. More than half of identified green spending (or USD 611 billion) is directed towards the energy and transport sectors, which are central to net-zero and energy security strategies. Within the transport sector, countries increasingly shifted investments from road to rail infrastructure, but more spending for sustainable transport modes is needed to achieve the goals of the Paris Agreement.

A well-being lens

Although "build-back better" has been limited, countries should continue to explore integrated approaches. Recognising that climate action can contribute to a broader reform agenda for greener, more resilient and inclusive growth, countries can explore coupling climate action with wider well-being objectives considering better designed tax codes, pro-growth long-term infrastructure investment, and energy and transport systems that support cleaner air, better health and a more diversified energy supply.

The OECD has developed a process – the Well-Being Lens – to support countries to identify and prioritise policies leading to transformational pathways which are essential to move towards net-zero. The process has three steps: 1) **envision** the outcomes a well-functioning system achieves; 2) **understand** why the current systems' functioning is not achieving such outcomes and how the system could be reorganised to lead to better results by design; and 3) **identify** the actions and policies with the potential to **change** the systems' functioning towards a better one. See Box 8.

Box 8. The Well-Being Lens in the Transport Sector

The Well-Being Lens approach has been applied to the **surface transport sector**, which has led to the following results:

- **Envision**: A well-functioning transport system fosters the sustainable delivery of accessibility, i.e. the possibility to access places with ease by creating proximity to places and privileging healthy, safe and sustainable transport modes (e.g. walking, cycling, public transport).
- **Understand**: A conflation between mobility and well-being has led to transport policies fostering physical movement (mobility). However, more mobility does not equal more well-being; high traffic volumes are thus not a inevitably, nor the result of people's independent preferences, as often claimed. High traffic volumes are the result of transport and urban systems organised around car driving, which leads to the dynamics of induced demand, urban sprawl, and the erosion of shared and active modes of transport. The key problem is thus no longer vehicles' emission performance but the systems' dynamics leading to an increase in the number of vehicles.
- **Change**: For climate strategies to accelerate the transition towards net-zero systems, priority is given to policies reversing the three dynamics mentioned above.

Policies with the potential to **change** the systems' functioning and accelerate the transition towards net-zero transport systems by design include:

- Street redesign and improved management of public space.
- Spatial planning aimed at redesigning territories to increase proximity.
- Multi-modal and sustainable transport networks.
- Changes at the level of governance and monitoring frameworks, as well as systems innovation.

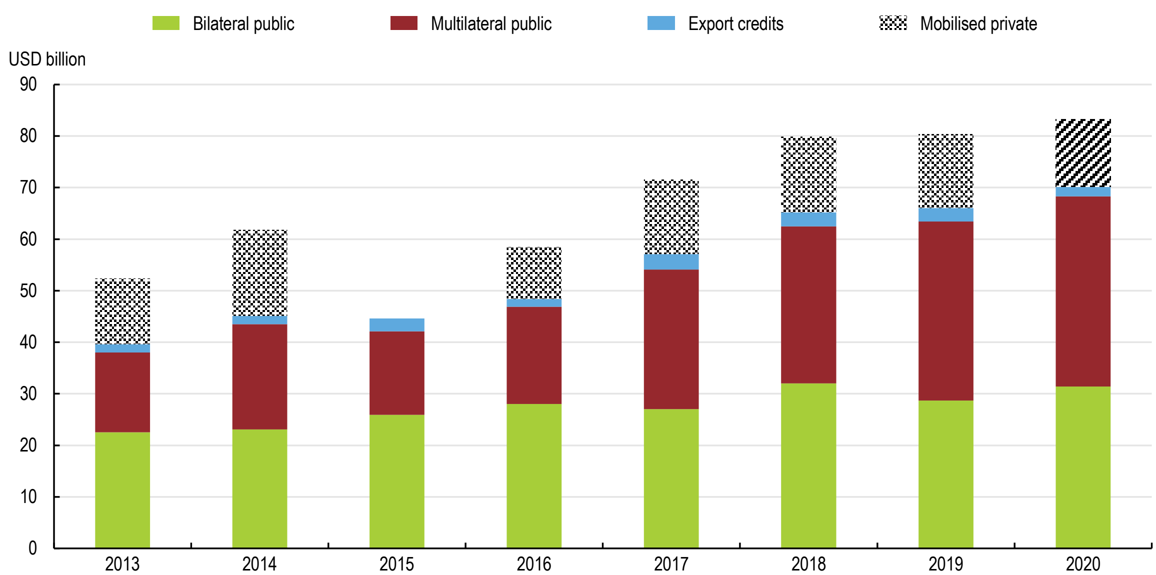
Source: OECD, 2022.

Supporting the transition in developing countries

At the Fifteenth meeting of the Conference of the Parties (COP 15) in Copenhagen in 2009, developed countries committed to provide and mobilise, by 2020, USD 100 billion a year for less wealthy nations to help them mitigate and adapt to climate change. To date, the total amount of climate finance provided and mobilised has reached USD 83.3 billion. The collective level of developed country climate finance was short of the goal by USD 16.7 billion. Nevertheless, financial resources provided have been steadily increasing. For example, total finance achieved in 2020 increased 4% from 2019, under the extraordinarily difficult conditions imposed by the COVID-19 crisis; this represents an increase of 42% since 2016 (OECD, 2022[104]) (see Figure 37).

Mitigation remains the principal area in which finance is directed, representing 58% (USD 48.6 billion) of total finance in 2020. It fell, however, 5% while adaptation finance increased by 40%, reaching USD 28.6 billion and representing 34% of total funds mobilised, the highest percentage registered to date. The sectoral distribution remains concentrated in energy projects, transport and agriculture.

Figure 37. International climate finance mobilised reached USD 83.3 billion in 2020



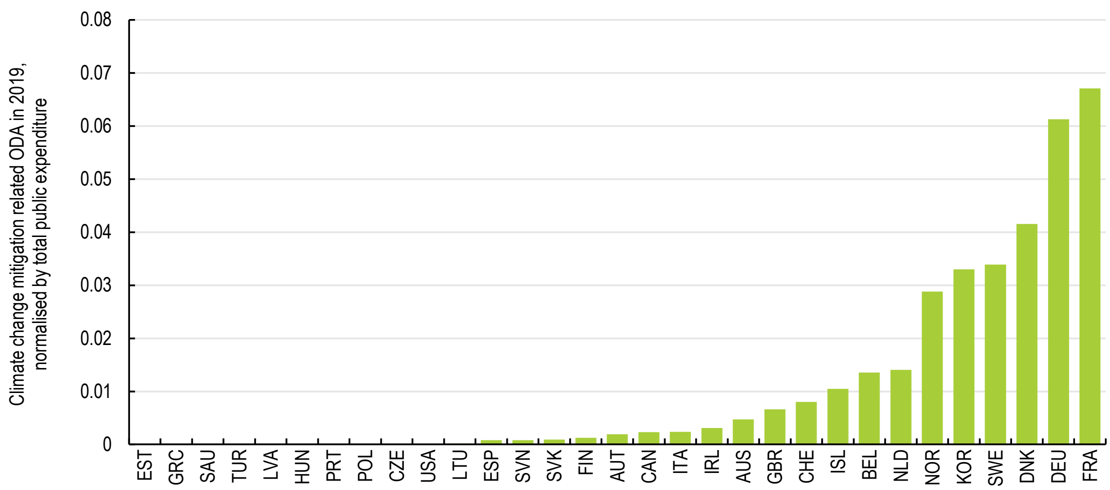
Source: The underlying data stems from (OECD, 2022[105]).

Mobilising additional private capital will be important as developing countries move to finance their energy transition. Official development assistance (ODA) from official donors rose to an all-time high of USD 178.9 billion in 2021. This represents an increase of 4.4% in real terms from 2020, triggered by support over the COVID-19 crisis. In 2019, about 27% of ODA targeted climate action. Furthermore, in 2019, members of the OECD Development Assistance Committee (DAC) committed USD 34.3 billion in bilateral allocable ODA that principally or significantly targeted climate action (screened against the Rio markers). This represents an increase in volume of 45% since 2014. Some 43% went to climate change mitigation activities, 33% to climate change adaptation and 24% to projects that addressed both climate change mitigation and adaptation (Figure 38) (OECD, 2022[106]).

The international community must give particular attention to extractive-based countries. The carbon footprint of oil and gas projects will affect prospects for continuous market access and has global equity implications, considering the weighted value of income in countries with a diversified industrial base compared to fossil-fuel-dependent developing economies, where diversification is challenging. Thus, these countries will need support to manage uncertainties and increased vulnerability, to build their resilience to external shocks, and embrace the challenge of undergoing unprecedented economic and social transformation (OECD, 2021[107]).

International trade, coupled with appropriate environmental and societal policies, can be a principal driver of the transition to an inclusive green economy. To achieve ambitious environmental outcomes, countries are expected to raise the level of stringency of their environmental policies; citizens are expected to demand more goods and services that are "environmentally friendly"; and businesses are expected to seek cleaner investment opportunities. This, in turn, can generate higher demand for products deemed "environmental" – which "measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems" (OECD/Eurostat, 1999[108]) – as firms and households seek to alleviate the compliance costs of new environmental regulations and access environmental goods and services.

Figure 38. Expenditure for climate change mitigation-related ODA differs between countries



Source: The underlying data stems from (OECD, 2021[109]).

Policies are developed under countries owns circumstances including their broader economic and institutional frameworks. These include both the opportunities and challenges that countries may face. Therefore, the effectiveness of climate policy choices will not only depend on effective design, but also on how countries consider and take advantage of this broader policy context, or tailwinds and headwinds, that interact with climate action.

Tailwinds are policies or trends that can enhance the performance or effectiveness of climate action. Headwinds are policies or trends that work in opposition to the direction of climate action efforts. Policy makers must be cognizant of these policies and trends to ensure that climate action is effective. However, in the long-term, climate action will only be viable, feasible even, if it is consistent with broader development and well-being objectives. Only by making decarbonisation an integral part of the global development effort where no one, across or within countries, is left behind, will it be possible to ensure a sustainable, inclusive, and resilient national and global development path.

Notes

1. In November 2018, there were public protests by the “Yellow Vest” movement against the planned doubling of a carbon tax — from 44.6 to 86.2e/tCO_2 in 2022.

2. A wave of protests and demonstrations began in Ecuador in October 2019 following the announcement of a series of economic measures, including the elimination of subsidies and price control on diesel and gasoline. Ecuador has one of the lowest gasoline prices in the world and these policies have implied millions in direct subsidies, generating what in practice has been a negative carbon price.

3. https://www.transicionjusta.gob.es.

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The Climate Action Monitor 2022

HELPING COUNTRIES ADVANCE TOWARDS NET ZERO

The Climate Action Monitor 2022 updates the International Programme for Action on Climate (IPAC) annual comprehensive assessment of country progress towards net-zero goals and the Paris Agreement commitments. This year's edition draws on two new sets of indicators developed by IPAC on climate-related hazards and climate action: climate hazard and exposure indicators and the climate actions and policies measurement framework. These indicators provide granular evidence that although climate action and policies are expanding across the world, government ambition must increase significantly to deal with the range of climate risks faced globally and affecting people's livelihoods.

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